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IV Czech-Slovak Scientific Conference

Transport, Health and Environment

editors: Vladimír Adamec & Vilma Jandová

Blansko, November 2nd - 3rd, 2010

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Ministry of Transportation
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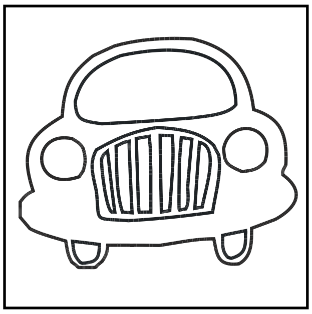
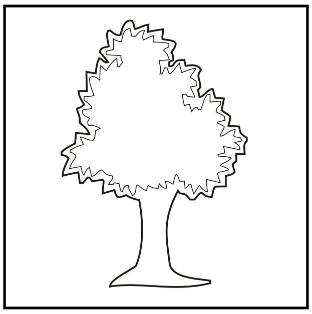
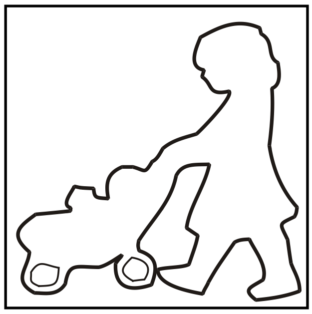
IV Czech-Slovak Scientific Conference

Transport, Health and Environment

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External Costs, Internalization and Optimal Use of Transport Infrastructure

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Abstract

This chapter addresses the issue of external costs of transport and their internalisation using pricing and related instruments as a means to optimising traffic and efficient use of transport infrastructure. It starts with outlining the theoretical basis and conceptual approaches to the quantification of external costs and policy tools for their internalisation, but at the same time the attention is also paid to European and national transport policies. Selected results on valuation of transportation noise achieved in the research project ‘Quantification of external costs from transport in the Czech Republic’ are demonstrated.

1. Introduction

In January 2010, the European Commission - Joint Research Centre (JRC) published a study on the effects of proposed amendments to the Directive 1999/62/EC on the charging for use of road infrastructure by heavy goods vehicles [1] under which the benefits of charging external costs - noise pollution, air quality and congestion – on six selected trans-European road corridors greatly outweigh the slight increase in carriers’ costs.

Although the negotiation of the draft is blocked in the Council of the EU for almost a year (what Belgian presidency is now trying to overcome), there are some indications of a proactive approach to charging environmental externalities in some of the Member States. Following the decision to postpone the introduction of charging for whole road network and of all users in the UK, the focus now shifts to another ambitious project – charging of the use of the road network in the Netherlands – that has been presented in the bill submitted to the parliament in late 2009 and the toll system should be a gradually introduced from 2012 to all users and entire road network.

With the aim to contribute to the debate on how to reduce negative impacts of transport in the Czech Republic, we discuss approaches and some results of a research project which focuses predominantly on monetary valuation of the effects from emissions of pollutants and greenhouse gases, noise, congestion and accidents in the road and (to some lesser extent) rail transport.

2. Conceptual background – externalities and internalisation

2.1. Externalities

The basic approach taken in the project is based on neoclassical economic theory, which makes our objective to estimate the loss of welfare due to sub-optimal allocation of resources in the transport sector in the presence of externalities. The concept of externalities, being one of the causes of market failure, is well known and used in economics. According to Verhoef external effect occurs if the utility function (or profit) of receiver includes a real variable whose actual value depends on the behaviour of another entity (the supplier) that does not account for the effects of their behaviour in their decision [2].

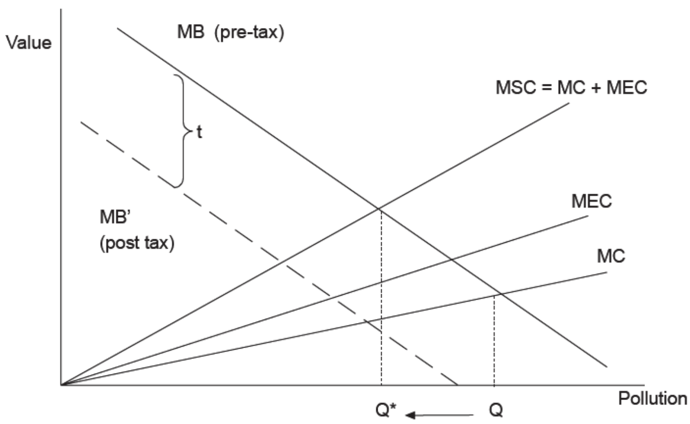
The condition that there must be a real variable implies that the externalities are not included in the normal relations of economic dependence, which passes through the market without disrupting the coordination and allocation function of the market (so-called pecuniary relations). Only the technological external effects (sometimes denoted as externalities in the strict sense), i.e. activities of certain entities that directly affect the production and utility functions of other actors, and the market does not cover the damage caused to them. A typical example of technological externalities is damage to the environment as a public good. Further, the precondition that the supplier does not include the effect in its decision-making means that neither barters, nor criminal offences, altruistic and charitable acts are considered as externalities.

In the presence of externalities, market prices fail to reflect the total social costs or benefits. Traditional but rather theoretical solution to the problem of externalities is to get the various market actors to internalize the total costs of their activities and has been associated primarily with the work of British economist A. C. Pigou, who suggested that the state imposes a tax on emissions at the rate which would be equal to the damage effectuated by the efficient level of pollution. The logic of this approach is based on the fact that consumption of a certain good causes additional social costs (*marginal social costs*), that the consumers, maximizing their own benefit, do not take into account, therefore, such costs must be added to the price of good consumed in the form of a tax. Price signal, in turn, affects consumer behaviour.

2.2. Internalization of external costs

The tasks carried out in the research project should serve to the objective of internalization of the external costs of transport. The principal instrument in this regard – *environmental costing* – is deemed to be a key contribution to optimizing traffic at the social optimum. This is the intersection of marginal social cost curve (i.e. the sum of private marginal costs and marginal external costs) and the marginal social benefit, as shown in the picture below.

Fig. 1:. Optimal level of internalisation



Source: [3]

Charging that is set corresponding to marginal external costs (the equivalent to Pigouvian emission tax *t* in the figure) serves at the same time as the core principle in the European Commission's Greening transport package and is endorsed to a limited extent in a draft Eurovignette directive amendment [4]. Though the EC Council has not adopted this proposal, it represents one of the key steps for at least a partial fulfilment of the objectives of European transport policy. Although the proposal is concerned with road freight transport, the Strategy of the European Commission for the implementation of the internalisation of external costs aims at a gradual implementation of the internalization in all major transport modes.

In doing so, however, the possible use of monetary values for environmental impacts includes not only internalization itself, but also use in the cost-benefit analysis of investment projects and policies and in devising indicators of sustainable transport, benchmarking and green accounting. Last but not least, the never-ending debate on the optimal development of transport infrastructure cannot do without the consideration of rather heterogeneous effects that are associated with transportation and economic evaluation allows for comparison using single denominator, i.e. money. In this respect, such requirement has been voiced recently in the evaluation of Common transport policy in relation to development of the trans-European transport network TEN-T.

2.3. Methodology

The outlines of methodology used to monetary valuation of external costs can be summarized into 7 steps:

1) setting the objective
2) specification of subject of research and system borders
3) identification of relevant (i.e. environmental) impacts
4) choice of causal relationships (i.e. exposure-response functions)
5) assignment to cost and benefit categories
6) economic appraisal
7) presentation of results

In the economic evaluation of externalities various objectives come into account, including project evaluation (e.g. in cost benefit analysis), setting of effective rates of environmental taxes and charges, estimation of environmental damage, prioritization of objectives within individual and/or among different policies.

The specification of research subject includes the selection of sources analyzed and/or relevant activities effectuating upon the environment and types of damage assessed. Determining the limits of the system serves as a decision criterion for defining the agents and activities, effects, impacts and damage considered. Setting the limits is connected to definition of spatial scale (street, city, region etc.), defined according to the assessed project, processes, or measures, as well as the time horizon (e.g. climate change impacts spanning over hundreds of years), as well as methodology and data accuracy and their level of detail.

Definition of the relevant impacts, such as those caused by emissions, land appropriation, releases of dangerous substances into waterways, etc., their aggregation and allocation to particular activities or actors. This can in principle be done either in a top-down or bottom-up way. Top-down approach is based on macroeconomic modelling of interdependencies between economic activities and environmental pressures (e.g. based on input-output aggregates).

In contrast, bottom-up approach builds on the damage function approach (see below), and traces the environmental burden in physical form from the source to the receptor and then to change in utility for humans. Bottom-up approach is suitable for those cases where site-specific valuation of external costs is necessary. This approach is usually constructed as a marginal valuation of external costs and is consistent with the approaches proposed and used in the implementation of the *Strategy for the internalisation of external costs* [5] and *Handbook on estimation of external cost in the transport sector* [6].

Evaluation of effects is the basis for valuation in relation to the environment. Usually, it comprises the identification of effects and their potential and/or detrimental impacts in the appropriate spatial and temporal resolution. All effects, that in their course affect benefits of economic actors, an economic value is assigned to. This step represents a link between physical evaluation (physical effects) and economic assessments (change in utility). This change may take some of the following forms:

- immediate restrictions on individual utility (e.g. negative impacts on health, impairment of quality of life, damage to private goods),
- a reduction in the production of goods and services (e.g. lower timber growth, lower productivity due to the deterioration of workers’ health)
- other (non-attributable) effects reflected in the national economy (e.g. lowering of groundwater, damage to facades)

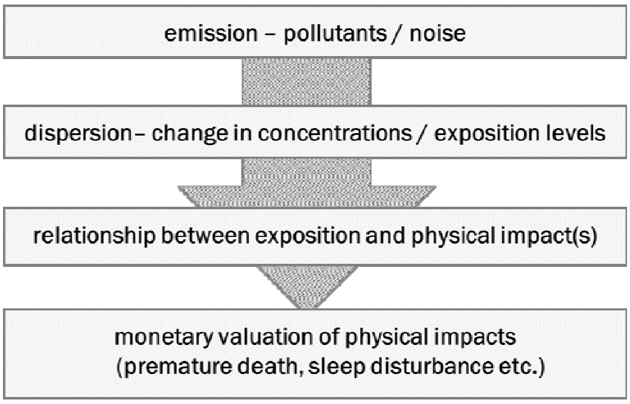
Another category, which does not directly affect the utility is non-use value (e.g. existence value of the wildlife).

Monetary valuation is based on assigning values identified in the previous steps, to either costs or benefits. Numerous valuation methods are available for this task, while some of the damage categories can be captured by combining certain methods only (but it is necessary to avoid double counting). In addition various normative assumptions have to be made (e.g. discount rates, risk rates), and the extent of variability should shown in the sensitivity analysis. Damage that cannot be monetized should be described qualitatively at least.

Presentation of the results has to document the transparency of the estimates made. It is therefore appropriate to present the results by different types of damage, different valuation methods (if available), including the indication of whether the estimates are damage costs or avoidance costs (opportunity costs). The results should be interpreted taking in the account the context of valuation objective.

Damage function approach to valuation of environmental impacts, impacts on human health and property is generally accepted as state-of-the-art analytical approach to valuation of environmental externalities [7], and is schematically depicted in Figure 2. For some types of environmental externalities - typically emissions - the damage function approach is often called as Impact Pathway Analysis (IPA) [8].

Fig. 2: Damage Function Approach



This framework represents a fundamental simplification of reality for the quantification and modelling steps. Damage function approach is consistent with both approaches to risk assessment and also with neoclassical economic theory, superior in the case of evaluation of marginal changes in the marginal (cost) analysis. This approach allows you to express how change in environmental effects (e.g. additional unit of emission) due to the implementation (or non-implementation) of certain measures would affect the welfare of society, or what will be the impact of an additional unit of environmental burden.

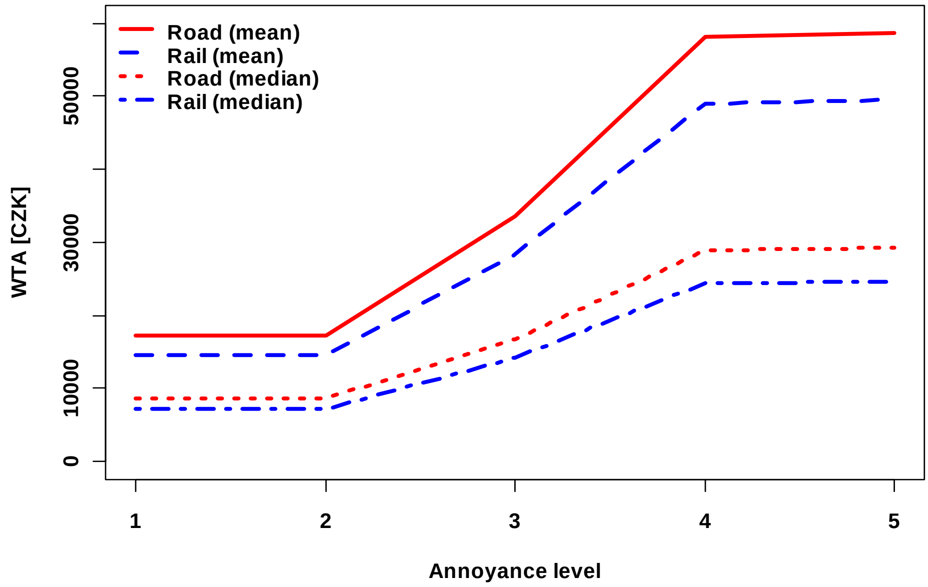
Marginal cost approach meets the objective of internalising external costs better than average cost approach, since, unlike the average externalities reflect the impact that an additional unit (e.g. vehicle-km travelled or LTO operation in air transport). It has, however, some particular consequences in the practice – while in congestion travel time is increasing with the growing traffic volume (and non-linearly as shown by prevailing evidence from abroad), the marginal external costs of traffic noise decrease with increasing traffic intensity as additional unit (vehicle) increases the noise level much less than in low-traffic situation.

Our research project endorses a bottom-up approach whenever appropriate starting in designed pilot areas, which were chosen with an attempt to capture the variability in the main attributes that affect total external costs the most (transport mode, infrastructure type, velocity, population density, vehicle fleet structure, meteorological conditions, etc.).

3. Quantification and pricing of external costs from traffic noise

To allow for valuation of noise annoyance, a questionnaire survey was conducted in selected localities of the CR in summer 2009, which derived the value of willingness to accept compensation no reduction in road and rail noise annoyance [14]. The choice of willingness-to-accept scenario is relatively infrequent in valuation of environmental dis-amenities, but proved to be particularly helpful in eliminating respondents' protests against valuation scenario frequently encountered in previous studies. The WTA estimates (totalling over 10 years) for individual annoyance levels derived using Weibull parametric model are shown in Figure 3.

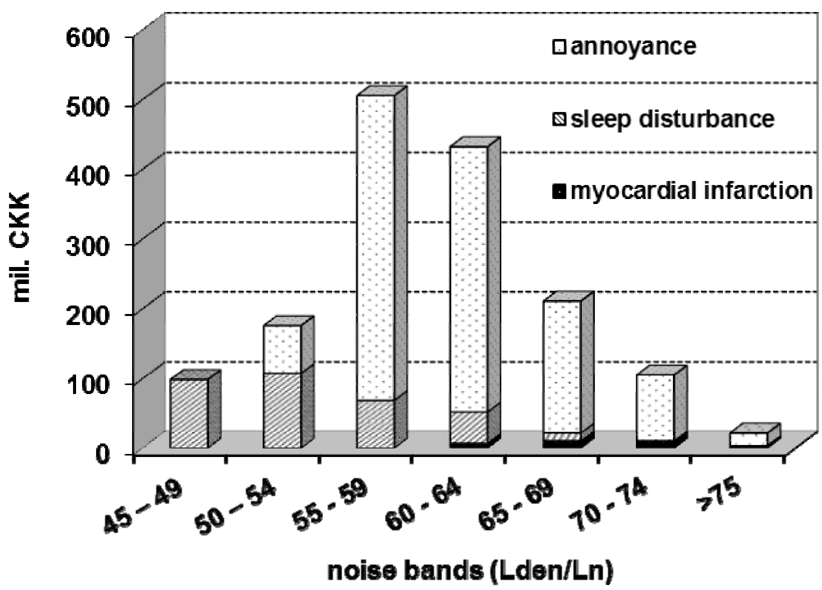
Fig. 3: Willingness-to-accept road and rail noise annoyance (in CZK over 10 years)



To outline the aggregation of noise impacts, a quantification of external costs from road traffic noise in the Prague agglomeration was calculated using the data from the strategic noise mapping [9]. The quantified impacts comprise not only the annoyance, but also productivity loss due to the high sleep disturbance and additional cases of acute myocardial infarction. The distribution of respective impacts is estimated based on previous studies on causal relationships (exposure-response) [10,11,12], the detailed calculation is provided in the research project report [13].

The external costs of road traffic noise in Prague agglomeration were estimated to amount to CZK 1.55 billion a year, exposure in the 55-59 dB noise band (Lden) contributing the most to the total economic impacts of noise (affecting 38% of total population) followed by noise band 60-64 dB (affecting some 27% of total population).

Fig. 4: External costs of road noise in Prague agglomeration (in million CZK by noise bands)



3.1. Pricing of noise

As mentioned earlier the marginal cost of noise decreases with the intensity of traffic and that makes the use of marginal pricing approach relatively hard to implement. A rough estimate calculated using the formula suggested in technical annex to the strategy for internalisation of external costs [15] gives average external costs of noise at about CZK 0.23 per vehicle-kilometre driven in Prague agglomeration, what broadly correspondent to the default unit values in abovementioned *Handbook on estimation of external cost in the transport sector*.

However, if these estimates are to be used for road charging they should preferably be further broken down according to time of the day, vehicle category and distinguish between rides in inner city and city outskirts to better reflect the goal of Pigouvian corrective taxation.

4. Concluding remarks

The quantification and internalisation of external costs is quite a broad and multidisciplinary subject, which has so far been systematically addressed only recently in the CR. Negative impacts from transport - in addition to the obvious benefits - significantly affects the quality of life, especially in cities – what is for example clearly evident in recent disputes on reduced speed on Prague’s north-southern express-way.

In our research project we seek to describe and quantify the external costs originating from main transport modes in the Czech Republic in a consistent and transparent way. Currently, the project follows up with an empirical study on valuation of travel time and attributes related to modal choice. Further, the attention will be paid to sensitivity analyses of external cost estimates, comparisons with existing studies and providing guidance on use of recommended values for monetization of major impact categories.

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The Czech NGV Market

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Summary

1. Introduction
2. The Agreement
3. NGV statistics - Czech Republic, Europe, and the world
4. OEM NGVs in the Czech Republic
5. Technical standards for NGV
6. International NGV Conference 2011 - INVITATION

1. Introduction

There is no question that climate change is reality today. Statistical data shows that emissions are globally increasing by 1.3 to 1.5 percent per year. Road transport is also expanding, specifically by almost 12 percent per year in the Czech Republic. Balanced reduction in emissions is a hot issue and has closely related economic, energy and strategic aspects.

Compressed natural gas, CNG, has become a completely fully-fledged and available alternative to oil-based fuels. It is currently the most promising alternative fuel for automobiles in environmental, economic and safety terms. Moreover, this solution is a well-developed one in technological terms, and can be deployed in practical life very quickly. CNG as a motor fuel has huge potential, which should be exploited to the full in an effort to achieve reductions in harmful emissions and liquid fuel savings.

The scheme of CNG use in transport is a major project, and it is being carried out in the Czech Republic in line with the European Union's strategy. In accordance with COM(2001) 370, White Paper on European transport policy, the target of achieving at least a 10% share of natural gas in overall consumption of fuels in transport by 2020 has been set. The scheme has been running since 2005.

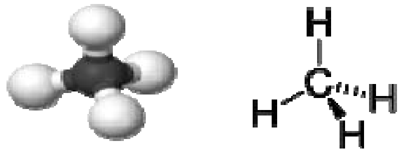
The relevant governmental resolution has helped to professionalise the approach, while the subsequent implementation of the objectives of an Agreement between the government and the gas industry on support for CNG has enhanced companies' awareness of, and interest in, this type of fuel and attracted new and most welcome foreign manufacturers of OEM NGVs and refuelling station equipment. (OEM = Original Equipment Manufacturer)

1.1. CNG is an inexpensive, safe and green fuel

The world's overall natural gas reserves, estimated at 511,000 billion cubic metres (bcm), have a lifetime of up to 200 years. [1]

From the chemical point of view, natural gas is a mixture of various hydrocarbon gases with a variable component of non-hydrocarbon gases. Its characteristic feature is a high level of methane, CH4. H-gas, which is used in most European countries, including the Czech Republic, usually contains more than 90 percent of methane by volume and less than 5 percent of incombustible compounds by volume. Natural gas is a combustible and explosive, colourless and odourless gas. It is non-poisonous, and its toxic properties are negligible. It is lighter than air. [2]

Fig. 1: Molecule of methane, CH_4



- The simplest hydrocarbon – each molecule of methane consists of one carbon atom (C) and four hydrogen atoms (H)
- In the Czech Republic, natural gas contains 95 to 98 percent of volumetric units of methane, CH_4
- From the perspective of fire safety, it is less risky than petrol or diesel
- It is lighter than air – it is naturally vented, and is easily miscible with air
- A narrow explosive limit (gas air mixture) of 4.4 to 15 percent of volumetric units
- Octane number up to 130
- When burned, natural gas releases lower amounts of harmful emissions (CO_2, NO_X, CO, …) than oil-based fuels
- It dissipates easily, and in a mixture with air it has a better explosive limit and a higher ignition temperature
- The fuel systems provide for a higher safety of CNG vehicles
    - The fuel systems most frequently consist of shock-resistant thick-walled (or composite) cylinders, CNG is let in through thick-walled pipes, and the fuel system is connected to the vehicle’s electronic control module
    - The check valve on the container has electromagnetic controls, and fuel systems also have pressure relief devices and thermal fuses
    - All components of the fuel systems and their mounting are subjected to crash tests
    - OEM manufacturers guarantee certified repair and maintenance
    - Fuels systems can be used for LNG, L-CNG, CNG/H_2, and CNG/diesel, including renewable biomethane

2. The Agreement

The Agreement on promoting natural gas as an alternative fuel in transport in the Czech Republic, signed by and between gas companies and the Czech Government on 16 March 2006, is one the basic parts of Government Resolution No. 563/2005, under which

The Programme of Support for Alternative Fuels in Transport – Natural Gas

is being carried out, and the EC’s indicative goal to reach a 10% natural gas consumption by 2020 in accordance with COM(2001) 370 is to be achieved.

2.1. Basic principles stemming from the Agreement

- Development of CNG refuelling stations
- A zero excise duty on CNG
- Development of NGV legislation
- Marketing support for the CNG use in transport programme

2.2. Goals

- *Achieve* an expansion of CNG bus fleets in cities
- *Attain* a gradual replacement with CNG fleets in governmental and other public organisations
- *Intensify* the use of CNG vehicles by businesses and companies
- *Increase* the use of municipal CNG vehicles as refuse collection trucks, etc.
- *Reduce* health and environmental risks caused by air pollution attributable to the enormous growth in transport

2.3. Governmental incentives for CNG

- *A zero excise duty on CNG – in effect from 1 January 2007 to December 2011*

Fig. 2:Tax structure until 2020

Excise duty on CNG intended for use, offered for sale, or used as a motor fuel in the Czech Republic (CZK/t - Year)

The tax rate will climb to CZK 3,355/t by 2020 (or will follow a new EU tax rate in 2020).

- *Zero Road Tax*
  Act No. 16/1993 (amended in May 2008) sets out a zero road tax for CNG passenger cars and up to 12t LDVs
- *Subsidies* for purchases of new CNG buses under the Czech Grant Policy supported by the European Commission; they will last until 2013
- *The Energy Regulatory Office (ERO)* has accepted suggestions related to daily contract capacity for CNG – a constant price for CNG has been determined.

2.4. Gas industry's incentives for CNG

- CZK 200,000 (EUR 8,000) for buying a new CNG bus - marketing support
- Marketing & media promotion of CNG (video, brochures, TV & radio…)
- Investment in CNG infrastructure – 100 CNG refuelling stations by 2020

3. NGV statistics, September 2010

3.1. Czech Republic: average annual growth

- CNG consumption in transport 25.1%
- Number of NGVs 41.5%
- Number of public CNG refuelling stations 22.3%

	Public CNG refuelling stations	Total vehicles	Passenger cars	Buses	Sales of CNG, in million m³
2004	9	250	150	100	2.773
2005	9	450	280	165	3.010
2006	11	580	400	180	3.584
2007	17	900	680	195	5.790
2008	17	1,200	950	215	6.758
2009	23	1,800	1,465	270	8.082
3Q2010	***30***	***2,275***	***1,900***	***295***	

NGV statistics: 3Q2010

Public refuelling stations *30*
VRA *75*
Total vehicles *2,275*
Passenger cars & vans *1,900*
OEM vehicle importers 6
Number of car models 16
Buses *295*
OEM producers / importers 5
Number of transport companies 20
Number of cities / branches 31
Municipal trucks
(refuse collection): PS a.s., AVE, Komwag, IPODEC *35*
OEM producers / importers 3
Number of cities / branches 5
Special vehicles *45*
Forklifts 41
Ice resurfacers 4

CNG average sales/month in 2009 *673,500 m³*
(563,166 m³ in 2008, 483,000 m³ in 2007)
Total CNG sales in 2009 *8.082 million m³*
2007: 5.792 million m³, annual growth 6.7%
2008: 6.76 million m³, annual growth 19.5%
Average CNG price *CZK 22.50/kg = CZK 15.80/m³ = EUR 0.62*

Fig. 3: Expected development until 2020

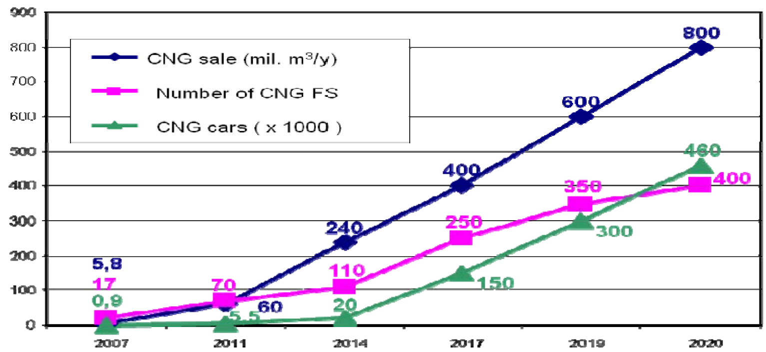


Fig. 4:CNG stations in the Czech Republic – September 2010

3.2. NGV statistics in Europe – September 2010

CNG vehicles: *1,302,382* (37 countries) – annual increase by ca 100,000
733,413 (2007), 1,106,857 (2008), 1,201,028 (2009)

- 23 OEM vehicle manufacturers
- 124 models of all types of vehicles

CNG refuelling stations: *3,490*

2,413 (2007)
3,073 (2008)
3,362 (2009)

Country	CNG vehicles	CNG refuelling stations	VRA
Italy	676,850	770; 150 cities	199
Germany	85,000	863; 530 cities	804
Bulgaria	60 261	81; 36 cities	
Sweden	23,125	134; 63 cities	21
Switzerland	8,599	122; 25 cities	117
Spain	1,863	42; 18 cities	21
Austria	4,983	208; 95 cities	58
Poland	2,106	33	49
UK	368	33	115
Slovakia	622	8	
TOTAL	***1,302,382***	***3,490***	***3,484***

3.3. NGV statistics in the world, September 2010

- *CNG vehicles:* *11,744,434 (more than 60 countries)*
  10,106,444 (2008), 11,111,615 (2009)
  Increase by 10% in 2009 (increase by 313% in 2002)

- *CNG refuelling stations:* *17,806*
  15,198 (2008), 16,554 (2009)
  1,279 under construction
  Increase by 85% over the last three years
- 65 vehicle manufacturers
- Some 300 models of all types of vehicles
- Annual CNG consumption in transport: 35.4 bcm (29.2 bcm in 2009)

Country	CNG vehicles	CNG refuelling stations	VRA
Pakistan	2,500,100	3,300; 53 cities	
Argentina	1,826,845	1,858; 328 cities	32
Iran	1,907,012	1,355; 611 cities	
Brazil	1,639,705	1,782; 290 cities	7
Italy	676,850	770; 150 cities	199
Ukraine	200,019	283	
USA	146,900	1,600	4,747
Russia	103,000	226; 172 cities	12
Germany	85,000	863; 530 cities	804
France	12,450	125; 26 cities	1,290
TOTAL	**11,744,434**	**17,806**	**1,279**

4. OEM NGVs in the Czech Republic

Range on offer in the Czech market:

- Light duty passenger cars & vans:
  Citroen, Fiat, Opel, Renault, VW, Mercedes-Benz, Iveco Daily;
  Škoda Auto (presented prototypes in May 2007), no progress so far
- Buses: Czech production: Tedom, SOR
  Imported: Irisbus Iveco, Mercedes Benz, Solaris
- Heavy duty trucks (refuse collection): Iveco, Mercedes Benz, Renault
- Special: Forklifts Linde
  Ice resurfacers Zamboni

4.1. Rental of CNG vehicles

Pražská plynárenská a.s. (a gas distribution company)

- Branches: České Budějovice, Cham (Germany)
- Fleet: 20 cars (7 Fiat Multipla, 11 Panda, 1 Dobló, 1 Iveco Daily)

SIXT – International Car Rental - Operates 40 CNG vehicles in Prague

- Mercedes Benz B 180 NGT
- Prague – Frankfurt a/M – Prague: 1,021 km
  Price: CNG CZK 1.06/km 100%
  petrol CZK 2.14/km 201.8%
  diesel CZK 1.65/km 155.5%

5. Technical standards for NGV

Legislation on NGV is being developed in an effort to:

Harmonise national technical rules, standards and regulations, including technological procedures, the component base of the fuel systems, and dispensers for refuelling stations.
Enhance the safety of the operation of CNG vehicles and CNG dispensers.
Ensure continuous growth in vehicle replacement with CNG vehicles.
Reduce health and environmental risks by using the latest NGV technologies and vehicle propulsion systems.

5.1. International legislation on NGV

5.1.1. UN ECE 49

Uniform provisions on the approval of compression-ignition (CI) and natural gas (NG) engines as well as positive-ignition (PI) engines fuelled with liquefied petroleum gas (LPG), including emissions of pollutants.

5.1.1.1. OEM vehicles

- *UN ECE R110* – Uniform provisions concerning the approval of

  I. Specific components of motor vehicles using CNG in their propulsion system
  II. Vehicles with regard to the installation of specific components of an approved type for the use of CNG in their propulsion system
  III Contains the provisions of the following standards: *ISO 11439* applicable to all types of CNG cylinders, and *ISO 14469-1* applicable to CNG refuelling nozzles.
  The amended regulation has been extended to include a part on pressure release devices and welded metal liners for composite cylinders.

5.1.1.2. Converted vehicles

- *UN ECE R115 – Uniform provisions concerning the approval of:*

  I. Specific LPG retrofit systems to be installed in motor vehicles for the use of LPG in their propulsion system
  II. Specific CNG retrofit systems to be installed in motor vehicles for the use of CNG in their propulsion system.

5.1.2. ISO documents and regulations on NGV

Their general methodology is "fit for purpose": priority is not given to the design principles and procedures, or materials, but to the safety criteria that components and systems *must* meet, including the operating parameters of the whole product.

- *ISO 11439* Gas cylinders – High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles *(incorporated in UN ECE R110, i.e., these requirements are STATUTORY requirements)*

Includes all types of cylinders:
CNG-1 Metal
CNG-2 Metal liner reinforced with resin impregnated continuous filament (hoop wrapped)
CNG-3 Metal liner reinforced with resin impregnated continuous filament (fully wrapped)
CNG-4 Resin impregnated continuous filament with a non-metallic liner (all composite)

- *ISO 19078* Gas cylinders – Inspection of the cylinder installation, and requalification of high pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles; this standard specifies the requirements for the periodic inspection of CNG cylinders and the assessment of cylinder integrity and operating condition. Not yet included in R110; inclusion would result in a mandatory European standard for periodic inspection.

5.1.2.1. Types of connectors:

- *ISO 14469-1* Road vehicles -- CNG refuelling connector -- Part 1: up to 200 bar connectors - It is a part of R110
- *ISO 14469-2* Road vehicles -- CNG refuelling connector -- Part 2: up to 200 bar connectors size 2, for large trucks - Preparations for inclusion in R110
- *ISO 14469-3* Road vehicles -- CNG refuelling connector -- Part 3: 250 bar.

5.1.2.2. Fuel systems:
(these standards are currently subject to revision after 5 years)

- *ISO 15501-1* Road vehicles -- CNG fuel systems -- Part 1: Safety Requirements
- *ISO 15501-2* Road vehicles -- CNG fuel systems -- Part 2: Test methods
- *ISO 15500* Road vehicles -- CNG fuel system components
  The standard has 20 parts (e.g., Part 3: Check valve, Part 5: Manual cylinder valve, Part 6: Automatic valve, Part 9: Pressure regulator, Part 17: Flexible fuel line, ...).

5.1.3. ISO/TC 193 standard:

- *ISO 15403* Natural gas – Natural gas for use as a compressed fuel for vehicles – Parts 1 and 2 – *see the part FUEL*

5.1.4. CEN documents and regulations on NGV

CEN/TC 326 set of standards

- *prEN 13638* NGV filling stations – *basic document for TDG 304 02*
- *prEN 13945* Vehicle refuelling appliances *(flow rate < 20 Nm3/h, CNG storage <0.5 Nm3, characterises VRA = slow-fill appliance) – basic document for TDG 982 03*

5.2. Czech legislation on NGV

- *ČSN 65 6517 standard:* Motor fuels – Compressed natural gas – Technical requirements and test methods
  - An implementing regulation attached to *Act No. 311/2006, On Fuels and Fuel Filling Stations*
- Amendment to *Government Order No. 615/2006, On the Setting of Emission Limits and Other Conditions for the Operation of Other Air Pollution Sources* – categorisation of CNG refuelling stations as *small pollution sources* (point 4.8). Expected to come into effect in 2010.

- *TDG 304 02* CNG refuelling stations for motor vehicles
  Currently subject to revision and transformation into a TPG (2011)
  - *Sets out the conditions* for the siting, execution, testing and operation of fast-fill CNG stations (national regulation related to prEN 13638)
  - *Reflects self-service refuelling* of motor vehicles by final customers – drivers
  - CNG refuelling stations are fit for self-service refuelling if they have dispensers with *NGV1 refuelling nozzles, and fuel lines with overload protection and a break-away connector*
- *TDG 982 01* Equipment of parking garages, servicing and repair shops and other facilities for CNG vehicles
  - Equipment for parking spaces
  - Single, self-standing parking garages
  - Multi-parking garages and areas (surface and multi-level facilities)
  - Equipment of rooms for inspection and maintenance work
  - Professional competence and requirements on facility operator
- *TDG 982 02* Requirements for the operation, repair, maintenance and inspection of CNG vehicles
  - Type and character of the vehicles and fuel systems
  - Passenger cars, delivery vans, buses, lorries and trucks, special purpose vehicles
  - Single-fuel (CNG), bi-fuel (CNG/petrol), professional competence
- *TDG 982 03* CNG refuelling appliances
  - Requirements on execution, installation and operation
  - Users' professional competence

6. International NGV Conference 2011 - INVITATION

4th International NGV Conference to be held in Prague on 9 and 10 February 2011

Prospects for the Development and Use of CNG in Transport

- One of the international NGV events in Europe, focused more on Central and Eastern European countries
- Designed to attract the attention of all NGV market players and policy makers
- Helps to exploit the potential that exists in the growing NGV industry
- Papers are delivered by pre-eminent international experts and first-class speakers dealing with government policies, transport, the environment, and state-of-the-art technologies, among other subjects
- Organised under the auspices of the Ministry of the Environment of the Czech Republic -- long-term support for CNG and methane as fuels and for new NGV technologies
- A new feature of the conference is a self-standing exhibition of NGV companies
- In close co-operation with NGVA Europe and NGV media partners *(the gvr, Czas na Gaz, Fleet and Fuels, and GNV magazines)*

The Conference is intended for all businesses operating in road transport, company managers, state administration and local government officials, mayors of towns and cities, and all those who are interested in CNG use in transport.

The key topics are:

- Projects and new trends in NGV
- Developments in NGV technologies and equipment
- Biomethane – a promising biofuel
- NGV manufacturers’ and operators’ experience

Evžen Tošenovský
Member of the European Parliament and EP ITRE Committee Vice-Chairman.

“I regard a conference on the topic of *Prospects for the Development and Use of CNG in Transport* as extremely important right at this time. The global debate on the search for new technologies in transport is crucial. CNG is one of the important fully-fledged and available alternatives to oil-based fuels. This technology supports a faster transition to a different type of fuel while using the currently existing engines. Moreover, this solution is a well-developed one in technological terms, and can be deployed in practical life very quickly. Most of vehicle manufacturers therefore have OEM CNG models in their range on offer today. Another clear advantage of this alternative fuel is the zero, or minimum, excise duty and zero road tax. This trend can be seen across the European Union. By its decision to adopt a directive on alternative fuel use in transport as early as 2001, the European Commission clearly indicated the direction in which transport would develop. In simple terms, we can say that CNG has huge potential that has to be exploited to the full. It is an economical, safe, environmentally friendly, and also highly powerful fuel”.

How to Further Promote Bicycle Transport? Be Inspired by Denmark.

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Abstract

Today Denmark is a laboratory of cycling, new trends and ideas are connected here with years of experience, and the Danish experts share them with the Czech ones at the conference in April. They recommended four fundamental principles for promotional marketing of the city cycling. 1. “From the point A to the point B” philosophy – quickly, comfortably, safely: the aim is to project and frame a modern city convenient for cyclists too. 2. Perception is (also) reality: the aim is to change general perception of which types of mobility are the most useful for both the citizen and the society. 3. People-friendly cities require mobility for all: the aim is to have the cities comfortable for living, well accessible, enabling their inhabitants be mobile. 4. Relocation of the cycling potential: the aim is to redemocratize bicycle and locate it among the main means of city transport.

1. Introduction

The objective of the current transport planning is a systematic support of environment-friendly transports. Cycling definitely ranks among these modes of transport. Its benefits are obvious – cycling is silent, with no emissions, financially inexpensive and requiring little space. A half-hour bicycle ride per day provides an excellent prevention against sedentary diseases, cyclists do not have so many problems of finding a parking space, with traffic collapses and congestion, the bicycle also contributes to a humaneness and sociability. Bicycle as a leisure-time activity and means of transport brings a significant benefit to the development of tourism as well.

During the last few years, cycling ceased to be a simple matter of individual users and it has fluently entered to the urban and regional planning, it coexists with other modes of transport and it took a natural path of respecting the rights and creating appropriate conditions for bicycle users. Cycling as a mode of transport is not a minority trend, but an alternative to other modes of transport. In cities, cycling makes daily trips more flexible and at least it partially completes the transport operation in the regions. Connecting the local cycling infrastructure into regional and local cycle networks gives wider possibilities for traffic of both target groups: daily cyclists and cycle tourists. Cycle tourism is also significantly present in urban areas. The cycling infrastructure in cities allows to reach the historic city centres, parks, recreation areas, swimming pools and other destinations without traffic congestion and road collapses.

Recreational cycling reflects into two ways of tourism as well: rural tourism and city tourism. Cycling makes its users flexible in time and in space: upon their interest they can choose a locality to visit without being depended on time schedules of public transport and usually they are not restricted by road infrastructure, as a variety of local paths is at their disposal. These advantages make cycle tourism a popular activity in the Czech Republic.

The use of cycling for daily travel and recreation purposes has an increasing tendency in the world and upon this trend many countries adjust the services, planning and supply of transport. Cycling expanses also under the motivation of healthy life style.

1.1. National cycling strategy in the Czech Republic

After four years of demanding preparation works, the Czech Republic can affirm: "Through the final governmental resolution n. 678, issued on 7th July 2004, the Czech cycling development strategy was fully approved". The strategy tackles the majority of issues presented at the Velo-City conferences, but actually, the crucial issue is not "what to implement", but "what is the best way" in Czech conditions?

The role of the ministries within the National Cycling Strategy is to co-ordinate activities between all the levels, to create a systematic and financial background, to include development of cycling into the projects prepared for co-financing from the EU structural funds. To implement this task, the National Cycling Strategy defines a responsible co-ordinator for the planned measures and assigns a timetable for their implementation.

The National Cycling Strategy is progressively recommended to regional and local governments, to businesses and to NGOs to be included as a complementary part of their activities, programs and documents. The National Cycling strategy is a live document, which realisation will be carefully followed and the document will be further supplemented and updated.

Key to the success - partnerships, high level of awareness and fund-raising
There have been elaborated many strategic documents, and it often occurs that they are not fully implemented or the actions prescribed by them are not always successful. Therefore our efforts are directed to create mechanisms which would help the National Cycling Strategy to avoid the same destiny. We deal principally with the five following specific focuses:

1. Partnership and human resources. The Czech Cycling Strategy has a big advantage, as during its preparation phase, many partnerships with various bodies have been established. The fact of existing partnerships is crucial for fullfilment of the strategic objectives.
2. Decentralisation. Thanks to good experiences with previous partners from cycling projects, the National Cycling Strategy can be decentralised. In this way, the partners from bigger cities and the regional governments naturally join the National Cycling Strategy actions. This fact shows that cooperation with public bodies will not be just formal, but very active.
3. Raising public awareness. Our first point of interest is the work with massmedia. They are usually interested in events, important social-economic trends, concrete facts, attractive and instructive examples and interesting stories. These facts make a basis of the mass-media communication strategy and the way how the public is addressed through them. To support this communication, there is established an informaftion portal: www.cyklostrategie.cz
4. Cross-cutting and complexity. The National Cycling Strategy is not restricted only within borders of the field of transport, but it is linked also with environmental, health and tourism issues, and in a broader context with

sustainable development as well. The cross-cutting and complex visions are missing in today´s society, so if we apply the wider view of cycling, it opens a possibility to involve more partners and interested bodies from more fields.

5. Financial resources. The implementation of the National Cycling Strategy in long-term will be financialy demanding. It is impossible to determine just one resource for its financing therefore to create a wide range of possibilities, the „cooperative financing“ - a condition for EU co-financing - is important. So far, the objective is to cumulate and associate the financial means progressively for implementation of projects and to effectuate actively fundraising. The regular basis for co-financing of cycling projects are subsidies from the national transport infrastructure budget for construction of cycle paths.

The main document of the National Cycling Strategy is accessible on internet - www.cyklostrategie.cz (incl. an English version) The website brings the full information on the strategic objectives, priorities and implemented measures. The National Cycling Strategy has the following main priorities:

(1) Development of cycling as a means of transport equal to others;
(2) Development of cycling to strengthen tourism;
(3) Development of cycling to help protecting the environment and strengthen health;
(4) Coordination of activities with other bodies and fields.

Realisation of these measures is ensured primarily through the three ongoing projects:

- “CYCLE21: Analysis of the needs for building the cycling infrastructure in the Czech Republic”, which is realised as a part of the National Research Program 2004 - 2009 of the Czech Ministry of Transport.
- “SONDA: Settting up the principles and methods for development of cycling and its infrastructure“, which is realised as a part of the National Research Program 2007 - 2011 of the Czech Ministry of Transport.
- “Sustainable transport: a chance for the future (part Cycling)” supported by the Czech Ministry of Transport - the methodology „21 pillars for construction of cycling infrastructure“ was elaborated in May 2007 (ISBN 978-80-86502-60-1). The facts on cycling are categorised within 21 thematic sections explaining the main cycling issues and bringing the references for details
- „ALARM - Modern forms of traffic education for children and teenagers as a means of reducing the accident rate in the road traffic network”, which is realised by the CDV as a part of the National Research Program 2004 - 2009 of the Czech Ministry of Transport.

2. How can the Denmark inspire us?

Regular national cycling conferences are part of the implementation outputs of the National Cycling Strategy – www.cyklostartegie.cz. The last one was held at the Czech Ministry of Transport in April 2010. We had an opportunity to meet a brand-new phenomenon: the first cycling embassy, a centre of services and knowledge for everyone who need some information on cycling. The aim was to introduce bicycle not only as a sports article, but also as a mean of transport, fashion accessory and a part of all social groups' life-style.

2.1. The world’s first cycling embassy

International interest in Danish cycling culture has grown rapidly. As an answer to this, a completely new phenomenon has seen the light of day. The world’s first cycling embassy: a centre for service and knowledge for anyone seeking information on cycling in Denmark. Today, Cycling Embassy of Denmark comprises experts in city planning, infrastructure, cycling promotion, parking facilities, bicycle tourism, biking, bicycles, equipment, health promotion and much more.

Starting from scratch

Building, or as is often the case, rebuilding a cycling culture is not an easy task. There is much more to it than simply constructing bicycle paths (or “Copenhagen lanes” as they have been named in some countries). But Denmark’s experience shows that with the right know-how it is possible to change habits and create cleaner, safer, healthier, and more liveable cities. “Many city planners, politicians and NGOs around the world begin from scratch when trying to build up a bicycle culture. One of the main goals for Cycling Embassy of Denmark is to share the experiences from Denmark and facilitate the development of attractive cycling cultures around the world. We cannot give people a cycling culture, but we can help them with ideas, share our experiences, show them the Danish cycling solutions, and help them take the first important steps,” says Troels Andersen.

Ask us about everything

Cycling Embassy of Denmark was launched in May 2009. Since then a huge number of delegations from all continents have visited Denmark, and many more have been in contact with members of the Embassy with inquiries concerning all aspects of cycling. Cycling Embassy of Denmark has participated in various international conferences, seminars, and exhibitions. The Embassy collaborates with other international organizations and Danish Embassies abroad in promoting cycling. In addition to this, the Embassy helps plan visits to Denmark for professionals, journalists, and students interested in cycling solutions and knowledge. “Some delegations have already been working with cycling for years. They are usually seeking detailed information on very specific subjects. Others come from countries with no cycling culture at all and are looking for answers on a very basic level. But everybody is welcome – and for us it is an endless source of inspiration to follow the development of cyclist cities all over the world,” Troels Andersen concludes.

2.2. How Denmark became a cycling nation?

In the 1960s, cars were threatening to displace bicycles in the main Danish cities. But the oil crisis, the environmental movement and a coule of controversial road projects reversed the trend. This is however just part of the story behind why Danes still cycle so much.

Is it possible to cycle in your city? Is it safe? Is it even attractive? If you can answer yes to all three questions, then the cycling culture in your city has good expectations for growth. But often the answers are in the negative, and then the next question is: how did this come about?

The answer lies in a city's historical development, because surprisingly many of the major cities that today are packej with cars actually have a past as cities of bicycles. A journey back into Denmark's history shows how and why Kopenhagen and other Danish cities have managed to maintain a flourishing bicycle culture. The bicycle was invented in the latter half of the 1800s. The first bicycles were quite primitive and somewhat awkward to ride. Nonetheless they soon became the big fashion craze – especially among zouny men in high society. Bicycles were first used for sport and recreation, but in the late 1800s some more practical types of bicycles gradually came into the market, and the general public, who otherwise had poor access to transport, quickly adopted them.

Freedom for all

With the bicycle, ordinary men and women suddenly gained much more freedom of movement. The bicycle was their ticket out of the inner city's cramped tenement houses and into the clean air of the rapidly growing suburbs. In a Danish context, the bicycle has been inextricably linked with freedom ever since.

Photographs of urban scenes from the 1930s clearly show how Danish cities became cities of bicycles in the first half of the 1900s. People from all social classes cycled on a large scale and several professions also adopted the bicycle – today cycling postmen and home helpers are still a permanent part of street life. The bicycles' first heyday lasted for half a century until around 1960, when the increasing standard of living slowly but surely made car ownership possible for more and more families. That development was welcomed because cars and single-family houses were vigorous symbols that the depression of the 1930s and the darkness of World War 2 had lifted, and that a brighter future lay ahead.

Decades of headwind

But what is a brighter future? The multitude of cars brought not only prosperity but also pollution, congestion and traffic accidents. It can be an eye opener to see photographs from Copenhagen in the 1960s. Many of the areas now treasured by the city's inhabitants and tourists alike are car-free areas, but in the 1960s they were characterised by dense traffic and car parks. Nyhavn, Strøget and Langelinie arem just some examples.

Until the 1960s, Copenhagen's history unfolded in parallel with developments in many other western metropolises. But then a number of things happened which made Copenhagen and several other major Danish cities depart from the beaten track.

During the 1960s it became increasingly difficult to turn a blind eye to the many traffic accidents and the growing pollution problem. Copenhagen was no longer the city of bicycles that most Danes knew and loved, and it upset a lot of people.

For more than half a century, bicycles had steered their way into the core of Danish self-perception through the visual arts, poetry and music. The cheerful spinning of the wheels and the summery image of a blonde haired girl cycling through the town – what was the city without this? At the same time the budding environmental movement and the oil crisis greatly helped to shake the dust off cycling culture, which in the 1970s again began to appear in a positive light.

The Danish model

From the 1970s to the 1980s, several conflicts arose between bicycle and car interests in Danish cities. One example was the wave of popular protests which followed in the wake of a proposal from the Copenhagen authorities to establish a motorway across the lakes which separate the inner city of olden times from the more recent suburban districts. There was an enormous outcry because, then as now, the lakes were some of the city's loveliest open spaces.

Gradually it became clear to most people that the solution to the problems had to be city planning that gave space to cars, bicycles, pedestrians and public transport. Out of this realisation grew the Danish model with its extended network of cycle lanes along the roads, which continues to be further developed.

In the last 10 years, new challenges have emerged. In Denmark, as in other countries, there is a desire to improve public health and combat climate change. In Copenhagen and several other Danish cities it has led to an intensified effort to maintain and strengthen cycling culture.

The bicycle is an additional choice

Cycling – especially in a wealthy country like Denmark – is for most an active additional choice which can easily change. So the only way forward is to make it safe, easy and attractive to cycle, and that does not happen solely by changing the infrastructure.

In Denmark there is a strong tradition for people from all strata of society to cycle. cities. Most Danes associate the bicycle with positive values such as freedom and and health, and in recent years cycling has actually become a symbol of personal energy. The bicycle has become ultramodern again, aided by societa development, successful political initiatives and conscious marketing. The three largest Danish cities – Copenhagen, Århus and Odense – have all carried out large branding campaigns that put cyclists in a positive light on advertising billboards, on the internet and by actively including cyclists in new bicycle projects. The result is an increasing number of cyclists and cleaner, healthier and more lively cities.

Today the vision of a pleasant city is different to that of the 1960s. We all want to make space for progress and development. But progress and development in the modern metropolis depends on whether we manage to make it a place where people want to live.

2.3. Live – cycling culture from the Danish point of view

What exactly is the cycling culture and why should we deal with it? Mikael Colville-Andersen tried to answer this question within the cycling conference at the Czech Ministry of Transport on April 21st 2010. Mikael Colville-Andersen is a film author, photograph, town and regional planning expert, director of the Copenhagenize Consulting company, he is also known as a “Danish cycling embassador”. He travels around the world, lectures and acquaints with how the cities are prepared for the “cycling culture” (www.copenhagencycleChic.com a www.copenhagenize.com) These are underlying information, the professional public should become acquainted with them in general.

He explained in his lecture that the hundreds of thousands of cycling people in the Copenhagen streets are neither “cyclists” nor “environmentalists”. They decided to use the bicycle because first they can use safe and fast infrastructure and second bicycle is one of the most effective means of transport.

Andersen invited the Czech republic to a cycling culture trip, where bicycle becomes permanent and integral part of professional and private life, where people start living with bicycle since their childhood and where cycling is lifestyle, not necessity. Cycling is a natural part of everyday life and everyone is cycling.

Copenhagen, in many ways, resembles other cities. An ancient city centre, sure, but it’s surrounded by wide boulevards and, farther out, urban sprawl. Visitors to the city can, if they squint a bit, see their own city in Copenhagen’s reflection and imagine what an organic mass of bicycles would look like at home. In addition, Copenhagen is constantly evolving and bringing new ideas to the table, all serving to encourage more people to choose the bicycle.

More than 30 years of transport and landscape planning helped to change the sight of cycling transport, which became an effective option with all social benefits related. Mikael Andersen's unique approach to promotion of city inhabitants' bicycle use and to stimulation of cities to infrastructure investments, is based on marketing fundamental principals and it piques interest all over the world.

What are the fundamental principals of marketing of city cycling promotion according to Mikael Andersen?

2.3.1. Creating a city of cyclists - “from the point A to the point B” philosophy – quickly, comfortably, safely

While many guests in the Danish cupital seem to think that Copenhageners must be really concerned with the environment since so many use a bike, it’s just not the reason why Copenhageners ride. Many Copenhageners are of course focused on environmental issues but, when asked, only 1 per cent of Copenhageners mention it as the main reason.

Cycling is the preferred means of transport because it’s the quickest and easiest way to get around town. It’s the glue that keeps our lives together – allowing us to connect our everyday tasks in a smooth manner. While this tells us a bit about the Copenhagener mindset it also demonstrates that given the right support, cities around the world can be modelled to be more sustainable.

But how do you create a city of cyclists? First of all you need to make cycling competitive and safe, and a great point of departure is having city planners armad with political will who make access for bicycles in public spaces a priority. In Copenhagen there is a coherent network of segregated lanes designated as cycle tracks in all city areas. That means you can ride from one part of the city to another almost without leaving the cycle track, which in most cases also ensures less travel time than going by car or bus.

2.3.2. Perception is (also) reality

Creating viable infrastructure and policie is important, but these are only some of the elements in developing a more sustainable and living city. As long as the common understanding of mobility is connected to the concept of driving a car, the road towards sustainable urban mobility through cycling will not be an easy one. Hence part of the work is also to change public perception of which kinds of mobility carry the greatest benefits for both citizen and society. Fortunately cycling leaves plenty of facto on the advocate’s side – to be used in campaigns and other communication activities.

2.3.3. People-friendly cities require mobility for all

A humanistic, people-friendly city is first and foremost an accessible city where mobility is possible for all. Many cities today are plagued by traffic congestion, and in densely populated city areas the fastest way of getting around is often on a bicycle, which is a highly efficient means of transport. In Copenhagen, a survey has shown that the majority of cyclists chaose this means of transport because they want to get quickly to their destination, and that this is one of the most important reasons why they use a bicycle instead of a car.

A well-developed cycle path network can also help social inclusion across age groups. Even in very wealthy cities, large groups of people such as children, zouny people and the elderly are severely limited in their mobility because the city is designed for cars – a means of transport that they cannot use. Cities that are designed for cars are also characterised by large distances and many obstacles which hamper movement on foot and by bicycle. Improving conditions for pedestrians and cyclists ensures that a lot more people can move around in the city. In some of the world's metropolises, the distances are so large that a well developed cycle path network is insufficient to ensure mobility for all.

2.3.4. Relocation of the cycling potential

A city of bicycles naturally needs the right infrastructure including cycle paths and bicycle parking, but also a number of communication initiatives such as campaigns to promote cycling, educating children and special initiatives targeted at groups who do not normally cycle. Such initiatives are important in building a bicycle culture in cities where it is otherwise absent.

It is also important to create a quality of urban environment that makes it attractive to move around both on foot and by bicycle. This is a self-perpetuating process since the presence of pedestrians and cyclists significantly contributes to the life of the city and thereby its attraction. In contrast to motorists, cyclists and pedestrians share the characteristic of moving at a moderate pace, making them visible in the cityscape. Cyclists are also flexible in the sense that they can quickly shift from being cyclists to beany pedestrians. This creates the conditions for people to see and meet each other in the city. It is equally important to highlight that both cyclists and pedestrians are physically present in the public spaces – in contrast to motorists who are essentially isolated from thein physical settings. But the desire to move around in a city on foot or by bicycle does not come by itself, and must be supported by a people friendly urban environment.

Pedestrians and cyclists are exposed to all sorts of weather – sun, wind and rain – and to the extent possible, these conditions must be incorporated into the planning of sidewalks and cycle paths. In addition, presence in and movement around a city must be encouraged by creating interesting and involving urban environments. Long, monotonous stretches have to be broken down into smaller sections and offer details that can be registered at head height, such as interesting features at ground floor level. These are significant principles that can be used all over the world, but different cities naturally need different strategie and initiatives.

When we realize these fundamental principals, we discover that we need neither more money nor more space. We need only thing now – to be interested more, to learn more and first of all to want more from the life.

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Road Traffic Safety as an Integrated Part of Injury Prevention Policies

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Abstract

Injuries and fatalities in road traffic have a very negative impact on the social and economic situation in the Central European Space (CEUS) countries: Just direct costs are more than 2% GDP in most of them. The Operational Programme highlighted "lower road safety in the new Member States" as a weakness in its SWOT analysis for CEUS. Even if all CEUS countries joined the goal of EU 15 to half the number of fatalities on EU roads to 2010, just few of them will be able to be close to the target in due time. Taking all this into account 12 partners from the Central European Space (CEUS), well experienced in the overall tasks of road safety and sustainability, joined their forces for the new project *SOL - Save Our Lives (A Comprehensive Road Safety Strategy for Central Europe)* within the Central European Programme to help cities and regions in targeted area to upgrade their safety standards to common EU level. The approach of SOL sees road safety as a broader problem of health prevention and within the context of sustainable mobility. SOL intends to support greater cohesion of the new member states within CEUS and the EU with regard to safe and sustainable transport. The paper is focused on general information about the project with special focus on activities which will be piloted in the Czech Republic.

CENTRAL EUROPE COOPERATING FOR SUCCESS. EUROPEAN UNION EUROPEAN REGIONAL DEVELOPMENT FUND

1. Introduction – project background

Quality of life in local communities is diminished due to daily problems as congestion, pollution and, above all, high rates of road crashes/trauma. 75% of the journeys undertaken in metropolitan areas are done by car and total kilometres travelled in EU urban areas are expected to increase by 40% between 1995 and 2030, with significant consequences for the health, quality of life and the economic performance of the cities themselves. Land use and transport policies are still mostly focused on the private motor vehicle and current planning does not always properly consider the risks of road transport to other road users (e.g. pedestrians and cyclists). Similarly urban policies and land use planning don't encourage sufficiently a "modal shift" from individual motorised transport towards more sustainable means of transport including the public one. The Operational Programme highlights "lower road safety in the new Member States" as a weakness in its SWOT analysis for CEUS. "Safety of transportation is stated to be a main issue in context with road transport, as e.g. in CARE report 2004 about 726,200 road accidents and 991,100 victims had to be counted in the Central Europe countries, about 55% of the road accidents and victims in EU-25.

Within both 3rd and 4th Road Safety Action Programme set by the European Commission (EC) transnational cooperation for mutual learning and the joint development of standards and innovative road safety measures has proved to be the most effective instruments for advancing the quality standards and effectiveness in managing road safety issues. This cooperation is highly supported by European Union programme CENTRAL EUROPE. CENTRAL EUROPE is a programme that encourages cooperation among the countries of Central Europe (Austria, the Czech Republic, Germany, Hungary, Italy, Poland, the Slovak Republic and Slovenia) to improve innovation, accessibility and the environment and to enhance the competitiveness and attractiveness of their cities and regions. The programme area covers an area that represents approximately a fifth of the EU landmass and 28 percent of the EU population.

Picture 1: Central European Space

The new member states from CEUS mostly have dedicated national and local government commitment to road crash/trauma prevention and sustainable transport development but the political commitment is often lacking to ensure that, these policies are properly implemented at all levels. Progress in reducing road crashes/trauma and promoting sustainable transport suffers by the fact that management, implementation and resources are very week. In addition there are generally weak links to community level government to facilitate local level action and enable the implementation of national policies at the community level.

However, there are some good practice examples in the region that could be capitalised and followed by the others. Outside the good practise examples from the targeted region, there are also a lot of already successful tools available on EU level, like ELTIS, SUPREME, Safety Net, CAST, DRUID and many others. Furthermore there are well experienced networks like GRSP, ETSC, Cities for Children, Health Cities, Safe Communities or Cities for Mobility which during years collect a lot good practises from increasing road safety on national, regional and local level.

1.1. SOL – proposal

All the above mentioned facts led 12 multi-sector partners from nine countries of CEUS to jointly developed a strategy that will support individual regions and cities in catching up with highest EU standards in road safety in the frame of the 2nd call of Central Europe Programme under the acronym SOL. *(Save Our Lives - Comprehensive Road Safety Strategy for Central Europe)*

Starting in April 2010 SOL consortium within 36 month has to:

1. Assess the problem, policies and institutional settings relating to RS and the regional/local capacity for road injury prevention;
2. Strengthen institutions and create effective horizontal and vertical multi-sector partnerships in regions and cities, but also on national level and internationally
3. Prepare regional/local strategies and action plans and allocate endogenous resources to address the problem;
4. Implement specific actions to prevent road traffic crashes, minimise injuries and their consequences;
5. Create a greater level of awareness, commitment and informed decision-making at all levels;
6. Develop replicable tools for CEUS and the EU;
7. Put RS policies in the context of promoting sustainable forms of mobility.

SOL will promote sustainable forms of mobility by increasing its safety and by contributing to the improvement of the overall road safety situation also the goal of increased quality of life will be addressed. The main objectives of SOL are completely in line with the major concerns of the Operational Programme. The "transnational approach" developed within the Operational Programme for Priority 2, will be pursued by sharing experiences on the preparation and implementation of sustainable and safe transport solutions, fostering applications, strategies and preparation of policy decision for more safety in traffic and transport".

2. SOL as a network

SOL has several of the most competent organisations from CEUS and Europe on board, some of them even with worldwide recognition of their RS competences. These organisations will bring in all their competences and network relations in order to ensure that SOL will be a full success, not only on the local and regional level where pilot instruments for RS promotion will be developed and tested and where organisational structures will be created/strengthened, but also an the national and transnational level. GRSP experience from RS work in other regions of the world with much more challenging conditions shows that the chosen strategy will allow overcoming the indicated challenges. Sol consortium consists of lead partner A.L.O.T., representing East Lombardy, partners, SOLAB (SOL Advisory board) and regions/cities, where pilot activities will be tested.

2.1. Lead partner

A.L.O.T. (Agency of East Lombardy for Transport and Logistics), was created by the provinces of Brescia, Bergamo, Mantova and Cremona in order to act as incubator, developer and management body of mobility projects on local and EU level.

2.2. Partners

- *Austrian Mobility Research* (FGM-AMOR) works for a variety of municipalities and regional governments in the field of mobility management, education, traffic safety and transport-telematics.
- *Province of Styria* - Department of the Styrian Provincial Government for Traffic Safety is responsible for the implementation of a sustainable and safe transport policy on the basis of Styria's General Traffic Programme as well as on Austrian and EU law and guidelines.
- *Institute of Geography, University of Tübingen*, will secure highest technical standards and the sound consideration of highest scientific standards within all major publications of the project.
- *HBH Projekt spol. s r.o.* started in 1992 as a design office for motorway design, engineering and construction supervision. Road safety and traffic engineering department has been established in April 2008 by integration several experts from this field. HBH cooperates with WHO network of Health cities, Safe Communities and also with a lot of Czech regions and municipalities.
- *ITS Motor Transport Institute of Poland* is active in safety improvements for the road traffic participants, limiting negative environmental impact of the road transport development, innovative design and material solutions for the road transport means, their elements as well as service materials.
- *University of Zilina* represents a research type of a higher education institution and it comes under the most important universities in Slovakia. It is oriented to all aspects of transport.
- The *GRSP Hungary* brings almost a decade of experience in road safety improvement in Hungary into the project. Its members represent national road safety stakeholders from government, business and civil society including the national traffic police, ministry of transport, roads department, multinational and domestic companies, research institutes and NGOs.
- *KTI* Research Institute for Transport Science is a background institute of the Ministry of Transport, Communication and Energy, thus KTI is involved in preparation of decision making processes and jurisdiction/ regulatory jobs of that ministry.
- *Automobile Association of Slovenia* is the largest NGO in Slovenia. It has 140,000 members, which are allocated to 81 local auto clubs. AMZS runs preventive and educational activities in local areas for schools, kindergardens, police etc.
- *ZAS* - The Association of the Driving Schools in the Slovak Republic is a partner with real skills in work in international project space, mainly in driving training, education and campaigns.

2.3. SOL Advisory Board

For the purpose of quality assurance the project consortium is completed by so called SOLAB (SOL Advisory Board). The SOLAB consists of organisations with an international scope of its activities that has proven expertise in the field of RS. SOLAB has been established during the Fourth World Congress of Cities for Mobility in Stuttgart in July 2010.

Currently SOLAB consists of the following organisations with their particular responsibility:

- *ETSC* - European Transport Safety Council, Brussels (BE) -- Road safety programmes and action plans:
- *GRSP* - Global Road Safety Partnership of the Intern. Red Cross, Geneva (CH) -- Road safety training:
- *Cities for Mobility*, CfM – worldwide network for sustainable urban mobility Stuttgart (DE) -- Road safety and sustainable mobility:
- *Cities for Children* CfC - European network with focus on road safety for children, Stuttgart (DE) – Children road safety
- *FAI* - Italian Federation of Truck Transporters, Rome (IT) -- Road safety in goods transport
- *DEKRA* – safety of vehicles
- …….. further RS networks are expecting to join SOLAB during the project

Picture 2: SOLAB constitutional meeting 4th World Congress of Cities for Mobility

2.4. Pilot regions and cities

Outside the region of Lombardia and Styria, which act directly in the project consortium as lead partner and project partner, proposed measures will be tested in following cities/regions: Province of Brescia, Province of Bergamo, Province of Mantova, Province of Cremona, Municipality of Brescia, Municipality of Kromeriz, Municipality of Prague, Region Liberec, Municipality of Olsztyn, Municipality of Lodz, Municipality of Lublin, Municipality of Zilina, Zilina – self governing region, Municipality of Gyor, Municipality of Bekeszaba, Municipality of Veszprem, Municipality of Lviv.

Taking into account all partners in one or another way involved in the project implementation, the project itself already create huge road safety network of 34 partners around CEUS. These local/regional RS networks will safeguard the permanent continuation of the work which will be started within SOL.

3. Methodology

The technical project methodology is based on recommendations of the “World report on road crash injury prevention” (WHO, World Bank, 2004) and “Preventing road traffic injuries: a public health perspective for Europe” (WHO Europe, 2004):

1. Strengthen institutions and create effective partnerships to deliver safer road traffic systems. Partnerships should exist horizontally between different sectors of government and vertically between different levels of government and governments and NGOs.
2. Assess the problem, policies and institutional settings relating to road traffic injury and the capacity for road traffic injury prevention
3. Prepare a strategy and action plan and allocate resources to address the problem.
4. Implement specific actions to prevent road traffic crashes, minimise injuries and their consequences and evaluate the impact of these actions: Activities should be evidence based, grounded in global good practice, tailored to the local situation.
5. Support the development of national capacity and transnational cooperation.
6. Create a greater level of awareness, commitment and informed decision-making at all levels (transnational, national, local) so strategies scientifically proven to be effective in preventing road injuries can be implemented.
7. RS policy must be seen in the context of sustainable transport.

3.1. Situational and institutional assessment

At the beginning of the project implementation process, there will be carried out a systematic analysis of international good practice cases in each of the thematic fields of road safety by all project partners. Based on that community teams will be later trained in using the tools and in collecting and assessing the necessary data. The core output will be a situational assessment report providing a broad-based understanding of the nature and scope of the road safety situation in the community and public perceptions towards preference of transport modes. The situational and institutional assessment reports will follow the same basic format for each community participating in the SOL. Thus the data collected will be comparable across the CEUS. This will be a unique contribution to increasing the knowledge about the scope and impact of road crashes/trauma in the context of sustainable transport in the region and a basis for motivating political commitment for effective action.

3.2. Road safety programmes and action plans

In WP4 under the lead of GRSP road safety training programmes will be developed and run according to a train-the-trainer methodology. Strategies and action prioritisation will be based on outcome of the assessment and global good practice, and consider national legislation & procedures, local capacity (financial, human), local interests. The action plans will be based on global good practice tailored to the local situation and considering national legislation/ procedures and local capacity.

3.3. Pilot actions

Activities undertaken as part of WP 5 will have the most direct impact on road crash/trauma reduction in the pilot areas. Individual measures will differ among the communities depending on the outcome of the situation assessment and content of the strategies/action plans, which will be tailored to the specific local situation. All pilot activities will have to sustain the overall objective of the project of developing effective and tailored measures under a transnational perspective and methodology to improve the RS situation in CEUS and to provide validated tools for RS management to a greater number of follower organisations. To safeguard the effectiveness of the developed and applied tools, a monitoring system will be set-up from the start of WP5 in order to control the performance of each pilot activity. This will allow intermediate adjustments of methodology and lay the ground for a later evaluation of the tools regarding their applicability within CEUS.

3.3. Implementation in the Czech Republic

Czech part of the SOL project will be led by HBH Project spol. s r.o., which as an European first ever Design and consultancy office for highway construction undersigned the European Road Safety Charta in May 2009 in Prague.

Czech part of the project consists of several tasks during the whole process. Outside all the above mentioned analysis and processes, some national and regional good practices will be further tested and developed in Kromeriz, region Liberec and selected parts of Prague. Special focus will be given to activities in increasing children safety and safe mobility. Safe journey to school guidelines, which were for the first time developed in 2005 and spread around the Czech Republic through sets of seminars in 2006 will be updated by the information reached through 5 years of implementation. New Step by step safe journey to school guidelines will be also updated by a WHO part promoting safe walking and cycling to the school. One of the activities of HBH project under ERSCH is children for all road safety campaign, Step by step in traffic without injury. This HBH idea, as a part of HBH agreement for ERSCH, was for the first time piloted in the Brno municipality in 2009. That idea connects also several programs of Healthy cities, starting with the children competition on the campaign proposals which is evaluated in late spring during Days without injury, continuing with the opening of campaign European mobility week and finishing campaign during Days for Health in September. Similar campaign will be further tested in all targeted regions of the SOL project in the Czech Republic.

The last activity is dedicated to increasing of infrastructure safety in school surroundings. Short road safety inspection has been originally developed for the Liberec region in 2008 and successfully implemented on more than 100 school surroundings during 2008 and 2009 projects. The idea will be spread to selected parts of the Prague and further.

4. Final manual

Tools, approaches and strategies that could prove their effectiveness will form the basis for the SOL manual to be elaborated within WP6. WP6 is of crucial importance for the continuation and spreading of the transnational SOL process within CEUS. The replicable concepts, structures, strategies, outputs and tools will be developed in the framework of the SOL project and validated regarding their applicability at the transnational level. The final outcome will then be made available through the website, the final manual, targeted campaigns and conferences to the greatest possible number of relevant public authorities, stakeholders and regular citizens in CEUS for subsequent implementation. All major outputs of SOL will be evaluated and validated regarding their applicability in other settings of CEUS and beyond.

5. Conclusion

The SOL concept is based on the principle of developing a toolkit that communities can use relatively easily to improve road safety. All tools and materials will be translated into the languages of the participating communities. The SOL mentor communities and SOL country PP- in cooperation with government stakeholders at other levels, including national and regional - will be able to transfer the concept to other communities in the country. At the transnational level, the project results will be transferable through the transnational network and communications activities, and in particular through the transnational road safety strategy. The SOL project results will form high profile “evidence based” transnational road safety strategy to drive political commitment for action and continual improvement in the region. Through the transnational network the project results will be communicated to other stakeholders throughout the region and inspire action based on the principles of SOL and using the tools created as part of SOL to enable all CEUS communities and regions to develop targeted, evidence based multidisciplinary approaches to road safety in the context of sustainable transport.

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Particle Re-suspension in City Areas with Intensive Traffic

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Abstract

A numerical modelling based on the finite volume method is used for a detail study of the relation between a wind velocity above buildings roofs and a near-ground air velocity in the city area. To simulate traffic, an original model is used that takes into account traffic density, speed of cars and number of traffic lanes (Jicha at al., 2000). The predicted near-ground air threshold velocity of re-suspension at the studied street canyon is compared with two theoretical studies on particle re-suspension from horizontal surfaces. The wind threshold velocity of re-suspension is derived from a long-term measurement carried out in the city of Brno.

1. Introduction

Many big cities are often heavily polluted with airborne particles released by road traffic. The highest concentrations of PM (particulate matter) are generally present in inner parts of urban areas, especially at a close vicinity of major traffic paths. The street particulate matter consists of a complex mixture of motor vehicle exhaust particles, various kinds of dust (tires, brake lining wear, soil, road surface) and other biological materials. Particles formation, transport, deposition and re-suspension are affected by many parameters at these locations. Particles movement is influenced by transportation in moving air, settling due to gravity, interaction with buildings walls, deposition on a ground surface and re-suspension of once deposited particles lifted by a local air movement and dispersed into a surrounding. Therefore, particles movement is highly complex process difficult for an accurate mathematical description. Advanced numerical modelling tools are necessary for correct prediction of detail air velocity fields in studied domains and for description of dispersion processes in urban areas. The numerical modelling represents the only tool capable to take into account detail geometry of urban areas as well as the interaction between moving cars and ambient air (Jicha M. et al., 2000).

It is impossible to quantify accurately production of all real PM sources within urban areas. Based on different studies (Moussiopoulos N., 2003; Rodriguez S., 2004) it follows that re-suspension of once deposited particles can be the most intensive source of urban airborne particles during “dry periods”. Re-suspension process depends on the actual air velocity field above the ground surface, a local slit load, a surface roughness, particle geometry and other particle parameters. Coarse particles (d > 2.5 μm) tend to re-suspend from dry-surfaces. On the other side, fine particles and ultra fine particles show only limited tendency to re-suspension from all surfaces. This results from a significant amount of a liquid fraction forming those particles smaller than 2.5 μm along with the existence of Van der Waals force between ultra-fine solid particles and surfaces. Re-suspension of particles is impossible from wet and adhesive surfaces. From the above mentioned follows that the re-suspension process is a very complex one and its physical description is generally connected with a high value of uncertainty. Numerical models for prediction of PM concentration fields in urban areas fall in two categories: i) detail solution of PM dispersion processes with simplified quantification of PM sources (Flemming, J., 2003) and ii) solution of concentration fields for gas species (e.g. NO_x) with known correlation to PM (Kukkonen, J. et al., 2001).

In this study, we employed the first type of numerical model with detail solution of re-suspension of deposited particles. The study is focused on determination of the near-ground air threshold velocity of re-suspension in the street canyon with two-way traffic. The CFD (Computational Fluid Dynamics) code StarCD was used to build up the numerical model of the studied area and process the calculations. We considered PM10 spherical particles with density 1200 kg/m^3.

Through all this paper, we use the expression “the wind threshold velocity of re-suspension” for the lowest wind velocity at the height of 10 m above the ground surface causing significant particle re-suspension. Analogically, the expression “the near-ground air threshold velocity of re-suspension” is used for the lowest air velocity at the height of 0.35 m above the ground surface causing significant particle re-suspension.

2. Particle re-suspension

Re-suspension of particles settled on surfaces results from the interaction of aerodynamic, electrostatic and mechanical forces. The Saffman lift force due to a velocity gradient near walls is an example of the aerodynamic interaction. This lift force affects deposited particles in a viscous fluid. Its orientation is perpendicular to a flow direction. An electro static force affecting charged particles can be determined only for the known particle charge and the particular magnitude of an electric field. The electro static force is usually not considered in dispersion studies. The turbulent intensity of a stream can also influence the air drag force affecting particles (Punjrath J.S. and Heldman D. R., 1972). The Saffman lift force and the fluid turbulence are sufficient for re-suspension of fine and ultra fine particles. Coarse particles are often moved by the drag force along the surface (Punjrath J.S. and Heldman D. R., 1972). An irregular shape of coarse particles together with the surface roughness causes irregular bouncing of the particles against the surface. This movement provides good condition for particles to be lifted up within a boundary velocity layer.

Various parameterizations of equations can be found in literature for determination of the windblown dust flux rate. Frequently used equations determine the particle re-suspension flux using the wind velocity (1) (Tegen I. and Fung I., 1994) or the friction velocity (2) (Claiborn C. S. et al., 1998).

$$F = C_{TF} u^2 (u - u_t), \qquad (1)$$

where F is the particle flux in μg m^{-2} s^{-1}, u is the wind velocity in m s^{-1}, u_t is the wind threshold velocity of re-suspension in m s^{-1} and the dust constant C_{TF} ranges from 43 μg s^2 m^{-5} for undisturbed soil to 179 μg s^2 m^{-5} for disturbed soil (Tegen I. and Fung I., 1994).

$$F = C u_*^3 a_g \left(u_* - u_{*t}\right), \qquad (2)$$

where F is the flux of PM_{10} in μg m^{-2} s^{-1}, a_g is the constant to correct for the use of hourly averaged winds compared to the nonlinear effect of near-instantaneous gusts upon dust production (~ 1.2), u^* is the friction velocity corresponding to a 10-m wind velocity measurement in m s^{-1}, u_{*t} is the wind threshold friction velocity in m s^{-1} and C is an empirical dust constant. For the early-season event (September 11, 1993) C = 0.0096 μg s^3 m^{-6}. For the late-season event (November 3, 1993) C = 0.0015 μg s^3 m^{-6} (Claiborn C. S. et al., 1998). This equation requires hourly friction velocities at 10 m.

The friction velocity for the neutrally stable atmosphere can be determined from the equation of the logarithmic wind velocity profile. The relation between the wind velocity and the friction velocity is expressed as

$$u = \frac{u_*}{k}\ln\left(\frac{z-d}{z_0}\right), \qquad (3)$$

where k is the von Karman constant (~ 0.4), z_0 is the surface aerodynamic roughness length and d is the displacement height.

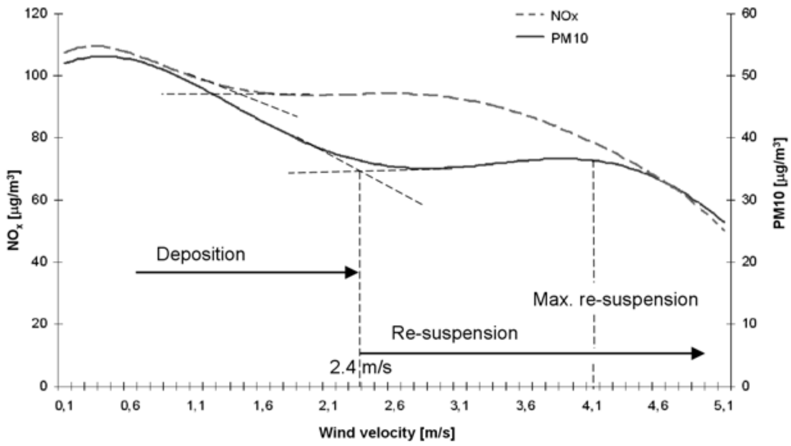
The critical point of particle re-suspension flux quantification is to correctly determine the wind threshold velocity of re-suspension in the studied domain. The wind threshold velocity of re-suspension is highly variable and it depends on the surface conditions, fluid-flow characteristics and particles parameters.

3. Wind threshold velocity of re-suspension

The wind threshold velocity of re-suspension is the lowest wind velocity measured at 10 m height for which the re-suspension process represents a significant contribution in urban air PM10 concentration. The particular value of the wind threshold velocity of re-suspension is strongly influenced by the actual geometry of the urban area, density and geometry of particles. Therefore, it is necessary to obtain corresponding wind threshold velocity of re-suspension for each particular urban area.

The centre of the city of Brno (population 400 000) was used as a convenient study domain. Data from PM10 long-term measurement in the city of Brno were used for determination of the wind threshold velocity of re-suspension. As the first step, we derived the relation between the wind velocity and concentration of PM10 and NO_x measured during the year 2005 in the studied urban area, see Fig. 1. The second step involved a detail analysis of the relation. Then, the particular wind threshold velocity of re-suspension was determined in this area. For this purpose, we analyzed the trend of relations on Fig. 1. Without the re-suspension, the relation of pollutant concentration and wind velocity can be assumed as a smooth regularly decreasing curve. The real relations show significant changes in its trend. These changes are connected with changes of particle production rate within the studied area. Re-suspension is considered as the only particle source directly connected with the wind velocity. Particle re-suspension is so probably responsible for significant changes of the trend of the PM10 – wind velocity relation.

Fig. 1: The relation between wind velocity and concentration of PM10 and NO_x measured in inner part of the city of Brno during the year 2005



The wind velocity range with a significant contribution of re-suspended particles is indicated in Fig. 1. The wind velocity 2.4 m s^{-1} (height 10 m above the ground surface) was determined as the wind threshold velocity of re-suspension in the studied urban area. This wind threshold velocity of re-suspension fully corresponds with previous studies carried out on urban areas.

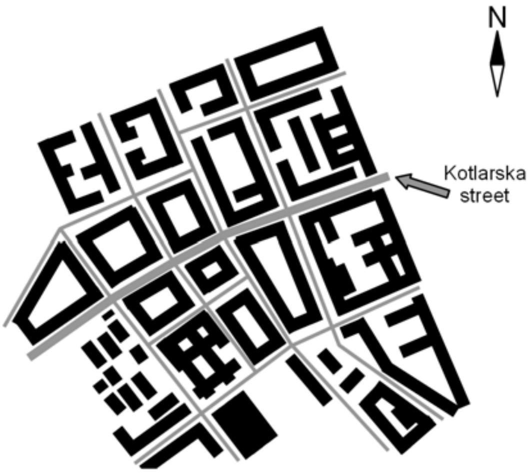
4. Near-ground air threshold velocity of re-suspension

Previous sections discussed the wind threshold velocity of re-suspension employing a driving wind velocity at the height of 10 m above the ground surface. But small scale models require a more detailed approach for the correct description of re-suspension, based on knowledge of the air velocity in the near-ground air layers. In this study, we focussed on the particular street canyon in the city of Brno where the air velocity field is mainly influenced by the buildings’ geometry and a cars’ movement. The numerical model of the studied street canyon was built up. Series of calculations were carried out focusing on the detail description of the air flow just above the ground surface.

4.1. Computational domain description

The computational domain ground dimensions are approximately 0.5 × 0.5 km. The computational domain is formed by blocks of buildings with internal yards. The domain includes one main street canyon, Kotlarska Street, and 4 streets that cross the main road perpendicularly, see Fig. 2. Traffic in the perpendicular streets is significantly less in comparison with the main street traffic. Therefore, the traffic in the perpendicular streets was neglected in the numerical model. The main street traffic load is 20000 cars/day. Two-way traffic (two lanes in each direction) runs through the main street. Five-story buildings (20 m high) surround the street. Kotlarska Street represents 22 m wide street canyon with an aspect ratio 1.1 (width/height).

Fig. 2: Top view of the computational domain



4.2. Numerical model

CFD code StarCD was used as appropriate tool for this study. The set of equations for the conservation of mass, momentum and passive scalar was solved for steady, incompressible turbulent flow. The equation for a general variable ϕ reads

$$\frac{\partial(\rho\phi)}{\partial t}+\frac{\partial}{\partial x_i}\left(\rho u_i\phi\right)=\frac{\partial}{\partial x_i}\left(\Gamma\frac{\partial\phi}{\partial x_i}\right)+S_\phi+S_\phi^P, \tag{4}$$

where the variable ϕ substitutes a velocity component, concentration of a passive scalar or equals unity in the mass (continuity) equation, ρ is fluid density, u_i is a velocity component, Γ is a general diffusivity coefficient (effective viscosity for the momentum equation and effective diffusion coefficient for the mass equation), S_Φ is a source term and S_ϕ^p is an additional source term of ϕ. The additional source term S_ϕ^p stems from the interaction between continuous phase (air) and discrete moving objects (cars).

The wind velocity and direction were imposed on the model with the use of the “wind velocity layer” boundary configuration. This boundary configuration prescribes a specified wind speed and direction at a horizontal layer of air. The air layer is located at height significantly above the building roofs; 45 m above the ground surface in this study. The pressure boundary conditions were prescribed on all sidewalls of the solution domain. The slip wall boundary condition was set on the top of the domain.

To simulate the traffic, an original model (Jicha et al., 2000) is applied. It takes into account traffic intensity, speed of cars and number of traffic lines. The k-ε RNG model of turbulence (Yakhot, 1986) was used. As it is known, moving objects induce a kinetic energy of turbulence that should be added as the additional source S_k to the k-equation. From different studies (Eskridge and Hunt, 1979; Sedefian et al., (1981); Sini & Mestayer, 1997) it follows that turbulence is induced mainly in the wake behind the vehicle. Therefore, the additional source S_k (Eskridge and Hunt, 1979) was added only along the trajectory that cars follow.

$$S_k=C_c\left(U_{car}-U_\infty\right)^2\dot{Q}_{car}, \tag{5}$$

where C_c is the model constant, U_{car} is the car speed, U_∞ is the air velocity and Q_{car} is the traffic rate in cars/s.

4.3. Quantification of the near-ground air threshold velocity of re-suspension

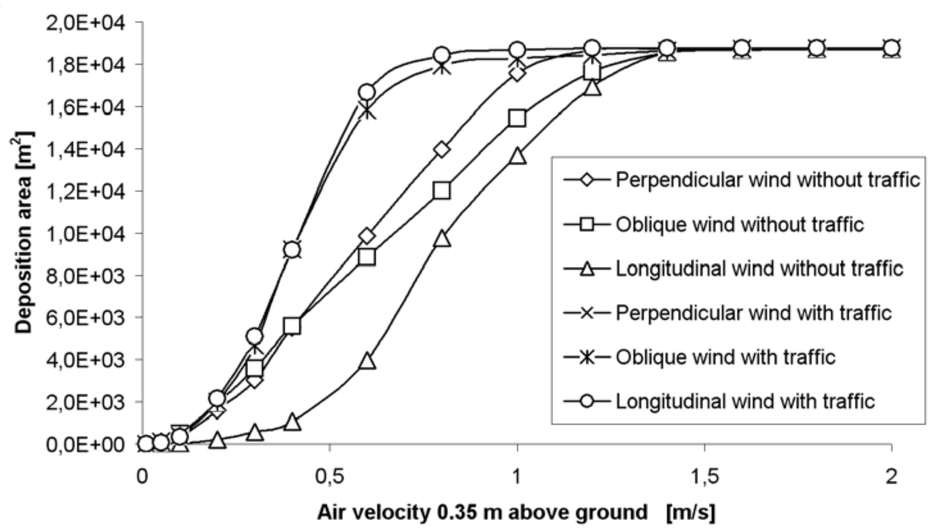
The above discussed wind threshold velocity of re-suspension was used for setting up of boundary conditions of the street canyon numerical model. We tested three different wind directions, namely: perpendicular, longitudinal and oblique (45°) to the main street canyon. Six different simulations were carried out altogether; three of them for situations without inclusion of moving cars and the other including the moving cars.

Moving cars divert air from the air pattern as established by the wind. Significant production of turbulence causes an increase of turbulent viscosity in a close vicinity of moving cars. Higher turbulent viscosity slows down a velocity of air flow in the street canyon, especially in boundary layers along the ground surface and building walls.

The air velocity predicted just above the ground surface was used for the following assessment as a representative value directly influencing re-suspension. The numerical model was built up using hexahedral control volumes The control volumes with the height of 0.7 m were used at the ground level. A calculation process provides information about the air velocity at the central nodes of the control volumes (0.35 m above the ground surface). A real wind velocity profile is substituted by the logarithmic wind velocity profile between these central nodes and the ground surface.

Fig. 3 shows results of a numerical prediction in the form of the relation between the near-ground air velocity at the height of 0.35 m above the ground surface and the area of the studied street canyon affected by this or lower air velocity. In Fig. 3, one can clearly identify air velocity range from 0.25 m/s to 1.2 m/s where a small change of the near-ground air velocity causes significant increase of the affected area. This provides good conditions for particle re-suspension during increasing wind velocity within the specified “sensitive” range. The range of "sensitive" velocities is quite wide. The street canyon near-ground air threshold velocity of re-suspension was determined as 0.75 m/s (at the height of 0.35 m).

Fig. 3: The predicted near-ground air velocity at the height of 0.35 m against the area of the studied street canyon affected by this or lower air velocity



4.4. Comparison with other studies

Different studies on determination of the near-ground air threshold velocity of particle re-suspension have been carried out in recent years. Majority of these studies considered particle re-suspension from a flat horizontal surface that fit well to the detailed solution of a bottom part of the studied street canyon. We compared the predicted near-ground air threshold velocity of re-suspension with the results derived from formulations published by Cornelis and Gabriels (2004) and Saho and Lu (2003). In all cases, we considered spherical particles with the diameter of 10 μm, density of particles 1200 kg/m^3, parametrical roughness of surface 0.0003 m and wind profile displacement 0 m. From the Cornelis and Gabriels (2004) formulation, we derived the near-ground air threshold velocity of re-suspension 0.724 m/s. From the Saho and Lu (2003) formulation, we derived the near-ground air threshold velocity of re-suspension 0.957 m/s.

5. Conclusion

The paper introduced the process of determination of the wind threshold velocity of re-suspension (at the height of 10 m) for PM10 particles in urban areas. The determination process utilizes data derived from a long-term measurement of meteorological conditions and PM10 concentration. This process was applied to the central part of the city of Brno (population 400 000). The wind velocity 2.4 m/s was determined as the wind threshold velocity of re-suspension in the studied urban area.

Subsequently, a numerical modelling based on the finite volume method was used for a detail study of the relation between the wind threshold velocity of particle re-suspension at the height of 10 m and the near-ground air threshold velocity of particle re-suspension in the particular street canyon. At this approach, only the mean velocity of air was used for a final assessment. The street canyon near-ground air threshold velocity of re-suspension was determined as 0.75 m/s at the height of 0.35 m above the ground surface. This near-ground air threshold velocity of re-suspension fully corresponds with theoretical studies on particle re-suspension from horizontal surfaces.

Utilizing CFD for a detailed small scale modelling in urban areas is a perspective application that enables the correct assessment of re-suspension from the ground surface in urban areas of complex geometry. The carried out simulations confirmed the relation between the wind velocity above building roofs and the wind velocity at the boundary layer just above the ground surface, obtained by previous studies. The presented numerical modelling approach can be successfully used even for inverse assessment of the wind threshold velocity of re-suspension with inclusion of detailed geometry of urban areas.

Acknowledgement

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The Evaluation of Air Pollution at the CHMI Traffic Stations in the Czech Republic

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Abstract

In 2004 the Czech Hydrometeorological Institute (CHMI) started to create the network of traffic oriented “hot spot” stations primarily focused on the air pollution monitoring of the busiest traffic “street canyons” locations in the most densely populated cities of the Czech Republic. There is also a number of other stations run or operated by CHMI at localities classified as traffic [1, 2]. This paper contains the selected summary measurement results from such localities for 2004–2009 (or based on the assessment of the seasons covering also the first quarter 2010 data).

1. Introduction

In 2004 the Czech Hydrometeorological Institute (CHMI) started to create the network of traffic oriented “hot spot” stations primarily focused on the air pollution monitoring of the busiest traffic “street canyons” locations in the most densely populated cities of the Czech Republic. There is also a number of other stations run or operated by CHMI at localities classified as traffic [1, 2]. This paper contains the selected summary measurement results from such localities for 2004–2009 (or based on the assessment of the seasons covering also the first quarter 2010 data).

There are measured hourly or daily average concentrations of nitrogen monoxide (NO), nitrogen dioxide (NO_2), sum of nitrogen oxides (NO_X), carbon monoxide (CO), benzene, toluene and PM_{10} or $PM_{2.5}$ suspended particles fractions at most of the stations. At some stations the counting of the number of passing vehicles is also carried out. At the Ostrava-Českobratrská locality indicative assessment of the PM_{10} particles genotoxicity impact based on the lowest and highest daily measurements and the verification of the number of passing vehicles were carried out.

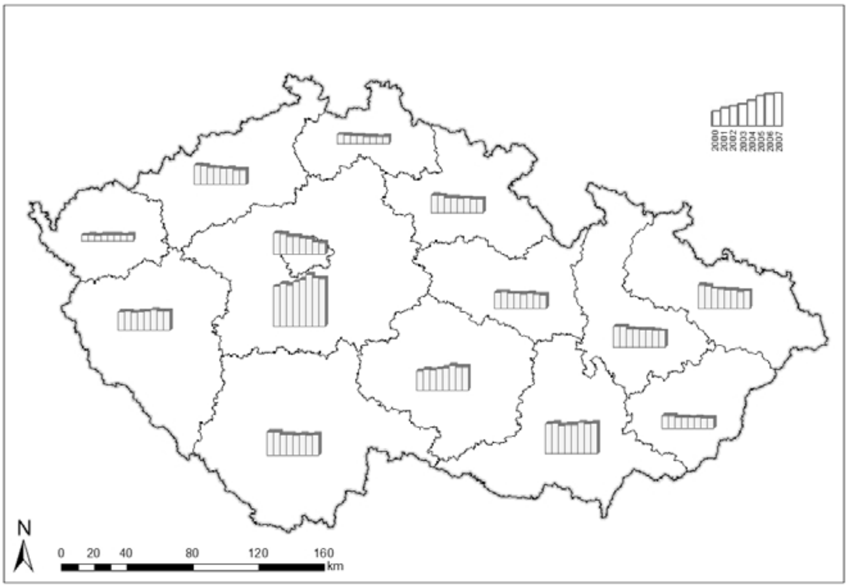
There are used station codes from the Air Quality Information System (ISKO) database in the tables and graphs (see *http://portal.chmi.cz/files/portal/docs/uoco/web_generator/locality/pollution_locality/index_CZ.html* for details).

2. Development of NO_X, TSP, CO and VOC emissions from traffic, 2000–2007

(At present the emission data for the year 2008 are not available yet.)
The development of nitrogen oxide emissions from transport (REZZO 4) from 2000 to 2007 in individual regions differs significantly. Clearly declining trend of emissions in individual years is apparent in the Moravian-Silesian Region, Olomouc Region,

Prague and Ústí nad Labem Region; on the contrary it is increasing in the Central Bohemian Region and Vysočina Region. In other parts of the country the values of NO_X emissions for the period are either balanced or fluctuating. The emissions of TSP have a significant upward trend in the Central Bohemian, Plzeň, South Moravian and Vysočina regions. Significant downward trend in TSP emissions for the period 2000–2007 is not shown in any region. Carbon monoxide emissions are declining or balanced in most regions, only in the Vysočina and Central Bohemian regions the trend is rising. Except for the Central Bohemian, South Moravian, Karlovy Vary and Vysočina regions the emissions of volatile organic compounds (VOCs) have a downward trend in most cases. Generally, the lowest emission totals of NO_X, TSP, CO and VOC for the examined period are in Karlovy Vary and Liberec regions, the highest in Central Bohemian, Prague, Moravian-Silesian and South Moravian regions, i.e. namely in the regions with higher concentration of industry and traffic. Although the emissions of pollutants in the Vysočina Region are not among the highest in the CR, they show an upward trend for the examined years, which may be due to the significant influence of the highway and adjacent communications.

Fig. 1: Emissions of nitrogen oxides in the individual regions, 2000–2007



3. Ambient air concentrations

3.1. Average annual concentrations (2005–2009), compared with the limits

The highest average annual concentrations of nitrogen oxides (NO_X) are reached at the station Prague 2-Legerova (hot spot). After comparison with the annual limit value valid until 2002 (80 $\mu g.m^{-3}$) we can conclude that the exceedances occur quite frequently (especially at the stations: Prague 2-Legerova (hot spot), Prague 5-Smíchov, Prague 9-Vysočany, Ostrava-Českobratrská, Ústí n. L.-Všebořická, Beroun). The lowest annual concentrations were measured in Příbram.

The annual limit value for nitrogen dioxide (NO_2) 40 $\mu g.m^{-3}$ set by the Government Order No. 597/2006 Coll. is mostly exceeded at the stations: Prague 2-Legerova, Brno-Úvoz, Brno-střed, Ústí n. L.-Všebořická and Ostrava-Českobratrská. At most stations the development of average annual concentrations shows the decreasing trend (e.g. Prague 2-Legerova, Brno-center, Hradec Králové-Brněnská), but for example O.-Českobratrská and Ústí n. L.-Všebořická have an increasing trend. However, the 5-year period is too short for the evaluation of the long-term trends.

The highest annaul averages of nitrogen monoxide (NO) as well as NO_X are reached mainly at Prague 2-Legerova (2005–2008).

The annual limit value for suspended particulate matter PM_{10} is also exceeded at the traffic stations in 2005–2009 (e.g. Prague 2-Legerova, Brno-center, Uherské Hradiště), especially in 2005 and 2006. At the station Ostrava-Českobratrská (hot spot), this limit is exceeded each year (2005–2009) – it is the only case of traffic stations CHMI in the Czech Republic, also influenced by a higher background of this pollutant is in the area.

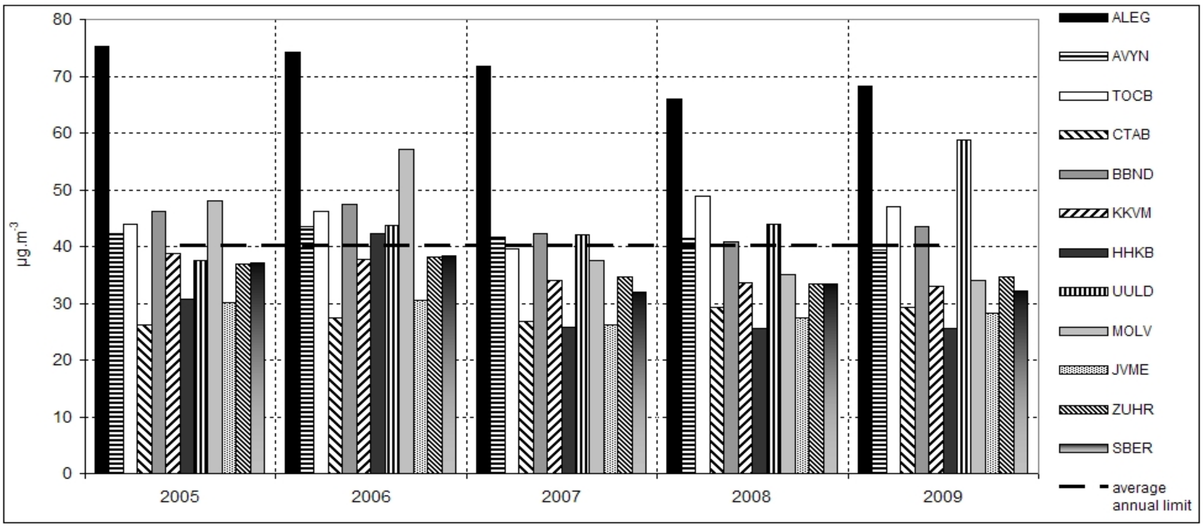
The highest annual average concentrations of suspended particles $PM_{2.5}$ were measured in 2005 and 2006, when the target limit value (25 $\mu g.m^{-3}$, the Directive 2008/50/EC of the European Parliament and the Council) was exceeded at stations Prague 5-Smíchov, Prague 9-Vysočany, Beroun and Hradec Králové-Brněnská; there was no exceedance in 2007–2009. But the measurement is carried out only at limited number of sites.

As for benzene, the annual limit 5 $\mu g.m^{-3}$ was exceeded only once, at the station Brno-center in 2006. In the past 3 years (2007–2009) the highest annual average concentrations were recorded at the station Ostrava- Českobratrská (hot spot), but the annual limit was not exceeded.

For the annual concentration of carbon monoxide (CO) the annual limit value has not been set by the legisalation. The highest annual average of CO was achieved at the station Ostrava-Českobratrská (hot spot), where there is a significant influence of the higher air pollution background in the area; the second highest is at the station Prague 2-Legerova (hot spot).

The annual average concentrations of toluene (similarly as in CO the annual limit value is not set) have a decreasing trend at the stations (except for Tábor, Hradec Králové-Brněnská). The highest annual average was measured in 2005 at the station Ústí n. L.-Všebořická (hot spot), and namely 7 $\mu g.m^{-3}$.

Fig. 2: Average annual concentrations of NO_2 at the selected CHMI traffic stations (2005–2009)



Tab. 1: Relative frequency of the annual NO_2 limit value (40 μg.m^{-3}) exceedances, traffic stations of the Czech Republic with a valid measurement

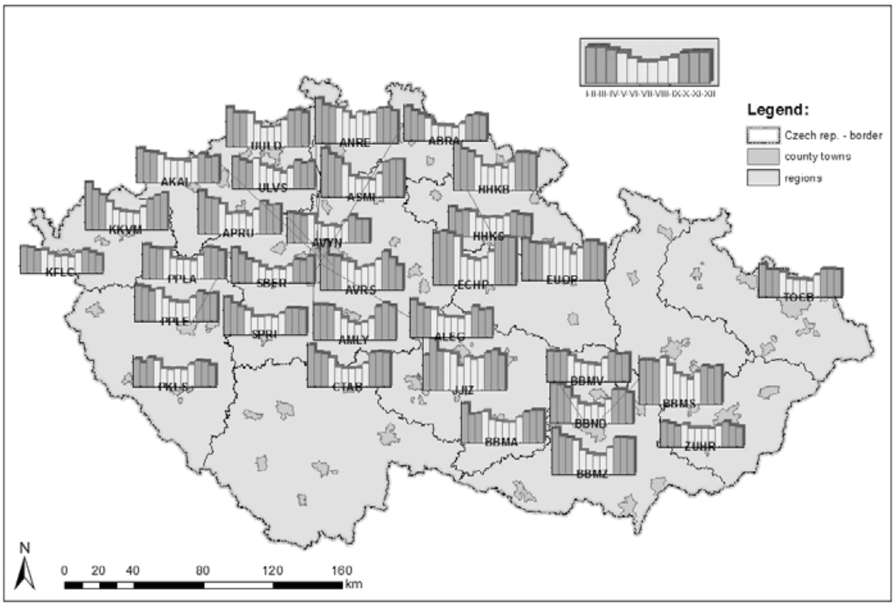
Year	%
2004	22
2005	48
2006	50
2007	42
2008	32
2009	28

At the locality Prague 2-Legerova the short-term limit value of NO_2 200 μg.m^{-3} is exceeded repeatedly more frequently than is the number of allowed 18 occurences per year (100–200 cases per year). At other locations, this allowed number was exceeded only occasionally (about 10 % of traffic stations per year). But in 2006 the over-run appeared at 30 % of traffic localities.

3.2. Annual course

The most significant annual courses are recorded in CO, NO_X, NO_2, NO, PM_{10} and $PM_{2.5}$, when the maximum average monthly concentrations are achieved in the cold season (from October to March), and conversely lower concentrations in the warmer months (from April to September). The annual course of benzene is not as strong, but in most cases higher concentrations are found mainly in cold months, and conversely lower concentrations in the warm ones. The annual course of toluene is quite irregular, except for Brno-Center and Karlovy Vary with peaks from October to March and minimum concentrations from April to September.

Fig. 3: Annual course of air pollution PM10, traffic stations, Czech Republic



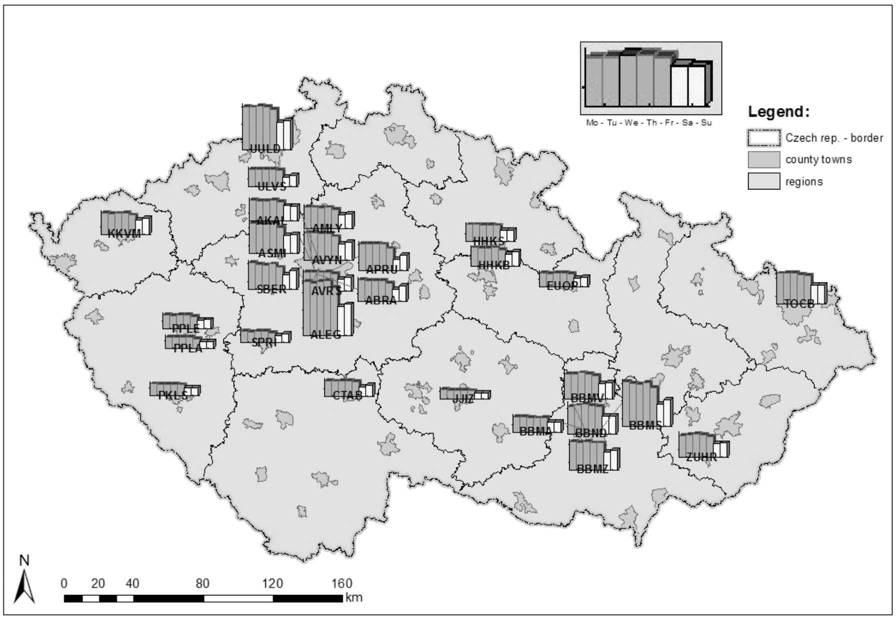
3.3. Weekly running

The most considerable differences between the concentrations measured on weekdays and weekends (see table 2) are visible in NO, NO_2, and toluene. While the weekend PM_{10} average concentrations ratio to weekdays values is 89 %, for $PM_{2.5}$ the ratio increases to 94 %.

Tab. 2: Relative frequency of the weekend values in weekdays concentrations, traffic stations, Czech Republic

Pollutant	AVG	MIN	MAX
	[%]		
NO	59.3	43.1	74.9
NO_2	76.3	63.0	93.7
NO_X	67.8	52.0	101.5
$PM_{2.5}$	94.1	90.2	96.9
PM_{10}	89.0	81.5	94.7
CO	89.6	78.2	97.2
BENZENE	88.6	75.9	98.9
TOLUENE	74.7	60.8	85.2

Fig.4: Average weekly course of NO_X



3.4. Nitrogen oxides components relations

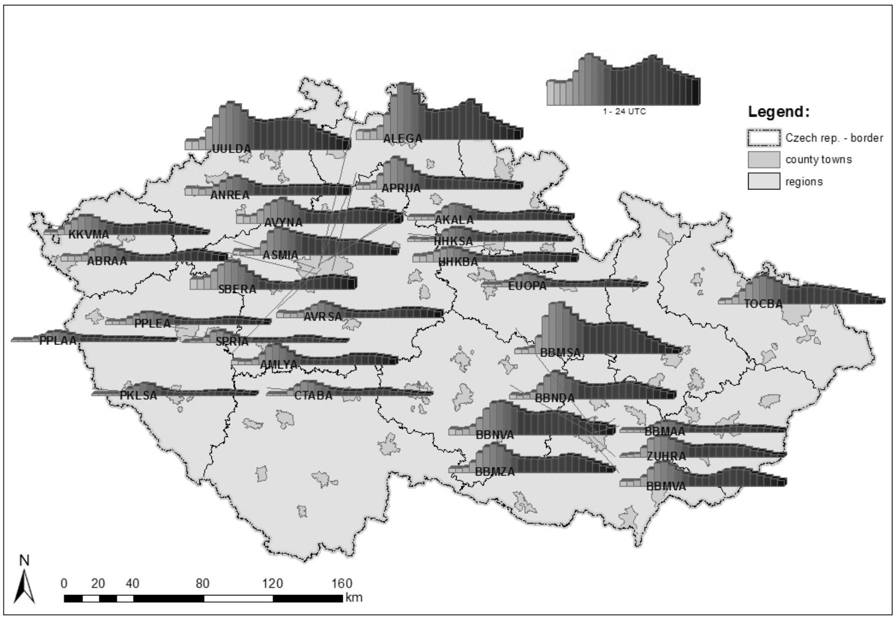
The selected traffic localities are different as for the rate of pollutants manifestation directly emitted from mobile sources at the concrete site. The locality character (specification) is expressed as the NO ratio to NO_2. The table 3 gives this ratio values from the localities with the measurements of both components in 1-hour intervals. The values over 1 (the traffic-loaded localities) are highlighted. The highest values with regard to this criterion are found during morning rush hours at most stations. The localities Ústí n. L.-Všebořická (hot spot) and Brno-Svatoplukova are highly loaded by traffic pollution all the day. The strong traffic character of these localities is seen also from the average daily NO courses (figure 5), where unlike other stations more significant morning NO peaks are seen. Hr. Králové-Sukovy sady, Ústí n. Orl.-Podměstí, Prague 10-Vršovice, Prague 8-Karlín, Plzeň-střed, Plzeň-Slovany, Příbram, Brno-Arboretum localities have lower traffic loads (as for the year-long average course).

Table 3: The average hourly concentrations of NO/ NO_2 ratio

UTC	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
HHKS	0.3	0.3	0.3	0.3	0.5	0.8	0.9	0.9	0.8	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3
PKLS	0.3	0.3	0.3	0.3	0.4	0.7	0.9	**1.0**	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.3	0.4	0.3
EUOP	0.3	0.3	0.4	0.5	0.7	0.9	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3
AMLY	0.4	0.4	0.4	0.5	0.8	**1.1**	**1.1**	**1.0**	0.8	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5
AVRS	0.4	0.4	0.4	0.4	0.5	0.7	0.8	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.4
SBER	0.8	0.9	**1.0**	**1.4**	**1.7**	**1.7**	**1.6**	**1.4**	**1.2**	1.0	0.8	0.7	0.6	0.6	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8
PPLE	0.4	0.3	0.4	0.6	0.8	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
PPLA	0.3	0.3	0.3	0.4	0.6	0.8	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.3
ASMI	0.4	0.3	0.3	0.5	0.8	**1.2**	**1.3**	**1.2**	**1.2**	**1.1**	**1.1**	**1.0**	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.4
ZUHR	0.2	0.3	0.3	0.8	**1.1**	**1.2**	**1.2**	**1.1**	1.0	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3
ALEG	0.5	0.5	0.5	0.7	**1.1**	**1.3**	**1.4**	**1.4**	**1.2**	**1.1**	1.0	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5
CTAB	0.3	0.3	0.3	0.6	0.9	**1.0**	1.0	0.9	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3
HHKB	0.6	0.7	0.8	1.0	**1.1**	**1.1**	**1.0**	0.9	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
KKVM	0.3	0.3	0.5	0.8	**1.0**	**1.1**	**1.1**	**1.0**	0.9	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.3
SPRI	0.2	0.2	0.3	0.6	0.9	0.9	0.8	0.7	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2
AKAL	0.3	0.3	0.3	0.3	0.5	0.7	0.8	0.8	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
AVYN	0.5	0.5	0.6	0.8	**1.1**	**1.2**	**1.2**	**1.1**	1.0	0.8	0.7	0.7	0.7	0.7	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6
UULD	0.8	0.8	0.9	**1.4**	**1.9**	**2.1**	**2.2**	**2.0**	**1.7**	**1.5**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.2**	**1.1**	**1.0**	1.0	0.9	0.8
APRU	0.4	0.4	0.5	1.0	**1.5**	**1.5**	**1.4**	**1.2**	**1.0**	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.4	0.4
TOCB	0.3	0.4	0.6	0.9	**1.2**	**1.3**	**1.3**	**1.2**	**1.0**	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.4	0.4
BBND	0.4	0.4	0.4	0.6	0.9	**1.2**	**1.2**	**1.1**	1.0	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.5	0.5
BBMV	0.5	0.5	0.6	0.8	**1.2**	**1.3**	**1.3**	**1.2**	**1.0**	0.9	0.8	0.7	0.7	0.7	0.8	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6
BBMS	0.5	0.5	0.7	**1.2**	**1.9**	**2.0**	**1.9**	**1.8**	**1.6**	**1.4**	**1.3**	**1.3**	**1.3**	**1.2**	**1.2**	**1.2**	**1.1**	**1.0**	0.9	0.8	0.8	0.7	0.6	0.5
BBMZ	0.4	0.5	0.5	0.8	**1.2**	**1.4**	**1.4**	**1.4**	**1.2**	**1.1**	1.0	0.9	0.9	0.9	0.8	0.8	0.9	0.9	0.8	0.8	0.7	0.6	0.5	0.5
BBMA	0.2	0.2	0.2	0.3	0.4	0.6	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3

Time is given in UTC (Universal Time Coordinated)

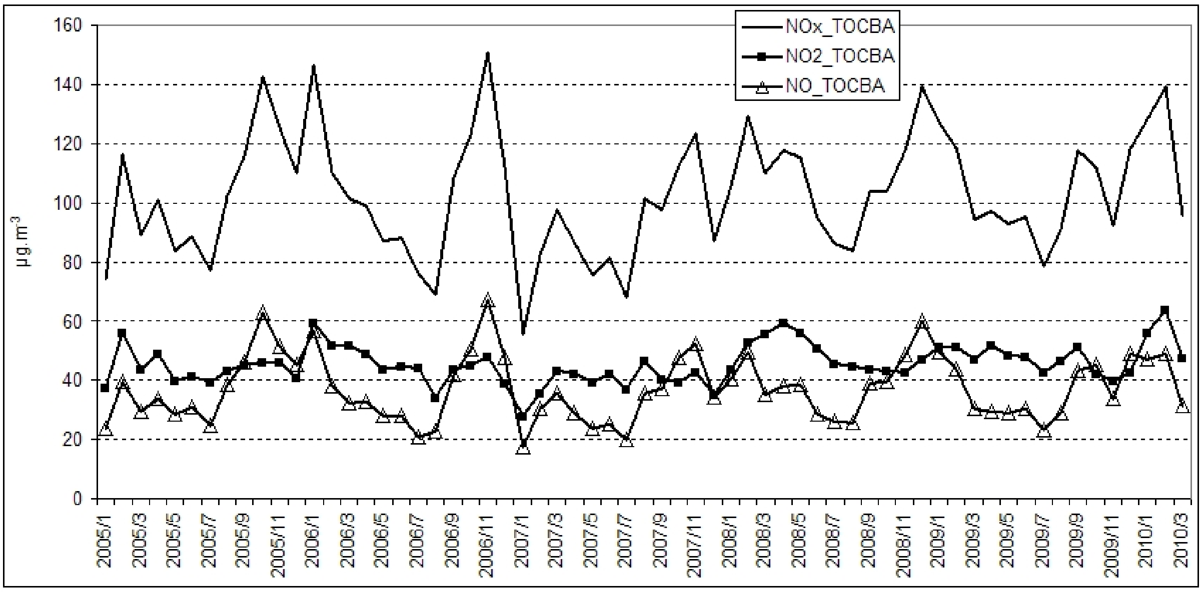
Fig. 5: The average daily course of NO concentrations



The shares of the various components of nitrogen oxides were determined from daily and monthly average concentrations of NO, NO_2 and NO_X in the period January 2005–March 2010 at CHMI stations (Prague 2-Legerova, Brno-center and Ostrava-

Českobratrská) and at the station Plzeň-Slovany (owned by the City of Plzeň). The highest average proportion of NO_2 in NO_X was achieved at the station Brno-center (over 60 %), the lowest at Prague 2-Legerova (around 45 %), conversely the highest proportion of NO in NO_X was found at the station Prague 2-Legerova (over 35 %), the lowest at Plzeň-Slovany (around 25 %). The highest average proportion of NO to NO_2 was at the station Prague 2-Legerova (over 90 %) and Ostrava-Českobratrská (over 80 %), the lowest at Plzeň-Slovany (around 45°%). Monthly average concentrations of NO, NO_2 and NO_X have a similar course, when there are increased concentrations of NO_X the proportion of NO and NO_2 components incresaes and the difference between the concentrations of NO and NO_2 is reduced or the concentrations of NO are even higher than the concentrations of NO_2, which could confirm the theory that the higher is the ratio between NO and NO_2, the heavier is the traffic impact on the locality.

Fig. 6: Average monthly concentrations of NO_X, NO_2 and NO at the station Ostrava-Českobratrská (hot spot), January 2005–March 2010



4. Genotoxicity

4.1 Materials and methods

Preparation for testing

Exposed filter (samples 251, 302, 357 from Českobratrská Street in Ostrava) was extracted in 100 ml dichloromethane p.a. (Merck) per Soxhlet extractor. The crude extracts were placed into a vacuum evaporator and concentrated to a volume of 10 ml. Only 0,5 ml was removed from each concentrated extract and completely dried in vacuum to determine the extractable organic matter (EOM). Rest of each concentrated extract was further evaporated under nitrogen atmosphere and redissolved in 6 ml of dimethylsulphoxide p.a. (Merck). These dimethylsulphoxide solutions were used for test toxicity testing with bioluminiscent bacterium.

Toxicity test

The bioluminescence inhibition assay is based on a marine gram negative bacterium, Vibrio fischeri (earlier referred as Photobacterium phosphoreum). The specific strain, Vibrio fischeri NRRL B-11177, has been widely used for acute toxicity estimation. Test with Vibrio fischeri were carried out following the standard (ISO 11348-1) [1] procedures. The samples were tested in a medium containing 2% NaCl and about 107 cells of bacteria were reconstituted from the HEPES medium. Control samples (bacterial suspensions to which 2% NaCl had been added instead of test samples) were run parallel to all the test samples. Tests were performed at 15 oC. Each test was performed with 9 concentrations in two duplicates, and with negative control. Luminiscence was measured using the LUMIStox 300 luminometr (HACH LANGE GMBH) at 15 and 30 min exposure times. Inhibition of luminescence was used for the EC5 and EC50 calculation (software Toxicita 3.01).

4.2. Results

Results of the acute toxicity test are summarized in Table 4. Value of EC5 and EC50 means contaminated extract concentration that caused 5% and 50% inhibition in the endpoints of the tests. The EC5 and EC50 values were calculated at different times of exposure to samples. Test using microbial test organisms (Vibrio fischeri) were sensitive to all of the contaminated extracts. The results of the acute toxicity test on Vibrio fischeri showed that with increasing concentration of the extractable organic matter in the samples the bacterial luminescence was decreases. The heavy acute toxicity was observed on the sample 357, the value of EC50 was 20.95µl of the contaminated extract.

Table 4: Results of the test acute toxicity with Vibrio fischeri

Sample [µl]	**EOM [mg/ml]**	**Inhibition in 15 min exposure times**		**Inhibition in 30 min exposure times**	
		EC5	**EC50**	**EC5**	**EC50**
251	0,25	3,25	32,53	3,57	35,68
302	1,00	2,40	24,03	2,41	24,13
357	2,30	2,09	20,96	2,09	20,95

4.3. Conclusions

Results of the toxicity test showed detectable responses of toxicity. Toxic effect was observed even at the lowest concentration (Sample 251) of extractable organic matter in the sample.

Literature

[1] Commission Decision 2001/752/EC

[2] Criteria for EUROAIRNET, Technical report no. 12, EEA

[3] ISO 11348-1 (1998): Water quality. Determination of the inhibitory effect of water samples on the light emission of *Vibrio fischeri* – Part 1: method using freshly preparated bacteria.

Reference Diagnostics of Air Pollution in the Vicinity of Local Roads

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Abstract

Air quality in the urban areas constitute a topic, which equally interests professionals as well as the general public. In order to provide for continuous monitoring of the environs it is not always possible to equip the road infrastructure with the demanding measuring equipment. Nowadays there are even less sophisticated portable measuring devices available of various types and sizes.

One of them is a portable device of AEROQUAL 520, by means of which pursuant to the information provided by the producer, concentrations of NO_2 and CO are able to be measured in extended time intervals. In the paper presented we offer the presentation of the first experience with this measuring device, following the measurements alongside the urban road communications.

1. Monitoring of gaseous polluting agents in the atmosphere by means of a portable handheld monitor of Aeroqual 520

Monitoring of polluting agents in the external atmosphere is a significant and crucial step towards the preservation of the outer environment. Determining the amount of Nitrogen Dioxide - NO_2 gases and carbon monoxide – CO, even volatile carbohydrates - VOC, whose elevated presence in concentrated form presents an increased risk for the environment, not only within the hazardous operations but at the same time in the outer environment.

Fig. 1: Aeroqual 520 Monitor, adjusted for the external use

Fig. 2: Aeroqual 520 Monitor

Fig. 3: Removable monitor head

Handheld monitor of Aeroqual 520 (Fig. 1 and 2) enables to measure various gaseous substances in the atmosphere (ammonia, ozone, sulphur dioxide, methane ...), in dependance with the utilized sensor head (see figures) (Fig. 3). [4]

1.1. Device Technology

The monitoring technology of the device is based on the principle of semiconductive sensor of oxide type.

Chemical sensors of semiconductive oxide type are based on the ability of some metal oxides to physically absorb and while exerted to higher temperature ionize on its surface the element of oxygen. Activated oxygen in various energy forms may react with oxidation able molecules in gases while unstable radicals are released. Mechnisms of these phenomena may lead to physical absorption, chemical absorption or in several cases to a chemical reaction. These phenomena are accompanied by changes in electrical conductivity within an oxide layer. In order to sustain the duration of reaction, the oxide layer has to be heated to a higher temperature. Reaction of oxygen with oxidation able gas are accompanied by changes in electrical conductivity of oxide layer. A semiconductor is in the majority of cases sprayed in a thin layer onto the medium of inorganic origin (insulator), which may bear the form of a board, tube or a roller.

Each sensor is equipped with a heating element which heats the sensitive layer bringing it to the operating temperature. The schematic depiction of the semiconductive sensor is drawn in Fig. No.: 4 [3].

Fig. 4: Semiconductive sensor for the Aeroqual monitor Series 500

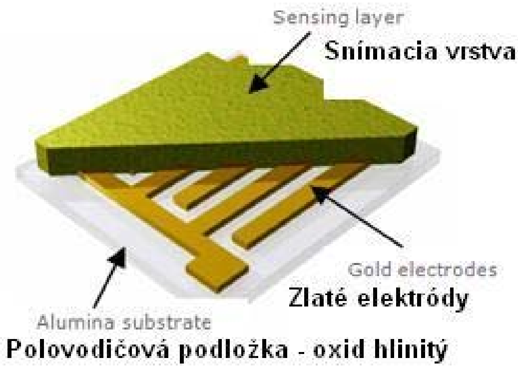
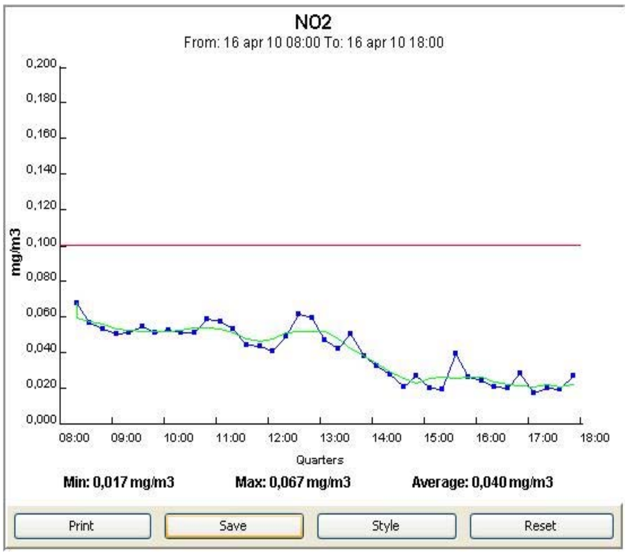


Fig. 5: Graphical output of measuring for the amount of NO_2



The disadvantages present related to oxide sensors are mainly their significant dependance on the relative humidity, temperature and air currents. Following the e by means of an elevated concentration of oxidation able gas, the signal in a very slow manner comes back to its initial value, in several cases the changes incurred within the semiconductor are irreversible.

Tab.1: Technical specification of sensor head for NO_2

NO_2	Maximum exposure	Range	Working range	
			Temperature	Humidity
	0.500 ppm	0 - 0.200 ppm/1 ppb	0 - 40 °C	30 - 70% without condensation

Source: [4]

These sensors are specifically fit for measuring and detection of minute concentrations of hydrocarbons and their derivatives (roughly tens of ppm), halogen-containing hydrocarbons alcohols, esters of nitro compounds, ammonia or carbon monoxide. [3].

Tab. 2: Technical specification of sensor head for CO

CO	Maximum Exposure	Range/ the lowest measurement	Working range	
			Temperature	Humidity
	200 ppm	0 - 100 ppm/0.2 ppm	0 - 70 °C	5 - 95% without condensation

Source: [4]

1.2. Software provisioning

An integral part of the Aeroqual 520 Monitor is a software package - Aeroqual S500 V5.1 (Fig. 5) with a chart-like or graphical output intended for the communication with the measuring devices by the mediation of a PC. By means of the programme one is enabled to operate the monitor directly and provision the following tasks:

- gas monitoring in real time,
- data recording,
- should the gas concentration exceed the level specified by a user, a measured value be stored in the created database,
- analysis of recorded data by means of a graphical output configured and set up observing the user's requirements,
- an option for viewing mean gas concentration while measuring the values in real time and at the same time while analyzing the recorded data,
- an option for storing the graphical outputs in the .jpg format,
- storage and export of the date in various output formats: non-decripted text or MS Excel™ file,
- an option for manual configuration of the monitor (device),
- a feature enabling the backup of data and recovery of recorded data,
- a feature enabling the conversion of measurements units : ppm (parts per million) or mg/m^3 (milligrams per cubic metre) [4];

2. Experimental determination of the amount of NO2 and CO in the vicinity of urban roads

During the first phase of testing the monitor the concentrations of the polluting agents dispersed in the air, and that of NO_2 and CO monitored in the outer environment next to the road communications in the city of Žilina. These recordings have been effectuated in order to test the measurement monitor of Aeroqual 520 so as to determine its suitability for its continuous usage in the external environment and at the same time in order to determine the measured values of gaseous concentrations brought about by the heavy traffic on a specifically selected road communication.

Withing the city perimeter there were various locations selected for the effectuation of measuring activities. Namely the following streets: Hlinská St., Kamenná St., A. Rudnaya St. for the presence determination of the NO_2 gas and the street of Komenského for monitoring the presence of CO.

Each of the urban communications is specific, given the fact it has a different position within the greater city, as well as due to the versatility of the traffic composition and traffic lanes, category and the neighbouring urban development.

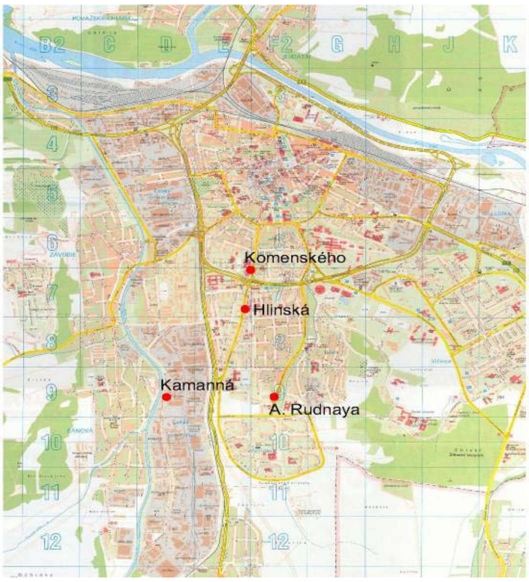
Measurements of NO_2 taken in the streets of Hlinská and Kamenná were performed in 3-day cycles between each Tuesday and Thursday, every day for ten /10/ hours (between the hours of 8:00 – 18:00), in the street of A. Rudnaya the measurements were taken within the duration of 3 days per week per 8 hours per day (7:00 – 15:00). The concentration of CO was measured only in the street of Komenského, equally for the period of three /3/ days for the duration of eight /8/ hours each day between the hours of 8:00 – 16:00.

2.1. Assessment of measurements within the city

Recorded concentrations of NO_2 and CO gases in the atmosphere in the vicinity of particularly selected urban road communications were determined by the intensity of the traffic, which was monitored on the road communications by means of a monitoring device of Sierzega SR4 /traffic detection device/.

The Aeroqual 520 monitor was set up so as the presence of polluting agents in the atmosphere was recorded every 15 minutes.

Fig. 6: Positioning of monitoring stands within the outer perimeter of the city of Žilina



The amount of NO_2 present in the close vicinity of road communications in the majority of cases for the duration of the whole day oscillated and the highest concentrations were determined during the morning hours.

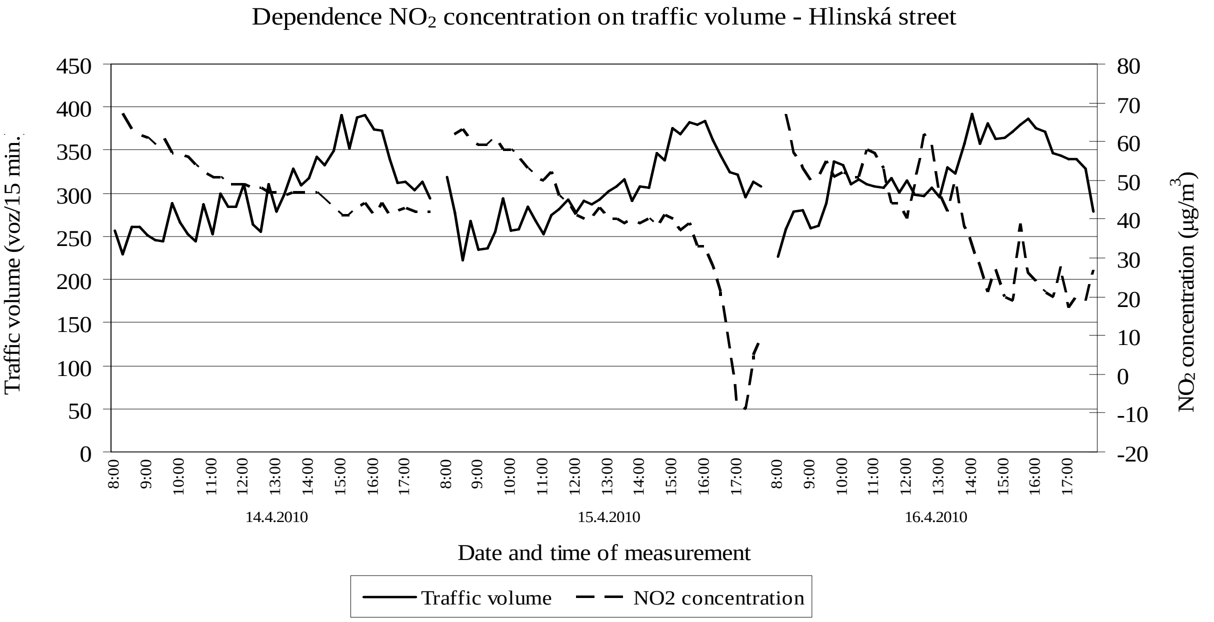
The intensity development of the traffic pollution was for each communication during a given day quite specific. The highest concentration of traffic was observed in case of Hlinská Street in the afternoon hours, in case of Kamenná Street (see figures 7. to 9) the rush hour started in the afternoon.

The dependance of NO_2 concentrations in the vicinity of urban roads in a direct relation to the density of traffic is not that clear as far as its development during the course of day is concerned. Local deviations might, however, be observed in the concentration of NO_2 gases, which are to be attributed to the growth or decline in the number of vehicles due to the very profile of the road communication.

In case of A. Rudnaya Street the dependence of the NO_2 gases and their presence in the air is the most significant. The rises and declines of NO_2 concentration in the air during all the three days were largely dependent on the rate and extent of traffic.

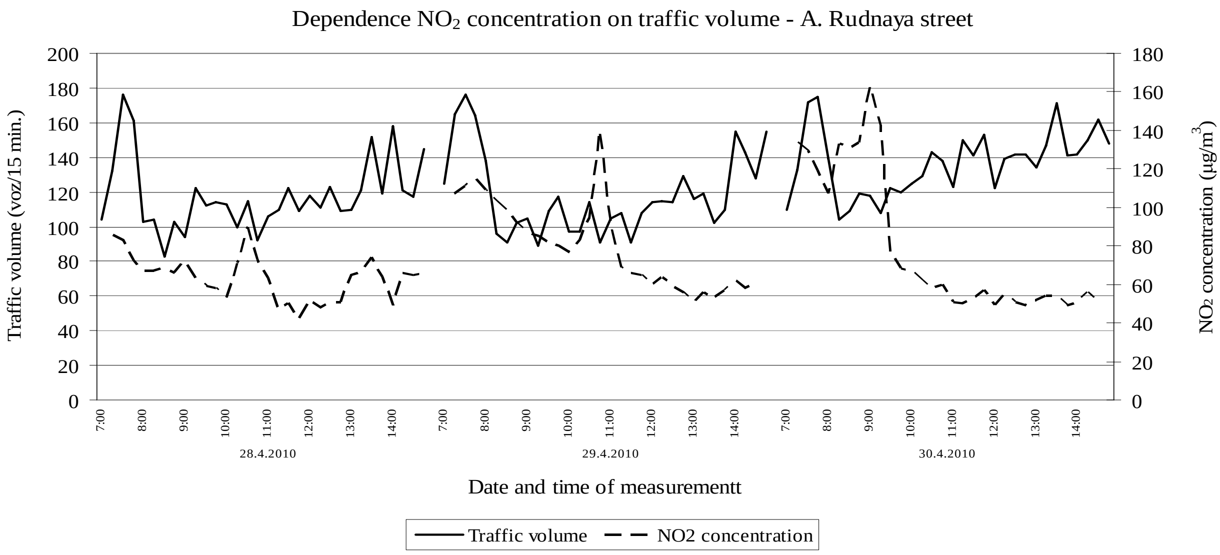
Unclear values in measured concentrations of NO_2 gases in a close relation to the rate of traffic may be attributed to several marginal factors. These for example may be climatic conditions, weather conditions (dissipation, dispersion conditions) during the phase of measurements taking, the neighbouring constructions, developed area, presence of other sources contributing to the values being measured.

Fig. 7: Measured values in concentration of NO_2 gases, traffic rate in Hlinská St.



The highest concentration of NO_2 gases was recorded in the Street of Kamenná, where the highest hourly mean value out of three measurements achieved the value of 218 $\mu g.m^{-3}$. In this street, however, the highest presence of heavy trucks was observed. In the Street of Hlinská the highest hourly mean value recorded attributed to the value of 63,25 $\mu g.m^{-3}$ (Fig. 8). In the Street of A. Rudnaya the highest mean value of NO_2 gases was established amounting to 142,75 $\mu g.m^{-3}$ (Fig. 10).

Fig. 8: Measured values of NO2 gases concentration and the rate of traffic in the Street of A. Rudnaya



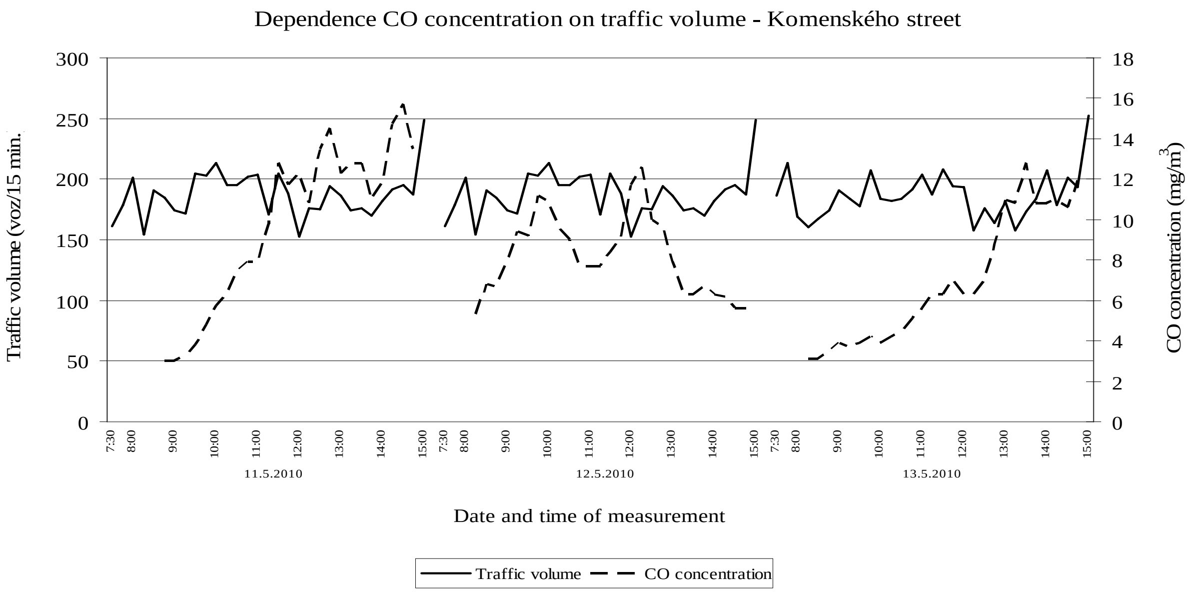
The Aeroqual 520 monitor is designed as a handheld monitor (manually operated device). Regarding its deployment in the real-life environment, it is equipped with an additional cover, which enables the monitoring process in the outer environment. During the process of measuring, several disparities had been uncovered related to the use of the NO_2 sensor. During some days negative concentrations of NO_2 gases were measured (The Streets of Hlinská and Kamenná). There might be several causes for recording the negative values, as the means for monitoring, sensor head design is sensitive to high temperatures, humidity and at the same time an increased presence of hydrocarbons in the external atmosphere.

The working range of temperature for monitoring, sensor head of NO_2 gases is according to the manufacturer the interval of between 0 – 40 °C. During the monitoring the sunny weather prevailed and the measuring monitor was shed in direct sunlight during the afternoon hours. In Kamenna Street, within the perimeter of circa 150 m from the monitoring position there is a service/petrol station selling fuels (a possible source of volatile carbohydrates). This, however, we realized following the termination of monitoring phase. We might have not selected the most convenient position for measurement reading.

Monitoring the concentration of CO gases was performed in the Komenského street. The dependance of CO gases on the rate of traffic shall not clearly be specified, similarly as with the values valid for NO_2 gases. Nevertheless while studying the curves in a detailed manner, it is possible to locate deflections and variations of concentration in relation to the rate of traffic. (See Fig. 9). Specifically these one-off rises in the concentration of CO gases in the afternoon hours, may be caused by a significant increase in the vehicular traffic in a given time. The maximum concentration of CO gases, which was determined by means of using the Aeroqual 520 gas monitor within the duration of three days, achieved the value of 15,7 mg.m^{-3} during the first day of monitoring and reading the values whereas the highest 8-hour mean value reached 9.7 mg.m^{-3}.

The measured values of CO gases have not shown any anomalies, regarding for example negative values, as in the case of monitoring NO_2 gases. The working ranges for temperature and humidity in these cases of sensor head are marginally higher.

Fig. 9: Measured values of CO gases concentration and traffic rate in Komenského Street



2.2 Comparative measurements

In order to monitor the comparative measurements of the outer atmosphere we have used a monitoring station of LMKO – a portable laboratory for monitoring the quality of air, assembled by the Envitech Trenčín company. The monitoring station is equipped with analyzing sensors for measuring specific polluting agents (normative methods), telescopic meteorological mast, control and assessment software and GSM module for the remote transmission of measured data.

Reading the values of nitrogen dioxide was performed by means of a specific method of chemiluminescence, reading the values of carbon monoxide was performed by means of the infrared spectrometry method.

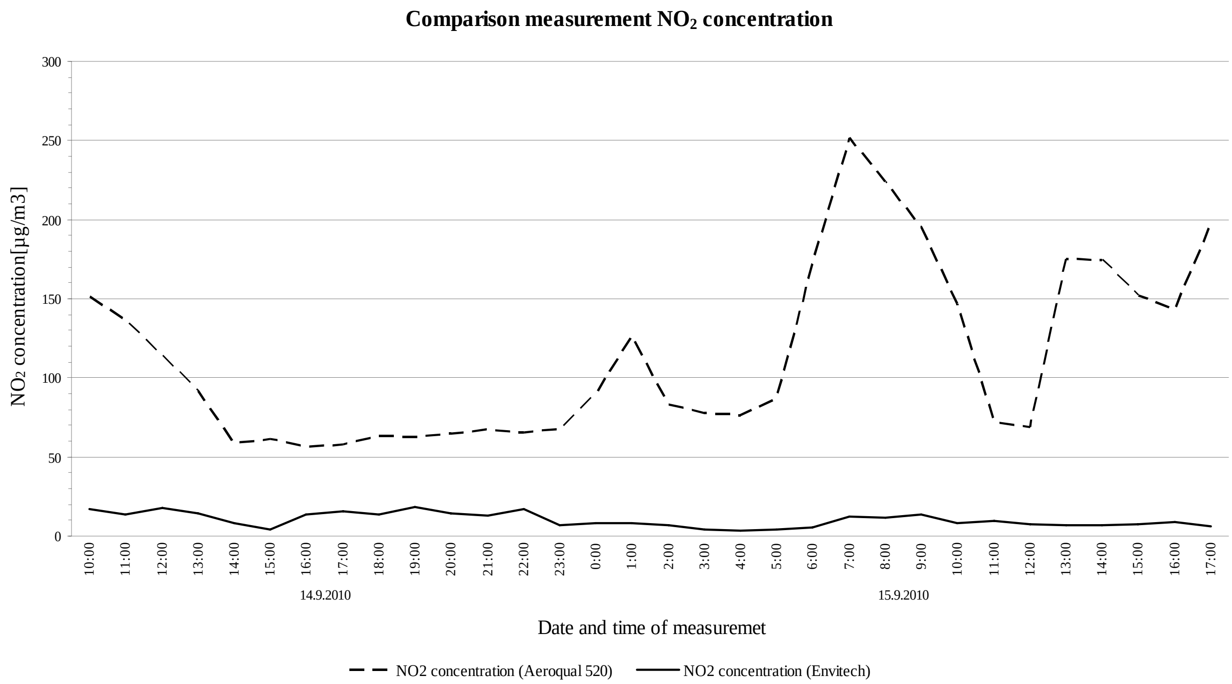
While taking the measurements, we have selected the same interval for taking the records for both the measuring devices /monitors/ - which amounted to 1 minute, in order to be able to read the deviations occurring within the measuring equipment.

Fig. 10: Monitoring Trailer

Despite all our efforts we have not succeeded in adjusting the measurements to a degree so as to be able to speak about comparative, comparable results. The portable monitoring device of Aerogual 520 is extremely sensitive to temperature variations. Following the first measurements and reading it was necessary to perform the alternations on the outer casing, housing of the equipment as the device was overheating and the monitored date were incorrect.

Following the excessive overheating of the device the device stopped responding and the system had to be re-booted.

Obr. 11 Comparison of the data from both the measuring devices



The output data have been partially adapted following the corrections done to the outer casing, protective housing, however despite this the disparity in measured values amounts to a 10 to 20 fold multiple, as can been seen in the graphical diagram taken during the measurements from Považsk7 Chlmec.

The quoted results are to be considered by us as preliminary and we have been pursuing the phase of verification.

3. Discussion regarding the achieved results

There are several models of monitoring devices dedicated to monitoring the quality of outer air and atmosphere as well as many of their adaptations. They use multiple technologies for reading the polluting agents from the outer atmosphere. The Aeroqual 520 monitor functions based on the principle of a semiconductive sensor of oxide type.

The device concerned is a piece of equipment ranked as a portable air monitor and we have been trying to establish and prove, whether it is suitable for use in the outer environment.

The use of device, monitor with the sensor head for NO_2 gases is more sensitive to the outer environment, where less stable temperature is imminent and the relative air humidity for the whole duration of monitoring process. On the contrary, monitoring using the CO sensor head is not that much sensitive to the changes in the weather conditions during the monitoring phase. We have established that it is also the outer protective casing, housing the monitor, which plays an important role, which is aimed at leaving the device for several hours in the area impacted by the traffic on urban roads.

That is why following the initial experience with this portable measuring monitor, device we have reached the following conclusions:

- it can be deployed in the outer environment, but remains more suitable for shorter monitoring operations, reading lasting from between 4 and 6 hours
- is a practical tool for establishing and displaying current status, values
- it would almost certainly find a place for its exploitation in regional medical and health centres as well as institutes
- further stages in the verification process shall be considered as necessary – establishing the effects of temperature, when it is necessary to be cooling the equipment by utilizing a fan inside the protective housing (when that on the contrary deems inconvenient)
- whether it is possible to gain the readings from the outer environment with the accuracy as being stated by the manufacturer, is still to be verified and succumbed to further observations.

Acknowledgement:

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The Traffic Influence on the Air-Quality in Brno

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Abstract

The aim of this work is to study the influence of traffic on air quality in agglomeration Brno with regard to the air quality in the zone Jihomoravský kraj. The air quality data comes from monitoring stations of Czech hydrometeorological institute (CHMI) and also stations owned by the city Brno. There was used both traffic and background stations to find the differences. The evaluation is targeted on pollutants produced by traffic – mainly particulate matters (PM_{10}) and nitrogen oxides. These pollutants also exceed the imission limits in the agglomeration Brno. Various trends of these pollutants are studied together with the meteorological conditions and from the view of the legislative – NV 597/2006 Sb. which set down the imission limits in Czech Republic. Small part of this work is also targeted on the CHMI portal, where the up-to-date information are displayed not only as a graphs or tables, but also as a model map of the Brno agglomeration.

1. Introduction

The environment of the agglomeration Brno is strongly influenced by the traffic, especially in the city centre. For the air pollution from the traffic there was a special traffic stations established near the streets with the highest intensity of traffic. These stations are operating by Czech hydrometeorological institute (CHMI) and the city of Brno. Together with the traffic stations data there are processed also background stations data from Brno and Jihomoravský kraj for background level detection or for better station classification.

2. Experimental

All stations run by Czech hydrometeorological institute come into national network of imission monitoring and is accredited by the norm ČSN EN ISO/IEC 17025:2005. The imission monitoring respects all technical norms for the air quality analysis. The city of Brno is authorized for the air quality monitoring by the Czech ministry of environment.

For the particulate matters analysis uses CHMI gravimetric method as a referential method and in automatic monitoring uses the radiometric method (beta ray). The city of Brno uses for the PM orthogonal nephelometry.

For the nitrogen oxides analysis use both CHMI and city of Brno the chemiluminiscence, which is referential method for nitrogen oxides analysis. CHMI uses also manual sampling of NO_2 and spectrophotometrical (guajakol) method for its laboratory analysis.

3. Results and discussion

First of all the annual average concentration was studied. This concentration has in Czech legislative an imission limit – 40 µg*m^{-3}. This limit was exceeded mainly on traffic stations (T) in previous years. The only exception is Brno – Lány in the year 2003. This station is classified as background (B), but some traffic influence was observed and will be discussed later.

Tab. 1: Annual average concentration of PM_{10}, 2002 - 2009

Annual average concentration of PM_{10} (µg*m^{-3})								
Locality	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Brno-Lány (B)		**42,67**	36,01		39,67			25,62
Brno-Svatoplukova (T)	**56,60**	**43,65**		**49,97**	39,69		**40,22**	**40,92**
Brno-střed (T)		**49,39**		**47,90**	**45,01**	35,16	34,41	35,88
Brno - Úvoz (T)							**44,00**	30,18
Brno-Tuřany (B)	34,20	39,47	31,39	33,39	36,15	27,83	25,93	27,53
Brno-Líšeň (B)								24,04
Mikulov-Sedlec (B)	26,68	30,71	24,70	28,51	28,02	22,03	20,98	23,24
Vyškov (B)				28,15	30,05	24,81	19,12	22,00
Znojmo (B)			34,44	37,49	35,74	25,52	25,82	26,48

The worst stations are Brno - Svatoplukova and Brno – Úvoz (hot-spot) which are situated only few meters from bustling street. On the other hand till the year 2008 the station Znojmo was also classified as a traffic station, but both PM_{10} and nitrogen oxides (see later) shows, that this station should be re-classified to background. The annual average concentration of station Znojmo and Brno – Tuřany (B) are nearly the same.

The second PM_{10} imission limit is for 24 hours average concentration and its value is 50 µg*m^{-3}. This value could be 35 times per year exceeded (90th percentile). Therefore the 36th highest 24 hours average concentration is analyzed.

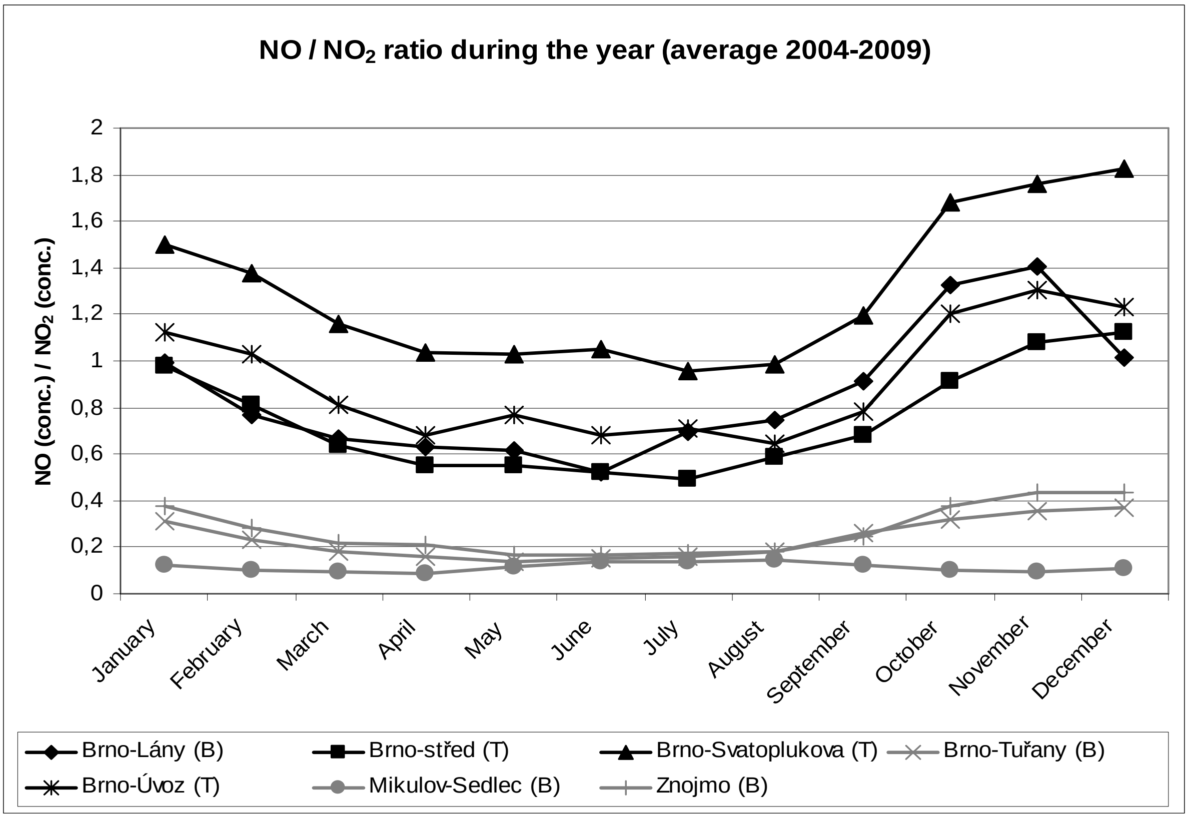
Tab. 2: 36th highest 24 hours average concentration of PM_{10}, 2002 - 2009

36th highest 24 hours average concentration of PM_{10} (µg*m^{-3})								
Locality	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Brno-Lány (B)	48,56	**63,25**	**54,87**		**57,55**			45,26
Brno-Svatoplukova (T)							**66,43**	**68,40**
Brno-střed (T)		**84,74**		**84,67**	**71,29**	**59,17**	**55,29**	**58,08**
Brno - Úvoz (T)							**71,00**	50,00
Brno-Tuřany (B)	**55,59**	**62,57**	**55,42**	**61,58**	**63,13**	**51,25**	44,88	47,21
Mikulov-Sedlec (B)	42,61	51,77	42,79	**53,29**	**51,08**	40,29	37,63	38,67
Vyškov (B)				**51,00**	**51,00**	43,00	37,00	37,00
Znojmo (B)			**59,62**	**70,75**	**66,92**	47,08	46,08	46,17

In this case is not the distribution for traffic and background stations so clear, because the meteorological conditions play important role too. In the winter 2005 / 2006 there was very bad dispersion conditions, there was many days with the temperature inversion a very low temperatures and nearly all stations in the Southern Moravia region exceeded the 24hour imission limit for PM_{10}. On the other hand last three years were fair winters, so only traffic stations exceed the limit. Also in this case are Znojmo and Brno – Tuřany concentration similar, so the reclassification was proper procedure.

Also in case of the nitrogen oxides are quite big differences between the traffic and the background stations. It is best visible in NO / NO_2 ratio, where the background station ratio is low (lower NO concentrations) and traffic station ratio is high (higher NO concentrations).

Pic. 1: NO / NO_2 ratio during the year (average 2004-2009)



It is clear from Pic. 1, that the reclassification of the station Znojmo was right, because the ratio is similar to other background stations (Brno - Tuřany and Mikulov - Sedlec). On the other hand the background station Brno – Lány ratio is similar to traffic station like Brno – střed or Brno – Úvoz (hot – spot), although it lays in the settlement. The D1 highway (distance 400 m from the station) influences this area quite a lot.

Even in the NO / NO_2 ratio is visible the annual trend – in winter season is the ratio highest, in summer lowest. This could correspond with the reaction conditions of NO to NO_2 oxidation – temperature is lower, so the reaction rate is slower and also the solar radiation is lower, so the photochemical reactions don't run in the range as in the summer. Therefore the higher amount of NO stays in the atmosphere and is measured by sensitive machines in monitoring stations.

The NO_2 concentration has an imission limit for the annual average concentration (40 $\mu g*m^{-3}$) and for the 1h concentration (200 $\mu g*m^{-3}$, could be 18 times per year exceeded – 95 percentile).

Tab. 3: Annual average concentration of NO_2, 2002 - 2009

Annual average concentration of NO_2 (µg*m^{-3})								
Locality	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Brno-Lány (B)	28,81	32,83	32,05	33,44	33,92			27,57
Brno-Svatoplukova (T)	**43,43**	**41,17**	**43,38**	**49,30**	**54,71**	**47,29**	**47,05**	**42,75**
Brno-střed (T)	**44,56**	**46,69**		**46,12**	**47,51**	**42,35**	**40,90**	**43,51**
Brno - Úvoz (T)							**48,27**	**51,01**
Brno-Tuřany (B)	20,40	23,07	20,22	21,85	23,62	20,54	19,97	19,38
Mikulov-Sedlec (B)	12,19	12,77	11,02	12,26	12,90	10,77	10,77	11,29
Vyškov (B)			19,06	22,78	22,38	20,89	15,66	15,77
Znojmo (B)			17,84	18,99	19,17	16,66	17,32	17,04

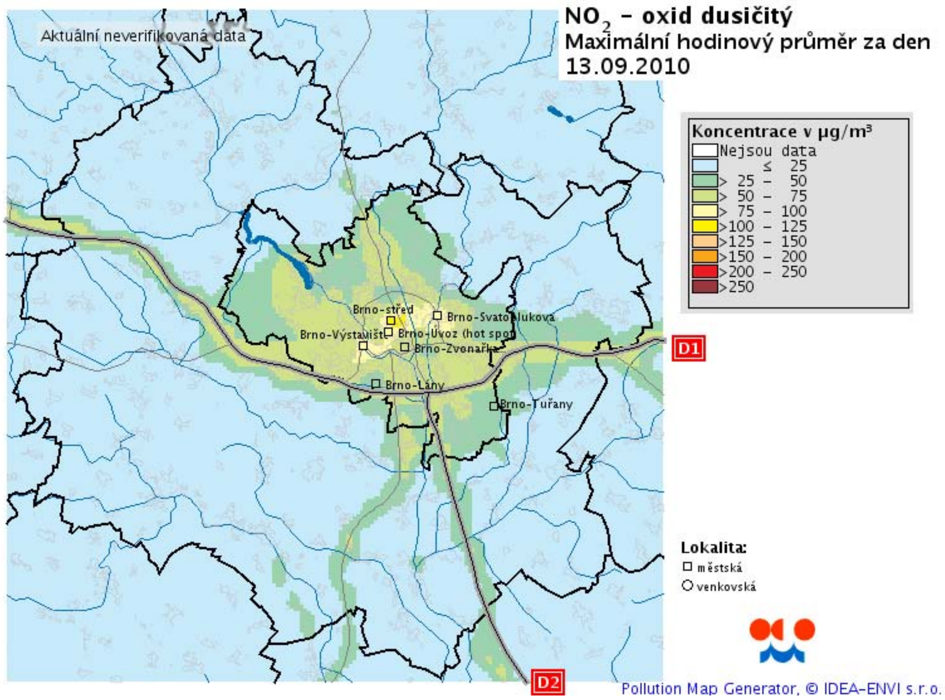
It is clear from the Tab. 3, that the annual imission limit for NO_2 is only exceeded on the traffic station. The background station Brno – Lány measures higher concentrations than the other background stations and in the years 2003 – 2006 exceed the upper assessment threshold. All other stations measures always under the lower assessment threshold.

The 1 hour imission limit is not exceeded on these stations in the years 2002 – 2009.

4. Actual information about air quality

The actual data about the air quality are published mainly on the CHMI portal http://portal.chmi.cz/. There are actual 1 hour data for whole republic expressed as an air quality index (map), but there are also the operative data from automatic monitoring network in tables and graphs. There are also last 5 days models of various pollutants in map for whole Czech Republic or for single region like Brno agglomeration.

Pic. 2: The model of the NO_2 maximal 1h concentration in a day



Except the actual data there are also tabular and graphical almanacs, where the air quality in previous years is documented.

5. Conclusion

The air quality of the agglomeration Brno is strongly influenced by the traffic, especially in the city centre, where several monitoring stations measure the highest concentrations in whole Southern Moravia region. The annual average concentration of PM_{10} and NO_2 exceed their imission limits only on the traffic stations in this region. On the other hand the background station never exceed these limits in last 8 years with one exception, where is the background station also influenced by traffic pollution from the D1 highway located 400 m faraway.

In the case of the 24 hours imission limit for PM_{10} is not the distribution for traffic and background stations so clear, because the meteorological conditions play important role too. In the years with bad dispersion conditions (in winter seasons) may also background station exceed the 24 hours imission limit, but the traffic stations exceed it even when the conditions are fair.

Because of the high traffic influence on the air quality in Brno agglomeration, the actual information is very important not only for researchers or officers, but also for citizens of Brno. This information is available on the http://portal.chmi.cz/.

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Transportation, Air Pollution and Physical Activities – An Integrated Health Risk Assessment

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Abstract

The aim of the paper is to introduce the reader to the international project "Transportation, Air Pollution, and Physical Activities: an integrated health risk assessment programme of climate change and urban policies (TAPAS)" and to compare characteristics of the case study areas analyzed under the project. The purpose of the TAPAS is to help decision makers design urban policies through assessing and quantifying impacts of these policies on health and climate change. Under the project, a concept of integrated health risk assessment will be used and a quantitative model, which will be calibrated on data of the six case study areas (Barcelona, Paris, Basel, Copenhagen, Warsaw, and Prague), will be developed.

1. Introduction

Various means of transport have different positive and negative impacts on the economy, public health and the environment. That is why it is useful to analyse possibilities of transport policy tools to influence transport behaviour and the modal split, and, consequently, its impacts on human health and climate change.

A wide range of economic tools to regulate the structure and output of transport are designed to support so-called ´active transport modes´ - walking and cycling – especially in cities, where a significant portion of trips is made across short distances[1]. The importance of active transport modes has been rising together with the increase in motor traffic and its adverse impacts on heath, accidents and climate change. Walking and cycling consume no oil, cause no air pollution, reduce risks of serious accidents and thanks to regular physical exercise, which is a prevention of obesity and a range of cardiovascular and respiratory illnesses and high morbidity rates, they improve human health. Possible injuries do not represent arguments against cycling. For evidence, see for example a summary of recent studies on the linkage among cycling and human health written by Pucher et al. [1]. The recent epidemiological studies indicate that the health benefits of bicycling far exceed the health risks from traffic injuries. Moreover, as bicycling levels increase, injury rates fall, making bicycling safer and providing even larger net health benefits [1].

The aim of the paper is to introduce the reader to the international project "Transportation, Air Pollution, and Physical Activities: an integrated health risk assessment programme of climate change and urban policies (TAPAS)" and to compare the case study areas analyzed under the project. The emphasis of the project is on active transport and policies supporting these travel modes. In the paper, I describe shortly the design of the TAPAS project, namely the main research problems, methodology and the case study urban areas. I focus on the state of the

[1] More than 50% of trips made by car is shorter than 5 km and more than 30% of these trips is shorter than 3 km [15].

art of cycling and walking in the TAPAS case study cities, especially on policies supporting active transport which have recently been implemented in these cities. I conclude with further research plans.

2. Design of the TAPAS project

The purpose of the TAPAS is to help decision makers design urban policies through assessing and quantifying impacts of these policies on health and climate change. Air pollution in urban areas is thought to be one of the most serious problems caused by traffic in cities including the Czech Republic and other Central European transition countries (see e.g. [2]). High concentrations of harmful air pollutants are considered one of the most important microenvironments for air pollution exposure [3]. According to growing evidence from epidemiological studies, even short-term increases of exposures during travel have a potential for cardiovascular ([4]; [5]) and respiratory ([6]; [7]) health impacts.

Other health problems associated with transport that will be taken into account by the TAPAS project are traffic noise and traffic accidents. A complex risk assessment methodology will be further used to analyze changes in the quality of life, as the rate of active transport directly influences the number of social interactions and, indirectly, crime rates as well.

The TAPAS consortium consists of six research institutions in Spain, France, Switzerland, Denmark, Poland, and the Czech Republic. The coordinator is CREAL in Barcelona, a joint initiative of the IMIM-IMAS, the University Pompeu Fabra (UPF) and the Government of Catalonia, specialized in the environmental epidemiological research agenda.

2.1. TAPAS methodology

To assess impacts of various urban policies supporting walking and cycling on human health and climate change, an integrated health risk assessment will be used. First, potential benefits and associated risks of analyzed policies will be identified. Then, a more specific computational model that addresses interactively travel behaviour and selected health and environmental impacts will be built. After that, a list of transportation policy scenarios will be made. The following inter-related components will be assessed under the computational analysis [8]:

(i) analysis of determinants of individual travel behaviour as a function of non-motorized transport policies and other contextual and personal factors;

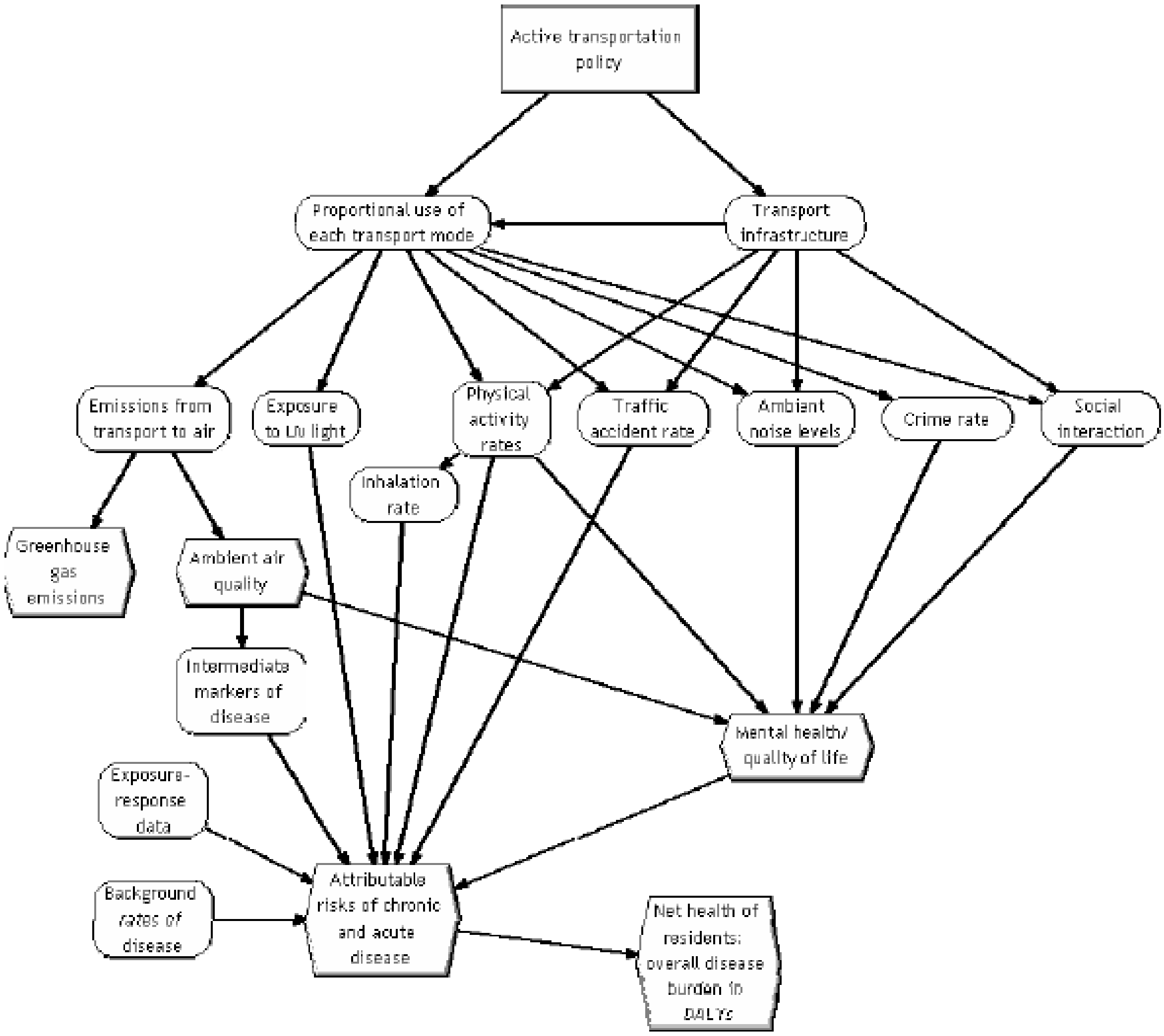
(ii) prediction of key environmental quality indicators (including greenhouse gas emissions and ambient air quality) resulting from these behaviours;

(iii) analysis of the links between these indicators of environmental quality, rates of physical activity and resulting uptake of air pollutants, traffic or other hazards; and

(iv) estimation of the net health of residents (integrating both health benefits and risks associated with the policy interventions).

The figure below shows the linkages among the main factors analyzed in the TAPAS project.

Fig. 1: Conceptual model of linkages proposed under the TAPAS project



Source: CREAL, 2008

We will parameterize and test the linkages in the resulting models in local case studies of both large and smaller European cities.

2.2. Policies to increase active transport in the case study areas

The TAPAS case studies will take place in the following European urban areas: Barcelona, Paris, Basel, Copenhagen, Warsaw, and Prague. These cities differ in many characteristics. This diversity should illustrate the influence of different factors like geography, demography, transport policies, etc., on the share of non-motorized transport.

The following text describes and compares the case study cities. The analysis is based on data obtained from the project partners and on city-level data from the Urban Audit [9]. The Urban Audit is a joint effort by the Directorate-General for Regional Policy (DG REGIO) and Eurostat to provide reliable and comparative information on selected urban areas in EU Member States and Candidate Countries. It includes 258 cities in 28 European countries. The database includes data on demography (population, nationality, household structure), social aspects (housing, health, crime), economic aspects (labour market, economic activity, income disparities and poverty), civic involvement (civic involvement, local administration), training and education (education and training provision, educational qualifications), environment (climate, air quality and noise, water, waste management, land use and energy use), travel and transport (travel patterns), information society (users and infrastructure, local e-Government, ICT sector), and culture and recreation (culture and recreation and tourism) [10].

Basel and Copenhagen are the cities in our case study sample that support active transport the most. Traditionally non-cycling cities like Barcelona and Paris are included as well. These two cities, however, have started supporting cycling substantially in the recent years. Besides building cycling infrastructure (cycling paths, lanes, etc.), bicycle sharing projects became the main drivers of cycling increase in Barcelona and Paris.

The idea of bike sharing is simple: to identify enough pick-up stations near the most attractive points in the city (including subway stations, railway stations, public offices and commercial districts) to give commuters different options to travel to and from work. Among the main European cities, apart from Dutch and Danish cities, Paris, Milan, Munich, Berlin, Seville, Lyon, Strasbourg, Brussels and Barcelona have started running some kind of bicycle sharing [11]. Unfortunately, the Prague bicycle sharing system in Karlin operated by Homeport does not seem to be as successful as those in Paris or Barcelona. According to the Homeport website, there were 30 bikes available in 2009, but the bike sharing system has been facing a big problem of vandalism and theft.

In Paris, the share of cycling has been rising since the beginning of this century. This trend seems to be directly connected with the cycling infrastructure improvement. The bike lane network more than tripled from 122 km in 1998 to 399 km in 2007. Bicycle parking on sidewalks tripled from 2,200 racks in 2000 to 6,500 in 2007. Consequently, in only six years, the share of bicycles in trips within the City of Paris more than doubled from 1% in 2001 to 2.5% in 2007 [1]. A 46% increase in bicycle trips from June to October 2007 occurred after the introduction of Velib' bicycle sharing program. Velib' started in 2007, and it soon became the world's largest bicycle sharing program. In 2009, it provided over 20,000 short-term rental bikes [1]. What is important to emphasise is that not only promoting cycling has helped to such a success in Paris – at the same time, the city has been eliminating free car parking throughout Paris [1].

Barcelona represents another success story: the share of bicycle trips more than doubled in only two years. Precisely, it was from 0.75% of trips in 2005 to 1.76% in 2007 [1]. This increase was initiated by expanding the bike lane network from less than 10 km in 1990 to 155 km in 2008. At the same time, bike parking places increased throughout city: 13,000 additional racks in 2007 and 2008, a total of 20,392 in 2008. ´Bicing´ bicycle sharing program was introduced in 2005, and had expanded to 6,000 short-term rental bikes by 2008. There are over 400 bike rental stations [1].

Another TAPAS city, Copenhagen, belongs to the best-known examples of cycling support in the world. Its success can be illustrated by the following figures. The share of bicycles in the modal split increased from 25% of trips in 1998 to 38% in 2005 for people older than 40 years. A 70% increase in total bicycle trips occurred during 1970–2006. Since the 1970s, fully separate bike paths and cycle tracks protected by curbs from motor vehicle traffic (345 km by 2004) plus 14 km of unprotected bicycle lanes were built [1]. Special intersection modifications were constructed, above all advance stop lines and bike boxes, bicycle access lanes, priority traffic signals for cyclists, bright blue marking of bike lanes crossing intersections, green wave for cyclists, with traffic signals timed to cyclist speeds. During 1995–2006, a 60% decline in serious injuries followed. Guarded parking facilities increased from one in 1982 to 30 in 2006; 15 schools had guarded bike parking. Today, there are over 20,000 bike parking spaces [1]. In 1995, Copenhagen was the first city to introduce a modern bike share system – “Bycyklen” or The City Bike. It is a pioneer city bike program, which places 2,000 free bikes at 110 locations throughout the city, while only small deposit is required.

Economic tools belong among other groups of transportation policies positively influencing health and climate change. As was shown by Brůhová-Foltýnová and Brůha [12] in their econometric estimation using Urban Audit data, a strong statistical association between the motor fuel price and the modal split exists. This statistical association indicates that – fixing investigated city characteristics – countries with a higher fuel price tend to have a lower share of the car in journeys to work. Other pro-bicycle policies – such as expansion of the bikeway system and bike parking, bicycling education, traffic calming, and congestion charging – are discussed by [1], [13] and [14].

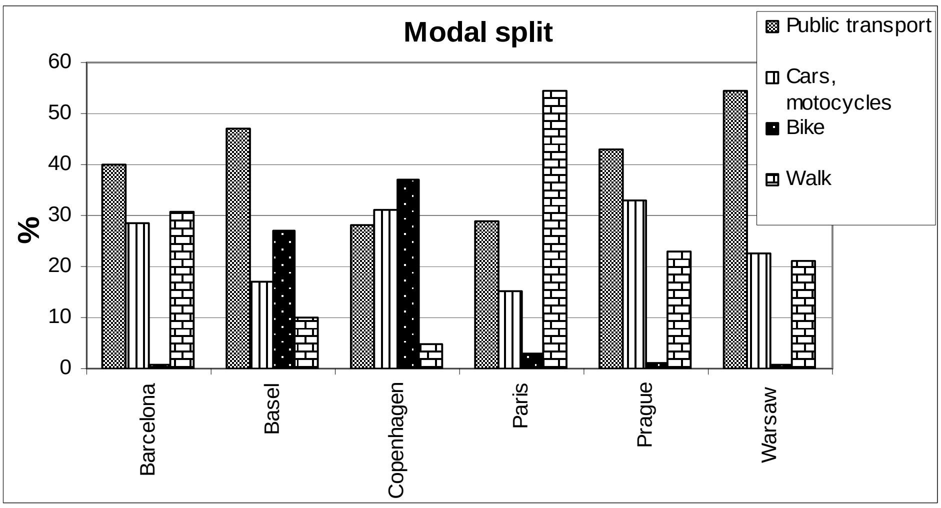
2.3. Analysis of factors influencing modal split in the case study areas

Regarding the modal split, the share of cycling in the whole modal split measured using the share of daily trips varies from 37% in Copenhagen and 27% in Basel to less than 1% in Barcelona, Prague and Warsaw. The share of bicycling in modal split correlates negatively with the rate of “automobilisation” (the amount of inhabitants per car). In Copenhagen, there are 16 inhabitants per car, compared to 2.1 and 2.3 in Prague and Warsaw, respectively.

On the contrary, the highest share of walking in the modal split (measured as the share of daily trips) is nearly 55% in Paris, and 31% in Barcelona, but only 5% in Copenhagen and 10% in Basel. Looking at both the modes of active transport cumulatively, the highest share was measured in Paris – nearly 58%, followed by Copenhagen (42%) and Basel (37%). The lowest share was observed in Prague (only 24%).

The share of individual motorized transport – cars and motorcycles – measured as the share of trips per day is the highest in Prague (33%) and the lowest in Paris (only 15%). The following graph compares the modal splits of the case study areas.

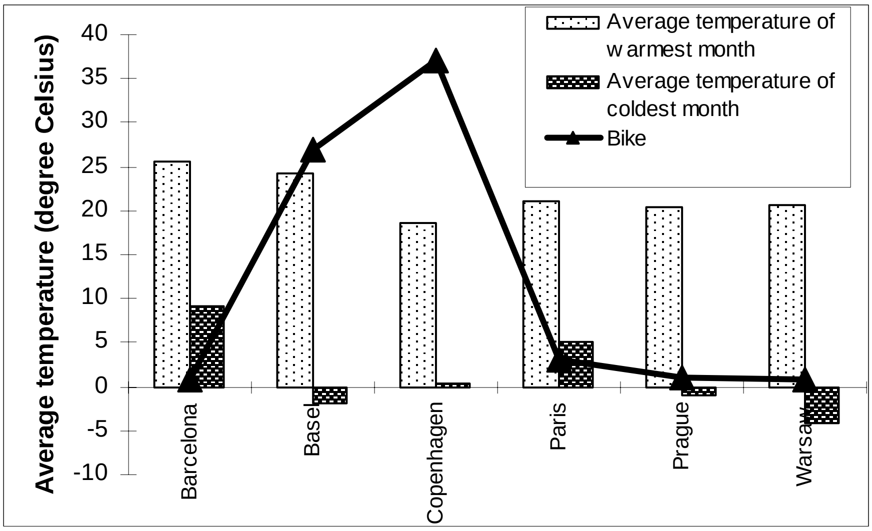
Graph 1: Comparison of modal split in the case study urban areas



Source: TAPAS members

It is often expressed by local politicians that the share of cycling is negatively influenced by the climate. As is illustrated in Graph 2, our case study cities show the opposite – the highest share of cycling occurs in colder cities. The average highest temperature in the hottest month in Basel is 24.2°C and the lowest temperature in the coldest months falls to -1.0°C, but the cycling share is 27%. Similarly, Copenhagen has an average highest temperature of 18.5°C and lowest temperature of 0.3°C, and the share of bicycling in modal split rises to 37%. On the contrary, hot Barcelona (25.6°C and 9.2°C, respectively) sees only 0.7% of cycling in its modal split.

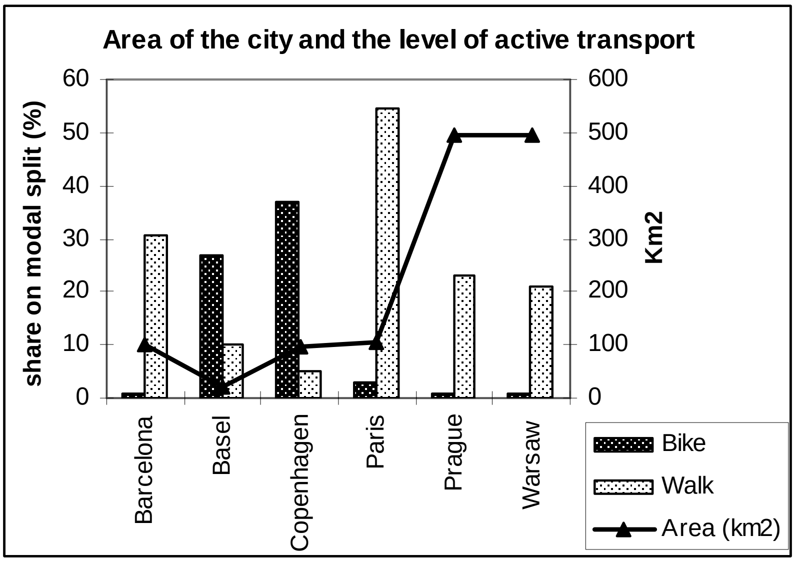
Graph 2: Comparison of the share of cycling and average temperatures



Source: TAPAS members

The areal extent of the city is another main geographical indicator. The data indicate that the size of the city may influence its modal split. In smaller urban areas in our sample, there is a higher share of cycling, while in larger cities a higher share of walking (see Graph 3).

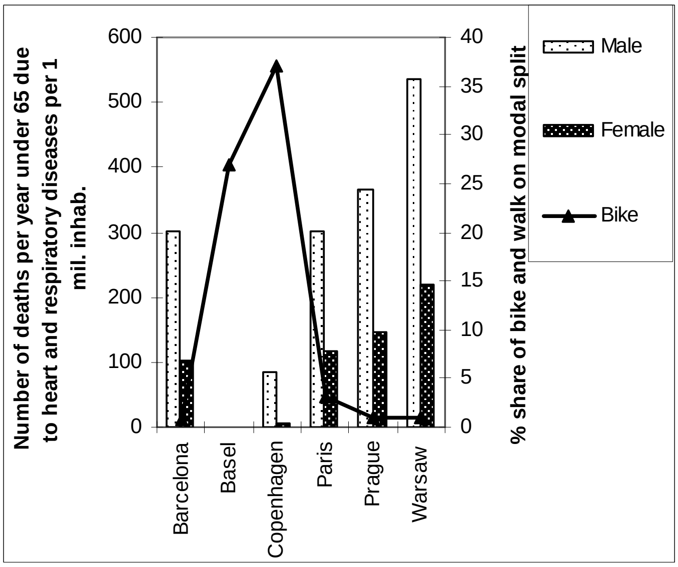
Graph 3: The areal extent of the case study cities and the level of cycling and walking



Source: Urban Audit and TAPAS partners

The next indicator reflects the public health. Looking at Graph 4, showing the rate of deaths under 65 per year due to heart diseases and respiratory illnesses per 1 million inhabitants, it seems that the highest rates of early deaths can be found in the cities in new EU member states (Prague and Warsaw). The rates for females are substantially lower than those for males. Surprisingly, the correlation with the cycling share in the modal split is positive, while there is no correlation when we take into account the share of active modes (walking and cycling) together.

Graph 4: The rate of deaths under 65 per year due to heart diseases and respiratory illnesses and the share of walking and cycling and walking in modal split



Source: Urban Audit and TAPAS partners

Note: Comparable data on the death rate for Basel are not available.

3. Conclusion and further research

The aim of the paper is to introduce the reader to the international project “Transportation, Air Pollution, and Physical Activities: an integrated health risk assessment programme of climate change and urban policies (TAPAS)” and to compare the case study areas analyzed under the project. According to the analyzed indicators (modal split, the numbers of deaths due to respiratory and cardiovascular diseases, temperature, area and population), Prague and Warsaw show a lower share of cycling in their modal split, and on the contrary a higher share of cars. These two cities also demonstrate worse death rate indicators in comparison with the other TAPAS cities. The most “cycling cities” in our sample are Copenhagen and Basel.

No direct relation between climate and geography indicators and the share of cycling in the modal was clearly proved. It seems that the main factor of cycling support should be transportation policies. Taking this into account, the importance of a proper choice of policy scenarios under the TAPAS project rises.

Our future research could show us the contribution of various policy tools towards the improvement in health and in lowering contributions of transport to climate change. However, implementation of policies supporting active transport may not necessarily bring the greatest benefits to the cities with the worst indicators such as Prague and Warsaw, as could be expected.

Acknowledgement

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Potentialities of Application of LCA in Personal Transport

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Abstract

The aim of this contribution is to geve an overview about possible application of Life Cycle Assessment method in comparison of possible environmental impacts of various traffic scenarios. As an example demonstration of application of LCA on personal transport from Kladno town to Prague City is shown. The example study of selected commuter routes between two cities was performed. Use of several routes and various vehicles was taken into account – personal car, bus, train, metro, tram and their combinations. The potential of LCA in the field of passenger transport was discussed on the basis of the study.

1. Traffic systems and Life Cycle Assessment - LCA

Transport is one of important sources of environmental pollution. Sustainable transport systems are needed. As different transport scenarios can have different environmental impacts it is not easy to compare them and select that one having lowest environmental impacts. Such a tool with potential to compare different environmental impact related to product/servise is a method Life Cycle Assessment – LCA. In the field of transport systems LCA can offer following:

a) Comparison of environmental impacts of different fuel use (for example biofuels).
b) Comparison of environmental impacts of whole life cycles of transport means – cars, motorbikes etc (for example one car VW Passat).
c) Comparison of different waste management systems of used transport means (recyclation or reuse of car wrecks).
d) Comparison of environmental impacts of different transport scenarios.

2. Principle of LCA

Life Cycle Assessment (LCA) is one of the most often used methodologies for giving complex assessments about the environmental impacts of human activities. LCA is a method which enables complex reviews of impacts upon the environment which have been caused by certain products or services. It is considered one of the most promising tools for implementing sustainable development. It's advantage lies in the available list of ISO specifications (14040) in their full details [1, 2], which offer usable procedures for LCA. This ensures a good interpretation, the possibility of reproducibility, and especially the comparability of the results. The LCA methodology is recognized as one of the basic analytical tools for sustainability. Above all, LCA evaluates the environmental impacts. In its upgrade into the economical sphere (LCC - Life Cycle Costing) it also allows comparisons of the environmental costs and benefits.

LCA is a methodology being used on an international level, and has been promoted by UNEP, as well [3]. LCA represents one of the priority sustainability methods used within the European Commission. There has also been created a reference LCA database for comparative purposes. Even though the method is somewhat less known in the Czech Republic, it is in common use in other countries. The new waste policy of the European Union (proposals for newly amended specifications for wastes from 12/21/2005; giving a thematic strategy for the prevention of waste creation, and its recycling) promotes further possible use of Life Cycle in waste management.

The method is based upon identifying flow streams, in and out of the system being evaluated, of both materials and energy. It monitors their quantity, content, character, and relevance to the environmental quality. From those streams, the causes and consequences become clear; from which the resultant changes to the environment can be evaluated. The basic data is processed through inventory analysis. Beforehand, a selected portion of the Life Cycle of the system being evaluated is separated into individual processes; and the streams in between are monitored. Emphasis is also placed upon those streams coming out of the system being evaluated. Their sizes are determined from measurements, calculations, or from the literature. Each system should be judged in its entirety. When LCA is being used in combination with other procedures, it enables the embodiment of environmental demands into a cohesive final decision.

LCA method is mostly used as [4]:

a) A supportive and/or justification tool for certain decisions (it can be also be used within the area of municipal waste management);
b) A tool for collecting information;
c) A tool for communication to the public; and as
d) A pedagogical tool.

LCA methodology can be used to support various kinds of decisions, *e.g.* on national levels (Ministry of the Environment), as well as on regional levels (counties, towns, villages, groupings of towns and villages, private investors). Regarding the possibilities of applying LCA as a tool for information collection (usually related to the data collection within the inventory portion of LCA), this actually represents the most important part; influencing the entire outcome. The next step is represented by the Life Cycle impact evaluation. The inventory outcomes are precisely described, with specified procedures of how to express interventions upon the evaluated system to the environment, through the usage of indicators; the so-called impact categories. Outcomes from this impact evaluation further enables impact identification of the surveyed scenarios, for example: Global Warming, Eutrophication, Acidification, and further impact categories, as defined by the chosen methodology.

3. Example of case study

From Kladno town 6839 persons travel daily to Prague City [5]. These persons use following transport means: car, bus, train, metro, tram and their combinations. We have modeled this route as several different transport scenarios with different level of occupation of every transport means. As in future a central transfer point will be selected from two possibilities (Dědina, Velesalvín), we used both these transfer points as possible scenarios. The case study is in detail published in this source [6].

3.1 Short characteristics of LCA study

Chosen function: personal transport form Kladno to Prague – Dejvice. In the study only use phase of transport means was considered. The fuel and electric power production was accounted.

Functional unit: transport of 10 000 persons from Kladno to Prague - Dejvice during one day.

Reference flow is a number of products, in this case person*km, needed to fulfill functional unit.

In following tables distances of transport means at route Kladno – Prague (Dejvice) are summarized.

Tab.1: Transport distances of personal cars and buses.

	city, km	Outside city, km	highway, km	total, km
Kladno-Dejvická	9	6,7	9	24,7
Kladno- Veleslavín	5,7	6,7	9	21,4
Kladno-Dědina	2	6,7	9	17,7

Tab.2: Transport distances of train, tram and metro.

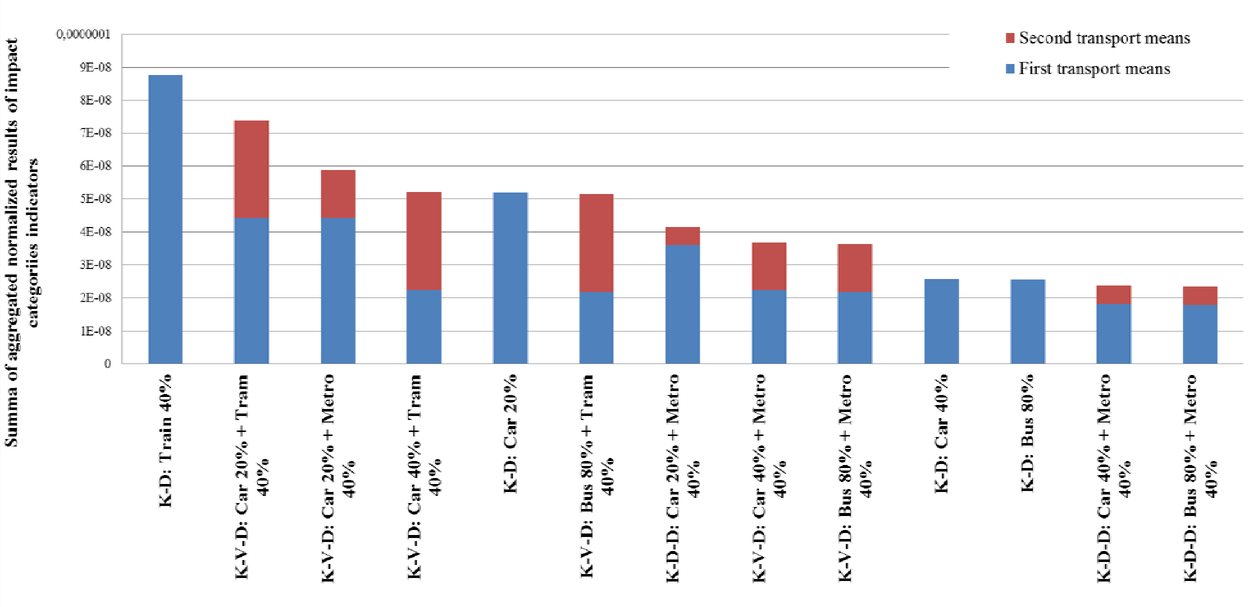
	train, km	metro, km	tram, km
Kladno-Dejvická	28		
Kladno- Veleslavín		3,3	3,3
Kladno-Dědina		9,6	

Following realistic scenarios for LCA calculation were considered:

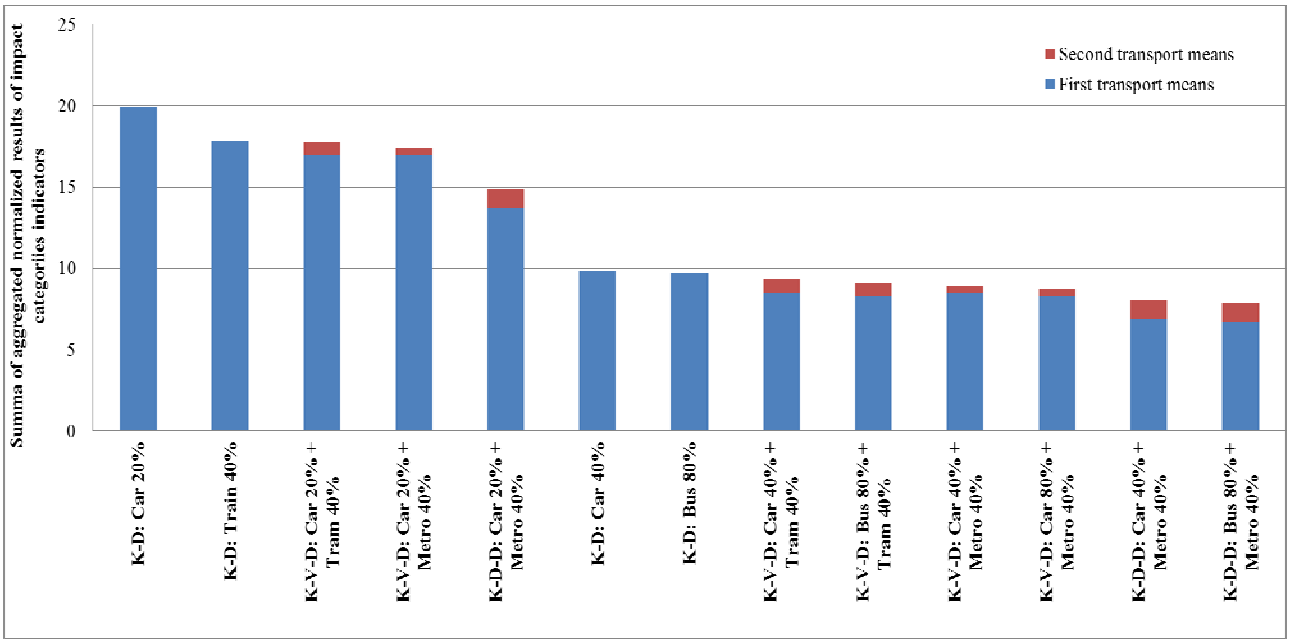
- Kladno-Dědina bus 80 % (56 pers.), Dědina-Dejvická metro 40 % (576 pers.);
- Kladno-Dědina car 20 % (1 pers.), Dědina-Dejvická metro 40 % (576 pers.);
- Kladno-Dědina car 40 % (2 pers.), Dědina-Dejvická metro 40 % (576 pers.);
- Kladno-Veleslavín autobus 80 % (56 pers.), Veleslavín-Dejvická metro 40 % (576 pers.);
- Kladno-Veleslavín autobus 80 % (56 pers.), Veleslavín-Dejvická tram 40 % (88 pers.);
- Kladno-Veleslavín car 20 % (1 pers.), Veleslavín-Dejvická metro 40 % (576 pers.);
- Kladno-Veleslavín car 20 % (1 pers.),Veleslavín- Dejvická tram 40 % (88 pers.);
- Kladno-Veleslavín car 40 % (2 pers.), Veleslavín-Dejvická metro 40 % (576 pers.);
- Kladno-Veleslavín car 40 % (2 pers.),Veleslavín- Dejvická tram 40 % (88 pers.);
- Kladno-Dejvická bus 80 % (56 pers.);
- Kladno-Dejvická car 20 % (1 pers.);
- Kladno-Dejvická car 40 % (2 pers.);
- Kladno-Dejvická train 20 % (130 pers.).

The results of LCIA are presented using following abbreviations: K-D-D (Kladno-Dědina-Dejvická), K-V-D (Kladno-Veleslavín-Dejvická) and K-D (Kladno-Dejvická). In following graphs environmental impacts of transport scenarios are presented. Becouse of extensive number of obtained data and results, here the aggregated normalized results of impact category indicators are shown.

Graph 1: Comparison of normalized impact category results based on CML 2001 of realistic transport scenarios. All data are related to reference flow. Normalization is based on CML2001 for EU 25+3.



Graph 2. Comparison of normalized impact category results based on Ecoindicator 99 of realistic transport scenarios. All data are related to reference flow. Normalization is based on Ecoindicator HA.



A highest contribution to overall normalized results of indicators of impact categories represents acidification. This impact category has the same major influence both in CML2001 and Ecoindicator 99 methodologies of LCIA.

4. Conclusion

Holistic approach is needed in order to understand and minimize the environmental load of passenger transport. Life Cycle Assessment (LCA) is one of the methods which can be used for environmental impact analysis of passenger transport. LCA represents a modern analytical method used for environmental assessment of products, services and technologies. The focus of the method is on characterization of multi-level environmental impact categories and definition of relations between them. The method then allows comparison of different impact categories.

The commuter routes and the combination of the vehicles with the lowest and the highest potential environmental effects were identified in the study. A combination of bus commuting and metro or tram commuting was identified as an option with the lowest environmental effects. A single person commuting in a car or in a train was identified as options with the highest environmental effects. These results were discussed in order to find out whether the method is applicable, or not.

Finally, it was concluded that the method is useful for analyzing the environmental effects of passenger transport. However, several weak points were identified. In further research, greater attention should be paid on data quality, system boundary, choice of characterization and normalization model and sensitivity analysis.

Ackowledgement

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Evaluation of the Life Cycle of the Standard Car Tyre by LCA Method

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Abstract

Assessment of the life cycle (LCA – Life Cycle Assessment) of a product, service or technology is one of the most important tools of environmental policy. This method is assumed to be a perspective voluntary instrument for implementation of sustainable development and allows us to assess both the demand for energy and raw materials, as well as the impacts on human life and on the life of ecosystems in the representative phases of product existence.

The main objective of the article is presentation of the LCA method application on the standard car tyre focused on the impacts of the whole life cycle of tyre, individual phases in life cycle and comparison of different methods of treatment with used waste car tyres (cement works, pyrolysis, recycling). The results were evaluating by elementary flows and impact assessment. Dominative phase in the life cycle of car tyre is extraction of raw materials, the technologies for waste car tyre treatment are comparable in environemntal impacts. The software GaBi 4 Professional and methodology CML 2001 for impact assessment were used.

1. Introduction

Presently a car tyre is part of our everyday life. The quantity of tyres that are produced and put into operation every year grows up with the development of transport and motoring. In this connection the quantity of waste is increasing – amount of the used waste car tyres. According to the Reports for Return of Certain Products being prepared for the Ministry of the Environment of the Czech Republic, the annual production of tyres introduced to the market exceeds 70 thousand tons of new tyres; however, according to producers of tyres, this quantity is significantly higher, estimated by producers at 100 – 120 thousand tons [Spur, 2006].

The life cycle is a concept including all cycles of product life or of the particular service. The LCA method enables to look into their life cycle and to find out weak points with negative impacts on the environment. Afterwards, the negative impacts found out in this way can be precisely identified and can be possibly avoided or mitigated. The comparative analyses can define precisely, which analysed product (or service, technology) is better in comparison with other products in relation to the impact on the environment. The method depends significantly on the accuracy and completeness of primary and actual data obtained for the study. If data are incomplete or inexact, the results can be inaccurate and incorrect conclusions can be interpreted on the basis of these results [Fava, 1991; Koci, 2009].

2. Experimental procedures

2.1. Methodology and software

LCA methodology was used in order to identify elementary flows and environmental impacts for whole life cycle of the car tyre with special focus on waste car tyre management. This study was based on the ISO 14040 regulations (ISO, 2006) that describe the four basic steps of the assessment procedure: goal and scope definition, life cycle inventory (LCI), life cycle impact assessment (LCIA) and life cycle interpretation [Guinée et al., 2002]. The software GaBi 4 Professional and the CML 2001 characterization model were used for life cycle impact assessment of a standard car tyre [Dreyer et al., 2003].

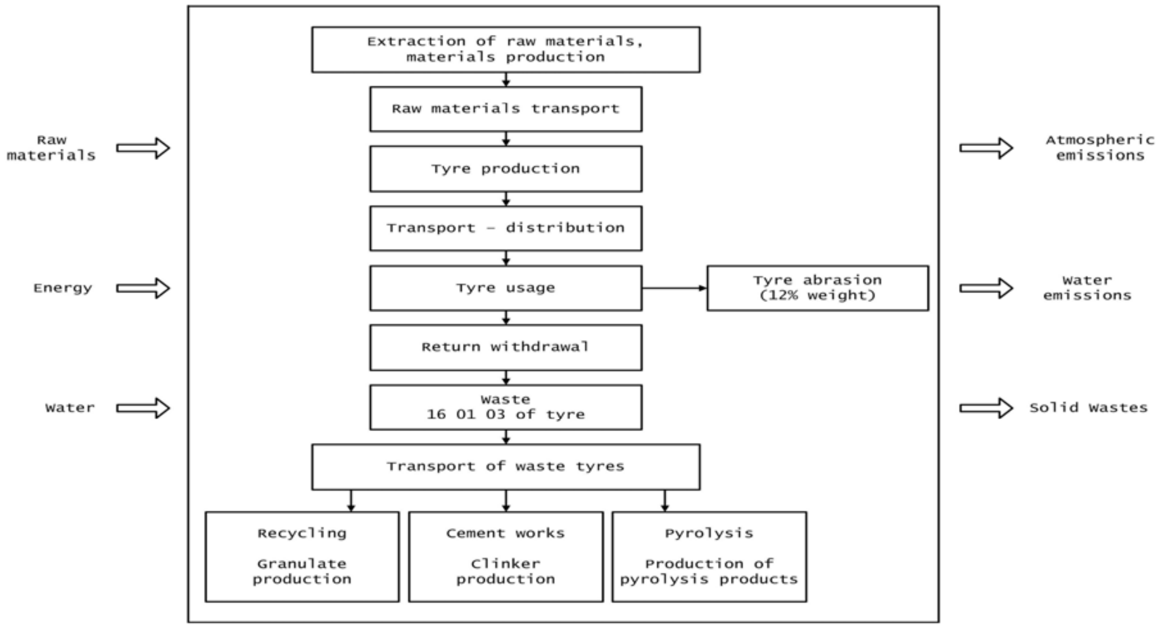
2.2. Goal and scope definition

The objective of preparation of the LCA study was to analyse any potential effects of the standard car tyre on the environment during the whole life cycle in accordance with the international standards ISO 14040 and 14044 regulations. The outcomes were also the comparison of different treatment methods of waste tyre management from the viewpoint of their elementary flows and impacts on the environment. The aim of this study was not to select or prefer any of technologies for waste tyre management, but to identify points of individual methods of management and mitigating the impact of the relevant technology on the environment. The study includes all the available inputs and outputs in connection with all processes of life cycle.

The function of the assessed system is to maintain the right direction, to bear the vehicle´s load, to absorb shocks and the transmission of engine output. The functional unit is 40 000 kilometres run off by tyre. The reference flow is the weight of standard car tyre weighing 6 kg; for the waste car tyre the weight of 5,28 kg is assumed, because of the loss of a 12 % weight – abrasion during the usage of tyre.

System boundaries have been defined and they include inputs and outputs associated with the extraction of primary raw materials, transport of raw materials to production, production of a new car tyre in factory, product distribution, tyre usage, transport of waste car tyre and waste car tyre management – recycling (granulate production), energy and material utilization in cement works (clinker production) and pyrolysis (production of pyrolysis products). System boundaries are shown on Fig. 1.

Fig. 1: System boundaries of the car tyre for the LCA study



2.3. Life cycle inventory (LCI)

The inventory analysis is very important part of each LCA study. The accuracy and credibility of the LCA study depends on the exactness and reliability of the information and data obtained from producers, companies, research institutions and universities and through own measurements or professional estimations.

The life cycle inventory analysis included the collection of all the available data within the whole life cycle. The more than 170 input data were used for the study. This time demanding work required a close collaboration with factories and other plants dealing with production, usage and disposal of tyres, with research institutions and universities. The research team approached various companies and organisations and the team utilized the data both from own measurements and from the calculations prepared by other organizations. The estimation method was chosen only as a marginal possibility and this method was always consulted with professionals from the relevant field.

2.4. Life cycle impact assessment (LCIA)

The life cycle impact assessment was based on CML 2001 methodology. The CML is the characterization model designed at the University Centre of the Environment in Leiden, Holland (Centrum voor Milieuwetenschappen Leiden). This characterization is based on the indicators of impact categories. The amount of damage by every category of the impact is expressed in the equivalents of the reference substance producing the same amount of damage.

In the CML 2001 the normalization of results from indicators of impact categories is carried out by the application of results of the category indicator on the reference result of the impact category determined for the corresponding geographic unit with the sum of all stressors affecting the given category of the impact. The model CML 2001 gives the reference values from the results of indicators of the categories for several geographic levels: global in 1990, global in 1995, west Europe, the Netherlands and others [Heijungs et al., 1992; Guinèe et al. 2001].

3. Results

Energy

In consumption of energy dominate phase *extraction of raw materials.* This phase is spending 68 % (345,47 MJ) from all energy consumption in the life cycle of the tyre. Significant is phase *tyre production* as well as which is spending 27 % (136,12 MJ) from all energy consumption.

Greatest energy requirement from chosen waste tyre treatments has *recycling* of the tyre. This phase is spending 12,09 MJ which is four time more than using car tyre in the *cement works* (2,57 MJ) and almost two times more than using car tyre in the *pyrolysis* (7,25 MJ).

Feed stocks (raw materials)

In consumption of feed stocks is absolutely dominating phase *extraction of raw materials.* This phase needs 95 % from all used feed stocks in all life cycle (especially nitrogen, rubber, iron, sodium chloride, lime, sulfur, bauxit and other). In zinc consumption show itself phase *tyre usage* for using zinc to counterweight.

Assessment technologies for waste car tyre are not significantly participating on all feed stocks consumption and they are comparable each other.

Atmospheric emission

Mostly emissions of PM_{10} are draing off in phases *extraction of raw materials* (12 g PM_{10}) and *tyre production* (8,5 g PM_{10}). Significant is phase *tyre usage* as well as where is draing off 1,9 g PM_{10} (tyre abrasion).

Mostly emissions of CO_2 are draing off in phases *extraction of raw materials* (16 kg CO_2) and *tyre production* (12 kg CO_2). Significant is phase *cement works* where is draing off 13,8 g CO_2. High emission of CO_2 in cement works are incurred by using waste tyre as a fuel in cement rotary furnace. Further explanation of high CO_2 emissions is necessary.

The operation of a cement furnace is accompanied by a great quantity of CO_2 emissions released into the atmospheric. From the total quantity of produced emissions of CO_2 from cement works, the 60 – 65% emissions come into existence by degradation of input raw materials, the remaining 35 – 40 % are the emissions from fuel burning (including the tyres). The amount of CO_2 emissions produced in combustion of tyres accounts roughly for 2% of total quantity of CO_2 emissions from the cement furnace.

If we use as energy fuel other crude (e. g. black and brow coal, heavy heating oil or other waste) there will be emission every time. Decisive are emission factor and heating power of particular fuels.

Results from comparison are demonstrating that actual amount of CO_2 emissions from using car tyre in cement furnace is lower than using of black or brown coal and same such as using of heavy heating oil. Aplication of waste car tyre in cement works is from view of emission CO_2 more suitable than common raw fuel.

Mostly emissions of SO_2 are draing off in phases *extraction of raw materials* (150 g SO_2) and *tyre production* (46 g SO_2). Phase *recycling* is producing 3,49 g of SO_2 (mostly from waste tyre treatments).

Mostly emissions of NO_x are draing off in phases *extraction of raw materials* (56 g NO_x), *cement works* (48,05 g NO_x) and *tyre production* (26 g NO_x). Significant are phases *pyrolysis* (7,92 g NO_x) and *transport of raw materials* (7,90 g NO_x) as well as.

In phase *tyre usage* are high concentration values for metal atmospheric emissions especially zinc (9,7 g), nickel (36 mg), copper (21 mg), cobalt (18 mg) and cadmium (4 mg). These metals are components of car tyre (vulcanized rubber) and they are draing off to the atmospheric during to using of the car tyre on the roads (emissions from abrasion). In other phases aren't concentration values for these metal atmospheric emissions recorded.

Water emission

In water emission is unambiguously dominanting phase *extraction of raw materials* where is 98 % of all water emissions producing (suspended solids 160 g; dissolved solids 4,7 g; COD 2,1 g; nitrates 2,0 g; sulfates 2,0 g; BOD 0,45 g). Assessment technologies for waste car tyre are comparable each other in terms of water emissions.

Solid waste (European waste catalogue)

Solid wastes are producing especially in phases *extraction of raw materials* and *tyre production.* Wastes from mineral metalliferous excavation are rising in phase *extraction of raw materials* (99 %, 590 g) which is connected with raw material mining for new tyre. Wastes from mineral non-metalliferous excavation are rising in phase *tyre production* (68 %, 780 g) which is connected with coal mining such as a fuel for Czech power plants and in phase *extraction of raw materials* (28 %, 320 g). At the same time in this phase are producing unprocessed slages (220 g) and bottom ashes, slages and boiler dusts (60 g). Bottom ashes, slages and boiler dusts are rising in phase *tyre production* too (240 g). In phase *raw material transport* are registering important amount of oil-containing drilling muds and wastes (hazard waste, 2,7 g) and chloride-containing drilling muds and wastes (2,1 g).

For waste tyre treatment is production of solid waste more significant catch in phase *recycling* primarily in wastes from mineral non-metalliferous excavation (52,8 g) and bottom ash, slag and boiler dust (18 g) which is connected with coal mining such as a fuel for Czech power plants. Amount of other wastes are for comparison ways of treatment with waste tyre approximately the same.

Impact assessment

Whole life cycle of standard car tyre participates mostly in consumption of abiotic raw materials and afterwards on acidification, global warming, production of photooxidants and terrestrial ecotoxicity. The more important impact is also recorded on the category of eutrophication. Zero values are shown in the loss of stratospheric ozone and ionising radiation.

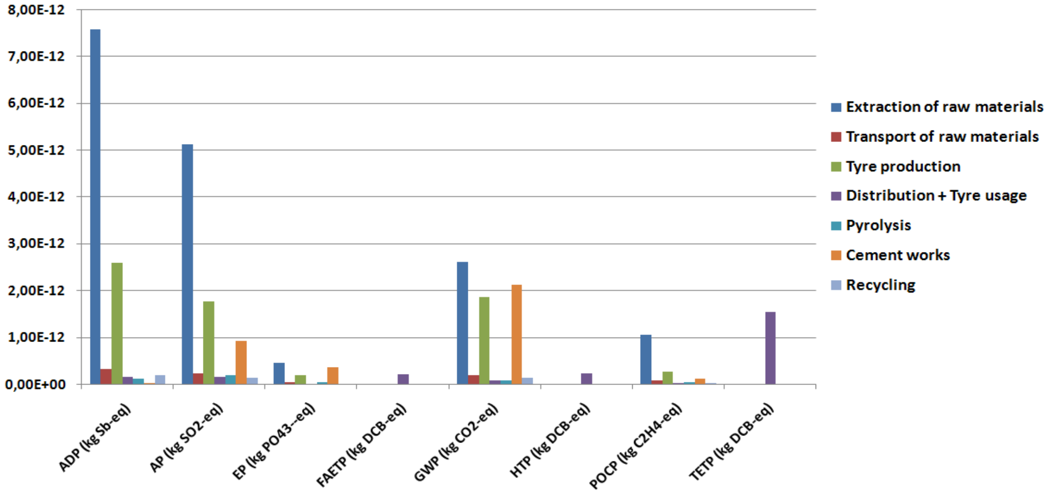
The phase of *extraction of raw materials* means the greatest load on the environment. This phase contributes significantly to the consumption of abiotic raw materials (69 %), production of photooxidants (63 %), acidification (59 %), eutrophication (39 %) and global warming (37 %).

The other important phases are *tyre production* and *transport – usage*. The phase *tyre production* participates significantly in the global warming (26 %), consumption of abiotic raw materials (24 %), acidification (21 %), eutrophication (17 %) and production of photooxidants (17 %); the phase *tyre usage* contributes greatly to terrestrial ecotoxicity (99 %), fresh water ecotoxicity (97 %) and human toxicity (81 %) which is due to effect of metal atmospheric emissions from abrasion.

The category of eutrophication (31 %) and global warming (30 %) are affected greatly by the phase *cement works*, subsequently in categoriy acidification (11 %). These impacts are creating by emisionss of CO_2 and NO_x. Analysis stated above confirms that CO_2 atmospheric emissions from using car tyre in cement furnace are lower than using of other fuels. Cement works combustion of waste tyre is giving rise to reduce the specific energy depletion for clinker burning and contributing to NO_x emissions reducing.

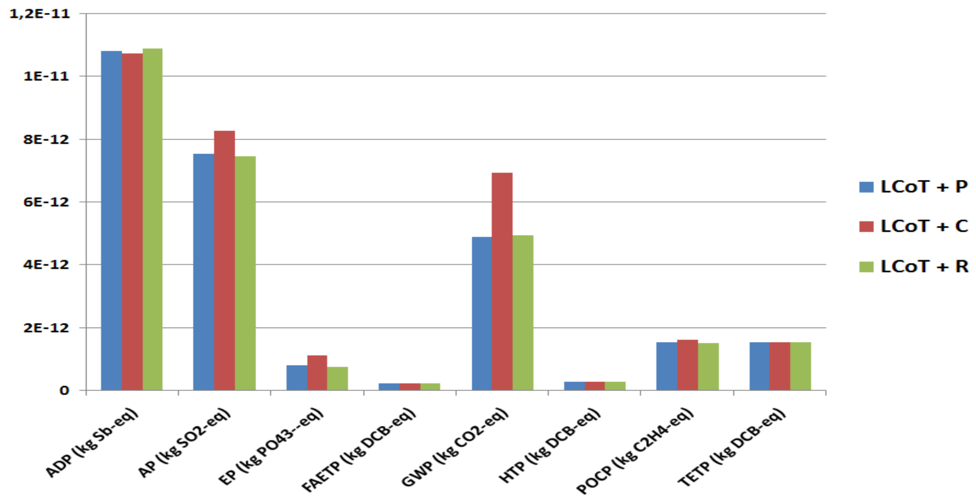
Other phases of waste tyre treatment are proving minimally in the whole life cycle. Zero values are apparent in the loss of stratospheric ozone and ionising radiation. Impact categories (normalization results, categories lost of stratospheric ozone and ionising radiation are breaking down because of zero values) for individual phases in whole life cycle are shown in Diagram 1.

Diagram 1: Impact categories for individual phases of life cycle of the car tyre



Compare of environmental impacts in individual impact categories is shown in Diagram 2 (normalization results, categories lost of stratospheric ozone and ionising radiation are breaking down because of zero values). Increased values in acidification, eutrophication and global warming for phase *cement works* are inccured by high atmospheric emissions. For other impact categories there are not significative differences in impact assessment for particular waste tyre treatments (in term of all life cycle).

Diagram 2: Impact categories for life cycle of the car tyre with different waste tyre management



4. Discussion

The life cycle of the standard car tyre contributes mostly to the consumption of abiotic raw materials and further to acidification, global warning, production of photooxidants and terrestrial ecotoxicity. Zero values within the whole life cycle of tyre are shown in the loss of stratospheric ozone and ionising radiation.

From particular phases of life cycle of the car tyre almost absolutely dominate process *extraction of raw materials* in the whole life cycle. This process is significant in energy, feed stock (raw materials) and water consumption, in atmospheric and water emissions and waste production. In impact categories contributes more significantly to the consumption of abiotic raw materials, production of photooxidants, acidification, eutrofization and global warming. It stands to reason that this is a weightiest phase in the life cycle of the car tyre.

The other important phase is *tyre production*. Primarily there is energy and coal consumption and atmospheric emissions. In impact categories are mainly affected global warming, consumption of abiotic raw materials, acidification, eutrophication and production of photooxidants. With regard to the pressure of tyre producers to produce the best and technically sophisticated products, we can understand the usage of many substances and raw materials to achieve the required quality. However, there is a question if the society is willing and ready to reduce their living comfort (e.g. to decrease speed parameters of new tyres) in relation to protection of human health and natural ecosystems.

During to using of car tyre is rubber abrassion generating with high amount of metals (zinc, nickel, copper, cobalt, cadmium etc.). These metals are escaping to the atmospheric such as the atmospheric emissions which show itself in fresh water, human and terrestrial ecotoxocity.

The assessment of individual methods of treatment with the waste tyre (cement works, pyrolysis, recycling) shows that all three technologies are comparable from the viewpoint of the impacts on the environment. More highly feed stock (raw material) or environmental loading wasn't to find out. The most energy consumption is for process *recycling* which is show in category abiotic raw materials, the most water consumption is for process *pyrolysis* (cooling water). The detailed analysis of the increased production of CO_2 (the impacts in the categories of global warming) in the phase *cement works* confirmed the assumption that the burning of tyres in cement furnaces is appropriate at present (high heating value, comparable or lower emissions of CO_2 with other fuels, important removal of great quantity of waste) and one cannot speak of the increased impact on the environment, because this is the replacement of raw materials and fuels. In other categories, the individual methods of waste tyre treatment are minimally demonstrated in term of whole life cycle of the car tyre. Cement works combustion of waste tyre is giving rise to reduce the specific energy depletion for clinker burning and contributing to NO_x emissions reducing.

5. Conclusions

In order to optimise flows and reduce impacts to the environment is necessary to decrease raw material and energy loading for new tyre producing. Raw material mining and tyre produce are the greatest problem in the life cycle of the car tyre.

During the tyre usage on the roads the hazardous substances are giving away which are causing toxicology and ecotoxicology environmental loading. These conclusions can be realized by research support in fields cutting of energy intensity of tyre production and alternations of material construction of new car tyre. Actual research for analyse of current car tyre rubber is necessary as well as because of speedy changes in tyre rubber constitution.

All the assessed technological methods of treatment with the waste car tyre are using the tyre as a raw or energy material and the result is always a new product (pyrolysis products, clinker, recycling products). The objective of this study was not to select or prefer any of technologies for waste tyre management, but to identify points of individual methods of management (consumption of resources, emissions of substances), which can be improved in the future, while mitigating the impact of the relevant technology on the environment.

For recycling technologies for waste tyre is suitable develop facilities with lower energy consumption, comparison of emission factors and heating power confirm usability of apply to waste tyre in cement works. Progress in pyrolysis technologies can be directed to reduce of amount technological cooling water. Authors of the project are encouraging all assessed method of handling with waste car tyre to utilize. It stands to reason that they are environmental acceptable, important in term of disposal of major amount of waste and indispensable in the future for waste management.

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The Screening of Phthalic Acids Esters in Construction Materials of Vehicles

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Abstract

Eight samples of new steering wheel coats for vehicles have been examined for checking of the presence of phthalic acid esters (PAE). Drivers are in touch with these materials. The results show that almost at all investigated samples the presence of phthalic acids esters was proved. Phthalates are animal carcinogens which are capable to cause necrosis or malformation of tissues. They are dangerous for liver action and they can cause reproduction toxicity of laboratory animals. Neither legislation of the Czech Republic nor EU deals with such problems.

1. Introduction

A lot of sorts of liquids and materials are used during service of motor vehicle, for example fuels (petrol, diesel, LPG, CNG) lubricants (oils, plastic lubricants), brake fluids and cooling fluids, cosmetics etc. Vehicles are made from different construction materials also. Especially it can be steels, glass, lights metals, textile, leather, plastics, thermoplastics, etc. These operational and constructional materials must satisfy a lot of requirements from the view of function which are demanded for example additional stability of construction of cars, minimal weight, heat removal (cooling fluids), transfer of braking power (brake fluids), optimalization of friction but they have to be researched from view health and ecology hazard.

Scientists, who checked chemicals released from materials, which interiors are made from, especially in the summer, they suggest ventilating. They have discovered that chemicals released from interiors of news cars could be dangerous for human health. They tested Lincoln Continental in 1995, and there were revealed more than 50 volatile organic substances revealed from cleaning and lubricating materials, colours, leather and vinyl parts, fuels, exhaust, latex glue etc. They repeated test at two months after the first testing and they revealed significant reduction of these substances (Overton et al., 1999).

In a report, which was published in 2000 by Americans scientist from University of Texas in Austin, was stated that during the first day of using a car, 7500 micrograms/m3 volatile organic substances were measured. They revealed more than 60 chemicals in interior of 4 cars (Grabbs et al., 2000). Two years long study from 2001 describes some health problems caused by these substances released from interior. They founded out orientation failures, headaches, incitement of some drivers of news cars. Substances revealed in the interior of car: carcinogenic benzene, next two possible carcinogenic substances cyclohexagon and styrene, and a few next toxic substances.

Materials which are interiors made from, often release a volatile and partly volatile substances. With the regard on human health, equipments of cars should be made from materials which release chemicals at a minimum level, which hasn't negative impact on quality of air in a close place. Health impacts could increase in case when substances react together, although the intensity of releasing of these substances is decreasing during first weeks. For improvement of elasticity chemical materials plasticizer based on the esters of acid phthalate (PAE) are used.

Majority of phthalates have an excellent adhesion and plasticizing attributes, therefore they are used widely for produce a lot of things in a chemical industry. It can be plastic materials, softened phthalates, building materials which are used in all human activities (construction materials of cars, cables, medical materials, cables, floor covering, roof covering). Because PAE are not strongly fixed in polymers they can diffuse, as well as they can be a source of potential contamination (BUSTAMANTE-MONTES., 2001; KRAUSKOPFLG, 2003).

The PAE are a big hazard for human health. Exposition of population can be by inhalation, oral, and by skin-resorption (KLIMISCH et al.1992). Huge production, large using, stocking of rubbish with PAE in the environment, have a negative impact of PAE on the human health means current world ecology and health problem. The Environmental Protection Agency (EPA) in USA ordered six esters of phthalate acid like dimethyl phthalate (DMP), diethyl phthalate (DEP), di-n-butyl phthalate (DBP), di-2-ethylhexyl phthalate (DEHP), di-n-octyl phthalate (DOP) a dibutylbenzyl phthalate (BBP). The ones that occur the most are DBH and DEHP.

The PAE are represented like consequential group of contamination heterogenous substances. They are industrially made since 1930. It is easy to produce them without economical impacts. The world production of di-2-ethylhexyl phthalates (DEHP) in 1994 was about 4 millions tones (KLÖPFER, 1994). Probably 1,8 % of year production is leaked to the environment (HUBERT et al., 1996).

The goals of our research were these subjects with which drivers and technical workers are in touch. Hazards for them can be plastic materials of like plastic wrap of steering wheel, gearing bar, and general interior of cars which is made from plastics or leathers. For technical workers these materials can be oils, lubricants, where we supposed present of phthalates with regard their physical attributes.

2. Materials and methods

Eight samples of coat of steering wheel were tested from view of presence of esters of acid phthalates. Evaluation was accomplished in the department of combat and special cars, University of Defence, Brno in cooperation with the Department of technology of groceries, Mendel University in Brno, Department of Food Technology. The analysis was accomplished in the laboratory of MZLU. Samples were tested twice; overall number of analyses was 16. The reliable methods were used for assessment of esters of acid phthalate in a plastic materials which are cars made from and they are used by drivers. For plastic materials were used methods for assessment of amount of PAE in fat dies, were used. (Jarosova, 1999).

The samples of plastic material were extracted by mixture of dichloromethane (1:1) 72 hours, laboratory temperature. After that contents of glass was shake in the shaker for one hour and then extraction was decanted through filler with cotton-wool. The extracting was repeated still twice. The combined extraction evaporated up to dry in the vacuum. For HPCL assessment evaporated part was dissolved in the hexane.

The detection and the quantification of PAE were accomplished by fluid chromatography. (mobile phase acetonitril : water, 99:1; flow 0,8 ml/min; colony Cogent e-Colum, C 18, granulation 5 µm, length 150 mm, Super Link) with UV and MS detection (Agilent Technologies LC/MSD VL).

3. Results and discussion

The Result of measuring of esters of phthalate acid in a coat of steering wheel is in the figures 1 to 8. Limit of possibility of determining DBP and DEHP is 0,03 mg.kg^{-1}.

From the figures it is possible to see that high values of presence of esters phthalate acid in materials of steering wheels were measured. Drivers are in touch with these materials. Long-term touch with these materials is very dangerous, because these materials are able to enter to human body by skin resorption (KLIMISCH 1992).

Fig. 1: The Contain of DBP and DEHP in the coat of steering wheel (sample 1)

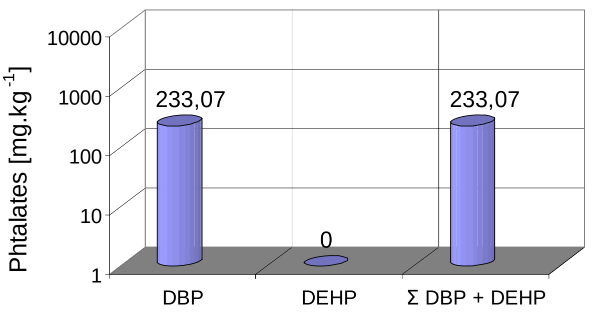


Fig. 2: The Contain of DBP and DEHP in the coat of steering wheel sample 2)

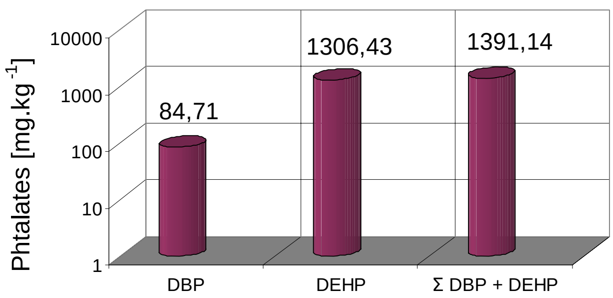


Fig. 3: The Contain of DBP and DEHP in the coat of steering wheel (sample 3)

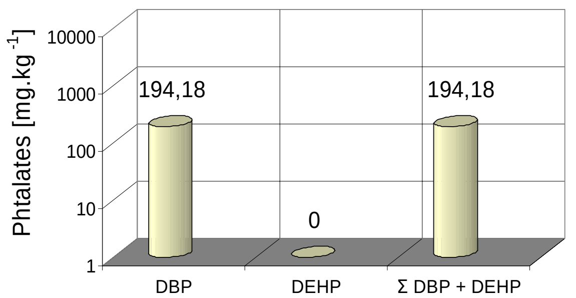


Fig. 4: The Contain of DBP and DEHP in the coat of steering wheel (sample 4)

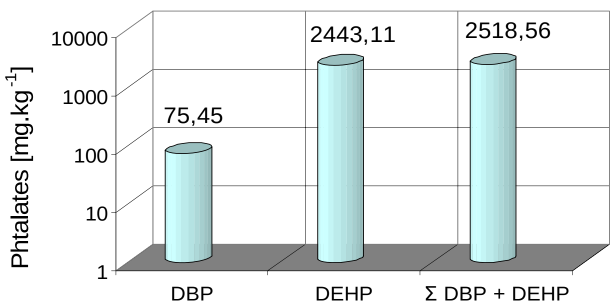


Fig. 5: The Contain of DBP and DEHP in the coat of steering wheel (sample 5)

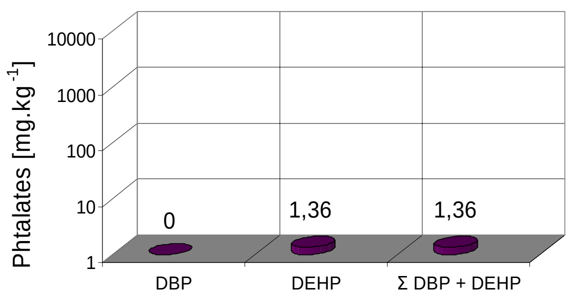


Fig. 6: The Contain of DBP and DEHP in the coat of steering wheel (sample 6)

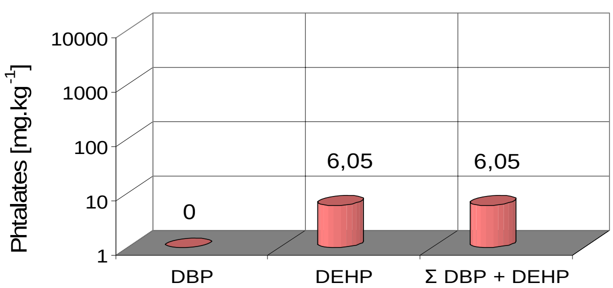


Fig. 7: The Contain of DBP and DEHP in the coat of steering wheel (sample 7)

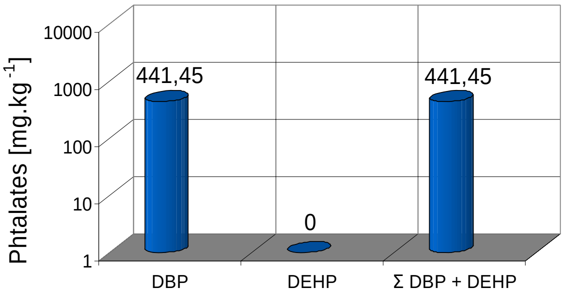
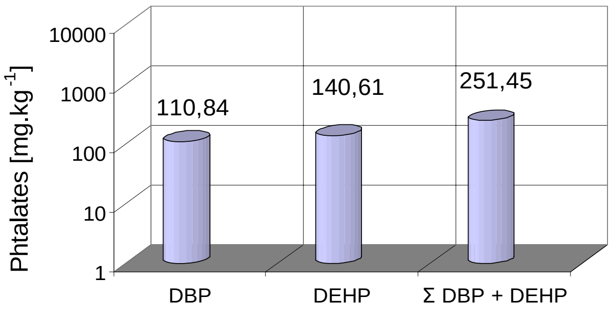


Fig. 8: The Contain of DBP and DEHP in the coat of steering wheel (sample 8)



The exposition is especially inhalation of particles of air or dust particles blocked with esters of ac phthalate acid (Salthammer et Bahadir, 2009).

Phthalates are animal carcinogens which are able to evoke death or malformation of tissues. They are dangerous for liver activity and they are able to evoke reproduction toxicity of laboratory animals (LATINI, 2005). Therefore the question is offered: *„What is the permitted concentration of DBP and DEHP for attendance of cars”?*

We need next experimental measuring for answer on this question, because legislature of Czech Republic neither EU does not deal with these materials which are mentioned in this paper.

4. Conclusion

According to the law number 110/1997 of digest (Czech law, valid up to 2004), which is about groceries and tobacco products, the permitted value of presence phthalates (the sum of DEHP a DBP) in muscles of animal for breeding 2 $mg.kg^{-1}$, and in fats 4 $mg.kg^{-1}$ was determined. With the passing bill of EU in 2004 these limit of value of phthalates was abolished.

In the public notice of ministry of health number 84/2001 of digest, which is about hygienic requirements for toys and products for children up to three years of age, toys made from softened plastic mustn’t contain more 0,1% of weight phthalates, is stated.

In the public notice of ministry of health number 38/2001 of digest, which is about hygienic requirements product which are in touch with groceries, plastic materials mustn’t loosen more than 10miligrammes/dm^2 of its substances, or limit of overall migration of loosened substances is 60 milligram’s for one kilogram of groceries or simulator of groceries.

The Czech or EU legislature is not dealing with requirements for concentration of phthalates in constructional materials and operational fluids. Published results are representing “screening” in this area. Therefore authors recommend dealing with these problems, incl. cooperation with car producers, search departments and medically institution.

Acknowledgement

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Evaluation of Transport Impact to the Landscape

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Abstract

The paper presents results of Research and Development project "Travel time as a transport indicator of urban sprawl, which deals with the impact of land-use changes on traffic flows with specific aim on the urban areas and the city's hinterland. Tool for evaluating the impact of changes in land transport is a multi-modal transport model that allows for the planned objectives to predict traffic flows in the future. The monitoring of changes in land-use pattern, together with socio-demographic data is the main factor of production and the attractiveness of different transport zones in the transport model. These characteristics are used as input data for the model in the program EMME/3 based on peak-hours traffic. The results of model are used for evaluation of current and predicted land-use changes impacts on the traffic flows. The travel time factor of individual, as well as public, transport is taken into account as the key transportation indicator for description of suburbanization processes.

1. Introduction

The transportation and changes in landscape structure have always been mutually continuous. Thanks to the rapid development of transport, initiated already during the second half of the 19th century - and still accelerating - inscribed on many processes affecting the form and spatial pattern of the city. Suburbanization has become perhaps the most significant phenomenon of the late 20th century - a move of inhabitants, some of their activities and functions from the core city to its hinterland. While the big U.S. cities are characterized by "urban sprawl", manifested primarily by the construction of brand new settlements arising "from green field" with no functional linkage to the existing residential structures, for the European environment is more typical the growth of existing settlements for new streets and the neighborhood - the expansion into the surrounding, usually loosing agricultural landscape. In the post-socialist countries, this phenomenon occurred after the changes around 1989, but with greater vigor.

2. Spatial structure of city and transportation

Spatial structure of the city and its immediate surroundings plays a very important role in relation to the demand for transport, capacity of transport networks and their usage. There are three basic views of the city and its structure with influence on traffic and its environmental impacts [1]:

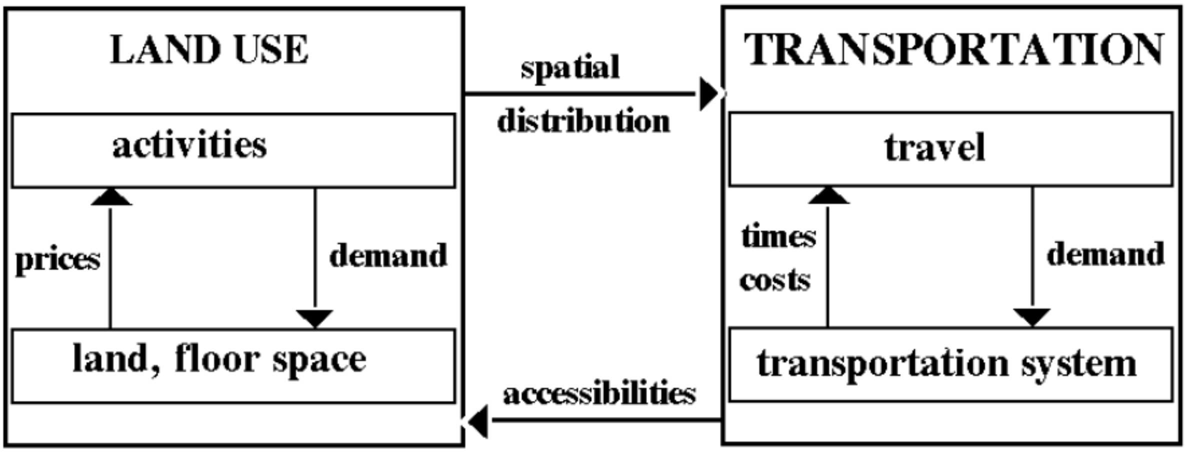
1. *spatial structure* – shape of the city and configuration of main development axis (radial-circular / fan / linear / rectangular),

2. *functional pattern of land-use* – spatial structure of main socio-demographical activities such as housing, shopping, industrial, services, leisure-time activities, etc.,
3. *spatial relations* – flows between the spatial-organizational structures of the city.

We can get by the study of the spatial arrangement of different functional areas an overview of the most important traffic flows in terms of their interactions. With the depart from the polyfunctional structure of city for the spatial segregation of different functional types of land-use, the pressure on the rapid growth of overall demand for transport is increasing as well as required average length of trips. There is an inverse relationship between the intensity of land-use and transport demand, including related effects such as energy consumption or environmental impacts.

The changes in land-use are quickly reflected in the traffic demand with direct influence to change the travel behavior patterns. Changes in land-use are very long process, but the transport is able to influence it. Therefore, the control of the suburbanisation process is a long-term task for which we can not expect results within a short time.

Fig. 1: Interaction between land-use and transportation [2]



3. Transport model of the city and land-use pattern

The aim of traffic modeling is using to forecast overall demand for transport and to identify expected changes in the spatial distribution and intensities of traffic. So it is a valuable tool in quantifying the environmental impacts and evaluation of the proposed traffic measures. It can be a tool for selection of the optimal development scenario and also for identification of locations where the further development may cause traffic problems.

The process of modeling is on the foundations established in North America in the late fifties and sixties (eg [3]) and consists total of four basic steps:

1. trip generation - determining the number of the trips, which start (traffic production) and end (traffic attraction) in each transport zone. The number is given separately for each of the main purposes of the travel (commuting to work, shopping, or leisure activities).

2. trip distribution - defining the matrix of distribution of the total number of trips between transport zones from one zone to different ones, based on their production and attractiveness. Commonly are used gravity models.
3. modal split – overall number of trips between two zones is divided among different types of transport (individual – transit – walking – cycling etc).
4. assignment - volume of demand for transport set out in the third step is allocated to the implemented transport network, separately for each of the transport modeled modes. The allocation of traffic on the network is iterative process by which such a balance is sought in which it is no longer possible to improve travel time for any trip (equlibrium). This process is capacity dependent - reflects the capacity of networks and if this capacity is exceeded then the speed of traffic is reduced, leading to prolongation of time to overcome the link and thereby reduce its attractiveness. This approach reflects the occurrence of congestion in the congested sections of the network.

The results of the process described above are traffic volumes allocated to the transport network, separately in different transport modes. Among other information, one can find out also capacity-dependent speed or travel time necessary to overcome the link or the entire route between the source and destination zone. Transportation at short distances within each zone (intrazonal) is not included in the model.

Transport model of Greater Brno area covers a total area of 1179 km^2 and comprises a total of 437 traffic zones, which are based on the basic residential units ("*základní sídelní jednotka*"; smallest statistical unit used for census). The model covers the entire area in the hinterland of the city of Brno, where the largest increases of built-up areas by the basic categorization of land-use [4] were identified. The model area includes nearly the whole district of Brno-country, and some of the surrounding counties and can be roughly defined by line of towns Blansko – Tišnov – Zastávka u Brna – Ivančice – Židlochovice – Slavkov u Brna – Jedovnice.

Built-up areas were categorized according to their functional usage, which is based on a List of standard types of land-use for digital processing of master plans in GIS [5] and modified for further use for determining the transport characteristics of different types of areas:

BI – individual housing,
BH – collective housing,
SX – polyfunctional areas (both commercial and residental),
OK – shopping,
OX – services, leisure activities (sports, public services, technical infrastructure),
DX – transport infrastructure,
VT – heavy industry and energetic,
VL – light industry, craft business, assembly plants,
VK – areas of logistics and warehouses,
VZ – agriculture farms,
ZX – urban green spaces and parks.

4. Trips production and atractiveness of transport zones

Regression analysis examines the relationship of population (as of 1 January 2009) in each zone – O_2009 - and the overall size of areas in the categories of BH, BI and SX (current scenario) was performed on the set of traffic zones located in the suburban zone (outside the city of Brno). The set was in the regression analysis divided into two parts which were processed separately. Based on cluster analysis K-means for the four clusters was set the threshold for splitting at 1650 inhabitants. Subsequently the multidimensional regression analysis found the following parameters:

Transport zones with number of inhabitants over 1650:

$$O\_2009 = a \cdot BH + b \cdot BI + c \cdot SX$$

Regression coefficient	Estimate	Standard deviation	Lower Bound	Upper Bound
a	142.49	8.07	125.99	158.99
b	26.26	1.49	23.21	29.31
c	37.65	4.00	29.46	45.83

Transport zones with number of inhabitants under 1650:

$$O\_2009 = b \cdot BI + c \cdot SX$$

Regression coefficient	Estimate	Standard deviation	Lower Bound	Upper Bound
b	19.17	0.53	18.12	20.22
c	36.55	3.27	30.08	43.03

The given equations allow to estimate the development potential of the population in individual traffic zones based on changes in function of the area. It is important for estimation of trip production, while attractiveness of each zone is given by activities that is the target of every trip - especially job opportunities (VT, VL, VK and VZ), capacity of schools (replaces jobs for a demographic group of pupils and students), sales area of large commercial establishments (OK) etc. To determine the number of trips is used the methodology by Martolos et al [6], together with data from other literature [eg 7, 8]. Ideally, the sum of the productions and attractions throughout the model should be balanced. But since it is almost impossible to cover all the complex of factors of the transport behavior. One can usually determine with sufficient precision only traffic production from the nature and availability of data. Determination of the attractiveness of each zone is sparse due to lack of accurate statistical data, particularly about the spatial distribution of job opportunities. Therefore, the basic data on the number of routes is considered the production and the attractiveness is adjusted to this amount (so called scaling). The attractiveness of each zone is determined for each of the observed trip purpose separately.

5. Distribution of roates, transport links matrix

For matrix calculations of transport links has been used model ENTHROPY [7], commonly used in the U.S. and Canada. Distribution is carried out according to the following equation:

$$g_{pq} = O_p \frac{e^{-\theta \cdot U_{pq}} \cdot D_q}{\sum_{q=1}^{n} \left(e^{-\theta \cdot U_{pq}} \cdot D_q \right)}$$

LEGEND

g_{pq}	number of trips from zone p do zone q
O_p	production of zone p
D_q	overall attractiveness of zone q
U_{pq}	travel time from zone p to zone q
θ	calibration constant (= 0,006)
n	total number of zones in model

The calculations based on the 24-hour traffic intensities are commonly considered in the Czech transport-engineering practice, although the transport system must be dimensioned so that is avoided the congestion in periods of increased demand for transport. However peak hours are different in relation to different trip purposes as well as the high volume of traffic varies from day to day and depending on the season, the category of communication and its role in the transport network. Also the traffic on the rural sections of roads is different over time compared to urban roads. Urban and suburban sections show much less variation, since a large proportion are fixed and regular trips, such as commuting to work or school, or shopping trips. However for full-time model is a breach of one of the essential conditions – the demand should be constant during the time period of modelling. Therefore it is modelled separately morning rush hour (6-9 pm) and the afternoon rush hour (15-18 hours).

There is a special matrix of traffic volumes for each of the possible purposes of the trips between zones (residence - work, school - residence, work - shopping mall, shopping center - the residence, etc.) Thus the calculated demand matrix is carried out by transport links of all modes. In the next step is such demand matrix divided by type of transport into 2 (or more) matrices: individual traffic and public transport, respectively integrated system of public transport. Modelling of the modal split is done using so-called utility function, each mode according to the logit type of relation. There are two basic variables - the total travel time and total cost of the trip.

The macro implementing modal split in EMME/3 :

```
~+|3.21|1|y|mf20|n
~+|-0.08*(3+mf2)-0.0209*3.5*mf14-0.05*md15+0.0085*mo16+0.0236*mo17
~+| | |n|1| |4
~+|3.21|1|y|mf21|n
~+|-0.08*mf3-0.0209*mf16+0.05*md15-0.0085*mo16-0.0236*mo17| | |n|1| |4
~+|3.21|1|y|mf22|n|exp(mf20)/((exp(mf20))+(exp(mf21)))| | |n|1| |4
```

LEGEND

mf2	travel time matrix – individual IAD [min]
mf3	travel time matrix – public trasnpost [min]
mf14	travel costs matrix - individual [Kč] – shortest path * price of travel per km
mf16	travel costs matrix – public [Kč] – tariff of integrated system
md15	parking costs for each zone [Kč/hour]
mo16	cars per household in each zone
mo17	share of individual housing in each zone

Properly calibrated function of the modal split is very important especially for evaluating future development scenarios of the area. For example the planned new public transport service should be assessed from the viewpoint of its potential for reducing the volume of automobile traffic as it will affect the (reduction) travel time of public transport, which is one of the main variables in calculation of the utility function.

6. Results of modelling

Ability of the transport model to assess changes in the traffic caused by changes in land-use have been practically verified on the scenarios which reflected the possible development of the situation both by the simulating effects of residential suburbanization, and through the realistic scenarios, processed through the study of development of available materials, particularly local master plans and the draft of the Principles of territorial development of Southern Moravia [9].

Theoretical scenario A (wild suburbanization) - The number of inhabitants in suburban communities grows by 10% with the exception of large cities, while the population in the city core decreases by same number of inhabitants. However this decline is not uniform so the most housing estates lost, while the attractive locations, for housing (eg “Masarykova čtvrť“) will have a population kept. Selected peripheral zones of core city, where the population is constantly growing (Útěchov, Jehnice, Kníničky) grow similarly to the villages outside the city limits.

Theoretical scenario B (controlled suburbanizace) – Population growth is concentrated in corridors served by major public transport routes (mainly by train). Improved public transport service will be reflected in a lower volume of automobile traffic than in the scenario A. The shift of the population is very similar to previous case, but affects only selected municipalities. In other communities outside the urbanization axis will be population unchanged.

Theoretical scenario C (restriction of suburbanization) – The move of people out of Brno virtually stopped - the population will grow only in a few villages near the city with excellent transport links - Moravany, Nebovidy, Ostopovice, Jinačovice, Rozdrojovice, Česká and Lelekovice. The number of inhabitants in Brno and in villages on the main transport axes is unchanged, while in other communities is considered a very slight decrease in population so the total population of the model area remained unchanged.

Development Scenario 2013 - a production and attractiveness of each zone is adjusted to include projects whose implementation will be completed by 2013, and that time will have significant influence on the traffic flows. Unlike theoretical scenarios changes in spatial distribution of activities is reflected, so the attractiveness of zones.

Development Scenario 2020 minimal - a similar scenario as above but for the time horizon of 2020. There were selected only those projects for which it can be assumed that in the year definitely has to be implemented.

Development Scenario 2020 maximal - a similar scenario as above but extended to projects which are expected to implement the 2020 case of the positive economic development, or even a little later.

For each of the above scenarios were developed independent cartogramm of traffic volumes and the results statistically analyzed. Key parameters are given the focus on evaluating the impact of spatial distribution of activities in the area of transport appears to compare different scenarios based on the average travel time of each way in the model separately for cars and separately for the subsystem of public transport. The results of the comparison of each scenario are listed in Table 1, which adds extra an interesting parameter of public transport - average number of transfers required per trip.

Table 1: Comparison of modeled scenarios

Scenario	average travel time - individual [min]	average travel time – public transport [min]	number of transfers
Basic	11,13	27,56	2,14
SC A	11,26	28,16	2,19
SC B	11,23	27,79	2,16
SC C	11,12	27,57	2,15
SC 2013	11,44	28,23	2,20
SC 2020 min	11,75	28,76	2,22
SC 2020 max	11,82	29,21	2,26

7. Discussion and conclusions

Results shows that the assessment of landscape development through the travel time could be an interesting tool to monitor the development of area and its impact on the landscape. At present however the transport assessment of projects in the area usually takes place only in the context of the location and the nearest neighborhood, with no evaluation of impacts on traffic in the wider context of relations. Also the landscape planning documentation is not commonly assessed as a whole but the traffic flows and travel time. Traffic model is an appropriate tool to identify the sites of potential problems in the future and try to avoid them, either through amendments or additions to roads, and even better by changing the spatial distribution of socioeconomic activities, which may lead to a general reduction in demand for transport.

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Effects of Winter Road Salting on Soil Microorganisms

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Abstract

Road salting is used as a dominant way to keep road safety in winter, even in the protected natural areas. In our study, possible effects of winter road salting on soil microorganisms in close road vicinity were investigated. Soil chemical and microbial properties were monitored at forest site in Krkonoše Mountains national park and at grassland site in Kokořínsko protected landscape area in two sampling campaigns (autumn and spring). Effects of road salting on soil chemical properties (Na^+ and Cl^- levels, pH, base saturation …) were clearly apparent. The most affected plots were 1 and 5 m from the road. At these plots, some changes of microbial parameters were observed in both autumn and spring sampling, which suggested influence of salts. Hence, possible influence on soil biological quality should be considered when assessing the ecological risks of this kind of road treatment, especially in natural protected areas.

1. Introduction

Snow and ice removal from roads is definitely necessary to improve safety of traffic in winter periods. Therefore, enormous quantities of deicing agents have been applied on roads since 1960's and released to the surrounding environment in many countries. Sodium chloride (NaCl) is the most common deicing agent due to low price, easy availability, storage and handling. Others are $CaCl_2$, $MgCl_2$, carbamide, calcium magnesium acetate (CMA). Each year, 8-12 million tons of road-salt (NaCl) are applied in USA [1], 5 million tons in Canada [2], and about 170 000 tons in the Czech Republic [3]. Despite all benefits for traffic safety, there are also many adverse effects, especially related to increased levels of chloride and sodium ions in the surrounding environment. Road treatment in winter is therefore legislatively regulated, especially in protected natural areas.

NaCl from road runoff is responsible for increased salinity or osmolality of surface and ground waters [4]. Ramakrishna and Viraraghavatan [5] reported that this could reduce water circulation, reaeration in lower depths which results in changes in population or community structure of aquatic biota. Negative effects of high concentrations of deicer salts on freshwater organisms have been frequently reported [6,7]. Chlorides up to 140 mg/l should be safe for acute exposure of aquatic organisms and up to 35 mg/l for chronic exposure [8].

In soil environment, salt transport, infiltration and effects depend on a variety of factors and local conditions, such as roadside slope, soil type, proportion of silt and clay, and vegetation cover [5]. Generally, the most affected area is up to 5-10 m from the roadside [9,10]. However, if there is a slope below the road and intensive rainfall, road salt may transport further. Effects of NaCl additions on soil chemistry are serious: increasing amounts of Na+ and Cl- affects soil pH, soil structure, permeability, hydraulic conductivity, air conditions, and osmotic potential. This leads to loss of soil stability and to osmotic stress for vegetation and soil macro- and microorganisms. Deicing agents facilitate mobility of several heavy metals in roadside soils [11,12], which can potentially increase their toxicity. Salt addition also affects soil fertility. Sodium exchanges other cations (Ca^{2+}, Mg^{2+}, K^{+}) and increases their loss from soil [13]. Salts also facilitate dispersal of organic matter with potential loss of dissolved organic nitrogen, carbon, and mineral nitrogen [14,15].

A number of studies reported damage of soil structure and negative effects on vegetation due to road salting [16,17]. Salts decrease nutrients availability from soil to plant and decrease also water and air uptake by roots. Plant damage may occur at 16 mg/kg Na and 30 mg/kg Cl^{-} [8]. Negative impacts of deicing salts on terrestrial organisms were proven in laboratory tests [6]. Environment Canada [8] reports general indication values of 60 mg/l for Na and 90 mg/l for Cl^{-} as safe for soil organisms and vegetation. On the other hand, relatively few studies have dealt with the impact of deicing salts on intrinsic soil microorganisms despite they are crucial in the maintenance of structure, quality and fertility of soils. The inhibition of sensitive soil microorganisms was observed at NaCl concentration of 90 mg/l and soil nitrification was significantly reduced at a concentration of about 100 mg/kg sodium and 150 mg/kg chlorides [16]. Green and Cresser [15] described long-term effects of road salts on soil nitrogen cycle. They reported enhanced release of ammonium-N from soil as well as increased nitrification caused by pH increase of acidic soils.

To investigate the effects of winter road salting on soil microbes, we performed study at three parallel forest sites in Krkonoše Mountains national park in 2004 [18]. Results showed increased concentrations of Na^{+} ions (up to 100 mg/kg) and pH values up to 8 at the plots closer to the road. Microbial biomass and respiration activity were significantly reduced at the roadside, and the metabolic quotients showed that the microbial community was apparently under stress.

The aim of the present study was to investigate effects of road salting on soil microorganisms at two sites with different vegetation cover and to relate the microbial biomass changes to the soil chemistry conditions. Two sampling campaigns (spring and autumn) can help to decide if the effects are only temporary or persistent: spring sampling shows the situation after winter road maintenance and after snowmelt while autumn sampling shows the long term status of soil microorganisms when the most salt is washed out from soil.

2. Materials and Methods

The sampling sites were situated in Kokořínsko protected landscape area (KOK site) and in Krkonoše Mountains national park (KRK site) nearby the roads with very intensive traffic. Both roads have been intensively treated by salting during winters (about 6.6 and 13 tons/km each winter at KOK site and KRK site, respectively). Sampling plots were placed at the transect lines perpendicular to the roads. At the both sites, sampling plots closest to the road (1 m) were at the roadside slope. They were covered by grass and they were sampled from 0-15 cm depth. At KOK site, soils were sampled at distances 5, 10 and 15 m from horizontal meadow (mowed reed) below the road. Soil was sampled from two layers: 0-5 cm and 5-15 cm. At KRK site, soils were sampled at distances 5 and 20 m at the slope below the road and also 20 m at the slope above the road (as control). All plots at KRK site were covered by spruce-beech forest and soil was sampled from Of and Oh horizons. Sampling was performed in autumn 2009 and spring 2010. Soils were sampled as several sub-samples at each plot which were then mixed. Soil samples were manipulated and stored in accordance with ISO 10381-6 [19]. For the microbiological analyses, fresh soils were sieved (2 mm) and stored at 4 °C in darkness with air exchange. For chemical analyses, soils were air-dried at laboratory temperature and sieved (2 mm).

Several chemical properties of soil samples were measured in accredited commercial laboratory by standard methods: organic carbon content (C_{org}), total nitrogen (N_{tot}), $CaCO_3$ content, humus quality parameters ($Q_{4/6}$, FA, HA), soil pH active (H_2O) and exchangeable (KCl), conductivity, concentrations of chlorides (Cl^-) in soil water extract (1:5), concentration of cations Ca^{2+}, K^+, Mg^{2+}, Na^+, cation exchange capacity, and base saturation (BS) in three types of soil extracts: water 1:5 (active concentration), in Mehlich III extracts (potential concentration), and 0,1 M BaCl2 extracts according to Gillman (exchangeable concentration).

Three basic microbial parameters of soils were measured: microbial biomass content (C_{bio}), basal (BR) and substrate-induced (SIR) respiration. In spring 2010 also potential ammonification (PAMO) was measured. All measurements were carried out in triplicates. Microbial biomass was measured by the chloroform fumigation extraction method according to ISO 14240-2 [20]. Basal and substrate induced respiration (BR and SIR) were measured by gas chromatography according to ISO 16072 [21] and ISO 14240-1 [22]. Potential ammonification was measured as deamination of arginine according to Alef and Kleiner [23]. From the measured parameters, eco-physiological coefficients were calculated – metabolic quotient qCO_2 (as BR/C_{bio} or SIR/C_{bio}) and microbial coefficient C_{bio}/C_{org} [24-26].

3. Results and Discussion

Parameters of soil microbial communities are frequently used in monitoring studies of different environmental problems as indicators of soil biological quality [27-29]. Microorganisms can early indicate that there is some factor causing degradation of terrestrial ecosystem. Therefore, soil microbial parameters were under focus in our study to observe if winter road salting can negatively affect soil microbial communities.

Effects of road salting on soil chemistry were clearly apparent at the both sites (Fig. 1, Fig. 2). The most apparent effects were detected at 1 m distance from the road. At the both sites, pH values were increased to 7-8 at 1 m plot. There was also strongly increased Na concentration and base saturation (BS) at this plot. Increase of Na was stronger in spring sampling which indicates actual influence after winter road maintenance. Base saturation changes at KRK site were the same in autumn and spring which indicated the changes in soil sorption properties are rather persistent. Base saturation at the plot closer to the road was much more evident at KRK site because forest soil at the further plots was naturally less base-saturated. At KRK site, the increase of Na was also clearly apparent at 5 m from the road when compared with 20 m plot or control. Relationships between Na levels and increased base saturation were reported several times at salinized soils [5,13,17]. Na levels as well as BS were lower in deeper soil layers at the both sites.

Chlorides showed strongly increased levels at the plots further from the road which confirms they are more mobile in the soil than Na. Increased levels were apparent at

5 m plot at KRK site when compared to control plot and 20 m plot. Levels of chlorides at KOK site increased with the increasing distance from the road but due to low levels at 10 m in spring it is not clear if they were related with road salting here. Chloride content was lower in deeper soil layers.

It is also important to notice, that C_{org} was apparently increasing with increasing distance from the road at KOK site. This is probably not attributed to the road salting but this behavior should be considered when interpreting soil microbial parameters. Possibly, it could be attributed to some loss of organic matter from soil due to increased mobility of dissolved organic carbon and nitrogen as described in the literature [14,15]. C_{org} in deeper soil layers was lower at the both sites.

Generally, soil chemistry results confirmed the literature findings [9,10] that effects of road salting on soil chemistry are mostly limited to the distance up to 10 meters.

Microbial parameters showed differences between sampling plots and some interesting trends related to the distance from the road (Fig. 3 and Fig. 4). Microbial biomass (C_{bio}) as well as its activities (BR, SIR and PAMO) showed strong dependency on the layer from which sample was taken: deeper layers (5-15 cm at KOK site and Oh horizon at KRK site) had significantly lower microbial biomass and its activity. In several cases, microbial biomass or its activity increased with increasing distance from the road (e.g. C_{bio} and SIR at KOK site in autumn, BR at both sites in spring). These trends must be interpreted carefully because soil microbial parameters are influenced by various soil physico-chemical properties and it is not easy to distinguish the effects of investigated intervention (salting) from the effects of other factors. The most important driver of soil microbial biomass is organic carbon in soil (C_{org}). Therefore, the microbial quotient C_{bio}/C_{org} was calculated to eliminate the impact of C_{org} on observed trends. High values of this quotient show potential for microbial growth, whereas low values indicate a stress situation [24,25]. In our study, however, increased value was observed at 5 m plot at the KOK site which rather than any positive effect indicates low C_{org} content (Fig. 1). At KRK site, strongly decreased value was observed at 20 m plot from unknown reasons.

Respiration activities of the soil microbes are related to the size of microbial biomass. Therefore, to avoid the influence of C_{bio} content on trends of BR, metabolic quotient qCO_2 was calculated. Higher values indicate increased energy demands of soil microorganisms and higher maintenance energy induced by stress conditions [24,26]. Increased values of qCO_2 at KOK site in autumn at 1 m plot might indicate stress caused by increased Na levels.

Potential ammonification as one of the important processes of N-transformation in soil showed decreased values at 5 m plot at KRK site when compared with the control or 20 m plot. This might be an inhibition due to increased Na level and consequent changes in soil chemistry.

Generally, it seems that some changes of microbial soil properties occurred at the soil affected with winter road salting in our study. Some changes might indicate long-term effects (decrease of microbial biomass and organic carbon in soil) and some changes rather short-term effects (changes in PAMO or stress indication by qCO_2). Negative impact of soil salinization on soil microbial characteristic (biomass, qCO_2) was observed also in other studies. Yuan et al. [30] reported that higher salinity in arid soil in China resulted in a smaller, more stressed, microbial community, which was less metabolically efficient. Restriction of microbial metabolism and C mineralization in salt-water wetland were detected also in Mamilov et al. [31].

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Fig. 1: Soil chemical properties at KOK site in autumn 2009 and spring 2010. Numbers below the columns show the distance from the road in meters. Gray column show the plot 1 m from the road sampled from 0-15 cm layer. From other plots, white and black columns show layers 0-5 cm and 5-15 cm, respectively. Parameters are explained in the text.

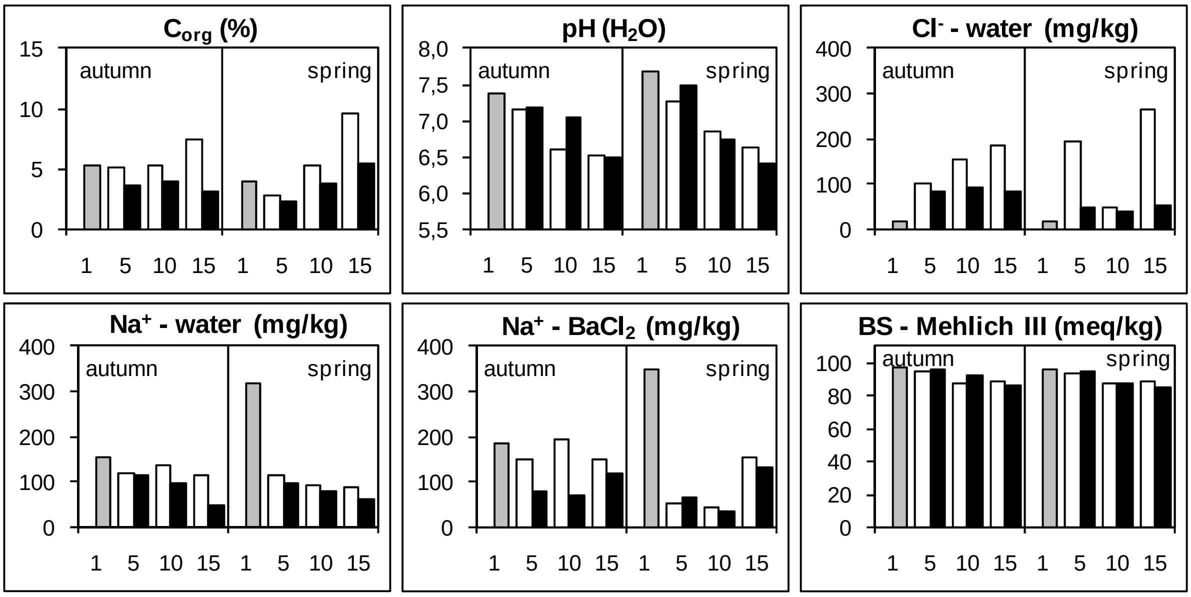


Fig. 2: Soil chemical properties at KRK site in autumn 2009 and spring 2010. Numbers below the columns show the distance from the road in meters (C is the control plot). Gray column show the plot 1 m from the road sampled from 0-15 cm layer. From other plots, white and black columns show Of and Oh horizons, respectively. Parameters are explained in the text.

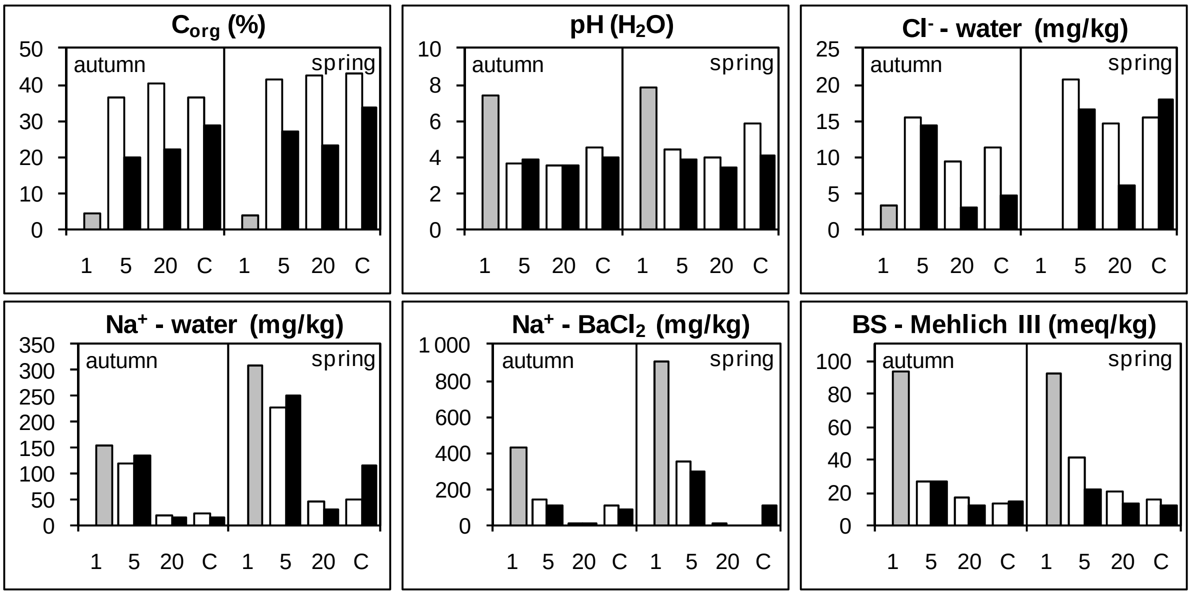


Fig. 3: Soil microbial parameters at KOK site in autumn 2009 and spring 2010. Numbers below the columns show the distance from the road in meters. Gray column show the plot 1 m from the road sampled from 0-15 cm layer. From other plots, white and black columns show layers 0-5 cm and 5-15 cm, respectively. Parameters are explained in the text.

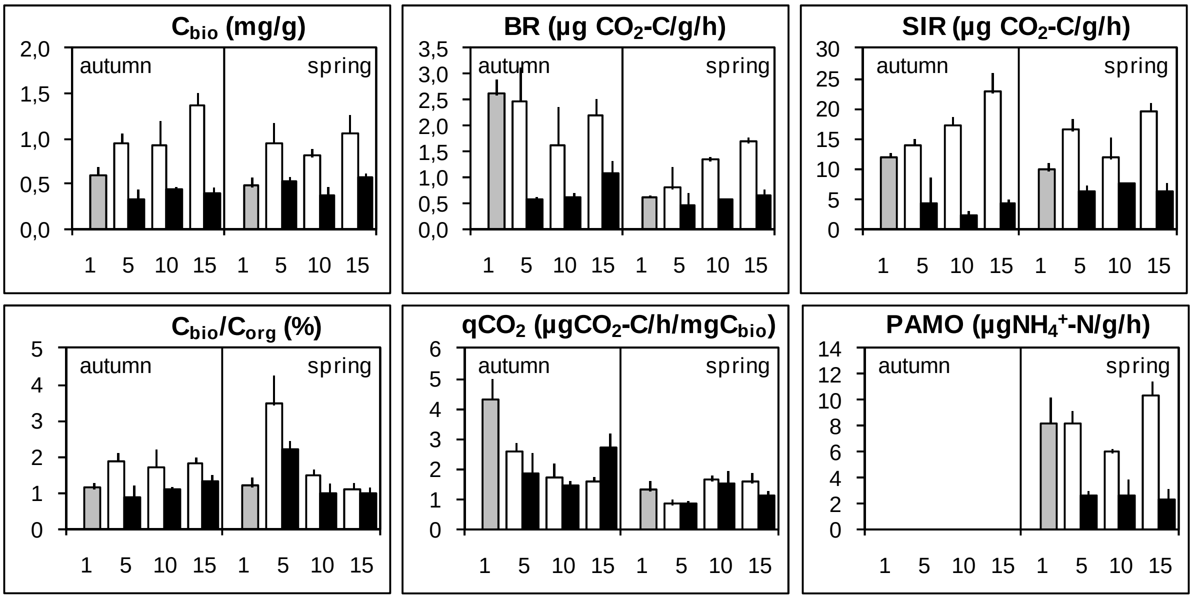
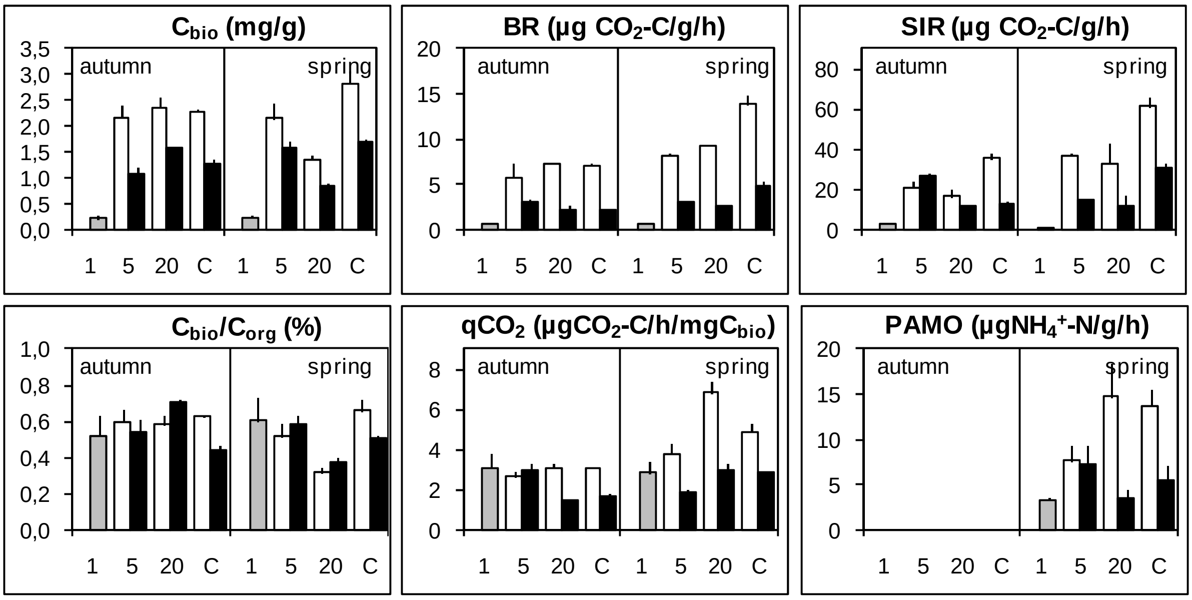


Fig. 4: Soil microbial parameters at KRK site in autumn 2009 and spring 2010. Numbers below the columns show the distance from the road in meters (C is the control plot). Gray column show the plot 1 m from the road sampled from 0-15 cm layer. From other plots, white and black columns show Of and Oh horizons, respectively. Parameters are explained in the text.



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Assesing Health Risks of Noise Exposure from Road Transport

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Abstract

Noiseinduced by transport has become a phenomenon of the last years of the modern era. Health Risk Assessment (the "HRA") is one of the accepted and commonly used professional tool to assess the potential impact of noise on the health of exposed population.

In this presentation I would like to focus on the HRA process from the standpoint of purpose, process, background issues, uncertainties and explanatory power.

1. Purpose

To understand the practical demonstrations of the HRA is necessarily short, a theoretical introduction about potential burden of disease from road traffic noise.

HRA is required to assess the impact of project on the environment according the Act No. 100/2001 Coll. „Assessing the impact of project on the environment“, as amended (EIA documentation). The purpose is to assess the assumed impact of proposed transportation project on the health of exposed population or to assess the suitability of several variants of the project solution.

2. Procedure for Health Risk Assessment (practical demonstration of processing)

The basis for each HRA is the "stand on the side of safety", which in practice means to evaluate the worst or the most uncovenient situation which in this case can be envisaged.

- Evaluation of variants (e.g. bypass proposed in several variants)
- Assessment of changes

The process of risk assessment (Risk Assessment) consists of 4 steps:

1st Hazard identification - identifying how and under what conditions the agents (harmful factors) can adversely affect human health

2nd Characterization of danger - to determine the relationship between dose and effect (the response of the organism) - a quantitative description of the relationship between dose and extent of damage, harm.

3rd Exposure assessment - to draw exposure scenario based on knowledge of the situation, respectively exposure conditions, intensity, sizeand frequency.

4th Risk characterization - integration (fusion) of data obtained in the previous steps, whose purpose is the quantitative expression of the probability degree of real health risk.

For the development of expertise, which undoubtedly HRA is, it is necessary that the processor has at his disposal the relevant documents relating not only to noise in the territory considered, but also demographic data (quite difficult to available).

Background noise of the load, respectively exposure of the population may be based on measurements of the noise or acoustic (noise) computed study. For assessing the impact of traffic noise are usually used a combination of these two methods - measurement and calculation, in which the measured values are used to calibrate the computational model.

Calculated acoustic study is a report containing the calculation of expected values of the selected noise index (metric) (e.g.the A-weighted equivalent sound level) and other crucial facts about noise exposure and those exposed for assessing health risks of exposure.

Basic data needed to assess the effect of line noise sources are noise values for the following descriptors: Ln, Ldn, Ldvn [1] , LAeq,16h, LAeq,8h [2].

Negative effects of noise from road transport can be divided into subjective, which are described as noise annoyance and sleep disturbance (disorder), and objective as the occurrence of coronary (ischemic) heart disease (IHD) and myocardial infarction (IM) in the exposed population.

Presentation will continue by discussing the uncertainties estimation and their explanatory power to the results of HRA.

The expected negative effects of noise exposure:

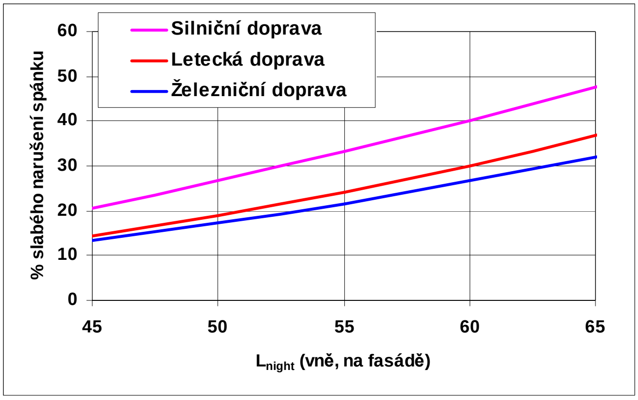
- *Sleep disturbance* - The effect of noise on sleep is the most of anticipated action effects of noise from traffic, influencing, the length and quality (depth) of sleep, especially REM phase reduction. The noise sleep disturbance meets both physiological and psychological aspect of noise. The effect of disturbed sleep affects the following day (annoyance, fatigue, low mood, poor performance, headache). Subjectively assessed sleep has three levels [3]:

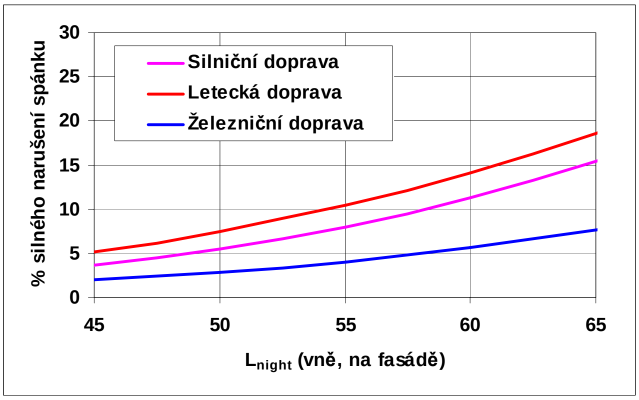
LSD (Low Disturbed Sleep), the first stage of sleep disturbance, which includes all persons who are at least "moderately or if slightly disturbed," i.e., includes all disturbed persons from all three levels

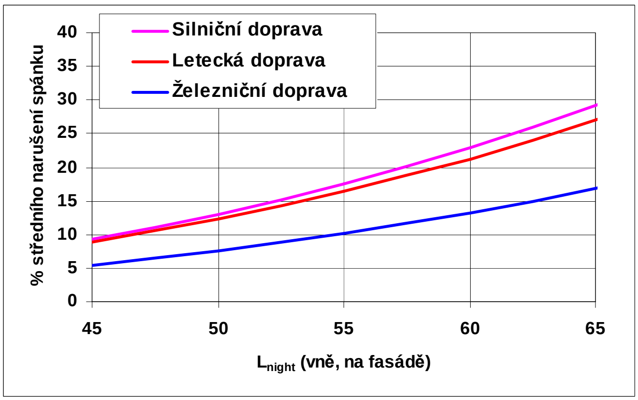
SD (Disturbed Sleep), the second stage of sleep disturbance, which includes people of at least "moderately disturbed", i.e, includes all medium and highly disturbed person

HSD (Highly Disturbed Sleep), third degree, which includes people with strong feelings of subjective sleep disturbance, i.e., only those highly disturbed

Graphs 1, 2, 3: Same night exposure levels of LAeq, 8h = Ln of air transport (in the graphs shown in red), road transport (on the charts pink) and rail transport (in the graphs shown in blue) is sleep at least distractetd by railway noise.







- *Noise annoyance* - This is the most common response of those exposed in the municipal environment (in the vicinity of transporation tracks). It is resulting in a lot of negative emotional states such as feeling resentful, frustration, bad moods, depression, hopelessness. For each individual there is some degree of tolerance to the disruptive effect of noise. There is quite individual perception of intrusiveness. In the general population there is 5-20% of highly sensitive people as well as highly tolerant individuals. According to WHO during the day, few people are seriously annoyed when their activities exposure LAeq, T <55 dB and slightly annoyed at

LAeq, T <50 dB. Harassment is evaluated in three levels [3,4,5]:

LA (Little Annoyed), first degree of harassment, which includes all persons at least slightly annoyed ", i.e. includes all harassment of those of all three levels

A (Annoyed), second degree of harassment, which includes people of at least "moderate annoyance", that includes all medium and high-harassment of

HA (Highly Annoyed), third degree, which includes people with strong (prominent) feelings of harassment, i.e., only those troubled high.

- *Cardiovascular disease*

\- High blood pressure, hypertension (hereinafter "HT")

According to WHO criteria is for [4]:

- Optimal blood pressure is considered as the value of systolic blood pressure <120 and diastolic blood pressure ≤ 80 mm Hg (120/80)

- Normotenzi treated systolic blood pressure ≤ 130 and diastolic <85 mm Hg (130/85)
- Higher normal pressure 130-139/85-90mm Hg,
- Mild hypertension pressure 140-159/90-99 mm Hg,
- Moderate hypertension pressure 160-179/100-109 mm Hg
- Severe hypertension pressure above 180/110 mm Hg
- Ischemic heart disease (hereinafter "CAD") (IHD)

Minimum LAeq, 24 hr with an effect on coronary heart disease in epidemiological studies was 70 dB. The general conclusion is that in case of traffic noise are the cardiovascular effects associated mostly with long-term, long-standing exposure to LAeq, 24 hr = 65-70 dB, and more.

According to recently published epidemiological studies conducted by W. Babisch for road noise and cardiovascular risk - myocardial infarction, increased risk was not found in the levels of LAeq, 16h < 60 dB; increased risk was found with increasing levels of LAeq, 16h > 60 dB. It is generally accepted that noise could have a decisive impact on health, where the LAeq, 16 h> 60 dB [7,8,9,].
Practical demonstration HRA author's contribution.

3. Backgrounds

Evaluator (authorized person pursuant to Act No. 258/2000 Coll., The protection of public health and amending certain related Acts, as amended, or the holder of a certificate of authorization for assessing health risks of exposure to noise by Act No. 100/2004 Coll.) must all relevant documents subject to professional criticism - in particular the results of noise measurements and acoustic studies.

Other documents are detailed maps and demographic data and their validity. Usually „in the field“ reconnaissance by processor is needed before processing starts.

4. Uncertainties

- Traffic data (estimation of intensity and composition of traffic flow is often done for a few tens of years in advance)
- Demography and its development estimate
- Uncertainty inherent to the model:
    - Uncertainty of geographic bases and elevation (altitude);
    - Uncertainty of parameters of objects and features of the model (properties of modeled objects and the surface absorption of the facade and screens, reflectance field, the height of objects and acoustic screens);
    - Uncertainty of input data on noise emission of modeled noise sources;
    - Uncertainty resulting from the properties of the computational standard;
    - Uncertainty resulting from the meteorological data;
    - The uncertainty caused by the processor as an user of model, user process/tool;
    - The uncertainty caused by the prediction software used;
    - Uncertainty resulting from the simplified model of the noise situation in order to accelerate the calculation.
- Uncertainty of the results of epidemiological studies in general.

5 . Explanatory power

When working with the HRA results, it is necessary to bear in mind all the uncertainties that enter into the assessment process. Always is necessary to bear in mind that this is an estimate (prediction), prediction of future state and potential development. Likewise, the number of reported population with probably sleeping disturbations and number of people probably annoyed as well as estimation of the number of cardiovascular diseases due to exposure to noise.

6. Conclusion

The above does not mean that the HRA is pointless to take. Just be aware that it is only predictive tool and its resulting value is limited by all used input data. However, at this moment, at contemporary level of experience (scientific knowledge) there is no better tool to assess the potential impacts of noise exposure on human health.

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Transport Risk Assessment for the Environment

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Abstract

Transport risk assessment for the environment has two important aspects – problem solving model and solution veracity. Problem solving model is larger understanding of tasks interconnection, which represent in itself partial solution of general risk assessment. Solution veracity says, to what degree are the results objectives and in consonance with reality. By researching of both aspects it rises many hitherto unanswered questions dealing with risk assessment results verification and validation. By risk assessment for the environment it is possible to meet wide variety of more or less good soluble problems. From simple problems based on risk rating from common traffic accidents with service charge outflows to complex problems of risk assessment connected with dangerous substances transport by traffic or pipelines. By simple problems solving there are not many questions about risk assessment veracity. It is possible to determine traffic accidents frequencies and service charge outflows consequences on the basis of examined events in transportation with great veracity. By complex problems the situation is quite different. The frequencies of large accidents are very low but the consequences for the environment may be large. Both are encumbered by large level of uncertainty. That is why the question is rising, to what degree is in these cases correct to make decision based on risk assessment.

1. Risk management

In all human life areas is targetly or intuitively realized risk management. It takes effect in many standards with the relation to risk whose purpose is to unite terminology, methods and procedures in this area. This fact is possible to document with brief summary of static standards from risk management area.

ISO/IEC Guide 73:2009 Vocabulary for Risk Management (Pokyn ISO/IEC 73:2009 Slovník pro management rizika)

This directive determines basic risk management terminology, which should be respected in all standards used for risk management in different fields. There are mentioned definitions of generally useable terms respecting risk management. Its main aim is to give support to mutual and consistent understanding of actions statement respecting risk management and logically advised access to this statement, as well as using uniform risk management terminology in processes and systems considering risk management. The directive is intended for:

- Workers engaged in risk management,
- Workers engaged in ISO and IEC activities,
- Workers engaged in elaboration of national or branch standards, manuals, procedures and principles concerning risk management.

It results many another standards from this basic terminological document, which have direct or mediate relation to the risk. Like such as standards example it is possible to mention:

ISO 13824:2009 General principles on risk assessment of systems involving structures

ISO 31000:2009 Risk management – Principles and guidelines

ISO/IEC 31010:2009 Risk management – Risk Assessment Techniques

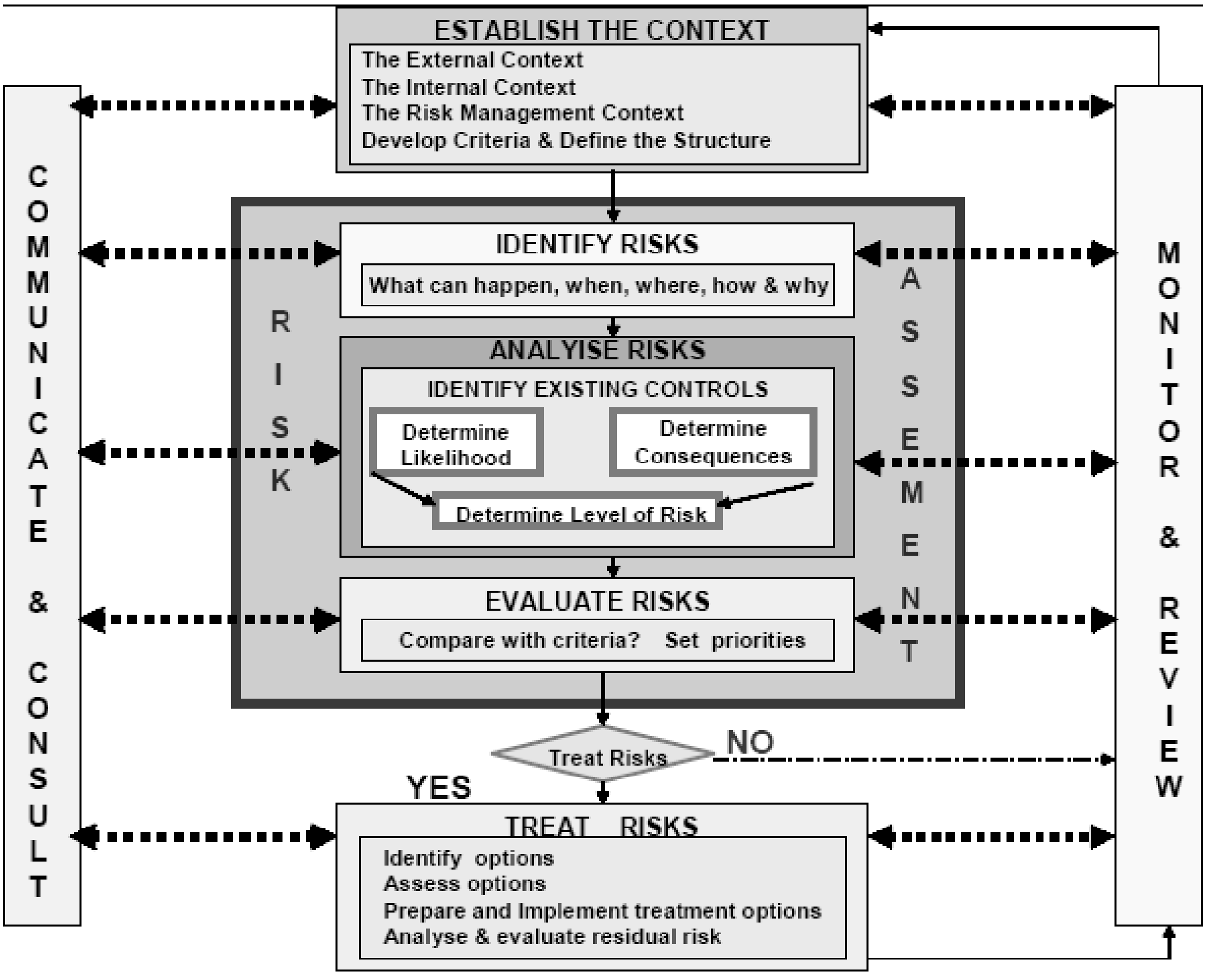
ISO/IEC Guide 51:1999 Safety aspects – Guidelines for their inclusion in standards

ISO/IEC Guide 50:2002 Safety aspects – Guidelines for child safety

These mentioned standards represent only small part of ISO standards concerning risk. More detailed instruction manuals and techniques are in IEC and EN standards. These standards regulate many different aspects of risk.

The principle of risk management is the risk assessment. Risk assessment is the process composed of partial processes, which are risk identification, risk analysis and risk evaluation. The risk assessment process represents the heart of risk management, see figure 1.

Fig.1: Risk management process [1]



It is necessary to be aware of what activities is the whole process of risk assessment composed. It always depends on solved case type. Otherwise it is possible to create general model of risk assessment in accordance with activities description, which have to be done and tools, which are useful for these activities, but activities and

[1] Taken from ISO 31000:2009 Risk management – Principles and guidelines

tools selection is always specific and valid for concrete case. From the general model of risk assessment, which can not be shown in the paper due to large graphic extent, it is possible to deduce risk assessment model of transportation. In contrast to general model of risk assessment has the deduced model already registered specific activities, which conform to solved problem.

2. Verification and validation of risk model

Verification and validation are two terms very often used in technical praxis. But not always understood in the same way in single areas. Most often these terms mean following processes.

Verification – process, by which the proof is get, that the existing activity was realized according to specified requirements.

Validation – process, by which the proof is get, that the product (service) meets relevant requirements of specification.

Veracity assessment, so solution validity confirmation, is not generally possible to do on the basis of solution outcome confrontation with the reality. So it is necessary to find another way of solution validity assessment of risk general problem of complex system. [8]

Useful way is the description of general problem solution with the form of technological risk model, which represents the transformation of risk assessment general process model to the model which is valid for risk assessment of concrete complex system. In our case it is concerned about model for transport risk assessment for the environment.

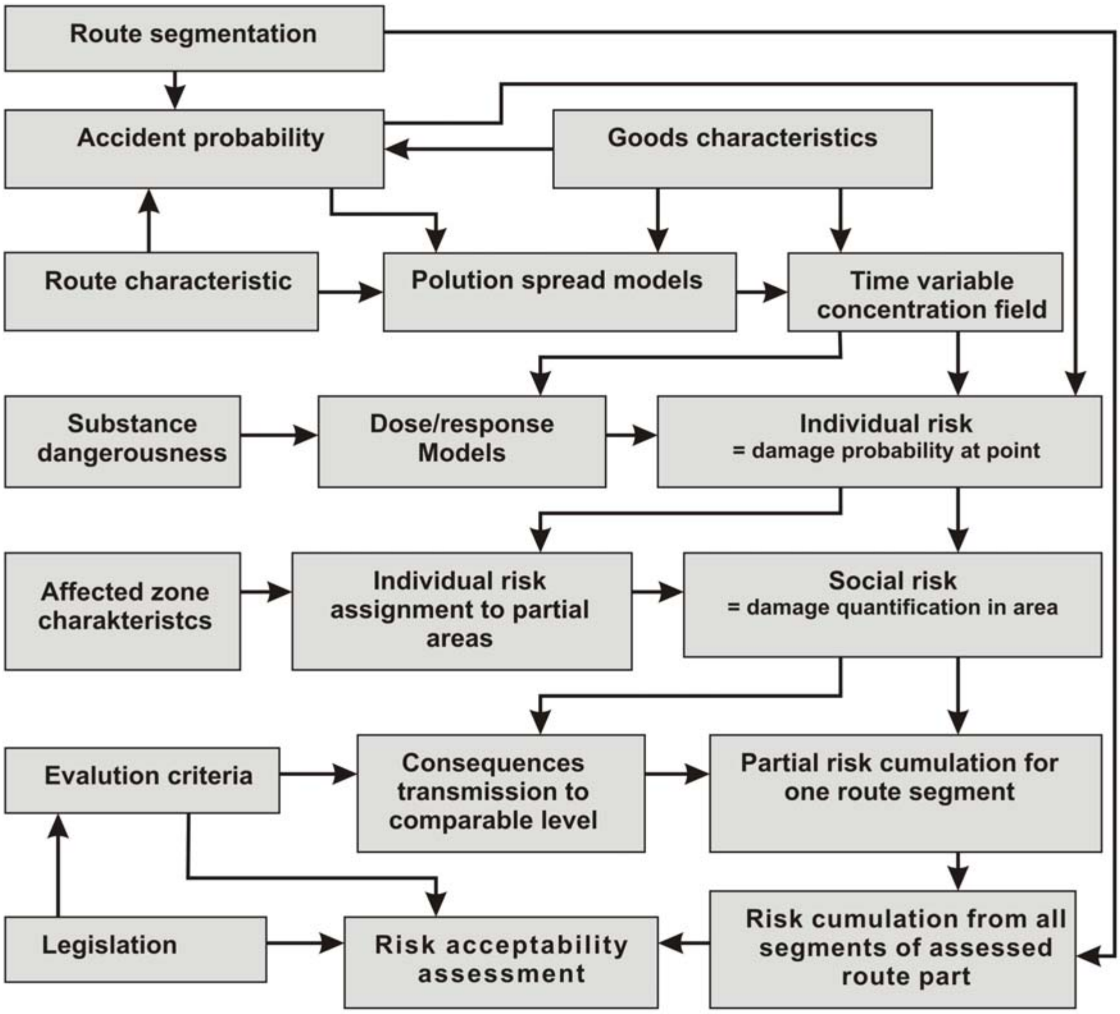
Risk technological model for concrete case of complex system is possible to put together with different ways. The risk general task is divided (discretized) into partial problems, which are solved by concrete tools and with concrete input data. Risk general task is possible to divide into partial problems also by different ways and these problems to solve by other tools. The verification and validation problem is by this access solved in several steps:

a) Verification of general task of risk, i.e. verification of technological model of risk,
b) verification and validation of partial tasks of risk (solution possibility, used tools and data),
c) validation of general task of risk.

In the step ad a) it is solved formal correctness of technological model of risk and so the formal correctness of complex system risk assessment. In steps ad b), c) it is solved the veracity of outcomes obtained by complex system risk assessment. These steps it is necessary to realize in mentioned sequence.

3. Process model of transportation risk assessment for the environment

Fig. 2: General model of transportation risk assessment for the environment



3.1 Input information

The transport risk assessment model for the environment needs several types of input information. It is possible to summarize this information to following categories:

Goods characteristics

- the quantity of transported substance,
- package,
- substance physical parameters.

Route characteristics

- traffic conditions,
- meteorological conditions,
- morphology of surroundings terrain.

Substance dangerousness

- toxicity,
- ecotoxicity,
- flammability,
- explosibility,
- radioactivity.

Affected zone characteristics

- population density,
- representation of single environment elements and its types
  - atmosphere,
  - soil,
  - surface water,
  - underground water,
  - biotic elements (flora, fauna, ecosystems).
- Environment elements vulnerability
  - sensitivity,
  - significance.

Evaluation criteria

- legislative,
- special.

3.2 Evaluation procedure

The evaluation requires the application of analysis models. Partial outputs from single steps represent always the input to the next step. It is useful to do the evaluation for short route segments. The total risk is then the sum of risks in single route segments.

At the beginning of the evaluation it is necessary to establish the scenarios determining which environment elements and types of actual conditions will be taken into account by the evaluation. It is also necessary to establish basic and special evaluation criteria for existing problem.

In the first step it is necessary to determine the accident probability. It can generally depend on goods type, traffic situation and actual conditions. It can be different in partial route segments according to its specific characteristics, but it can be set by single value flowing from traffic accident statistics.

Then it follows the calculations of dangerous substances spread into the environment. It is mostly concerned about sophisticated deterministic physical models. But these models are largely different for different environments (atmosphere, soil, surface water, underground water). Large number of physical parameters, which these models require and also large complexity of detailed solution is the problem. Always it is necessary to accomplish some simplification of mathematical formulation of the problem, which has to respond to requirements for outcome exactness. The outputs are time variable concentration fields of the substance in single types of the environment.

There are very important dose/response models, but they are in light of the environment at the time not ideal. These models should quantify degree of damage of specific environment element by calculated exposure, which is the function of substance concentration, fire heat flux, overpressure by explosion or radiation and exposure time. Well sophisticated are probit models for human death probability. In case of the environment there is a problem of width spectra of natural environments with different vulnerability against mentioned dangerous parameters of various substances. The outcome is the risk level for single environment elements, so the probability and level of negative effect in specific point. The quantitative or semi-quantitative risk level for single elements is possible to superimpose for different hazards, most often for accident effects of one vehicle in different transport route segments. The outcome is possible to display on maps.

Final social risk represents the quantification of total potential damage in threatened area. For its assessment it is necessary to identify the representation of assessed environment elements in the area, their range, value and level of their damage in partial areas of their occurrence. It is necessary to suit the quantification procedures to the evaluation purpose. Simpler is the risk quantification for population and financial damage, caused by degradation of farmland quality, agricultural, forest or fishing produce or reduced land efficiency. Much more difficult is the quantification of externalities, which contains „services“ of natural environment for human (clear atmosphere, clear surface waters, country-side), biodiversity preservation, nature reserve and protected areas significance. But also here it happen first quantification attempts to financial formulation level. [7]

By quantitative formulation at the comparable level (e.g. monetary units) it is possible to cumulate risks for single environment elements directly. By semi quantitative formulation it is necessary to determine the importance of single elements, eventually of single evaluation aspects. It is necessary to establish criteria for risk acceptability evaluation. These criteria have to respect legislative notes and also they can include special requirements for specific localities, transport methods, etc.

4. Uncertainties in transport risk assessment for the environment

Different partial problems are encumbered by uncertainties in varying degrees. Accident probability assessment is based on accident statistic data. Here is the uncertainties source some disagreement between different institutions (MDČR, ŘSD, PP). The thing is not only ordinal difference. Problems can arise by expression of different probabilities on roads of different category and especially in single route segments depending on their local characteristics. The distribution of large set to many smaller may lead to reduction of dependability statistic evaluation.

It is available many models for dangerous substances spread calculation. For gas dispersion they are most often used well verified models of Pasquill-Gifford. More complicated is the liquid spread calculation at the land surface. Small roughness, which has random character, largely affects liquid diffluence in the landscape. It exist verified infiltration models, but their application is encumbered by large error because of incomplete knowledge of parameters, which change in dependence on actual conditions. The models of contaminant movement in surface waters are encumbered by smaller error. It is possible to agree, that the liquid spread is encumbered by larger uncertainties than the gas dispersion. The range of possible pollution is by real transport vessel volumes restricted to tens or maximal first hundreds meters from the route, so that is why it is mostly possible to consider these deficiencies as acceptable.

The uncertainties in exposure dose calculations result mostly from the fact, that the procedures (relatively good proof), developed for human population are used. It stands not to reason to what degree they are useable for various environment elements. It is connected with large uncertainties in damage level assessment of different fauna and flora forms, but also abiotic nature components (etc. underground water reserve). The attention is focused on economic important nature elements, which represent however only smaller part of threatened natural assets. Exposure response assessment for width variety of natural forms is one of most important uncertainties sources in whole problem solution.

All above-mentioned uncertainties are reflected to final social risk value. The level of potential damage in partial area is necessary to confront with natural objects, which are situated here. Here the uncertainty source can be the necessary categorization of these objects and formulation of their value (most often relative then absolute).

5. Conclusions

- Risk assessment for the environment is much more difficult than risk assessment for human. It is necessary to explore risk for single environment elements and their concrete forms, which occur in threatened area separately and then to synthesize total risk.
- It is useful to put together the technological risk model. The concrete complex problem is partitioned into the set of consequential and parallel partial problems. These problems are then solved by concrete tools.
- Solution procedure of most of partial problems is possible to verify and often also to validate. It is not generally valid for exposure dose assessment and damage level of single nature environment forms.
- Validation of whole problem is difficult and practicable only in simple cases, where it is possible to make do with partial evaluation.
- It is necessary to focus on development of classification tool for evaluation of verification and validation level of risk technological model. It is important especially in cases of extreme low probability of unwanted event and large consequences.

Acknowledgement

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The Spill Flow Simulation Next to Road

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Abstract

The traffic accident can evoke environmental risk. When the vehicle transports the dangerous liquid, it may means leak of liquid into environment. There must be known, how the spill of liquid flow. It can be estimated by developed numeric model of spill spreading. The zone of danger may be set on the basis of calculated results. The spill extent can be the basis for the risk assessment.

1. Introduction

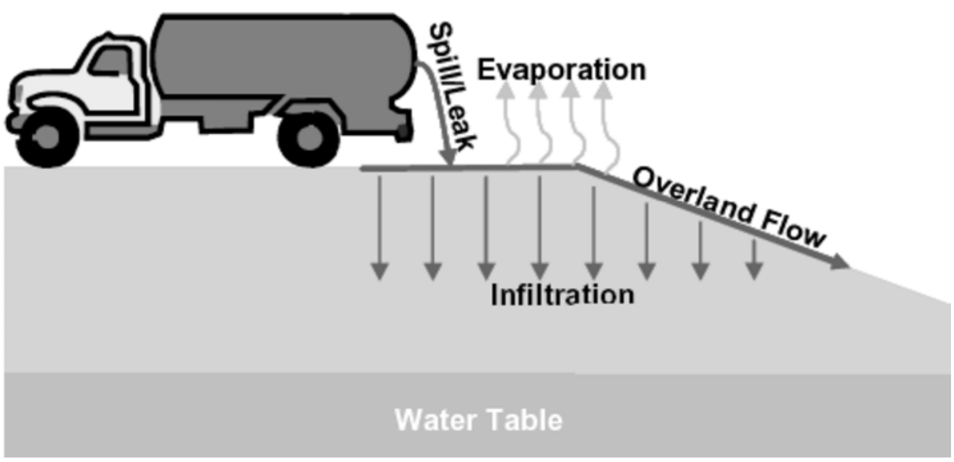
The traffic accident can evoke the environmental risk along the road. This environment risk may be greater when the vehicle transports dangerous liquid. For example, when the oil outflows from the crashed oil tank, the spreading spill may cause danger soils, streams or vegetation. There is the risk assessment possibility.

There is necessary to estimate the spill flowing progression to the risk assessment. This estimation means big problem for the real environment. We try to solve it by our developed simulation model. There are next solutions also described in the literature [1], [2], [3], [4], [5].

2. Spill behaviour

When the liquid outflows from the tank, there is created the spill on the land surface. The spill spreads from the accident place. The land surface is wetted and some amount of liquid stays on the surface. The next part of a liquid is infiltrated below the land surface. The infiltrated amount of liquid may be very different and depends on lend surface parameters. The part of liquid amount is vaporize also. These processes are demonstrated by figure 1.

Fig. 1: The schema of the liquid leak (taken from [1])



The flowing spill is formed by thin layer of liquid. The deep of spill is under a few centimetres very often. The spill behaviour is given by terrain slope mainly. Every small variation of terrain may influence the spill flow direction and spill shape. These variations are for example: Footpath, road, side ditch or building. The spill flowing is influenced also by the land surface type. It determines, how fast the liquid flow, how fast the liquid infiltrates or what liquid amount is retained by the surface.

When the liquid leaks from the road, surface waters and soils are the most in danger. The environment damages consist in liquid properties and leaked amount.

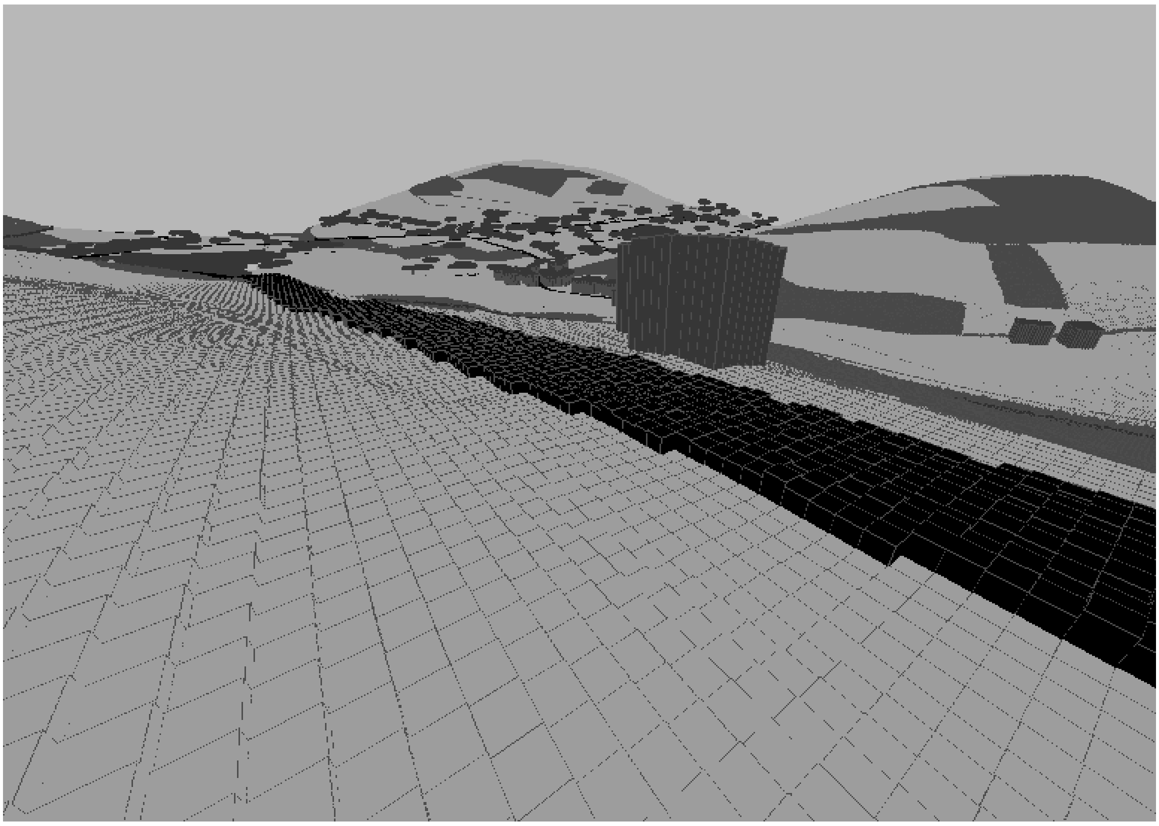
3. The spill flow simulation

There is necessary to know for risk assessment, how liquid will spread from the outflow place. Spill spreading may be calculated by numeric simulation model. There is developed our own simulation model by our department.

Calculation requires data about land surface. It means elevations and description of land surface. Elevations data are usually available as the point grid or level lines. We have some data resources about land surfaces in Czech Republic. There is geographic model ZABAGED for example, Data are available in the ESRI shape file format, which is used in geographical information systems.

The terrain model is built on the base of these geographical data. The terrain model has rectangular area. It is divided into square elements with same side lengths. The terrain model example is presented on the figure 2.

Fig. 2: The example of terrain model

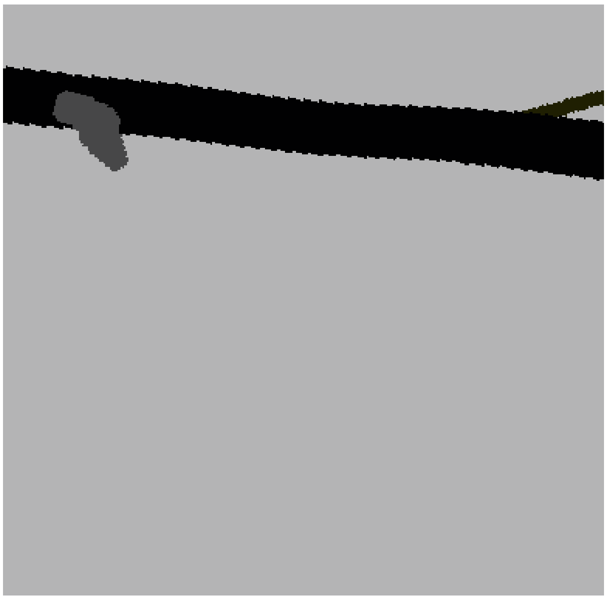


Every square element contains elevation and land surface parameters. Parameter is for example surface conductivity. The asphalt surface has different conductivity than meadow.

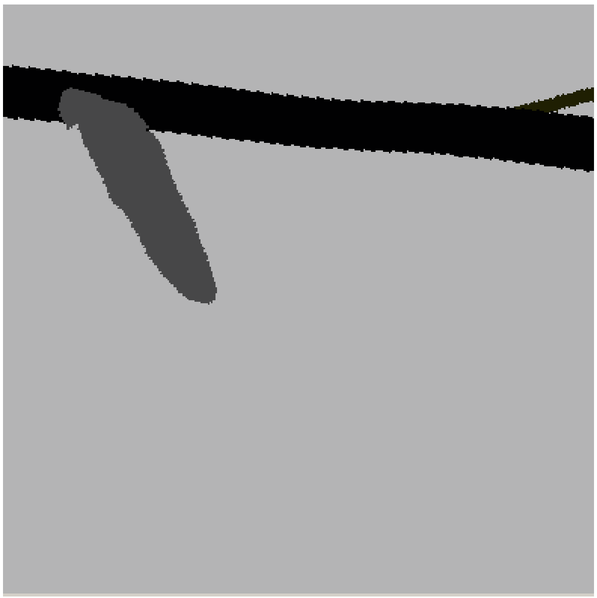
Every element is described also by three state variables. These variables describe amount of liquid contained in element for given time. State variables are amount on the surface, infiltrated amount and vaporized amount. The spill spreading is simulated by the time progression of these state variables. There is presented example of calculations result on the figure 3.

Fig. 3: The example of spill flow simulation

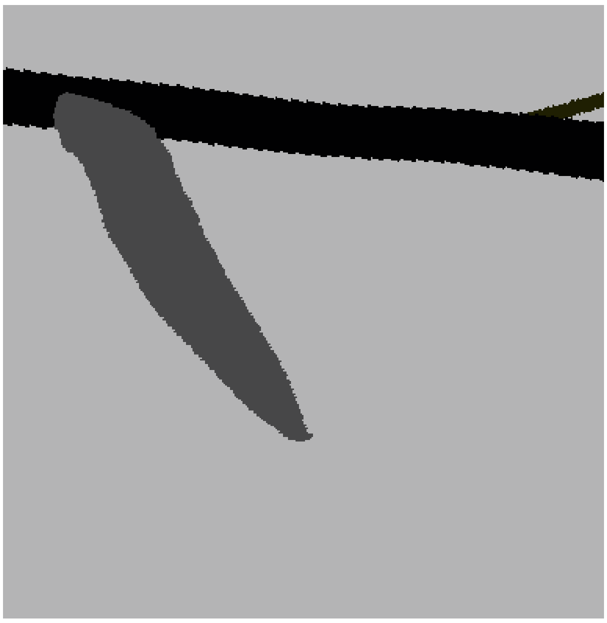
After 5 minutes



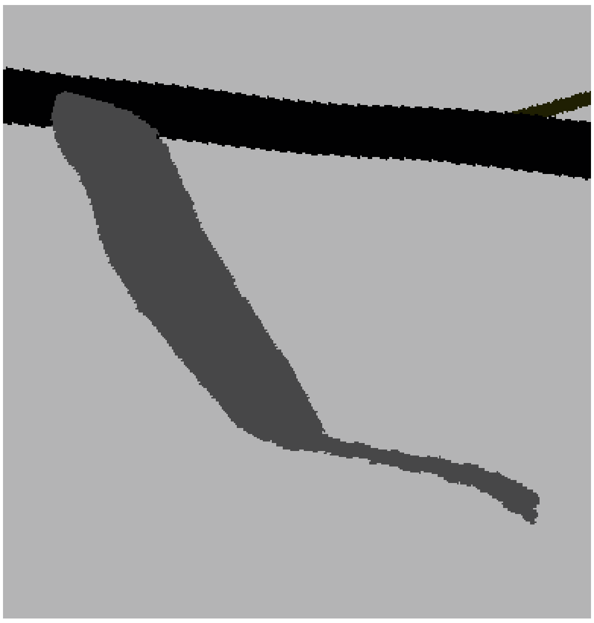
After 10 minutes



After 15 minutes



After 20 minutes



Surface parameters are encumbered by uncertainty. It means, there are many variants of terrain model. Parameters of square elements are not numbers (deterministic approach), but they are random variables (stochastic approach). This case is solved by Monte Carlo method.

The results of state variables are created by group of values. There are calculated statistical results. We can retrieve for example, what probability the liquid flow in the river.

4. The danger zone next to road

The simulation model presented above is built for point source. It means, the accident with dangerous liquid leak may be in one defined place. The road is line source. The accident may happen somewhere on the road. The road is presented as a group of discrete points. The distance of points may be about ten meters. The fluid outflow is simulated for all of them. We can get the group of calculated spills. It is viewed on the figures 4 and 5.

The spill spreading depends on many conditions. when the land surface conductivity is smaller, the spill area and the spreading velocity is faster. The soil with grass has large conductivity, the asphalt road has is not conduct. The liquid flows very fast and very far. The spreading velocity depends also on the liquid viscosity.

The danger zone of road must be set for different weather or different seasons. We can choose the worst case. It means, the soil is saturated after the rain or it is frozen. The spill area is the largest in this case.

Fig. 4: Danger zone created by calculated spills

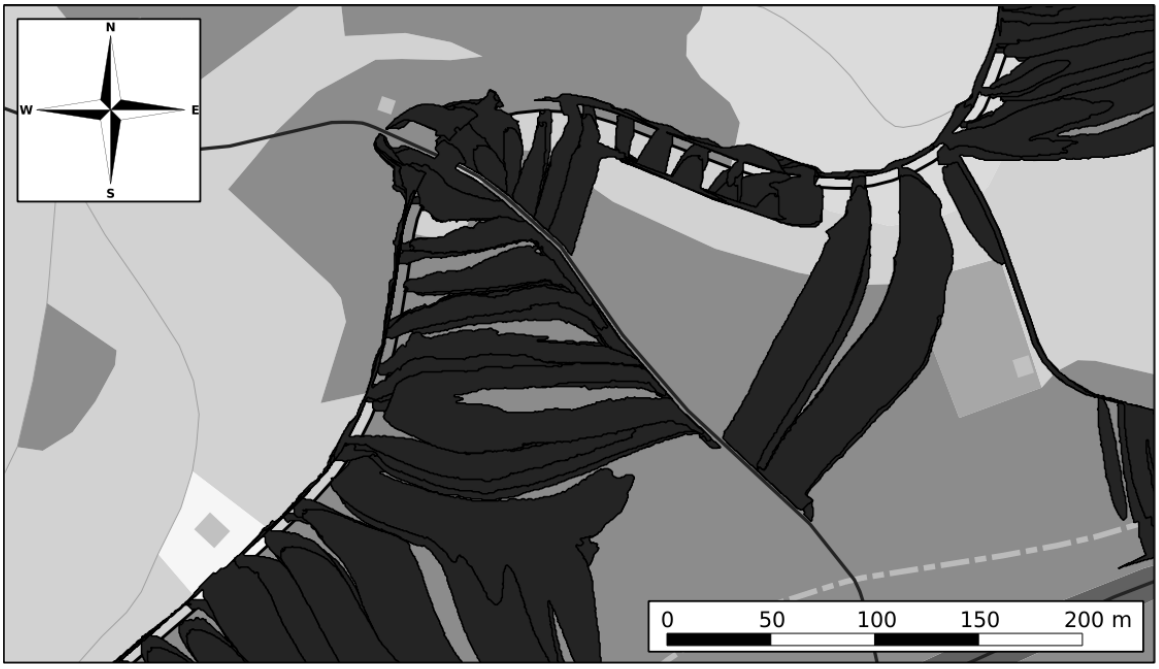
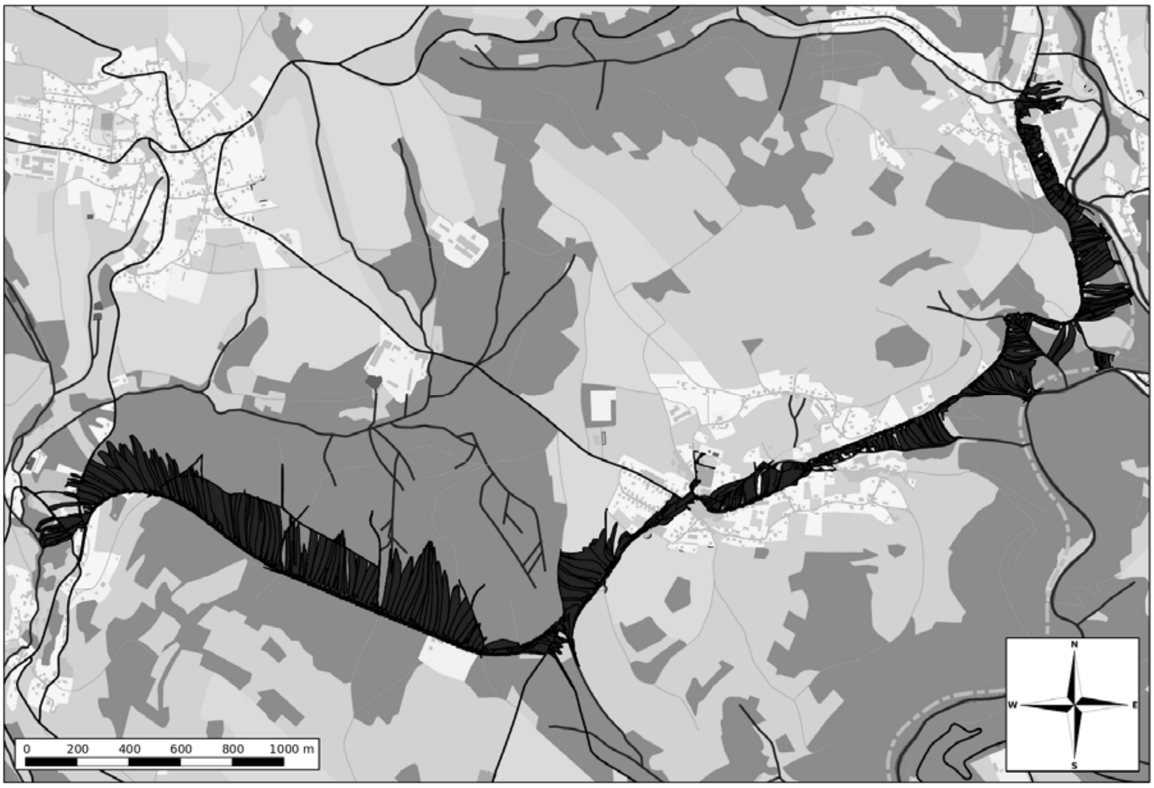


Fig. 5: Danger zone small details



5. Simulation software

The spill spread simulations are calculated by developed software. The software is divided to two parts. First part is intended to spill flow calculating. The second part is intended to result presentation on 2D or 3D view.

The calculation are time consuming, when group of spills on the road is calculated. Fortunately, Modern information technologies provide multiprocessor systems. Their using is optimal for this case.

6. Conclusion

This text describes the developed simulation model of spill spreading when traffic accident happens with liquid leak. The knowledge of spill progression is very important for the risk assessment. There is many uncertainties, which enter into spill spreading calculation. It means, the stochastic approach must be applied for proper results. The danger zone may be set next to road on the basis of calculated results. The simulation model is implemented into software application.

Acknowledgement

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The Route for the Decreasing of Air Pollutants Using Photocatalysis over Titanium Dioxide Incorporated in to Different Kinds of Concrete Surfaces.

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Abstract

Elevated amount of the gaseous pollutants occurring in close vicinity of traffic arteries represent still pressing issue. One way, how to fulfill the efforts for decreasing of pollutants concentration in localities affected by the traffic is utilizing photocatalytically active titanium dioxide (TiO_2) applied on the surface of concrete structures and buildings located in close area of traffic junctions and other localities influenced by traffic. The photocatalytical reactions can run only if the irradiation with suitable wavelengths interacts with surface of a photocatalyst. Final effect of degradation over photocalysts is strongly dependent on light intensity, humidity and air flow rate as well as on the concentration of gaseous pollutants. Except the conditions mentioned above, the nature of the photocatalyst, its surface structure and of course its amount on the surface of the hardened concrete plays crucial role in the photodegradation process. The present work refers the results of photodegradation activity of different types of concrete materials with characteristic surface roughness.

1. Introduction

Nitric oxides (NO_x) comprise namely NO and NO_2 belong to the most significant air pollutants. Transportation and energy industry are two main sources of NO_x and approx. 90 % of NO_x emitted by these sources is composed by NO. NO_2 originates subsequently by the reaction of NO with ground-level ozone. Whereas, NO_2 represents more dangerous substance compared to NO, namely for its capability to form photochemical smog. Till the 1999 the emissions of gaseous air pollutants have decreased due to the legislative regulations. Since this year the amount of pollutants in air stagnates, whereas increase of transportation is one of the significant reasons for this phenomenon. Despite the utilization of the high efficient catalyst converters built in cars the pollution in close vicinity affected by transportation represent still serious problem. The degradation of NO_x using photocatalytical reactions is one of the promised way how to decrease the amount of this serious gaseous air pollutants.

Titanium dioxide (TiO_2) is probably the most often studied photocatalyst. There are three modifications of TiO_2 occurred at ambient conditions – anatase, brookite and rutile. The surface and structural properties of TiO_2 were summarized in detail by Diebold [1] and the principle of photodegradation mechanisms over TiO_2 can be found in review article published by Carp et al. [2]. Among TiO_2 modifications, anatase form is the most studied for its highest photocatalytic activity. Most studied application of anatase falls to the field of photodegradation of environmental contaminants. Photodegradation activity of TiO_2 is proved with degradation of model substances presented in liquid as well as in gaseous phase. Among the most often studied model substances in gaseous phase belong nitric oxides [3], toluene [4] and formaldehyde [5].

The reason for the application of the photocatalyst to the surface of concrete products is connected to the general fact, that just concrete is the second most utilized „material“ after water. Almost three tones of concrete per capita is produced annually and has become dominant building material namely thanks to its low cost and easiness of its production. Utilizing of nanosized photocatalyst to the composition of concrete mixtures brings next advantage what is photocatalytically active surface. The surface modified by the photocatalysts can eliminate pollutants [6] in air or suppresses concrete biodeterioration [7]. Other benefit which photocatalysts can bring is antibacterial properties as was shown e.g. by Allen et all. [8]. Typical final applications of the photoactive TiO_2 related to building industry were comprehensively summarized by Chen and Poon [9] and comprise exterior and interior paints, pavement blocks, roof tiles etc.. Other possibility how to incorporate photocatalytysts to cement based materials is utilization of clay/TiO_2 composites [10].

In this work we studied the usage of photocatalyst PRETIOX PK-20A (commercial trademark for nanosized TiO_2 produced by PRECHEZA a.s.) as photoactive admixture in various types of concrete products. Photocatalytic activity of the prepared samples was tested according to the standard ISO 22197-1:2007 Fine ceramics (advanced ceramics, advanced technical ceramics) -- Test method for air-purification performance of semiconducting photocatalytic materials -- Part 1: Removal of nitric oxide.

2. EXPERIMENTAL DETAILS

2.1 Samples description

For the photodegradation experiments five recipes were used for preparation of mixtures based on the cement binder which after hardening represented five different surface structures commonly occurring at concrete products, composition of initial mixtures is shown in Table 1. The first sample (Fig. 1) assigned by symbol **A** represents hardened mixture prepared according to ČSN EN 196-1 and with respect to added aggregate the samples show relatively embedded matrix, with unexpectedly higher population of pores on the surface. Sample **B** (Fig. 2) represents formulation of wear layer of pavement and represents probably the most utilized kind of the surfaces of vibro-pressed pavements. Light-weight concrete mortar is presented by the sample **C** (Fig. 3) and in this work this sample was utilized as a standard of flat closely packed surface structure. In common practice this kind of mortar is utilized as non-structural concrete filling, which often contain also light-weight aggregates. The composition of absorbing surfaces of anti-noise screens were prepared in two variations: i) as sample **D** (Fig. 4) which represents common porous concrete and ii) as a sample **E** (Fig. 5) which represents light-weight porous concrete. At all of the mentioned samples the load of the photocatalyst PRETIOX PK-20A reaches the same value 12.5 g what allows easier comparison of the photodegradation activity of prepared samples.

Tab. 1: Composition of laboratory prepared samples of concretes with different surface rougnhess

List of admixtures	Formulation according ČSN EN 196-1	Formulation of wear layer of pavement	Light-weight concrete mortar	Porous concrete	Light-weight porous concrete
	A	B	C	D	E
	[g]	[g]	[g]	[g]	[g]
Cement CEM I 42,5R (Hranice)	450	250	250	150	150
Water	225	87,5	-	60	80
PRETIOX PK-20A (Precheza)	12,5	12,5	12,5	12,5	12,5
Standardized sand CEN	1350	-	-	-	-
Sand PR30/PR31/ PR33 (Provodín)	-	1000	-	-	-
Natural aggregates fr. 4-8 mm (Náklo)	-	-	-	650	-
Light-weight aggregate Liapor 0-1mm (previously soaked in water)	-	-	0,7 [L]	-	-
Light-weight aggregate Liapor 4-8 mm (dry)	-	-	-	-	0,7 [L]

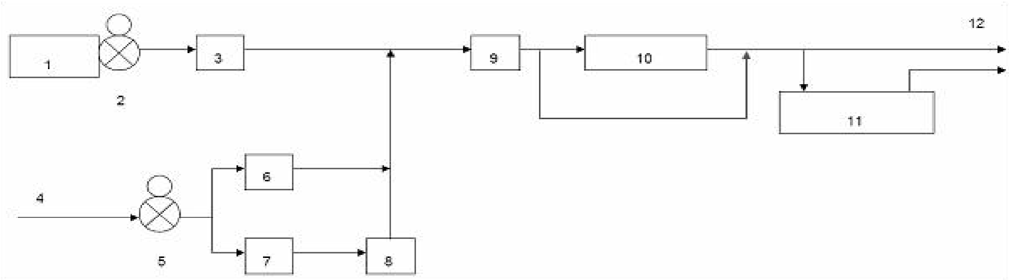
Fig. 1: Sample A Fig. 2: Sample B Fig. 3: Sample C Fig. 4: Sample D Fig. 5: Sample E

2.2 Photodegradation experiment

The apparatus for testing of photodegradation activity against NO was built up according to standard ISO 22197-1:2007. The whole process of testing given by this standard is divided into the two main parts: i) own photodegradation test in apparatus described in scheme in Fig. 6 and ii) determination of nitrates originating on the sample surface. Only the first part of standardized method was used for testing of the prepared samples in this work. To describe the affect of input NO concentration on photodegradation activity of the prepared samples the photodegradation tests were performed for two input concentrations 1 and 0.1 ppmv, respectively.

As a testing gas serves mixture of air containing 1,00 (0,1) ppmv of NO and is prepared by the mixing of pressure air (4) and N_2 enriched with NO (1). Pressurized air (4) is divided by the two stage reduction valve into two independent branches. Air in the first branch goes through the glass gas wash bottle (8), air in the second branch flow directly to the mixing point. Flow of the air in both branches is regulated by the thermal mass flow controllers (Sierra 100 Smart-Trak) (6 and 7). The ratio of the „dry“ and „wet“ branches is regulated to give final humidity 50% (25 °C). The concentration of NO in testing stream is given by the amount of the mixture of N_2 enriched by NO (1) which is driven using the thermal mass flow controler Sierra 100 Smart-Trak (3). After the gasses are mixed they pass through the stainless steel cell containing mounted probe (Greisinger electronic GmbH GMH 3330) for humidity measurement (9). The flow rate of testing gas is kept constant to give value 3.0 Nl/min during the experiment. Testing gas than flow directly to NO_x analyzer (Horiba APNA-370) (11). After the stabilization of the registered concentrations, the stream of testing gas is switched to the photoreactor (10) containing testing sample. Before the UV light is turned on the measured concentration of nitric oxides has to be stabilized, what means equilibration of nitric oxides absorption in photoreactor, it takes no more than 15 min. After this period the source of UV light (Osram L 40/79 K) is switched on, the distance of UV tube from sample surface is adjusted to reach the intensity of UV light measured at 365 nm 10.0 ± 0,5 W/m^2. After one hour of irradiation the dosing of testing gas is terminated and photoreactor is scavenged with the air for next 15 min.

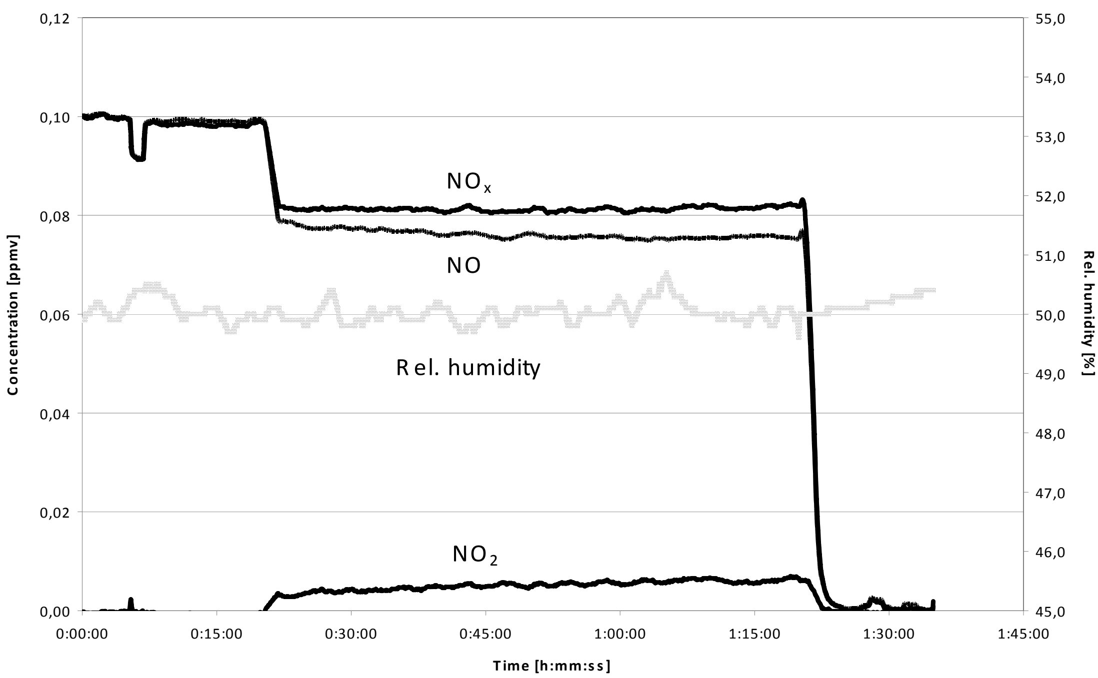
Fig. 6: Schematics of apparatus used for phototodegradation tests.



3. RESULTS AND DISCUSSION

The example of time dependency of NO_x, NO and NO_2 concentration and relative humidity during photodegradation experiment with 0.1 ppmv NO registered for sample D is pictured in the Fig. 7.

Fig. 7: Graphical presentation of NO_x concentration during photodegradation test



The amount of the degraded NO and originated NO_2 after the photodegradation tests was calculated and expressed in µmol. The difference between both concentrations gives the amount of degraded NO_x. The results for both NO input concentrations (0.1 and 1.0 ppmv) are shown in table 2.

Tab. 2: Mass balance of NO, NO_2 and NO_x in µmol for both NO concentrations

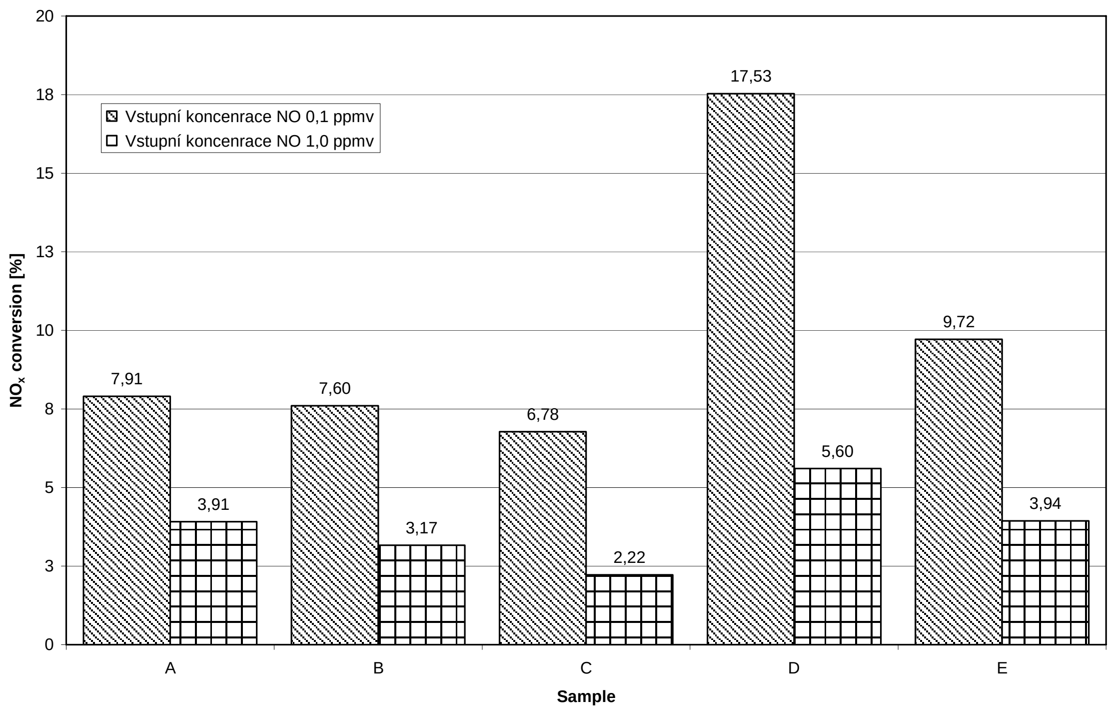
Sample	Degraded NO	Amount of NO_2 originated	Degraded NO_x	Degraded NO	Amount of NO_2 originated	Degraded NO_x
	0.1 ppmv			1.0 ppmv		
A	0.0883	0.0259	0.0624	0.4576	0.1322	0.3254
B	0.1042	0.0446	0.0597	0.3946	0.1379	0.2568
C	0.0888	0.0371	0.0517	0.3165	0.1312	0.1853
D	0.1831	0.0436	0.1395	0.7280	0.2621	0.4659
E	0.1020	0.0255	0.0765	0.4282	0.1094	0.3188

For simplification, the degree of NO_x conversion caused by the UV irradiation was calculated using equation (1) and obtained values are graphically presented in Fig. 8.

$$NO_x(conversion) = \frac{cNO_x(1) - cNO_x(2)}{cNO_x(1)} \cdot 100 \qquad [\%] \qquad (1)$$

$cNO_x(1)$ ... average NO_x concentration before UV irradiation applied
$cNO_x(2)$ ... average NO_x concentration during UV irradiation

Fig. 8: NO_x conversion during irradiation



Comparing the calculated data of NO_x conversion it is evident that photococatalytical efficiency is strongly dependent on the surface roughness. The sample D exhibits the highest photodegradation activity against NO_x as evident from Fig. 8. The efficiency of the degradation is also dependent on the amount of NO in testing gas and with growing NO concentration this value decreases as well.

4. CONCLUSIONS

All of the prepared samples show significant ability for photocatalytic degradation of NO_x. Obtained results show that photoactivity of concrete surfaces is strongly dependent on the concrete composition. The samples of porous concrete show the highest values of NO_x conversion. With respect to applicability of photocatalysts into formulations of photocatalytically active concretes any obvious difficulties does not occur regarding the technological aspects of concrete production.

The addition of photocatalyts based on TiO_2 into concrete formulations is relatively cheap solution bringing significant ecological benefit.

ACKNOWLEDGMENT

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Education and Edification – an Important Part for Improving the Air Quality

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Abstract

Air quality is a complex never ending problem changing in time. Majority of pollutants is produced by chassis energy sources, industrial and chemical operation and significantly also by residential areas.

It is the pollution from residential areas that is becoming a serious Langer for the health of its residents. The health risk is moving to smaller towns and to the country. Main sources of pollution are:

- Agriculture (large scale production and partially small scale production)
- Local furnaces (heat sources in households)
- Traffic.

Small and medium size residential areas the pollution produced by household heating systems is combined with the traffic pollution thus increasing the risk of health damage above the level of large cities. Desulphurization of power plants, decrease of pollution, new legislation…all of this was publicly presented and citizens became aware of it. Many specialized agencies were established and many specialists in the area of environmental protection grew up. Daily information on the environment was published in mass media almost the moment national network of pollution monitoring was built. Cities presented the information on the environment on information desks.

Later this information in mass media was limited to information on smog episodes and political battles concerning the new Act on environment. The awareness on environment has evaporated. Nevertheless there is a lot of information on various levels, from various institutions and specialists including on-line data provided by servers on various organizations dealing with monitoring. These data, however, are scattered and difficult to understand unless one is a specialist. All this information can be used on the area of education in the broadest sense, from kindergarten to universities.

1. Virtual centre on information concerning the environment

In order for various royalty free data on environment could be used on the area of education it is necessary that these data are gathered in a central point, where they will be kept up to date and available for general public. These data must meet the following criteria:

a) Assorted
b) Logical
c) Comprehensible

It is important to realize that these data will be used for didactic purposes for teachers as well as students and pupils. This is the basic idea behind the Virtual centre of information on environment. It is Virtual because it uses links on the internet and on-line data provided by various institutions providing instant information on the environmental situation. The aim of the Virtual centre is to cover all available area sof the environment.

2. Logical scheme of the Virtual centre

Virtual centre of information on environment is dividend into modules covering all areas of the environment:

Module Air covers air pollution and related processes
Module Water covers surface water and ground water pollution
Module Soil covers the changes on the soil quality as a result of changes in the environment
Module Nature (flora and fauna) describes the status of nature, endangered species in the area, and specifications of the biotope

Each Module has the following structure (an example of module Air for presentation at elementary schools):

Description of air, its composition…..
Basic texts, simple presentation
Air pollution
Basic texts, simple presentations in the entire range
On-line data
Extending and demonstrative links on servers providing related information, mainly data from current monitoring.
News

Sources of pollutions are described together with ways of preventing it.

The Virtual centre is divided in to the following sections:

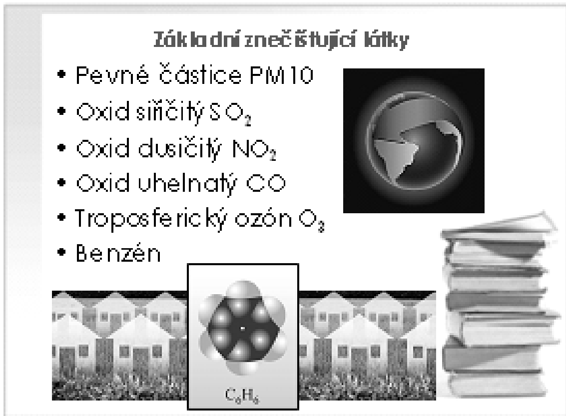
a) Encyclopedic section is used for preparation of teachers and as a centre of information for additional educations.
b) Teaching section – ready-to-use presentations
c) On-line section – links on updated information on the environment from various servers with focus on the local area.
d) News – links on updated information from the studied area.

3. Didactic division

Encyclopedic section contains various articles by specialist customized to the needs of teachers. It contains complex information for teachers and it is divided into various modules

- Primary School (1-4th grade)
- Elementary School(5th – 9th grade)
- High School I (10th and 11th grade)
- High School II (12th and 13th grade)

Presentations for Primary Schools contain not only teaching materials but also photocopiable worksheets. In the other levels the worksheets are replaced by knowledge test. An example of a teaching material:



4. Opportunity to use the Virtual centre

The main aim of the Virtual centre is to facilitate and provide information useful in the course of teaching specialized subjects dealing with environment and to bring the science closer to reality.

Virtual centre is being made accessible via Internet and its capacity is not limited, except the limit of the server size.

Teaching materials are downloadable in PowerPoint format or eBeam for interactive boards.
Information gathered in the Virtual centre can be used by anybody who has the Internet access.

5. Basic information provided by the Virtual centre

- Complex information on the protection of environment assembled and selected according to the topic.
- Teaching presentation for the given area
- Updated sample data
- Related links (articles, interesting facts, etc.)

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Technologies of Decreasing of Harmful Pollutants in Road Vehicles´ Exhaust Gases

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Abstract

The article deals with road-transport emissions´ problem. The opening part of the article is formed of „Euro“ standards´ characterization. The main part of the article describes two systems of exhaust gases´ cleaning – Selective Catalytic Reduction (SCR) and Exhaust Gas Recirculation (EGR). The main characteristics, advantages, disadvantages and principles take place here. The last part of the article solves the view to the future in emissions´ reduction range – especially EEV and Euro 6 standards.

1. Emission norms Euro

Emission (also ecological) norms „Euro“ are founded on the principle of California-laws. These laws were founded in the fifties of last century in the USA. Euro norms define allowed limits of harmful emissions such as – nitrogen oxides (NO_x), particulates (soot, PM), carbon monooxide (CO), carbon dioxide (CO_2) and hydrocarbons (HC, C_xH_y).

Euro-norms came to be implemented since early nineties of 20th century. Concretely the first ecological norm Euro 1 came into force in 1992. Norm Euro 1 has been stepped up by Euro 2, 3 and 4. Since 2009, Euro 5 has been obligatory. [1] Certain limits[1] of harmful substances for petrol- and diesel-powered vehicles are shown in tables *Tab. 1*. and *Tab. 2*.

Tab. 1: Limits of harmful substances for petrol-powered vehicles

Year / norm Euro	CO (g/km)	NO_x (g/km)	HC (g/km)	NO_x + HC (g/km)
1992 Euro 1	3,16	-	-	1,13
1996 Euro 2	2,20	-	-	0,50
2000 Euro 3	2,30	0,15	0,20	-
2005 Euro 4	1,00	0,08	0,10	-
2009 Euro 5	1,00	0,06	0,10	-
2014 Euro 6 (?)	1,00	0,06	0,10	-

Source: Autolexikon [10]

Tab. 2: Limits of harmful substances for diesel-powered vehicles

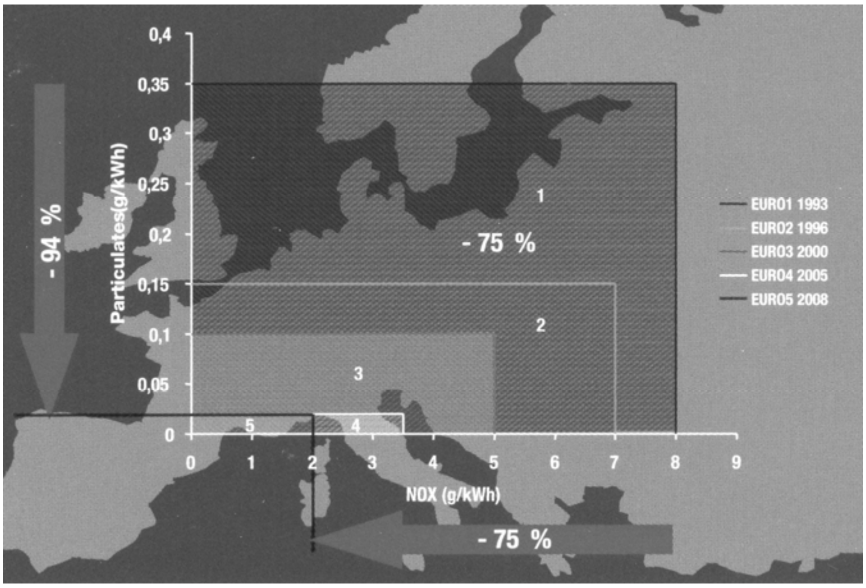
Year / norm Euro	CO (g/km)	NO_x (g/km)	NO_x + HC (g/km)	PM (g/km)
1992 Euro 1	3,16	-	1,13	0,18
1996 Euro 2	1,00	-	0,70	0,08
2000 Euro 3	0,64	0,50	0,56	0,05
2005 Euro 4	0,50	0,25	0,30	0,025
2009 Euro 5	0,50	0,18	0,23	0,005
2014 Euro 6 (?)	0,50	0,08	0,17	0,005

Source: Autolexikon [10]

[1] values may vary according to adopted literature

Norms Euro 1, 2 and 3 involved mainly combustion process´ effectivity increase – elevation of injection pressures, multi-point injection, electronically controlled combustion process, multi-stage supercharging, etc. Also better-quality fuel has been obligatory – unleaded petrol, low-sulfur diesel. As from Euro 4 the additional modification of exhaust gasses has been necessary. Systems of additional modification of exhaust gasses are described *in chapter 2*. The process of emissions´ production decrease from Euro 1 to Euro 5 shows *Fig. 1*.

Fig. 1: The decrease of emissions´ production in road transport



Source: DAF [8]

The *Fig. 1* showes that a significant decreases of allowed limits brought mainly norms Euro 2 and Euro 4. Totally, the decrease of NO_x since 1993 has been of 75 % and the decrease of PM (particulates) has been even of 94 %. It is also evident, that Euro 5 tightens up norm Euro 4 in the case of NO_x only. Limits of PM stood on the same level – ca. 0.02 g/kWh.

Comparing the limits of harmful substances, which have been allowed by Euro 3 and later by Euro 4, we'll realize that the decrease of NO_x is of 30 %, the decrease of CO_2 is of 10 % and in the case of PM the decrease is of 80 %.

Comparing limits of harmful substances allowed by Euro 3 and by Euro 5, we'll realize that the decrease is up to 60 % in the case of NO_x. In other words: Euro 5 compared to Euro 4 has cutted limits of NOx emissions of 30 %.

2. Technical systems of decrease of road vehicles´ emissions

Starting with Euro 4, it has been necessary to fit up vehicles by systems of additional modification of exhaust gasses. There are two ways of exhaust-gasses´ cleaning. The first one is „Selective Catalytic Reduction“ (SCR) and the second one is „Exhaust Gas Recirculation“ (EGR). The first mentioned system – SCR – need for its operation a special liquid called AdBlue. System EGR does not require any additional substances. Although SCR and EGR systems are mentioned in context of trucks and busses mainly, the truth is that system EGR has been used in passenger cars too. System SCR has not been used in this sphere at all.

2.1. SCR technology

The principle of this system consists in electronically controlled injection of 25.25 % aqua urea[2] (ammonia, NH_3) into exhaust pipe (in front of exhaust-gas catalyst) of a vehicle. Urea in the catalyst decomposes NO_x into nitrogen (N_2) and water (water vapour). These substances are generally in the atmosphere. Commercial name of urea is „AdBlue“. Price of AdBlue is approximately one half of diesel price – 15-17 CZK/litre. [2]

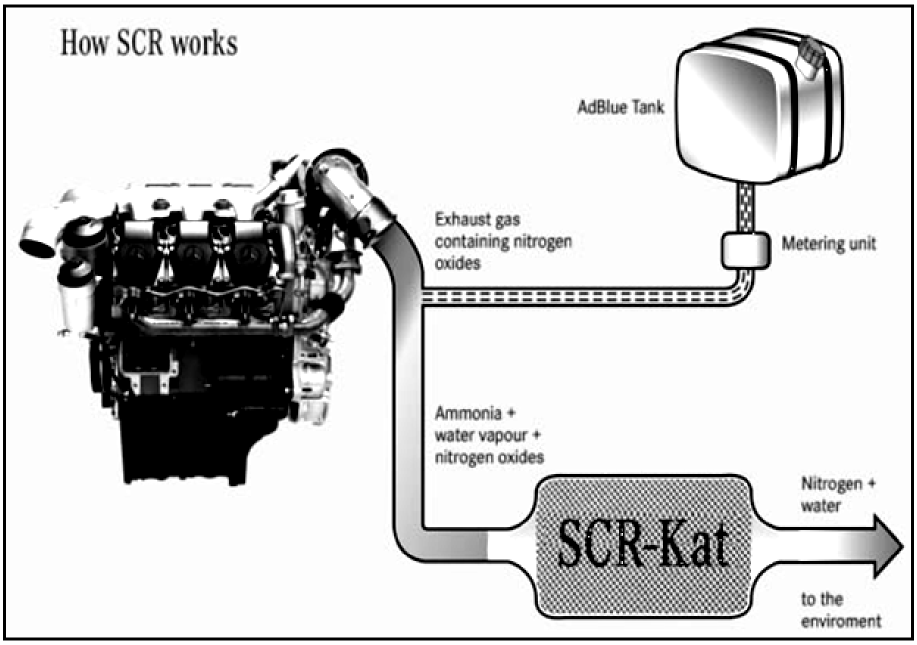
AdBlue is colorless and odourless liquid, biodegradable in nature. AdBlue can be bought at petrol-stations – either in canisters, or at dispensing pump (similar to fuel dispensing pump). A driver has to fill AdBlue into a special tank in a vehicle. Capacities of the tank vary from 75 to 150 litres. Tentatively – if a vehicle is equipped by the biggest AdBlue-tank, the reserve of AdBlue cleans exhaust gasses on up to 7000 kilometres (by average fuel consumption of 30 litres per 100 kilometres). The disadvantage of SCR system is that AdBlue freezes by -10°C. In this case, the vehicle does not comply with Euro 4 or Euro 5 until AdBlue is not defrozen[3] by a heat of exhaust silencer.

The consumption of AdBlue is proportional to fuel consumption of a vehicle. It is expressed as a percentage of diesel consumption. Concretely, ca. 4 % in the case of keeping Euro 4 and ca. 7 % in the case of Euro 5. [1]

According to information from ÖMV, thirty-five Euro 4 vehicles produce the same quantity of PM as the only one Euro 2 vehicle. Similarly – seven Euro 4 vehicles produce the same quantity of NO_x as one Euro 3 vehicle.

The principle of SCR system is displayed in *Fig. 2*.

Fig. 2: SCR system principle



Source: BlueCat [9]

[2] according to literature [2] the water solution of urea is of 32.5%
[3] during this time period the vehicle comply approx. with norm Euro 2

2.2. EGR technology

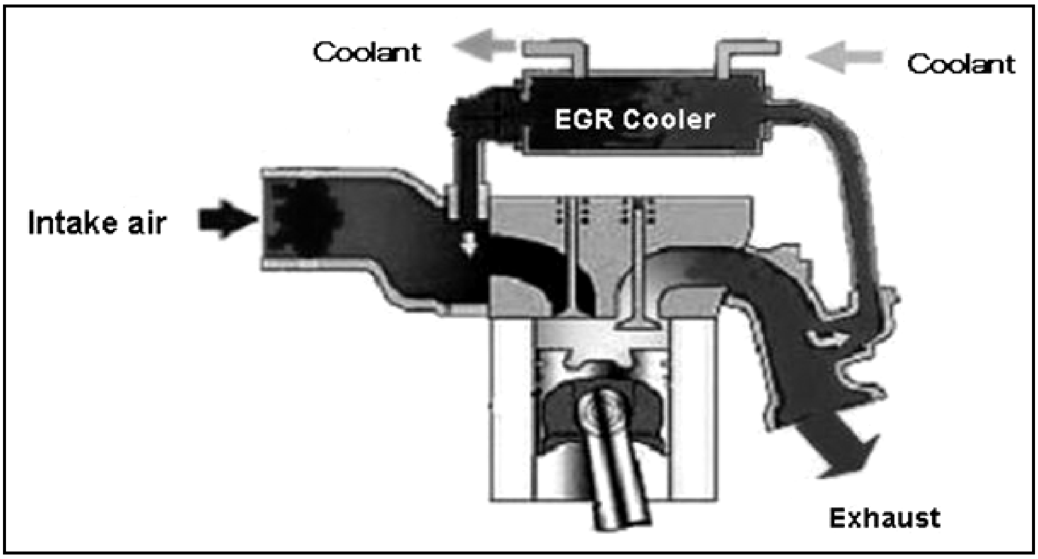
System EGR offers another possibility to comply with Euro 4 and Euro 5 emission norm. Some literature names this system by abbreviation „AGR“. In this case it comes from German „Abfall Gas Rezirkulation“ or „Abgasrückführung“. [3] [4]

Compared to SCR, system EGR does not need any special liquid for cleaning of exhaust gasses. Other advantages of EGR are savings of weight and space in a vehicle. The whole cleaning procedure is made „in the engine“. On the other hand EGR compared to SCR is technically more difficult and involve strengthened cooling system, high-pressure injection system, double-stage supercharging, double-stage intercooling and sometimes filter of particulates (e.g. referred to as PM-KAT in MAN vehicles). [5]

The principle of EGR system is as follows. Approximately 10 % of exhaust gasses outgoing from the engine is taken away from exhaust pipe, cooled in a special cooler (EGR-cooler), mixed with induced air and sucked back into the engine. Doing so, there is less quantity of „fresh“ air in the engine, so the temperature of combustion is lower, so the production of NO_x is lower. The major problem is that production of NO_x is in indirect proportion with PM. Therefore if we lower NOx emissions, we automatically raise PM emissions and vice versa. That’s why we have to PM production reduce subsequently using high injection-pressures (more than 2000 bar) and sometimes a vehicle must be equipped with a special catalyst (filter) in its exhaust-pipe, as mentioned above. [1]

The principle of EGR system is illustrated in *Fig. 3*.

Fig. 3. EGR system principle



Source: T.RAD Corporation [11]

3. The summary and the view into the future in further road transport ecologization range

3.1. Euro 4 and Euro 5 norms

As mentioned *in chapter 1*, norm Euro 5 takes place these days. It is interesting that Euro 5 vehicles have been given on the market together with Euro 4 vehicles (in 2005) – so approximately three years before Euro 5 came into force. This shows that vehicle-producers are not underestimating the meaning and obligation of Euro norms.

The length of Euro 5 force is not certain yet. But years 2012-2014 are coming into account. Than, Euro 6 will replace current norm. According to available sources, certain limits of Euro 6 have not been given yet.

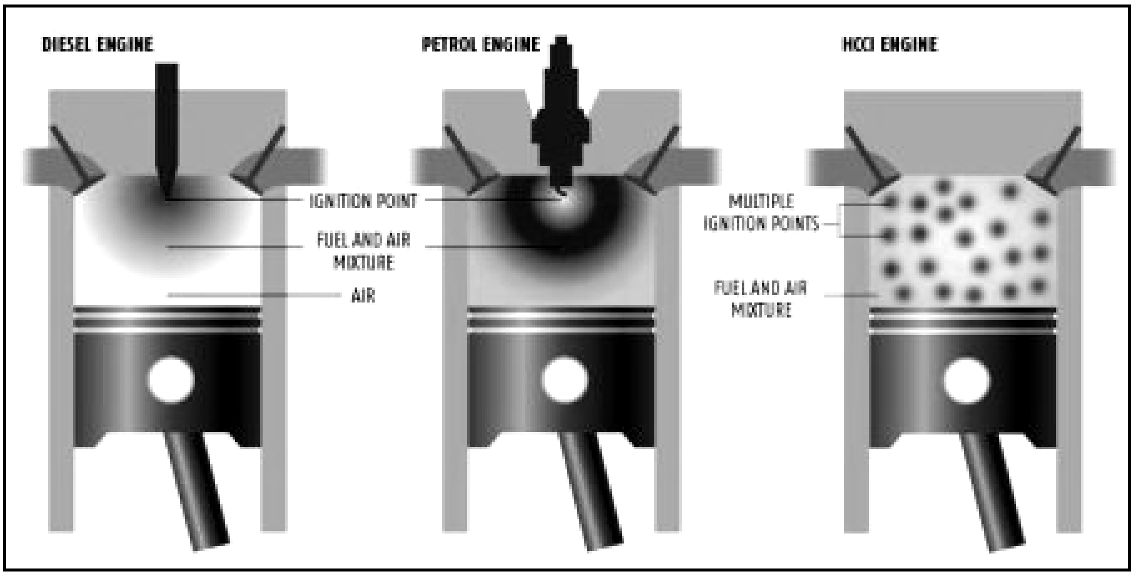
3.2. Euro 6 and EEV norms

Since 1999, a voluntary emission-norm EEV (Enhanced Environmentally-friendly Vehicles) forces together with Euro norms. A row of truck- and bus-producers fulfils limits of this norm for many years. Among these producers belong e.g.: Scania, MAN and Irisbus Iveco.

Concerning fulfilling limits of on-coming norm Euro 6, probably combination of EGR and SCR system will be used. In other words – vehicles will probably be equipped with both these systems together. Also system HCCI (Homogeneous Charge Compression Ignition) will be in use – see *Fig. 4*. [12]

Question arises whether after norm Euro 6, norms like Euro 7 etc. will be coming. Authors think that after Euro 6, the next step in road-transport ecologization will vest in next lowering of fuel consumption mainly, because emissions of road vehicles will be as low as possible. As for consumption lowering, noticeable reserves are identified. Partly in vehicle-construction range and partly in drivers´ behaviour range – namely in *eco-driving principles*. Truck-producers (such as Volvo, Scania, DAF, Renault etc.) offer these special courses.

Fig. 4. HCCI system principle



Source: Tundra [12]

3.3. Fleet Management and its potential in emissions´ lowering sphere

A special attention in the sphere of trucks and busses has been paid to ITS systems applicable to management of vehicle fleets. It is called „*Fleet Management System*" or also „*Fleet Controlling*" (FC). This instrument brings a row of benefits for a road-hauler. The potential of FC in the range of operation economics and ecology is very high. For example thanks to application of Volvo's system DynaFleet, the fuel consumption and emissions´ production (of CO_2 mainly) can decrease of 15 %.

FC offers vehicle tracking and monitoring of operational conditions in real time with possibility of active influence of driver’s behaviour during driving. Since the production of emissions is proportional to vehicle’s consumption, it´s evident that the engine has to operate in optimal range of revolutions so that its fuel consumption is as low as possible. By current vehicles this revolution range is ±900-1500 rpm.

A sufficient inflation of tyres is also very important for optimal consumption and minimal emissions´ production. This problem can be solved e.g. by system *TPM (Tyre Pressure Monitoring)*. Information from TPM is transferred onto driver’s dashboard and in cooperation with FC-system even dispatcher or vehicle fleet manager sees this information on his/her computer. So a dispatcher can warn a driver in the case a driver does not pay attention to warning message on vehicle’s dashboard. [6] [7]

Economical and ecological benefits from FC´s implementation are evident.

Acknowledgement

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Roadsides Function as Halophyte Habitats in the Landscape

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Abstract

Vegetation lines along roads are localities of secondary habitation of salt-tolerant species. Along roads in the Czech Republic, at least sixteen wildly growing halophytes and many other salt-tolerant species were found. Roads are known for being corridors for not only migration of small animals, but also expansive, invasive and halophytic plants. Since many plants growing along roads are weeds, there is a real danger that these plants will invade nearby agricultural crops. Thus biological degradation of agricultural areas can be started, and consequently financial loss due to damaged harvest can be caused. This article discusses weed species and salt-tolerant species growing along roads of various types in the Czech Republic.

1. Introduction

Roadsides are affected by construction repairs, road maintenance, and mowing [1,2]. The vegetation of road verges and lines close to roads is affected by traffic emissions and substances added to road spreading [3]. Salt is the most commonly used agent for de-icing of roads. The extent of harm caused to plant species depends on sensitivity of the plant species and amount of salt applications. Repeated applications of salt have led to changes in plant composition in many roadsides. They also have affected dispersals of halophytic and salt-tolerant plant species [2]. All of these plants grew in the brims of the asphalt edges, about 0.25 to 0.35 m width [4-7].

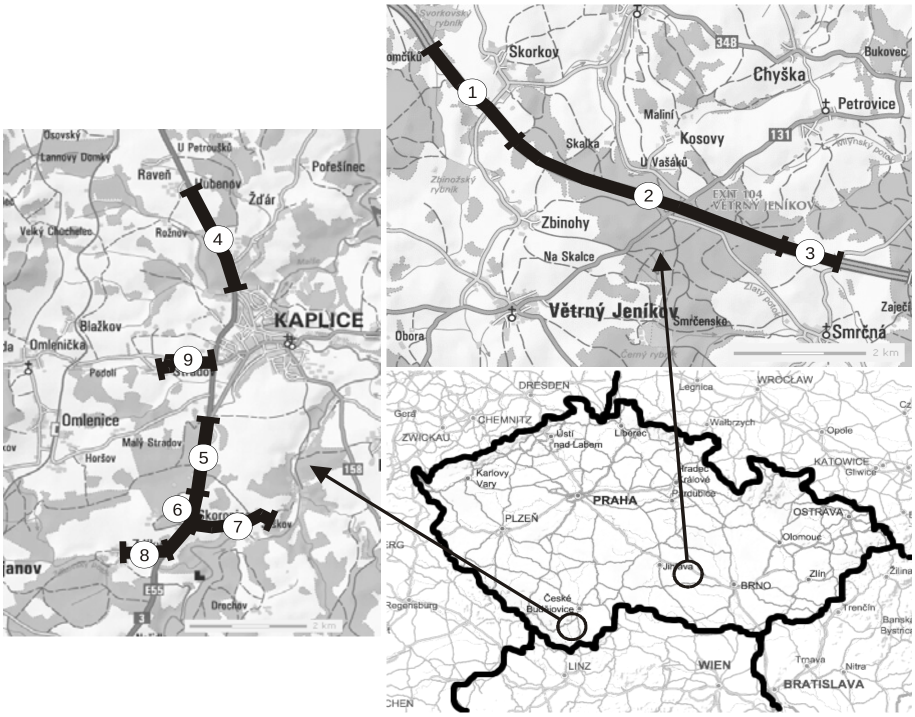
On the other hand, roadside verges are suitable habitats for both the occurrence and spread of weed and ruderal species [5,6,8,9]. Above all, roadsides are often considered as reservoirs for non-native or invasive plant species [5,7,10-12].

This paper is focused on research of weed, ruderal and alien species of salt-tolerant character and their possible spreading via road network into agriculture areas. The first preliminary result is presented in this contribution.

2. Methods

Two investigated territories included various types of roads (motorways, roads of class II and of class III, according to http://rsd.cz) in the mesophytic region of the Czech Republic. The first study area was situated in The Českomoravská Highlands (localities number 1-3) and the second in the South Bohemian region (localities number 4-9, Figure1).

Fig. 1:. Site locations



The first area: vegetation lines and median stripe of the D1 motorway from Humpolec to Jihlava: sites 1-3 in sections Skorkov – Smrčná (total length 7.4 km). The second area: included the vegetative lines along the IInd class E55 road, from Č. Budějovice to Horní Dvořiště: sites 4-6 in sections Hubenov – Kaplice and Kaplice – Skoronice (total length 4.3 km); and adjoining the IIIrd class road branches: sites 7-9 in sections Kapice – Stradov, Skoronice – Ježov, and Skoronice – Zdíky (total length 3.2 km).

Both areas belong to hilly, agricultural-forest landscape with forest, field and grassland patches [13]. Average annual temperature is 7.5-8.5°C and yearly precipitation range is 700-900 mm. The areas are characterized by a short, moderate to moderately-cold and moderately-dry summer, with a moderate spring and autumn, and with a normally long winter [14]. Annual traffic volume amounted to around 17,000 heavy vehicles and 38,000 all vehicles in the investigated motorways and about 3,000 heavy vehicles and 7,400 all vehicles in the secondary roads [13]. Natural and abiotic characteristics of nine investigated localities are described in more detail in [5].

The vascular plant species have been recorded on both sides of the roads (width 1.5 - 3.0 m) and in the median stripe in the spring (from April to June) and autumn (from September to October) since 2002. Botanical nomenclature was taken from [15]. The main objective was focused on halophytic species. The indicator values of tolerance to saline soil conditions were taken from [16]. The recorded species were classified into three anthropogenic statuses: weed, ruderal and common wild plant species [15,17-23]. Plants registered as alien species were identified according to [24]. This subset was complemented with these characteristics: invasive status (casual, naturalized, invasive, post invasive), residence time (archaeophyte, neophyte). Obtained qualitative data were calculated using contingency percentage ratio.

3. Results

251 plant vascular species (except trees and mosses) were recorded, including 35 (14 %) species tolerant to saline soil conditions. One species was from category three (*Spergularia salina* J. Presl et C. Presl), two species from category two (*Elytrigia repens* (L.) Nevski, *Puccinellia distans* (Jacq.) Parl.), and the rest of the species from category one [16].

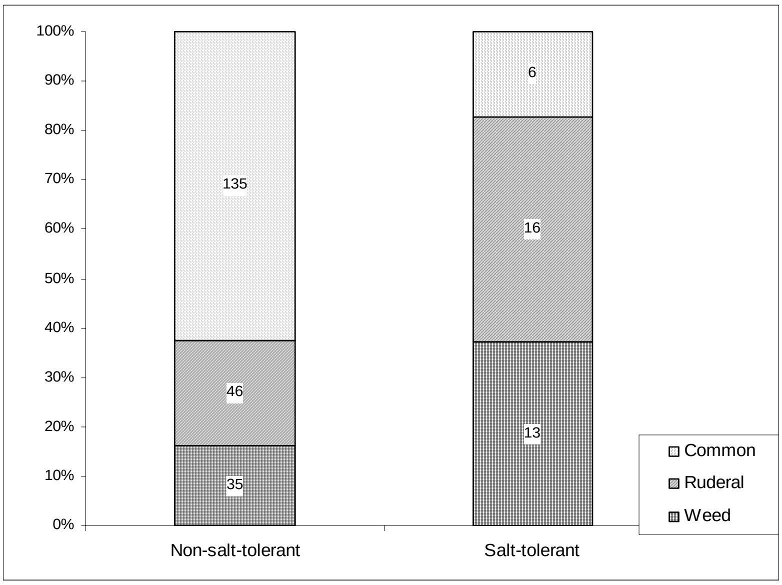
These salt-tolerant species were from 38 botanical families. The most plants belonged to the families of *Poaceae* (23 %), *Asteraceae* (20 %), *Chenopodiaceae* (11 %), *Caryophyllaceae* (6 %), *Fabaceae* (6 %) and *Juncaceae* (6 %). The full list of botanical families is in Table 1.

Tab. 1: List of the botanical families and number of species (n).

Family	n	Family	n
Amaranthaceae	1	*Juncaceae*	2
Asteraceae	7	*Oenotheraceae*	1
Brassicaceae	1	*Plantaginaceae*	1
Caryophyllaceae	2	*Poaceae*	8
Crassulaceae	1	*Polygonaceae*	1
Fabaceae	2	*Ranunculaceae*	1
Gentianaceae	1	*Rosaceae*	1
Chenopodiaceae	4	*Typhaceae*	1

The investigated anthropogenic structure differed from salt-tolerant and non-salt-tolerant species (Figure 2). The structure of salt-tolerant plants was: 46 % ruderals, 37 % weeds and 17 % common wild species. The structure of non-salt-tolerant plants was in ratio: 21 % ruderals, 16 % weeds and 63 % common wild species.

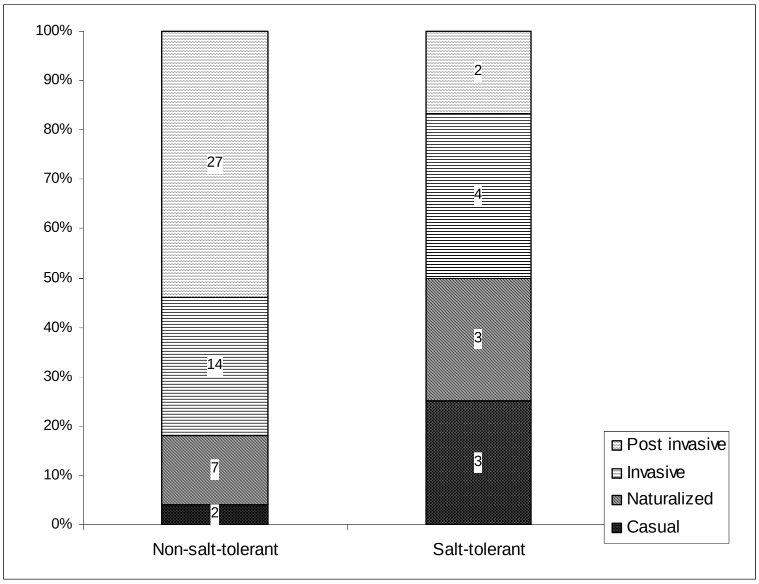
Fig. 2: Anthropogenic status of non-salt-tolerant and salt-tolerant species growing in research areas. Number of plant species is given.



Almost one quarter of the plants growing along roads were alien plant species. This subset was classified into salt-tolerant and non-salt-tolerant species. The invasive status of alien salt-tolerant plants differed from alien non-salt-tolerant species: invasive species dominated in the salt-tolerant category (33 %) (Figure 3). High number of salt-tolerant species had tendency to casual invasive status (25 %), in comparison to non-salt-tolerant species, where casual status had a minority distribution (4 %).

Archaeophyte and neophyte species were in salt-tolerant category in proportion 1 : 1. On the other hand, the structure of non-salt-tolerant plants was in ratio 4 : 1.

Figure 3. Invasive status of non-salt-tolerant and salt-tolerant species growing in research areas. Number of plant species is given.



The salt-tolerant species grow entirely in a short distance from the road asphalt, or in the median stripe. They grow in the zone of salt maintenance effect along all class roads. It was found that many species, which did not have the ability to tolerate salt, grow in a short distance from asphalt too. For example: *Agrostis gigantea* Roth, *Apera spica-venti* (L.) P.B., *Artemisia vulgaris* L., *Atriplex sagittata* Borkh., *Cardaria draba* (L.) Desv., *Centaurea jacea* L., *Dactylis glomerata* L., *Digitaria sanguinalis* (L.) Scop, *Echinochloa crus-galli* (L.) P.B., *Eragrostis minor* Host, *Lactuca serriola* L., *Medicago lupulina* L., *Polygonum aviculare* agg. and *Spergularia rubra* (L.) J. Presl et C. Presl.

4. Discussion

About 35 salt-tolerant species have been recorded on localities along roads and in the median stripe (mesophyticum region). One species growing along roads (*Spergularia salina*) is a critically endangered species in the Czech Republic [25]. Roadsides are secondary habitats of its distribution.

The comparison of the functional traits shows that salt-tolerant species are, comparing to non-salt-tolerant species, often weed or ruderal species. The analysis of alien plants growing along roads also showed that species with the tendency to salt tolerance are above all invasive or neophyte species. Roadsides are generally known to be often inhabited by ruderal, weed or non-native species, due to human activities [5-9]. The results showed that the brims closest to the asphalt part of the roads, although contaminated by salt spreading, are a suitable habitat for occurrence and spread of these species.

The most important halophytic species of road vegetation is *Puccinellia distans,* which was found along all class roads [5]. *Puccinellia distans* forms mono-species lines of 0.25 - 0.35 m width close to the asphalt edges and to the median stripe [4]. All 35 salt-tolerant species classified by Ellenberg occurred within a short distance from the asphalt edges. But it was found, that some other plant species, not indicated by Ellenberg salt number [16], grew in saline soil conditions, too. Their niches have probably larger tolerance to salinity than it was presupposed.

This result is in agreement with Piernik [26]: many species have ecotypes that are able to complete their life cycles in salty environment, even at very high salinity levels. Some of the plants mentioned by Piernik [26] were found growing in saline lines along roads: *Agrostis gigantea, Artemisia vulgaris, Centaurea jacea*, *Dactylis glomerata*, *Echinochloa crus-galli*, *Lactuca serriola*, and *Medicago lupulina*. In addition, other species found in the asphalt edges were: *Apera spica-venti*, *Atriplex sagittata*., *Cardaria draba*, *Digitaria sanguinalis*, *Eragrostis minor*, *Polygonum aviculare,* and *Spergularia rubra.* All the above mentioned plant species grew either very close to asphalt, or along the mono-species line of *Puccinellia distans.*

It is supposed that the number of invasive weeds (i.e. non native species) will increase with climate changes [27]. Weeds appear in higher-level locations more often, which is the consequence of global warming [28]. High abundance of the ruderal species *Digitia sanguinalis* recorded along roads created late-summer dominant lines, and thus took place of past-blossomed *Puccinellia distans*. *Digitia sanguinalis* (Large crabgrass) and *Echinochloa crus-galli* (Crab grass) probably belong to dangerous species that could spread to agricultural areas via road network. *Digitaria sanguinalis* and *Echinochloa crus-galli* are non-native, invasive species [24], which produce a large number of seeds per year [29]. *Digitaria sanguinalis* is considered to be an aggressive weed in some subtropical crops, mainly sugarcane, corn and soya. In Europe, it is a troublesome weed in corn [30]. *Echinochloa crus-galli* originates from central and eastern Asia. This species became a very significant weed, which does harm all around the Czech Republic due to the type of field management for the last fifty years [30,31]. Both of these species have spread very quickly along all class roads (motorways with median stripes; roads of the I, II and III classes) in the Czech Republic [4]. Roadsides probably supported the spread of these species from salt verges to agricultural areas.

Acknowledgement

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Walking as a Greenest Mode of Transport in Cities

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Abstract

Walking was the dominant mode of transportation in our cities for centuries. For this reason, the needs of pedestrians, besides other important things like defence, played a central role in the design of the shape and size of our cities. Amenities were located within walking distance and public spaces as well as all pedestrian routes were designed to enable easy waking and thus fostered social life in the public realm.

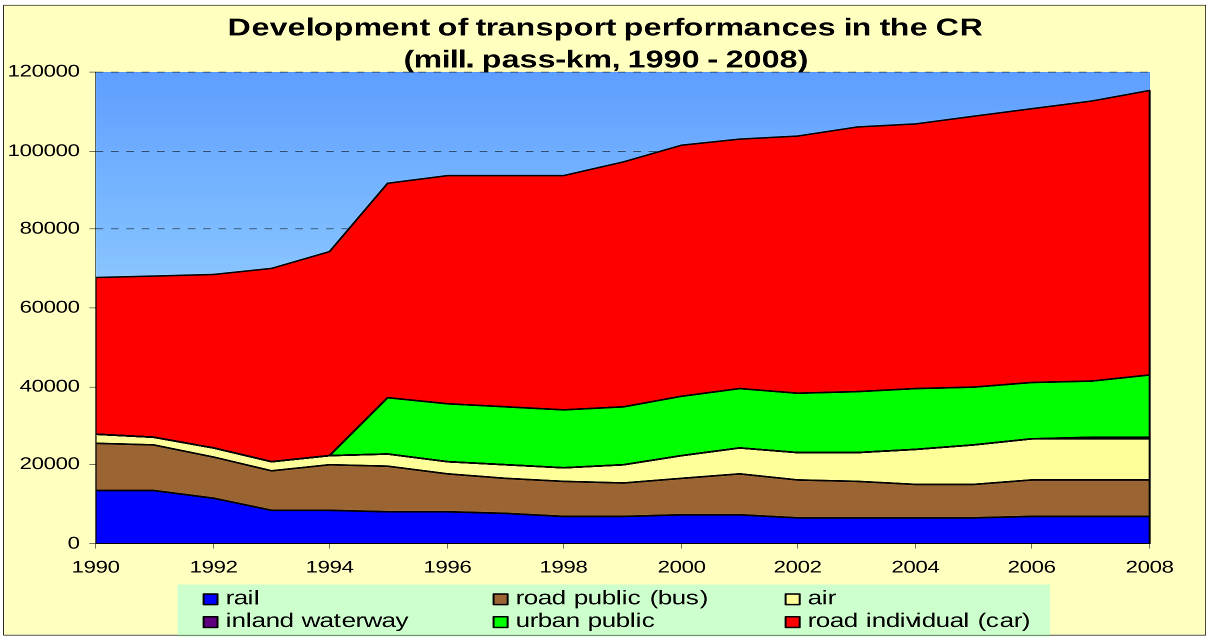
The industrial revolution changed this situation dramatically. Mass production and the advent of motorised transportation changed the size and shape of the European city. The rapid development of this new means of transportation and its related infrastructure fuelled urban growth at an unprecedented rate and dramatically changed the relationship between the various loci of activity within the quickly evolving city structure. The dramatic increase in private automobile ownership encouraged urban sprawl, leading to the need to commute and ultimately making city inhabitants and visitors dependent upon motorised transportation. In Central and Eastern Europe, these changes were much faster: within two decades, they reached the same level of motorisation and developed the same automobile-related problems as their counterparts in Western Europe. Due to decreased accommodation time and the lack of proper infrastructure, the problems seem even worse. Central and Eastern European state and regional transportation authorities have not learned much from the latest environment-oriented developments in Western Europe.

Ongoing problems, such as climate change, growing congestion and environmental pollution, call for both short- and long-term solutions, which can sustain mobility and provide healthy environments for urban inhabitants. The realization of liveable and sustainable cities is connected with many changes such as a shift from private motorised transportation to public and non-motorised forms of transportation, the coordinated interaction of land usage and transportation planning, transit-oriented development and user-friendly design, and sensitive renovation of European cities for their inhabitants and visitors.

1. Changing urban structure and its impact on walking conditions

The enormous increase in urban vehicle traffic has meant more mobility for its inhabitants as well as greater residential distribution. At the same time, however, it has created a series of conflicting situations in people's every day lives, both disrupting their living environment and disturbing the functional purpose of towns as self-contained entities. (See Fig. 1)

Figure 1: Diagram illustrating the rapid increase of individual car use in the Czech republic as well as the decline of other modes of transportation during the last two decades.



Source: RNDr. Jan Tecl, CDV, Brno, 2010

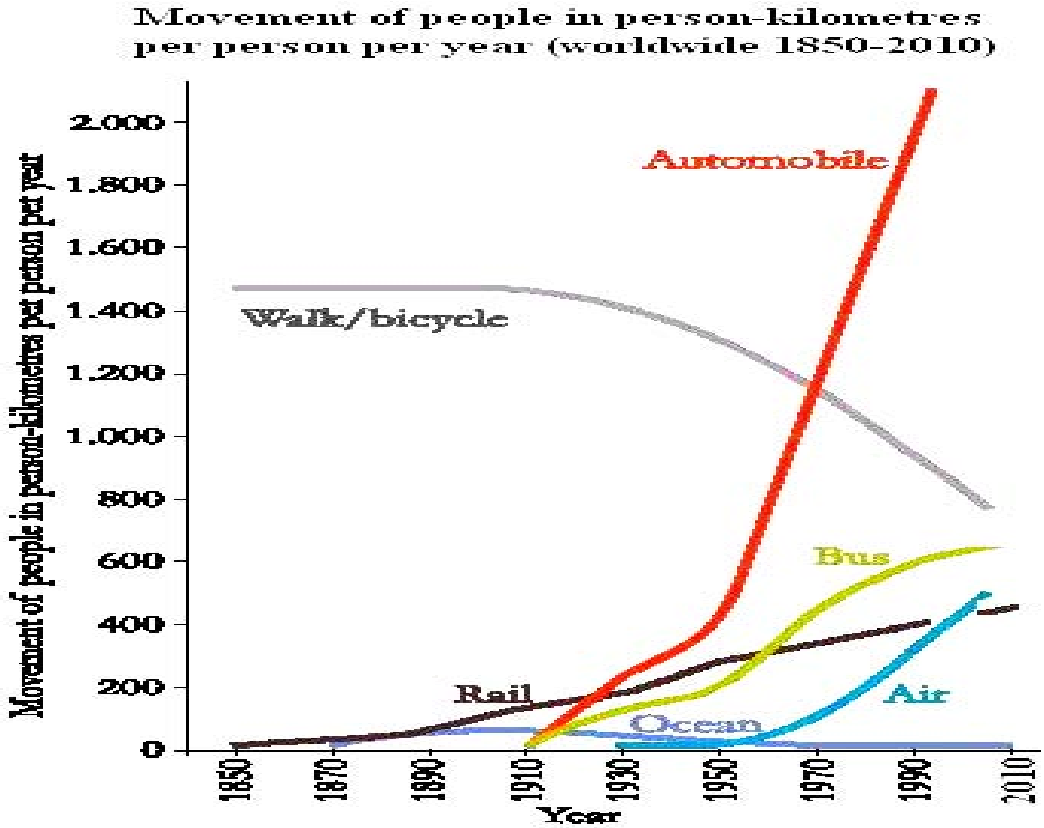
The poor environmental conditions for urban inhabitants – especially pedestrians – and the currently unsatisfactory condition of public spaces in many European cities are caused by a number of things. One is the inability of historic, traditionally structured urban design to meet the requirements of modern high-volume vehicle traffic. The physical urban environment was originally designed for less demanding modes of transportation – particularly for walking. Additional problems are caused by the uneven distribution of urban activities, which is currently increasing at an unacceptable pace.1 This distribution is strongly affected by a strict segregation of living functions as a consequence of the widespread adoption of the pre-war Charter of Athens. Traffic origins and destinations have spread over a large area, resulting in both an enormous increase in urban motorised traffic as well as a corresponding decline in walking (see Fig. 2). The current situation is also due to the application of predominantly technically-oriented solutions to problems that have shown no respect for sensitive urban planning and environmental requirements.

2. Impact of transport on the development of settlements and urban areas.

In the early stages of pre-industrial and industrial urban development, walking was common. At that time, people were used to walking upwards of 15 kilometres to reach their workplace. Businesses, homes and places for cultural and religious activities and leisure were built mostly in proximity to one another, as other modes of transportation were prohibitively expensive for the majority of the population.

[1] According to our last estimate, the average distance to services in some Czech cities has become five times longer since WWII. (Schmeidler K.: *Key role of Urban Planning in Creation of Green Transport Network*. 2008)

Figure 2: Diagram illustrating the rapid increase of motorised transportation and the decline in walking during the last 160 years.



Source: Jan Perner Faculty of Transportation, University of Pardubice, Czech Republic adopted by RNDr. Jan Tecl, CDV, Brno, Czech Republic, 2010

3. Spatial development based on proximity of places of activities and fast-developing urban transport

The urban population in Europe has exceeded eighty percent, which means that Europe as a whole has reached the “ceiling of urban development.” No further development is awaited in this direction. In Central Europe and Eastern Europe in particular, this process bears some special features that differ from the general model when compared to Western Europe. Changes have often been delayed by several decades, and the transformation of settlement structure was not so aggressive due to various political factors and the slow pace of modernization. The term “suburban development” is used to describe situations in former socialist countries. The level of infrastructure is not in balance with the amount of urban population, so newcomers usually settle in housing estates on the outskirts of the cities.

Walking was widely supported by the government in communist-ruled states such as Czechoslovakia as the general health of the population was seen as an important prerequisite for maintaining a “healthy nation” capable of performing military service. Walking competitions such as the “100 Kilometre Walk” for adults and the “50 Kilometre Walk” for youths were organised on a massive scale, and extensive footpath networks were built. From that time on, Czechoslovakia and the Czech Republic have had some of the best footpath networks in the world. Walking was seen as an important leisure activity for the masses with an impact on the health of the nation and its cultural and demographic development.

4. Suburban development and car dependency increase

The uncontrolled growth of cities further reinforces unhealthy social trends regarding both power consumption and preservation of recreational and agricultural areas. Weekend trips to the country taken by members of the urban population begin to resemble the movement of nations that pollute the environment with exhaust – provided, that is, that the strained transportation system is capable of handling the increase in traffic. Under these circumstances, we need to view countryside utilization and the structure of population distribution more pragmatically as this highlights transport requirements. Many cities in Central and Eastern Europe suffer from the fact that private automobiles have encroached upon areas traditionally utilized exclusively by pedestrians. Cars have taken over roads, pavements, squares and embankments. The reason for this has been the desire to be able to reach any point by car, which is often equated with a feeling of freedom. The following formula applies here: the denser the population within the city, the lower the requirements for transportation and the greater space for free countryside, wild nature and walking.

Suburban development as the growth of the city at its outskirts is closely linked to the process of spatial specialization and segregation. It connotes both the concentration of certain branches of industry in certain parts of the city as well as the concentration of certain segments of the population into specific zones of the urban structure. Specialization and segregation, for example, lead to an increase in distances between homes and places of work, education, shopping, leisure or recreation. Since these processes are usually not coordinated and occur independently of the existing transportation system, distances are constantly increasing, favouring the use of private transportation to the disadvantage of public transportation and/or walking. This is a gradual process in which public transport looses its validity and, subsequently, ceases. As a result, numerous segments of the population - children, teenagers, mothers with children and senior citizens in particular - have reduced access to transport and their spatial mobility decreases.

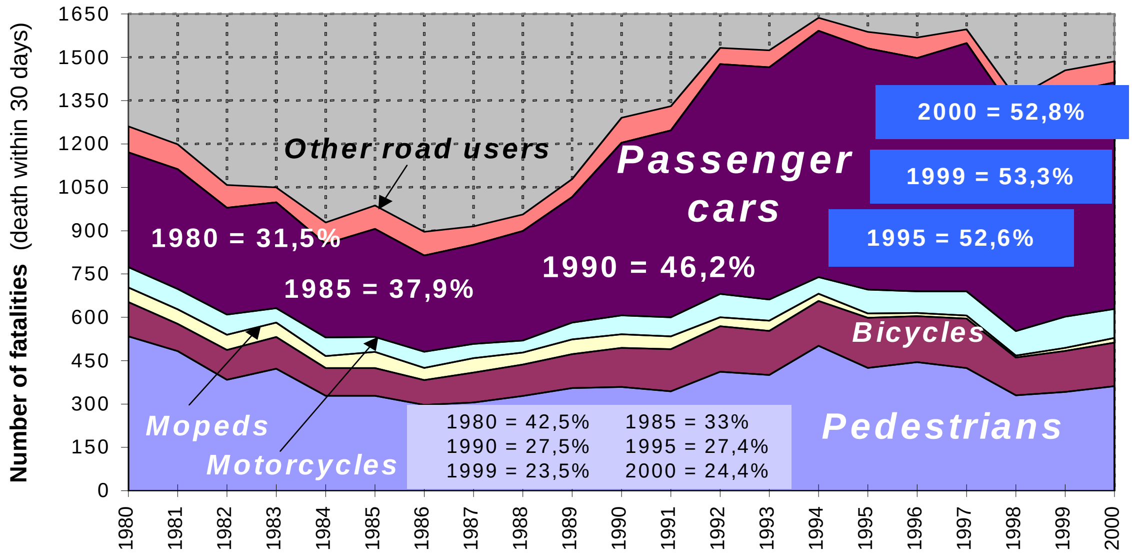
5. Urban De-development and decline of walking in cities

With the assistance of telecommunication technology, business and financial operations can be conducted from distant locations. Due to traffic congestion, inner-city areas are becoming less accessible to their inhabitants. This is accompanied by the unregulated growth of cities, transportation systems crises and the increased use of private automobiles due to the construction of commercial shopping centres and residential zones, and sometimes, due to non-coordinated residential building (see Figure 1). Essential changes in the settlement structure patterns of European countries have affected the style and quality of life of their inhabitants. This is particularly applicable to children, senior citizens, the handicapped and women, who are generally of ill health, less wealthy, more vulnerable and less mobile.

Since the introduction of motorized transportation, pedestrians have received a decreasing mount of attention. With the steadily increasing number of vehicles and roads for them to travel upon, the position of pedestrians is steadily worsening. The disadvantaged position of pedestrians is also underlined by their significantly greater vulnerability in road traffic as compared to other road users (see Fig. 3).

Figure 3: The diagram illustrates the increase of fatalities after societal changes in 1989 and stable portion of vulnerable road users - pedestrians killed in the same time.

***Fatalities according to category of the road users in the Czech Republic** (1980 - 2000)*



Source: RNDr. Jan Tecl, CDV, Brno, 2010

To deal with the issues of traffic and parking, costly transportation and parking facilities have been built. Prerequisite conditions for enabling an intensification of transportation are also being established. As a consequence, we are witnessing a massive mobilization of people and a corresponding devastation of the environment, even beyond the borders of the directly affected regions. Historic city centres are often damaged and the internal environment is deteriorating. It is paradoxical that the construction of freeways which connect developing suburban areas with the city centre are contributing to the destruction of the city centre itself by enhancing the dispersion of the functions crucial to the health of urban centres. This means that, if the concentration of retail, light industrial production, recreational, cultural and educational functions, which are vital for urban livelihood, decrease, city centres will be destroyed. The road system supports the spatial distribution of the population, but also enables the shift of vital activities to new, more distant centres.

The urban population thus leaves the city, first to places in their immediate vicinity. Due to the extending suburban areas, however, they are forced to drive longer distances in their hopes of coming into contact with an intact natural environment, and to spend time in the untouched countryside. The increased use of private cars damages the environment dramatically, and this phenomenon has also begun to encroach upon previously unaffected areas. The term “urban sprawl” is used to describe this tendency. Shopping and cultural centres are also built outside the city in the proximity of motorways because of the availability of mass customer parking space. And this again aggravates transportation conditions (congestions, combustion gases and dustiness, incidents, traffic accidents etc.) near large cities.

Figure 4: Negative prognosis – artist’s view of the future state of inner city areas if no countermeasures are applied - ‘There are two kinds of pedestrians: the quick and the dead’

In European cities, senior citizens comprise a relatively large portion of inner-city inhabitants. Due to uncontrolled urban development and inappropriate urban planning policies, they have lost access to the facilities they need to live (e.g. shopping, sport, leisure and medical care). Cities are endangered by the flight of investment from central portions, the so-called “urban sprawl”, growing social segregation arising from different income levels and social statuses, deteriorating living environments in cities, loss of agricultural land and original rural environments, and erosion of architectural monuments. The image of city centres is aggravating; the press refers to the “crisis of cities”, “decline”, “pathology”, “alienation” and decreasing investments in these areas. Changed accessibility and deteriorated environmental quality (noise, air pollution, traffic vibration, etc.) limits walking and strolling in public spaces and may induce greater migration. People of a higher economic status move out of these locations because they feel they are becoming less habitable. The population migrates to less urbanized places which have, however, easy accessibility. Then it is followed by services that contribute to the rapid development of new settlements, often at the expense of the quality of the environment. Increased mobility becomes a feature of the era. It has, however, some drawbacks. In reality, attachment to a certain place is not restricting: it enables, for example, intensification of human relationships. Every year, several hundred thousand inhabitants leave our large cities.

6. Urban re-development and an attempt for restoration of pedestrian friendly cities

Negative tendencies related to walking prevail in many prognoses. Private car ownership in Central and Eastern Europe is still growing and the building of transport infrastructure and huge transit-related constructions follows. Social life is more atomised, city inhabitants still prefer privacy at home than intensive social life in streets. Leisure activities tend to be more passive, less physical or movement-demanding activities. The physical condition of urbanites is deteriorating, because, having sedentary professions, jobs and hobbies, they move much less. Especially alarming is the quickly deteriorating physical condition of young people, as paediatricians and military physicians confirm.2 Low physical activity and unhealthy

[2] Regular walking is from the point of view of positive influence on human body not possible to substitute. (Children’ physician MUDr. Pavel Stejskal, Czech republic) According his statement, the average distance made by Czech people by walking is about one or two kilometres every day. It is

lifestyles result in a high occurrence of obesity with related illnesses in young age that sharply reduce the abilities to move and walk. This is a vicious circle. These circumstances have been highlighted more frequently only in recent years, when suitable solutions have been searched on the worldwide scale particularly with regard to healthy lifestyles, support of walking making especially the roads in towns safer and friendlier to pedestrians.

To stop such dangerous tendencies, many strategies have been designed. Their aim is to make cities liveable places again, to restructure important activities, to use sustainable modes of transportation and to reverse the negative trends that endangered living conditions. According theory used they can be summed under common description Urban Re-development.

Urban development has become a tool for making cities more attractive for living - business, investment, social life, sport and tourism, and for increasing real estate values in the highly competitive global market. This is demonstrated by a renewal of the formal image of the cities, for example by restoring liveable public spaces, walkable street systems, urban avenues, embankments and squares for municipal celebrations, building new, and restoring old parks, or building shopping streets and green areas. This brings some segments of the population back to the cities (i.e. yuppies – young urban professionals). To make this trend sustainable, central urban areas are renovated to become attractive for light industry, business, tourism and walking. In newly restored parts of the inner-city, more solvent groups move to renovated houses, thus pushing lower classes out of that housing market (gentrification). Administration offices and businesses often replace habitable units. It is not always necessary to tear down older buildings: it is often possible to find new uses for old warehouses, breweries or assembly halls. These buildings, abandoned in the past by the middle class and businesses, are offered by some prudent and enterprising city administrations to attract companies and international capital to re-invest in these locations. The effort aims at the restoration of existing city centres with coherent urban regions, the reconfiguration of large, rapidly growing city suburbs to communities with positive neighbouring relationships, and maintaining the natural environment and architectural legacy of past generations.3

At the beginning of this 21st century, some European cities are experiencing a kind of renaissance. City centres – often considered bad and, therefore, ignored and abandoned –have, after repeated waves of suburban development, become centres of life once again. Renewed cities have restricted private automobile traffic, supported and developed public means of transportation as well as walking, cycling, intermodal and ecological transportation and have given preference to pedestrian comfort over cars (see Fig. 5). This was justified by the fact that between 10 and 20% of all trips by car are to destinations within walking distance. Thus, there is considerable opportunity for reducing ecologically disadvantageous automobile use and replacing it by walking.

much less than previous generation did. About 80 years ago people when walking to work made about 15 kilometres distance. (Lidove Noviny, Praha, July 2010)

[3] This process is described in different ways: revitalization; gentrification; renewal - where the transformation is of the negative, “dead”, “poor” and “non-productive” environment into something positive: “live”, is emphasized; and the quality of the environment and the commercial price of land is increased in a costly manner; which results in situations where city centers adopt the apparent features of sub-urban administrative parks.

Figure 5: Picture illustrating the designed remodeling of street space in Brno for pedestrians as an example of a pro-pedestrian policy and the restructuring of urban spaces.

Source: Artist G. Kopacik, Brno, FA VUT, Czech Republic

7. Conclusion

Experience with traffic control and planning the development of towns has demonstrated that supporting walking as a green mode of transportation and ensuring harmony between traffic and town infrastructure presents one of the most serious problems of contemporary communal policy. This problem involves two levels of treatment. On the social level, it is a question of the social, economic and cultural problems in the processes of town planning; it is of the possibility to control these processes, and in this way orchestrate the restructurisation, remodelling and sometimes growth of towns. Furthermore, it is a question of value orientation of the society in its approach to economic development, to the protection and creation of sustainable living environments, and to the development of sustainable modes of transportation. At the level of operational and developmental control of the city, it is a question of selecting the optimum sustainable multimodal transportation system, of ensuring pedestrian and motorist safety, and of removing or minimising the negative influences of traffic on the urban environment by support of non-motorised modes of transportation. This is especially possible with regard to ensuring harmony between the city structure and the traffic network including pedestrian pathways, and to maintaining a balance between organized operational exploitation and the determination and development of an acceptable level of urban growth in a given area.

The basic requirement for a purposeful planning process is the understanding of the multi-layered mechanism of urban transport, pedestrian needs and their effects on the urban structure and environment. Over the last few decades, basic research has gained a better understanding of the regularities and cause/effect relationships regarding mobility, urban development and transportation. Of particular interest are the complex, dynamic, and time lag-determined connections between sustainable traffic, land-use, urban planning and their effect upon the environment.

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Noise from Rail Transport - Squealing Noise

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Abstrakt

Squealing noise is a result of wheel sliding on the rail when the railway vehicles negotiate a curve having closed radius. This kind of noise is very annoying for people living in surrounding areas. There does not exist any description or monitoring data concern to squealing noise done in Czech Republic. Squealing noise is not included to calculation of prediction software. The article is concern to monitoring of conditions and appearance of squealing noise in abroad and in Czech Republic. There are also introduced possibilities of simulation of squealing noise in prediction software.

1. Introduction - squealing noise

Squealing noise (hereinafter Q noise) is by far the loudness noise generated by rail vehicles. This kind of noise is very annoying for people living in the surroundings locations where this phenomenon occurs. The Q noise is a kind of sound generated by a rail vehicle negotiating the closed curve. Curve squeal is a tonal, high frequency noise which can be more than 10 dB higher than rolling noise. This noise does not occur permanently and cannot be predicted totally reliably. The generation and the possibility of controlling the Q noise are described in this article.

2. Generation of squealing noise

Q noise is the dominant noise made by tram vehicle riding through curves having radius less than 100 m. Q noise is a result of wheels' sliding on the rail when a tram negotiates a curve. Sliding can occurs because of three phenomenon possibilies:

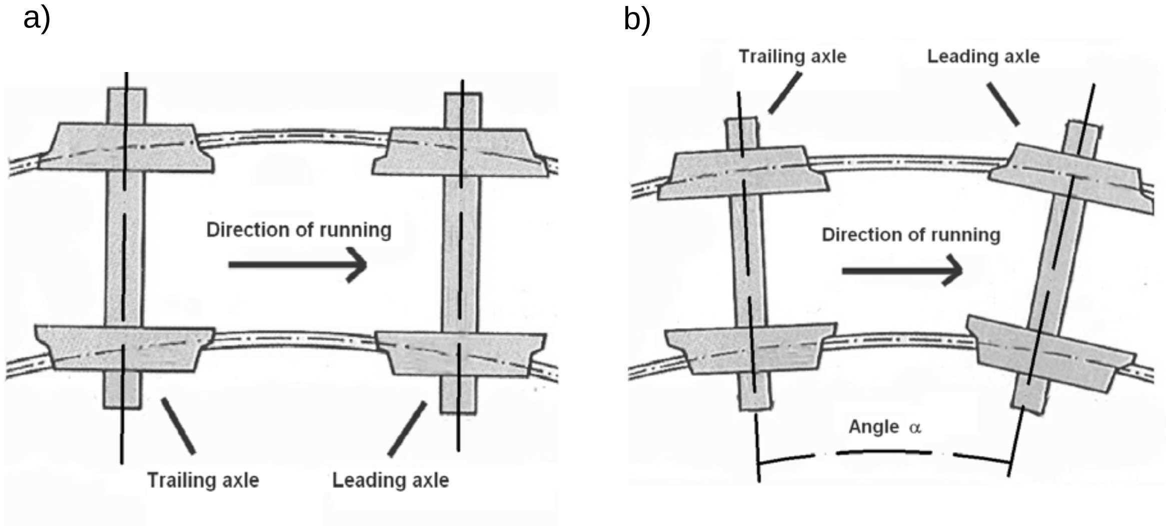
- lateral sliding;
- longitudinal sliding;
- installation of restraining rail.

Under all these conditions metal wheels make squealing noise. Factors which affect squeal generation include curve radius, vehicle speed, truck geometry and rigidity, wheel damping and climatic conditions (temperature and humidity) [1].

2.1. Lateral sliding

At common two-axle vehicles the axle holds parallel (figure 1a) and the curve negotiation forces make the tram wheels to slide perpendicular to the direction of rolling. The wheel than creep across the top of the rail. Due to finite length of the two-axles truck and the curvature radius of the rail, both axles cannot lie upon curve radius (figure 1b). Under actual conditions, the leading axle of the truck rides toward the outside of the curve, while the trailing axle travels between the two rails, it means a reduction of the wheel creeping across the top of the rail at the trailing axle, but an increase of the wheel creeping across the top of the rail at the leading axle [1].

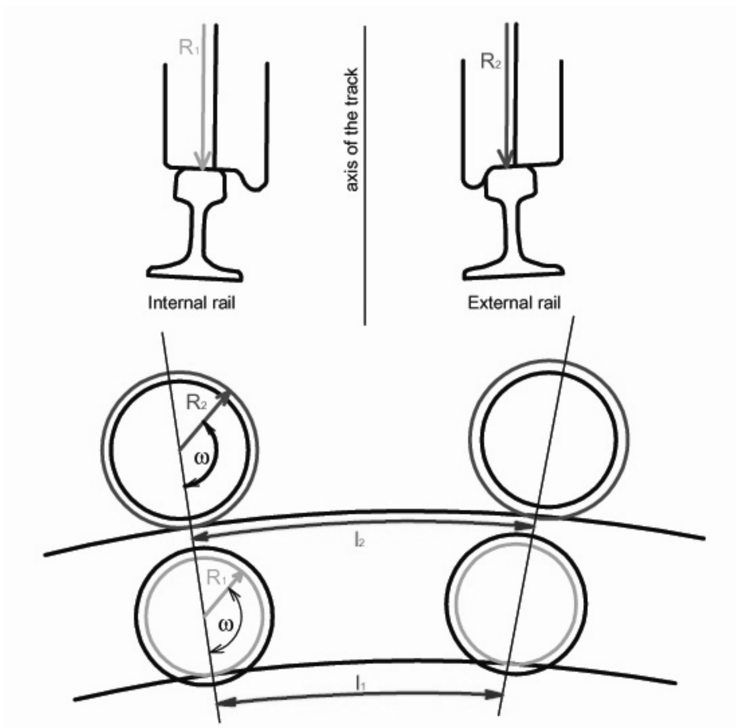
Fig. 1: a) Position of wheel set in the curve causing the lateral stick - slip, b) Desired position of wheel set upon curve, adapted from [5]



2.2. Longitudinal sliding

On a curve the outside wheel have to negotiate longer distance than the inside wheel (figure 2), but the wheels roll the same distance because they are attached on the same axle. The difference in path length must be made up by the wheel sliding in a direction parallel to the rolling motion [1].

Fig. 2: Position of wheel set in the curve causing the longitudinal stick - slip [2]



2.3. Installation of restraining rail

Sometimes there is installed a restraining rail next to the inside rail on curves, which safely helps negotiate the curve, therefore rubbing and Q noise ensues [1].

3. Control of Squeal noise

There are a few possibilities to avoid or eliminate Q noise on rail tracks. Many of them are still at the stage in investigation and development. Measures leading to reduce Q noise can be classified into two groups:

- rail track measures;
- vehicle measures.

3.1. Rail track measures

A measure to prevent Q noise is to construct curves with larger radius.

For instance new construction of tram rail track "*Quiet tram track – CDM COMFORT PLUS*" was developed in the framework programme "Quiet City Transport" and it is used in tramway track in Athens (Greece) [3]. It is an elastically encapsulated construction in a prefabricated concrete slab.

Another way to reduce noise is installing a system which applies a small amount of lubricant to wheel flanges when the tram negotiates a curve.

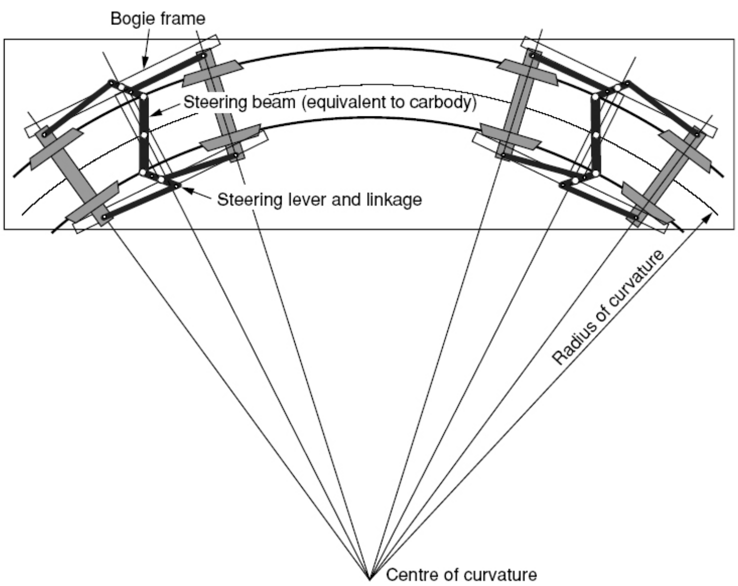
3.2. Vehicle measures

Another measure is use vehicles that permit their axles to align with curve radius instead of holding them parallel. This mechanism can reduce lateral force on the rail so to reduce the Q noise.

The link-type forced steering bogie has been developed and is currently used on *JR Hokkaido Series 283 DMU* express train (figure 3).

Another vehicle measure is to use a damping wheel.

Fig. 3: The link-type forced steering bogie permit the axles align with curve [4]



4. Measurements of squealing noise

Measurements were made on light rail track in Porto (Portugal) - campaign I and on tramway track in Prague (Czech Republic) - campaign II. The result of measurement was spectral analysis from each measurement locality and defining theirs dominant frequencies.

4.1. Measurement set-up: Campaign I - Porto (Portugal)

The measurements were made on Yellow Line of metro system in Porto (Portugal) between the metro station “IPO” and station “Pólo Universitário”. The metros - Bombardier Flexity Outlook "Eurotram" - run with two vehicles coupled and their total length is 70 m on the Yellow Metro Line. The average speed is 19 km/h in this segment of the track. The track is build with sleepers in concrete surrounded and it is finished with granite kerbstones. Grooved rails are used and rails are welded. The gauge of track is the standard 1435 mm. The track is without significant slope in the measurement segment. The outside curve has a radius of 54 meters and the inside curve has a radius of 50 meters.

The measurements were made using a sound level meter Brüel & Kjaer type 2260. It was mounted 1.5 m above from the metro track (running surface of the rail). Measuring point I was located inside of the curve, 7.5 m from the centre of the inside line (10.6 m from the centre outside line). Measuring point II was located outside of the curve, 7.5 m from the centre of the outside line (10.6 m from the centre inside line).

4.2. Measurement set-up: Campaign II - Prague (Czech Republic)

The measurements were made on tramway track in Prague (Czech Republic) between the tramway station “Pobřežní cesta” and station “Nádraží Braník”. The Prague Public Transit use trams 14T, T3R.P, T3.PLF, T3SU, T6A5, KT8N2 and KT8D5 for this tram track. The average speed is 42 km/h in this segment of the track. The track is build with concrete sleepers. Grooved rails are used. The gauge of track is the standard 1435 mm. The track is without significant slope in the measurement segment. The measured inside curve has a radius of 210 meters.

The measurements were made using a sound level meter Brüel & Kjaer type 2250 light. It was mounted 1.2 m above from the track (running surface of the rail). Measuring point was located inside of the curve, 3.0 m from the centre of the inside line.

5. Results of the measurements - spectral analysis

5.1. Campaign I - Porto (Portugal)

Data from the measurements in the curve were processed and comparisons were done with data from the measurements in straight line, to found the frequencies where the Q noise appears. The average noise level for Q noise $L_{Aeq\ (global)}$ = 85 dB was found after processing the measured values. It is above 16 dB(A) more than average noise level of running metro in straight line which was 69 dB(A). The comparative graph of these measured values is shown on figure 4. It was found that the Q noise appears in some different frequencies - 630 Hz, 800 Hz, 1.6 kHz, 2 kHz and 4 kHz. The sound pressure levels octave spectrum of outside line, inside line and straight line are presented on figure 5. From these graphs is apparent that the 2 kHz band has the highest noise levels (around 82 dB(A) in outside line and inside line). The largest difference between noise levels in side line and straight line is 25 dB(A) at the frequency band of 1.6 kHz.

Fig. 4: Comparison of sound levels in the curve and straight line

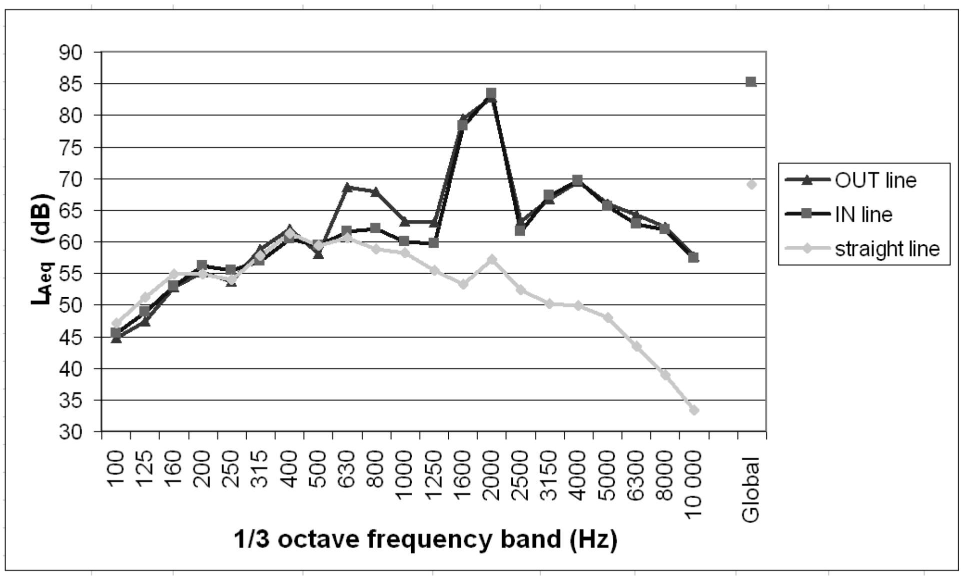
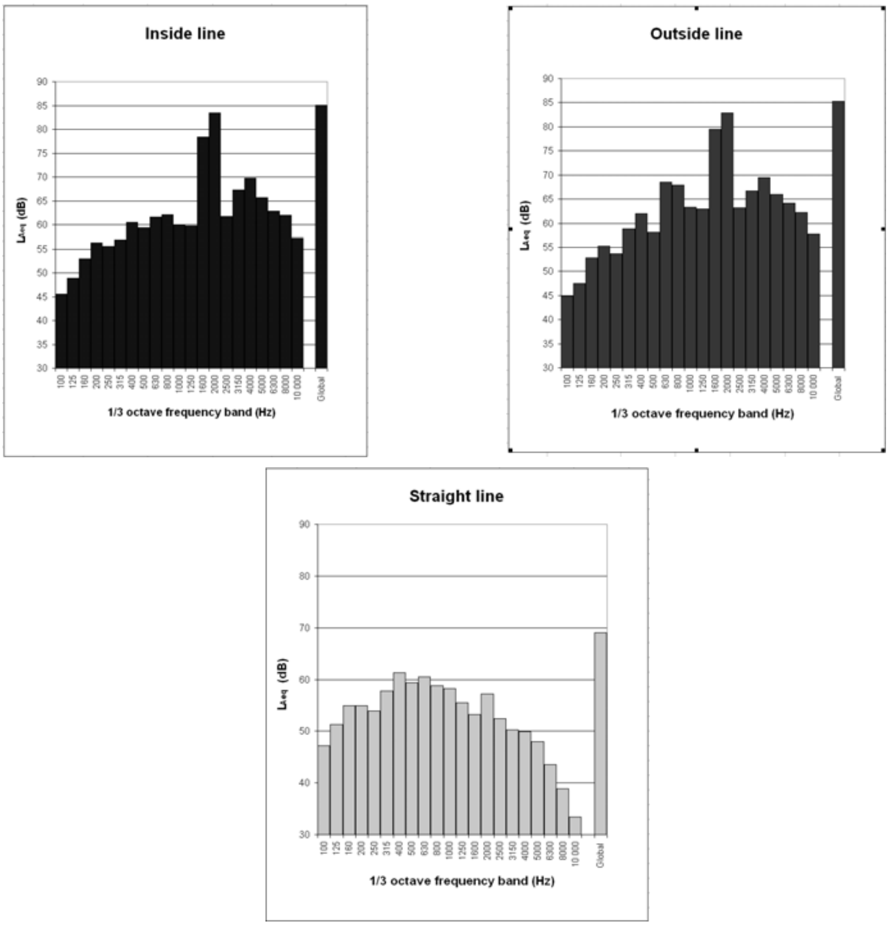


Fig. 5: LAeq – 1/3 octave spectrum in the curve and straight line



5.2. Campaign II - Prague (Czech Republic)

Data from the measurements in the curve were processed and comparisons were done to found the frequencies where the Q noise appears. The average noise level for Q noise $L_{Aeq\ (global)}$ = 90 dB was found after processing the measured values. It is above 7 dB(A) more than average noise level of running metro without Q noise which was 83 dB(A). The comparative graph of these measured values is shown on figure 6. It was found that the Q noise appears in frequencies from 2 KHz to 8 KHz and the maximum is on 6.3 KHz. The sound pressure levels octave spectrum tram with Q noise and tram without Q noise are presented on figure 7. From these graphs is apparent that the 6.3 kHz band has the highest noise levels (around 84 dB(A)).

Fig. 6: Comparison of sound levels in the curve of tram with Q noise and tram without Q noise

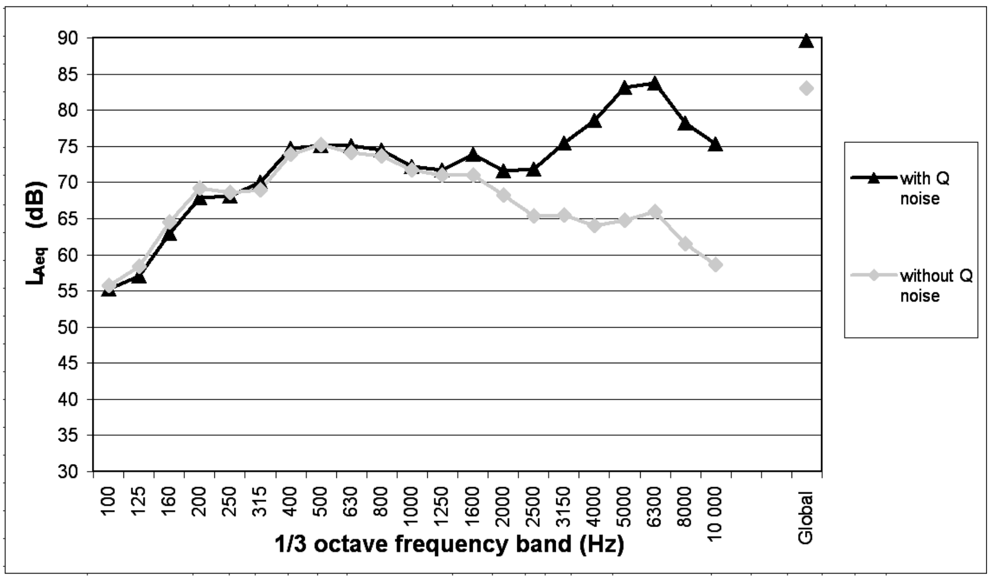
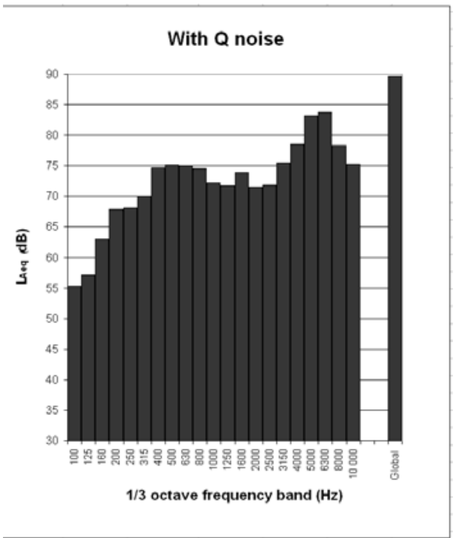
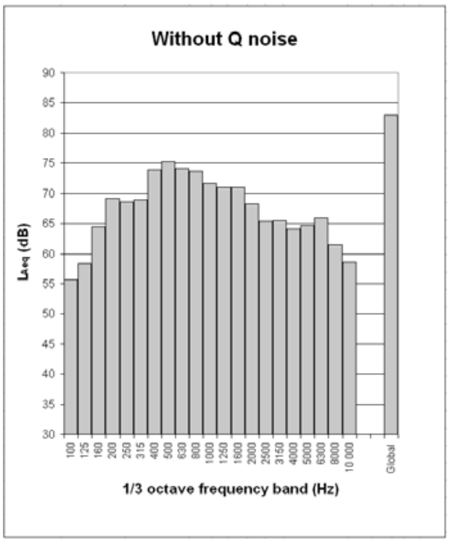


Fig. 7: L_{Aeq} - 1/3 octave spectrum in the curve of tram with Q noise and tram without Q noise





6. Acoustic simulation in Cadna/A

The Q noise is not included in official noise calculation models and it is not integrated in noise mapping (with the exception of the German standard *Schall0*3 [6]). The measured data of Q noise from this work were used for simulation of Q noise in software Cadna/A Version 3.6119.

6.1. Creation of model

The goal was to use the L_{Aeq} values from measurements in curve, for simulation in software Cadna/A for that, it was necessary to make the model of the study area using the topographic digital map and to determine the traffic flow data.

To simulate the noise emitted by the Metro running on the curve (including the generated Q noise) a line source was modeled. This line source replaced the rail track on the curve segment of the Metro line. The sound power level of the line source was characterized using the immission spectrum (L_{Aeq} in octave spectrum) measured in the field. In order to specify the noise emission for the line source in Cadna/A as frequency dependent. The spectrum in octave band had to be calculated.

6.2. Calculation - results

Data from measurement were processed and used for simulation in software Cadna/A. Three variants of noise simulation are compared in the same location, surrounding the rail track in Porto using software Cadna/A, for simulation.

One simulated variant was made using the data for Q noise which were measured in the field. Others maps were made using standard *Schall03* implemented in software Cadna/A.

Calculations were made regarding the noise indicator L_d (noise level - day) in Point I and the results are presented in table 1. This point is placed inside of the curve (7.5 from inside line) in measurement rail track segment. The value of noise indicator L_d calculated in software Cadna/A in Variant B (with consideration of Q noise measured in the field) is about 17 dB(A) higher than in Variant A (calculation without consideration of Q noise). And about 10 dB(A) higher than in Variant C (using for calculation correction for curvature radius). The difference ΔL_d between Variants B and A , and Variants C and A shows table 1.

Tab.1: Noise indicator L_d dB(A) and difference ΔL_d dB(A) calculated in Point I

Point I	Noise indicator L_d dB(A)	ΔL_d dB(A)
Variant A – without consideration of Q noise	58.8	0
Variant B – with consideration of Q noise measured in the field	75.7	16.9
Variant C– with Cadna/A radius of curvature correction	65.3	6.5

7. Conclusions

This work describes squealing noise propagation in the surrounding of an urban rail. The goal was to characterize the acoustic spectrum and acoustic effect in noise map development of this type of noise. After the results obtained from measurements the squealing noise was simulated using software Cadna/A.

The measurements (campaign I) were made on the track line “Metro do Porto” in Porto (Portugal). The average noise level for squealing noise L_{Aeq} = 85 dB was found after processing the measured values. It is above 16 dB(A) more than average noise level of running metro in straight line which was 69 dB(A). There can be seen the dominant frequencies (630 Hz, 800 Hz, 1.6 kHz, 2 kHz and 4 kHz) for squealing noise caused by the metro vehicle.

The measurements (campaign II) were made on the tram track in Prague (Czech Republic). The average noise level for squealing noise L_{Aeq} = 90 dB was found after processing the measured values It is above 7 dB(A) more than average noise level of running metro without squealing noise which was 83 dB(A). It was found that the squealing noise appears in frequencies from 2 KHz to 8 KHz and the maximum is on 6.3 KHz.

During each measuring campaign were found different dominant frequencies. This difference can be caused by using different type of vehicle (with different wheels). There was also different average speed and the radius of curvature what could cause the different dominant frequencies.

Data from measurement in Porto were processed and used for simulation in software Cadna/A. Three variants of noise simulation are compared in the same location, surrounding the rail track in Porto using software Cadna/A, for simulation.

Calculations were made regarding the noise indicator L_d (noise level - day) in Point I. It was found that the value of indicator L_d in Variant B (with consideration of squealing noise measured in the field) is about 17 dB(A) higher than in Variant A (calculation without consideration of squealing noise).

It shows that it is necessary to account for the squealing noise from urban rail transport in the noise mapping.

This difference of squealing noise level can be dependent on many factors as radius of curve, quality of the track, speed of the train, type and quality of vehicle, climatic conditions and etc. These dependencies will be investigated to future with measurements in Prague, in Czech Republic.

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New Trends in Reducing Noise Emissions in Railway Track

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Abstract

An active approach to searching possibilities of reducing noise emissions is a major issue. The noise arising during the operation of rail traffic causes big problems not only in urban areas. A frequent measure to be seen along linear structures in the last years is the construction of so-called noise barriers. Depending on local noise levels, these barriers are designed in various height and material versions. Each of these barriers must comply with the regulations specified in the General Technical Conditions for Noise Barriers. The construction of these barriers in urban zones may evoke out-of-place associations in people. Noise barriers seem to divide the urban space into separate, apparently disconnected territorial units.

The growing demands for searching alternative options of reducing noise stress lead to testing new constructions and elements reducing noise emissions directly at the noise source in the rail construction. One of these possibilities is mounting so-called noise absorbers directly to the rail web. The article deals with the description of measuring A-weighted equivalent sound pressure levels from railway traffic using Corus and Vossloh noise absorbers in the rail construction.

1. Rail damping systems

New rail damping elements reducing noise emissions directly at the source have been developed and are being tested as part of various European projects. According to the type of damping element, noise absorbers may be composed either of plastics (polymers) filled with iron ore (manufactured by Vossloh Company, Fig. 1a) [1] [2] or of polymers containing several steel segments (by Corus Company, Fig. 1b) [3]. The arrangement of individual steel segments and the polymer thickness are designed depending on the track type.

Fig.1: Systems of damping elements: a) Vossloh [2], b) Corus [3]

a) b)

Absorbers work on the principle of damping the frequencies emitted by the rail web. These damping absorbers are placed by the rail web and are fastened by adhesive tapes located directly on the absorber, by bonding cement or by fixing clips. Absorbers fixed in position in the above-mentioned ways absorb the noise emitted by the rails during the passage of wheels. Absorbers may be produced in different lengths. Depending on the type, they may be fastened to the rail web continually, i.e. along the whole length of the rail, or only in spaces between the sleepers. Absorbers may be used both in the constructions of newly designed tracks, and in existing tracks, therefore, absorbers are designed to fit specific characteristics of individual tracks.

The above-mentioned rail damping systems were also used during the operational verification of superstructure modifications aimed at damping the propagation of noise and vibrations on the track of the all-national railway line No. 1191 Kolín – Lysá nad Labem as part of the project “Noise reduction measures in Poděbrady“.

2. Description of investigated section

The section under investigation is located on the railway track No. 1191 (231) Kolín – Lysá nad Labem ranking in the category of all-national railway lines. The monitored section is situated on the rail section between the stations Libnice nad Cidlinou – Poděbrady (rail km 313.7019 – rail km 314.7636) passing along U Bažantnice Street in the south-east part of the town. The site is located on the cadastral territory of the town of Poděbrady.

The railway line is of a double-track, electrified type. The monitored section, 1.0617 km in length, is in its greater part situated between two watched crossing, i.e. Na Hrázi Street and Jiráskova Street. In the north-west part of the investigated site, the section closely adjoins the Poděbrady Station gridiron.

In the proximity of the crossings, the railway track is led in a straight line and on the surrounding terrain level. In the section between the crossings, the railway track is led in a gentle right-side bend on the terrain level, or partly on the embankment (max. embankment height – 1.5 m).

The superstructure was composed of R 65 rails with stiff fastening of K type – plane ribbed R 4pl sole-plates with ŽS 4 screw clamps on concrete SB8 sleepers.

The vegetation surrounding the railway track is mostly represented by a herb layer and partly a shrub layer. The high tree layer grows only along U Bažantnice Street.

The nearby built-up area mostly consists of detached houses bordering on a continuous development of low-rise prefabricated houses.

The selection of this section where the designed noise reduction measures were gradually implemented was based on the Resolution of the Regional Public Health Station of the Central Bohemia Region (2525-213/07/Mb/Rm of 3.8.2007).

3. Designed noise reduction measures

The plan of designed noise reduction measures (hereinafter NRM) was subdivided into three implementation phases, which were performed during the autumn months of 2009.

1st implementation phase

During the first phase, the existing R65 rails with stiff fastening were replaced with new UIC60 rails with elastic fastening of KS type – plane ribbed sole-pales with elastic Skl 24 tension clamps on concrete SB8 sleepers. Further more, rubber pads under the sleeper head were replaced. The edges of the reconstructed section were fitted with UIC60/R65 transition rails. The reconstruction involved the replacement of the existing points, which is part of the Poděbrady Station gridiron. The reconstruction of the monitored section also included the modification of the adjoining railway crossings. This phase was performed on 30.9. - 5.10. 2009. The changes in sound pressure levels in the vicinity of the replaced points were not the objective of the study.

2nd implementation phase

During the second phase, the reconstructed track section between the crossings was fitted with Vossloh noise absorbers: on Rail No. 1 in a total length of 750 m and on Rail No. 2 in a total length of 552 m, and with Corus absorbers on Rail No. 2 200 m in length. The absorbers (Fig. 2) were placed in the splice chamber on both sides of the rail and fixed by bonding cement and auxiliary fixing clips.

Fig. 2: Mounted Vossloh (Rail No. 1) and Corus absorbers (Rail No. 2) (December 2009)

3rd implementation phase

Unless the A-weighted equivalent sound pressure levels in the proximity of investigated structures are reduced below the public health limits after the implementation of the 1st and 2nd phase, individual noise reducing measures will be taken. These include, above all, the replacement of windows in the residential houses where the admissible public health limits will still be exceeded in the outdoor or indoor protected space of buildings after the implementation of the previous NRM phases. The third implementation phase does not involve the construction of any other noise reduction measures. The measurement of sound pressure levels inside the protected space of selected buildings was not the subject of this study.

4. Monitoring of sound pressure levels

Check sound pressure measurements were planned to be performed during the implementation of works with the aim of detecting any potential changes in sound pressure levels and the efficiency of the used absorbers. These measurements of sound pressure levels were divided into two measurement phases. Together with measuring sound pressure parameters, the operation on the railway track was recorded on a digital camera for subsequent re-evaluation and verification of recorded data referring to the train traffic (Fig. 3).

Due to the position of the rail, the surrounding terrain and development, the observation stations selected were situated in a gentle right-turning bend in the profile of 314.1696 rail km along both sides of the double-track railway line. The selected observation stations complied with all regulations for outdoor measurement of sound pressure levels, including the free field for measurement. The relevant regulations are stated in the ČSN EN ISO 3095 standard Railway Applications – Measurement of Noise Emitted by Railbound Vehicles [4]. The position of the sound meter microphone was always set at a distance of 7.5 m from the axis of the outside rail and at a height of 1.2 m above the rail surface. A-weighted equivalent sound pressure levels ($L_{Aeq,Tp}$) were measured during the passage of individual trains. The recording of A-weighted equivalent sound pressure levels ($L_{Aeq,Tp}$) was performed using a sound meter manufactured by the Brüel Kjaer Company of 2550 Lite type. The velocity of monitored trains was measured using the Bushnell radar gun. The sound meter microphone was checked against the gauge before and after each measurement.

Fig. 5: Sound pressure measuring equipment

Depending on the measuring equipment – sound meters ranking in the first class of precision, the uncertainty (reliability) of the A-weighted equivalent sound pressure level measurements was set at 1.8 dB.

The measurements of A-weighted equivalent sound pressure levels were split into two measurement phases. The time schedule of these phases used intermediate periods between individual implementation phases. Other measurements were planned and performed as follows:

1st measurement phase of sound pressure levels – following 1st implementation phase

Rail No. 2 (Kolín – Poděbrady)
29. 10. 2009 – 21 passages of train units were measured and evaluated
30. 10. 2009 – 22 passages of train units were measured and evaluated

The evaluated train units were classified into the following train categories:

Electric suburban units of 471 type (City Elefant)	11
Freight trains	11
Motor-coach passenger trains of 854 type	4
Passenger trains (fast trains)	17

Rail No. 1 (Poděbrady – Kolín)
11. 11. 2009 – 26 passages of train units were measured and evaluated
12. 11. 2009 – 23 passages of train units were measured and evaluated

Electric suburban units of 471 type (City Elefant)	12
Freight trains	17
Motor-coach passenger trains of 854 type	4
Passenger trains (fast trains)	16

2nd measurement phase of sound pressure levels – following 2nd implementation phase

Rail No. 2 (Kolín – Poděbrady)
9. 12. 2009 – 27 passages of train units were measured and evaluated
10. 12. 2009 – 24 passages of train units were measured and evaluated

Electric suburban units of 471 type (City Elefant)	13
Freight trains	17
Motor-coach passenger trains of 854 type	4
Passenger trains (fast trains)	17

Rail No. 1 (Poděbrady – Kolín)
15. 12. 2009 – 27 passages of train units were measured and evaluated
Subsequent measurements could not be performed due to unfavourable climatic conditions.

Electric suburban units of 471 type (City Elefant)	6
Freight trains	11
Motor-coach passenger trains of 854 type	2
Passenger trains (fast trains)	8

5. Evaluation of measured values

The measurement of A-weighted equivalent sound pressure levels was accompanied by the occurrence of non-standard conditions, which might have affected the resulting values of the A-weighted equivalent sound pressure levels. These included, in particular, concurrent passing of trains in both directions, train hooting during its passage in front of the measurement point, significant slowing down or even stopping of a train or incorrect handling of sound meters (frequently independent of the sound meter’s operator – switching over to the standby mode immediately before measurement, discharged batteries in the sound meter etc.) Based on these conditions, some measurements were not included in the evaluation.

The average velocity of individual train categories differed. For this reason, the velocity values were standardized in accordance with TSI for conventional vehicles – Noise (technical specifications for interoperability) [5], where the basic velocity for measurement specified is 80 km/h. Prior to comparison, the values measured at the maximum velocity *V* of a measured train must be recalculated using the following formula:

$$L_{Aeq,Tp}(80\,km/h) = L_{Aeq,Tp}(V) - 30 * (V/80\,km/h) \qquad [dB]$$

The following Tables 1 and 2 display the average (mean) values of A-weighted equivalent sound pressure levels ($L_{Aeq,Tp}$) measured, and the average (mean) values of A-weighted equivalent sound pressure levels ($L_{Aeq,Tp}$) for $V = 80$ km/h for the respective train categories. They also present the average train velocities of the respective train categories. The difference of $L_{Aeq,Tp}$ values for the average velocities V of individual train categories and $L_{Aeq,Tp}$ standardized for V = 80 km/h before and after mounting absorbers is shown in Table 3.

For better orientation in the tables, the following abbreviations were used for the respective train categories:

Electric suburban units of 471 type (City Elefant)	City E
Freight trains	Ft
Motor-coach passenger trains of 854 type	Mt
Passenger trains (fast trains)	Pt

Tab.1: Evaluation of measured values on Rail No. 1 (Poděbrady – Kolín)

Poděbrady - Kolín	**Before mounting absorbers**				**After mounting absorbers**			
	City E	**Ft**	**Mt**	**Pt**	**City E**	**Ft**	**Mt**	**Pt**
$L_{Aeq,Tp}$ [dB] for ∅ V	85.7	89.4	93.2	94.3	84.8	88.9	92.1	93.2
$L_{Aeq,Tp;}$[dB] for V = 80 km/h	82.8	92.3	94.7	91.3	82.3	91.6	94.1	90.5
Average train velocity V [km/h]	99.1	61.8	70.3	100.4	97.2	64.2	60.0	99.4

Tab.2: Evaluation of measured values on Rail No. 2 (Kolín – Poděbrady)

Kolín - Poděbrady	**Before mounting absorbers**				**After mounting absorbers**			
	City E	**Ft**	**Mt**	**Pt**	**City E**	**Ft**	**Mt**	**Pt**
$L_{Aeq,Tp}$ [dB] for ∅ *V*	83.3	93.4	91.6	90.3	80.1	89.4	88.2	89.2
$L_{Aeq,Tp}$ [dB] for *V*= 80 km/h	81.0	93.1	91.7	88.2	78.5	90.5	88.5	87.9
Average train velocity *V* [km/h]	92.0	75.3	95.0	92.9	89.6	75.0	79.5	88.9

Tab. 3: Difference of $L_{Aeq,Tp}$ values for ∅ V and $L_{Aeq,Tp}$ for V=80km/h [dB] before and after mounting absorbers

Train categories	**Difference of $L_{Aeq,Tp}$ values [dB]**			
	Poděbrady – Kolín (Rail No. 1) Vossloh		**Kolín – Poděbrady (Rail No. 2) Corus**	
	$L_{Aeq,Tp}$ (∅ *V* km/h)	**$L_{Aeq,Tp}$ (*V*=80 km/h)**	**$L_{Aeq,Tp}$ (∅ *V* km/h)**	**$L_{Aeq,Tp}$ (*V*=80 km/h)**
Electric units No. 471	0.9	0.5	3.2	2.5
Freight trains	0.5	0.7	4.0	2.6
Motor-coach passenger trains	1.1	0.6	3.4	3.2
Passenger trains – fast trains	1.1	0.8	1.1	0.3

6. Summary

Based on the data sample obtained from the measurements performed after the first and the second phase of the superstructure reconstruction, it is evident that the overall A-weighted equivalent sound pressure levels were reduced. On Rail No. 2 fitted with Corus absorbers considering the average velocity (of individual train categories), there was an average reduction by 2.7 dB (calculated using the weighting filter taking into account the number of train units within a category). On Rail No. 1 fitted with Vossloh absorbers the average reduction was by 0.8 dB.

Considering the basic velocity for measurement of 80 km/h under TSI for conventional vehicles – Noise, the average value of $L_{Aeq,Tp}$ using the Corus absorber was reduced by 1.8 dB (calculated using the weighting filter taking into account the number of train units within a category), and using Vossloh absorbers by 0.6 dB.

The initial results obtained, however, manifested a relatively low efficiency of the absorbers themselves as compared to previous assumptions. This may be caused by different factors affecting both the superstructure reconstruction design, and the performed measurements of A-weighted equivalent sound pressure levels.

The resulting A-weighted equivalent sound pressure levels obtained during the measurement on Rail No. 2 (Kolín - Poděbrady) may have been affected by potential gradual speed reduction or even braking of the train units before the semaphore at the entrance to the Poděbrady Station rail gridiron.

Analogically, the resulting A-weighted equivalent sound pressure levels on Rail No. 1 (Poděbrady - Kolín) may have been affected both by non-uniform train velocities and the passing of train units through the monitored section at the maximum output of the tractor. Due to the fact that velocity was measured at one point and the uniformity of the section was presumed from its characteristics, in real conditions, however, non-uniformity could have occurred, too. A precise detection of the average velocity of train travel would need 2 optical gates interconnected with all the microphones into a single recording system.

To conclude, it must be added that in order to unambiguously confirm the above-mentioned results, we would have to work with a larger data sample. It would also be necessary to obtain a larger number of measured passages of train units. Due to a shortage of time and also limited possibilities of the technical equipment, more measurements could not be performed. Nevertheless, the results obtained at least indicate certain positive trends and possibilities in reducing noise emissions from railway traffic.

Acknowledgements

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Possibilities of Reducing the Consumption of Lubricants in Traffic

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Abstract

In the operation of transport means, it is possible to achieve significant reduction in the consumption of lubricating oils and plastic lubricants through applications of a wide range of tribodiagnostic methods – from the simplest field tests, standardized laboratory tests up to advanced instrumental methods (FTIR spectrometry, analytical ferrography with subsequent image analysis, scanning electron microscopy with EDX-analysis, etc.). The use of simple methods may not replace the results from laboratory methods but due to their low economic and time demands they may be an effective tool for periodic monitoring of the technical condition of engine directly in operation.

The paper presents results of experimental studies carried out in this area at Jan Perner Transport Faculty, Pardubice University. Their objective is to reduce the negative effects of transport on the environment – in particular, to save materials and energy, increase operational safety, and minimise soil and water pollution and the amount of hazardous waste.

1. Introduction

There are ever increasing demands made on the technical condition of transport means in connection with the requirements regarding extension of their good technical condition, securing of high operational reliability of vehicles, and reducing negative impact of transport on the environment. Tribotechnic diagnostics (TTD) may be amply used in this area – in particular due to the fact that optimisation of changing of oil fillings is a serious issue in terms of economy, safety and the environment. Therefore, physical-chemical instrumental methods are being developed to assess the degree of wear of oils; besides standard laboratory tests specified by standards and other regulations, express methods of fast operational diagnostics and advanced instrumental methods are being used. The TTD Laboratory of Jan Perner Transport Faculty at Pardubice University deals with the practical application of these methods and the development of new procedures.

2. Overview of tribotechnic diagnostics methods

2.1. Field tests

This group of methods is used for informational tests of the technical condition of lubrication fillings. They are significant especially in situations when deterioration of parameters of lubricating oils might result in economic losses due to an accident of a machine, in the case of operating of a greater number of vehicles or in the case of vehicles or machines with large oil filling volumes. With these machines it is necessary to monitor continuously the condition of the lubricating oil during the change interval which may be extended based on good results of field tests. In the event of deterioration of oil parameters, the results of simple operational methods may be used as an impulse for a laboratory analysis of the oil following which the motor oil may be changed or regenerated.

For evaluating characteristics of motor oils by these simple methods it is used the blotter test, described below, and then also e.g.,

− *Viscosity test* – methods based on comparison

a) of the time necessary for flowing of the given volume of new and used oil or oil with the known viscosity and the measured oil; the Ford oil viscosity cup is used for this measurement,

b) of the distance to which the used and new oil have flown in a specified time; the oil runs down a sloping plate with a slope of 40–60 °.

In practice it is usually allowed to the operate motor oil deviating from the recommended value of viscosity within max. ±20 % (this value is specified for large volume compression-ignition engines). In the case of spark-ignition engines it is possible to allow greater deviation towards lower values; in these cases the drop in viscosity by as much as 30 % [1] is admissible.

− *Water presence test* – it may be qualitatively evaluated using the heating (crackle) test. It may be easily realized on a thermostated surface at ca 150 °C (simple analogy of procedure according to ČSN 65 6231, according to which the principle of the test consists in heating the sample to 150 °C in an oil bath). Water or cooling liquid which has penetrated into motor oil has corrosive effects, may induce decomposition of additives, limits their solubility in oil, and supports their precipitation from the oil phase. The generally accepted limit stating the maximum admissible content of water is 0.1 % hm. In laboratory (art. 2.2) the content of water in oil is determined, e.g. by titration according to K. Fischer, distillation or infrared spectrometry. When the oil is dropped onto the hot surface, the cracking sound may be well heard caused by the quick evaporation of water. Oil contaminated by water foams, the drop spreads on the hot metal surface. The disadvantage of this method is the fact that it is not possible to determine the quantitative amount of the water present in the oil and the considerable subjectivity of the evaluation [2].

Blotter test is cheap and simple, it provides quick basic information on oil contamination, on its detergent-dispersant characteristics possibly even the presence of water, cooling liquid or fuel in oil. The disadvantage is the longer waiting for the result (ca 60 minutes), nonexistence of standards for commonly available oils and difficult interpretation of results for an inexperienced user. The result of the blotter test may be the basis for the decision to perform further (laboratory) tests of motor oils.

The colouration and character of the blot which is formed after a drop of oil is placed and absorbed by a suitable (chromatographic) paper is connected with the wear and contamination of oil. Following the placing of the oil drop a number of physical and physical-chemical processes (diffusion, adsorption, etc.) occur which results in stratification of contaminants. The central zone of the blot contains mechanical impurities, its transparency is connected with the degree of contamination of the oil by insoluble substances, carbon deposits, etc. Further diffusion circular concentric zones may be created around the central zone provided that the oil contains sufficient amount of detergent additives. The last border zone contains a small amount of the finest contaminants. Its yellowish colouring is given by the character of the base oil and contingent content of oxidized distorted fractions of the fuel or products of thermal-oxidative reactions which occurred in the oil during its use.

New or little contaminated oils do not create characteristic zones. A light-grey to grey blot corresponds to a mild contamination, a dark-grey blot means medium contamination, a non-transparent black blot often with shiny surface means high contamination of oil.

Detergent-dispersant (D/D) characteristics of oil may be qualified according to the width, arrangement and external termination of the diffusion layer. A wide diffusion layer slowly dissolving towards the outer edge means a very good detergent ability. Exhaustion of D/D additives is characterized by narrow zones of homogeneous grey or black surfaces with sharply defined edges. The water present in oil creates sharply defined very light annulus at the inner side in the external perimeter of the blot.

The results of the blotter test may be objectified to a considerable extent by digitalizing the resulting patterns [3] and by their image analysis.

Another requirement often occurs in practice: It is necessary to determine whether the lubricated mechanism does not produce excessive amount of abrasion particles and roughly qualify the technical condition of the machine. These route-identification tests may be performed by a quick and cheap test [4], which is a simplified version of analytical ferrography. The principle consists in intercepting abrasion metals using sufficiently strong magnet and microscope evaluating the separated particles. According to the proposal of the authors it is suitable to use the special device for separation of particles and photographic documentation may be performed by digital manual microscope which may be connected to a PC via USB interface; using a program for image analysis it is possible then to determine the percentage share of the area covered with abrasion particles (art. 3.2).

2.2. Standardized laboratory methods

There are tens of standardized methods which require laboratory equipment for testing of oils. These methods are most often used for evaluation of physical-chemical characteristics of oil, e.g. for determining of kinematic and dynamic viscosity, acidity (TAN) or alkalinity (TBN) of oils, content of water, content of mechanical impurities, content of individual metals and other elements, flashpoint, etc.

2.3. Advanced instrumental methods

Monitoring of chemical and physical changes which occur in operation provides a rather exact idea of the actual condition of the lubricant and the possibilities of its further use. The numerous methods used for this purpose include infrared spectrometry; differential scanning calorimetry allows the assessment of oxidation stability of oils, electrochemical methods may be applied when determining antioxidants, etc.

The course and extent of wear of components which are lubricated by the lubricant may be monitored by another group of methods suitable for qualitative and quantitative characterisation of abrasion particles, in particular for the description of morphology and dividing of particles consisting of metal abrasion, fibres from filtering materials, contaminants from external environment, etc. They include, e.g. analytical ferrography combined with light microscopy, scanning electron microscopy with the possibility of subsequent image analysis, analysis using particle counters, etc. Atomic absorption spectrometry, emission spectrometry with inductively coupled plasma, x-ray fluorescence or electrochemical (voltammetric) methods are used for determining of the total concentration of metals.

3. Experimental part

3.1. Applied experimental methods

a) Field tests

Blotter test: It was performed on the chromatographic paper 3004–6514 CHR Roll (Whatman, Great Britain). The results were evaluated after 3 hours of the application of the sample.

Simplified operation ferrography: An equipment of our own design was used for fixation particles on a plastic film; a digital microscope Chronos with a USB connection was used for documentation and evaluation of ferrographic traces.

Image analysis was used for evaluation of results (images of ferrographic traces were transferred to binary images, then the ratio of the area covered by particles and the total area of a 10×10 mm selected field in the defined position at the ferrogram was calculated). The freeware program ImageJ [5] was used for complete processing of taken ferrograms.

b) Instrumental methods

Scanning electron microscopy and energy-dispersive electron micro-analysis: The particles separated from oil filter inserts from various vehicles were examined at the scanning electron microscope TESCAN VEGA TS 5130 with EDX spectrometer Quantax 200 (Bruker). The surface of samples was covered with a golden conductive layer in the sputter coater SC7620 (Quorum).

Infrared spectrometry: Analyses were performed at FTIR spectrometers Vector 22 (Bruker) and iS10 (Nicolet) using the procedure HATR (crystal ZnSe) in the spectral range 600−4000 cm^{-1}.

Ferrography: Separation of particles on a plastic pad was performed at the ferrograph REO 1 (Reo Trade Ostrava). Evaluation of ferrograms was performed using the assembly of bichromatic trinocular microscope type H 6000 and the digital camera Micrometrics 318 CU connected to a PC equipped with a system for image analysis LUCIA G (Laboratory Imaging, spol. s r. o. Praha) and the program ImageJ.

3.2 Experimental results

Within the performed experimental work, samples of new and used motor and gearbox oils were analysed. The course of operational wear of oils was monitored in samples taken from motors and gearboxes of various types of vehicles – from buses, passenger vehicles, heavy trucks and towing vehicles, traction units of Czech railways, military combat vehicles, both road and off-road motorbikes, tractors and agricultural machines. Hydraulic oils, oils for industrial gearboxes and plastic lubricants were also analysed.

a) Field tests

Blotter test

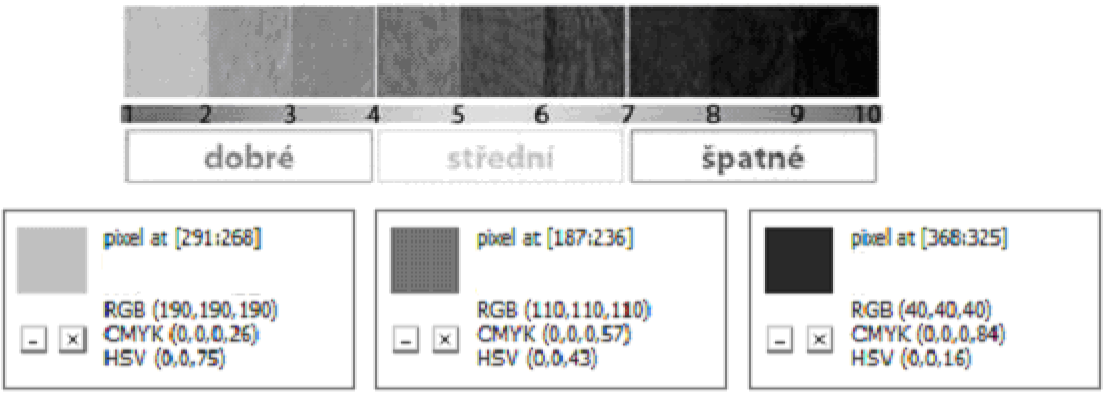
Within this section of work image analysis was used allowing quantification and archiving of the results of this simple test. The freeware program ImageJ was applied and used for objective comparison of the shape of histogram of colour shades of chromatographic patterns. A desktop scanner with the resolution of 1200 DPI was used for digitalization; a lower resolution is not suitable due to the possible distortion of the image, a higher resolution would be difficult for processing on common PCs due to the size of the processed files (hundreds of MB and larger).

A histogram of colour shades was used for evaluation of oil wear. To achieve clearer display of multiple samples the data was exported to MS Excel and the trend line – running average curve was interlayed by a histogram. A trend line was calculated as the average value of two successive values. The shapes of histograms for RGB are similar – only their coordinates change in the scale 0-255. Therefore, for further evaluation of blotter tests histograms with grey colour shades were used (0 – black, 255 – white).

Before the actual display of a histogram the shades of white colour were filtered in the plug-in Threshold colour [6], which corresponds to the colour of the chromatographic paper.

A benchmark scale according to the methodology MOTOR CHECK UP™ [7] was used for estimation of oil wear limit (fig. 1) which could be monitored on the course of the curve of the running average of the histogram. The freeware program Pixie [8] was used for determining of the value of coordinates of colour shades. A detailed description of digitalization and further processing of results is stated in the work [9].

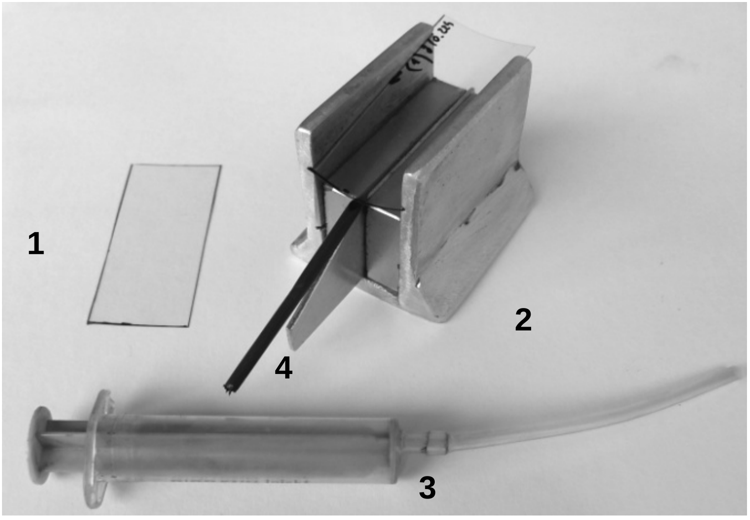
Fig. 1: Limit of wear of motor oil (in grey shades) [9]



Simplified operational ferrography:

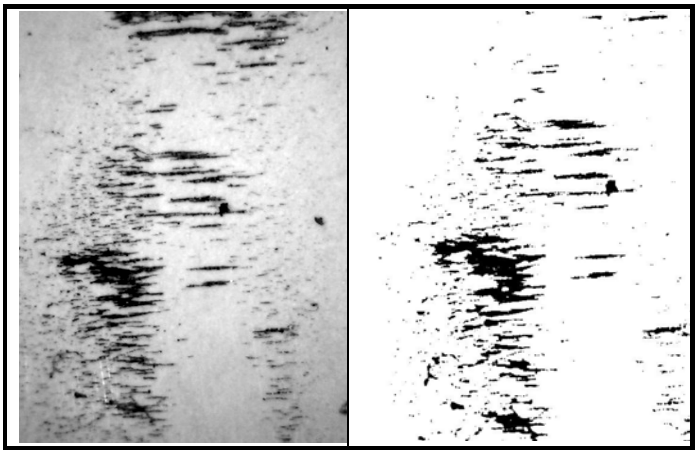
Image analysis was also used for the needs of periodic evaluation of content of mechanical impurities in motor oils. Ferrography was applied in both the classical arrangement (ferrograph is used for separation of particles, bichromatic microscope with digital camera is used for evaluation) and the simple operational variant. Authors developed a simple method applicable in operation, which does not require costly instrumentation of laboratory conditions. It allows semi-quantitative evaluation of the content of mechanical impurities in the lubricant (in the oil either without further treatment of the homogenized sample or after being dilute with benzine, in the plastic lubricant after it has been dissolved in a suitable solvent) using image analysis while using commonly available means (fig. 2) [9].

Fig. 2: Equipment for a simplified ferrographic test, 1 – plastic pad, 2 – aluminium holder with groves for sliding in the pad, 3 – syrette for application of the sample, 4 – tube for draining of waste



To create a ferrogram by this method an aluminium holder of our own design was used with an inserted FeNdB based magnet (N35, ABC Magnet Kralupy n/V.). Ferrograms were digitalized by USB microscope, images of ferrographic traces were transferred to a binary image and the ratio of the area corresponding to mechanical impurities (AF, %) and the total area of the 10×10 mm section was calculated.

Fig. 3: Image of ferrographic trace (magn. 230 x) and its binary image; AF = 5.85 %



The increase in the area covered with particles during the continuous evaluation of technical condition of the monitored machine may signal the occurrence of abnormal wear. To monitor undesirable changes occurring in operation it is important to monitor in particular relative changes between individual samples and evaluate trends of changing concentrations of mechanical impurities.

A user who does not have access to a tribotechnic laboratory or does not have the financial means for paying for laboratory tests by an external body may continuously by his own efforts obtain information which may be used for decisions whether to send the oil sample to laboratory testing to an accredited laboratory or put the vehicle out of operation (in particular if extreme increase in the amount of abrasion particles is established exceeding common trends resulting from long-term monitoring of lubricant condition) and to determine the cause of the abrasion after disassembly in an expert service company.

b) Instrumental methods

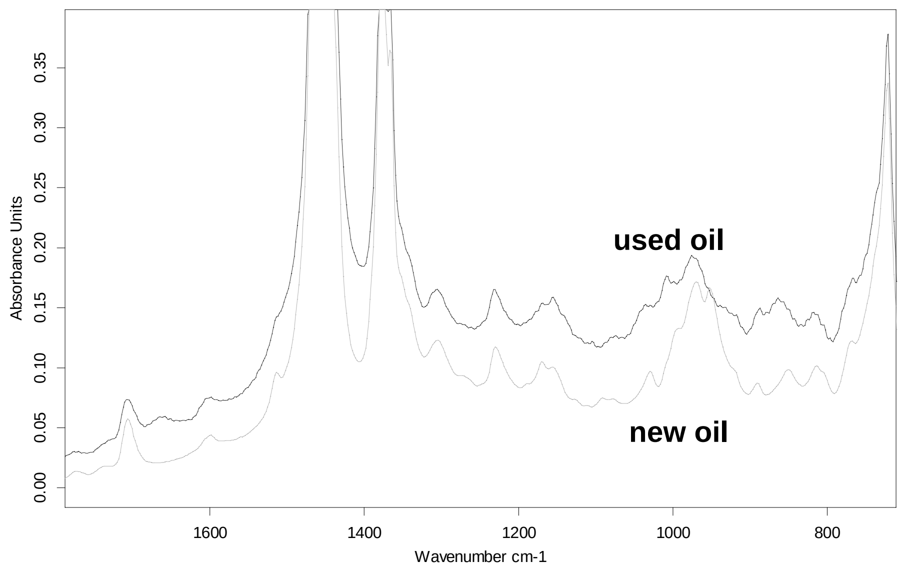
A combination of several methods is used at the tribotechnic workplace DFJP: Infrared spectrometry which allows monitoring of contamination and the degree of deterioration of oil, analytic ferrography and scanning electron microscopy – i.e. methods suitable for examination of morphology of particles and energy-dispersive analysis which may be used for determination of chemical composition of particles.

Application and benefit of these methods may be illustrated on several examples (further possibilities of these methods are described e.g., in [10−12].

Infrared spectrometry

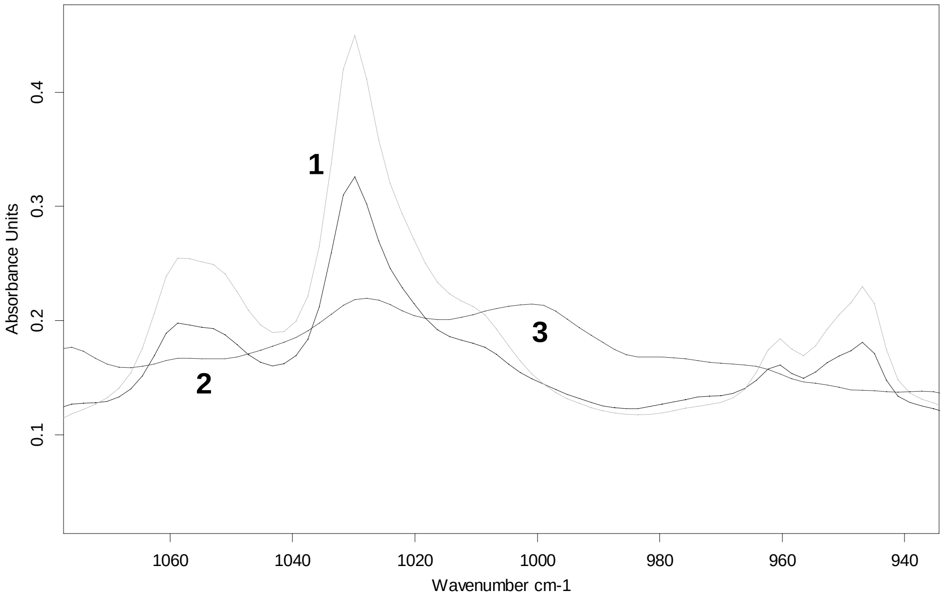
The spectrum of the motor oil allows deducing whether the concentration of anti-abrasion additives or antioxidants is sufficient (fig. 4) – it is evaluated in the area of wave number around 960 cm-1 or 1180–1120 cm^{-1}, whether there has not been any ingress of fuel to oil (area (815–750 cm^{-1}), whether the samples of oil do not show contamination by nitrogen compounds (displayed by sharp peak at wave number ca 1610−1630 cm^{-1}) due to blowing-by of exhaust fumes into the area of the crank case through untight area between the piston and the cylinder. Presence of flat peak in the area of 3300–3600 cm^{-1} or a triplet of peaks at the wave number 880, 1040 and 1080 cm^{-1} signals penetrating of water or glycol-based cooling liquid into the lubricating system. The presence of soot and carbon causes increased absorption of infrared radiation by the sample (it is monitored in the area around 2000 cm^{-1}).

Fig. 4: Infrared spectrum of motor oil Castrol Power Max 15W40, tractor New Holland T506058 (detail of area 1800–700 cm-1)



The analysis of plastic lubricant also allows monitoring the decrease of additives, deterioration of base oil, contamination from external sources, etc. Fig. 5 of a spectrum of oil sample from recovery tank wheel bearings documents the drop in concentration of additives (it is shown by the significant reduction of absorbance of wide range in the area of 1110−950 cm^{-1} with peak at 1037 cm^{-1}). With both samples, i.e. the sample from the travelling wheel and in particular the sample from the track adjusting wheel (where the lubricant is under greater stress) serious changes of chemical composition occurred. With regard to the significant reduction of concentration of additives, more frequent lubricant replenishment was recommended to the user.

Fig. 5: Infrared spectrums of plastic lubricant NH2 Neoma; a sample from the bearings of the recovery tank T-55 VT (detail of area 1080̃940 cm-1); 1 new unused lubricant; 2 lubricant from the travelling wheel; 3 lubricant from the track adjusting wheel



Analytical ferrography

The particles were studied that circulate with oil in the lubricating circuit of the given machine and individual wear mechanisms were determined. Analysis of morphology, size and number of abrasion particles (fig. 6) allows discovering imminent machine breakdown.

Scanning electron microscopy and energy-dispersive analysis

The use of scanning electron microscope allows detailed examination of morphology of metal particles separated from the lubricating oil or filter inserts; the chemical composition of individual particles established by EDX analysis specifies from which component the particle originates.

Within the performed experimental work, particles separated from oils and oil filters of various mechanisms were examined. The presence of various metallic and non-metallic particles was documented. Main attention was paid in particular to metallic particles (fig. 7). Abrasion particles were located whose occurrence is associated above all with fatigue wear and further with adhesive and abrasion wear. The non-metallic particles originate in particular from impurities from the surroundings and from wear of tightening structural elements.

Fig. 6: Particles of emergency wear (max. dimension ca 1 mm), which were isolated from motor oil

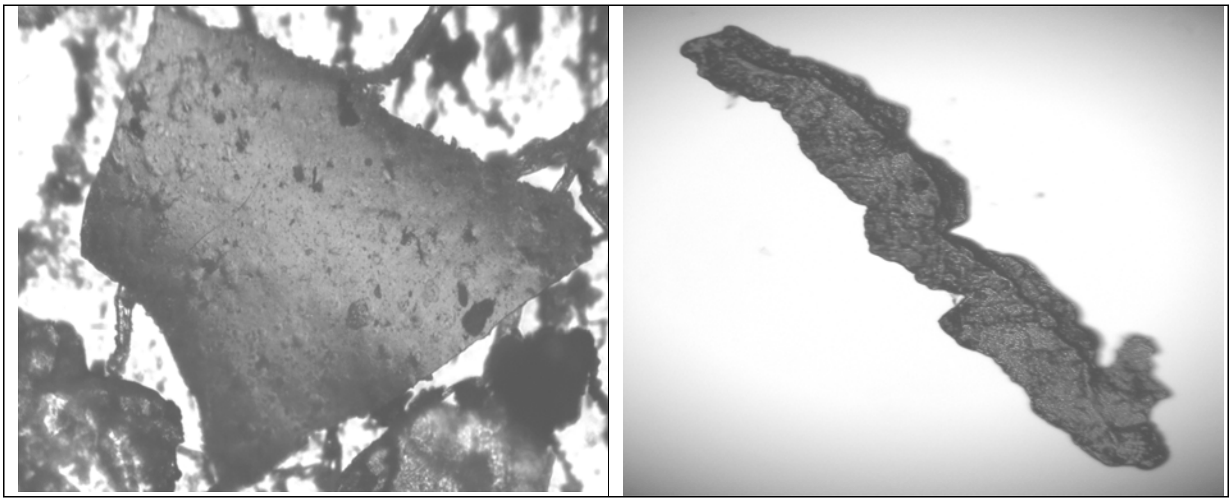
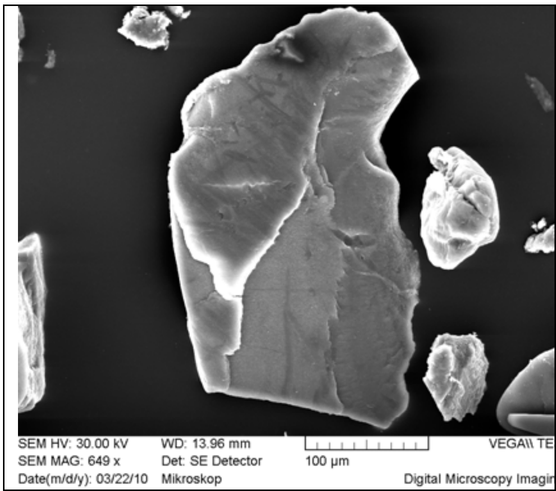
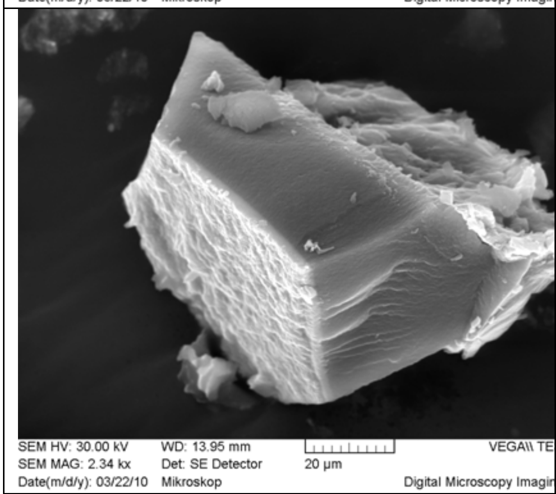


Fig. 7: Particles separated from a tractor oil filter (a – a flat particle of emergency wear, released from the surface layer of a steel component, b – a sharp-edged silicon particle of a seizing character from the surroundings)



El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error [%]
C	6	K-series	7,93	8,43	30,66	1,0
Cr	24	K-series	16,03	17,05	14,31	0,4
Fe	26	K-series	58,61	62,31	48,71	1,5
Ni	28	K-series	6,51	6,92	5,15	0,2
Au	79	L-series	4,97	5,29	1,17	0,2
		Total:	94,06	100,00	100,00	



El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error [%]
O	8	K-series	30,74	40,02	56,77	3,5
Na	11	K-series	7,27	9,46	9,34	0,5
Mg	12	K-series	1,62	2,11	1,97	0,1
Al	13	K-series	1,47	1,92	1,61	0,1
Si	14	K-series	24,66	32,10	25,94	1,1
K	19	K-series	0,45	0,59	0,34	0,0
Ca	20	K-series	4,15	5,40	3,06	0,1
Au	79	L-series	6,45	8,40	0,97	0,2
		Total:	76,80	100,00	100,00	

Note: With regard to the limited extent of the paper the detailed image documentation will be presented in the course of the conference in the form of a poster.

4. Conclusion

The analysis of lubricants based on combination of several methods creates conditions for acquisition of complex information on the course of operational wear of both the oils and the mechanisms lubricated by them.

Within the performed experimental work
a) a simple and cheap methodology for monitoring and semi-quantitative evaluation of content of mechanical impurities was proposed and verified;
b) a combination of selected advanced instrumental methods was used for identification and evaluation of the degree of wear of lubricants and machines.

By optimising lubricant management and applying tribodiagnostic procedures it is possible to achieve the reduction of negative impacts of traffic on the environment.

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Monitoring of the Atmospheric Deposition Loads of Selected Elements in Moss Occurring in the Forest in Relation to Traffic Intensity

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Abstract

The goal of the study was to test *post hoc* if different intensity of traffic along roads close to sampling sites of moss, representing bio-indicator of territorial background air pollution loads in the Czech Republic, could affect element concentrations in this substance. The concentration of 37 elements (Ag, Al, As, Ba, Be, Bi, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Hg, In, La, Li, Mn, Mo, N, Nd, Ni, Pb, Pr, Rb, S, Sb, Se, Sn, Sr, Th, Tl, U, V, Y, Zn) was determined in samples of forest moss (mainly *Pleurozium schreberi*) collected at 284 sites accross the Czech Republic in the frame of the international moss monitoring campaign (programme UN ECE ICP-Vegetation) in 2005. The moss sampling sites were situated further than 100 and 300 m from local and main roads. Additionally data about the distance to the nearest road (no more than 2000 m away) and the data about average intensities of traffic of cars, trucks and motorbikes at the given road segments in 2005 were included in the analyses.

Relationships between concentration of studied elements in moss samples and the distance of the sampling sites from the nearest road in the zone 100(300)-2000 m and 100(300)-500 m away from these roads were analysed. Relationships between element concentrations in moss and intensities of traffic of the given vehicle categories along these roads were studied as well.

No significant increase in the element concentrations in moss samples collected in the tested zones towards the road proximity was found. However, significant increase of Cr, Cu, Fe, Mo, Sb, and Zn concentrations in moss in the zone 100(300)-2000 m was detected for the increasing intensities mainly of cars. In the zone 100(300)-500 m, the element concentrations in moss were not significantly correlated with the distance of the sampling site from the road edge. In this zone the increase of traffic of all types of vehicles significantly increased total content of nitrogen in moss and increasing intensity of the motorbike traffic significantly increased concentration of Cu, Mn, S and Hg in moss.

Methods used in the geographical information systems and statistical analyses, mainly basic statistics and multiple regression methods were explored in this study.

1. Introduction

Some forest mosses serve as suitable bio-indicators of atmospheric deposition loads of elements. Having no genuine roots moss is not capable of element uptake from solution from soil covers. Moss effectively retains dry and wet deposition on aboveground parts. When moss plants are wet dissolved nutrients and cations of other elements are adsorbed on intercelular pectin and cell structures. That is why element content in moss tightly correlates with the atmospheric deposition loads measured, for example, in retaining vessels (bulk atmospheric deposition). A regular determination of distribution of element concentrations in moss is used for revealing operation of local anthropogenic and natural pollution sources, and output of emissions in most of European countries, including the Czech Republic.

In the frame of the last European moss survey (International Co-operative Programme UN ECE ICP-Vegetation 2005/2006) the element concentrations in moss were determined at about 280 sites in the Czech Republic. In order to interpret moss surveys properly effect of other site factors (e.g., elevation of the sampling plots, annual precipitation sums, geological and geomorphologic conditions, settlement density, local land use, etc.) on element content in moss has been tested.

Traffic is a substantial source of pollution along roads, which may affect element composition in moss. In the past, Pb contamination near roads was frequently investigated. Even if leaded petrol distribution was ceased in the Czech Republic in 2000 car traffic still remains an important source of toxic and risk metals, organic compounds, etc. [1]. Metals (e.g., Cd, Cr, Fe, Pb and Zn) are released into the environment due to corrosion of fuel cells, metal parts of cars, paintings, etc. Metals released from catalytic converters (e.g., Pt, Pd, Co) and metals from oils and lubricants (e.g. Mo, W) also appear in exhaust fumes. Friction of moving parts of vehicles, mainly breaks and clutches, is an important source of Al, Ba, Cd, Cu, Fe, Mg, Mn, Mo, Zn. Particles released from tyres contain elements from rubber pigments and additives (e.g., C, Fe, S, V, Zn). Friction of roads release particles containing terrigenic elements, such as, Si, Al, Fe, rare earth elements, U, etc. and tar particles. Metals (Cd, Pb a Zn) were found in salts used for de-icing roads in winter [2]. Terrigenic elements may be released from inert spreads. Primary size of released particles increase due to hydration, absorption and electrostatic interactions. Road dust contains mainly coarse particles coming from cars, road and local soil covers. [3]. Coarse particles are fast deposited and may be resuspensated by moving cars. The zone of main contamination of soil covers and plants along roads influence by deposition of coarse particles reaches only several meters from the road edge, and the contamination level decreases exponentially from the distance from the road, e.g. [4],[5],[2]. The contamination of soil surface was studied, for example, in distances 1,5; 10; 25 a 60 m from a road in Jordan [6], contamination of soil and plants in intervals 0-50-200-500-1000 m far from busy roads in Lithuania [7]. Determined concentrations of heavy metals in soil and crops along roads can be found for example in [8] (Cd, Pb, Zn), [9] (Cu, Ni, Pb, Zn), [10] (Cd, Cu, Ni, Pb, Zn) and [11] (Cd, Cu, Pb, Zn). Decrease of the element concentrations to the background level is stated in several meters from the road edges.

In order to avoid collection of moss samples affected by traffic contamination the manual of the international moss surveys [12] obliges to collect moss samples in distance larger than 100 and 300 m from local and busy roads, respectively. These limits respected mainly reported zones of Pb contamination caused by deposition of coarse particles along road.s However, present studies have showed that current vehicle engines emit also fine (PM) and ultrafine particles of diameter less than 10 μm [13] that can contain metals. These particles sediment very slowly and can carry metals and other pollutants for much larger distance from roads than coarse particles.

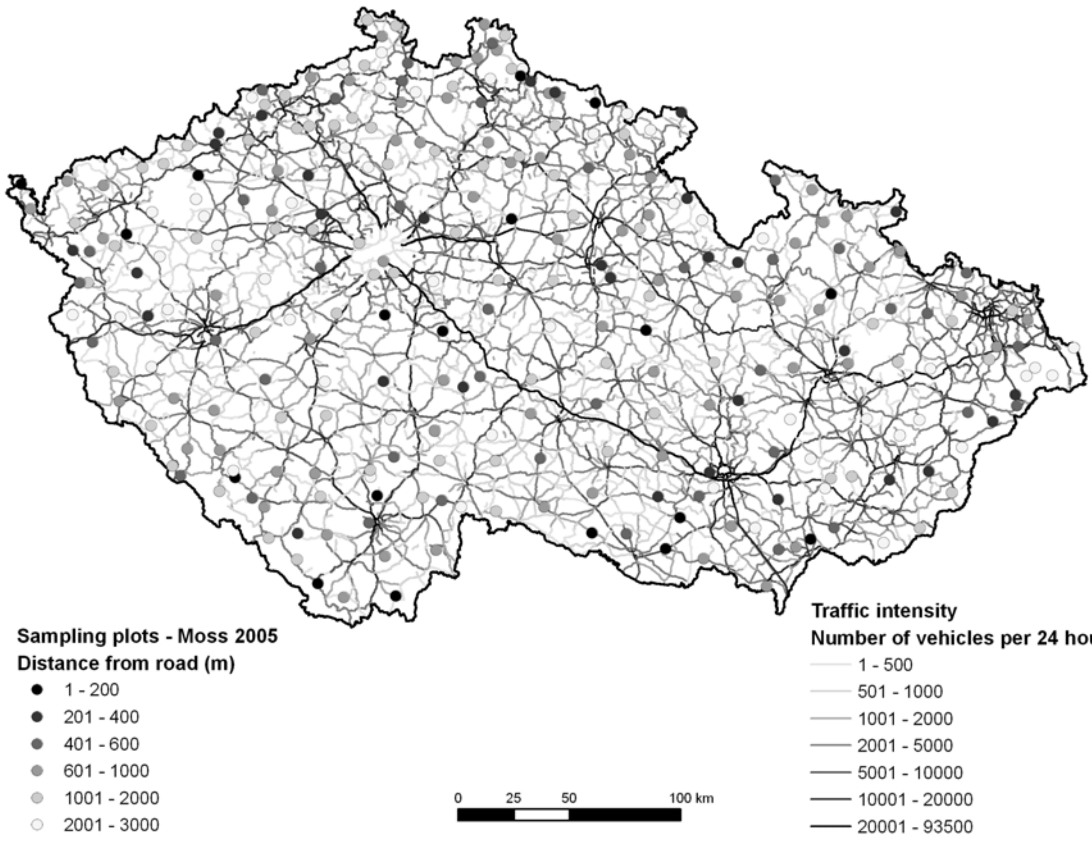
Thus we are interested if the deposition of these fine particles could affect element content in moss samples collected in the moss survey 2005 at the sampling plots situated along roads in distances larger than 100 or 300 m. In order to answer this question a *post hoc* analysis of the moss results from the biomonitoring campaign 2005 was carried out.

2. Material and methods

For the *post hoc* analysis the analytical results exclusively from the moss survey 2005 were included. No additional moss samples in the zones 0-100 m or 0-300 m, or along linear transects running through these zones were carried out.

Data about concentration of 37 elements (Ag, Al, As, Ba, Be, Bi, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Hg, In, La, Li, Mn, Mo, N, Nd, Ni, Pb, Pr, Rb, S, Sb, Se, Sn, Sr, Th, Tl, U, V, Y, Zn) determined in moss (mg/kg), mainly *Pleurozium schreberi*, collected at 282 monitoring plots accross the Czech Republic (Fig. 1) in 2005 were evaluated. More details about collection and processing of the moss samples are available in [1]. Moss samples were digested in a microwave system (CEM) in nitric acid and hydrogen peroxide (Merck suprapure). Concentrations of most elements were determined using ICP OES and ICP MS methods. Concentration of Hg was determined directly in pulverized moss samples using Hg analyser (AMA-254). Total nitrogen content was determined after microwave digestion in sulphuric acid and hydrogen peroxide and distillation (Kjeldahl). All samples were analysed in triplicate. Quality of analytical results was checked through analyses of plant and moss reference materials and participation in international interlaboratory tests (University Wageningen, programme WEPAL). For more details see [14].

Fig. 1: The traffic intensity map and distribution of the moss sampling plots in the Czech Republic in 2005



The data about traffic intensity at the nearest roads near the moss sampling plots (up the distance 2000 m) were obtained from the Road Traffic Census 2005 carried out in the Czech Republic in 2005. These public records are available at the web pages of the Road and Motorway Directorate [15]. The traffic intensity map includes figures for trucks, cars, motorbikes and all vehicles flow at counting segments of each road (total number of counting road segments 7800).

The data about position of the moss sampling plots and the nearest roads with available figures about the traffic intensity in 2005 were processed in the geographical information systems, in the software ArcGIS 9.x and in the supplemented programme Spatial Analyst. The concentrations of elements in moss (logarithms), distance of the moss sampling plot from the nearest road (m) and flows of the individual categories of vehicles (vehicles/24 hours) at the given road segment were evaluated. However, if the nearest road was more than 2000 m distant such data were not included in this evaluation. Basic statistics and multiple regression analysis were carried out using programme StatSoft STATISTICA 8. In the first step effect of roads on the element concentrations in moss were analysed for the moss samples collected 100(300)-2000 m from the nearest road and in the second step the analysis was undertaken for moss samples collected in the zone 100(300)-500 m from these roads.

3. Results

The comparison of the element concentrations in moss showed that mean concentrations of the investigated elements were higher in the zone 100(300)-2000 m than in the zone 100(300)-500 m. This was confirmed by the multiple regression results. The concentration of 17 elements in moss significantly ($p \leq 0.05$) increased with the distance of the sampling plot from the nearest road in the zone 100(300)-2000 m. Table 1 shows all significant regressions between element concentration in moss and the distance of the sampling plot from the nearest road within the zone 100(300)-2000 m from the road (pure effect of distance from roads without effect of different traffic intensity along individual roads).

Tab. 1: The significant regressions between element concentrations in moss and the distance of the moss sampling site from the nearest road in the zone 100(300)-2000 m in 2005. (n = 229, r – correlation coefficient, p – significant level)

Concentration in moss	**Distance from roads 100(300)-2000 m**		**Concentration in moss**	**Distance from roads 100(300)-2000 m**	
Element	r	p	Element	r	p
Al	0.17	0.010	**Mo**	0.15	0.026
As	0.18	0.005	**Ni**	0.14	0.032
Bi	0.13	0.042	**Se**	0.14	0.037
Hg	0.16	0.016	**Sn**	0.14	0.040
Ga	0.16	0.018	**Sr**	0.15	0.026
In	0.16	0.015	**U**	0.15	0.021
La	0.14	0.038	**V**	0.16	0.013
Li	0.14	0.030	**Zn**	0.13	0.045
Mn	0.16	0.018			

Table 2 presents the found significant relationships between element concentrations in moss and the traffic intensity for all investigated categories of vehicles along the nearest road in the distance up to 2000 m from the site of moss collection. This table shows the pure effect of the different flow of vehicles on elements concentration in moss in the zone 100(300)-2000 m without effect of different proximity of the sampling site to the nearest road.

Tab. 2: Significant regressions between element concentrations in moss and different traffic intensity of given categories along the nearest road in 2005. (n = 227, r – correlation coefficient, p – significance level)

Concentration in moss	**Flow of vehicles (number per day)**							
	Cars		Trucks		Motorbikes		All vehicles	
Element	r	p	r	p	r	p	r	p
Cr	0.14	0.028			-	-	0.15	0.029
Cs	-	-	-0.16	0.016	-	-	-	-
Cu	0.15	0.023			-	-	0.14	0.033
Fe	0.16	0.016	0.14	0.036	-	-	0.16	0.017
Mo	0.17	0.010	-	-	-	-	0.16	0.018
Rb	-0.14	0.041	-0.17	0.010	-	-	-0.15	0.025
Sb	0.14	0.042	-	-	-	-	-	-
Zn	0.14	0.030	-	-	-	-		

For evaluation of the traffic effect on element content in moss the moss samples collected in the zone 100(300)-500 m from the nearest road (65 cases) were used for the regression analysis. Data about the traffic intensity were available for 63 cases.

The regression analysis did not find any significant regression for concentrations of the investigated elements in moss and the distance of the sampling sites of the moss samples from the nearest road in the zone 100(300)-500 m. Surprisingly, also effect of different traffic intensity on the element concentrations in moss growing nearer to the roads was small. Significant relationships were revealed only for content of 5 elements in moss growing in the zone 100(300)-500 m from the nearest road and the motorbike flows. Only total nitrogen content in moss significantly correlated with flows of the remaining vehicle categories at the investigated zone. These significant relationships are documented in Table 3.

Tab. 3: Significant relationships between concentration of elements in moss in the zone 100(300)-500 m from the nearest road and the flow of vehicles along the nearest roads in 2005, (n = 63, r – correlation coefficient, p – significance level)

Concentration in moss	**Flow of vehicles (number per day)**							
	Cars		Trucks		Motorbikes		All vehicles	
Element	r	p	r	p	r	p	r	p
Cu	-	-	-	-	0.31	0.013	-	-
Mn	-	-	-	-	0.28	0.028	-	-
S	-	-	-	-	0.33	0.009	-	-
Hg	-	-	-	-	0.34	0.007	-	-
N	0.32	0.011	0.31	0.014	0.41	0.001	0.33	0.009

4. Discussion

Let's suppose that investigated elements are bound on coarse and fine particles emitted from the running of vehicles. The coarse particles are deposited in a narrow zone along road edges. The fine particles have very small speed of sedimentation and they are deposited far from roads.

The element content in the moss samples did not indicate positive effect of roads on accumulation of elements under investigation in moss growing in distance larger than 100 and 300 m from the local and major roads, respectively. Unexpectedly, significant increase in element concentrations of 17 elements in moss was found with distance from the nearest road in the zone 100(300)-2000 m (Tab. 1). These elements are emitted not only from the road traffic but other industrial and natural sources of atmospheric pollution. Majority of coarse particles from traffic of local and major forest roads is deposited within the zone 100-300 m from the road edge. There are no published data about contamination of plants by metals emitted from road traffic in so large distance from roads. In the larger distance from forest roads atmospheric deposition of particles emitted from other pollution sources may operate. Emissions from other sources are caught by trees in an edge zone of a forest. Increased accumulation of elements in moss with increasing distance from forest roads can be explained by the operation of emissions emitted from other sources of pollution and increased penetration of these emissions to the forest floor towards the forest edge.

However, significant increase in accumulation of Cr, Cu, Fe, Mo Sb and Zn in moss in the zone 100(300)-2000 m in dependence on flow of vehicles along the nearest roads may indicate effect of fine particles released from running vehicles. In contrast to the coarse particles these fine particles may have a longer residence time in the atmosphere and they are deposited hundred meters away. It was stated that these fine particles showed the constant horizontal deposition in distances 200-600 m from roads or decreasing concentrations to half for each 100-200 m from road [16],[17],[18]. Small or no significant effect of trucks and motorbikes on element content in moss in the zone 100(300)-2000 m can be explained by small flow of these vehicles along the forest roads.

Concentrations of Cs and Rb in moss showed significant decrease with increased truck flows. These elements are not included in industrial emissions but they are frequently present in some granite types. In case of these elements probably accidental correlation between Cs and Rb concentration in moss and distribution in the Cs and Rb rich rock types should be realised.

It may be interesting that concentration of not any element in moss in the zone 100(300)-500 m significantly correlated with distance from the nearest road. The moss samples were collected out of the zone of sedimentation of coarse particles emitted from traffic (ca 5-50 m). The concentration of fine particles emitted from traffic in atmosphere and their sedimentation in the zone 100(300)-500 m may be constant. Coarse particles approaching to the sampling plots from other sources are filtered at the outer forest margin. That may explain no (or constant) effect of distance of the nearest roads from the moss sampling sites in the zone 100(300)-500 m on the element concentrations in moss.

Increased flow of trucks and cars significantly increased total nitrogen in moss everywhere in the zone 100(300)-500 m. Considerable amounts of nitrogen compounds are emitted by vehicles. Rather gaseous character of the nitrogen compounds causes their small deposition speed and increased concentrations in the atmosphere in forests in distance up to 500 m from roads.

Unexpectedly, concentrations of many elements in moss correlated with the motorbike flows. However, number of running motorbikes was relatively small. It is difficult to explain this phenomenon. Either emission from motorbikes contains high concentrations of Cu, Hg, Mn, N and S compounds or accidental correlations were found for these elements.

Preliminary results indicate some important relationships between element content in moss and traffic. The topic should be investigated in more detail in next investigations when data from moss and traffic surveys 2010 are available.

5. Conclusions

Significant increase in concentration of Al, As, Cr, Hg, Ga, In, La, Li, Mn, Mo, Ni, Se, Sn, U, V and Zn in forest moss *Pleurozium schreberi* with distance of the moss sampling sites from the nearest road in the zone 100(300)-2000 m is probably caused by deposition of these elements from other pollution sources and decreasing filtration effect toward forest edge.

Concentration of Cr, Cu, Fe, Mo, Sb and Zn in moss in the zone 100(300)-2000 m from the nearest road significantly correlated with flow of vehicles, mainly cars. However, the concentration of elements in moss in the zone 100(300)-2000 m from the nearest road did not correlate with the motorbike flows. The concentrations of Cs and Rb in moss were rather controlled by distribution of rock types rich in these elements than with the truck flows.

In the zone 100(300)-500 m no significant effect of distance of the moss sampling site from the nearest road on element content in moss was found probably due to constant concentration of fine particles emitted from traffic. However in this zone content of N in moss significantly correlated with increasing flows of all types of vehicles and concentration of Cu, Hg, Mn, and S with the increasing motorbike flows.

The relationships between element concentrations in moss and traffic intensity along close roads should be investigated in the future. New findings may contribute to the knowledge of spreading the emissions from traffic in forests and initiate changes of distance limits along roads for the moss-monitoring campaigns if needed.

Acknowledgement

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Urban Sprawl Syndrome and Transport

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Abstrakt

This contribution aims at transport and environment, particularly relation between the transport and spreading of urbanized area. Transport is an inseparable part and parcel of our life. Considerable increase of transport, mainly in the last century, brings many benefits but on the other side this process is attended by some side effects. Our health is destroyed by air pollution and traffic noise and our land is fragmented by traffic roads. Transport, especially road transport, is also one from the driving forces of urbanization.

At the beginning of this paper the historical context of suburbanization is mentioned. Next parts of this contribution present one from the 16 syndromes of Concept of the syndromes of global change that was developed by the German Advisory Council on Global Change in 1996 – Urban Sprawl Syndrome. The article mainly focuses on the role of transport in this syndrome. Last but not least the possible actions are mentioned.

1. Introduction

Excessive and uncontrollable spreading of urbanized areas in the countryside caused many problems and also induces the transport, especially road transport.

Destruction of landscapes through planned expansion of urban infrastructures is called Urban Sprawl Syndrome. This syndrome is one from the 16 syndromes within the frame of Concept of the syndromes of global change. This Concept was developed by the German Advisory Council on Global Change (WGBU) in 1996.

There are three groups of the syndromes in the Concept. Utilization syndromes represent over cultivation, overexploitation (for example Overexploitation Syndrome or Mass Tourism Syndrome), development syndromes such as above mentioned Urban Sprawl Syndrome or Asian Tigers Syndrome represent unsustainable development and the last group of syndromes – sink syndromes - contain three syndrome (Smokestack Syndrome, Waste Dumping Syndrome and Contaminated Land Syndrome).

2. Urban sprawl syndrome

This syndrome is caused by unsustainable development, especially by unsustainable urban development. Main characteristic of this syndrome is the growth of transport. The term Urban Sprawl appeared in an essay Urban Sprawl by William Whyte in 1957.

There are many various definitions of urban sprawl, and sprawl is usually characterized by [8]:

- Low-density residential development
- Rigid and large-scale separation of homes, shops, workplaces, civic uses, and gathering places
- A lack of distinct, thriving activity centres, such as strong downtowns or suburban town centres
- A network of roads marked by very large block size and poor pedestrian access from one place to another

There is a relationship between the kind of transport and the form of the cities. Transport influences the location and shape of the settlement. The most cities were tied to the waterways and were developed along the ports, rivers and canals in the 1st half of the 19th century. In the end of the 19th century the competition from the railways tried to increase. The growth of cities began to significantly affect investment in the railways. The towns lying on main railway lines were developed rapidly. The cities spread further away from the railway because of the development of public transport. Structure of the city gradually changed to a compact centre surrounded by residential areas due to the quality provided by public transport. But public transport has grown competition from cars in the half of the 20th century.

Reduction in real prices of transport and an extension of regular routes brought increasing of city areas. For example nowadays enormously extended mega-urban regions Beijing or Shanghai in China are developed along infrastructure corridors.

Roads transport allowed the expansion of many cities but with low density of inhabitants. This process is called suburbanization and represents outflow of residents from the city centre to suburbs with low-density built-up and the suburban landscape.

Urban sprawl affected the cities through the continents. The Global report on human settlements 2009, published by UN-HABITAT, the United Nations agency for human settlements, observed that North American cities are typical examples of this syndrome. James Howard Kunstler wrote in The Geography of Nowhere in 1993 [8]: „Eighty percent of everything ever built in America has been built in the last fifty years, and most of it is depressing, brutal, ugly, unhealthy and spiritually degrading.“ By 2000, sprawl was increasing at twice the rate of urban population growth in the United States.

The Canadian cities Calgary, Vancouver and Toronto are the three of the world´s ten urban areas with the most extensive sprawl. European cities were more compacted before the era of the automobile explains, but now is there a lot of suburbanization areas too [6].

The picture 1 [8] presents a caricature of Conventional Suburban Development and its contrast with Traditional Neighbourhood Development. Urban sprawl and its features, like low population density, dispersed pattern, automobile dependency and separation of uses (work, homes, shops, school) is represented on the top of the graph. The traditional neighbourhood characterized by the different types of housing and mix using is shown in bottom of the graph.

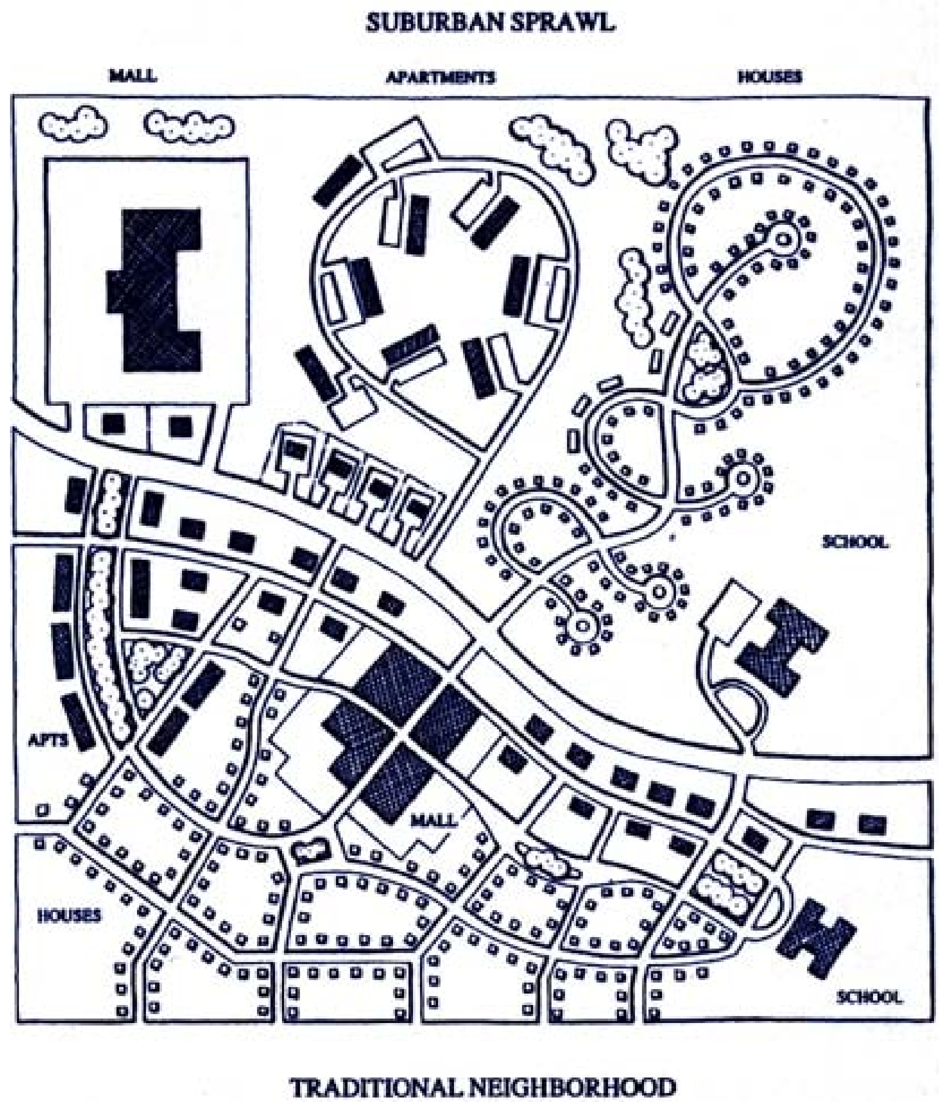
The picture pointed the problem with automobile dependency very illustratively. Single-use development that is spread out over large regions causes two groups of problems.

On the one hand this development creates a settlement pattern that is completely dependent on automobiles. People need automobiles for all daily tasks such as going to work, going to school, seeing a doctor, visiting a friend, and so on.

On the other hand sprawl contributes to air and water pollution, and occupies surrounding landscape.

Sprawl also destroys the traditional communal places (town square, town centre, urban nature), and segregates people by their income.

Picture 1: Conventional Suburban Development and Traditional Neighbourhood Development [8]



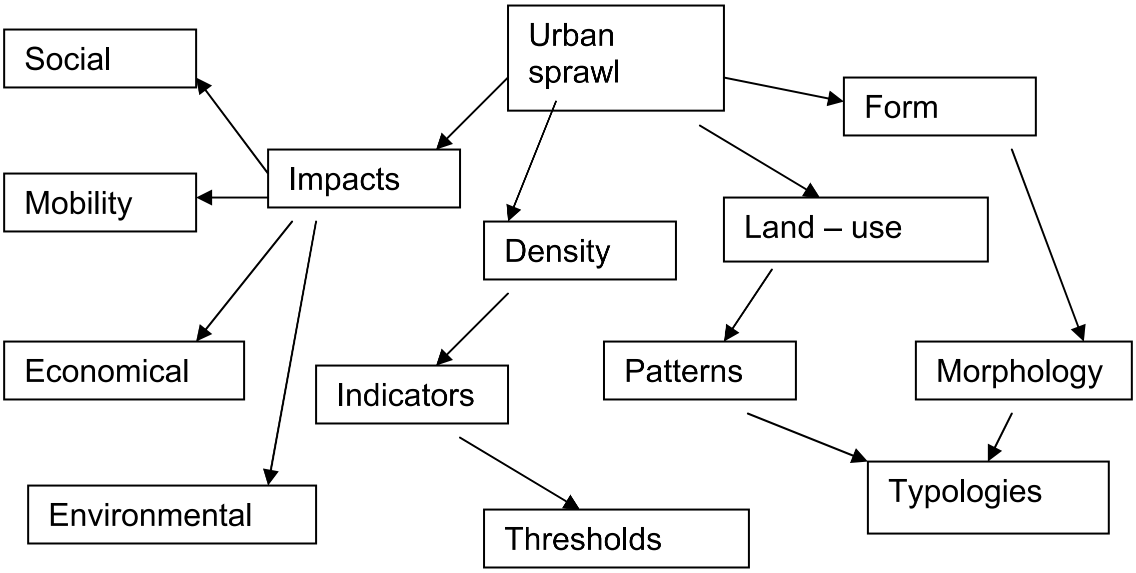
There are two kinds of suburbanization - residential and commercial. Purely residential settlement usually of family houses, often with no connection to any civic facilities generates roads transport. People living there are dependent on the automobiles.

The commercial suburbanization means the large one-storied production and storage halls, warehouse, and so on. This monofunctional surfaces are creating low-quality architectural design, often near or along roads.

Measures and criteria for the assessment of urban sprawl are on the graph number 2 [5]. Urban sprawl is describing by the urban form, land-use, density and impacts.

Impacts that related to sustainability are divided into four groups - economical, social, environmental, and impacts connecting with transport. Indicators, patterns and morphology are used for measure and thresholds and typologies are used for evaluating.

Picture 2: Measures and criteria for the assessment of urban sprawl [3]



3. The role of transport in the urban sprawl syndrome

The spreading of development areas in to landscape, that influence population density cause dependency on automobiles. The consequences of automobile dependency include [8]:

- Increased traffic congestion
- Longer commutes that steal time from family and work productivity
- Built-in costs of owning, maintaining and insuring multiple automobiles per household
- Dependence on gasoline and no transportation alternatives to offset rising gas prices

3.1 Consequences of Urban Sprawl

There are three main consequences of urban sprawl, environmental, economical and social (see table 1 [3]).

Table 1 Consequences of Urban Sprawl [3]

Environmental consequences	**Economical consequences**	**Social consequences**
Disturbance in water balance	Infrastructure investments	Social segregation / exclusion
Increase in flood risk	Loss of fertile soils	Concentration of poverty
Loss of biodiversity	Rising land prices / speculation	Uneven distribution of burden
Deterioration of landscape	Increase in individual travel needs	Formation of suburban milieu
Increase in emissions	Rising tax-revenues (and additional infrastructure) in suburbia	Societal retreat
Degradation of soils	Fiscal constraints of core city	Deterioration of inner cities
Local climate changes	More space available	

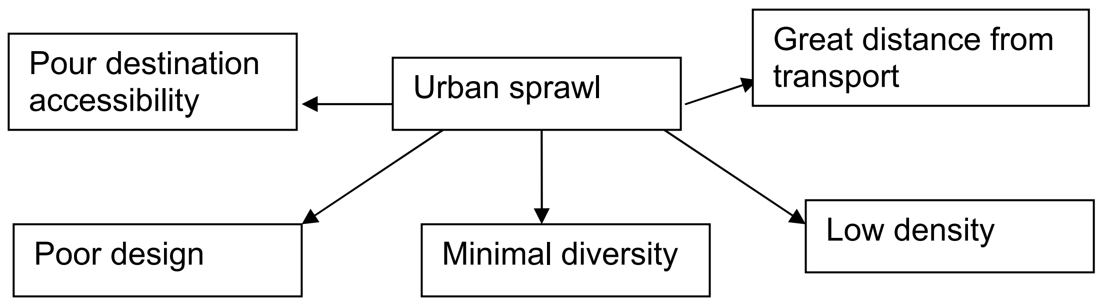
Zdroj: [3]

But there is another consequence – consequence of sprawl for traffic. Impacts of transport on urban sprawl cause increasing in traffic demand and private automobiles are predominating kind of transport. Consequences of sprawl for traffic include more traffic jam, increasing of energy consumption and noise and air pollution, health problems, more infrastructure investments and declining of public space.

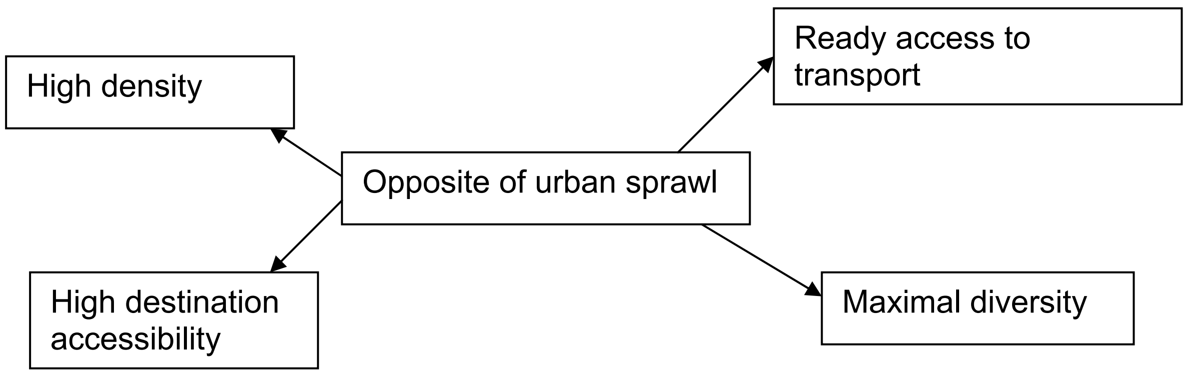
3.2 Reduce the traffic impacts caused by urban sprawl

There are several ways to minimize driving. One from them is developing in existing centres, because there is high destination accessibility, such as employments, shopping or recreation facilities. The next factor helping to increase impacts from sprawl syndrome is mixed-use, where workplaces, schools and shops are near to people´s homes. Next picture number 3 [2] shows the urban sprawl and what causes. Picture number 4 [2] shows options to reduce the impact of urban sprawl.

Picture 3: Urban sprawl [2]



Picture 4: Opposite of urban sprawl [2]



Another possibility for decreasing urban sprawl syndrome impacts is increasing of density. There are three ways such this increasing take place [1]:

- High population density enables people to go to work, to marketplaces or to meet friend without cars
- High population density means a higher number of facilities in a small area. This arrangement reduces the need of long travels
- High population density influences situation for improving public transport

4. Conclusion

Urban sprawl is a major issue not only for transport engineers. This phenomenon has occupied planners and policymakers. The first study about the sprawl syndrome called “Costs of Sprawl” was published by the Real Estate Research Corporation in 1974.

Urban sprawl affects different areas of our lives. This contribution discusses particularly the relationship between suburbanization and transportation. But there are also the economic and fiscal impacts such as higher taxes needed to pay for public services or declining in economic opportunity in existing towns and cities.

The social costs of urban sprawl are for example already mentioned segregation of people and decreasing opportunities for social interaction between people of different backgrounds, races or classes.

Sprawl influences also the landscape from which the open fields, farmland, forests or wetlands disappear very quickly. Sprawl also participates in flooding through massive increases in impervious surfaces such as roadways, parking lots and buildings.

There are several ways to stop or to decrease urban sprawl. It is necessary to support mix–use development with the high density and focused on existing centres. These tasks are for transport experts as well as for politicians and city planners.

One from the possible ways offers the new urban design movement called New Urbanism. This movement, evolved in the early 1980s, is strongly preferred walk-able neighbourhood, sustainable communities with a mix of uses, public transport, and so on.

"Sprawl is now a bread-and-butter community issue, like crime," said Jan Schaffer, executive director of the Pew Centre for Civic Journalism [8] "and Americans are divided about the best solution for dealing with growth, development and traffic congestion."

Last but not least is necessary to add that it is the converging views on dealing with urban sprawl that is essential for further development.

Acknowledgement

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Influence of Newly Added Bio Components on the Fate and Performance of Fuels in Environment

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Abstract

In agreement with European Union (hereinafter EU) regulations, fuels used in the EU member states must be enhanced by bio components and the ratio of bio components to petrol will continue to increase incrementally. Although the use of biofuels is positive in many ways, it is not yet known how these substances influence fuel properties in the case of leakage and the consequent clean-up operation.

Within the presented work several comparative tests were held, orientated mainly on biodegradability of fuel mixtures, their affinity to commonly used sorbent materials and their ability to penetrate the soil horizon.

This project is being performed under financial support of the Ministry of Transport of the Czech Republic (project no. CG912-039-520) within the program “Support of sustainable development in the transport sector”.

1. Introduction

The addition of fatty acid methyl ester (hereinafter FAME) to the diesel and the addition of bio-ethanol and methyl tert-butyl ether (hereinafter MTBE) to the petrol may cause some changes in the physical properties of said fuels, which can influence potential clean-up operation timetable. Different tests were held to clarify these effect and the findings should help to upgrade the methods of procedures of the clean-up operations if needed. Only partial results are presented as the project is still ongoing.

2. Materials and methods

All the fuels and chemicals used in the tests were obtained from the Litvinov refinery, fresh and pure. The fuel mixtures were prepared in laboratory. 0,1 % w/w of butylated hydroxytoluene (hereinafter BHT) was added to FAME for preserving it. BHT is an antioxidant commonly used for preserving FAME, therefore its performance in the tests is correct and refers to the real conditions.

Evaluation of the test samples was partly made in Dekonta’s laboratories in Dretovice and partly in laboratories of the Microbiological institute - Academy of Sciences in Prague. The appropriate methods are specified in relevant chapters.

3. Influence of FAME on diesel attenuation rate in model soils

The presence of an easily degradable FAME in the diesel may influence the natural attenuation rate of this mixture in the environment. This may influence the petrol hydrocarbons attenuation speed positively - as said in [1, 2, 3], or negatively, referring to [4]. To verify this, the laboratory-scale and pilot tests were held.

3.1. Laboratory tests

Following tests were conducted, to specify the difference between attenuation rate of pure diesel and diesel with 5 % V/V of FAME. Three different soil types were chosen: soil “A” was brown clay with middle humus content, sample “B” was a yellow sandy soil poor in humus and nutritional elements and soil “C” was river sediment, rich in humus compounds. Apart from these differences, each soil sample had also a different structure and the level of microbial population.

Two out of three soil samples were contaminated to concentration of about 10 000 ppm (10 g/kg) with either diesel or diesel with 5 % V/V of FAME and one sample was left blank (see tab.1). The samples were then irrigated regularly.

Tab. 1: Laboratory tests, composition of samples, three soil types, labelled “A”, “B” and “C”.

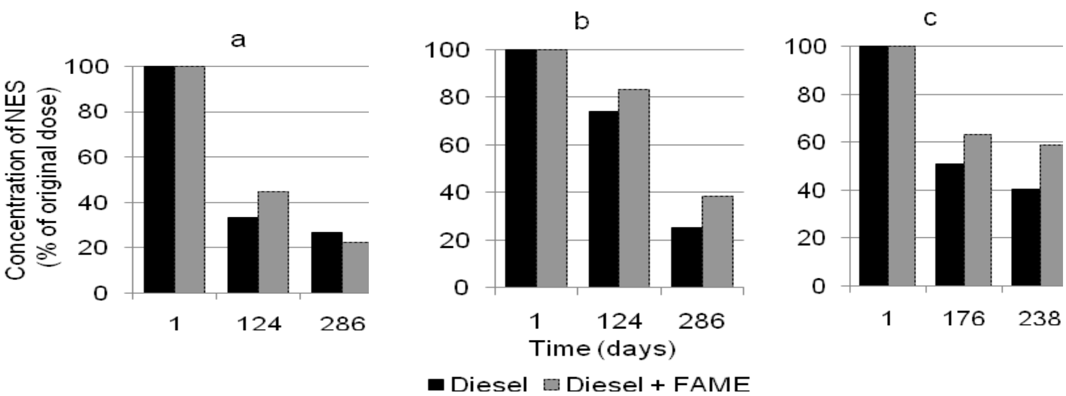
Sample lbl.	Contaminant type	
	Diesel	FAME
A1	10 000 ppm	-
A2	10 000 ppm	5 % V/V
A3	-	-
B1	10 000 ppm	-
B2	10 000 ppm	5 % V/V
B3	-	-
C1	10 000 ppm	-
C2	10 000 ppm	5 % V/V
C3	-	-

Gas chromatograph with mass selective detector was used to evaluate the results from testing samples, according to the Czech technical norm CSN EN 14039. Non-polar extractive substances (hereinafter NES) were evaluated.

Tab. 2: Laboratory tests, concentration of NES in samples, (% of the original dose).

Day/Sample	A1	A2	B1	B2	C1	C2
1	100	100	100	100	100	100
124	33	45	74	83	51	63
238	-	-	-	-	40	59
286	27	22	25	39	-	-

Graphs 1a-c: Laboratory tests, the decay in NES concentrations (% of original dose) in the soil sample “A” (graph a), sample “B” (graph b) and sample “C” (graph c).



The results of control sampling are shown in tab. 2 and graphs 1a–c. The natural attenuation rate of petrol hydrocarbons of the diesel-FAME mixture was slower than pure diesel.

3.2. Pilot field tests

The field tests were carried out to try to confirm the laboratory findings in the natural conditions. Soil type “B” was chosen for these tests and about 18 tons of this material was used. The soil was placed on the testing field, divided into piles and contaminated to concentration of about 5 000 ppm (5 g/kg) with either diesel or diesel containing 5 % V/V of FAME. Each pile was than divided again, one half was left to natural attenuation and the second half was treated by bacterial preparation Biotech IV – commercially used biopreparation of Dekonta company (see tab. 3).

Tab. 3: Field tests, composition of sample piles.

Sample lbl.	Diesel	FAME	Biological treatment
D	10 000 ppm	-	no
D-Bio	10 000 ppm	-	yes
D+F	10 000 ppm	5% V/V	no
D+F-Bio	10 000 ppm	5% V/V	yes

Biotech IV is a bacterial preparation, composed by strains able to utilize diesel hydrocarbons as a carbon source and thus help to decontaminate the affected material. It was applied on one half of the tested contaminated soil on the 2nd, 17th, 38th and 81st day of the test, while the other half was left without any treatment, for comparison.

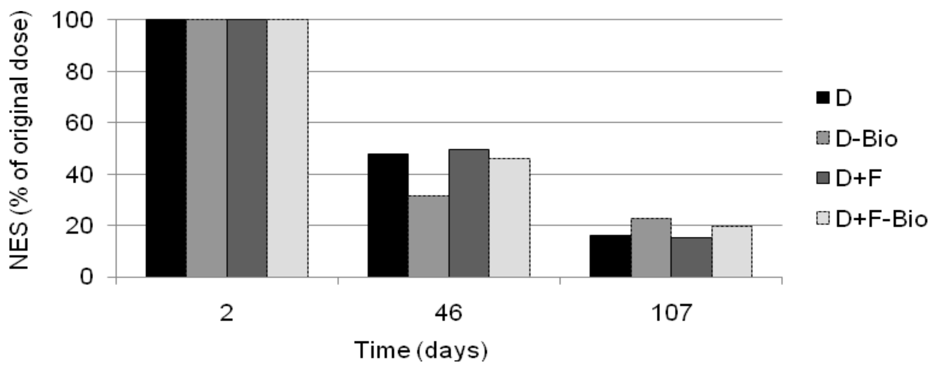
Fourier transform infrared spectroscopy was used to analyze the samples on NES, always 8 samples were taken from each pile.

The field tests are still ongoing and so far available results are shown in tab. 4 and graph 2.

Tab. 4: Results of field tests, concentration of NES in samples (% of the original dose).

Sample lbl. / day	2	46	107
D	100	48	16
D-Bio	100	31	23
D+F	100	49	15
D+F-Bio	100	46	19

Graph 2: Field test, the decay in NES concentrations (% of original dose) in the samples, D - pure diesel, D-Bio– diesel treated by the biological preparation, D+F – diesel with 5 % V/V of FAME, D+F-Bio- diesel with 5 % V/V of FAME treated by the biological preparation



Although the test have not been finished yet, the available results (tab. 4, graph 2) already show a substantial correspondence with the laboratory tests, proving that the presence of FAME in this case causes lowering of the biodegradation rate in the first 50 days. The addition of the bacterial preparation Biotech IV improved the biodegradation rate in the first 50 days. During these 50 days it was applied 3 times, when in the second half of the test it was applied just one time so far.

4. Influence of biocomponents on affinity of fuels to sorbents

To find out whether the content of the biocomponents in the fuel mixture influences the affinity to four representative common sorbents, a simple laboratory test was carried out. Chosen sorbent materials are routinely used for clean-up of unwanted fuel leakages and they differ according to the matrix they are made out of. VAPEX is representing hydrophobic pearlite materials, PEATSORB is based on hydrophobic peat, LITE DRI is made out of cellulose and ECO DRY is a bergmeal based sorbent material.

Three diesel and three petrol mixtures were tested.

4.1. Influence of FAME on affinity of diesel to sorbents

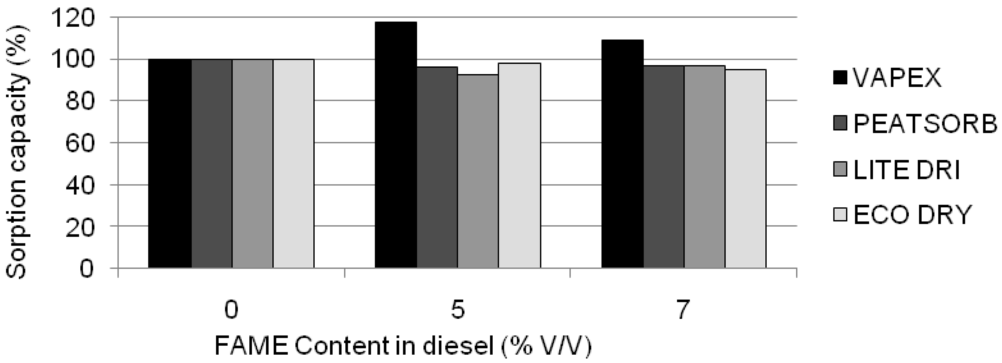
The following three diesel samples with different FAME contents were tested: Sample D1 was a pure diesel, sample D2 contained 5 % V/V of FAME and sample D3 contained 7 % V/V of FAME.

The defined amount of sorbent was in contact with the defined amount of fuel for one hour. The sorbent samples were than seeped for twenty hours and weighted. Each diesel sample was tested in four parallels and the result is an average value. Sorption capacities found in the experiment are shown in the tab. 5 and graph 3.

Tab. 5: Sorption capacities (g diesel/ g sorbent) of VAPEX, PEATSORB, LITE DRI and ECO DRY with diesel mixtures D1- pure diesel, D2- 5 % V/V of FAME, D3- 7% V/V of FAME.

Sorbent / mixture	D1	D2	D3
VAPEX	9.47	11.10	10.33
PEATSORB	4.50	4.31	4.36
LITE DRI	0.92	0.85	0.89
ECO DRY	0.98	0.96	0.93

Graph 3: Sorption capacities of VAPEX, PEATSORB, LITE DRI and ECO DRY with diesel mixtures containing 0; 5 and 7 % V/V of FAME respectively.



On the basis of the results we can conclude the following: The addition of 5 and 7 % V/V of FAME respectively increases the affinity of the diesel mixture to the pearlite material by about 10 % (VAPEX). The affinity of the FAME enriched diesel to the other three tested sorbents on the contrary decreased by a few percent.

4.2. Influence of ethanol and MTBE on affinity of petrol to sorbents

Three petrol samples with different bio-ethanol and MTBE contents were tested. The composition of tested petrol mixtures is shown in tab. 6.

Tab. 6: Composition of tested petrol mixtures.

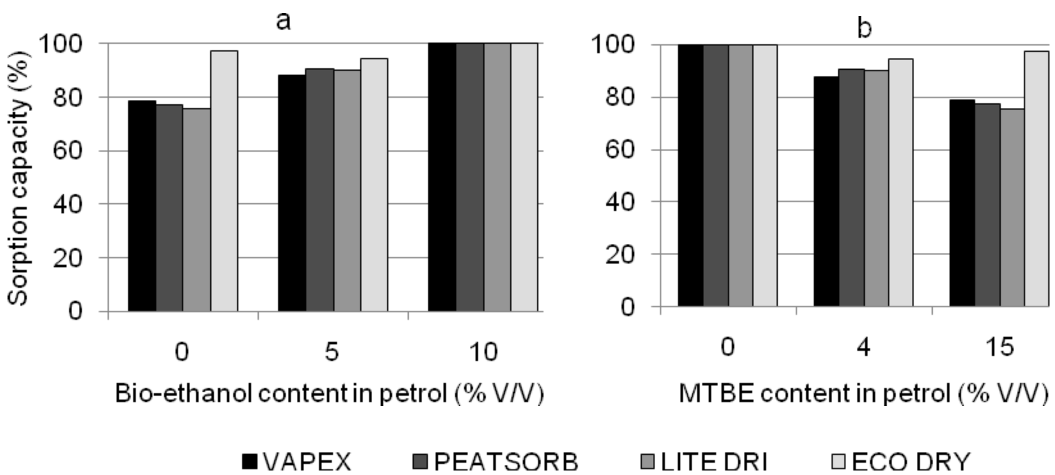
Sample label	Bio-ethanol	MTBE
P1	-	15 % V/V
P2	5 % V/V	4 % V/V
P3	10 % V/V	-

The defined amount of sorbent was in contact with the defined amount of fuel for one hour. The sorbent samples were than seeped for four hours and weighted. Each petrol sample was tested in four parallels and the result is an average value. Sorption capacities found in the experiment are shown in tab. 7 and graphs 3a-b.

Tab. 7: Sorption capacities (g petrol/ g sorbent) of VAPEX, PEATSORB, LITE DRI and ECO DRY with three petrol mixtures, P1- 15 % V/V of MTBE, P2- 5 % V/V of bio-ethanol and 4 % V/V of MTBE, P3- 10% V/V of bio-ethanol.

Sorbent / mixture	P1	P2	P3
VAPEX	6.63	7.41	8.44
PEATSORB	3.46	4.06	4.49
LITE DRI	0.67	0.80	0.89
ECO DRY	0.68	0.66	0.70

Graphs 3a-b: Sorption capacities of sorbents VAPEX, PEATSORB, LITE DRI and ECO DRY with three petrol mixtures, with the reference to bio-ethanol content (graph a) and MTBE content (graph b).



Graphs 3a-b shows that when the amount of added bio-ethanol is increased and the amount of MTBE is decreased the result is that the affinity of the fuel to the tested sorbents rose by 10 – 20 %. Only the bergmeal based sorbent type (ECO DRY) is quite inert to the influence of added bio-ethanol and MTBE.

5. Laboratory tests of migration rate of the fuel mixtures trough soil horizon

Another question which rises from the possibility of changed physical properties of fuel mixtures is a possible faster penetration though the soil lawyers of the fuel with added bio-components than the fuel without any amendment. In that case, more fast and immediate clean-up action would be needed, to prevent possible groundwater contamination.

Brown soil typical and frequently found in the Czech Republic was used for the tests. Its natural appearance is formed by three lawyers: upper “A_d”, middle “B_v” and lower “C” and this layout was also kept in the testing columns. Polypropylene chemical resistant columns were used for the tests. Polypropylene lid which was previously drilled though was placed on the bottom of each 10 cm wide and 57 cm long column. Soil was then added in the order of precedence and amount: 1kg of soil type C, 2.5 kg of soil type B_v and 4 kg of soil A_d. The width of each lawyer and labelling of the samples for analysis is shown in tab. 8.

50 ml of appropriate fuel mixture was then added on the top of the soil in each testing column (only tests with diesel mixtures presented here). Covered with a tinfoil, the columns stayed 5 or 10 days respectively. After the designated time period, the whole column was frozen by the carbon-dioxide ice and let 12 hours until completely frost. Then it was cut into pieces labelled A, B, C, D and E as indicated in tab.8 and analyzed for NES. Each column was made in four parallels.

Tab. 8: Migration tests, filling of testing columns and labelling of samples.

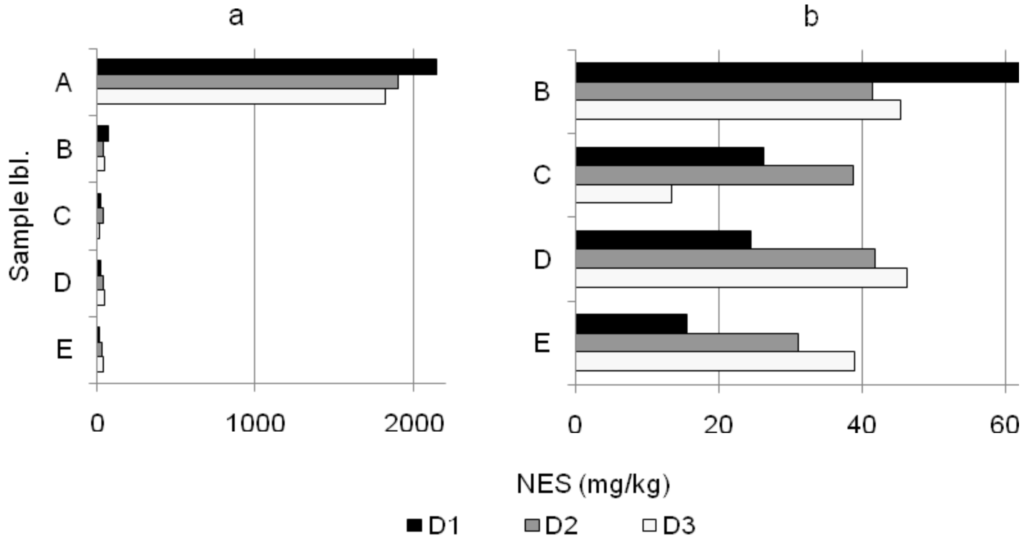
Sample lbl	Soil type	Column height	Soil lawyer thickness
-	-	57 - 49 cm	-
A	A_d	49 - 36 cm	13 cm
B	A_d	36 - 23 cm	13 cm
C	B_v	23 – 15 cm	8 cm
D	B_v	15 - 7 cm	8 cm
E	C	0 - 7 cm	7 cm

Head-space in combination with gas chromatograph with mass selective detector was used to evaluate the results from testing samples. Results are shown in tab. 9 and graphs 4a-b and 5a-b.

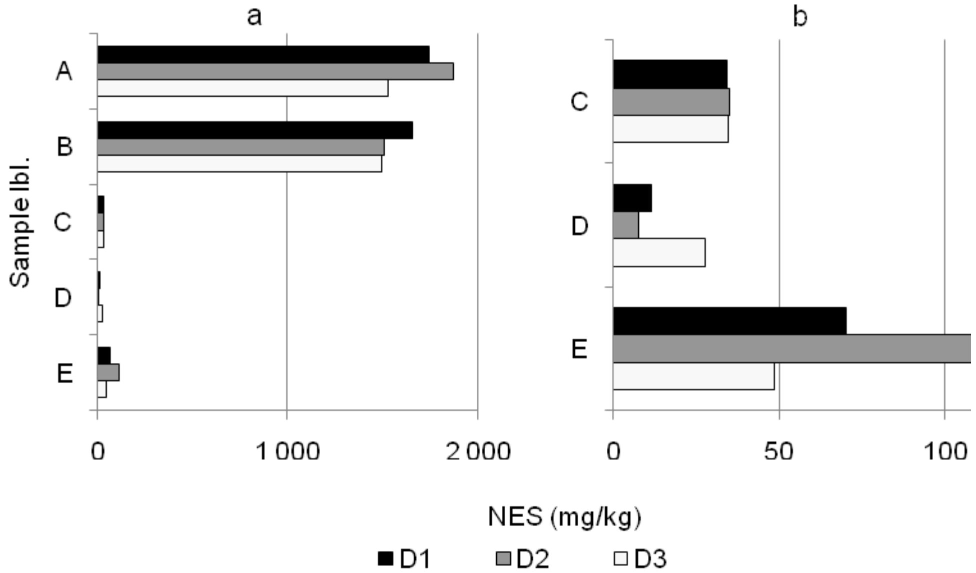
Tab. 9: Migration tests, analytical results (mg/kg). D1- pure diesel, D2– diesel + 4.7 % V/V of FAME, D3– diesel + 7 % V/V of FAME, A,B,C,D and E – column parts from bottom to top.

	5 day test			**10 day test**		
Label	**D1**	**D2**	**D3**	**D1**	**D2**	**D3**
A	2 145.3	1 899.0	1 817.3	1 741.5	872.3	1 529.1
B	70.8	41.4	45.4	1 659.3	1 505.1	1 493.1
C	26.2	38.8	13.3	34.2	34.9	34.8
D	24.4	41.9	46.2	11.6	7.8	27.7
E	15.6	31.1	38.9	70.1	116.7	48.5

Graphs 4a-b: 5 day migration tests, NES concentration in soil (mg/kg). D1- pure diesel, D2– diesel with 4.7 % V/V of FAME, D3– diesel with 7 % of V/V FAME, A,B,C,D and E – column parts from bottom to top. Whole profile (graph a), profile excluding part A (graph b).



Graphs 5a-b: 10 day migration tests, NES concentration in soil (mg/kg). D1- pure diesel, D2– diesel + 4.7 % V/V of FAME, D3– diesel + 7 % V/V of FAME, A,B,C,D and E – column parts from bottom to top. Whole profile (graph a), profile excluding parts A and B (graph b).



Graphs 4a-b show that specially when the 5 days tests are concerned, the mixture containing 4.7 or 7 % V/V FAME penetrates more easily to the lowest parts of tested columns labelled C, D and E. After another five days, the difference with the pure diesel is not so declarable any more.

6. Summary

Based on the results of undertaken tests, it can be stated that the addition of bio-components into fuels changes its properties and consequently its performance in the environment moderately. Even the project is still ongoing and some of the tests are yet to be evaluated, we can already conclude the following.

It was proved by laboratory and field tests, that the addition of 5 % V/V FAME can influence the biodegradation rate negatively, independently on the type, structure and microbiological quality of the treated soil. Similar findings were made by Junior at al. in [4].- and the reason indicated was the influence of tert-butyl hydroquinone (TBHQ) in FAME. TBHQ is an antioxidant, used for preserving FAME similarly as BHT used in our tests. Special biodegradation testing would be needed to prove possible negative influence of BHT on the biodegradation of FAME and the diesel mixtures containing FAME respectively.

Based on the results of the sorption tests, it can be recommended to use pearlite-based sorbent materials for clean-up operation of diesel with FAME content effectively. The differences are however in the level of few percent.

When dealing with petrol containing bio-ethanol it is more effective to use sorbents based on hydrophobic pearlite, hydrophobic peat or cellulose, than bergmeal materials. The difference in the sorption capacity can be up to twenty percent.

The partial results of migration tests show higher ability of the diesel containing 4.7 and 7 % V/V of FAME respectively, to penetrate the soil. The difference is more declarable when the 5 days tests are concerned. Other tests monitoring the mobility of fuel mixtures in the soil horizon are still ongoing, different type of soil will be applied.

Results of this short 2-years project are raising more questions than answers. More detailed testing would be needed to answer all of them with certainty.

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Platinum, Palladium and Rhodium in the Environment

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Abstrakt

Catalytic converters are used in effort to decrease pollutants emission originating during the fuel combustion by modification of exhaust gasses. Platinum group elements (PGE) - platinum, rhodium, palladium - are used as the effectual catalytic substance in this equipment. Catalytic converters are during the combustion process physically and chemically loaded with rapid changing of oxidation and reduction conditions, high temperatures and mechanical abrasion that is the reason of PGE emissions to the environment especially near roads and in urban agglomerations with high traffic intensity. Results of study focused on platinum, rhodium and palladium contents in selected environmental matrices on localities burden by traffic in the Czech Republic in years 2002 – 2009 are presented in this paper and document dependency of concentration increase on traffic intensity.

1. Introduction

Catalytic converters are used in effort to decrease gaseous pollutants emissions such as carbon monoxide, nitrogen oxides and hydrocarbons originating during the fuel combustion. Converters are formed by steel carrier with honeycomb structure with highly porous layer (so-called washcoat) of aluminium oxide resistant to both high temperatures (highly above 800°C) and frequent temperatures changes. Catalytic layer formed by very fine scattered platinum group metals (PGE) especially platinum (Pt), palladium (Pd) and rhodium (Rh) is deposited on this porous part. Converter is during the vehicle operation chemically and mechanically stressed by quick changing of oxidative and reduction conditions, high temperature and mechanical abrasion. These processes are the reason of PGE emission primarily to the atmosphere with consequent contamination of other environmental matrices especially road neighbourhood and city agglomerations with high traffic intensity (Ravindra 2004). PGE are emitted from converters in the amount of ng.km-1 in the form of fine dispersed metal nanoparticles adsorbed on aluminium oxide particles from washcoat [1, 2, 3]. Wide range of studies indicates accumulation of PGE in separate environmental matrices such as particulate matter (PM) in the atmosphere [4, 5], road dust [6, 7], soil [8] or sediments [9]. PGE were found out also in plants [6, 7] and in organism bodies [10]. Higher PGE concentrations are not restricted to emission sources surroundings but these were determined also in distant localities in central Greenland [11]. Pt in metal form is considered to be biologically inert [12] but contact with soluble compounds induce irritation and origin of hypersensitivity mostly in the form of rashes and due to longer exposition also breathing complications such as rhinoparynx and lower air passages inflammation [13]. Share of PGE soluble fraction in overall emissions varied from 1 % [1] to 10 % [3]. Catalytic converters in vehicles so transport is considered the main source of environment pollution by PGE and this is supported by the fact that the Pt/Rh rate determined in separate environmental matrices was till 1999 the same as the rate of these elements in catalytic converters [12]. Results of studies focused on PGE contents in selected environmental matrices on localities burden by traffic in the Czech Republic in years 2002 – 2009 are presented in this paper.

2. Methods

Samples of separate environmental matrices were taken on selected sites in the Czech Republic and consequent analyses have proceeded with the aim of determination of environmental burden by PGE. Potential health risks related to this anthropogenic burden in connection with transport were taken into account during the localities selection hence the most of the sampling points were situated in the city of Brno and its surroundings. Soil was sampled also next to main highway connecting the capital city (Prague) and the second largest city of the Czech Republic (Brno) to determine the accumulation of PGE during the period of using the catalytic converters in vehicles.

2.1. Particulate matter (PM)

Middle volume samplers Leckel MVS6 were used for PM sampling in 24 hours intervals. Devices were placed just next to roads with different traffic intensities and PM were captured on nitrocellulose filters. Exposed filters were transported to the laboratory in ice box and placed here in constant temperature and humidity. PM concentrations were determined after 48 hours under these conditions using gravimetric method (Mettler-Toledo MX5/A balances). Weighted filters were digested using ultrapure water, hydrofluoric and nitric acid under higher pressure and temperature in ultraClaveIII® device. PGE concentrations were consequently measured using ICP – MS Agilent 7500 device.Při zpracování textu Vás prosíme o dodržení následujících pokynů:

2.2. Soil

Soil sampling was conducted under stabile grass stand on localities with different burden by traffic in the urban area. Samples were taken from three depths of 0 – 2 cm, 0 – 5 cm a 0 – 20 cm using boring bar Eijkelkamp. Samples on all localities were collected from approximately 10m2 area and quartering was done to obtain suitable amount of the sample right on the locality. Samples were dried up under room temperature, homogenized and lay down through 2 mm screen to separate off coarse particles and organic matter. Prepared samples were melted to nickel sulphide (docimastic method) that allows efficient extraction and concentration of PGE. PGE concentrations were consequently measured using ICP – MS method VG Elemental plasma Quand 3 device. Soil was also sampled in exits from D1 highway connecting Prague and Brno, two largest cities in the Czech Republic. Samples were collected as 10 separate samples taken 0,5 m from each other in the line of 4,5 metres parallel to road in two distances from road – 5 and 10 m and from two depths 0-2 cm a 2-5 cm using boring bar Eijkelkamp. Samples were dried up under room temperature, homogenized and lay down through 2 mm and 1 mm screens to separate off coarse particles and organic matter. Quartering was done to obtain suitable amount of the sample for analyses by ICP – MS method.

2.3 Tunnel dust

Samples were swept down on the roads surface (raod dust) and also were taken from air conditioning system (fine dust). After drying were samples laid down through 5,6 mm screens to separate off coarse particles and organic matter. Prepared samples were as well as soils melted to nickel sulphide and PGE concentrations were determined by ICP-MS method on VG Elemental plasma Quand 3 device.

2.4 Runoff waters

Runoff waters were sampled both from drainage systems in tunnels and from storm water setting tanks along the highways to polyethylene bottles. Superpure nitric acid was used for sample stabilization. PGE concentrations were determined by ICP-MS method on Elan 6000 device.

2.5 Data statistical evaluation

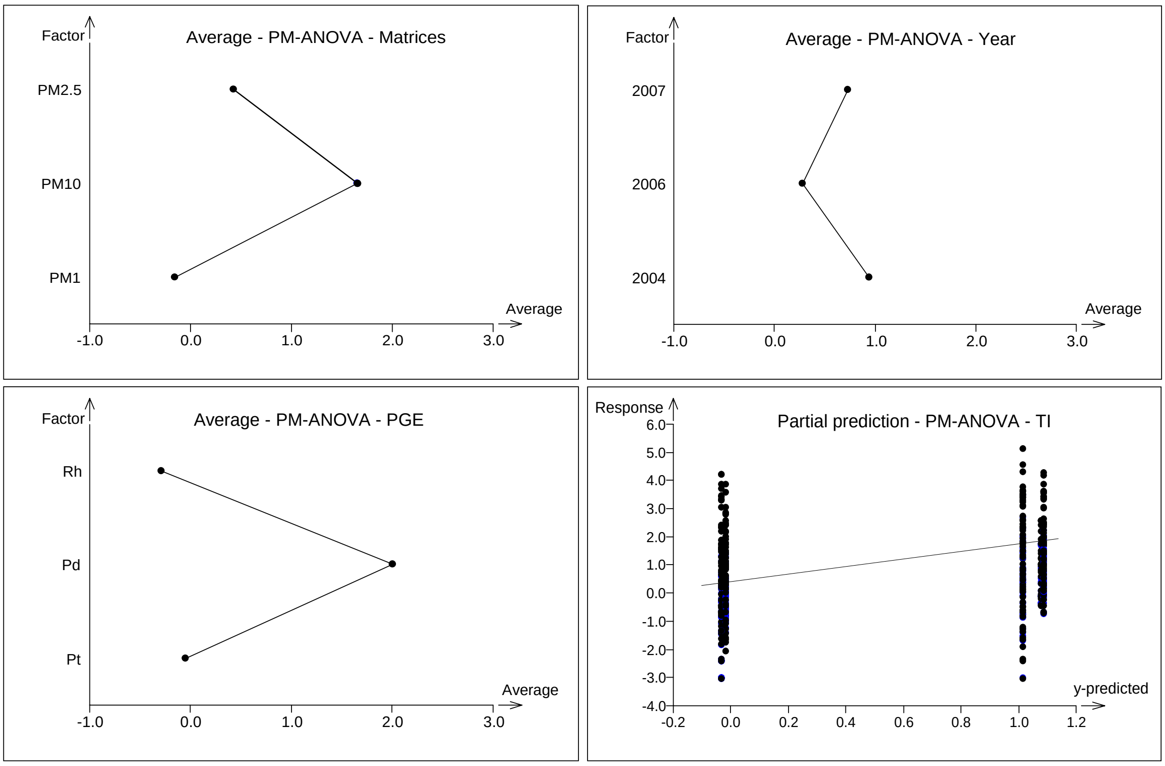
Statistical evaluation of obtained data sets was conducted using QC Expert 3.0 software. To gain the proper information about PGE concentrations in separate environmental matrices, the different statistical approaches were used to determine the most accurate mean value. Geometrical mean was calculated when the set contained more than 20 data or less than 2 data. Horn procedure for mean value calculation of small sampling was used when the set contained from 4 to 20 data and median was calculated when there were only 3 results.

3. Results and Discussion

PGE in the air are mostly adsorbed on particulate matter in all fractions and their concentrations range for Pt <0.093 – 32.4 pg.m^{-3}, Rh <0.18 – 13.2 pg.m^{-3} and Pd 0.2 – 166.1 pg.m^{-3}. PGE concentrations in waters were for Pt <0.01 – 0.208 µg.l^{-1}, Pd <0.02 – 0.80 µg.l^{-1} and Rh <0.005 – 0.01 µg.l^{-1}. PGE are not naturally contained in these matrices so measured concentrations represent environmental burden by anthropogenic processes and in these cases by transport. PGE concentrations in dust sampled in road tunnels range in interval of 67.79 – 637 ng.g^{-1} for Pt, 19.93 - 705.2 ng.g^{-1} for Pd and 15 – 564.6 ng.g^{-1} for Rh. PGE concentrations in soil sampled in urban area were determined for Pt in interval between 0.4 – 39.6 µg.kg^{-1}, for Pd in interval between 0,5 – 12,2 µg.kg^{-1} and for Rh in interval between 0.06 – 4.89 µg.kg^{-1}. These element mean concentrations in Earth crust, just for comparison, are averaged at about 0.01 ppm of Pt, 0.015 ppm of Pd and 0.0001 ppm of Rh. Concentration data in separate environmental matrices were analysed of dispersion (ANOVA) to find out factors affecting PGE concentrations. Due to considerable asymmetry of statistical distribution Napierian logarithms of concentrations that have normal distribution necessary for usage of ANOVA process were analysed.

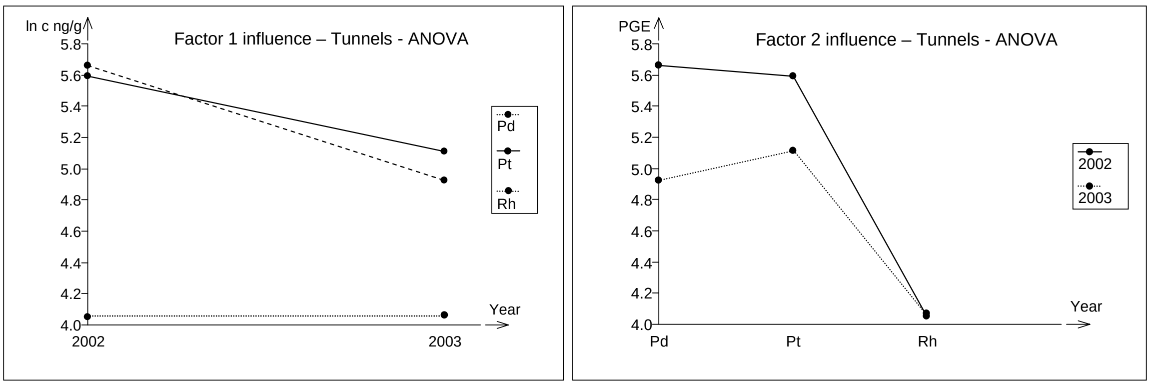
Multifactor ANOVA for PGE concentrations data in the air indicate that their concentrations in separate PM fractions are statistically significantly different with 95% probability. As it is showed in fig. 1 the most of PGE is adsorbed to coarse PM fraction PM2.5-10. Time progress is inconclusive although time factor is statistically significant and for its more accurate determination would be necessary longer sampling periods in separate years. Results also indicate significantly higher concentrations of Pd adsorbed to PM than other PGE elements. Transport intensity influence is also significant described by the positive prediction factor 0.043 that indicates higher PGE concentrations on localities with higher traffic intensity.

Fig. 1: Multifactor ANOVA analysis for PGA concentrations adsorbed on PM.



Multifactor ANOVA for PGE concentrations in tunnel dust indicate no statistically significant differences among road dust (from road surface in tunnels), fine dust (air conditioning system in tunnels), year of sampling and locality. Two factor ANOVA analyses (fig. 2) shows statistically significant higher concentrations of Pt than Pd in contrast to their concentrations in the air (Factor 1). Rh concentrations in tunnel dust are the lowest as well as for air concentrations. Concentrations were 1,5 times higher than in 2003 and this difference is statistically significant (Factor 2).

Fig. 2: Two factor ANOVA analysis for PGE concentration in tunnel dust.



Evaluation of PGE concentrations in soils data indicates that depth of sampling was not statistically significant. Statistically significant factors were sampling locality, PGE concentrations and transport intensity. Variation of PGE concentrations Napierian logarithms mean values according to localities is shown in fig. 3. Localities with high traffic intensities especially crossroads are the most contaminated sampling sites. Pt concentrations in soils were the highest, Pd concentrations were lower and Rh concentrations were the lowest. Transport intensity influence is statistically significant described by the positive prediction factor 0.019 that indicates higher PGE concentrations on localities with higher traffic intensity.

Fig. 3: Multifactor ANOVA analysis for PGE concentrations in soils – localities variability.

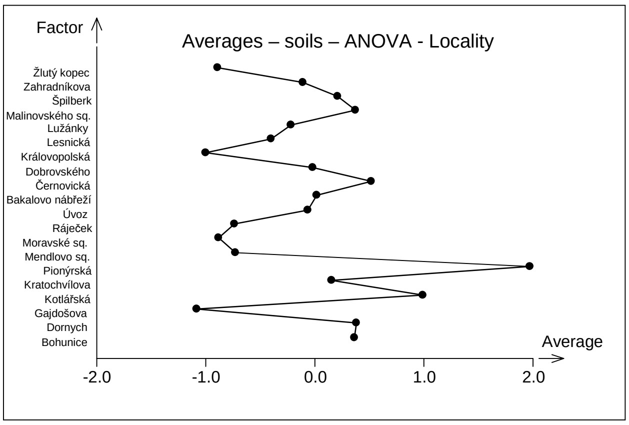
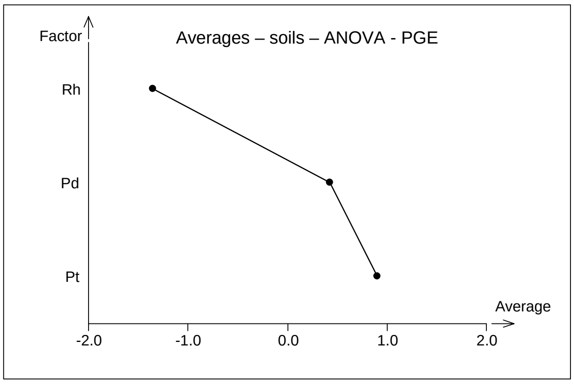
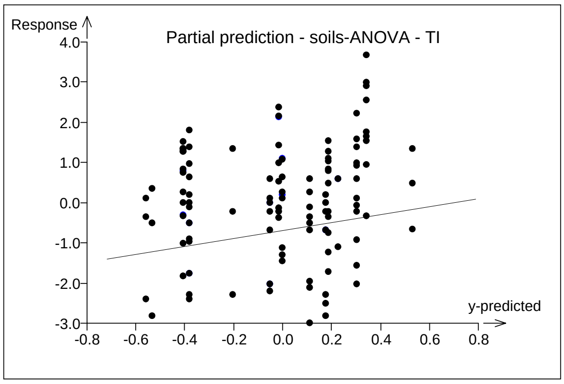


Fig. 4: Multifactor ANOVA analysis for PGE concentrations in soils – PGE concentrations variability and transport intensity.





PGE concentrations in runoff waters and porous waters were mostly under the detection limits for analytical method except Pd concentrations.

Measured concentrations of PGE adsorbed to PM in the air are in a good accordance with concentrations data published in literature (see table 1). Especially Pt concentrations in PM10 in Brno are nearly similar with concentration measured in Wien and significantly lower than concentrations measured in Madrid probably due to much higher transport intensities. Pt concentrations in tunnel dust mean values measured in Brno are the highest comparing with data from other European countries whereas the highest Pd concentrations were determined in Munich where the highest transport intensity among compared sites was. PGE concentrations in soils in urban area in Brno belong to the lowest in compared set of data, lower concentrations were determined only in the United Kingdom. The highest PGE concentrations were measured next highways in Germany and Athens in Greece. Large fluctuation of PGE concentrations in separate environmental matrices can be found in results in table 1. Some of the data show significant increase in different years especially in Germany. However this fact was not documented in samples taken in the Brno and its surroundings.

Table 1: PGE concentrations in separate environmental matrices in different European cities [5, 6, 8, 12, 13]

Environmental matrices	Locality	Year	TI	Pt			Pd			Rh			Unit
				mean value	lower limit	upper limit	mean value	lower limit	upper limit	mean value	lower limit	upper limit	
PM10	Wien, Austria		high	4.30			2.60			0.40			pg.m^{-3}
	Madrid, Spain	1998-1999	75 - 100	12.80	<0.1	57.1				3.30	<0.2	12.20	
	Brno, Czech Republic	2004-2007	8 - 34	3.3	0,047	32,4	23.7	0,195	166	1.9	00,9	13,2	
Tunnel dust – road dust	Steiermark, Austria, Tanzenberg tunnel	1997	high	55.00	47.00	63.00	4.00	2.70	5.30	10.30	8.90	11.70	µg.kg^{-1}
		1998	high	81.3	78.9	83.7	6.00	4.20	7.80	12.80	11.60	14.00	
	Germany, Frankfurt am Main, Harbor tunnel	1994	high	165	137	193	113.7	78.30	149.1	24.00	20.00	28.00	
	Bialystok, Polland	2000	28	23.30	19.50	27.10	23.90	22.70	25.10	6.76	5.48	8.04	
	Brno tunnels, Czech Republic	2002-2003	26.5	205.0	67,8	638	124.8	19,9	705	70.7	15	565	
Soil	Braunschweig, Germany	2005	16	50.30			43.30			10.70			µg.kg^{-1}
	Frankfurt am Main, Germany	1991	15	6.00	3.00	13.00		2.00	4.00				
		1994	15	46.00	12.00	82.00	4.00	2.00	8.00	9.00	3.00	19.00	
	Richmond, United Kingdom	1995	high	1.51	0.30	8.00		2.10	28.7				
	Athens, Greece	2003	48.6	141.1	73.3	254	125.9	25.40	239				
	Brno, Czech Republic	2006	11 - 46.5	2.46	0,4	39,6	1.53	0,5	8,2	0.26	0,05	4,89	

TI.................................transport intensity [thousands of vehicles.day^{-1}]

4. Conclusion

Pt concentrations are higher than Pd concentrations in soils and in tunnel dust (road dust) whereas in waters and PM in air are concentrations of these metals reverse. So Pd is probably occurred in the environment in mobile forms and it can spread to longer distances from the source than Pt. Rh concentrations are nearly order of magnitude lower. Transport intensity is the important factor that influences PGE concentrations in the environment and it was confirmed also by the measurements conducted in Czech Republic in Brno. PGE concentration values determined in Brno and its surroundings are nearly similar to data from other European cities published in literature. Some studies also indicate increase of PGE concentrations in the environment but this fact was not explicitly documented by measures conducted during the period of 2002 – 2007 in Brno area. Longer measurements of PGE concentrations in separate environmental matrices seem to be necessary to find out time dependency progress.

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Tools for Promoting Clean Vehicles in Cities and Environmental Assessment

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Abstract

The article deals with tools for promoting clean vehicles in cities, which are motivated by their acquisitions through indirect motivational factors. Describes the appropriate support tools favoring the use of environmentally friendly vehicles during the operational phase of their life cycle. The impact of these instruments is assessed with traffic model of the city, where is demonstrated the difference in the emission stream before and after application of instruments for promoting clean vehicles.

1. Introduction

Road transport contributes significantly to overall emissions of pollutants including greenhouse gases. Transport share is 43% for CO, 35% for NO_x, VOC reach 21% and 10% PM. In the case of greenhouse gases share is 16% for CO_2 and 10% for N_2O. In city traffic, there is significant increase in emissions due to unstable flow and frequent changing modes of engine operation. Reducing the impact of road traffic on air quality in cities can be achieved through traffic calming tools or tools for promoting the replacement of car fleet to be energy efficient and environmentally friendly vehicles. As an example, a payment of toll in the heart of Stockholm can be shown. It has reduced emissions of pollutants in the historic center and also increased the number of clean vehicles in the city to 1.4% [1].

This article discusses the tools of promoting environmentally friendly vehicles that fall into the competence of local government units. The tools are designed not to directly burden state budget or motorists with the increased spending for using the vehicle for example with a differentiated toll. They are based on the indirect motivating factors of users of "clean" vehicles. Evaluation of the impacts of the proposed tools for promoting environmentally friendly vehicles is done by using the transport model of the small town under 100 thousand inhabitants.

2. Tools of promoting clean vehicles

Tools motivating users to purchase clean vehicles with the advantages during time of their usage can be divided for better orientation to [2]:

- legislative,
- organizational,
- economic.

2.1. Legislative tools

Among the legislative instruments may be included ecological public contract under the Directive 2009/33/ES on the promotion of clean and energy efficient vehicles and Program of fleet replacement in public administration for "environmentally friendly" vehicles. Directive 2009/33/ES requires enhancing of procurement assessment on the internalisation of external costs concretely the cost of energy consumption, CO_2 and pollutant emissions associated with vehicle operating during their lifetime. This evaluation should be used as a criterion for the contract assign. The aim of the Program of fleet replacement in public administration in behalf of "environmentally friendly" vehicle is a 25% share of these vehicles used in the fleet by the public authorities to the 1st January 2014. Involving government is expected to stimulate the market for environmentally friendly vehicles and reduce their prices based on increased demand.

2.2. Organizational tools

Organizational tools are based on adjustments of the rules for the operation of vehicles on local roads and road surfaces. These tools limit the movement of vehicles that don not meet minimum emissions standards, or give priority to the environmentally friendly vehicles. Among the organizational tools can be included low emission zones, reserved lanes, permission to acces to the city center permission to acces to the pedestrian zones and reserved parking.

Low emission zones, called the LEZ, are areas in which the entry of vehicles causing more pollution is restricted. LEZ are often the most effective measures that cities can take to reduce emissions from transport. The base criterion for limitation on vehicle access to low-emission zones is compliance with emission standards. A particle filter is often asked for diesel engines. For example, in Dutch cities, where the restriction applies only to trucks, NO_2 concentrations decreasing of 5-10% and more than 10% of PM_{10} [3] is predicted after comprehensive introduction of low emission zones. The basic assumption for creating of low emission zone is sufficiently sized bypass road. The zones are therefore implemented within small and large urban ring roads.

Reserved lanes are used primarily to ensure the smooth urban mass transport, public bus transport or perhaps even taxis driving. The assemption for realization of this is sufficient capacity remaining lanes. Especially in small towns there is very difficult to find suitable road sections for the implementation of such measures.

The reasons for regulating entry to the inner city are mainly safety, bad dispersion conditions in the dense house-building, etc. For these reasons, the individual and freight traffic in the historic city centers and urban conservation areas is undesirable. Using this tool it is possible to reduce traffic in city centers by type of vehicle, emission standards for vehicles and time periods.

Entry permit into the pedestrian zone is related to distribution vehicles, other vehicles should be banned from the pedestrian zone. In pedestrian zone the driving ban would be applied during the main opening hours of shops. Distribution vehicles may have entry temporary limited, limited by type of vehicle or by vehicle emission standards.

In urban centers with a limited number of parking places is an appropriate tool for promoting clean vehicles the reservation of parking spaces available for environmentally friendly vehicles. The measure relates to public parking garages, car parks and parking places along the roads.

2.3. Economic tools

Economic instruments are based on the economic benefits of environmentally friendly vehicles in the form of savings from charges for use of roads and traffic areas. Economic instruments may include charging the entrance to the city center, charging for entrance into the pedestrian zone and discounted or free parking.

The main reason for the introduction of charging for entrance into the center of the city is effort to reduce congestion in the city with all its negative effects. It turned out that this restriction causes increased demand for public transport. Increased frequency and number of connections is funded from revenue system introduced. At the same time the use of the Park and Ride system increasing. The system does not charge the environmentally friendly vehicles, which is crucial for their support.

Charging for entry into the pedestrian zone covers distribution vehicles. Ideal option is charging for a certain time period, for which entry permits shall be issued. Promotion of clean vehicles can be realized by reducing the rate or total exemption from these fees.

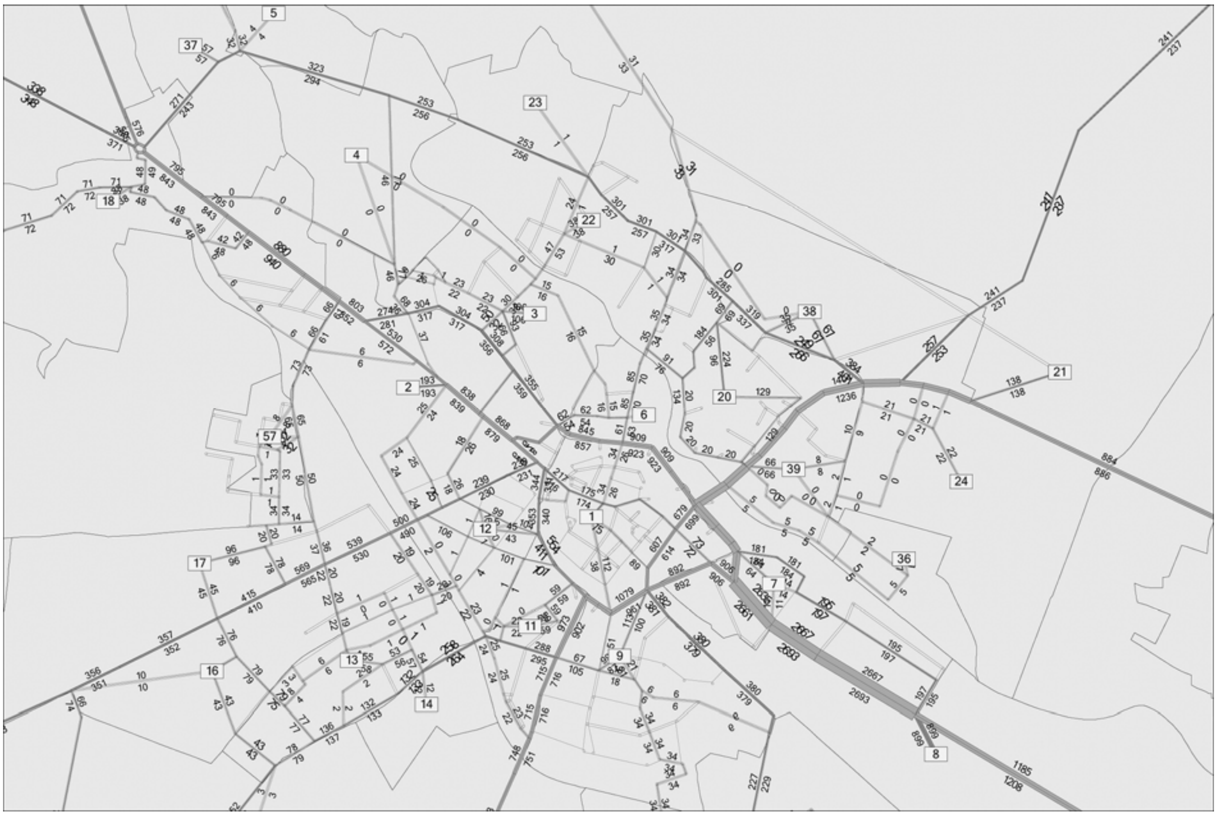
In case of parking, this promotion consists in the possibility of reduced rates or free parking in paid car parks and garages in the bulk of the city which are engaged by the municipality.

3. Modelling of environmental impacts

Creation a traffic model of a small town predated verification enviromnental impacts of tools for promoting clean vehicles. For model creation was used a Canadian software EMME / 3 (Equilibre Multimodal - Multimodal Equilibrium). The traffic model processed in EMME represents an equilibrium model of supply and demand. Demand in the model represents the so-called matrix of transport relations, based on the known socioeconomic and demographic characteristics of each zone and showing a number of trips made between sources and targets of traffic (represented by each zone). By this the transport production (number of trips from) and the attractiveness (number of trips into) are set for each zone. For distribution of trips the gravity model is most frequently used. The supply side is constituted by the road network.

The actual determination of the pollutant emission then depends on the calculated traffic volume, emission factors for the pollutant and the supposed composition of the fleet. Emission factors were entered into the model as an attribute section, depending on the capacity-dependent speed of traffic flow, which reflects the deceleration of vehicles due to increasing of traffic congestion. The evaluation was executed for PM_{10}, NO_2, benzene and benzo(a)pyrene emissions, whose immission limits are often exceeded in the Czech Republic, or have significant health implications. Results of baseline scenario for emissions of PM_{10} are depicted in Figure 1 and are expressed in the form of cartogram. The observed emission flow is expressed in $g.km^{-1}$, the thickness of a road segment with numerical value is represented its size.

Fig. 1: Particulate emissions from the transport in model area



Traffic model was subsequently extended with the proposed tools for promoting clean vehicles. Modeling of low-emission zones proved the most demanding. In the model it was necessary to simulate a situation where drivers of older vehicles cannot go by car to the trip destination but park somewhere outside of the low-emission zone and then they get to LEZ on foot or by public transport. For this simulation, the system of so-called third-zone operations was used. For each pair of zones in the model system the problem of finding the shortest route through a third zone has been solved. It was represented in this case by car park (it refers only to vehicles with worse emission parameters). After this step, the final traffic demand matrix is equal to the sum of the three matrix, namely the matrix of trips made by vehicles with EURO 3 and higher, the matrix of EURO 2 vehicle and older with a target out of low-emission zone and the matrix of trips realized by EURO 2 vehicle and older with a target destination in LEZ, redirected to the nearby parking. Model traffic volumes are determined using multi-class loading, where the resulting three matrix of relationships functionate as classes. The results of each class, i.e. numbers of vehicles on different parts of the network are written separately in the attributes of the sections. For each attribute is then used relevant emission factor (EURO 3, EURO 2). The modeled scenarios differ significantly mainly due to differences in the size of the low-emission zone under consideration, other modeled tools have significantly less effect to change of the emission flow. The results of scenario with a smaller low-emission zone (Fig. 2) and scenario with larger low-emission zone (Fig. 3) for particulate emissions are expressed by differential cartogram. Dark lines represent the increase of emission flow, lighter line represent decrease of emission flow. Monitored emission flow is expressed in $g.km^{-1}$.

Fig. 2: Difference cartogram of PM emissions - scenario with a smaller low emission zone compared to the current state

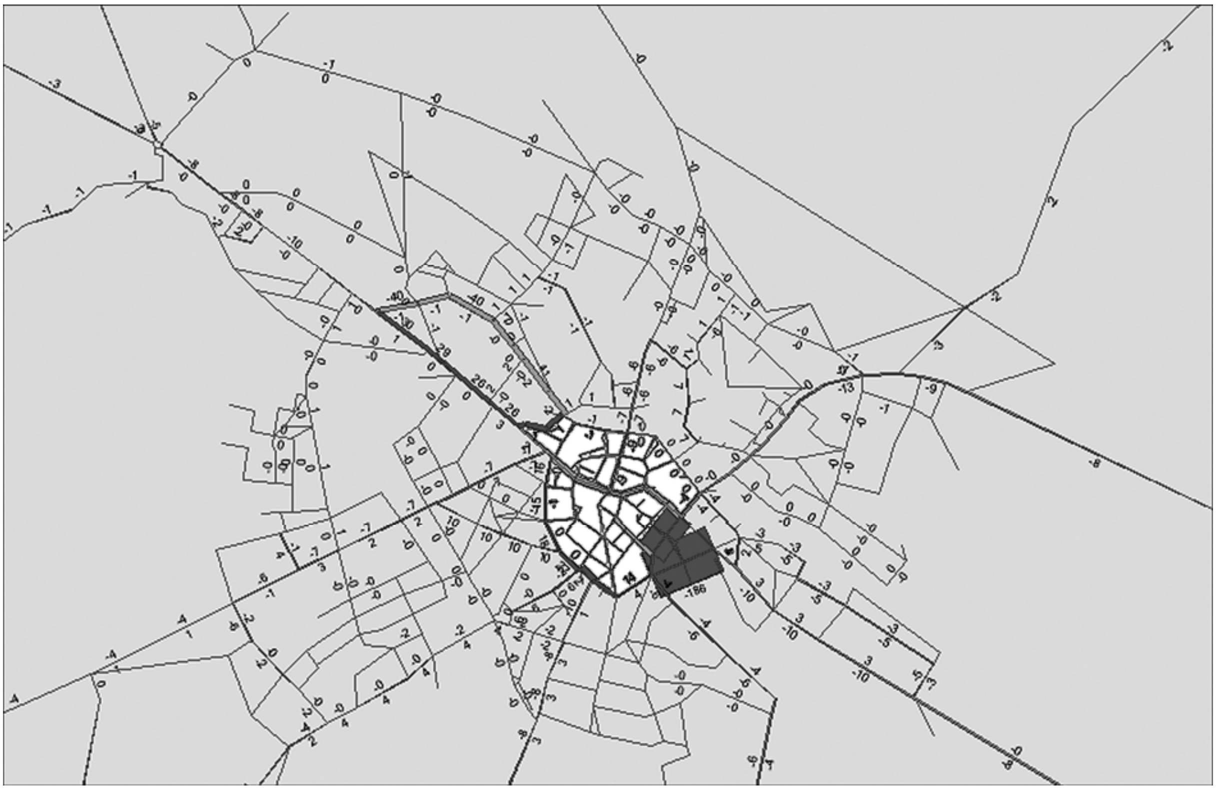


Fig. 3: Difference cartogram of PM emissions - scenario with a greater low emission zone compared to the current state

4. Conclusion

Modeling enabled to quantify the emission differences caused by the implementation of the measures especially by introducing low emission zones in various range. Differences in emissions are more pronounced in case when low-emission zone is greater. However, this depends also on other factors - in particular on the possible construction of parking areas outside the zone that are not currently here. In this case, if drivers do not have adequate parking, some routes in the model did not assign to a network (which reflects the thin line in the outer zones in the model).

Low emission zones have been already operating in several cities in Europe (eg, Berlin, London, Utrecht, etc.), and their implementation is a potential tool for improving air quality. The existence of bypass routes with enough capacity is a qualification for a low-emission zone. Modelling of the impact on the environment showed that for the implementation of this measure would be very useful to build a car parks outside the zone on the main access directions. These car parks would serve for owners of older vehicles not meeting the emission limits for entry into low-emission zone.

Acknowledgement

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Static a Dynamic Method for the Measurement of the Noisiness of Road Surfaces

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Abstract

The very important role in the process of reducing traffic noise will play road surfaces with the reduced noisiness because the effect of the low-noise surface is realized immediately after placement. That means that it is not needed to reduce noise emissions, which would be generated by tyre/road contact, in a costly way by other noise reduction measures. Thus it is possible to achieve reduction of negative impacts on the environment, human health, by implementing suitable low-noise surfaces, when long term sustainability will be assured together with reducing noise burden at the same time. Especially the SPB (Statistical Pass-By) and CPX (Close-Proximity) method are being used in Europe for measuring traffic noise generated by tyre/road interaction [1]. This paper deals with measurements according to the above mentioned methods.

1. Introduction

The sound environment is the integral part to the environment. Generally, noise represents each sound or sounds, which are undesirable, disturbing or harmful for people. Road transport has been the dominant noise source in the outside environment for many years. Power units (vehicle engines, etc.) belong to main noise sources especially at lower speeds tyre/road noise dominates at higher speeds.

Traffic noise can be evaluated in the wider context by the sound level meter, which creates the base of the measuring chain, together with other instruments. Due to the fact that tyre/road noise is dominant noise from road traffic at speeds approximately above 40 km/h, research in the field of road traffic is focused on the mentioned tyre/road noise [2]. The most frequently used measuring methods are the SPB and CPX. Concerning the SPB method, the radar for speed measurements is used together the sound level meter, and concerning the CPX method, the special measuring trailer equipped with the reference tyre is used together the sound level meter.

1.1. Measurement according to the SBP method

The principle of the SPB method is the simultaneous measurement of the maximum *A*-weighted sound pressure levels of a statistically significant number of individual vehicle pass-bys at a specified road-side location together with the vehicle speeds – see Fig 1. Each vehicle is classified into one of three categories: passenger cars (category No. 1), dual-axle heavy vehicles (category No. 2a), multi-axle heavy vehicles (category No. 2b) [3].

Vehicles of the traffic stream pass by the microphone place in the horizontal distance 7,5 m from the centre of the measured lane. The category of the vehicle, its speed and maximum sound pressure level are registered. Based of the usage of more than

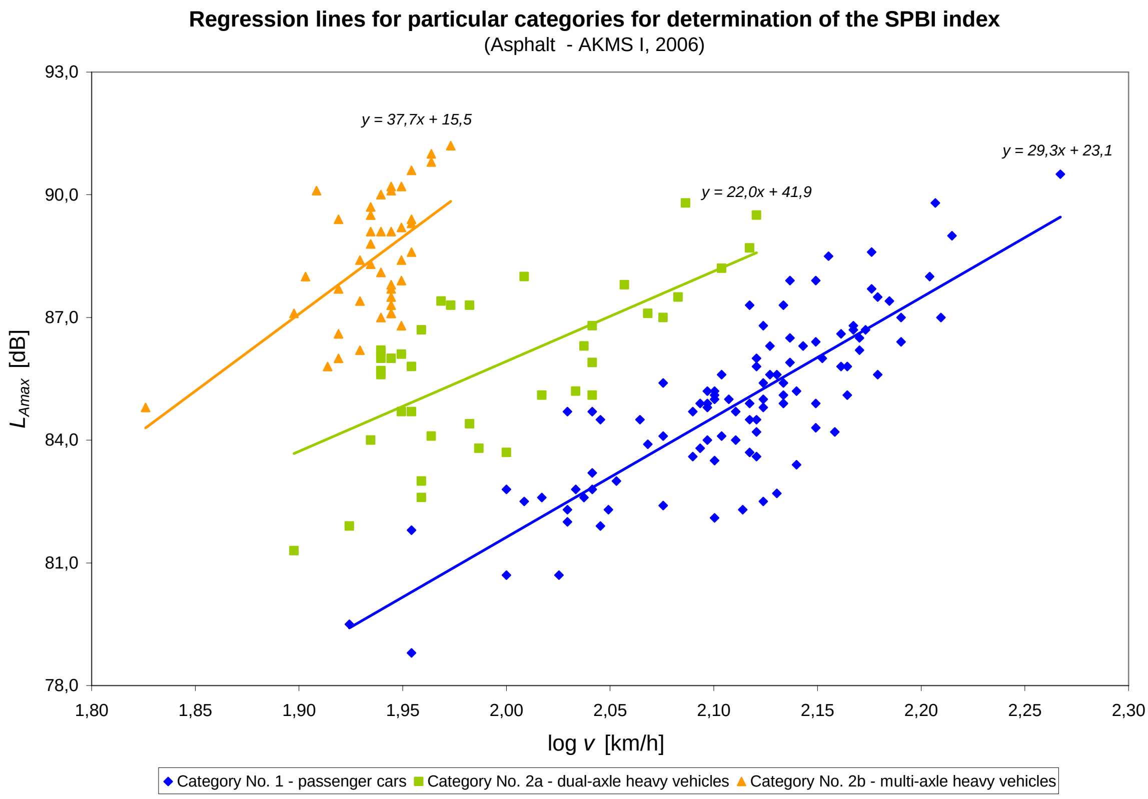
100 passenger cars and 80 heavy vehicles, the regression line of the maximum *A*-weighted sound level versus the logarithm of speed is calculated for each vehicle category. The maximum *A*-weighted sound level for one of the reference speeds, i.e. 50, 80 and 110 km/h (passenger cars), 50, 70 and 85 km/h (heavy vehicles), is determined from the regression line. This level is called the vehicle sound level, L_{veh}. For the purpose of the calculation of an aggregate final index of road surface influence on traffic noise, the vehicle sound levels for vehicle categories (passenger cars, dual-axle heavy vehicles and multi-axle heavy vehicles) are added on a power basis provided the certain proportion of those vehicle categories. This index is called the statistical pass-by index (SPBI) and it could be used for comparison of road surfaces.

Fig. 1: Measurement of the speed of vehicle pass-bys by the laser gun.

For better occupational safety during measurements, the modified measurement chain for the SPB method was designed and implemented. The basic idea is the replacement of the previous measurement of the speed of vehicle pass-bys by the laser gun, which was placed cca 40-80 metres behind the noise measurement site (in the driving direction) see Fig 1, with the measurement by the radar and equipment enabling vehicle categorization, which are placed near the noise measurement site. The automatized radar operating on the basis of the Doppler principle was used and it was completed by the unit which enables the wireless data transfer between the radar, measured vehicle and portable computer. The advantage of the application of the wireless equipment is especially that the radar stand can be situated in the vicinity of the measured road. Then the measurement staff registers vehicle pass-bys around the microphone in a suitable distance from the road into particular electronic record from the measurement and thus the manual registration and retyping do not take place, see Fig 2.

Fig. 2: Measurement chain for the SPB method applying the radar with the wireless data transfer.

Fig. 3: Regression lines of the maximum *A*-weighted sound level versus the logarithm of speed for all three vehicle categories.



1.2. Measurement according to the CPX method

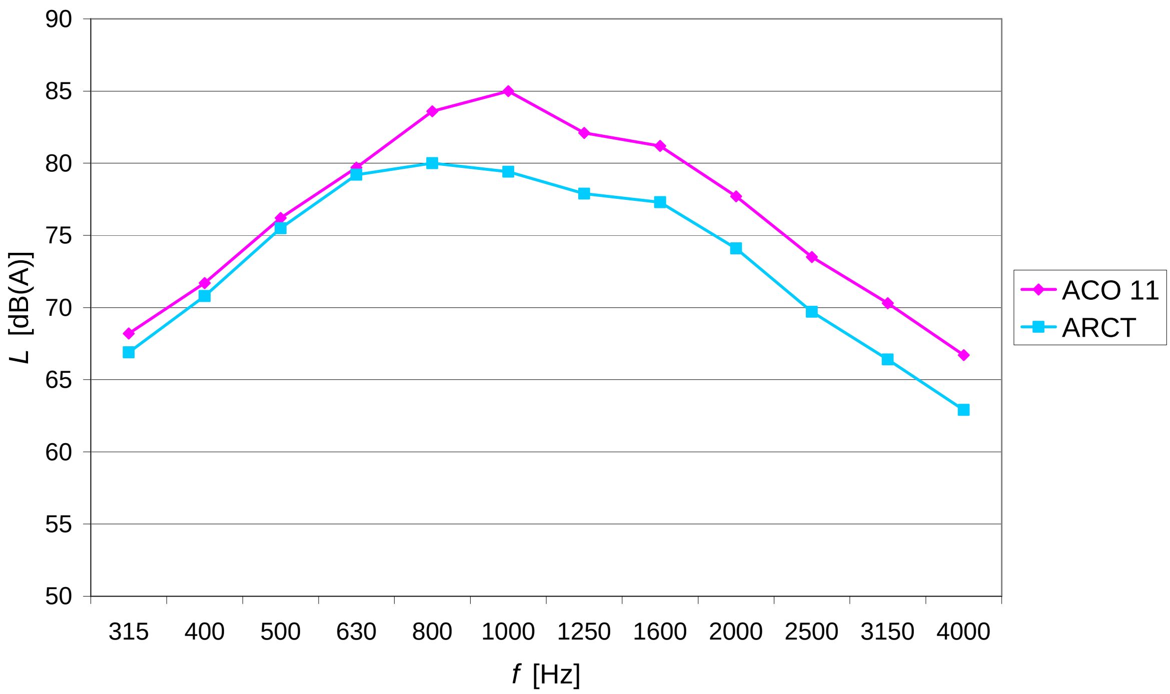
In the CPX method, the average A-weighted sound pressure levels emitted by one or two test reference tyres are measured (see Fig 4) over a tested section together with the vehicle testing speed (reference speeds are 50, 80 and 110 km/h) [4]. The sound pressure levels are scanned by five microphones by each wheel. For the measurement, a special test self-powered vehicle or a trailer towed behind another vehicle is used (see Fig 5). Thus during the measurements, the average tyre/road noise levels, which correspond to the particular road surface, are recorded.

Fig. 4: Setting up the measurement microphones on the testing CPX trailer against the reference tyre SRTT.

The roads are measured during normal traffic, see Fig 5. The measurement microphones are directional and placed at very small distances both from the measured tyre and road surface (10 and 20 cm), where great noise is emitted and scanned. The influence of surrounding traffic on the acoustical situation scanned by the microphones, which sources are at least at 10 times larger distances, is negligible – the distance of particular noise sources is sufficient. Nevertheless it is recommended to select such a period when traffic is minimal especially by reason of keeping the constant speed during the whole measurement in the given lane. As an example of the measurement results, in Fig 6 there is the comparison of the noise emission versus the frequency for two different road surface types of approximately same age and from the same place at the speed 50 km/h, ARCT is the antinoise layer with the CRmB binder of the ARI type.

Fig. 5: Look at the measurement vehicle with the testing trailer for the measurement on the given road according to the CPX method.

Fig. 6: Third-octave characteristics of the sound pressure using the A filter for the comparison of two road surfaces.



2. Conclusion

In the paper, the static measurement by the innovative measurement chain, which uses the radar with the wireless data transfer for the SPB method, was presented. The SPB method is intended for comparing traffic noise on different road surfaces for various compositions of road traffic for the purpose of evaluating different road surface types. The method is applicable for free flowing conditions, traffic travelling at constant speed.

The second part of the paper deals with the dynamic method when the noisiness of road surfaces on their whole length is evaluated by the CPX method. In the frame of the research project „Optimization of technical measures to reduce noise burden in the neighbourhood of roads“, No. CG712-102-120, which is supported by the Czech Ministry of Transport, CDV designed and developed the own test trailer for the measurement according to the CPX method. The trailer is the only equipment in the Czech Republic for the CPX noise measurements. The method gives good estimation of acoustic characteristics of road surfaces. It can be used with the advantage for studying homogeneity of road surfaces on long distances and under various conditions or for the purpose of monitoring the maintenance and achieving its effectiveness – testing noisiness and confrontation with requirements given in the documentation, monitoring acoustic behaviour of road surfaces during many year operation.

Acknowledgements

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Planning for Sustainable Development of Towns and Villages

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Abstract

The report deals with sustainable development planning not only at the level of towns and villages, but also in relation to strategic and land use planning. The report aims to present outcomes and conclusions of a project which is particularly focused on the implementation of strategies development at municipal level with the use of regional development planning.

1. The issue definition

With regard to the preparation of new land use plans in compliance with the new Building Act1, planning documents are being produced which are to determine the development of towns and villages within next 15 years.

The land use plans, as being prepared in the Czech Republic, are one of the parts of complex sustainable development planning. Another, more general, part consists of strategic plans of towns and villages, which determine a long-term development strategy and provide priorities to be solved. This strategy is to be then reflected in a land use plan offering a clear functional use of individual areas including the regulatives.

Since the strategic municipality planning in the Czech Republic is not unified in terms of legislation and methodology, a situation arises that a large number of municipalities have no strategic development document and no clearly defined development priorities. Some municipalities have such document, but do not work with it systematically. Furthermore, the relation between strategic and land use planning is not unified in terms of legislation and methodology, which has an effect on the content of land use plans, where the requirements of investors and inhabitants are poorly coordinated, so the planning function of the content is diminished. Thus a situation arises when land use plans are subjected to a large number of changes according to raised requirements and some areas are only recorded in land use plans in order to correspond with really implemented plans.

At the municipal level, the planning system should be changed so that in the closed cycle the basic elements followed each other: general strategy of sustainable development – land use plan – monitoring of municipal sustainable development with the use of a set of indicators.

[1] Act no. 183/2006 Sb., on land use planning and building regulations including relevant regulations

2. Sustainable development strategy and its relation to land use planning in the Czech Republic the issue definition

Regarding the sustainable development strategies, within the course of the project a historic shift in sustainable development planning occurred through the preparation and adoption of the so-called Strategic framework of sustainable development in the Czech Republic. This document is a breakthrough for it was produced on the basis of general discussion and is a certain consensus of all key groups and resorts which determine the development in the Czech Republic, and thus it can be the respected overarching document of the sustainable development in the Czech Republic, which was not the case of the previous strategies. An important phase in its preparation, which is currently in progress, is the setting of its implementation, which should provide not only the respect from other national planning documents, but also its implementation at regional and local levels. The project outcomes will be used for setting the implementation of the Strategic framework of sustainable development in the Czech Republic and for optimizing of the system of assessing effects on regional sustainable development, or its connection to Strategic framework of sustainable development in the Czech Republic and its implementation to lower levels, which can be used for potential restoration of currently suspended process of the Building Act amendment preparation carried out by the Ministry for Regional Development (Land use planning department). But this document came into force in January 2010 (in the final phase of the project). The outputs of analyses described below there are focus only to the documents in force at the time of processing the first phase of the project (November 2008-June 2009).

Regarding the research of the existing sustainable development strategies in the Czech Republic at local, regional, and national levels, it was found that, apart from the National Strategic Framework of Sustainable Development, there are only 2 regional and 5 local SDSs. The above mentioned shows, that the sustainable development strategy, as a basic type of development documents, is not particularly widespread in the Czech Republic. Nevertheless, other development documents were examined at all levels based on whether they contain sustainable development goals. The results show that there are a large number of strategic documents (sector based as well as general development ones) containing sustainable development goals.

Furthermore, the research examined whether sustainable development strategies goals and other sustainable development goals specified in strategic documents correspond with land use planning documents (principles of regional land use development and municipal land use plans). In case they do not correspond, the research examined whether land use planning documents offer priorities and goal of development on the same basis like the land use planning document. The research results are as follows:

- Land use development principles set land use planning priorities to ensure regional sustainable development; in some cases, these priorities are formulated with a strategic aspect, they are not only focused on the description of principles for spatial development, as is the case with municipal land use plans, but through their complex design of strategic priorities they exceed the framework of land use planning. (When formulating priorities, e.g. land use development principles of Ústí nad Labem Region sets a good example).

- The designed functional use in spatial development principles often do not correspond with land use planning priorities set in this document.
- Majority of municipalities whose land use plans were analysed have no strategic development document.
- When producing a land use plan, as the only planning document for a given town or a village, often neither municipal development strategy, nor reference to a development strategy that would determine a specific functional use are set in the land use plan.
- All goals formulated in a textual part of the draft or a concept of municipal land use plans (most often chapter B) rather represent a generalization of the designed functional use of an area or a list of specific principles for land use plan preparation process.
- Only land use planning documentation of a higher category or from nearby municipalities are often the references for materials for the land use plan preparation. However, conception documents are rarely used as materials for the land use plans preparation.
- Majority of strategic documents, including sustainable development strategies, formulate goals with a high degree of generality and without a more specific way of meeting these goals. In addition, a large number of strategic document goals have no geographical projection and thus may not be considered a full-value material for the land use planning document preparation.

The land use planning use strategic documents, or their set goals, only in a limited extent as materials for the preparation of land use planning documentation, particularly at the local level. In cases of missing strategic documents, the municipal land use plans often do not set more long-term development goals for a given area, just the design of a specific functional use of the area without creating a development strategy for a given area. However, this, in any case, cannot replace strategic goals, which should be reached within a given municipal land use plan.

In the Czech Republic, the integrated planning is not legislatively codified yet. It is necessary to integrate strategic goals into real process of producing land use planning documents at all levels.

The existing situation in this matter is not very satisfactory. Clearly defined methodological approach is missing which would ensure the implementation of strategic plans. This unsatisfactory situation of separated land use and strategic planning reflects the history of both processes. After the previous regime, Czech legal system inherited a public administration dual planning system based on the classification of development documents for regional and local administration units as “area” planning (planning or programming of social economic development) and land use planning (planning of a functional use and spatial arrangement).

3. Sustainable development in Norway

Historically, the situation in Norway is different. The principles of sustainability are adopted by the government and systematically fulfilled. To promote the principles of sustainable development the government produces a document containing national expectations in regional as well as local planning. The sustainable development is controlled by a Ministry of Finance; however, all ministries in Norway are responsible for the application of sustainable development. The issue of land use planning, or the issue directly related to sustainable development, is a part of national conceptions.

There is a Strategy of Norwegian sustainable development at the national level. Every year ministries submit a report on trends in given sectors and on the use of policy tools to meet sustainable development goals. The national strategy contains goals for land use planning at lower levels.

At regional and local levels, complex development projects are produced which consist of a general (strategic) part, closely related to a design of a specific regional solution (similar to our land use planning). The role of the sustainable management is not only to provide statements and deal with environmental conflicts resulting from the development accompanied by the environmental degradation, but also to provide conditions for making long-term decisions to create new values.

Regional authorities help municipalities with planning and may interfere with municipal plans, if find them insufficiently compliant with national and regional interests. At present, many competences in other areas of public administration in Norway are moving towards local authorities.

The key moments of effective planning in Norway are:

- pressure on respecting superior documents,
- determined hierarchy of planning documents,
- applied a planning system – rules, methodologies, outcomes requirements, process rules, legislation support,
- high quality planning act with good portfolio of methodological procedures,
- transparency of the planning process for public – the processes to involve public are similar in terms of legislation, the pressure on contacting the involved persons repeatedly and with the use of different means, information on planning at initial stages, communication and co-operation with involved stockholders,
- the stress on long-term planning and its impacts.

The act specifies what the plans are to comply with and how they are to set goals. The act requires the plan to be based on financial conditions and availability of financial sources for its implementation. The act imposes the obligation to have such plan for all municipalities.

4. Coordinated Planning

The project shows that it is necessary to start systemic changes at the national level, in order to harmonize and coordinate two planned systems of public administration (strategic and land use planning), which were the subject of the project. It is necessary to introduce more systematic approach towards strategic planning (both regional and professional), particularly in terms of hierarchization and interlinking of individual documents, as well as their implementation at lower levels. It would beneficial to introduce certain quality standards of strategic documents and process form of their preparation, negotiating, and implementation. An emphasis needs to be placed on the implementation of these documents and systematic and continual work with these documents. The key factor is the cooperation of regional planning and land use planning personnel. The proposals and recommendations to improve the coordination of strategic and land use planning were summarized in a separate document.

A support handbook (see separate document), which summarizes basic planning principles and activities at municipal levels with the stress on the cooperation of strategic and land use planning, was designed for municipalities which got the major attention. Since it was found in Activity 1 that a large number of towns and villages have no such strategic document, the handbook was among others focused on justifying the production of such document including major principles and requirements for its production. Among others, the handbook aims to provide basic information for assigning the strategic plans production, checking their quality (see criteria system) and producing a strategic document that could be used as a material for the preparation of a land use plan and its changes including the possibility to share activities, information, and processes when preparing these documents in municipalities. Another aim was to provide materials and information on linked processes preparation of strategic and land use plans. Municipalities' personnel are often insufficiently informed of the plans due to a short history of these processes. When producing the handbook, the initial aim was to summarize all planning process running at the municipal level, i.e. including land use planning. However, due to the fact that these processes are bound by the Building Act and relevant regulations, and due to the negative reactions of relevant land use planning bodies, this part was left out. Based on the final handbook version, a leaflet containing the key principles of planning and accompanying processes in municipalities was produced. .

The handbook "Coordinated Planning" is a live document, i.e. based on finding other more practical experience, discussions, and objections, and based on the application of systematic rules in the area of strategic planning at the national level, it will be further amended and complemented and will be used as a material for the implementation proposal of the above mentioned system at the municipal level.

5. Conclusions

Sustainable development strategies are not common parts of public administration planning processes in the Czech Republic, there is neither definition of these strategies (requirements for their form and content), methodology, nor legislation support for their production. However, the strategic goals of sustainable development are usually contained in other strategic documents at all levels (national, regional, local).

Apart from some exceptions, the land use planning does not use strategic documents very often as materials for the preparation of land use planning documentation, particularly at the local level. In cases of missing strategic documents, the municipal land use plans often do not set more long-term development goals for a given area, just the design of a specific functional use of the area without creating a development strategy for a given area. However, this, in any case, cannot replace strategic goals, which should be reached within a given municipal land use plan.

It is necessary to integrate strategic goals into real process of producing land use planning documents at all levels. The existing situation in this matter is not very satisfactory. Clearly defined methodological approach is missing which would ensure the implementation of strategic plans.

Regarding the inspiration form Norway, it is obvious that the key factor for success in promoting sustainable development is the adoption and application of sustainable development principles by the government and determination of requirements for sustainable development for lower levels (municipalities, regions) and their control. Another important issue is a clear hierarchical structure and relations between individual planning documents, including the rules for horizontal and vertical relations between the existing documents and documents that rare being prepared. It is necessary to apply a planning system – rules, methodologies, outcomes requirements, process rules, legislation support in the form of a high quality planning act with a good portfolio of methodological procedures. The quality of planning is also influenced by the transparency of the planning process for public, the processes to involve public should be similar in terms of legislation - pressure on contacting the involved persons repeatedly and with the use of different means, information on planning at initial stages, communication and co-operation with involved stockholders. The stress needs to be laid on a long-term planning process and its long-term impacts.

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