Infrastructure planning and environmental protection – case study of Slovakia

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1 Urban Air pollution

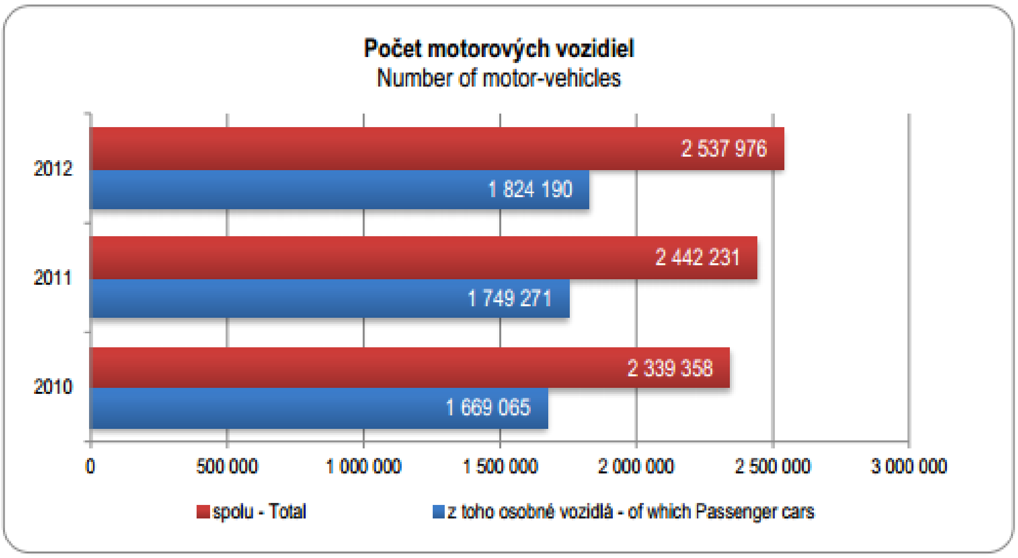
The fleet

The number of motor vehicles has considerably increased since 2000 (see figure 1). In 2010, the number of passenger cars exceeded 1,669 million.

The increase passenger car numbers were markedly higher in the Slovak Republic than the EU average. Between 1990 and 2005 (the period with comparable data), the original EU15 experienced an average increase of 24%, the EU25 of 31% while in the Slovak Republic alone the increase amounted to 7.8% between 2010 and 2012. These data reflect the dynamic growth in motorisation in the Slovak Republic after 1989, in contrast to Western Europe, where the market was a lot more saturated in 1990.

The average age of registered vehicles is among the oldest in the EU (17,2 years total, 13,9 for passenger cars in 2007).

Figure 17: Number of motor-vehicles in Slovakia



Source: ŠÚSR, 2014

The transportation network

Historically, the Slovak Republic has been among the world` s leading countries with respect to the density of transportation networks. In 2013, there 0,53 km of roads (0,99 km in the EU15) and 0,014 km of highways (0,016 km in the EU15). The length of routes stagnated between 1989 and 2006 (see Table 1). While the total length of roads decreased by 1% during this period, the length of motorways and high-speed roads increased considerably. The use of the road network, while its length stagnates, is massively increasing. In the areas with the heaviest traffic, transportation intensity reaches tens of thousands of vehicles per day. The most frequented is the D1 motorway and 1 st class road I/18 where, near Žilina`s city limits, the average intensity is close to 60 000 vehicles per day. The capacity of the most frequented routes is becoming insufficient, resulting in frequent traffic congestion and a higher risk of road traffic accidents.

Table 3: Infrastructure of road in Slovak Republic

year	Roads and motorways					Total	Local communications
	Motorways	Expressways	Roads 1st class	Roads 2nd class	Roads 3rd class		
	km						
1999	295,0	*	3220,1	3826,2	10392,6	17733,9	24978,7
2000	295,7	*	3221,7	3826,3	10393,7	17737,4	25219,9
2001	298,7	*	3220,4	3827,9	10391,4	17738,4	25219,9
2002	306,5	*	3224,3	3828,7	10395,5	17754,9	25219,9
2003	318,2	*	3334,7	3728,7	10396,0	17777,6	25219,9
2004	322,4	78,0	3263,3	3729,0	10393,9	17786,5	25219,9
2005	333,7	79,7	3341,1	3733,5	10400,6	17809,0	25219,9
2006	333,7	104,7	3359,0	3742,1	10398,8	17833,6	25942,0
2007	372,5	*	3365,9	3742,4	10403,4	17884,2	25942,0
2008	392,8	159,0	3275,0	3686,3	10402,0	17915,1	25942,0
2009	399,9	180,0	3317,0	3644,0	10406,0	17946,9	25942,0
2010	427,0	190,0	3318,0	3643,0	10408,0	17986,0	25942,0

Source: ŠÚSR, 2014

Figure 18: Infrastructure of road Slovak Republic – percentage in year 2010

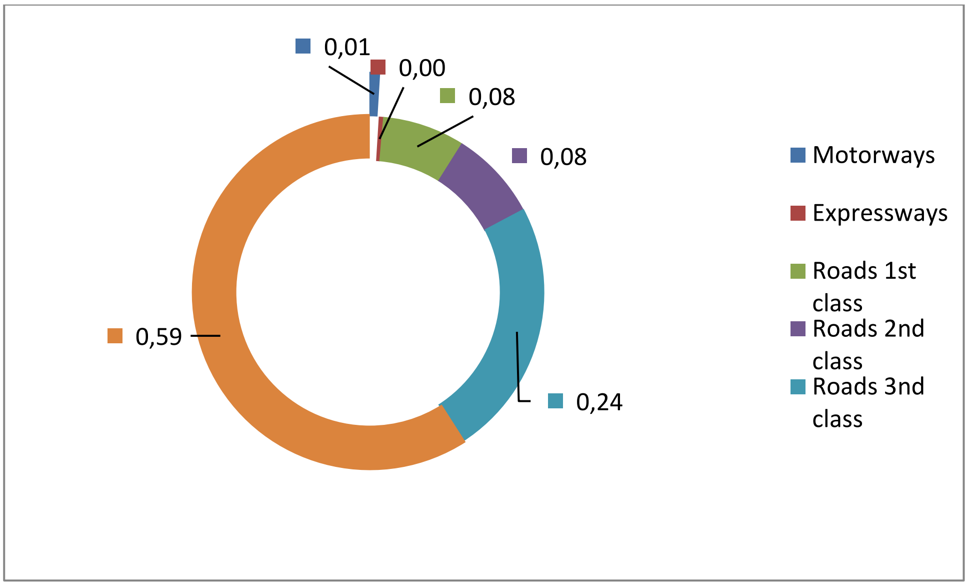
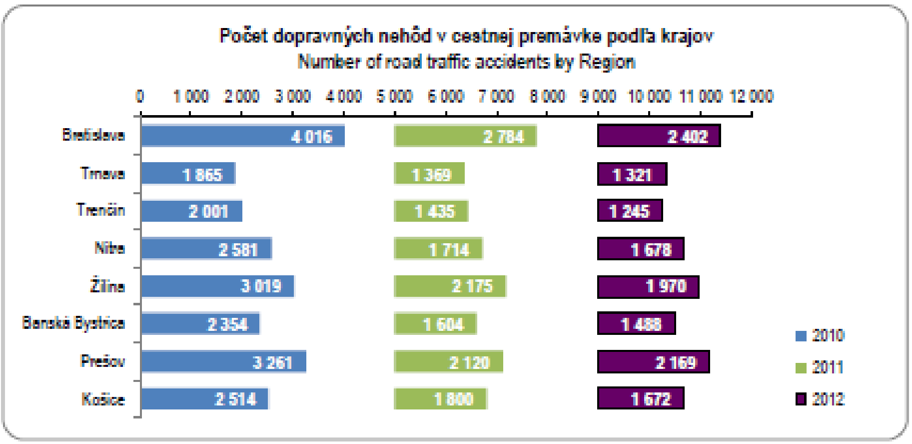


Figure 19: Number of road traffic accidents by Region



Transportation emissions

Emissions from motorised transportation modes (hereinafter `transportation`) represent a major burden on the environment and also a pressing problem of today. The share of transportation in total air pollution is on the increase even in spite of clearly decreasing specific emissions (per unit of transportation performance of the individual transportation modes), especially for private automobile transportation.

Secondary dust pollution means particulate matter settled on routes that are stirred up by passing vehicles and returns to the atmosphere. This can include transportation emissions, tyre and brake wear, and pollution from other sources, e.g. from heating, construction activity etc. The danger of dust pollution (both primary and secondary) lies mainly in the fact that dust particles attract other toxic substances, e.g. carcinogenic benzo [a] pyrene, for which it is easier to enter the human respiratory tract on such particles, jeopardizing human health.

As shown in Figure below, the share of transportation in the total air pollution in the Slovak Republic increased for substances PM and NOx. A significant aspect for pollution-related health risk is that transportation pollutes the surface layer of the atmosphere, especially in densely populated areas, which contrasts, for example, with the energy industry, which is characterised by long-distance pollution transmission affecting more remote areas that are often less densely populated.

Figure 20: Trends of transport emissions of air pollutants in Slovakia (thous. tonnes)

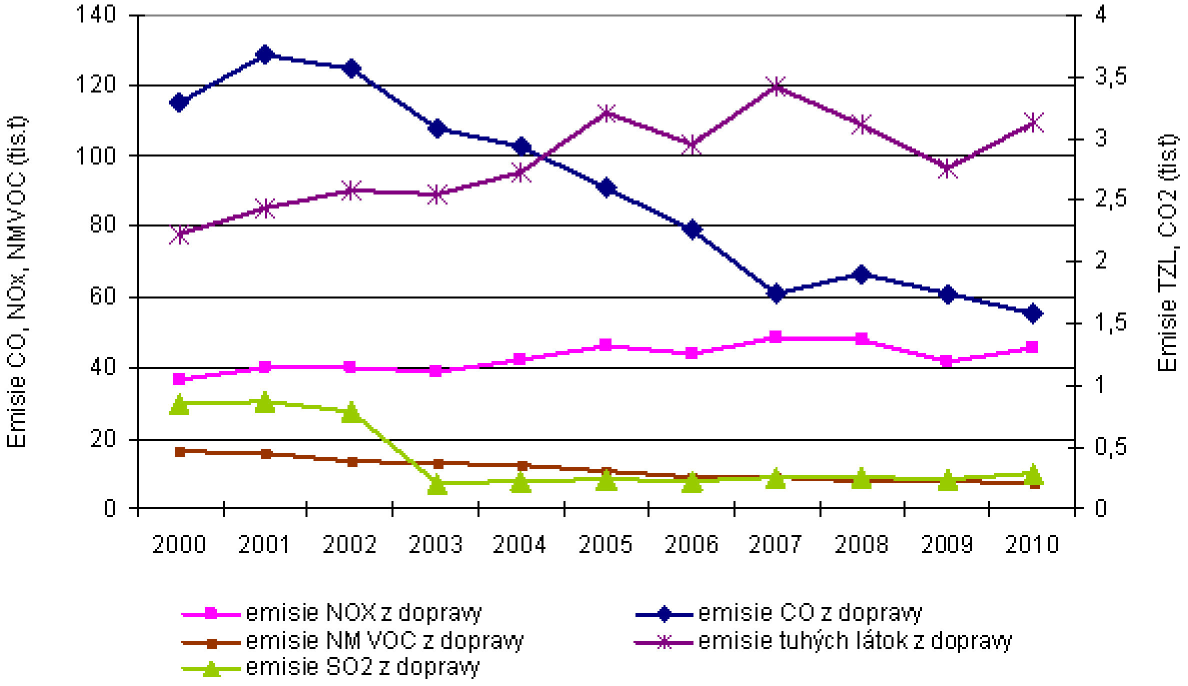
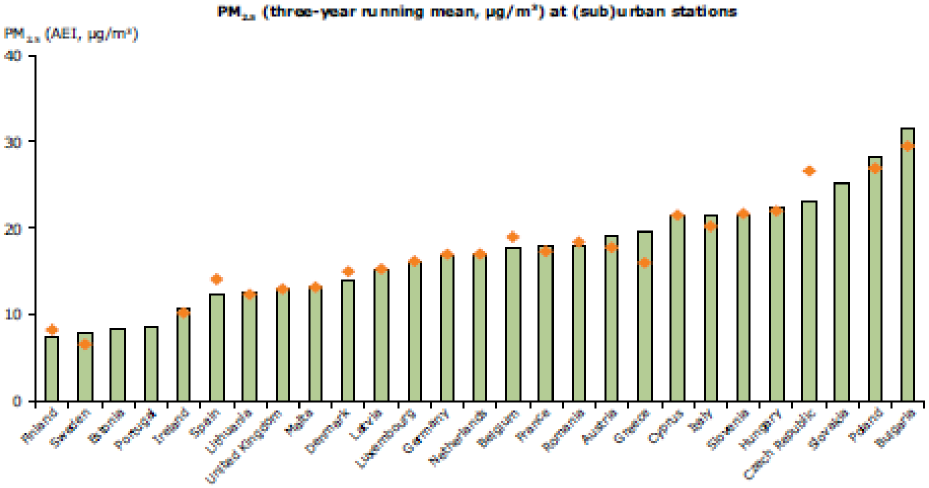


Figure 21: Urban PM2.5 concentrations presented as multi-annual average in EU, 2009–2011



Note: The three-year running mean of PM$_{2.5}$ concentrations (2009–2011) is calculated as the average over all operational (sub) urban background stations within a Member State in the period 2009–2011. The orange dots correspond to AEI-values as provided by the EU Member States in the air quality questionnaire (reporting year 2011; reference period 2009–2011 except Poland: reference period 2010–2011).

Source: EAA, 2013

The effects of transportation on the atmosphere

Emissions from transportation, especially in highly-trafficked localities, considerably reduce air quality. Transportation tends to be connected mainly with nitrogen oxide pollution (the highest concentrations have consistently been detected in Prague, in Legerova street, where there is no other significant pollution source) and the photochemical smog. This means air pollution by toxic products of photochemical processes in the atmosphere (especially low level ozone) from the precursors that are largely generated by transportation (nitrogen oxide, VOC and others). These processes mainly take place in summer, at higher temperatures and when there is more intensive solar radiation, which is why photochemical smog is also sometimes referred to as summer smog.

Table 4: Annual averages of ground level ozone concentration [µg.m^{-3}],

Station	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Babská Bystrica, Zelená					**53	56
Bratislava,Jeséniova	68	66	59	59	60	61
Bratislava, Mamateyova	53	50	49	48	48	46
Humenné, Nám. Slobody	60	62	56	55	59	53
Jelšava, jesenského	52	55	56	51	49	44
Košice, Ďumbierska	67	*49	57	56	81	63
Nitra, Janíkovce					**74	53
Prievidza, Malonecpalská			48	53	50	49
Žilina, Obežná	41	44	44	46	48	47
Gánovce, meteo stanica	67	68	60	65	62	63
Chopok, EMEP	95	*96	91	92	90	87
Kojšovská hoľa	86	84	79	76	85	90
Stará Lesná, SAV, EMEP	70	73	68	74	61	67
Starina, vod.nádrž, EMEP	66	*62	62	59	58	51
Topoľčany, Aszód, EMEP	60	60	58	60	59	55

** 50 – 75% of valid measurements, ** ozone measurement introduced in 2009*

Source: SHMU, 2010

In 2010, the annual average concentrations of ground level ozone in urban and industrial locations of Slovakia ranged within the interval 46 – 63 µg.m–3 (Tab. 2). The concentrations in the rest of the territory ranged between 51 and 90 µg.m–3, mainly depending on the altitude.

2 Impact of road transport on air pollution

Traffic participates very strongly to the polluting of ground layer of the atmosphere, where the life matures, especially an emission - the concentration of emitted polluting substances. It is caused by emission of the main polluting substances from traffic (CO – carbon monoxide, NOx – nitrogen oxides and VOC – volatile organic compounds) near the earth ground.

The problem of air polluting from the traffic is impossible to solve by increasing the height of air polluting substances release, what is the solution of industrial sources, where achieving the allowed emission limits is reached by determination of the minimal height of the chimney. The way of reducing effects of the traffic to polluting the ground layer of the atmosphere is in reduction of emissions from the vehicles with the technical development of combustion, with intercepting, eventually transforming polluting substances with the catalysts. Another solution may be deflection or redirection of the traffic in the most polluted area.

Effects of the traffic to air pollution

Loading the environment by human activity – the traffic – rises with the bringing the chemical, physical and biological components into environment. Important is don't exceed sustainability of the territory and do not damage it. The traffic loads environment during the construction and operation, most with the noise and emissions. Nowadays there are such a technological methods and technical equipment of the roads, which can protect overrun of the specified hygienic limits.

Traffic and traffic industry in Europe consumes 20% of the overall energy, from this amount 83% consumes road traffic, which also produces 81% CO and 51% NOx. Motorways can decrease this average in about 25%. In Slovakia, the traffic shares about 23% of the air polluting, the main contaminator is power engineering with 42%.

Pollutions from cars exhaust and raising dust, caused by whirling the sedimentary particles on the surface of the pavement and its vicinity, contributes at most in air pollution near the roads.

3 Possibility of minimalization traffic effects to environment

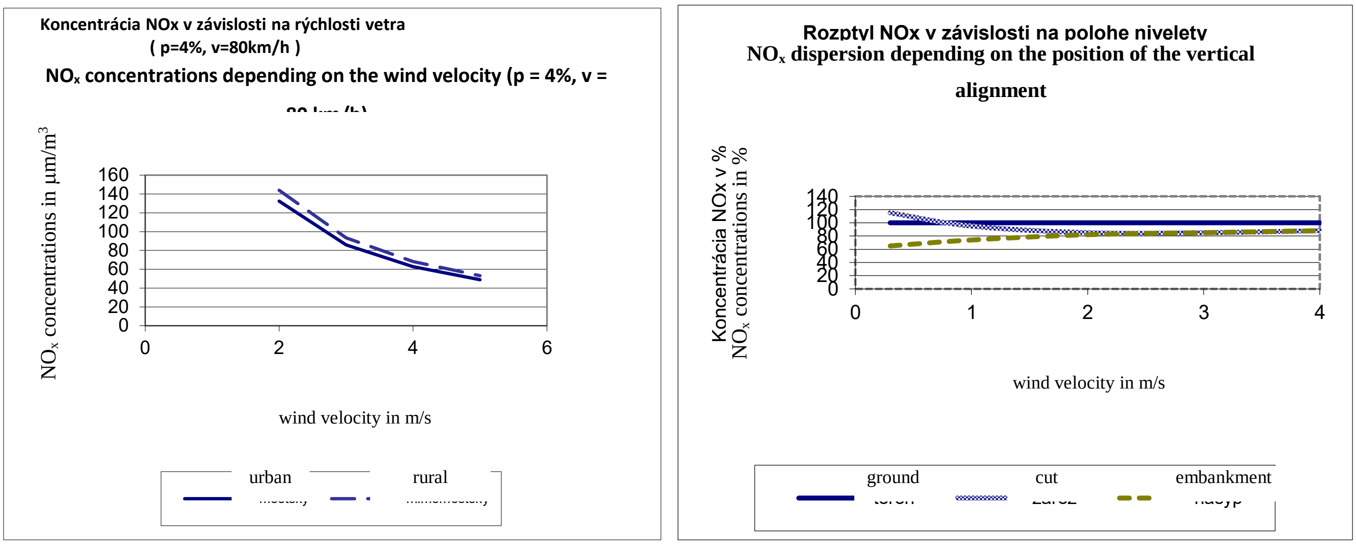
Next traffic progress is in separately conjunct with the demand of significance the life style, the way of living and economy. The framework defined through politics, where the traffic concepts can be set, depends on the changing the attitude of society to these demands. Traffic policy must therefore consider global and regional conditions. Such a strategy has got a perspective, which consider with the change of the traffic systems and with the limitation of ineffective traffic. Harmful effects of the traffic to environment must be restricted with the enforcing faster, safer and more comfortable public traffic service, as well as limiting the individual traffic, especially in large cities.

The influence of the layout to the emissions dispersion

The quality and cleanness of the atmosphere has become a serious problem in traffic networks planning in and outside the cities, in traffic organization and regional planning. Traffic collapses in the cities, means increase in concentration of pollutions.

Nitride oxides are one of the most significant parts of exhaust, because they reach the highest concentration of pollutants produced to the atmosphere. They are also easy to monitor and can be estimated. That's why they are used as an indicator of air pollution with the exhaust from the traffic.

Figure 22: The influence of the wind velocity to the emission dispersion and the influence of the construction limits position



The position of the road is permanent after the construction, so it is necessary to pay attention in design of the communication systems. By (Mlus-92) the dispersion of pollutants in dependence of the vertical alignment position (in the cut, on the ground, on the embankment) was monitored and the results show, that this dependence on the position manifests in the wind velocity lower than 3 m/s, when the formation level seems to be more suitable for emission dispersion. Concentrations of NOx monitored near the road on the embankment were 2 times lower than near the road placed on the ground.

In the Figures 1 and 2 are presented comparative entries calculated for the road section with the same directional orientation and the length of 1km, the category MS 21.5 for urban driving mode, which responds to local distributor road and R22.5 for rural (fluent) driving mode. Considered number of passenger cars was 10’000 / 24 hours, trucks 1’000 / 24 hours, peak traffic in half of an hour was considered as 5% from 24 hours’ traffic.

Road greenery

Effective usage of the road greenery can considerably reduce negative impact of the automobile traffic. In the past the effect of the greenery was not enough used. Nowadays, the protection and creation of the environment and its enhancement comes into dependence with the problem of balance between civilization and biological element of a human. One of various functions of the greenery is filtration, so the greenery plant is applied along the roads.

But not every form of planting betters the situation. Very important is the depth of the planting and its filtering efficiency. The greenery can capture the dust and equally disperse the emissions.

Regulation of the wind velocity with the dense planting, increase the dust in the vicinity of the road. More effective are species, which allow the wind to blow through.

Figure 23: Dense greenery

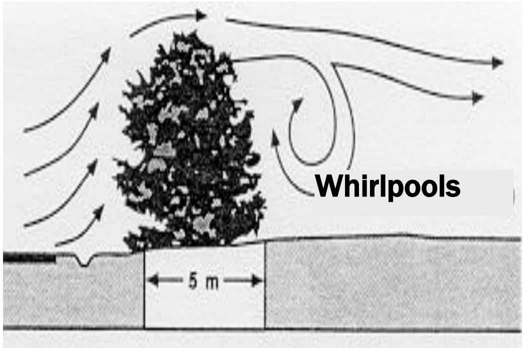
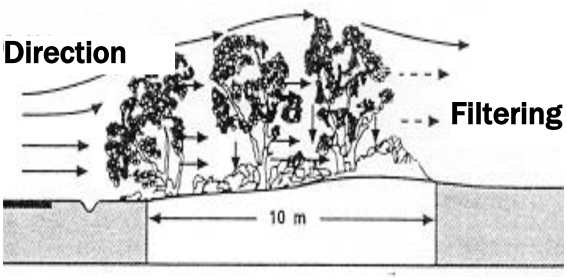


Figure 24: Foliage greenery



Bushed foliage dense greenery, with the width of 5 m reduces the dispersion of the pollutants to the environs in 20%. The greenery with the width of 10m reduces the dispersion of the pollutants in 60% in the summer. The most proper is the combination of the foliage and coniferous species. There is no oscillation in the efficiency of the planting between summer and winter.

Arrestment of the particulates with the oxygen production and consumption of the carbon dioxide is wear by the foliage and coniferous species. By gas pollutants the greenery is effective only in low concentrations. Failing which the coniferous species are drying up. From presented comparisons is resulting, that it is necessary to solve the question of the traffic impact to air pollution in the urban agglomerations in land planning documentation, where the location of the roads is determined.

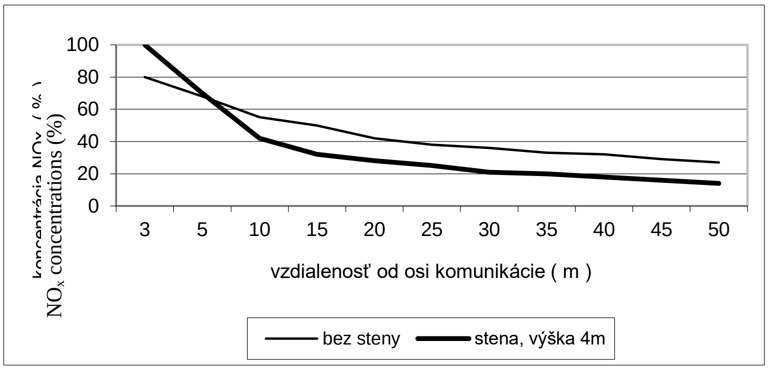
The need of balance, between civilization and biological element of the human, manifests especially in urban agglomerations, where the automobile traffic makes the environment worse.

Also the noise from the traffic is significant in urban agglomerations. The greenery mutes this noise depending on the width of the green belt. More expressive muting manifests from the width of 15 – 20 m. In the green belt there is appropriate combination of the trees and brushes, in order to effective protection from the noise. It is necessary to combine foliage and coniferous species, because the foliage species has got no effect to noise protection in vegetal standstill. The reduction of noise energy, consist in large amount of reflections on the leaves, branches and needles, so not in absorption.

Noise barriers

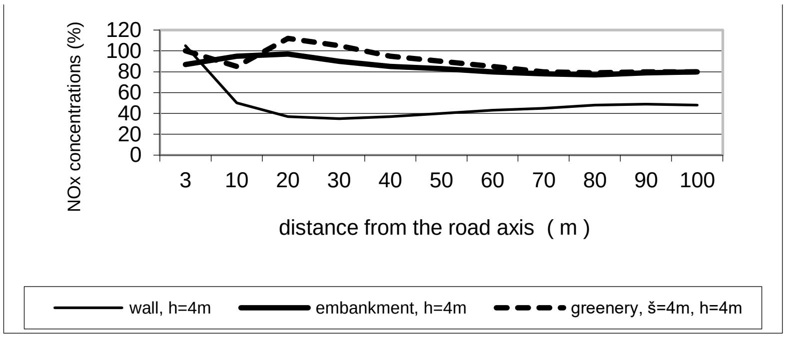
Construction of the noise barriers has got positive influence also to the emission dispersion. Otherwise, the wall makes a barrier that affect the concentration of the gas elements near the road, but if it is properly situated, it can reduce this concentration behind the wall. Therefore, it is suitable to construct the footpaths behind the noise barriers.

Figure 26: Effect of the noise barrier to the emission reduction (wind velocity > 2m.s^{-1})



Source: Pischinger, 1991

Figure 27: Comparison of greenery, noise wall and embankment

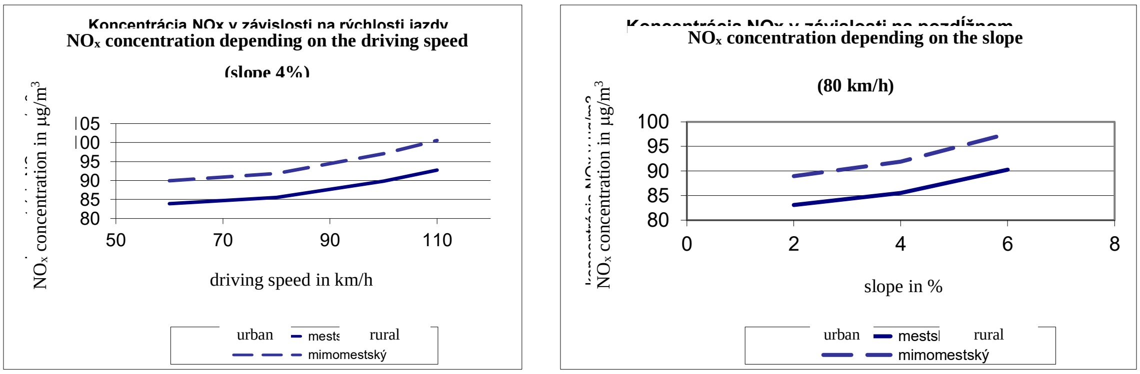


From the presented comparisons result, that it is necessary to solve the impact of the traffic to air pollution on the level of land planning documentation, where is determined the location of the roads.

4 Possibility of the emission production affection

Reducing the source of the pollutants means the change of the traffic flow intensity, reducing the freight traffic, limiting the speed, what can be done with the roads signs and synchronization of the traffic mode in the communication system (green waves).

Figure 28: Effect of the driving speed and slope



In the figures above are presented comparative entries calculated for the road section with the same directional orientation and the length of 1km, the category MS 21.5 for urban driving mode, which responds to local distributor road and R22.5 for rural (fluent) driving mode. Considered number of passenger cars was 10’000 / 24 hours, trucks 1’000 / 24 hours, peak traffic in half of an hour was considered as 5% from 24 hours’ traffic. The calculation follows the SAV (Slovak Science Academy) methodology.

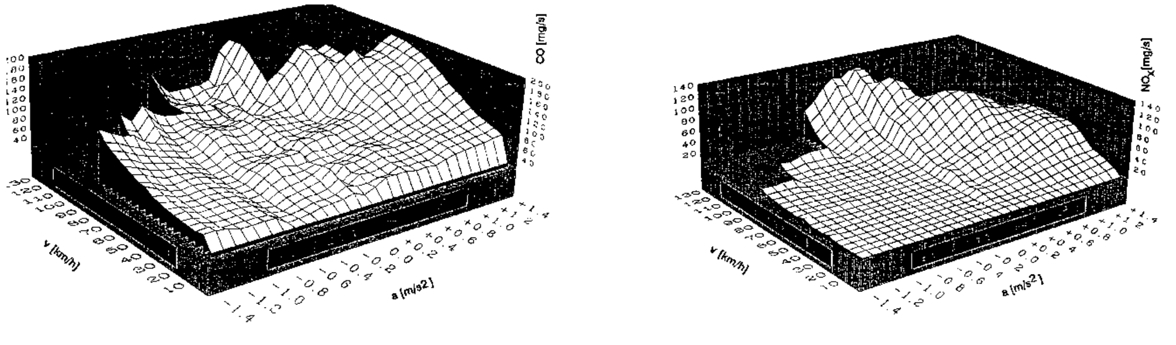
Effect of the traffic regulation to the emission production

In the enhancement of the environment in the urban agglomerations, a significant role acts preventive approach to solving the problems. Nowadays, traffic is a problem of every city. One of the example how to solve this problem, in term of air pollution from the traffic is a large study of Technical University of Graz (Pischinger, 1991).

Research workers from TU Graz elaborated a study, based on testing the traffic in selected part of the town, where they evaluated fuel consumption and emissions from the traffic in uncontrolled zone, with the speed limited at 30 km/h and 50 km/h in the same zone.

Emissions of nitrogen oxides NOx, carbon monoxide CO, hydrocarbons HC, fuel consumption and travelling speed were monitored. These factors were calculated to passenger car unit (PCU), which is based on the traffic flow composition, where 67% are vehicles, with gasoline engines (Otto’s engine) without catalyst, 21% gasoline engines with catalyst and 12% diesels.

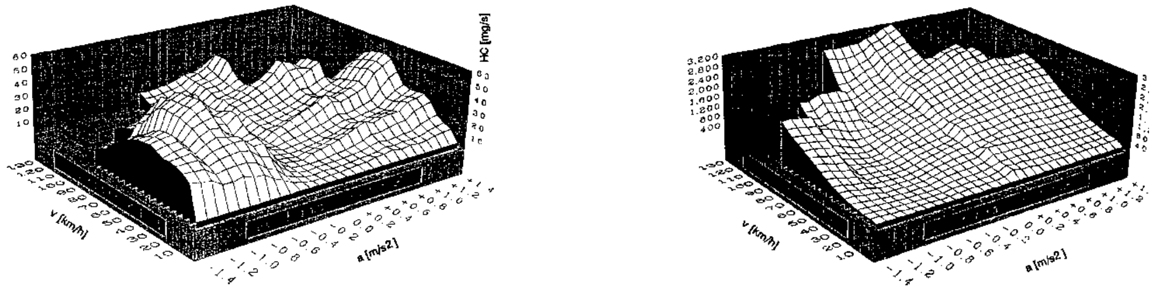
Figure 29: CO and NO$_x$ production for PCU



Because the engine activity relates to the road profile, there was evaluated the productions of the emissions of the passenger car unit before, in front of and between (where we can expect constant speed) the junctions (see figures above).

Production of the CO strongly depends on the traveling speed, as well as production of the hydrocarbons, but in the production of the nitrogen oxides, the traveling speed is not significant.

Figure 30: HC production and fuel consumption for PCU



5 Mathematical modelling of the air pollution

In the first approximation a street may be taken as a line source of pollutants, where produced pollutants are distributed equally. There are several different methods of mathematical modelling of air pollution from the traffic.

Analytical model – linear source

The easiest model of the air pollution from the traffic is based on an elementary half empirical Gauss relationship for pollutants distribution in a smoke tow from linear source. For the ground concentration of a pollutant stands:

$$C(x,y,0)=\frac{2q}{\sqrt{2\pi}U\sin\varphi\sigma_z}\cdot E(y_1,y_2) \qquad (1)$$

where q is emission from the linear source ($mg.m^{-1}.s^{-1}$), U is wind velocity ($m.s^{-1}$), φ is angle between the wind direction and the road axis, σ_z is empirical parameter characterized vertical dispersion of the pollutants. Function $E(y_1,y_2)$ expresses effect of the linear source finality to the distribution of the pollutants near the ends of the road.

$$E(y_1,y_2)=\int_{p_1}^{p_2}\frac{1}{\sqrt{2\pi}}exp\left(-\frac{p^2}{2}\right)dp=erf(p_2)-erf(p_1) \qquad (2)$$

where $p_1 = y_1 / \sigma_y$, $p_2 = y_2 / \sigma_y$, σ_y is parameter characterized horizontal dispersion of the pollutants.

For unlimited source, where $y_1 = -\infty$, $y_2 = \infty$, function $E(y_1,y_2)$ will be $E(y_1,y_2) = 1$.

Presented model is simple and reliable and is used to compute the air pollution from the traffic over large areas. Detailed description of this model is in Ďurčanská & Hesek, 2000.

Description of the program for modeling the emission production

Mathematical modelling performs after traffic prediction. Horizontal alignment of the road must be placed to coordinate system. Studied area around the road or object is fit into grid of the size 10 or 100 meters between the points, according to the largeness of the area where the emission production and nitrogen oxides concentration is enumerated.

Assumptions and mistiness of the computing model:

- estimated average speed of the traffic flow,
- specific emissions are considered for general composition of the traffic flow, for actual traffic volume and perspective in next years,
- windy conditions about dominant wind direction based on average data from long-term monitoring of SHMU (Slovak Hydro-Meteorology Institution), average wind velocity is determined from all measurements, include doldrums,
- the most unfavourable air stability is considered, when the breathing zone is most charged.
- Modeling input data
- In numerical model for modeling the emissions from mobile sources are considered:
- emissions factors for actual and future fleet,
- traffic volume and its composition according to vehicle type,
- longitudinal slope of the road,
- urban or rural traffic mode (driving fluency, buildings along the road),
- period of emission production evaluation,
- driving speed,
- meteorological conditions (direction and velocity of the wind),
- climatic conditions (according to Pasquill-Gifford categories of stability).

6 Model utilization

As an example we present modelling of the air pollution from the traffic in Šaľa.

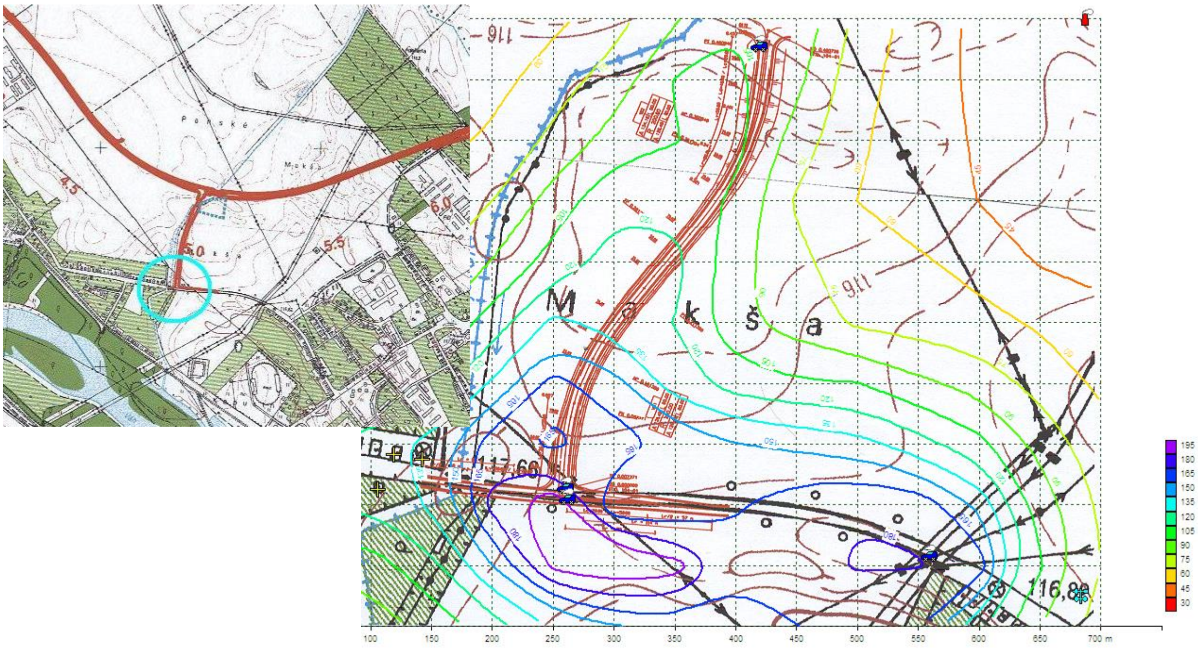
Performing of the mathematical modelling is based on traffic forecast for monitored area. Forecast of present state is based on state-wide traffic count. Next data about traffic volume are taken over traffic-engineering details, which were prepared for project of the bypass around Šaľa. Traffic volume for 2015 is calculated by forecast coefficients from state-wide traffic census.

The communication system of the city was fitted to a grid of point with spacing of 100 m, where concentrations of nitrogen oxides were modelling.

Expected effects of the traffic in the city

In modeling the air pollution was appreciated overall number of production of pollutants in the atmosphere (t/year) from 24-hour traffic, also were compared concentrations of nitrogen oxides NO_x ($\mu g.m^{-3}$) on the sections with the highest traffic volumes, originated from average daily traffic and were compared with permissible limits concentration of NO_2 (Ďurčanská & Moravčík, 2003).

Figure 31: Average daily co



The impact of static traffic to air pollution in urban agglomerations

Till recent time the impact of parking places wasn't appreciated for the quality of atmosphere. Relative to the construction of hypermarkets there have been built large parking places with the capacity over 300 standings. Legislatively, each parking place is evaluated as small source of air pollution, but huge parking places can markedly affect the quality of its environment. A parking place works as a ground source of pollutants. During unfavourable meteorological conditions – the temperature inversion and a weak wind motion – in surroundings of the parking place can be created the zone with excessive air pollution. Negative impact of parking places can be almost completely eliminated by collective garages. Polluted air can be exhausted and lead over the roof of the garage, where it is dispersed into the atmosphere in much better disperse conditions.

7 Static traffic by the shop centre

The survey of static traffic

The static traffic census can be realized for finding various matters: to discover the compound of parking vehicles, hour and elapsed time of parking. These parameters have the expressive influence on the parking places emissions.

Because we want to deal with parking by supermarkets, we know that there are parking just a personal vehicle during shopping in the supermarket. The values related to the time of parking and saturation of parking through the day is very interesting. That's why the surveys were carried out, where the notations on the entry and exit roads to the parking places were made.

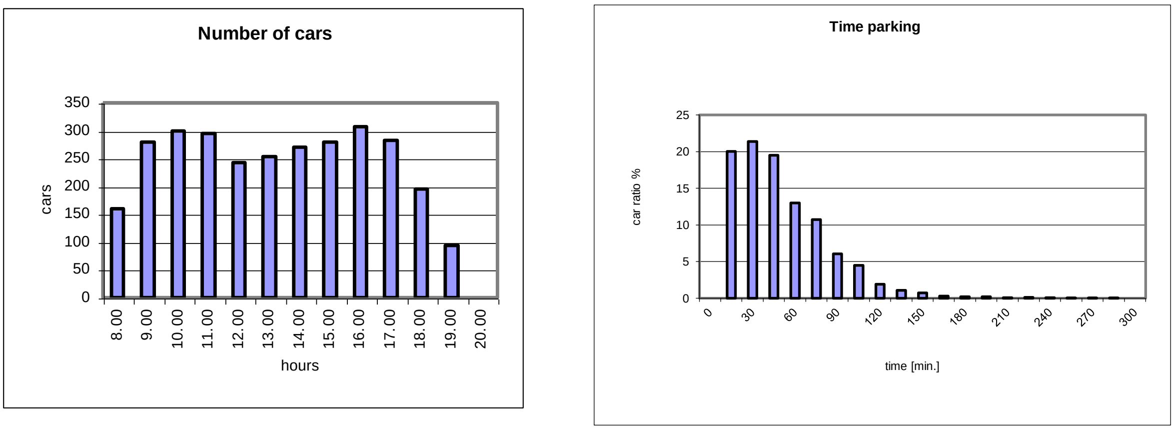
The saturation of daily static traffic

By the construction of a new pollutant source we need to know the current air pollution in this area. The active stationary heating sources with regard to their height of chimney have the minimal impact on the pollution of the surface air. The busy contiguous roads and huge adjacent parking places have the most negative influence on the air quality. By the evaluating of the contribution of the designed hypermarket on the air pollution therefore at first the parking place and the due to hypermarket increased traffic on the adjacent roads is taken into consideration. In addition, the influence of heating sources on the air pollution is calculated. For the evaluation of the negative impact of the parking places we need to know the parking mode or changing of the cars on the parking.

By the project of traffic prediction in the region where the shopping centre will be built we start from already curried out surveys. This is why we present the comparison of the results of parking monitoring by the standard shopping houses in the centre of the city and parking by a big shopping centre out of a city.

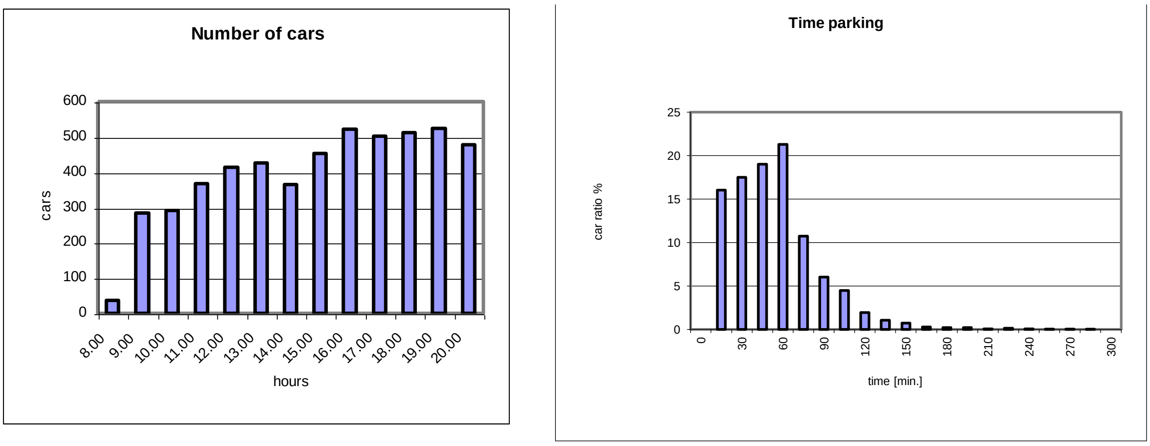
On the Figure 21 the occurrence and time of parking vehicles of the shopping house in the centre of a city is showed. On Figure 22 the situation on the hypermarket parking place is shown.

Figure 32: Number of cars and time parking in city



Source: Ďurčanská & Hesek, 2000

Figure 33: Number of cars and time parking in hypermarket



Source: Ďurčanská & Hesek, 2000

It can be seen from the graphs the saturation of the shoppers through day differs in the shops from the hypermarkets. The distribution of the parking in the shop during the day is almost constant from 10.00 till 18.00 o'clock, in the hypermarket it is concentrated after the working hours, e.g. after 15.00 o'clock, with the about double number of the parking cars, comparing with the morning hours. Different is also the time of parking, whereas the hypermarkets have got a larger area and greater offer of services, so the parking time is in longer. As it is seen from the histogram, the parking time in the hypermarkets creates almost the ideal Gaussian curve with the mean parking time round 1 hour. If we assume, that the time, during that the car is on the parking place with the started engine (standing + moving) is about 3 minutes, by the mean parking time 1 hour 5 % from all cars have started engines.

Emission of parking place

On the assumption that the car arriving to the parking place moves slowly, leaving it starts with the cold engine the emission of one car will be:

$$\text{CO} - 55.0\ \text{mg.s}^{-1},\ \text{NO}_x - 2.1\ \text{mg.s}^{-1},\ \text{VOC} - 7.7\ \text{mg.s}^{-1}.$$

If we assume, that 5 % of all N cars have started engines, then emission of parking place will be

$$\text{CO} - 2.75\ N\ \text{mg.s}^{-1},\ \text{NO}_x – 0.105\ N\ \text{mg.s}^{-1},\ \text{VOC} – 0.385\ N\ \text{mg.s}^{-1}.$$

In these days by the hypermarkets the parking places with the capacity of 300 till 1000 vehicles are built. Such parking places produce every second 1.825 till 2.75 g CO, 0.0315 till 0.105 g NO_x and 0.1155 till 0.385 g VOC. Overlapping of the parking place with the efficient air-ventilation could the one of solutions of this problem. Such solution is expensive and therefore not realistic. By this time this problem is solved by the constructing of hypermarkets out of living zone, but not as a rule.

With regard to that the parking place is a surface source; it can under the unfavourable dispersion conditions (temperature inversion, low wind velocity) produce the relatively high air pollution.

Modelling of the air pollution from the static traffic

As it was shown sooner the collective garages minimize the negative impact of static traffic on the air pollution of the surroundings. The calculation of the air pollution from the collective garages is made by means of the method for the stationary sources. The collective garage is considered to be a point source, the height of which we can propose so that the impact will be minimal. In the case of a parking place it is not possible. The construction of the anti-noise barriers, eventually of the strip of the trees round the parking place could release its negative impact.

As a rule, we calculate the long-term pollutant concentration and maximal short-term (30 min.) concentration. There is no problem with the long-term pollutant concentration, because it is calculated over a long time interval (usually one year) and its value is low and usually not much higher than the background concentrations. For the evaluation of the negative impact of the parking place on the living area, the pollutant concentration for the most unfavourable meteorological conditions, under which the concentration is highest, is calculated – temperature inversion and the lowest wind velocity 1.0 m.s^{-1}.

For the calculation of maximum short-time pollutant concentration from the area source the relation is used:

$$C(x,y,0)=\frac{Q}{2\sqrt{2}U_s\sigma_z x_0}\left[erf\left(\frac{r_0+y}{\sqrt{2}\sigma_y}\right)+erf\left(\frac{r_0-y}{\sqrt{2}\sigma_y}\right)\right], \qquad (3)$$

where $r_0 = x_0/\sqrt{\pi}$ is an effective radius, Q is the emission of the source,

$$\mathrm{erf}(p)=\frac{2}{\sqrt{\pi}}\int_0^p \exp\left(-\frac{t^2}{2}\right)dt$$

is the error function, U_s is the wind speed at 10 m and σ_z, σ_y are the vertical and horizontal "sigma" dispersion parameters.

A place for parking of one car has standard dimension 2.5m x 5.0m. To each place leads a 3 m wide road. Then the area for parking of one car is 20 m^2. The shape of a parking place is usually irregular. The calculation by the relation (3) assumes the square area. Therefore, it is necessary to divide the parking place into several square parts. We show as an example the huge parking place.

Parameters of the parking place:

Dimension	150m x 150m,
Capacity	1000 standings,
Working hours	18 hours.

Meteorological parameters:

(the most stabile) category of stability,

Wind speed 1.0 m.s^{-1},

Urban dispersion mode

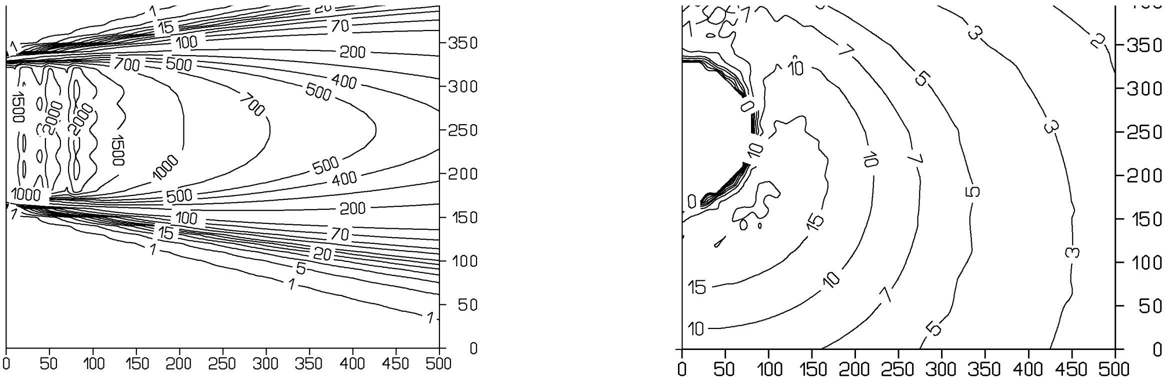
Emission of the parking place is given at the table below.

Table 5: Emission of the parking place

pollutant	emission (g.s^{-1})	
	short-term	long-term
CO	2,75	2,0625
NO$_x$	0,105	0,07875
VOC	0,385	0,28875

The calculation of the distribution of long-term and short-term CO concentration is shown at the Figure 32.

Figure 34: The distribution of maximum short-term CO concentration [$\mu g.m^{-3}$] by the west wind after splitting the parking place into 25 x 25 parts and The distribution of long-term CO concentration [$\mu g.m^{-3}$] round the parking place



Similar as the busy road traffic also the static traffic can be the source of the excessive air pollution. Therefore, it is important to devote the adequate attention to this problem. It is necessary to obtain more exact enter parameters of the calculation method (time parking, time during that the cars have on the parking place started engines). It is also important to monitor the surroundings of the huge parking places and thus to verify and to specify the calculation method of air pollution from the static traffic.

8 Modelling and simulations

Urban models for transportation and spatial planning

Urban transport is essential for citizens to perform their daily activities, but at the same time constitutes one of the major sources of urban pollution (GHG emissions, local air quality, and noise), directly affecting citizens' health and well-being. Urban traffic produces 40% of CO2 emissions and 70% of emissions of other pollutants (CO, NOx, SOx, particulate matter) produced by road traffic. Traffic accidents are also increasing, with two thirds of the accidents and one third of the victims taking place in cities. The quest for environmentally sustainable urban transport, while ensuring competitiveness and addressing social concerns such as health problems or the needs of persons with reduced mobility, is a common and urgent challenge for all major cities in Europe (COM, 2009).

To tackle the challenge of sustainable urban mobility, urban planners need models, decision support tools, and input data allowing the assessment of policies and their resulting effects. Cities have been treated as systems for several decades, but only recently has the approach changed from aggregate equilibrium systems to complex, evolving systems of systems. Different types of urban models have been developed, from the static and aggregate land use-transportation interaction (LUTI) models first developed in the 1960s, to recent, bottom-up, activity-based microsimulation models which seek to represent cities in more disaggregate and heterogeneous terms (Batty, 1976, Batty 2007, Heppenstall et al. 2012).

In recent years, quantitative models for transportation and spatial planning have received a renewed attention. Urban development along the last two centuries has been driven by an increasing mobility of people and goods facilitated by relatively cheap energy. The growth of urban areas, the increasing concerns about sustainable development, and the challenges posed by energy scarcity and climate change, raise new questions such as the influence of higher transport costs on mobility and location (e.g. will distances to workplaces, shops, services and leisure be reduced?) or the impact of new policies (e.g. promotion of more efficient vehicles, transport demand management, anti-sprawl legislation) aiming at fostering a more sustainable mobility and location behaviour (Wegener, 2010). In parallel, the emergence of new social media and electronic communications is leading to profound changes in social relationships, which is in turn modifying location and mobility patterns in cities. This new landscape makes it necessary to develop new models, tools, and methodologies enabling city governments and their citizens to design sustainable mobility policies.

Urban models serve various purposes. First, models help achieve an enhanced understanding of urban dynamics (in an explanatory role). Second, they enable virtual experimentation allowing the prediction of the impact of new infrastructures, technologies, or policies (in a predictive role). Finally, models are powerful tools to facilitate participatory processes for collaborative decision making (in policy and design roles). Despite significant effort carried out in the last two decades, urban models still require progress along several axes to fully satisfy these three objectives, and ultimately to support the assessment of urban mobility policies in terms of a comprehensive set of economic, social, and environmental sustainability indicators. Further research is needed in three main directions:

Data collection. Urban modelling is a data-intensive task. The development and validation of improved models critically relies on the availability of data.

Theoretical research - EURFORUM. On the transport demand side, many questions are still open, such as the social determinants of mobility behaviour, i.e. norms, social perception, age and demographic, personal security, or comfort; the activity patterns underlying human travel behaviour; the impact of information campaigns on user behaviour; the social acceptance of transport systems and mobility policies; the expectations that transport systems have to meet to be accepted and successful without inducing new travel needs; or the relationship between land use and transport demand. As for the transport supply side, research must be undertaken to investigate the potential of technology to supply integrated mobility services and transport systems.

Link between modellers, decision makers, and societal actors. The use of system models in policy making and planning is very heterogeneous. Many cities do not use any quantitative models at all; among the cities using simulation models, traditional LUTI models are still the most applied (Batty 1976). The use of more advanced, state-of-the-art models—particularly of agent-based models—for policy-making purposes is still scarce, and in many cases the potential users do not have the skills to use such models or are not convinced of the benefits. To bridge this gap, the development of the models needs to be user-driven and account for the requirements of the policy makers. The use of system models in a policy decision context will only be successful if the development of these tools is accompanied by user-model interaction methodologies and procedures facilitating a smooth integration into the decision-making processes (EUNOIA, 2012).

Challenges and opportunities

Despite the close interrelationship between land use and transportation, and the profound effects of such interaction on quality of life and the environment, in most urban areas of the world land use and transportation have historically been planned separately. Urban transportation planning has been the most active application area of simulation models, while land use planning has to a large extent been based on qualitative considerations and urban planners' experience, with computational land use models being used to a lesser degree than in transportation planning.

According to a recent survey of U.S. Metropolitan planning organisations (MPOs) with more than 200,000 residents (Lee, 2010), a few MPOs (7%) do not use any kind of modelling tool; 46% use transport-only models; and the remaining 47% use transport and land use models, though only 27% carries out an integrated planning. There have been various surveys in a European context, but the focus has been much less on models, and more on the use of ICT in planning agencies. This betrays the fact that most planning agencies are not engaged with the use of related urban models in their policy deliberations.

Depending on the size of the urban area and the available skills at the local level, standard four-stage models including logit choice of mode and destination choice are commonly employed. About 90% of the transportation demand models currently in use, either in an isolated manner or combined with land use models, are variations of the traditional four-step model; TRANSCAD, VISUM, and CUBE are the tools most widely spread. These models seem to satisfy the demands of the local and regional political processes, even if implemented less than optimally from a technical viewpoint (TRB, 2007).

Software PTV VISUM

PTV Visum is a comprehensive, flexible software system for strategic traffic and transport planning. The system is used for metropolitan, regional and state-wide infrastructure planning:

- Multimodal network modelling
- Tour-based and 4-step demand calculation
- Various static and dynamic assignment methods for private transport
- Two distinct public transport assignment procedures and operational planning modules
- Traffic engineering incl. signal time optimization
- Graphical and tabular analyses of results, output of reports
- Environmental impact evaluation methods
- Manager for the easy handling of various scenarios traffic

Impact Assessment of transport by module HBEFA (PTV VISUM)

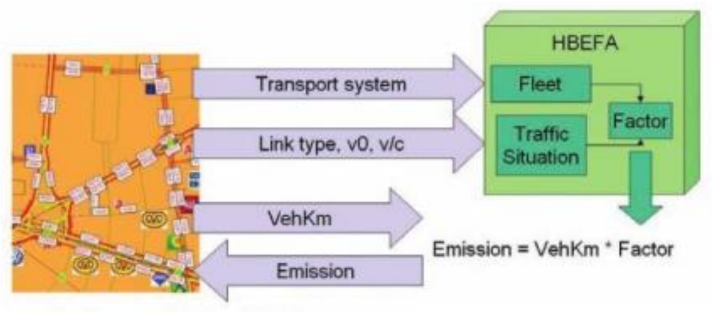
Why HBEFA?

This type of research project consumes vast resources, making a supranational approach desirable, and more than 10 years ago the German, Swiss, and Austrian environmental agencies pooled their resources to compile a comprehensive database of emission factors. The result was published as the Handbook of Emissions Factors (HBEFA). After several revisions, the HBEFA now faces the next major revision in which the emission factors will be updated to take into account new engine concepts and emission standards, including the findings from the EU-funded Artemis research project on transport emission models and systems.

ARTEMIS proposed a new set of systematic descriptors for traffic simulations that simplifies mapping from transportation models to emission models. Sweden, the UK, and France have now joined the HBEFA consortium, so that the revised HBEFA should eventually, become a truly European emission factors` standard. Against this background, VISUM developers toot the logical decision to make HBEFA3.1 the emission model to be integrated with VISUM.

Linking PTV`s Visum with HBEFA 3.1 will help planners to improve the increasingly important environmental assessment, through emissions calculation.

Figure 35: Data flow between VISUM and HBEFA



The basic approach for emission calculation follows a very straightforward equation:

$$\text{Emission} = \text{Traffic Volume x Emission Factor} \qquad (4)$$

In this equation emission stands for the total mass of a pollutant species such as CO_2 or NO_x emitted by the vehicles on a network link during a given time interval. The traffic volume is the number of vehicles that traverse the link within that time interval. Demand models, such as those developments in VISUM (PTV`s flexible software system for transportation planning, travel demand modelling, and network data management), yield traffic volumes, either as total or broker down by vehicle type such as cars, light trucks, and heavy trucks. These volumes are then multiplied by emission factors, the unit costs in emission modelling.

Obviously, emission factors are not constants, but functions of several factors. Speed, link type (such a s motorway versus city street), engine type, gradient, even temperature – all have a considerable impact. The functional relationship is determined through a vast amount of empirical work, measuring actual emissions in the field and in the lab, taking a variety of driving patterns into consideration (Nokel, Hoffmann, 2010).

Comparing traffic data

The scope of data types supported by PTV TrafficCountManagement includes both primary traffic-count data and environmental data. Pollution values for air pollutants such as NO_x, CO and PM emissions can be imported into the PTV TrafficCountManagement database for further evaluation. In particular, the visualization on the environmental data together with traffic volumes, or speed characteristics, enables users to evaluate relationships between the following two factors: the amount and speed of traffic.

In recent years, the effectiveness of traffic management has been judged on its impact on flow and on its contribution to the reduction of the traffic`s environmental footprint. This dual emphasis is likely to be increasingly important and the TrafficCountManagement is a comprehensive system to quantify these effects.

Figure 36: Emission analysis - centre of Žilina

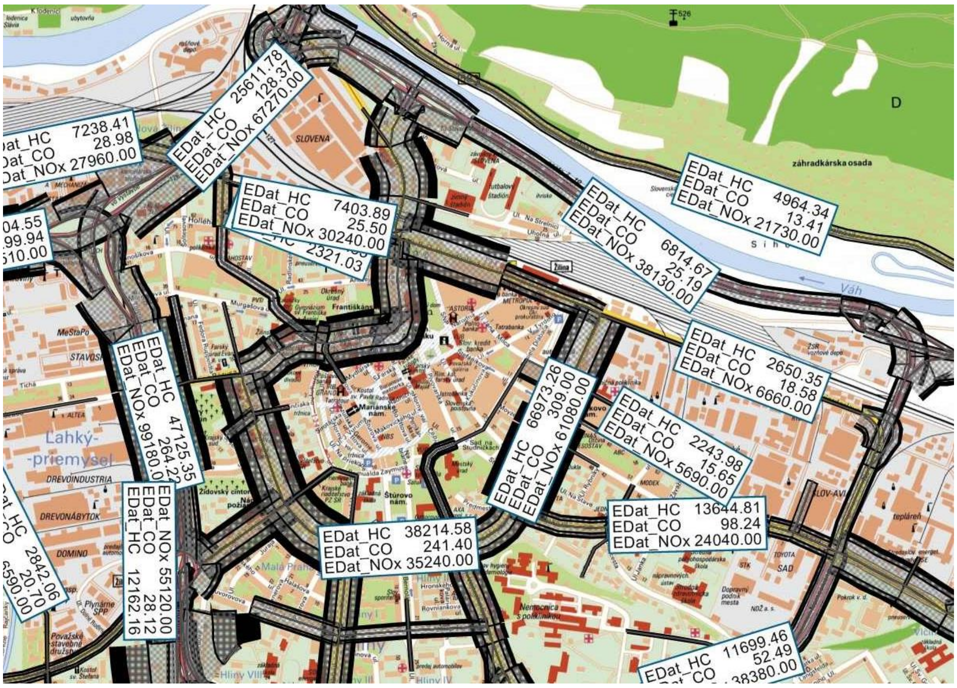
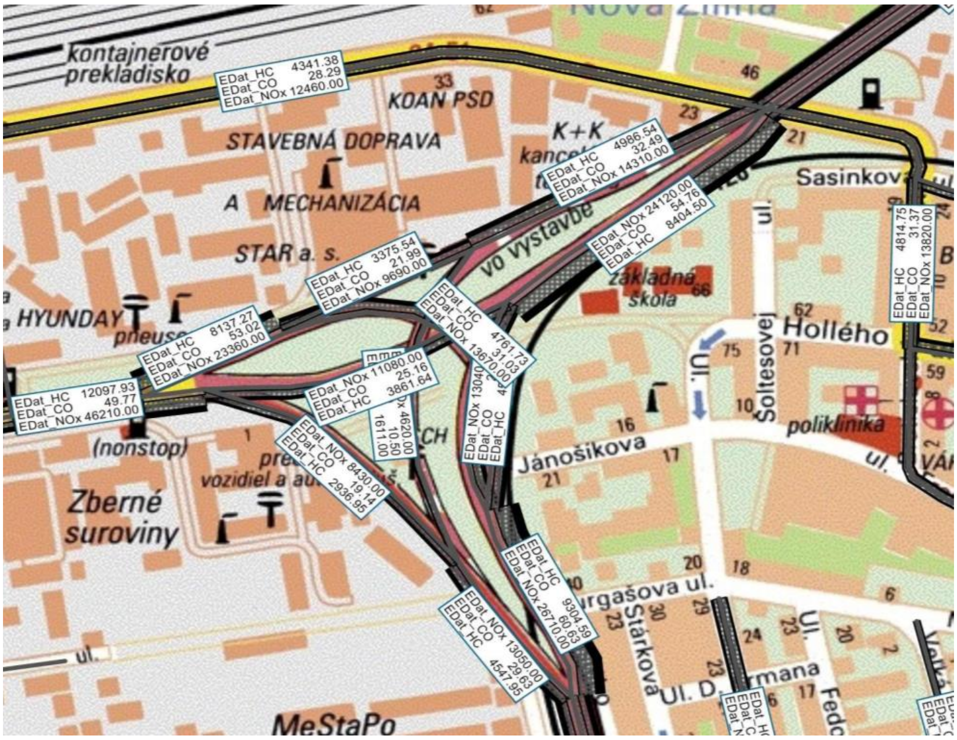
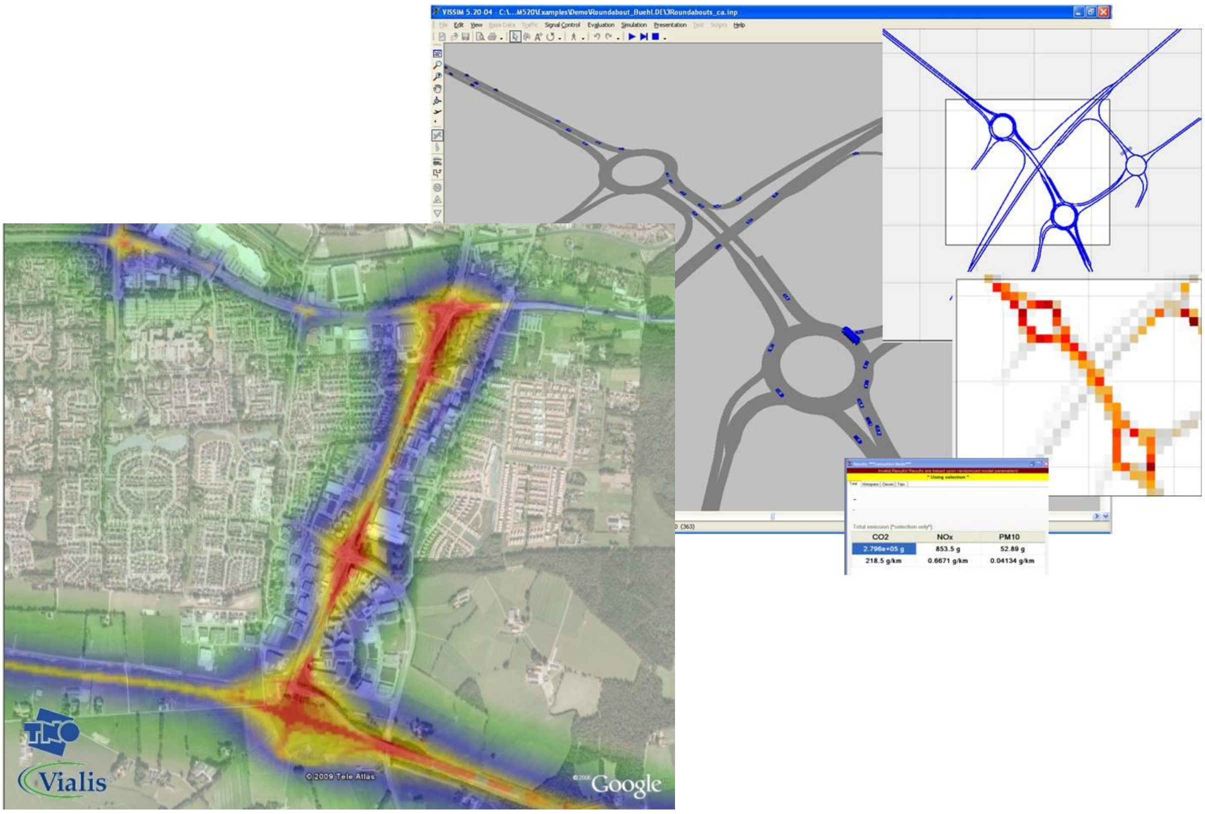


Figure 37: Emission Analysis - intersection in city Žilina



Source: Čelko, et al., 2010

Figure 38: Microsimulation – modul VISSIM EnViVER



* Using selection *

Total emission (*selection only*)

CO2	NOx	PM10
2.796e+05 g	853.5 g	52.89 g
218.5 g/km	0.6671 g/km	0.04134 g/km

Examples from Slovak Towns

The establishment of transportation relations in a given territory is correctly perceived as a challenging task. It requires the interaction of all the parties involved in the creation of the land-use plan. The quality, extent and accessibility of input data should in the final analysis determine the quality of its outcomes. The manner of their compilation plays a significant role in the process of determination of transport relations. At present we can state that specialized programs for transport modelling bring a new dimension to the process of forming land-use plans. Their primary task is to define territorial modelling in greater detail and thus include in the calculation the largest possible number of effects.

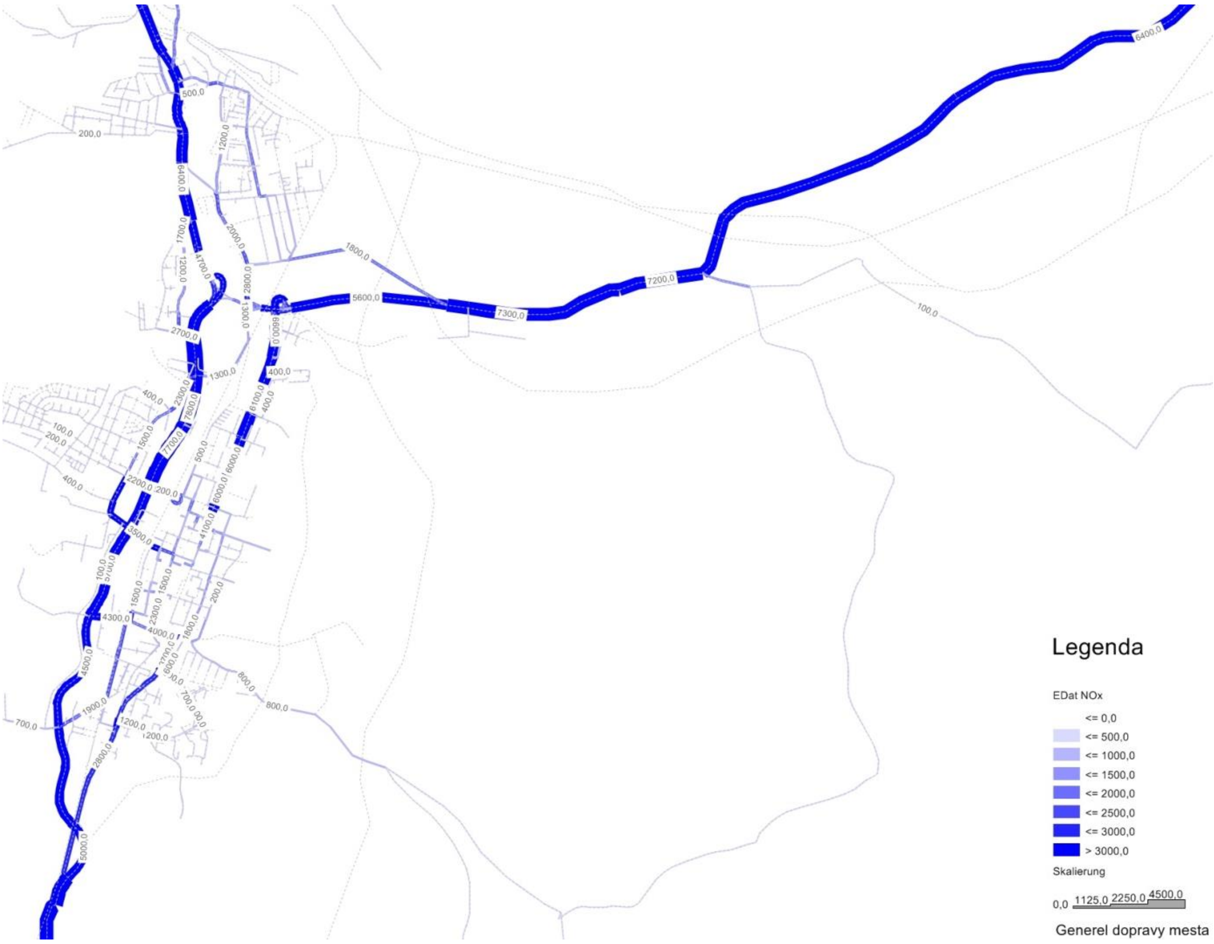
<u>Transport solutions City Martin</u>

In the cities Žilina and Martin in the years 2010-2013 was processing traffic planning documentation. Dealt with the transport model city. There was compiled the traffic model of supply and demand model. These solutions are based on detailed traffic surveys. Based on these cities receive quality materials for transport solutions and solutions for sustainable development in the future.

Figure 39: Transport solutions City Martin

Source: Čelko et al., 2013

Figure 40: Air analysis – City Martin (Modul HBEFA)

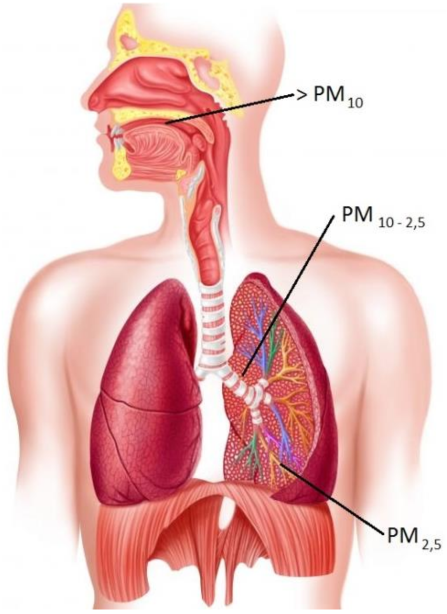


Source: Čelko et al., 2013

Quality of urban air – Monotiring Particulate matter and Heavy metal from traffic

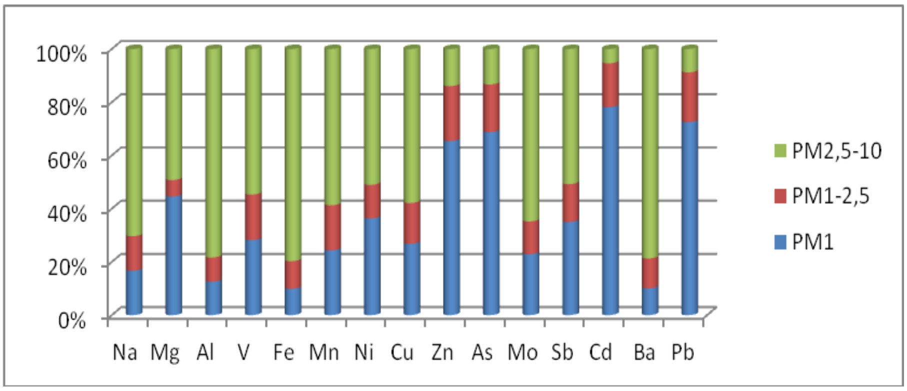
Readings of particulate matter are performed in the close vicinity of the urban connecting route, road in regular intervals, more specifically 4 times per year. The goal was a long-term monitoring of the proportional representation of particulate matter, particles in the ambient atmosphere and their behaviour with reference to the external conditions. In the second phase a chemical analysis of the particulates, particulate matter was performed in order to determine the amount of selected heavy metals in concerned fractions of PM.

Figure 41: Health impacts of PM



Source: EEA, 2013

Figure 42: Presence of metals in specific fractions of PM



Source: Ďurčanská & Jandačka, 2013

Measures for reducing environmental impacts of transportation

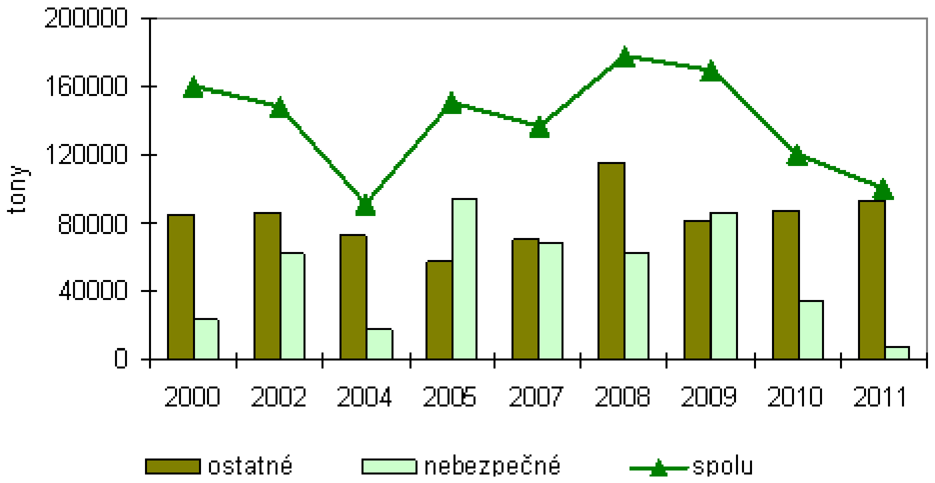
The measures for increasing environmental friendliness of transportation can be divided into the following categories:

Reducing air pollution (emissions) and noise from transportation

Reducing transportation`s effect on the structure and functions of the landscape (e.g. preferential development of track transportation, considerate placement of new routes and, as the case may be, the construction of ecoducts across highways near biocorridors)

Systemic and enviromentally friendly waste management (car wrecks, batteries, used motor oil)

Figure 43: Developments in waste within the transport sector (tones)



Others dangerous together

Source: SHMU, 2010

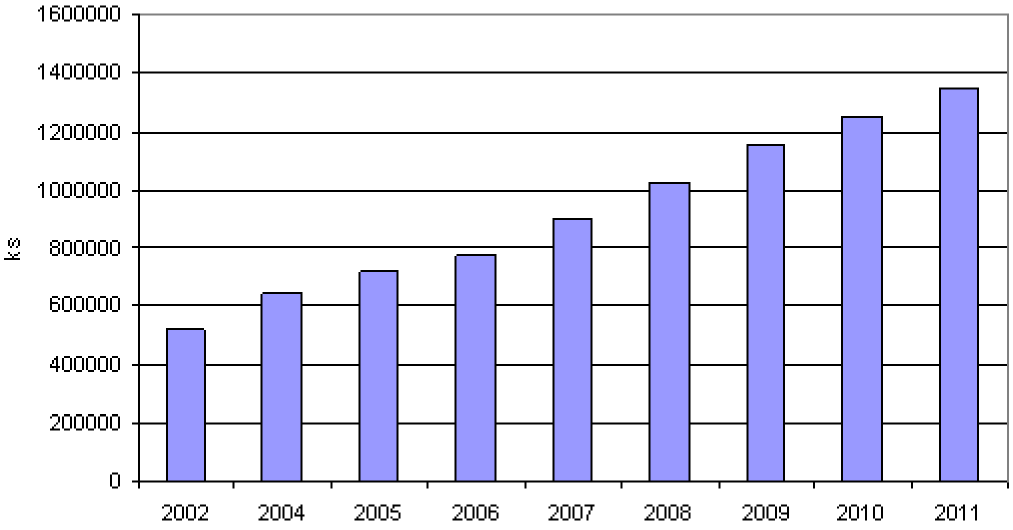
The measures can be of a technical character (e.g. the construction of anti-noise barriers, reduction of noise from rail transportation by installing flexible bedding for tracks or by reducing electrification of railway routes, the construction of ring roads around cities), a legislative character (e.g. emission limits for automobiles) or an economic character (taxes, charges, subsidies).

Emission limits specified by legislation are effective for the protection of fair quality. Such limits can only be met by fitting new automobiles with three-way catalytic converters. The share of these automobiles increased from 2002-2011 (see figure above).

Alternative methods for the propulsion of motor vehicles have yet to establish themselves. While the number of electric automobiles has stagnated, the number of LPG-powered passenger cars is the only figure to see any increase, with LPG use becoming more widespread in road freight transportation. The state uses lower excise tax rates to promote the production and consumption of environmentally friendly fuel types. The amount of this support, including the support for biodiesel through its placement under the lower Value Added Tax (VAT) rate, has fluctuated considerably.

The great majority of these measures depend on the economic condition of the state.

Figure 44: Number of passenger car in Slovakia fitted with catalytic converters



Source: SHMU, 2010

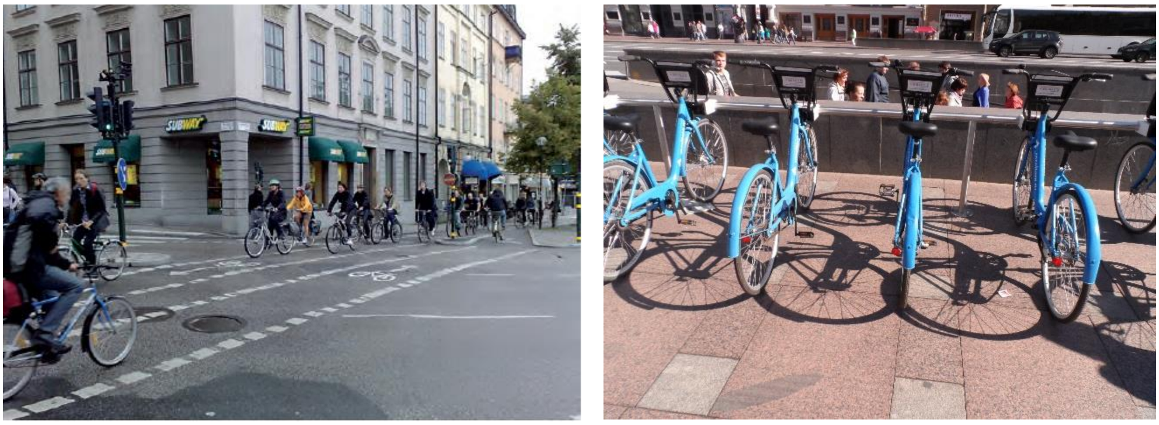
Today’s rapidly expanding transportation demands are caused not only by new investments which increase the transit attractiveness of a region, but also by the increasing potential of traffic-producing areas. While such development is legal, it is also open to influencing. The purposed creation of land-planning documentation, its unequivocal maintenance, and long-term benefits and detriments analyses can create a symbiosis of all types of transportation and ensure the quality of the environment. Unfortunately, in our situation the positive influences run up against various interest groups and an overall lack of professionalism. Experience from more advanced countries however shows that effective solutions can indeed be put in place. What are the main transport problems in urban areas, and what are the possibilities for overcoming them?

Figure 45: La Défense, Paris – The entrance to the lower level and La Défense, Paris – center

Figure 46: Partial separation of public transport in Bordeaux and sharing transport area in Helsinki

Examples from the Netherlands, bicycle paths in Parma de Mallorca, Stockholm and urban bikes in St. Petersburg, they are in conditions off major Slovak cities so far only in long-term vision.

Figure 47: Bicycle communication in Stockholm and urban bikes in St. Petersburg



In neighboring countries is an essential part of every new project in built up areas the simulation of transportation movements after the project.

The transport is a phenomenon that significantly affects the life of the population. Ensure its functionality while protecting the environment and social environment in residential areas is a task that should be a priority for traffic planning activities.