Environmental impacts on soils from transport systems in various cities in Lithuania

P. Baltrenas & E. Kliaugiene
Vilnius Gediminas Technical University, Environmental Protection Department, Lithuania

Abstract

The object of this research program is the environmental impact of the Transport system (motor and railway transport sectors) on soil. The main objectives of this program are investigations of the environmental impact of pollution caused by the transport sector in Lithuania: evaluation of environmental impact of transport sector on soil: simulation of pollutant dispersion by computer programs. preparation of suggestions and recommendations for the reduction of impact on environment.

The motor and railway transport sectors are the main sources of pollutants in Lithuania. Therefore these two sectors are under the more detailed research than the other two – air and water transport sectors.

The main goals of this program are the environmental impact of motor and railway transport sectors on soil (topsoil). The most important thing in this program is to set the sample net and to choose the right method of collecting the soil samples. The whole territory of Lithuania was divided into the areas where the environmental impact of motor and railway transport sectors on soil is the most intensive. Some other areas were selected where the pollution impact is the lowest. for the purposes to compare polluted and not polluted areas. For evaluation of pollution caused by the motor and railway transport, the soil samples were collected across the road or railway, and one profile of samples contained about 12-14 samples depending on the relief. One sample was composed of five sub-samples collected according to the "envelope" principle.

After transportation of the topsoil samples to the laboratory the following analytical method was used AAS-ES. Heavy metals (Zn, Co, Cr, Ni, Cu, Pb) were analyzed for the purposes to evaluate the composition of contaminants in the topsoil.
1 Introduction

Since 1980 the main goal of geochemical investigations in Lithuania has been the estimation of technogenic changes of microelements in the Earth's surface sediments [1]. The transport system is the main source of pollution in Lithuania. Motor transport and railway transport sectors are more developed than air and water transport sectors. Therefore the main goal of this research is to evaluate the environmental impact caused by motor and railway transport sectors. For some time in past the main source of lead pollution was the transport system in Lithuania [2]. Motor transport and railway transport cause pollution not only with Pb, but also with other chemical elements as Cu, Co, Cd, Cr, Ni, Zn, etc. These transport sectors impact various ecosystems as air, water, soil and biosystem. It is also necessary to note that soil pollution by heavy metals is most dangerous, first of all it is not so obvious, and metals can be transferred to other environments (plants, water, animals, man) by ecological food circuits and have pernicious influence on organisms.

When investigating pollutant dispersion in the environment, it is important to assess other factors as well. Pollutant dispersion is very dependent on atmosphere also, it is determined by some synoptic processes. e.g. in a case of powerful anticyclone, calm and sunny air is prevailing, temperature inversions are developed, and dispersion of pollutants is slower. Usually, conditions for pollutant dispersion are better at noon, when soil-surface inversion fully disappears, wind increases and turbulent mixing becomes more intensive, and at night pollutant concentrations go down because car traffic on the streets is considerably lower [3].

2 Methodologies

It was very important to set the sample network correctly for the evaluation of environmental impact on soil by transport sector (Fig. 1). The whole territory of Lithuania was divided into the parts where heavy traffic is present causing the great pollution of soil. The topsoil samples were taken across the motorways and railways and also across the roads that are not so very contaminated in the regional parks just for the purposes to compare the heavily polluted areas to not polluted ones. Nine topsoil profiles were already taken next to the motorways and 6 profiles next to the railways. Each profile was composed of 12-14 topsoil samples accordingly to the topographical situation. Each sample was composed of 5 sub-samples, which were taken at depth of 0-20 cm. Some sample profiles in the sandy soils were taken at depth of 20-30 cm just for evaluation of vertical migration of chemical elements. The distances between the samples in profile were 1 m, 2 m, 5 m, 10 m, 25 m, 50 m, 75 m, 100 m depending on the relief. Topsoil samples were taken with a spade from the surface layer of 0-20 cm thick. The samples were composed of five sub-samples collected according to the "envelope" principle. The length of the "envelope" lines was 1-5 m. The samples were put into cotton bags or into "zip"-type bags.
3 Results

The median values of defined trace elements on the whole territory of Lithuania are shown in the Table 1 [4].

Table 1. Median values of microelements in topsoil of Administrative districts of Lithuania. ppm

<table>
<thead>
<tr>
<th>Districts</th>
<th>Co</th>
<th>Cr</th>
<th>Cu</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klaipeda</td>
<td>4.8</td>
<td>37.3</td>
<td>9.7</td>
<td>14.3</td>
<td>19.8</td>
<td>30.7</td>
</tr>
<tr>
<td>Varena</td>
<td>2.6</td>
<td>16.2</td>
<td>3.9</td>
<td>7.6</td>
<td>14.3</td>
<td>21.8</td>
</tr>
<tr>
<td>Vilnius</td>
<td>4.8</td>
<td>32.9</td>
<td>8.8</td>
<td>12.3</td>
<td>16.0</td>
<td>30.9</td>
</tr>
<tr>
<td>Ignalina</td>
<td>4.9</td>
<td>29.7</td>
<td>9.3</td>
<td>11.8</td>
<td>13.0</td>
<td>21.9</td>
</tr>
<tr>
<td>Kedainiai</td>
<td>5.8</td>
<td>44.6</td>
<td>10.5</td>
<td>18.1</td>
<td>13.6</td>
<td>35.0</td>
</tr>
<tr>
<td>Panevezys</td>
<td>4.4</td>
<td>29.8</td>
<td>9.0</td>
<td>12.2</td>
<td>13.4</td>
<td>26.2</td>
</tr>
<tr>
<td>Radviliskis</td>
<td>5.2</td>
<td>38.4</td>
<td>9.9</td>
<td>15.9</td>
<td>14.7</td>
<td>26.8</td>
</tr>
<tr>
<td>Svencioniai</td>
<td>3.9</td>
<td>25.2</td>
<td>7.7</td>
<td>11.3</td>
<td>15.2</td>
<td>25.0</td>
</tr>
<tr>
<td>Telsiai</td>
<td>5.3</td>
<td>38.3</td>
<td>11.2</td>
<td>16.0</td>
<td>15.0</td>
<td>33.6</td>
</tr>
<tr>
<td>Siauliai</td>
<td>4.5</td>
<td>34.4</td>
<td>10.5</td>
<td>12.9</td>
<td>15.2</td>
<td>26.0</td>
</tr>
</tbody>
</table>
The defined quantities of trace elements in the sample profiles, that have been taken at different administrative districts, in comparison to background values are higher. For example, concentration of lead in Klaipeda district profile, which was taken to evaluate pollution caused by the motor transport across the traffic circle, is very high (Fig. 2).

![Graph of distribution of trace elements](image)

**Figure 2.** Distribution of trace elements in Klaipeda roadside topsoil (0-10cm)

The traffic is very intensive on this traffic circle. It is evaluated, 1056 motor vehicles pass per hour in average. Lead is concentrated mostly in sediments of ditches where it is related to mechanical deposition of translocated particles. The quantities of other trace elements in this profile are related mostly to pollution caused by the motor transport, but they don’t reach very high concentrations. This may be related to the fact, the traffic circle is located on the open area where translocations by air flows aren’t restricted by forests or relief elevations. On the open place the pollutants are deconcentrated and are spread widely.

Distribution of trace elements on the Vilnius-Valkininkai road is variable and depends on the distance from the road (Fig. 3). Concentrations of trace elements are not very high there and could be related to the traffic which is not very intensive on this road. Lead is concentrated in lower places of the relief. The similar situation is on the Kaltanenai-Ignalina road where the forest grows at both sides of the road. The trace elements are concentrated mostly in the zone in front of the forest (Fig. 4).
Figure 3. Distribution of trace elements in Vilnius-Valkininkai roadside topsoil (0-10cm)

Figure 4. Distribution of trace elements in Kaltanenai-Ignalina roadside topsoil (0-10cm)

Distribution of trace elements on the Ukmerge-Panevezys road is related to the distance from the road (Fig. 5).
On the road-dividing zone the quantities of trace elements are much higher than that in the farther roadside soil. At greater distance from the road, the samples were taken from the cereal field. Therefore, on such the open area, increased quantities of microelements are distributed rather evenly in the whole profile. Distributions of trace elements on the road Seduva-Radviliskis in fields and forests are different (Figs. 6, 7). The most intensive pollution of soil on the fields is in the first few metres from the road, and farther distribution of trace elements vary comparing to the profile that was taken in the forest (Fig. 7).
Figure 6. Distribution of trace elements in Seduva-Radviliskis left-roadside topsoil (0-10cm)

Figure 7. Distribution of trace elements in Seduva-Radviliskis right-roadside topsoil (0-10cm)
The soil samples profiles were taken across the railway track for the purposes to evaluate distribution of trace elements which are the result of pollution by railway transport. Soil investigations on railway tracks were carried out at different distances from the axial line of tracks. It was determined, airborne pollutants together with dust, perhaps because of air turbulency generated by the passing trains, settle at different distances depending on relief conditions. When the railway bed is high, pollutants settle on bed sides and ditches next to the tracks. This zone is polluted most intensively. The most intensive pollution of soil was determined at the Radviliskis railway station (Fig. 8). This railway station is the biggest one in the Baltic countries. The traffic of the trains is very intensive there. The quantities of Pb are very high in comparison to median values in topsoil of Radviliskis administrative district (Table 1). The last topsoil sample was taken 50 metres from the station in the living area between the houses. The quantities of all trace elements are very high in this samples profile.

Figure 8. Distribution of trace elements in Radviliskis railway station topsoil (0-10cm)

The pollution of soil by trace elements next to the railway road in Vilnius district is quite obvious (Fig. 9).
The defined quantities of trace elements in comparison to median values are very high. The same zone of the railway has been investigated in 1998 and the quantities of trace elements were different in comparison to the present results:


According to the results, the situation has been changed to the better side. This could be related to use of cleaner fuels or decrease of traffic intensity, etc.

4 Conclusions

1. Substances emitted are exposed to various aerodynamic and gravitation forces resulting in their separation and, depending on their physical and chemical properties, they settle selectively on the soil surface at different distances from the road surface.
2. The main amount of heavy metals is settling on the soil surface in the narrow limited zone of the highway itself, its slopes and ditches.
3. On the railways, the heavy metals are settling in the narrow zone next to the tracks depending on relief conditions.
4. Investigations carried out at various locations in Lithuania have shown, operation of the railway system determines changes in soil properties and chemical composition.
5. The highest concentrations of heavy metals in the soil are found on the territories of the railway stations and in the vicinity.
References