CONTAMINATION OF ROADSIDE AREAS WITH HEAVY METALS

Zhuravleva, Margarita A. *– senior lecturer of Russian Open Transport Academy within Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*

Zubrev, Nikolai I. *– Ph.D. (Tech.), professor of Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*

Kokin, Sergey M. *– D. Sc. (Physics and Mathematics), professor of Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*

ABSTRACT

On the basis of conducted studies the authors analyze the distribution of heavy metals in the soil of areas adjacent to railway at the example of two railway hauls in the Northern Administrative District of Moscow. Conclusions allow to reveal existing environmental regularities, assess the degree of influence of roadside pollution on the environment, evaluate peculiarities of background anomalies, and determine prospects of similar studies with regard to the task to reduce man-caused impact on the urban area.

ENGLISH SUMMARY

Background. *The problem of reduction of anthropogenic impact on the environment is relevant to many countries around the world. The main pollutants are usually enterprises of chemical and metallurgical industries, as well as enterprises, extracting and processing of minerals, manufacturing construction materials, but also transport enterprises. In this regard, it is clear that it causes concern of people living in areas where such risk facilities are concentrated. In particular, in such a large metropolitan city like Moscow, environmental monitoring is of particular importance, allowing not only to evaluate the quality of the environment, but also to give recommendations on reducing man-caused impact on the urban area.*

Objective. *The objective of the authors is to investigate distribution of heavy metals in the soil of areas adjacent to railway at the example of two hauls in the Northern Administrative District of Moscow.*

Methods. *The authors use analytical method and comparison.*

Results.

Factors and risk areas

Typical examples of objects that cause suspicion among environmentalists are urban roads: highways and railway lines, without which it is impossible to imagine life of any large settlement. Transport infrastructure of the city was not originally focused on the preservation of the environment and therefore worsened its condition. This is indicated by numerous publications in specialized journals and media [1, 2]. However, it is necessary to say that the severity of the problem was the impetus for a series of environmental measures, which yielded the expected environmental effect [3].

Heavy metals entering into the air along with emissions of various industries are deposited on soil, plants, living organisms and may accumulate there approaching high life-threatening concentrations. As a result of soil-forming processes they are redistributed in the soil profile, bleached and transported by groundwater [4].

The main factors that control the behavior of heavy metals in nature are their chemical and physical properties, as well as environmental conditions, in particular, alkali-acid, redox conditions, sorption capacity of the soil, capacity of absorbing complex.

For example, soils and grounds in the areas adjacent to highways, are sustaining regular contamination with heavy metals, oil products, and polycyclic aromatic hydrocarbons (PAH), which are contained mainly in gas-dust emissions of vehicles. According to the observations out of total emissions of particulate matters, including heavy metals, approximately 25% remain on the roadway until they are washed off, and 75% are distributed on the surface of adjacent area, including road shoulders. Depending on the structural profile and the area of coverage from 25 to 50% of particulate matters get into sewage rainwater or wash water.

A similar situation is observed near railway tracks: the data [5–6] highlight this, the authors note that the concentration of heavy metals occurs mainly in the near-surface soil, and a maximum of pollution falls on territories adjacent to railway tracks within 15 m.

From this perspective, we can introduce our studies of soils adjacent to railway tracks at such distances from outer rail base, where zone of responsibility of urban services (50 m and more) begins.

Sample areas

Soil samples were collected in 2004–2008 along hauls of Riga direction of the railway in the Northern Administrative District of Moscow between the stations Krasniy Baltiets and Grazhdanskaya (length is 1,9 km), Pokrovskoe-Streshnevo and Leningradskaya (length is 1,36 km).

The first section of Krasniy Baltiets-Grazhdanskaya passes near Timiriazevsky parkland and buildings of railway use (the park is located northeast of the road). Near the station Krasniy Baltiets, on the south side there are locomotive and refrigerator depots In the zone along the northern right-of-way from the station to the park there are garages, and there is a residential sector adjacent to southern and northwestern sectors of the haul.

The second section Pokrovskoe-Streshnevo-Leningradskaya is located along the greenbelt and ponds, from the platform Pokrovskoe-Streshnevo it is limited by Volokolamsk highway, crossing railway over the bridge (the distance between it and the platform is 50 m). Prior to Leningradskaya platform (750 m of the starting point for which we take the beginning of the platform Pokrovskoe-Streshnevo) Riga direction intersects with Moscow circular railway, which runs above the roadbed at the height of the subgrade of 5–6 m. Besides garage complex, located near the intersection of railways, there are no other enterprises along the haul.

Each soil sampling was performed at five points with «envelope» (with sides of 1 m) method at sample areas 50×50 m along the station and the railway line towards Moscow circular railway from the soil horizon (0–20 cm) at different remoteness

Table 1

The values of C (mg / kg), Kc and ZC at different distances from the I-th track in two hauls of Riga direction of the railway

Hauls	Distance from the track, m	Indicator	The metal content in soil samples								Z_C
			Ni	Cu	Pb	Cr	Zn	Co	Mo	Sn	
Pokrovskoe-Streshnevo-Leningradskaya	50	K_C	1,3–2,7	0,4–2	0,75–3	0,8–1,6	1–3	1,3–2,5	1–3	1–4	5–13,7
		C	20–40	20–100	30–120	40–80	100–300	8–15	1–3	5–20	
	100	K_C	2–3	0,4–0,6	1–2	1–1,2	1–2	1,3–1,7	1,5–3	1,6–3	4,6–10,3
		C	30–45	20–30	40–80	50–60	100–200	8–10	1,5–3	8–15	
	150	K_C	2,0	0,6	0,75	1,2	1,0	1,0	2,0	3,0	8,6
		C	30	30	30	60	100	6,0	2,0	15,0	
Krasniy Baltiets-Grazhdanskaya	50	K_C	1,3–2	1–2	1–1,5	1,2–1,6	0,8–2	1	1,5–2	0,6–1,6	6–13
		C	20–30	50–100	40–60	60–80	80–200	6	1,5–2	3–8	
	100	K_C	1,3–2,7	1–3	0,8–2	1,2–1,6	0,6–1,5	1–1,3	1–2	0,4–1	6–13,6
		C	20–40	50–150	32–80	60–80	60–150	6–8	1–2	2–5	
	200	K_C	1,3–2,7	0,6–1	1,25–1,5	1,2–1,6	0,6–0,8	1–1,6	1,5–2	1–2	8–12
		C	20–40	30–50	50–60	60–80	60–80	6–9,5	1,5–2	5–10	

(50, 100 and 150 m) from the track from the side of the I-th track on the territory of the park complex «Pokrovskoe-Streshnevo». Since on the park territory there are three ponds, long perpendiculars of sampling deeper into the park have been attributed to the railway line marks 0, 100, 200, 300, 350, 450, 550, 650 and 700 m.

Between stations Krasniy Baltiets and Grazhdanskaya sample areas 100×50 m were used of soil horizon along the railway tracks (I track) at distances of 50, 100 and 200 m from the track on the territory of Timiryazevsky park. No sample selection was performed along the station Krasniy Baltiets due to asphalting of near-platform territory, garage site and motor roads, located there.

Soil texture of park areas is represented mainly by gray forest soils with a constant pH = 5,5–6,8.

The samples were dried at a temperature of about +40°C, crushed, and sieved through a sieve (0,5 mm fraction). After quartering soil lots of 50 ± 0,1g were crushed in steel ball mills to 44 microns (300 mesh). The samples were analyzed at an accredited analytical center IMGRE with atomic emission spectral method for the maintenance of a wide variety of metals. The obtained data were subjected to statistical analysis by standard techniques.

The intensity of the anthropogenic load of the soil was determined by the concentration factor K_C, which is the ratio of the element content in the studied object C (mg / kg) to its average background content. Background content refers to the presence of a chemical matter in soils of areas not suffering from anthropogenic load [7]. Samples for the background are not selected in the areas of roads, enterprises that are located along the railway tracks, i. e. they must be taken in the cleanest in terms of any contamination zones of the city. In the absence of anthropogenic load on the adjacent roadside territories determination of a background is valid at a distance of not less than 500 meters from the road [8].

Since technogenic anomalies typically contain multiple elements, total pollution indicators Z_C were calculated, characterizing the effect of impact of a group of elements [9]:

$$Z_c = \sum_{i=1}^{n} K_c - (n-1),$$

where n is a number of elements taken into account.

Assessment of hazard of soil pollution with a complex of elements in terms of Z_C is performed on a scale, gradations of which are based on the study of the health status of the population living in areas with different levels of soil contamination. According to [9] the first category of pollution comprises soils with $Z_C < 16$ («acceptable»), the second comprises soils with an average level of soil contamination Z_C=16–32 («moderately dangerous»). Serious soil contamination is with Z_C=32–128 («dangerous»), and the maximum level is Z_C over 128 («extremely dangerous»).

Total indicator of soil pollution Z_C was calculated with regard to nine man-made elements, concentration ratios of which are higher than background values.

The results of studies

1. Such toxic metals of the first hazard class as cadmium and mercuric were lacking in all samples.

2. The total soil contamination with heavy metals on two hauls with increasing distance from the railway uniformly decreased (Table 1), and soils were classified as having ecologically «acceptable» level. On the section Pokrovskoe-Streshnevo- Leningradskaya near Volokolamsk highway pollution degree also decreased in proportion to the increase in distance from the railway, but in the area of intersection with Moscow circular railway there were sampling points at a distance of 100 m from the tracks with the overall pollution Z_C=55. Such a high level (category «dangerous") can be explained by the presence of a garage complex and possible dusting [10] during carriage of goods by circular railway, and samples contain mostly zinc content K_{Zn} = 40, zirconium K_{Zr} = 8, lead K_{Pb} = 10 and silver K_{Ag} = 20. At the same section there was a steady decline in molybdenum, nickel, copper, manganese, chromium, cobalt and tin proportionnally to the distance from the road.

3. The highest content of zinc and copper at a distance of 50 meters from the railway was recorded on the perpendicular relating to marks 300 and 350 m of the starting point on the railway tracks (K_{Zn} = 20, K_{Cu} = 8). Here, the maximum pollution falls on a forest road between the first and second ponds, which go to the railway. This contamination is correlated with a strong pollution of soil in previously collected samples at a distance of 3 m from the railway track [11] at the same marks. Wherein the zinc concentration at 100 and 150 m remains insignificant.

Near Volokolamsk highway constancy in the content of chromium, cobalt and molybdenum is fixed *with increasing distance from the I-th path. With removing to 50 m there was an increase in lead concentration, because here goes a local unmade road. Then, at a distance of 100 and 150 m from the railway deep into the park concentration was reduced to background values.*

4. At the haul Krasniy Baltiets- Grazhdanskaya with increasing distance from the railway a sharp decline in pollution was not recorded, soil refers to the «acceptable» category. This occurs due to re-uniform contamination at seasonal fall of leaves from trees of Timiryazevsky park, on which heavy metals were adsorbed due to the transport of dust over the summer period. Thus, the content of nickel, lead, chromium, molybdenum and tin remained constant, and only the presence of zinc significantly reduced. Opposite the station Grazhdanskaya first reduction of pollution was observed, and then at a distance of 200 m the presence of heavy metals reached Z_C=20 because of domestic pollution in the park location (K_{Cu} = 6; K_{Pb} = 3,8; K_{Zr} = 5).

Data analysis on two railway sections at different distances from it (see also [11]) indicates a downward trend in the content of heavy metals in proportion to increase in distance from the roadbed in the absence of enterprises in the area.

Conclusions. *Generally, the results of the study prove: it is impossible to give an opinion about the negative impact of the railway on the quality of the soil in the area of urban development adjacent to right-of-way. This finding is consistent with the view expressed in a recent paper [12]. At the same time, it is known that the level of soil contamination may depend on many factors such as type of precipitation, dynamics of soils filtration at various slopes of relief, erosion under wind load, on dusting, scattering and pouring of transported goods, and so on.*

To verify the data, to repeat or to refute these conclusions, to correlate the results of measurements with braking events or dusting of goods [10] it is necessary to select hauls with a greater length, in the areas where there are no any enterprises and forest-park plantations, with smooth surface and approximately the same slopes, and the very control area should be significantly expanded.

It is clear that such activity is costly, which, however, can be significantly reduced, for example, if graduate students – future environmentalists are involved in the professors activity. Working under the guidance of their professors (and with the participation of representatives of the environmental management units of JSC «Russian Railways»), they could not only gain professional experience, collect relevant and valuable material for their future graduation and scientific papers, but also make a real contribution to environmental protection.

Keywords: *ecology, pollution with heavy metals, railway, right- of- way, possibilities of monitoring, sample areas.*

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Координаты авторов (contact information): Журавлева М. А. (Zhuravleva, M.A.) – crane_64@mail.ru, Зубрев Н. И. (Zubrev, N.I.) – nZubrev@mail.ru, Кокин С. М. (Kokin, S.M.) – kokin2@mail.ru.

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