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Using of the geoinformation technologies for estimation of heavy metals distribution in the soils of urban ecosystems (on example of the city of Kaliningrad, Russia)

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Urbanization can be described as a global socio-economic process, accompanied by a profound change of the anthropogenic environment and as a replacement of the natural ecosystems by the urban ones. Heavy metals occupy an important place among the different types of urban environmental pollutants. Since they do not undergo physico-chemical and biological degradation, they can accumulate in the surface soil layer for a long time, being available for the roots of plants and actively involved in the migration processes via trophic pathways. Study of accumulation of heavy metals in the most important component of urban ecosystems, which is soils, allows us to get a reliable estimate of the intensity of technogenic processes and to trace the major migration flows of these toxicants in the urbanized area.

The geographic information systems (GIS) are a useful tool for collection, analysis, processing, synthesis and management of the spatially-distributed and other types of data. They provide the two-way communication between cartographic objects and databases. The aim of this study was to investigate the possibility of using of GIS technologies for estimating of distribution of heavy metals in the soil of the city of Kaliningrad.

A Kaliningrad land region of 18.4 sq.km was investigated. Locations for the collection of samples were determined based on the analysis of anthropogenic loading of the streets of Kaliningrad. The total number of the locations was 57. The selected locations were marked with squares of 1.5 km per 1.5 km. Within each square 7-9 soil samples were collected using the "envelope" method, each sample was collected three times.

The abundances of heavy metals (strontium, lead, zinc, copper, nickel, chromium, arsenic) in the soil was determined using the X-ray fluorescence method (Spectroscan Max, NPO Spektron, Saint-Petersburg, Russia). Each sample was purified, in order to remove roots, large rocks, glass, etc., before placing to the cell of the spectrometer. Purified samples of 10-50 g were dried to constant mass at a specified temperature (105 $\pm$ 2) $^\circ$ C and then were grounded using an agate mortar to reduce the particle size to $\leq$71 microns. The analysis was simultaneously performed for two parts of each sample.

For calculation of the surface distribution of the heavy metals we used the geographic GIS package QuantumGIS 2.8. The coordinates of the sampling points were first marked at the raster substrate and then were exported to a vector layer in the Shapefile format.
To calculate the surface distribution in the raster format we used the topotorastr module, which includes different interpolation methods. For the visualization of this study we used two methods: inverse-weighted state (IDW) and natural neighborhood methods). The results obtained with the IDW method appeared to be not representative and we further used only the method of natural neighborhood.

Using the built-in tools of the QuantumGIS the heavy metal abundances were divided into 9 classes and the raster surfaces were obtained. We then built contour plots of the distribution of the studied heavy metals. The described approach revealed two areas in which the lead abundance 4,5-5,4 times exceeded the maximum permitted norms, arsenic 9.5 - 11 times, zinc 7.2 – 9.6 times and nickel 5.2 – 6.75 times.