Geodesy and Cartography
ISSN 2029-6991 / eISSN 2029-7009
2021 Volume 47 Issue 4: 181–185
https://doi.org/10.3846/gac.2021.12922

UDC 528.481

ASSESSMENT AND MAPPING OF LANDFILLS ON SOILS IN THE SERPUKHOV DISTRICT (MOSCOW REGION)

Azamat SULEYMANOV[1,2*], Evgeny ABAKUMOV[1], Igor ZAKHARENKO[3], Ruslan SULEYMANOV[4]

[1]*Department of Applied Ecology, Saint Petersburg State University, Saint Petersburg, Russia*
[2]*Department of Environmental Protection and Prudent Exploitation of Natural Resources, Ufa State Petroleum Technological University, Ufa, Russia*
[3]*Belarusian State University, Minsk, Belarus*
[4]*Department of Geodesy, Cartography and Geographic Information Systems, Bashkir State University, Ufa, Russia*

Received 11 June 2020; accepted 29 October 2021

Abstract. Cartographic materials are an important tool for different purposes. Environmental maps are essential for various activities aimed at protecting the environment. The work presents the experience of creating a map called "*Landfills in the Serpukhov district*" using GIS and remote sensing data. Garbage wastes polygons sites are divided into three types: municipal solid waste, illegal landfills and biological waste. The soil cover of the region is mainly represented by Retisols and Luvic Retic Phaeozem soils. The map allowed us to evaluate the current situation and the spatial location of landfills on different soil types (including the variation of soil texture).

Keywords: environmental cartography, ecology, soils, urban ecology, landfills, GIS.

Introduction

The transition of society into an industrial stage of development has led to an increase in the anthropogenic load and transformation of the natural environment. Urbanized soils are under constant anthropogenic influence. This leads to their destruction, contamination, disturbance of hydrological, temperature, microbiological and biochemical regimes (Beyer et al., 2001; Gerasimova et al., 2003; Suleymanov et al., 2020; Polyakov et al., 2021). Nowadays, waste management is one of the keynote problems in large urbanized territories (Aparin & Sukhacheva, 2014). Different types of rubbish polygons: municipal solid waste (MSW), illegal landfills, biological waste, impacting negative impact on land cover, water and air quality. These environmental components have a direct impact on human health. The main harmful elements from landfills and dumps are leachate and landfill gases that can persist in the soil for decades. Leachates seep through the waste thicknesses, accumulate various poisonous substances that are part of the waste or are products of its decomposition. The leachates then flow freely over the relief and enter the soil, surface and groundwater, which leads to dangerous pollution of the environment not only harmful compounds but also pathogens.

Cartographic materials are a useful research tool for scientists in many fields of science and industry. Environmental maps are an important tool for analyzing and monitoring environmental conditions. The ecological map shows the territorial distribution of environmental factors and the degree of anthropogenic impact on them. Soil-ecological mapping refers to the topic of thematic mapping (Leontief, 1981; Salishchev, 1991; Sturman, 2003). Such data is widely used for land, forest and water management. A comprehensive assessment of the environmental situation requires relevant and reliable data obtained and interpreted using modern methods, such as geographic information systems (GIS) and remote sensing (RS) (Suleymanov et al., 2018). Moreover, nowadays cartographic information and spatial data are rapidly becoming outdated and need to be updated both at regional and local levels.

In an intensively urbanized region such as the Moscow Region (MR), the environmental situation is one of the pressing socio-economic problems. The localization of landfills makes it possible to identify areas of anthropogenic impact on a particular soil type or subtype and assess their scale. The availability of soil texture data

*Corresponding author. E-mail: *filpip@yandex.ru*

provides information on potentially hazardous areas of disposal, as mechanical composition affects seepage of leachate deep into the soil.

The work aims to create a map of the distribution of landfills on different soil cover types and subtypes of the Serpukhov district (MR). For this purpose, we detect landfills using descriptive sources, online map services, and remote sensing data. The projected map refers to the direction of thematic cartography. According to the grouping of ecological maps (Kasimov, 1997), the map most refers to the groups "Anthropogenic impact on the natural environment and their consequences" and "Ecological risk".

1. Materials and methods

The Serpukhov district with an area of 1080 km^2 is situated in the south of the MR (Figure 1). The area is located in the southern part of the Oka-Moscow Plain, nearby the Nara River, near its confluence with the Oka. The length of the district from west to east is 39 km, from north to south – 48 km.

Soil cover is mainly represented by Retisols and Luvic Retic Phaeozem soils, according to classification WRB 2015 (IUSS Working Group WRB, 2015). The climate is temperate-continental. The average temperature in January is −10 °C, the average temperature in July is +18 °C. The average annual air temperature is +3.1 °C. Precipitation is about 600 mm per year, two-thirds of which is rain and one-third snow. The maximum precipitation is in July, while the minimum precipitation is in February.

The main cartographic material for the projected map is a soil map of the MR (Soil map of Moscow Region, 1985) at scale 1: 300 000 (Figure 2), published in 1985. The map allowed us to determine the distribution of types and subtypes of soil cover and define their characteristics: soil texture, areas, etc. The first stage was the preparation of a soil map for working in GIS. The map was preliminary geo-referenced and further digitized in the QGIS 3.6.0 geographic information system.

The main content of the maps, besides soils, is the location of municipal solid waste, illegal landfills, and biological waste. On the projected map MSW was classified into active and inactive. Descriptive and cartographic

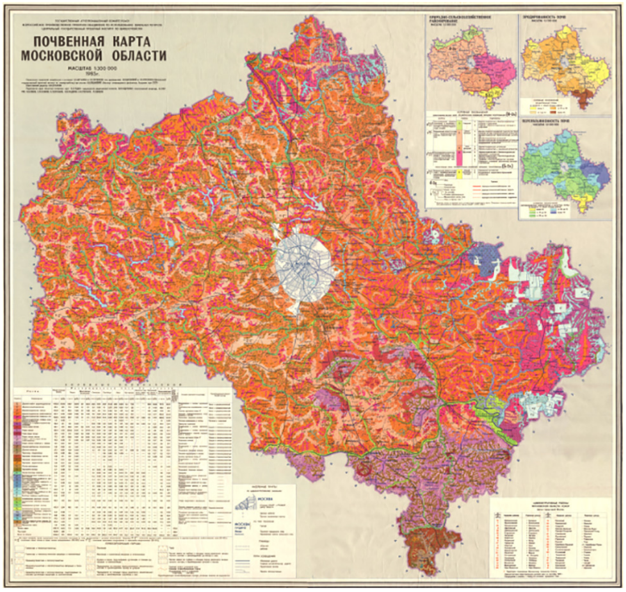

Figure 2. The soil map of the MR, 1:300 000, 1985

sources were used to search for spatial location and identification of polygons. Online mapping services were used to determine the current state of rubbish polygons and to establish coordinates: *Plandex.ru* – to find and establish the status of MSW; *Wikimapia.org,* and *Google Earth* – to identify MSW, illegal landfills and biological waste using space images.

Thematic GIS projects allow us to collect attributive data and various cartographic materials on one spatial-temporal area. Based on the collected data, relevant cartographic works are designed. All spatial data (soil cover, anthropogenic objects, and geographic content) were imported into the GIS. Thus, a digital soil map and identified anthropogenic impact objects are the main content of the projected map. The final cartographic work was designed and finalized in vector graphics software Adobe Illustrator.

2. Results and discussion

Mathematical projection

We used Gauss Krueger's projection – transverse cylindrical equilateral map projection. This projection is

Figure 1. Location of the study area

also known as the Transverse Mercator projection which is similar to the Mercator projection. However, in this case, the cylinder is not turned around the equator, it is turned around one of the meridians. Applying this projection makes it possible to image rather large areas of the Earth's surface with almost no significant distortion. The landscape orientation has been chosen to display the map.

The scale of thematic maps is determined considering the size of the territory and inner frame of the map. Since the first stage of creating maps was performed using GIS, the scale of each map was determined automatically. A linear scale was selected for display on the map. For the map grid, we selected the step of 15 minutes.

Soils

A qualitative method was used to display the soil cover. According to the topography of the territory, our map shows the soils of only flat territories. The colors of soil types and subtypes were shown by accepted standards used to display soil cover.

The following types of soil cover were displayed on the projected map: Retisols, Retisols truncated, Retisols slightly Gleyic, Retisols Gleyic, Luvic Retic Phaeozem, Luvic Retic Phaeozem truncated, Histic Gleysols Humic, Fluvisols and Truncated soil of gullies, beams, small river floodplain and slopes.

Soil texture of soil-forming rocks

The soil texture of soil-forming rocks was divided into 4 types: clayey and heavy loamy, medium and light loamy, sandy loam and sand, frequent change in depth and area of rocks of various the soil texture with a predominance of loam and clay. The dotted line shows the zone boundaries of soil texture. This phenomenon was shown by the area method and was displayed according to the basic cartographic material. Each type has its own, clearly distinguishable, and readable filling-in sign.

Municipal solid waste (MSW), illegal landfills, biological waste

Elements of municipal solid waste, illegal landfills, biological waste were shown with symbolic icons causing association with the phenomenon being mapped. We used two colors to show the status of the MSW – active (red) and inactive (black). The symbol of the illegal landfills was shown as a black garbage bag. A yellow triangle with a pattern inserted in it was chosen to symbolize the biological waste, since that icon is actively used to signify a biological hazard.

Settlements

Settlements with more than 1000 people were shown in circles. The circles have different sizes depending on the population, and different fonts depending on the type of settlement.

Hydrography

Hydrography was represented by rivers, canals, lakes and reservoirs. Rivers less than 15 mm long at the map scale were not displayed. For better presentation, rivers with a large number of meanders were generalized. Signatures were given for the main rivers in the district. The following rivers were signed: Nara, Oka and Loposnya. Among the objects of the hydrography area, the signatures are the Lake Pavlenskoye and the Drakinsky quarry.

Borders

The border of the region was given by a standard symbol – a dash-dotted line in black with fringing of purple. The boundaries of city districts (Protvino, Serpukhov, Pushchino) are a dash-dotted black line.

Labels

The signatures were used for settlements and hydrography. Black fonts, which differ in size and stroke style, were selected for settlements. Rivers, lakes, and quarries were signed in blue.

Map legend

The legend of the projected map consists of conditional signs with explanations in the textual form and was located to the left and bottom of the map. The legend includes the following sections: MSW, illegal landfills, biological waste, soil types and soil texture of parent rocks. The MSW was divided into two types: active (red) and inactive (black), according to their visualization on the map. Biological waste and illegal landfills were presented as separate phenomena with no classification.

We identified 4 illegal landfills and 3 biological wastes on the study territory. There are 5 MSWs on the territory, 4 of which are inactive. Active MSW – the "Lesnaya" (0.43 km^2) was opened in Soviet times and is located 2 km west of Serpukhov city. In 2001, due to numerous appeals from citizens, an environmental impact assessment was conducted at the site. It turned out that the filtrate had already entered groundwater, causing a hepatitis outbreak, poisoning the water well (New Izvestiya, 2013). Landfills are located on almost all soil types, as well as near fluvisols. The location of landfills near rivers creates an additional danger.

As a result of the work, a map called "*Landfills in the Serpukhov district*" was developed (Figure 3). According to modern data, the illegal landfills, biological waste, and MSW, which were divided by status, were shown. Also, the soil cover of territories was shown in detail, with the soil texture. The map is based on various relevant materials and data collected in recent years, using GIS and RS. Since various objects were displayed on the map, special attention is given to linking all elements of the map contents for they are better readable.

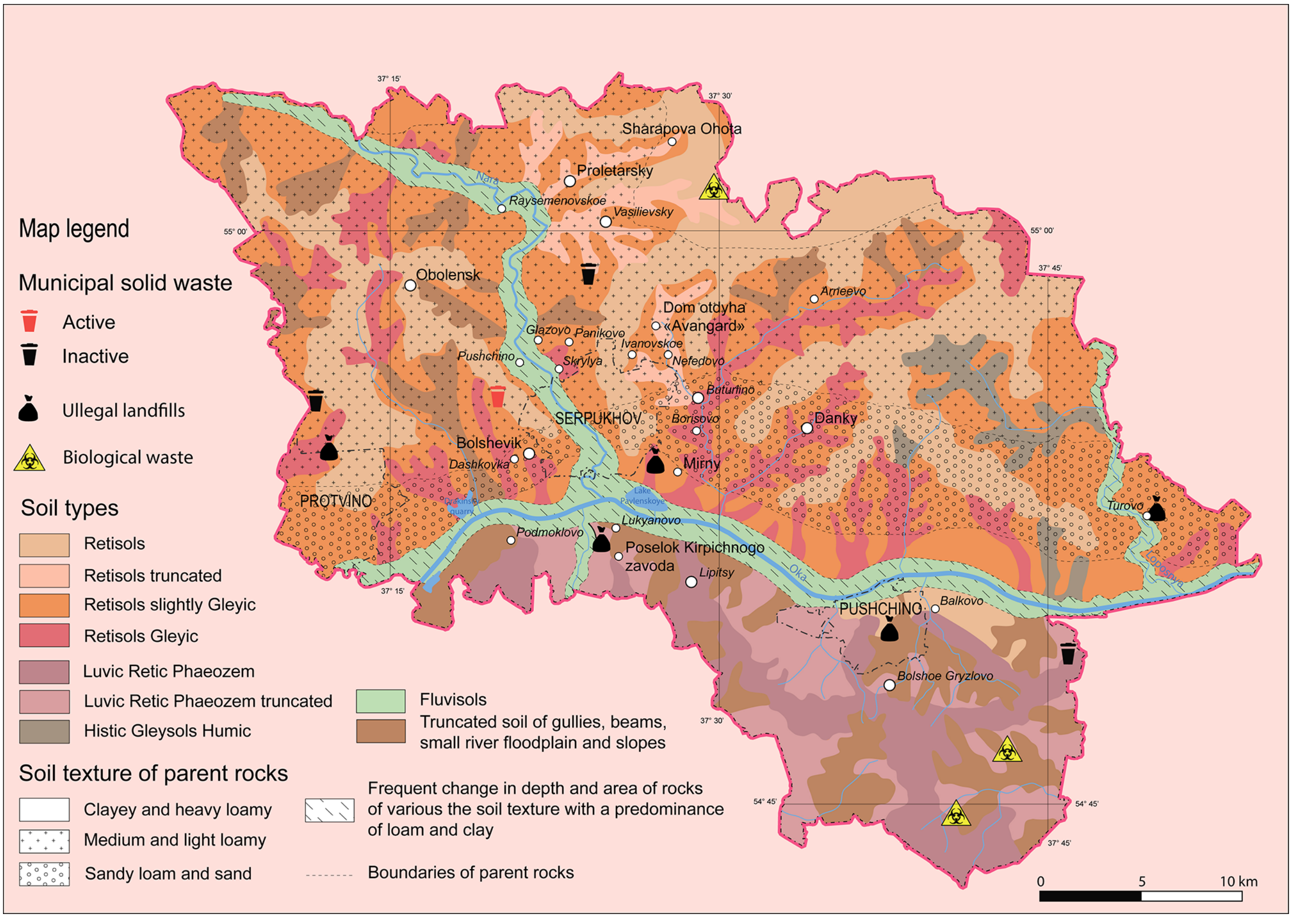

Figure 3. The map "Landfills in the Serpukhov district"

Conclusions

The problem of waste storage and recycling is one of the most pressing issues worldwide. Under conditions of constant anthropogenic impact on the environment, especially in urbanized areas, ecological cartographic materials need to be updated. Remote sensing data is an important source for ecosystem monitoring. In our study, such data made it possible to identify the spatial location of landfills and create up-to-date cartographic materials. Although modern mapping is universally implemented with GIS systems, the requirements for accuracy and design of maps have not changed. When designing the map, we paid a lot of attention to the accuracy of the main mapping elements and their good visualization in terms of readability.

The created map "Landfills in the Serpukhov district" can be used for effective management and conservation of biological resources. Also, such cartographic materials can be applied to the planning and implementation of activities aimed at environmental improvement, in particular – to protect against nature degradation and anthropogenic impact.

Acknowledgements

We thank the anonymous reviewers for their careful reading of our manuscript and their many insightful comments and suggestions, also for their English editing.

Author contributions

AS – data collection, analysis using remote sensing data and web services, create and design final map; EA – literature analysis, correct the final article; IZ – generalization of results, wrote the article; RS – data collection and analysis using remote sensing data, correct the final map.

Disclosure statement

The authors declare that they have no conflict of interest.

References

Aparin, B. F., & Sukhacheva, E. Yu. (2014). Principles of soil mapping of a megalopolis with St. Petersburg as an example. *Eurasian Soil Science*, *47*, 650–661. https://doi.org/10.1134/S1064229314070035

Beyer, L., Kahle, P., Kretschmer, H., & Wu, Q. (2001). Soil organic matter composition of manimpacted urban sites in North Germany. *Journal of Plant Nutrition and Soil Science*, *164*, 359–364. https://doi.org/10.1002/1522-2624(200108)164:4<359::AID-JPLN359>3.0.CO;2-M

Gerasimova, M. I., Stroganova, M. N., Mozharova, N. V., & Prokof'eva, T. V. (2003). *Anthropogenic soils: Genesis, geography, reclamation*. Oikumena, Smolensk (in Russian).

IUSS Working Group WRB. (2015). *World reference base for soil resources 2014, update 2015. International soil classification system for naming soils and creating legends for soil maps* (World soil resources reports No. 106). FAO, Rome.

Kasimov, N. S. (Ed.). (1997). *Integrated environmental mapping.* Moscow State University, Moscow (in Russian).

Leontief, N. F. (1981). *Thematic cartography*. Nauka. (in Russian).

New Izvestiya. (2013). *Serpukhov residents will decide the issue of the "Lesnaya" landfill at the election* (in Russian). https://newizv.ru/news/society/07-08-2013/186874-zhiteli-serpuhova-namereny-na-vyborah-reshit-vopros-poligona-tbo-lesnaja.html?format=html&slug_for_redirect=lenta%2F2013-08-07%2F186874-zhiteli-serpuhova-namereny-na-vyborah-reshit-vopros-poligona-tbo-lesnaja

Polyakov, V., Kozlov, A., Suleymanov, A., & Abakumov, E. (2021). Soil pollution status of urban soils in St. Petersburg city, North-west of Russia. *Soil and Water Research*, *16*, 164–173. https://doi.org/10.17221/95/2020-SWR

Salishchev, K. A. (1991). *Cartography*. Moscow State University, Moscow (in Russian).

Soil map of Moscow Region. (1985). Scale 1:300 000. Federal Agency of Geodesy and Cartography.

Sturman, V. I. (2003). *Ecological mapping: a training manual*. Aspect Press, Moscow (in Russian).

Suleymanov, A. R., Suleymanov, R. R., Abakumov, E. V., Nigmatullin, A. F., & Khamidullin, R. A. (2020). Soil-ecological assessment of the M. I. Kalinin Park Ufa City, Russia. In V. Vasenev, E. Dovletyarova, Z. Cheng, R. Valentini, & C. Calfapietra (Eds.), *Green Technologies and Infrastructure to Enhance Urban Ecosystem Services* (pp. 18–28). Springer, Cham. https://doi.org/10.1007/978-3-030-16091-3_4

Suleymanov, R., Urazgildin, R., Amineva, K., Suleymanov, A., & Abakumov, E. (2018). Ecogeochemical assessment of soil cover of the Ufa City, Bashkortostan. In V. Vasenev, E. Dovletyarova, Z. Chen, R. Valentini (Eds.), *Megacities 2050: Environmental Consequences of Urbanization* (pp. 57–61). Springer, Cham. https://doi.org/10.1007/978-3-319-70557-6_8