Emissions from stationary pollution sources in the Republic of Crimea in 2013-2018

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Abstract. This article is concerned with the visualization of the monitoring data of the emissions into the atmosphere from stationary pollution sources on the territory of the Republic of Crimea in 2013-2018 with the help of geographic information systems. A brief overview of the use of geographical information systems for various types of environmental monitoring is provided. The structure of geographical information systems is analyzed in detail. In the paper, map building is performed by means of the ArcGIS software package. In the period from 2013 to 2018, the emission volume from stationary sources within the Republic of Crimea changes every year. The largest contribution to atmospheric emissions from stationary sources is made by industrial enterprises in the cities of Krasnoperekopsk and Armyansk.

1. Introduction

In connection with the constantly growing pace of the human activity impact, it is necessary to provide constant operational monitoring of the environment and if it is needed to take administrative decisions for the development of a particular territory [1, 2, 3, 4, 5]. According to [6], “Monitoring is a system of regular and long-term observations in space and time, providing information on the state of the environment in order to assess the past, the present and to forecast changes of the environmental parameters important for humans in the future”.

In Russia, environmental monitoring is entrenched by the federal law dated January 10, 2002 No. 7 “On Environmental Protection” and resolutions of the Government of the Russian Federation dated June 06, 2013 No. 477 “On the implementation of the governmental monitoring of the state and pollution of the environment” and August 9, 2013 No. 681 “Regulation on state ecological monitoring (state environmental monitoring) and the state fund of the state environmental monitoring data (state environmental monitoring)” [7].

Environmental monitoring of the Republic of Crimea is the part of the all-Russian system of environmental monitoring. According to [7], environmental monitoring of the Republic of Crimea is “a system of collecting, processing, transmitting, storing and analyzing environmental information in
the region, providing an assessment and forecast of its environmental status, development of scientifically sound recommendations for making decisions on preventing negative changes in the state environment and environmental safety requirements”. Geographic information systems (GIS) are best suited for organization, realization and evaluation of the results of environmental monitoring.

2. Materials and methods
At the present stage of the development of science and society, digital technologies are increasingly penetrating into all spheres of activity. A new direction of science called geoinformatics is developing with the integration of geography and computer science. Software systems (a geographic information system (GIS)) are the basis for the development of geoinformatics. Geographic information systems (GIS) provide the collection, storage, processing, analysis, visualization and escalation of spatial (geographical) data. Accordingly, geographic information systems (GIS) are an effective basis for practical application in various fields of activity related to spatial information and they integrate archival and modern cartographic information, data from remote sensing of the earth, statistics, hydrometeorological observations, environmental monitoring, etc. [8, 9, 10].

In recent years, geographic information systems (GIS) have been actively used in environmental monitoring in various countries: Neofitou and co-authors [11] used GIS to study the spatial and temporal effects of fish farming on the water column of the Pagasetic Gulf; Righini and co-authors [12] took a GIS assessment of the spatial representativeness of air quality monitoring stations using pollutant emissions data on the territory of Italy; Shalaby and Tateishi [13] used GIS for mapping and monitoring land cover and land-use changes in Egypt; Al Sahli and Al-Harbi [14] identified the optimal districts for air quality monitoring stations with the help of GIS; Dewan and Yamaguchi [15] used GIS to monitor changes in land use in Bangladesh in 1960–2005; Rawat and Kumar [16] used remote sensing data and geographic information systems (GIS) for monitoring land use in India; Banzhaf and co-authors [17] used GIS to monitor urban development in Germany, etc.

The structure of geographical information systems (GIS) consists of four subsystems [8]:

- Subsystem of the input and processing of spatial data (geodata) obtained during field research, aerial photography, remote sensing of the earth, as well as from maps, statistics and literature data, etc.
- Subsystem of the creating and saving databases, that organizes spatial data with the goal of their prompt receipt, updating and editing
- Subsystem of processing and analysis responsible for performing various tasks based on spatial data, grouping them, and implementing a modelling function;
- Subsystem of data output (output) that visualizes the entire database or its part in a different form (maps, tables, images, block diagrams, graphs, digital terrain models etc.).

Geographic information systems (GIS) support spatial queries (including SQL-queries), allowing you to compile lists and selections of indicators and characteristics of interest. During interactive work with maps on a computer, geographic information systems (GIS) can create new information that was not explicitly entered. Thus, the use of geographical information systems (GIS) is a new way of analyzing, processing and visualizing large amounts of data, and also allows you to receive and process incoming information in real time and make management decisions when changing observed indicators.

3. Results and discussion
The pollution of the planet’s aerosphere and especially its floor altitude with various impurities and agents relates to the basic environmental problems in the atmosphere. According to [7], such impurities include smog, exhaust gases, aerosols and other substances. The main sources of air pollution data in the Republic of Crimea are data from the Federal State Statistics Service in the Republic of Crimea and the city of Sevastopol (https://crimea.gks.ru/) and the Ministry of Ecology and
Natural Resources of the Republic of Crimea (https://meco.rk.gov.ru/ru/index). The Ministry of Ecology and Natural Resources of the Republic of Crimea annually publishes a report on the state and protection of the environment in the territory of the Republic of Crimea. However, the data is presented in tabular form and is poorly visualized spatially. Emission dynamics for 2013-2018 years is considered further.

As the spatial data visualization done using the ArcGIS software package shows, in the territory of the Republic of Crimea the distribution of atmospheric emissions is geographically distributed unevenly (see figure 1-6).

In the period from 2013 to 2018, the emission volume from stationary sources within the Republic of Crimea changes every year. The largest contribution to atmospheric emissions from stationary sources is made by industrial enterprises in the cities of Krasnoperekopsk and Armyansk. There is an increase in atmospheric emissions by more than 500 tons per year in the city of Krasnoperekopsk for the period from 2013 to 2018, in the city of Armyansk there is a decrease of more than 1000 tons per year. However, these two settlements are the largest air pollutants in the Republic of Crimea. The volume of emissions from stationary sources of pollution in Armyansk in 2018 is approximately 4,500 tons per year, and in Krasnoperekopsk it is 6,400 tons per year. The city of Simferopol with an indicator of air emissions of more than 2500 tons per year takes the third place in terms of air emissions in the Republic of Crimea.

In the Republic of Crimea, the enterprises of the Krasnoperekopsk industrial hub – LLC Titanium Investments and PSC Soda Crimea Plant are the leaders in pollutants emissions into the atmosphere. Various pollutants are emitted into the atmospheric air from production activities, the main of which are nitrogen dioxide, sulfur dioxide, carbon monoxide and suspended solids. However, it is worth noting (see figure 1-6) that from 2000 to 2018, there is a decrease in production at the above mentioned enterprises, which leads to a decrease in atmospheric emissions.

As it is shown in [7], within the cities of Krasnoperekopsk, Armyansk, and Kerch, in 2018 excess of the maximum permissible concentration (MPC) was observed in about two percent of all air samples taken. MPC excesses are periodically observed in these cities in the general series of the dynamics under consideration. For example, in 2018, there occurred a chemical spill in Armyansk as a result of which many plants and animals died in the city and a threat to people's lives was created, because the part of the harmful substances lodged on metal products. An emergency was declared by the authorities and the children were evacuated at the time of the elimination of the consequences.
4. Conclusion

The environmental monitoring system is an effective tool for assessing the human impact on the environment. However, statistics don’t often contain any geographic information at local, regional, and federal terms, thus in most cases it is necessary to take into account the location and position of natural and economic objects. Geographic information systems (GIS) are effectively suited for these purposes, allowing you to get a reliable spatial drawing of various characteristics that are studied during environmental monitoring.

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