Anthropogenic impact of industrial production on the environment (on the example of the Siberian region)

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Abstract. The anthropogenic impact of industry on the environment depends on the nature of its territorial localization, extraction volumes and raw material and energy consumption, on recycling and the extent of production cycles. As a result of environmental and geographical studies, we identified industry sectors, as well as industrial facilities, that have the most negative impact on the environment and the livelihoods of the population. As a rule, industrial facilities are located extremely unevenly in the territory of the region, they are concentrated in cities and large settlements, and have a significant negative impact not only on the environment, but also create an uncomfortable living environment for the population. Areas of technogenic pollution with an extremely tense environmental situation, which enhances the natural discomfort of the living environment and worsens the quality of life of the population, have been identified. Special attention is paid to industrial facilities that have ceased their production activities, but continue to have a strong anthropogenic impact on the environment, because the disposal of industrial waste creates a tense ecological situation and poses a threat to the environment and the population.

1. Introduction

Human being and his economic activities have a huge impact on the environment. The most powerful source of pollution is industry. It has a leading role among the sectors of the national economy, it determines the profile of the regions and their place in the territorial and sectoral division of labor. Industry remains the basic sector of the economy of many regions and cities, which can be interpreted as an element of sustainability, setting the vector for further development [1]. The industrial function is subsequently supplemented by service, managerial and scientific-educational specializations.

The higher is the concentration of various industrial facilities, the wider and more intense is the transformation zone of the natural environment. It is quite difficult to establish the exact boundaries of the impact on the natural environment; therefore, the boundaries of the ranges of anthropogenic impact are arbitrary. The environmental impact of industry is an integral indicator, since all natural spheres are interconnected. By their nature, depth and area of distribution, duration of action and nature of application, anthropogenic impacts can be different.

The impact of industry (both functioning and ceased operating) on the environment is considered on the example of the Irkutsk oblast, which is a large industrial region of Siberia, with a developed industry that has not only a diverse industrial composition, but different natural conditions for its location and functioning.
2. Objects, data and methods

The research is based on theoretical and methodological approaches of socio-economic geography, scientific ideas about the territorial features of the industrial facilities location system and their functioning, taking into account the environment. The method of ecological-geographical mapping stands out in particular, and can systematically consider the anthropogenic factors in the formation of the ecological situation in the territory.

Not only ecologists, but also economic geographers [1, 2] assessed the anthropogenic impact on the environment at different periods of time, and laid the basis for ecological and economic regionalization of environmental factors [3].

The study of heterogeneous environmental information and the implementation of integrated ecological and geographical assessments of the study area are not possible without mapping support, as it furnishes insights into the nature of the territorial aspects of environmental quality problems. A map acts as a visual and accessible result of ongoing territorial studies. The basis of this study is methods developed by I. Savelieva and tested in mapping the atlas [4]. This methodology was taken as a basis and, with certain changes, was used in generating the maps “Industry and its Impact on the Environment” for the “Ecological Atlas of the Baikal Basin” [5] and its electronic version [6]. The environmental impact of industrial production is shown from two sides. The main industrial centers were mapped according to the total demographic load (population density, people/km²) and the impact on its individual components - atmosphere, hydrosphere, lithosphere and biosphere - were highlighted, besides industries that have a decisive effect on the disturbance of the natural environment were noted. Areas of focal impact as a result of the mining industry are separately identified. The investigation using the cartographic method identified areas of concentration of environmentally hazardous industrial facilities in the Irkutsk oblast.

3. Results and discussion

The largest enterprises of heat power engineering, oil refining, non-ferrous metallurgy, chemical and petrochemical, forestry, woodworking and pulp and paper, light and food industries located in the Irkutsk oblast, determine the quantitative and qualitative composition of pollutants emitted into the environment. Areas of high impact are Irkutsk – Cheremkhovo, Sayansk-Zima, Bratsk and Ust’-Ilimsk. In addition to existing industrial facilities, a significant contribution to environmental pollution is made by industrial facilities that ceased their operating, but their industrial waste has not been disposed, and industrial sites have not aligned with environmental standards.

Special areas with high and very high impacts on the lithosphere and hydrosphere were also formed as a result of the mining industry in the Bodaibo, Cheremkhovo, Tulun and Nizhneilimsk districts. In the Bodaibo district, this is the exploitation of bulk gold deposits (drainage method) during more than 150 years. In Tulun and Cheremkhovo districts the open-pit mining of coal is carried out, and in Nizhneilimsk - iron ore, in Slyudyanka - marble mining.

Big contribution in atmospheric pollution is mad by a large number of thermal power plants and small boiler houses, a residential sector with furnace heating, vehicles, and forest and peat fires.

In the cities of Bratsk, Angarsk, Shelekhov and Irkutsk, the air is oversaturated with the harmful substances as benzapyrene, nitrogen dioxide, formaldehyde, hydrogen fluoride, carbon disulfide, suspended solids, carbon monoxide and sulfur dioxide [7]. In eight industrial cities of the region, the level of atmospheric air pollution is estimated to be high and very high: Bratsk, Zima, Irkutsk, Svirsk, Usof’e-Sibirske, Cheremkhovo and Shelekhov have a very high level and Angarsk has a high level of atmospheric pollution (table 1).

On the territory of Irkutsk there are about 250 enterprises with more than 3 thousand stationary anthropogenic sources of emission, which supply 113 substances to the atmosphere and create high levels of pollution. Irkutsk is included in the list of cities with the highest level of air pollution.

Baikalsk and Slyudyanka are the industrial centers that produce the most dangerous ecological situation at water bodies as well as a number of industrial centers located in the central regions of the region where large water bodies are absent; therefore the problem of dilution and self-purification of
wastewater is extremely acute. The vast majority of the region’s polluted wastewater is in the Angara river basin and most of which are released directly into the river and its reservoirs. The Angara is particularly heavily loaded on the river section below Irkutsk and in the upper part of the Bratsk reservoir (about 50%) and in the upper part of the Ust’-Ilimsk reservoir. The maximum negative impact on the hydrosphere is exerted in the Ust’-Ilimsk reservoir (anthropogenic impact of the Vikhorevka river, where wastewater from the Ilim Group and household wastewater from the city of Bratsk are discharged, as well as discharges from the Korshunovskii MPP (the Korshunikha river), Rudnogorskii MPP (the Gandyukha river)) [8]. The main contribution to water pollution is made by the main industrial centers - Irkutsk, Angarsk, Usol’e-Sibirskoe, Bratsk and Ust’-Ilimsk. A special place is occupied by the enterprises of industrial centers engaged in the extraction of gold by dragee and hydraulic methods, located in the Bodaibo district (Artyomovskii, Balakhninskii, Kropotkin, Marakan, and Perevoz settlements).

Table 1. Emissions in the cities of the Irkutsk oblast (for 2017, according to stationary sources).

| Cities                  | Thou t | % of the total emissions |
|------------------------|--------|--------------------------|
| Irkutsk oblast         | 2980.011 | 100                       |
| Angarsk                | 879.883  | 29.5                      |
| Bratsk                 | 299.880  | 7.7                       |
| Sayansk                | 663.229  | 22.3                      |
| Irkutsk                | 403.368  | 13.5                      |
| Ust’-Ilimsk            | 182.100  | 6.1                       |
| Shelekhov              | 149.511  | 5.01                      |
| Usol’e-Sibirskoe       | 128.642  | 4.3                       |
| Cheremkhovo            | 29.109   | 1                         |
| Other settlements       | 244.289  | 10.59                     |

The mining industry, with the enterprises mining minerals (coal, gold, iron ores, rare metals, and non-metallic minerals such as gypsum, talc, marble, etc.), has the strongest negative impact on the lithosphere.

The most powerful environmental impact is exerted by enterprises that have long ceased their activities. Owing to the closure they ceased their nature preservation activities, but environmental problems associated with the disposal of the remaining industrial waste, most often very toxic, and decontamination of the industrial site, are very acute.

In the Irkutsk oblast, such industrial facilities are the Baikal Pulp and Paper Mill (BPPM), closed in 2013 (Baikalsk) and Usol’eKhimProm (Usol’e-Sibirskoe). Until 2011, the Angarsk Metallurgical Plant, located in Svirsk, posed a huge danger to the natural environment and the livelihoods of the population. During 1934-1949 the plant produced refined arsenic trioxide for chemical plants for the production of chemical warfare agents. After the plant stopped, property, plant and equipment were left without dismantling and stripping equipment. The remaining dilapidated buildings and production waste represented a great danger to the population as a source of arsenic, which subsequently enters the soil and water bodies. Only in 2011, all building structures of the plant, cinders (waste from arsenic production) were disposed of, however the arsenic content in the soil was 2 times higher than the MPC, and the territory continued to be dangerous for the life of the population.

Currently, the issue of waste reclamation of the BPPM, located on the shore of Lake Baikal is topical. Over the years of the plant’s operation (1965-2013), more than 6.2 million m³ of wastes of hazard class IV were accumulated and stored in 14 pools of sludge collectors: lignin sludge, ash, wood bark, industrial, household waste and alkali-containing liquid [9]. A huge environmental hazard for Baikal is the waste stored at the industrial site of the enterprise, as well as the buildings of the former plant, which are destroyed due to non-use and vandalism. Almost 6 years after the closure of the
enterprise, the utilization of lignin sludge did not begin, water was not pumped out of the sludge collectors, and after heavy rainfall (summer 2019), the hydraulic structures were crowded and overhang the village of Solzan. The territory of the BPPM is located in a mudflow area [10]. In the event of a small earthquake (seismic hazard zone), containment dams can be destroyed and all waste will flood into Lake Baikal. Despite the fact that the state has allocated funding to solve this problem, so far there is no consensus on technology for waste management.

Another place of environmental disaster in the oblast is the industrial site of the former chemical plant Usol’eKhimProm, which occupies 24 km² and is situated in direct proximity of the city of Usol’e-Sibirskoe, where 83.5 thousand people live. The enterprise was one of the largest producers of chlorine and its derivatives in Siberia by the method of diaphragm electrolysis of brine. At the end of 2013, it was mothballed, but all the most important life-supporting arteries of the city (power supply, water intake and treatment facilities) pass through its territory, which creates certain problems for the protection of the industrial site. Since November 2018, an emergency mode was introduced on the territory of the enterprise, after a registered leak of toxic chemicals [11]. Currently, a special danger is represented by: a mercury electrolysis workshop, tanks with silicon tetrachloride and epichlorohydrin cylinders with mercury residues. Some objects require further investigation. The project of demercurization of the mercury electrolysis workshop received a positive conclusion from the state expert review, and the waste management will begin in 2020.

4. Conclusion
The findings of the study allowed to identify the areas of maximum impact of industrial facilities on all natural environments, these are large industrial centers unevenly located in the Irkutsk region (Irkutsk – Cheremkhovo, Sayansk-Zima, Bratsk and Ust’-Ilimsk), which is associated with the economic development of the territory. It is in large cities, which are industrial centers, there is a high concentration of industrial enterprises, which are characterized by significant emissions and large amounts of wastewater. High and very high levels of air pollution are observed in the cities: Angarsk, Bratsk, Zima, Irkutsk, Svirsk, Usol’e-Sibirskoe, Cheremkhovo and Shelekhov, water contamination in Ust’-Ilimsk and Bratsk reservoirs (Bratsk, Ust’-Ilimsk - the pulp and paper industry, as well as discharges of the Korshunovskii MPP (in the Korshunikha river)). The maximum local anthropogenic impact is exerted by industrial facilities engaged in the extraction of minerals, which is explained by production features. They represent the greatest pollution danger for soils, surface and groundwater with toxic substances during the extraction of mineral raw materials and from tailing dumps. Special attention is paid to industrial enterprises that ceased their activity, but did not go through the process of recycling production waste and reclamation of the facility.

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