

Local and Regional Changes in Natural Complexes of the Chechen Republic Caused by Oil Production

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Abstract

The purpose of this paper was to identify local and regional changes in natural complexes of the Chechen Republic due to long and intensive operation of the petro-complex in its area. Therefore, the author of this article, basing on the analysis of field study, mapping study, and statistical and library materials, assessed the impact of petro-complex facilities on the natural and anthropogenic environment of the Chechen Republic. As a result of the studies and processing materials of modern multi-zone chorometry in satellite images from "LANDSAT"-7, current environmental situation in the republic in the postwar period was assessed. At the same time, it was noted that ecologic and geochemical situation is characterized as rather stressful only in the areas where oil production facilities are located. Local pollution foci are mainly typical of the city of Grozny. Here, consolidated figures of pollution by geochemical assessment are many-fold higher than the maximum permissible norms (MPN) and indicate a critical and extreme environmental emergency. According to the results of the research, geo-ecologic zoning of the republic was made with highlighting landscape and ecologic zones and geo-ecologic regions that are characterized by uniformity of economic development and types of anthropogenic impact. The results of the research made it possible to:

Assess impact of the oil complex components on natural objects and elements of landscape structure in the republic;

Identify main patterns of chemical elements and organic compounds distribution in urban landscapes that are of technogeneus origin and indicate critical and emergency ecologic situation in the area in question;

Complete geo-ecologic zoning and territory mapping by the factors of dynamics and stability of natural and anthropogenic environment with regard to impact of the oil complex.

Keywords: petro-complex, environment, technogeneus leakages, ecologic and geochemical situation, geo-ecologic zoning

1. Introduction

Unfortunately, development of industry and pollution of environment are interrelated processes. One can say that the environmental problems in the Chechen Republic arose long ago when the first oil spring appeared in the city of Grozny (Ibragimov et al., 1993). Oil production, transportation, storage and refining are usually accompanied by emergency and technogeneus leaks, oil spillages to the surface. Therefore, it is not surprising that oil is the major pollutant of the environment of the Chechen Republic where oil has been processed for a long time using low-tech waste disposal schemes (Gayrabekov, 2011).

Maximum violations of natural landscapes and their transformation into natural-anthropogenic and anthropogenic ones are observed in the area covering the city of Grozny and its surrounding area. Soils, surface water and groundwater in the entire area of the Zavodsky district of the city were subject to total contamination. Technogeneus hydrocarbon deposits that formed on the surface of the ground water have become the source of contamination of city's groundwater and drinking water intakes. It is here that the maximum anthropogenic loads occur, which, however, are due not only to direct impact of the oil complex, but to indirect (corresponding supporting infrastructure) as well. Ecological state of the city could not but affect the ecosystem of the republic and the areas downstream the Sunzha and the Terek Rivers.

Behavior of oil and petroleum products in case of ingress into the landscape, especially the processes of their

migration within the landscape and metabolism are extremely complex and very long-term (Cresswell, 1977). Toxic effect of light oil fractions is observed on microbial communities and on soil animals. Volatility of these compounds promotes their evaporation (up to 20-40%) (Mc Gill, 1977).

Individual petroleum products migration rate in soils is determined by their viscosity: the higher the viscosity is, the lower the rate is. All other conditions being equal, oil and oil products penetrate most in light-textured substrates (Eizenhut, 1969; Bartz et al, 1969; Lippok, 1966; Laboratory ..., 1989). According to observations of E. Eizenhut (1969), oil products (naphtha residue) were found after 2 years at the depth of 8.65 m (clay loess); after two days – at the depth of 2.25 m (loam with pebbles); after 7 years they were steadily found at the depth of 8.5 m (sandy loam).

Balance of areas with manifestations of primary and secondary landscapes violations depends on stability: the more stable the natural systems are, the less the secondary changes are, as evidenced by actual data (Walker et al, 1987).

Oil technogeneous degradation is worst manifested in hydromorphic landscapes with anaerobic environment (Green, Trett, 1989).

Duration of oil decomposition processes in natural systems largely depends on the energy potential of the territory, humidity and mechanical composition of the substrates (Brown, Donnelly, 1983). The optimum temperature for oil decomposition is 20-37°C. Therefore, oil in cold ecosystems is very stable and its degradation can last for decades (Engelhardt, 1985).

Processes of soil, fresh water and landscapes pollution, as well as long-term effects thereof under the impact of the oil complex are poorly considered in literature. One of the reasons for such a situation is the fact that many researches of oil and gas complex impact on the environment are closed in a number of countries, and materials of research are not published (Pimlott, 1977). Nevertheless, recent years have seen many works disclosing various aspects of oil complex impact on the environment. Research showed that oil extraction had been for many years causing ingress of organic and mineral substances of both natural and anthropogenic origin into the landscape. Pollutants effect on the ecology typical for oil production depends, on the one hand, on the amount and composition of pollutants, i.e., their geochemical activity, and on the other hand - on properties of the natural systems that accept these agents. The same substances in different landscape-and-geochemical conditions behave differently: in some cases they are stable and even inert, in other cases they are not only subject to rapid transformations, but actively interact with the soil-and-ground mass (Glazovskaya, 1983, Solntseva, 1988). With regard to the above mentioned, there is no bug-free system of methods of sparing environmental management and rehabilitation of environmental violations, although there are numerous experimental and methodological studies for prevention and stabilization of some unwanted processes and recultivation of such land (Mc Gill, 1977; De Jung, 1980). Therefore, the issues discussed here are relevant for the Chechen Republic, which has been experiencing active impact of an oil complex for a long time.

2. Materials and Methods

This paper is based on the results of research performed by the author in order to evaluate impact of oil complex facilities on the natural environment of the Chechen Republic. In this work we used materials of deciphering satellite images from "Landsat-5, 7", library materials, statistical and literature sources on the subject.

Geochemical contamination of the territory of Grozny was assessed basing on the results of tests of various environment components – soil, surface water, benthal deposits and plant ash. All in all, in various parts of the city, 8 sites 300×300 m each were tested. 16 soil samples were taken from each of them, analyzed for content of heavy metals and some organic compounds.

In addition, testing was performed according to three geochemical profiles across the flood basin of the Sunzha River by taking samples of water, soil and vegetation. All in all within the limits of Grozny, 145 samples of soil were takes along with 36 samples of vegetation and 6 water samples from the Sunzha River.

3. Results of Research and Discussion

The Chechen oil-producing area has been formed for about two centuries, which fact has led to forming an extensive and internally heterogeneous area of oil industry impact on surrounding natural systems, transformation of natural landscapes from natural-anthropogenic and anthropogenic. Development of the petro-complex predetermined creation of a well-developed network of oil-and-product pipelines connecting oil fields with processing enterprises (Gayrabekov, 2012).

In the first years, operation of the deposits was unreasonable. Due to the absence of necessary capacities, difficulties

with transportation and general unpreparedness of companies for blows, most part of oil was lost during storage in earthen barns and pumping through ducts due to seeping into the ground, and lighter fractions of it evaporated. In those years, there was neither mechanical nor biological recultivation of the disturbed lands. They market the reference point for counting contaminated areas dedicated for drilling and for "waste" after the first refining.

Spontaneously built refineries have become major sources of environmental pollution in Grozny and areas downstream the Sunzha River. The methods of refining that existed at that time did not allow obtaining the most valuable petroleum products. Gasoline found no sales; it was often burned in pits as a worthless product. Kerosene and fuel oil became main oil product and merchandise for Grozny in the early XX century. Naphtha that had no sales was discharged into absorption wells. "Millions of pounds of naphtha have been absorbed by soils around Grozny", wrote L.A. Selsky (1920).

With an increase in production, processing, storage and transportation of oil and oil products, the scale of pollution in the republic increased as well. Oil processing and petrochemical plants, waste dumps, oil pipelines and storage tanks that had been used for a long period caused severe pollution of the Grozny urban landscapes. The Zavodsky district of Grozny accumulated large volumes of hydrocarbons that amounted to 1.5-2.0 million m³ by the end of the 80s. Technogeneous deposits created a real threat of drinking water sources pollution in the city. Besides, to the northwest from the Zavodsky district, in the Andreevskaya Valley, a large industrial dump of oil processing toxic wastes from IE Groznetfteorgsintez was formed; with the wastes amount of over 1 million tons. Downstream here, content of phenols in groundwater exceeds 4 mg/l (Report about performing..., 1992). The resulting environmental situation turned the entire territory of the Zavodsky district into an area of environmental disaster (State Report ..., 2004).

Since 1893 due to development of oil fields, in the territory of the Chechen Republic 4,701 oil wells have been drilled and over 5,000 barns for drilling waste have been created. Commercial oil production amounted to 313.6 million tons (Исрапов, 2003). About 1.0 billion tons of oil has been processed in the republic. During this period, local violations grew into regional ones and affected entire landscapes. Natural components in many cases experienced such a profound impact that made it impossible to return to their natural state. Moreover, new landscape and technogeneous structure has been formed with its own "substitutes" of natural elements.

Events of the nineties have lead to destruction of oilfield and factory facilities of the republic. During this period, negative impact on the natural-anthropogenic environment increased in many areas. Deterioration of oil storage plants, oil and product pipelines, as well as low level of their technical operation was detected. Operational discipline fell to the lowest level. Oil leaked from flowing wells and pipelines everywhere and ingresses widely into the Terek River. Oil wells burned. Artisanal mining and oil condensate processing was widely used, and did not stipulate waste disposal. Wastes from artisanal processing were dumped into soil and water bodies. Water protection zones and the surface of rivers' reception basin in the republic became polluted, which caused penetration of oil and petroleum products into water bodies (Gayrabekov, 2012).

The period of political instability was characterized by aggravating violations in certain local areas. While in the previous stages some negative violations had been compensated by centrally planned activities, natural environment was chaotically destructed at this stage, and the environment was polluted. Thus, development of the oil complex during a prolonged period, and consequences of military actions led to formation of a new environmental situation in the republic that requires a comprehensive study and implementation of measures for optimization of land use. It is paramount to perform ecological and geochemical mapping of the area where the oil complex had been functioning for a long time, transforming the territory exposed to its influence into the area of ecological disaster. Therefore, according to results of field studies in 2001-2004, and processing materials of the modern multi-zone chorometry using LANDSAT satellite images, environmental situation in the republic during the postwar period was assessed.

It also may be noted that the ecologic and geochemical situation is quite stressful only in the central parts of the republic, where oil complex facilities were concentrated, as well as in the areas of old oil fields, where numerous oil spills and accidents at oil wells and pipelines have occurred in recent years. Most of the territory of the republic that remains unaffected by oil complex can be assessed as background and permissible.

According to the results of a comprehensive assessment of the ecological status of the republic in all settlements where soil samples were taken, high content of hydrocarbons in soils, Pb, Zn, and other pollutants was detected. Results of soil sampling at some settlements of the republic are shown in Table 1.

Assessment of the environmental situation made it possible to perform geo-ecologic zoning of the territory of the republic (see Figure 1).

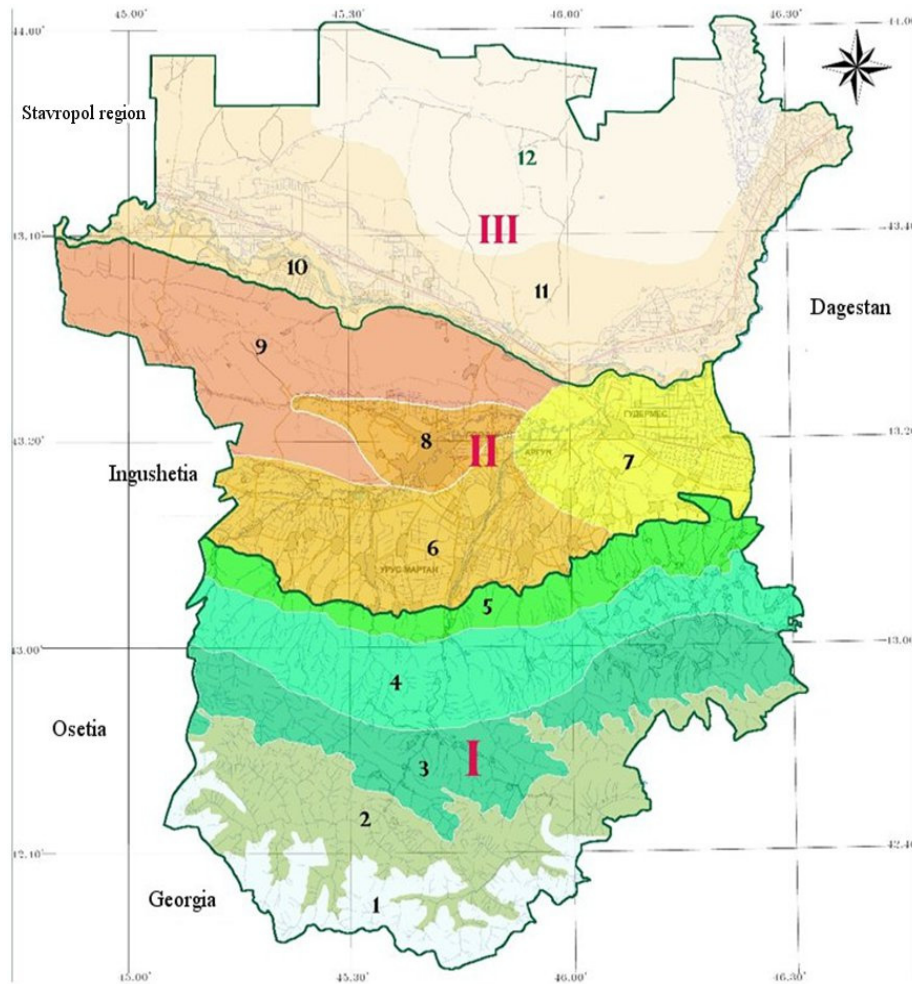


Figure 1. Zoning of the Chechen Republic according to the urgency of the environmental situation

I. Southern mountainous landscape – ecological zone

1. Alpine nival-glacial subsoil area
2. Alpine subsoil area of alpine meadows
3. Alpine subsoil area of subalpine meadows with an admixture of coniferous-leaved forests and intermountain arid basins
4. Midland forest subsoil area
5. Lowland forest-meadow subsoil area

II. Central landscape-ecological zone of front ridge and plains

6. Piedmont plain steppe subsoil area
7. Eastern plains hilly steppe subsoil area
8. Grozny hilly steppe subsoil area
9. Terek-Sunzhensky hilly steppe subsoil area

III. North Zatrechny plain landscape-ecological zone

10. Zatrechny plain steppe subsoil area
11. Zatrechny plain steppe subsoil area
12. Zatrechny plain semidesert subsoil area

According to the methods introduced by B. Kochurov (2003) (Kochurov, 2003), the basis of zoning was breaking the territory into landscape-ecologic zones and geo-ecologic regions with regard to urgency of the ecologic situations (see Table. 1). On that basis, the republic is divided into 3 landscape-ecologic zones and 12 geo-ecologic regions, which are characterized by uniform development and by types of anthropogenic impact.

Table 1. Characteristics of geo-ecologic regions of various ranks in the Chechen Republic according to the degree of severity of environmental urgency

Regions	Rank of the region	Ecological urgency			Area in % of the entire area of the republic in km ²
		Characteristic	In conventional units (points)		
			interval	average	
1,2,12	I	Permissible	1-7.9	4	5.5
3,4,5,6,11	II	Moderately hazardous	8-16	12	7.1
7,9	III	Hazardous	16.1-32	24.05	2.7
8	IV	Extremely hazardous	32.1-128	80.05	0.6

Environmental tension for geo-ecological regions is understood as the degree of changes in the natural environment (landscape) that is a result of certain combinations and ratios of areas with environmental situations with varying degrees of severity (Kochurov 2003). The level of environmental tension in geo-ecological regions was estimated in arbitrary units (points), based on spatial relationship of areas with different degrees of severity of environmental emergencies within the region, marked on the ecological and geochemical map.

Assessment of environmental situation was determined by the total pollution index (Z_c). Geo-ecological areas were allocated based on the total degree of pollution (Z_c). With that, ecological tension was characterized as permissible at Z_c values less than 8 points; as moderately dangerous - at 8-16 points; as dangerous - at 16-32 points, and as extremely dangerous at more than 32 points. These regions are characterized by similarity of geo-ecological situations within the borders of these geo-complexes (Table 2).

Table 2. Characteristics of geo-ecologic regions of various ranks in the Chechen Republic after the degree of severity of environmental urgency

Regions	Rank of the region	Ecological urgency			Area in % of the entire area of the republic in km ²
		Characteristic	In conventional units (points)		
			interval	average	
1,2,12	I	Permissible	1-7,9	4	5,5
3,4,5,6,11	II	Moderately hazardous	8-16	12	7,1
7,9	III	Hazardous	16,1-32	24,05	2,7
8	IV	Extremely hazardous	32,1-128	80,05	0,6

Consolidated indicators of pollution in the territory of Grozny by geochemical assessment are several times higher than MPN and indicate a critical and emergency environmental situation.

The results of soils and ground analysis on the territory of Grozny makes it possible to conclude that all anomalies here are technogeneous and are caused by industrial emissions of enterprises and motor vehicles. The main polluting elements of urban landscapes are Pb, Zn, to a lesser extent Sb, Cd, Cu, and Hg. Out of organic compounds, elevated contents of benz(a)pyrene and petroleum products are detected in many places. Apart from various kinds of organic compounds (dioxins, benzpyrenes, etc.), toxic metals (Hg, Cd) and radioactive products (Rn) are present in combustion products. These materials, along with all available research data were used for mapping results of geochemical soil contamination. Using these data, a map has been made that reflects the nature of soil contamination in Grozny (see Figure 2). The map shows that soils within the boundaries of land acquisitions at the Oktyabrskoye and the Starogroznsenskoye oil fields are most exposed to contamination. Such pollution is caused by accidents in drill wells, with oil burning and flowing.

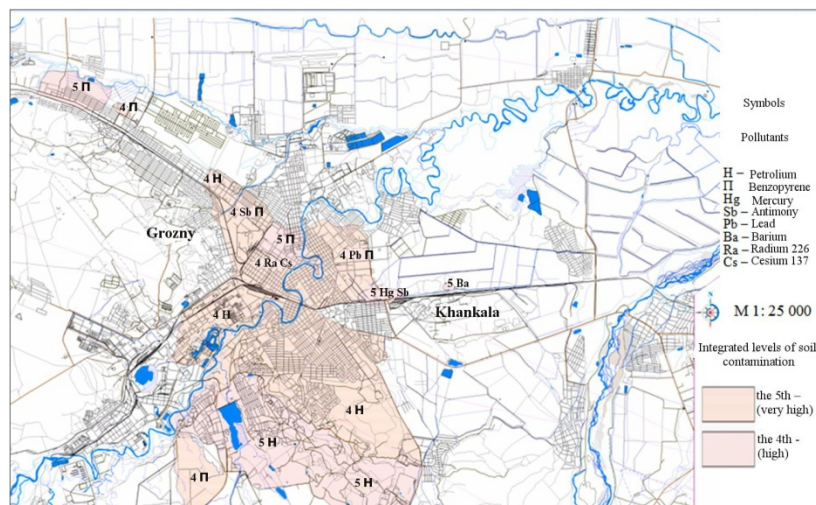


Figure 2. Map of the nature and intensity of soil contamination in Grozny

Taking into account the fact that all natural processes of contaminants migration from the territory of the republic along the Terek and the Sunzha Rivers are directed towards the Caspian Sea, current environmental situation exacerbates the problem of ecologic safety of the Caspian region.

4. Discussion

Studies for evaluating the impact of oil complex facilities on natural-and-anthropogenic environment made it possible to assess geo-ecologic situation in the Chechen Republic due to long-term functioning of the oil complex in its territory, to identify regularities of local and regional changes in landscapes under the impact of oilfield production facilities.

5. Conclusions

Local level research made it possible to identify particularities of the impact of oil complex components on natural objects and elements of landscape structure of the republic.

Geochemical analysis of soil samples in the areas with maximum saturation petro-complex facilities revealed main regularities of chemical elements and organic compounds distribution in urban landscapes of technogeneous origin.

Geo-ecologic zoning and mapping of the territory according to the factors of dynamics and stability of natural and anthropogenic environment due to the impact of petro-complex made it possible to identify landscape-ecologic zones and regions with uniform development and types of anthropogenic impact within the territory of the Chechen Republic.

Presently observed aggravation of the ecologic situation is the result of long-term functioning of an oil complex with obsolete technology, non-compliance with environmental laws and military action in the republic.

Existing ecologic situation aggravates already complicated ecologic situation in the region and is a threat to unique ecosystems of the Caspian Sea. Therefore, in order to ensure ecology safety, immediate action is needed to normalize ecologic situation in the republic.

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