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ASSESSMENT OF OIL AND GAS INDUSTRIAL INFLUENCE INTO THE ENVIRONMENT BY APPLICATION OF SPACE TECHNOLOGY ADVANCES

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Abstract- There is no doubt that study of contribution of any possible consequences to the environment has a vital place in our daily life. The fact is that to point out high efficiency of such research works bring important outcomes in future decisions for protection and forecasting of negative impact to the environment.

The main aim of research work is to identify the patterns and dynamics of changes of the soils, contaminated as a result of industrial impact, oil, gas and construction materials production and other forms of economic activity. It has been offered to use advances of space technology for monitoring and assessment of impact of foregoing indicated factors to the soil condition. The research of contamination for selected area has been undertaken between the years of 1995 and 2013. The baseline level of contaminating materials, as well as the current state and geographic outline of the contaminated area, was established. The physical properties and geographical conditions have been closely analysed. The collected materials were used as a basis for presenting current land condition polluted by oil and oil substations. In the Absheron District the specifics of interaction between environment and industrial activity, associated with the use of natural resources, is primarily related to the high environmental pressure due to dense territorial concentration of main industrial facilities. The fact is that the key environmental problems in the area are mainly connected with the regional production complex, which was formed based on the production of oil, gas and various construction raw materials. At the same time, vigorous growth of production operations, in combination of the high density of population and high percentage ratio of urban population, dictate the significance of ecological measures in this area [4]. The analyses of certain trends in the distribution of oil, gas and construction material resources, i.e. factors causing environmental impact within the area, enable the identification of lands, contaminated in the process of the above resources development and production. An onshore oil and gas production in the Absheron District is related to the similarly named Absheron petroleum bearing area. This area includes Absheron Peninsula, Absheron Archipelago, situated to the east of the Peninsula, and the insular zone of the Baku Bay towards the south [4].

Keywords: Environment, Soil and Soil Contamination, Remote Sensing and GIS, Space Image, Satellite Data Processing.

I. INTRODUCTION

Absheron District of Azerbaijan Republic is characterised by abundant natural resources and one of the developed industrial sectors. Thank to oil and gas production the soil in the area is highly contaminated with petroleum wastes, produced water, construction debris, as well as other types of wastes (industrial, construction, domestic, etc.). There are soils, contaminated with residual oil and covered with bitumen, oil pools, abandoned oil wells, disused stone quarries, construction landfills, associated with oil fields and stone quarries are in evidence everywhere in this region.

For the time being estimated area contaminated as a result of oil, gas and construction materials production, as well as other kind of industrial activities in Absheron District is covering of 21 thousands hectares. Due to the development of new industries in this region, tens of hectares of land are constantly newly contaminated [4] with such kind of substances. As a result, the patterns of natural conditions, as well as the resources used within the Absheron District are changing, which, in turn has a significant impact on the environmental state and economic development of the District. Therefore, the rehabilitation of the contaminated soil and their use as a reserve source of resources to satisfy the demand in different sectors of industrial activity is paramount in this District.

Comprehensive analyses of production processes show that negative impact on commercial lands as a result oil and gas field development takes place during three stages:

- geological exploration;
- construction works; and
- operation of the field.

There are two ways taken place negatively impacting on land. The first negative impact is the technological processes, which could be eliminated using effective measures during field development. The second is the negative environmental impact of oil and gas products spills as a result of accidents during production operations.

Analyses of technical and technological factors of oil field development shows that the method of artificial interference on the soil layers is the most efficient. Re-injection of produced water is mainly used on onshore oil fields in Azerbaijan. About 85 of produced oil is extracted from the fields, where water is re-injected from different directions [5]. The utilization of water re-injection method in oil fields of Sabunchi and Binagadi settlements contributes to increase the oil production. For re-injection mainly uses reservoir water, extracted from the wells. Oil is delivered to the surface driven by reservoir pressure.

II. DISCUSSION

Statistical data shows that electrical energy consumption required for production of 1 ton of oil is about 10-15 kW/hr. From the producer wells oil is delivered to the group metering stations, and then to the booster pumping station. H_2O content of oil, which passed two stages of separation is decreased to below 2%, before the oil is finally directed to the tank farm. The process described above depicts the production of oil as a closed loop (in theory), however, in reality it is associated with a number of hidden wastes. To accommodate such wastes barrow pits are dug close to the oil fields, emergency containers with 200-300 m^3 capacity are provided and natural relief indentations are used. The process flow diagram, based on the process described above, distinctly shows negative environmental impact on the oil field. Here waste water, oil and gas are discharged to the environment, which leads to its contamination (Figure 1).

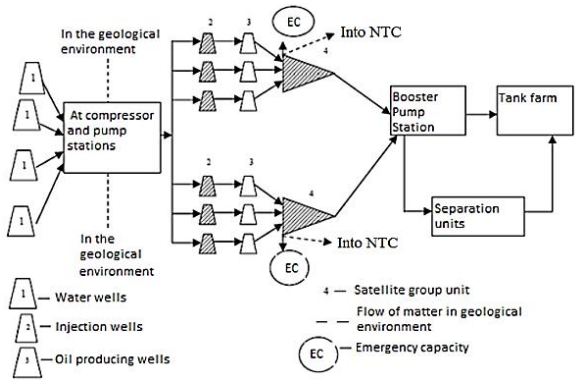

Figure 1. Impact of oil and gas production complex in the oil field area

It should also be noted that evident negative impact on the environment and land surface has also taken place in the District as a result of indiscriminate movement of vehicles within the field area, as well as the pipelines network, etc. Huge environmental impact takes place during oil and other petroleum fluids transportation by pipelines. Significant negative impact results from corrosion and accidental pipeline rupture, which has a potential of significantly increasing contamination.

Lands, retaining the toxic substances, have negative impact in the all areas of life. Analysis of the impact on the natural environment of oil and gas complex within the study area, particularly as a result of oil, gas and construction materials extraction, allows to identify the distribution and extent of contaminated soil. It is rather difficult to determine the total area of contaminated soils in the district, due to the extensive development of oil and gas in different parts of the district. A variety of methods applied during production of oil and gas reserves, resulted in a large distribution of contaminated soil.

Economic evaluation of the current state of the environment, as well as analyses of the patterns and trends of the changes, provide clearer picture of the negative impact of oil and gas production. It helps to identify measures aimed at restoring or normalizing ecosystems in the territory of environmentally sensitive and protected areas [4]. In determining the areas of contaminated soil in Absheron District, the following have been reviewed:

- lands contaminated with oil, covered with fuel oil and bitumen;
- lands with indentations and pits filled with oil and produced water, dumps, landfills, ash land, flooded and wetlands and land with other forms of contamination; and
- total area of these lands and the degree of contamination, their depth, and other characteristics.

During investigation of the studied area it was established that the negative impact of the oil and gas complex on the environment and land resources was caused as a result of the production process itself. As a result of oil, gas production and construction materials extraction, as well as other sources of activities, lands with different degrees of contamination appeared on the territory of this district. Findings of the conducted calculations show that the total area of contaminated soil on the territory of the district is above 21 thousand hectares, including:

- total area of lands contaminated during oil and gas production – 19,405 hectares;
- total area of lands contaminated during extraction of construction materials – 1,079 hectares;
- total area of lands contaminated as a result of other economic activities – 845.8 hectares (Figure 2).

Total area of soil contaminated as a result of oil and gas production on the Absheron Peninsula is distributed as reflected in the Table 1.

Main parts of soil contaminated by fuel oil is located within Bina, Gali, Sabunchi, Binagadi I Bibieybat fields, where oil products have saturated up to 100 cm of top soil layer. On these areas volume of soil humus is 0.13-1.23%, carbons – 6.24-36.24%, total volume of absorbed alkalis – 14.8-24.4 mg equivalent, phosphorus – 4.5-9.2; potassium – 83.6 – 171.8 mg/kg. These lands have been assessed in the below table in terms of their level of contamination and morphogenetic properties (Table 2).

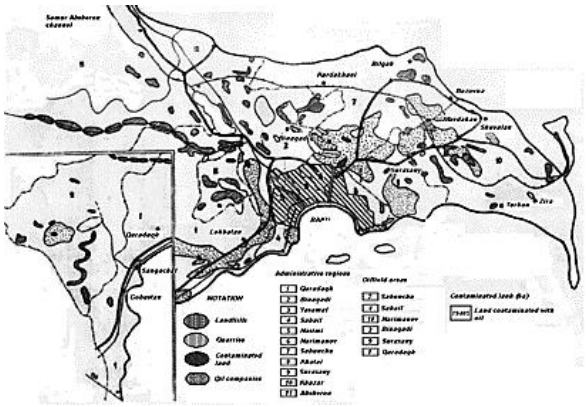

Figure 2. Layout map - Sources of environmental pollution in Absheron Peninsula

Table 1. Characteristics of lands contaminated as a result of oils and gas production

Total area of lands contaminated as a result of oil and gas production (Hectares)	Lands contaminated by oils and oil products		Drilling Wastes (Hectares)	Formation Water (Hectares)
	Fuel Oil (Hectares)	Bitumen (Hectares)		
19,405	6,670	5,950	4,442	2,343

Table 2. Characteristics of lands contamination level with fuel oil and bitumen

Lands Contaminated with Fuel Oil			
Level of contamination	Site humidity	Depth of fuel oil layer	Depth of oil waste penetration, cm
Low	Low	0-5	0-15
Medium	Medium	5-15	15-30
High	High	15-25	30-50
Very high	Very high	> 25	> 50
Lands Contaminated with Bitumen			
Low	Low	0-5	0-15
Medium	Medium	5-15	15-30
High	High	15-25	30-50
Very high	Very high	> 25	> 50

In the process of drilling operations on oil and gas fields of Absheron District, lands have been contaminated by chemical substances, slags contained in the drilling fluids, waste water and scrubbing solutions. On these lands the volume of soil humus is 0.11-0.89%, carbons – 7.43-18.83 %, total volume of absorbed alkalis – 11.4-28.6 mg equivalent, phosphorus – 4.7-7.2; potassium – 68.3-133.4 mg/kg. Lands contaminated with drilling wastes are more dominant in the area of Baladjari, Binagadi, Bina, Buzovni and Yasamal fields. Information on soil contamination with drilling wastes is shown in Table 3.

Table 3. Characteristics of soil contamination level with drilling fluids

Level of contamination	Site humidity	Height of above ground piles	Depth of pits, cm	Depth of oil waste penetration, cm
Low	Low	0-50	0-70	0-30
Medium	Medium	50-100	70-120	30-50
High	High	100-150	120-180	50-70
Very high	Very high	> 50	> 180	> 70

Highly mineralized formation waters also had strong negative impact on soil in the Economic District. According to S.A. Buzmakov, S.M. Kostarev and other authors, one of the main industry-related factors, determining transformation of the environment during oil fields development, is the discharge of petroleum products and salty water into the environment [2]. Lands flooded with the produced water is more common on the territory of Surahani, Zabrat, Sabunchi and Binagadi oilfields, as here oil is produced by injection of water into the reservoir. These lands comprise such elements as soil humus is (0.61-1.18%), carbons (16.17-20.66%), absorbed Alkalies (11.9-26.4 mg equivalent), phosphorus (4.2-6.5), potassium (65.4-88.9 mg/kg).

Table 4. Characteristics of soil contamination with reservoir waters

Level of contamination	Site humidity	Depth of bitumen layer	Depth of oil wastes penetration, cm
Waterlogged lands	Variable	0-30	< 0.01
Changes to water table	High	30-50	0.01-0.1
Constantly flooded lands	High	> 50	> 0.1

Total area of the Absheron Peninsula is 222 thousand Hectares, the area of Baku is 192 thousand Hectares or 86.5%. The main sources of pollution of soils in Absheron, as well as in Baku, capital of the Azerbaijan are industry, urban development, transport, engineering infrastructure and recreation. The soil cover of Absheron peninsula is divided into several regions and sub-regions. Among these regions, the Central man-made region of Absheron, surrounding Baku city rim-land by a semi-ring, has very high levels of industry related pollution.

Contamination with oil and petroleum product is especially harmful for soils in Baku. 15-20 thousand hectares of lands on the Absheron Peninsula, or 7-10% of its total area, have varying levels of contamination by oil, petroleum products, drilling muds and oil processing related wastes. Due to the alternation of built-up and industrial areas, the development of urban fabric becomes rather difficult. All of the above necessitated, back in 1980, the move of 450 thousand m^2 of habitable area from the territory of oilfields and out of the non-built-up areas [5].

The depth of the contaminated layer of soil is between 0.1 and 1.0 m and in some places it reaches 2.5 m. According to different sources, between 20 and 33 thousand hectares of Absheron lands have been contaminated with oil and oil products [1, 4].

In 1989-1991 has been conducted research for delineating and re-cultivation of contaminated oilfield lands in Absheron Peninsula. The main sources and characteristics of pollution and technical and economic indicators have been identified (Table 1).

According to the studies conducted in 2000 within the framework of TACIS program, total oil-fields areas on the Absheron Peninsula is around 12,512 Hectares. From the re-cultivation point of view, all lands are generally subdivided into two types:

- soils allocated for permanent use;
- soils allocated for temporary use.

After the termination of drilling works, lands allocated for temporary use, should be re-cultivated and returned to the land owners/users. However, quite often it is neither cultivated nor landscaped.

Table 5. Oil product content in soil sample

Environment	Probe No	Concentration of oil products	Standards	
Water, mg/ml	1	4.6	0.3	
	2	9.8		
Soil, mg/ml	3	9259	< 300	Pure
	4	71974	300-1000	Slightly contaminated
	5	1396		
	6	9749	1000-3000	Moderately contaminated
	7	76095	3000-5000	Heavily contaminated
	8	1118		
	9	2251	> 5000	Extremely contaminated

III. SPACE TECHNOLOGY APPLICATION

The fact is that information performed above in an excellent source for further study of dynamic changes of soil of the area contaminated by oil and any other substances affecting negatively to the environment.

In the other hand, it can play useful place in soil condition definition as a tool and indicator for large areas of territory. There is no doubt that in this case the use of traditional methods cannot be useful in such a problem solution. It demands to apply non-tradition approach of monitoring of the process, which especially important in environmental studies including soil contamination investigations.

Obviously, application of space technology advances has a key point in similar explorations. There are following advantages can be indicated as:

- large area cover;
- use of available indicators for assessment of soil condition;
- high accuracy of soil condition dynamic change observation; and
- prompt measurement process in real time reflecting condition in current stage of monitoring.

It is valuable aspect of space technology application in study of environmental condition of the soil since the process is much dynamic and observing rapid changes of the situation. For this reason the use of space technology outcomes open the opportunity to detect and study of damage to the environment on the duly base which is playing vital place for decision makers.

In the other hand, it is the instrument makes easily observe dynamic changes based on comparative analyze of old and newly processed space data.

IV. IMPLEMENTATION OF THE TECHNOLOGY

The first stage of space technology method application was related to the identification of administrative contours of selected areas expected to study of soil contamination.

Figure 3 shows sketch-map of the area where conducted investigation of soil condition polluted with oil and construction materials. It is important to emphasize that space image has to be merged to the topographical map with use of referenced points. The process of superposition of image-topographical map is an important stage in order to have a high level of data integration. It creates positive aspect of assurance of the study area and suitable integration of available data in further use.

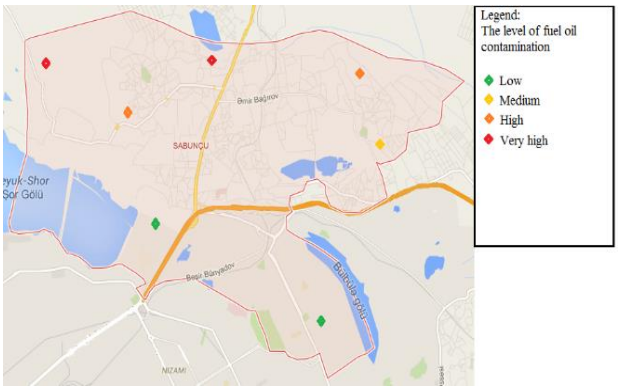

Figure 3. Classification of soil contamination reflected in sketch-map

The next stage of the method is to process space image by means of spectral parameters of the Earth segments reflecting from the soil contaminated area linked into the soil pollution degree by oil and other pollution consequences indicated above (Figure 4).

Figure 4. Satellite image processing for soil pollution

As it has seen from the Figure 5 there is legend of soil pollution divided into the four level degrees of pollution as low, medium, high and very high. This segmentation is more than enough in identification of soil pollution and contamination definition. It can be successfully applied in current stage of environmental aspects as well as future dynamic change observation and assessment.

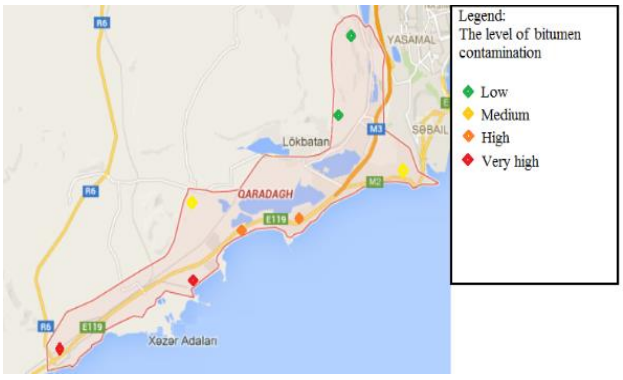

Figure 5. Sketch-map of Garadagh district of Absheron peninsula with oil polluted soil levels

Figure 6. Remote sensing data processing for Garadagh district of Absheron Peninsula

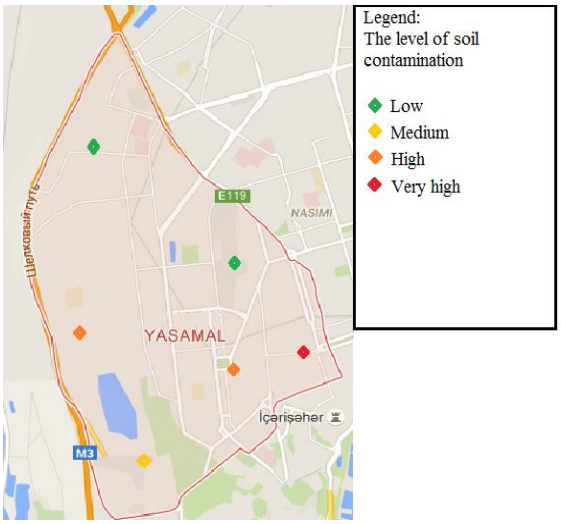

Figure 7. Soil contamination level for Yasamal district of Absheron Peninsula

Figure 8. High resolution spatial data processing

Undoubtedly, space technology application has advantage to consider a large area for investigation. The same approach of oil contamination measurements has been used for other districts of Absheron peninsula with purpose of assessment of soil contamination condition (Figures 6-8).

The fact is that processed space data can be integrated into the geographic information system by layers of developed legend reflecting soil condition by defined levels of degree.

V. CONCLUSION

It has been demonstrated suitable integration existing old data and refreshed space data for study of soil oil and other impacted contaminations. It is advantages of space technology successfully assess and evaluate dynamic changes of environment by oil and construction materials in soil contamination monitoring and observation.

In the meantime, space data processing makes available to develop geographic information system, which is the key instrument in soil condition investigation and archiving of the data as the main source for state authorities during decision-making stage of soil recovery.

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BIOGRAPHIES

Eldar Y. Salayev was born in Nakhichevan, Azerbaijan in December 31, 1933. He has specialized in Semiconductor Physics. He was in charging of functioning of Azerbaijan Academy of Sciences, Baku, Azerbaijan taking the position of President for the period of 1983-1998. Currently he is senior scientist of Institute of Physics, Azerbaijan National Academy of Sciences, Baku, Azerbijan. He is an author of four monograph and more than 400 scientific papers. His research area fields are in development and application sensors and sensitive elements operating in spectrum of infrared wavelengths.

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Namig Rahimov was born in Baku, Azerbaijan, in May 1948. He has a high degree in Mine Engineering with further specialization in Geodesy from Azerbaijan State Oil Academy, Baku, Azerbaijan. He has an experience more than 45 years in the indicated area leading many complicated projects in geodesy. Currently, He is working at Encotec Company, Baku, Azerbaijan providing geodetic and topographic services within the scale of different projects.

Rustam B. Rustamov was born in Ali Bayramli, Azerbaijan, on May 25, 1955. He is an independent expert on Space Science and Technology. In the past, he was in charging of the Azerbaijan National Aerospace Agency activities as an Acting Director General. He has mainly specialized in space instrumentation and remote sensing and GIS technology. He has graduated Ph.D. at the Russian Physical-Technical Institute, S. Petersburg, Russia. He was invited for the work at the European Space Agency within the Framework of the United Nations Program on Space Applications at the European Space Research and Technology Center, The Netherlands. He has appointed for the United Nations Office for Outer Space Affairs Action Teams (member, Vienna, Austria), United Nations Economical and Social Commission for Asia and the Pacific (national focal point, Thailand), International Astronautically Federation (Federation's contact, France), Resent Advances in Space Technologies International Conference Program Committee (member, Turkey). He is an author of 11 books published by the European and United States famous publishers and more than 100 scientific papers.