USE OF GIS TECHNOLOGIES AND ARCGIS SOFTWARE IN THE DETERMINATION OF OIL POLLUTION IN THE CASPIAN SEA

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Abstract

Earth remote sensing (ERS) is one of the most important and rapidly developing types of space activities, which is most susceptible to innovation. It ensures the rapid receipt of practically significant results, which are already making a major contribution to the economy of developed countries of the world. This sector of space activity is based on the use of high science-intensive technologies and the latest achievements of fundamental and applied science. Space information is used in many areas, primarily for preventing and eliminating the consequences of natural disasters and man-made accidents, research and rational use of natural resources,environmental protection, energy, urban planning, transport complex, meteorology and climatology, forestry and agriculture, cartography, creation of geographic information systems, etc.
Naturally, this information should be widely used for the benefit of the oil and gas industry.
One of the most perfect tools for monitoring natural objects is remote sensing. Techniques for non-contact measurements provide extensive operational information about environmental changes. This is especially true for water pollution. Remote sensing methods are dominant in the large-scale comprehensive study of pollution areas in the Caspian Sea. In order to determine the dynamics of pollution of the Caspian Sea, assessment of the situation parameters based on space images and conducting complex monitoring are urgent issues.

Keywords: monitoring, multispectral, aerospace, ArcGIS, Caspian Sea

I. Introduction

As the first step in solving the problem of pollution of the sea surface with oil products, monitoring of polluted basins is one of the important issues. This requires the joint use of remote sensing methods (RS), aircraft and space systems for observation of water areas, detection of pollution, physical characteristics and control of its distribution in areas. The monitoring system should also provide observation in any weather, should not depend on lighting conditions (cloud cover), determine the volume, type, and location of pollution [1].

Remote Sensing (Earth Remote Sensing) transmitters must work on a real-time scale and distinguish anthropogenic pollution from biogenic substances formed in the sea as a result of the life activity of marine organisms. Modern ERS tools used for detection use a wide range of electromagnetic radiation wavelengths: ultraviolet and visible (0.26-0.8 μm), near (0.9 - 3 μm) and far (7 - 14 μm) infrared, ultra high frequency (1-100 sm) bands. They provide virtually real-time marine observations today.

Already at the present time, with the use of aerospace methods and technologies, it is possible to solve many problems in the interests of the oil and gas industry, first of all, who, how:

- conducting fundamental scientific research processes of the formation of hydrocarbon immigration using aerospace information;

- the study of the geological structure of oil and gas-bearing territories, including the study of lineament network and deep tectonics, annular structures,

- conducting tectonic zoning of these territories on the basis of space data for the informational support of prospecting work for the discovery of new and prospective evaluation of existing oil and gas deposits;

- monitoring of the current condition of oil, gas and product pipelines for the detection of leaks, violations of the technical condition, etc.;

- determination of potentially dangerous sections of pipelines, including assessment of changes in floodplains of rivers, reservoirs and swamps as a result of changes in permafrost and hydrophysical properties of soils,

- assessment of the dynamics of the frozen soil regime and the results of its impact, as well as the identification of the most favorable geoecological conditions for the laying of new pipelines;

- monitoring of dangerous natural and man-made processes during the development and transportation of hydrocarbons, including earthquakes,floods, avalanches, landslides, tsunamis, tropical cyclones, etc. on the basis of aerospace data;

- remote monitoring of the ice situation in arctic regions, in vol including locations of drilling platforms and the Northern Sea Route;

- operational space monitoring of fires in buffer zones of main pipelines and other objects of the oil and gas complex;

- environmental monitoring of places of extraction, transportation, processing and distribution of hydrocarbons on land and at sea to assess the consequences and reduce risks from the activities of enterprises in the oil and gas industry, including: no contamination of soil, vegetation and snow cover with petroleum products within the limits of drilling wells, oil storage facilities and oil pumping stations; marine platforms, places of loading, unloading and movement of ships for the transportation of oil, petroleum products and liquefied gas;

- underground and underwater pipelines; revealing the blooming of lakes as a result of the introduction of mineral and organic suspensions, etc.;

- control of tempos and evaluation of the efficiency of recultivation of lands and polluted territories based on aerospace data.

- carrying out ecological passporting of objects of the oil and gas industry using aerospace information;

- determination of the location of pipelines, structures and other objects of the oil and gas industry and formation of their cadastres based on aerospace data;

- creation of digital maps, three-dimensional terrain models, geoinformation systems (GIS) of different thematic orientation for oil and gas districts and others. with the use of aerospace information;

- remote monitoring of unsanctioned cuts into main oil and product pipelines;

- detection of unauthorized economic and construction activities, as well as the appearance of man-made objects in the zones of withdrawal of objects of the oil and gas complex based on aerospace data;

- remote monitoring of districts of construction of new facilities of the oil and gas complex;

- monitoring from space of places of combustion of accompanying gas and control of the functioning of torch installations;

- informational provision of long-term planning and management of the activities of these enterprises and the liquidation of accidents on them using aerospace data and others.

The spectrum of these tasks can be expanded as the methods, technologies and technical means of remote sensing and processing of the received information are developed.

II. Research object and methodology

Geographical Information Systems (GIS) are widely used today to determine water quality models and parameters. As we know, ArcGIS software is one of the integrated programs included in the GIS system. In this article, ArcGIS 10.4.1. the version of the software was used, the parameters causing oil pollution in a certain area of the Caspian Sea and the assessment of the degree of pollution were analyzed.

In order to determine the sources of pollution of the Caspian Sea in the Neftchala area, the space image of the AZERSKY satellite provided by Azercosmos was used. Satellite resolution 1.5m panchromatic / 6m multispectral; color range: 4 bands (red, blue, green, near infrared); shooting scene: min. 60X60km, max. 60X600km; height: 694.9 km; ability to draw the same point: 2 days (45°) .

Due to the fact that the Caspian Sea is a unique lake, it is very important today to evaluate its characteristics and ecological condition, as well as to study its hydrometeorological, hydrogeological and hydrophysical characteristics, and to analyze the variability of hydrochemical and hydrobiological processes. Among the problems of the Caspian Sea, along with the fluctuation of the level, the pollution of the sea waters and the related deterioration of the environmental conditions are the most important problems of the last period. The main sources of pollution of the Caspian Sea are the rich natural resources of its basin and the sewage flows of cities and industrial facilities located on the coasts of its basin, oil tankers, offshore oil fields, oil refineries, ship and boat lubricants, oil pipelines, oil wells, accidents, as well as the negligence of service personnel. The dynamics of the ecological situation of the Caspian Sea and, at the same time, its pollution by oil products occupy a key place in the ecological assessment. The first step is to identify the sources that pollute the sea as a result of natural and anthropogenic influences. A deeper study of the interaction of hydrophysical processes occurring in the water basin is important in order to reveal the regularity of the characteristics of the distribution of pollutants throughout the water area. On the other hand, the study of these factors separately and at the same time reveals that they play a more influential role and shows the main reasons for such a distribution [1,4].

III. Analysis of results

The spatial image includes the combination of the image of the Neftchala area in 2020 in panchromatic and multispectral bands (Figure 1). The description opens in the ArcMap version 10.4.1 interface of the ArcGis software. ArcMap has high-quality cartographic production functions that enable graphical and verbal data display, data registration, query and analysis, and development of images and reports. "Add Data" command is used to open the spatial image in ArcMap.

In order to facilitate the processing of the space image, a range shift was performed between the bands of the (Mosaic_2020) image presented to us.

With this, it is more convenient to work on the objects we need in the image. It should be noted that the color range of the image consists of 4 bands (Blue Band_3, Green Band_2, Red Band_1, Infrared Band_4). As seen in the mosaic image, Red Band_1 to Red Band_4, Green Band_2 to Green Band_1, Blue Band_3 to Blue Band_2, and Infrared Band_4 to Infrared Band_3.

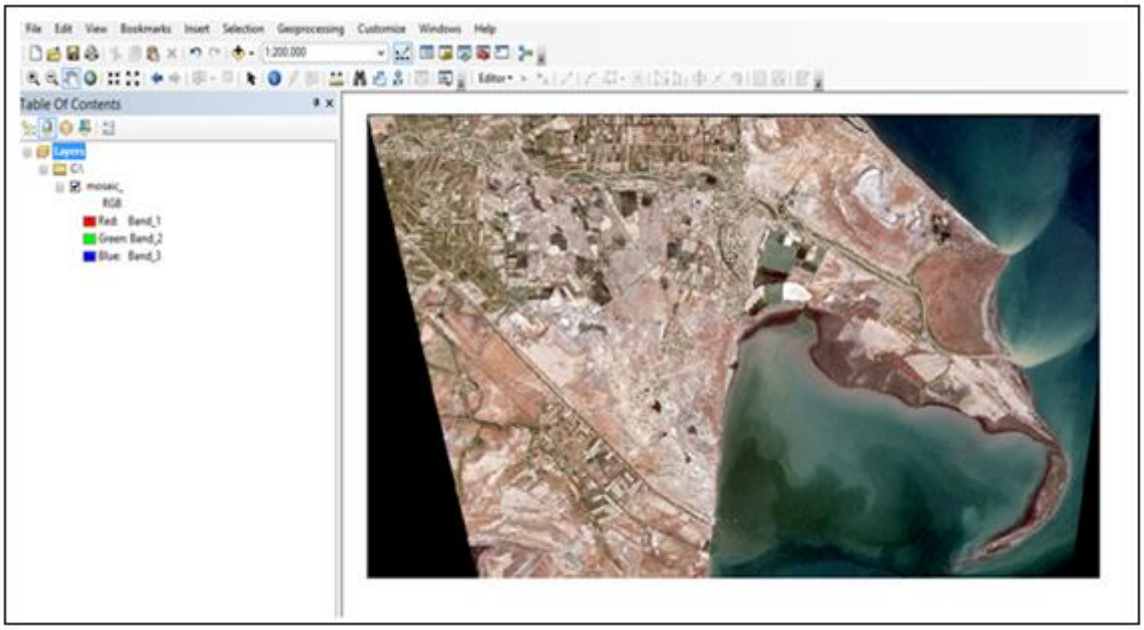

Figure 1: *Space image of Neftchala area in panchromatic and multispectral bands*

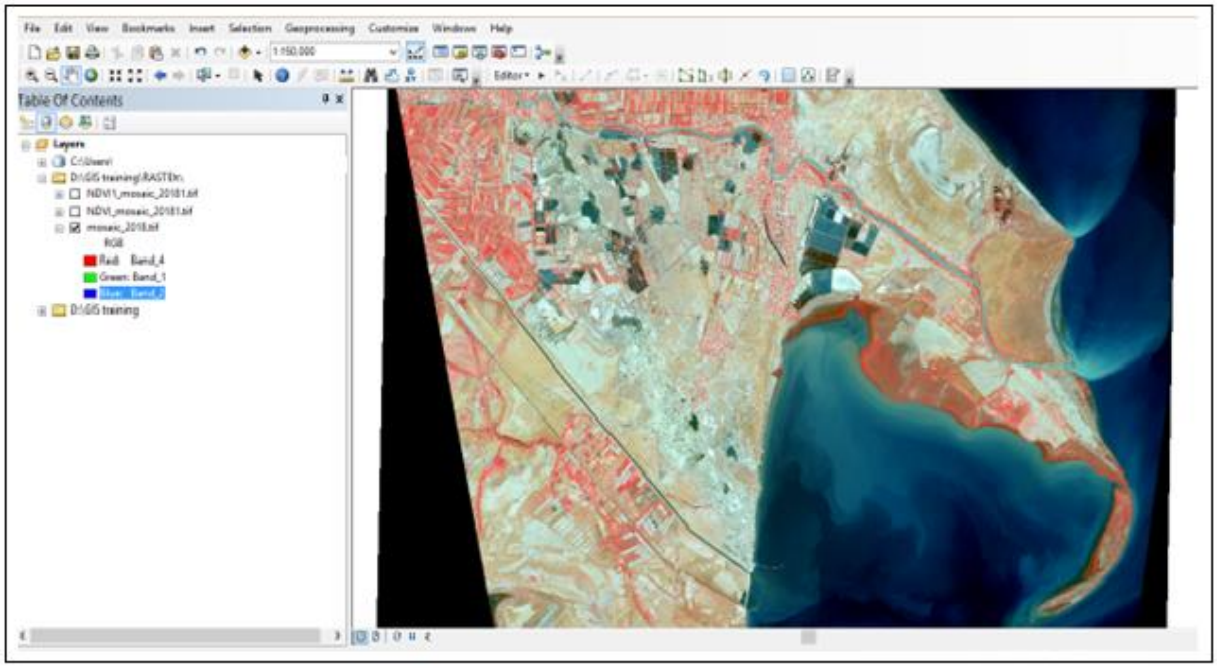

Figure 2: *Bandwidth-shifted space image*

After changing the color ranges, we get a chance to more clearly select water bodies in the image, and the "Start Editing" command is selected from the "Editor" button on the ArcMap toolbar, and mapping work is carried out on the image (Fig. 3).

Hasanabad and Gobu canals have been designated in the description and processing works have been carried out on them (Figure 3). It should be noted that the Hasanabad collector starts from Boyat village of the region, passes through the territory of "Anshad-Petrol" MM, collects groundwater in the flow direction and flows into the Caspian Sea. Where the stream empties into the sea, the coastline is semi-swamped.

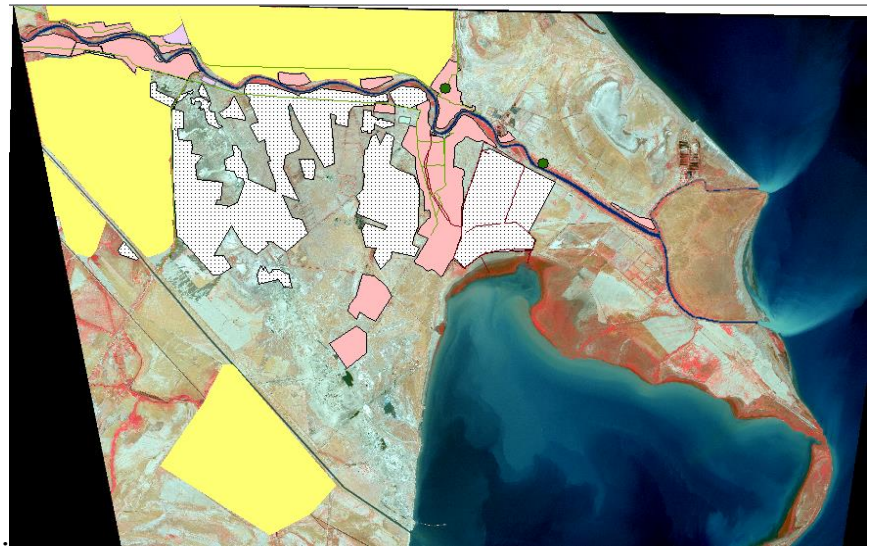

Figure 3: *ArcGis 10.4.1 in Neftchala area. conducting vectorization work through software*

Mapping works are carried out mainly in the coastal part of the Neftchala area close to the Caspian Sea, as well as on runoff waters discharged into the Caspian Sea, fishing facilities, unused land and other objects. Neftchala region is from Salyan to the north, Masalli, Lankeran to the south. It borders Bilasuvar and Jalilabad from the west, and the Caspian Sea from the east for 123-130 km.

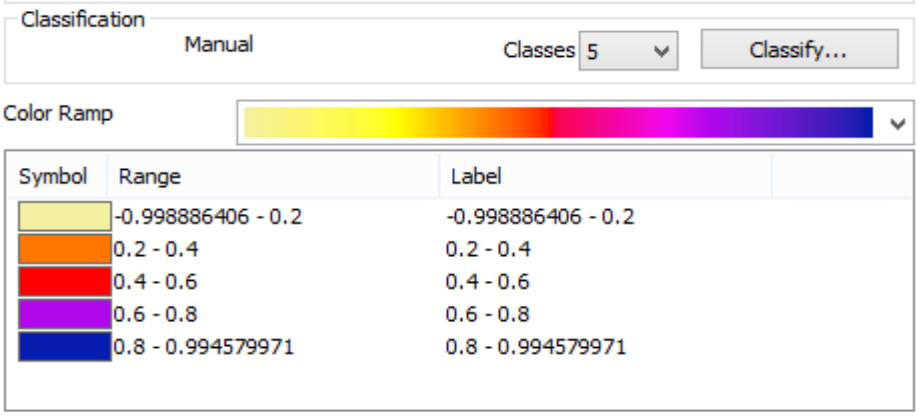

Figure 4: *Classification assessment of the Caspian Sea with NDWI*

In NDWI, a combination of green (Band_2) and near-infrared (Band_4) bands was used as a range for defining and delimiting the open water surface (1). The NDWI (Normalized Water Index Difference) index is expressed as follows.

$$NDVI = \frac{GREEN}{GREEN+NİR} \quad (1)$$

Here, NDWI - Normalized Water Index Difference
GREEN - Green range
NIR - Near Infrared range.

In our research, using the NDWI index, we were able to clearly determine the level of pollution of the Caspian Sea in our aerospace image. For more accurate monitoring, 5 values are included in the classification of the image (Fig. 4).

As can be seen from Fig. 5, the degree of water transparency increases from orange to blue. The white color represents dry land.

We clearly see that the Hasanabad channel in the Neftchala area coincides with the ground data mentioned above as a result of the email, and that it pollutes the Caspian Sea. The water discharged from the canal is represented by the orange color of the NDWI index according to the level of pollution.

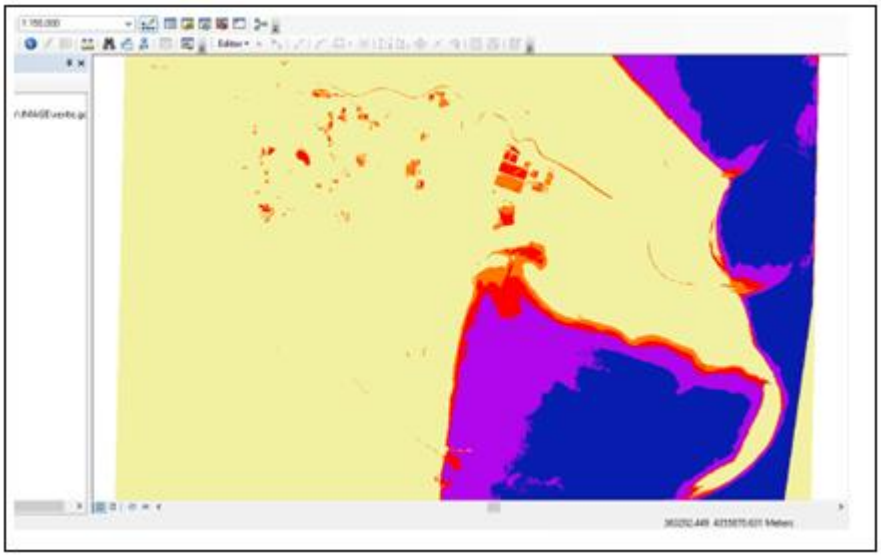

Figure 5: *ArcGis 10.4.1 of the Caspian Sea in Neftchala area. contamination rate estimation through software*

The cartographic basis for the oil pollution distribution map is the GIS-Caspian Ecological program overlay, which contains the following data: the coastline of the Caspian Sea, the hydrographic network (rivers and lakes), settlements, locations of oil fields on the shelf and on the coast, important oil pipelines of the region, the integrated scheme of the flow, digital model of underwater topography.

After preparing the cartographic base, an information layer containing data on the distribution of oil and oil products cover was added to the map. Then the layers are automatically combined and the final shape of the map is made.

The obtained map of the distribution of oil and oil products cover in the water area of the Caspian Sea characterizes its situation (real scale 1:1 500 000). The general pattern of distribution and transport of oil and oil products cover is related to the active exploitation of oil fields on the shelf and on the coast and is consistent with the global flow system of the Caspian Sea.

As can be seen from the map, the water area of the Caspian Sea is highly polluted by oil products. Due to the modern development trend of oil fields in the Caspian Sea, it can be concluded that if appropriate measures are not taken, the scale of pollution will increase. In this regard, the need to create an international oil pollution monitoring system based on a periodically updated map of their distribution, integrated with the geodatabase [2-4] is obvious.

In order to solve the issue of efficient use of resources, it is important to take an ecological-economic approach, and even to protect the environment and bioresources together with industrial activity in the shelf area. The main indicator of the level of change in the ecological situation is the concentration of pollutants and the distribution of areas in the water area. The analysis and evaluation of the indicators of oil products in the area of the Caspian Sea belonging to the Republic of Azerbaijan and the construction of maps based on the data collected in recent times have been of great importance in solving environmental issues.

As can be seen from Fig. 7, high-volume oil pollution (0.20-0.15 mg/l) in the Baku Bay area is characterized by the next result based on the average annual oil pollution data for 2017-2020. For these years, the average annual distribution of petroleum products areas in the Caspian Sea area was determined by the degree of pollution in those areas (0.09-0.06 mg/l). Analyzing the dynamics of the ecological situation based on the average annual calculations of these indicators and the

constructed maps is very useful for predicting the ecological situation in the future from a scientific theoretical point of view.

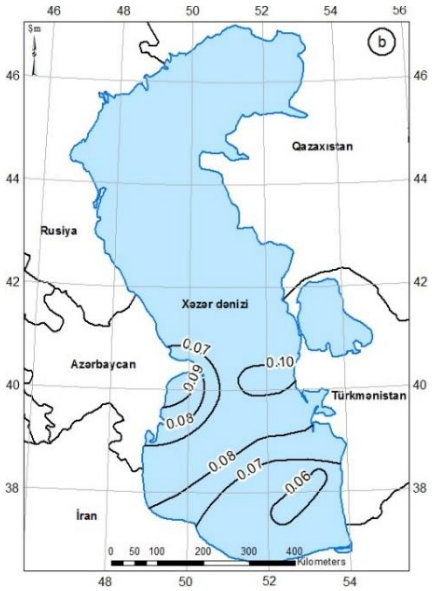

Figure 6: *Average annual distribution of oil products to fields for 2017-2020*

Crude oil spills on land and seas have created the need to develop environmentally friendly and efficient methods for cleaning up these pollutions. Petroleum hydrocarbons, which cover large areas of the water surface with the thinnest layer, reduce the amount of dissolved oxygen by reducing gas exchange. A surface layer that reduces water evaporation leads to a violation of heat transfer. A further decrease in the amount of dissolved oxygen is associated with the biodegradation of hydrocarbons by microorganisms. As a result of these processes, decomposition products that are toxic to living organisms also accumulate in water. In addition, in the presence of oil hydrocarbons, the toxicity of other pollutants, especially metals and chlorinated hydrocarbons, becomes more pronounced. Due to the negative effects on living organisms in the environment, it is necessary to eliminate the consequences of oil spills. As can be seen from the literature [5-7], in modern times, various reagents and there are many methods of cleaning oil-contaminated objects using adsorbents.

IV. Conclusion

Based on the NDVI and NDWI indices, the pollution dynamics of the coast line of the Caspian sector of the Caspian Sea were investigated, the values of these indices were calculated, the pollution zones corresponding to certain intervals were determined and the corresponding areas were calculated. It has been shown that using GIS technologies and remote sensing data, it is possible to calculate the change and pollution of the coastal zone of the

Azerbaijani sector of the Caspian Sea based on the values of NDVI and NDWI indices. The proposed methodology allows to easily calculate what part of the total area the research area is. The obtained results can be used in the assessment of the change trend of the objects and processes that shape the dynamics of the coastline in the following periods and in the preparation of predictive proposals.

Figure 7: *Integrated map of distribution of oil, oil products and surfactants in the Caspian Sea*

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