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Prediction, Monitoring and Mapping of Soil Salination through Remote Sensing

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ABSTRACT/ANNOTATION

In arid and scmi-arid word areas, soil salinization is one of the most important environmental issues due to its adverse impact on agricultural productivity and sustainable development. It must be recognized that unconscious irrigation and old watering methods are extremely damaging to fertile lands and hastening waterlogging and the accumulation of salt in the soil. In this study, we used methods for predicting and monitoring soil salinity in the Salyan and Nefchala regions. Most studies were previously focused on the qualitative differentiation of saline and non-saline soils by analyzing the distribution of salinity and monitoring its dynamics. Remote sensing (RS), geographic information systems (GIS) and modeling have recently surpassed traditional methods. This study considers the use of various satellite images to delimit soil salinity maps by drawing either salinity indices generated by different spectral bands or vegetation indices.

Key words: Geoinformation systems, Monitoring, Remote sensing, Soil salinity, Analyses.

INTRODUCTION

The application of traditional methods in monitoring and evaluating soil salinization in Azerbaijan in modern times is a cause for concern.

This article discusses the application of new technologies in monitoring soil salinization in Azerbaijan as well as in different regions of the world.

Our goal is to present a new example of monitoring soil salinization based on digital soil maps.

Monitoring of soil quality and salinization with new methods is proposed as the main direction.

Here, the advantage of remote sensing and modeling based on geographic information systems over traditional methods is brought into consideration.

In arid zones, it is impossible to obtain crops from cultivated plants without applying irrigation.

Therefore, it is necessary to use clean water sources for irrigation of such areas.

For a number of reasons, rivers have an easily changing chemical composition as a component of the hydrosphere, depending on weather conditions, the composition of atmospheric water, the geological structure of the earth and the composition of the rocks through which the water passes. [1]

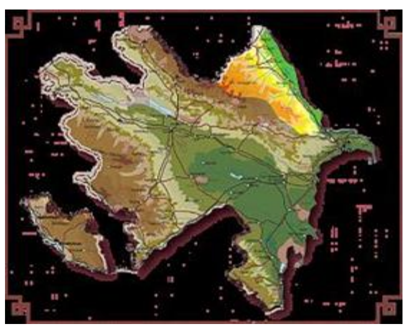
The composition and properties of natural waters, as well as other elements, have a certain influence.

Therefore, the concentration of salt in the soil and its changing value should be kept in mind by constant monitoring in irrigated arid areas. is one of the important measures.

In humid climatic conditions, in the washing water regime, salts do not accumulate because they are washed from the soil profile.

In regions dominated by a dry climate, especially in desert and semi-desert regions, evaporation several times higher than precipitation creates favorable conditions for the accumulation of salts in groundwater and soil-forming rocks.[3]

As a result of applying primitive methods of irrigation in soils prone to salinization, in addition to salinization of the soil, nitrogen and phosphorus salts are also lost in the soil, as a result of which the natural structure of the soil is destroyed.



Methodology and object of the research

The study covers the administrative territory (305,440 ha) of both regions, including the administrative territory of Salyan district (160260 ha) and the administrative territory of Neftchala district (145180 ha), which are 22-25 m below sea level.

This includes 45,193 ha of irrigated land in Salyan region and 38,158 ha in Neftchala region. The general area is connected to the Caspian Sea from the east. This area is the main agricultural regions of the country.

In our research, the actual issues of soil salinization were considered with the application of remote sensing technology as the main direction.

Remote sensing is based on the processes of absorption, reflection and scattering of sunlight by objects on the surface of the earth. The following ranges of electromagnetic waves were used here: ultraviolet 0.27 - 0 .4 µm, visible 0.4 – 0.78 µm, near infrared (IR) 0.78 – 0.9 µm, thermal 3.5 – 5 µm and 8.0 – 14 µm. The study of salinization with a new method is distinguished by the accuracy and promptness of the obtained results. [4]

In the research on salinization mapping, the information of multi-spectral and infrared rays obtained from remote sensing devices was used.

DISCUSSION AND ANALYSIS OF RESULTS

Mandatory intensification of agriculture for the purpose of obtaining more benefits, not conducting soil research and ignoring its results, improper management of land and water resources are the main reasons for increasing salinization. The current agricultural sector is facing problems such as global warming, water scarcity, soil erosion and so on.

During this period, it is an urgent requirement to identify the lands, make a digital map and conduct constant monitoring through it.

Here, there is no doubt that effective real assessment of salinization and its control is extremely important.

At present, monitoring using traditional methods (laboratory analysis, field tests) to determine salinity is considered insufficient and inappropriate, and it is also very expensive.

Recently, the application of electronic technologies, including satellite images and remote sensing methods, has made it possible to monitor soil salinity. A phenomenal evolution has occurred in monitoring methods.

The new method determines many mineral elements, organic substances, moisture, and iron oxides distributed in certain parts of the soil based on the correlation dependence of the reflection of the sun's rays from the earth's surface.

Modern ground-based and space-based sensors record the reflection of the Sun's rays from ground objects, as well as the specific heat radiation of the ground in the thermal infrared microwave ranges of the spectrum.

Such systems are passive remote sensing systems.

A certain space and time limitation has been taken into account in the study of the soil by aerospace methods.

So, depending on the geographical conditions of the area by repeating the measurements several times in certain seasons, the properties of the soil were evaluated more accurately. The characteristics of absorption and reflection of electromagnetic waves of the soil are mainly influenced by the following parameters: mineral content, particle sizes, structure and surface smoothness, amount of iron and organic (humus) compounds, leveling, etc.

Repeating aerospace measurements has allowed some variable parameters to be averaged and accuracy of measurements to be increased in soil surveys.

The mineral composition of the soil takes the first place among the parameters that affect the spectral characteristics of the soil and the composition of the soil.

Depending on the influence of individual minerals, reflection coefficients and signal strength vary.

At the same time, the reflection and absorption of energy varies depending on the amount of sand and clay, iron oxide, organic matter and salts in the soil.

A comparison of the results obtained during laboratory and field investigations shows that the granulometric composition of the soil also affects the reflection of energy.

For example, the spectral reflectance intensity of sandy areas in field conditions was higher than that of soil mainly composed of clay.

However, in laboratory conditions, in the range of 0.45-2.5 µm, the comparison of the radiation of sandy and clayey soil shows that the clayey soil reflects the radiation more. becomes high.

This is explained by the fact that, in field conditions, the degree of smoothness of sand-containing soils is greater than that of clayey soils, so its coefficient of erosion is high.

In principle, the soil cover reflects the flood of light falling on it very poorly. As the wavelength of the incident energy increases, the strength of the reflected signal increases. The spectral characteristics of the soil are more clearly reflected in the near, medium and thermal regions of the red spectrum of the visible region.

This method is an effective method determined by spectroradiometric measurement of light reflection and absorption abilities based on different color shades of mineral salts and soil moisture.

In the research, different indices of salinity and distinguishing values of plant indices were used. In this case, the salinization indices are more accurately evaluated, especially the plant and salinization indices affect the results according to all natural conditions.

Thus, the indices vary according to variable natural conditions, soil type, vegetation and depth.

In this way, the soil salinity has been selected more sensitively in the base of the indicators of visible spectral bands. In the case of plant indicators, the normalization of different plant indices is considered an uncertain indicator. The presence of chlorophyll in plants causes confusion in determining salinity.

Thus, errors are made in the classification due to mixing of the spectral patterns of Different Vegetation Index Normalization (NDVI) with salts. However, the determination of different salinity levels for different salinity plants has also been useful in salinity assessment.

Thus, to eliminate such cases in the classification, taking into account the Adjusted Soil Vegetation Index (SAVI) and other indicators helps to separate plant and soil signals.

In addition, the Generalized Vegetation Indices (GDVI) affect the results of the separation of salinity indicators at certain times of the year.

In this study, results were obtained by measuring the amount of salt in the soil using the estimated salinity (GDVI) model in the studied area with an accuracy of R2=0.86.

It is considered optimal to receive information in more spectral channels.

However, the physical properties of the atmosphere (mainly absorption and scattering) prevent this to be done in all spectral ranges.

Despite this, at present, the information received from multispectral satellite sensors has been proven to be more accurate with alternative means.

Laboratory analyzes were carried out by taking samples from the selected areas in order to clarify the remote sensing data and also to study the salt content. The main indicators of soil salinization are different with the presence of cations - $Na+$, $K+$, Mg_2+, Ca_2+ and anions - CO_3-, HCO_3-, $Cl-$, SO_2 in the soil. formed due to salt compounds. $Na+$, $K+$ salts are more dangerous for plants. The amount of $Na+$, $K+$ cations was measured with the iCAP 7200 ICP-OES Duo device and the flat contents of the soil were calculated.

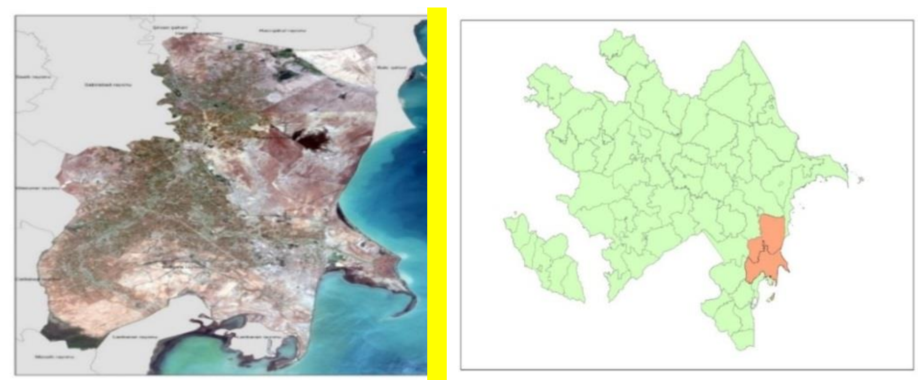


Figure 1. Location of the area

During the study, a Managed Classification (MLC) operation was performed for the accuracy of the results.

Here, the main goal was to match the classification results to the sample values collected on the basis of field samples, thereby determining the salinity rates corresponding to the natural salinity rates throughout the area.

Digital Elevation Model of the area and land cover and land use land cover (landcover) map was used.

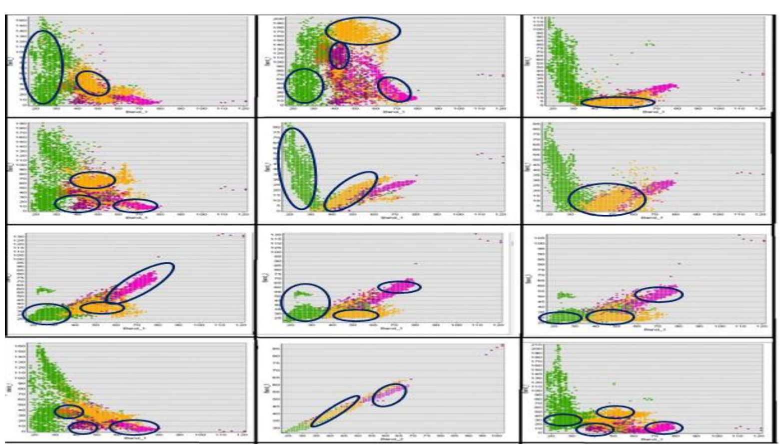


Figure 2. Differentiation of classes

The difference of pixel values in different band combinations of used satellite images and indices of different dates prevented misclassification of areas with close value but not salinity.

At present, the drawing up of salinization maps with multispectral satellite sensors is considered satisfactory.

Mapping with minimum cost-capacity images prepared on such a principle shows the condition of the earth's surface.

Nevertheless, multispectral information has limited diagnostic potential. [4].

Basically, the accuracy of multispectral data is low. There are hundreds of facts about the use of multispectral images in determining salinity.

In such studies, it is considered necessary to achieve appropriate accuracy by determining the salts collected on the earth's surface with field studies.

When the amount of salt reaches 15%, it becomes very difficult to separate it from other ingredients on the surface of the earth.

Salinity maps with multispectral images may have significant limitations in some cases where halophytic vegetation dominates the surface or other non-saline data. [5].

It should be noted that in reflection with multispectral sensors, non-saline soils are confused with areas without vegetation. Such areas include bare soils and rocks without vegetation.

Recently, hyperspectrometers have been used to solve remote sensing problems. Hyperspectrometers have more than 100 channels, which allows to increase the volume and quality of received information. In these systems, the visible, near, and mid-infrared ranges are divided into narrower bands. [4].

Hyperspectral sensors are suitable for selecting narrow and unique adjacent color bands and have the advantage of having sufficient information to distinguish similar spectra.

Hyperspectral air sensors have significant advantages over multi-spectral sensors for detailed mapping of salinity on the earth's surface by separating spectral bands with high precision that allow distinguishing vegetation.

Salt-resistant and salt-sensitive vegetation of a general nature is affected in minimally weak and mildly salinized soil areas.

There are certain difficulties in the selection and mapping of lightly spotted salinized areas between the salinized and non-salinized areas exposed to such effects.

Therefore, it is considered more appropriate to use hyperspectral weather data to obtain valuable data for conducting salinization monitoring in large areas, having intermittent and periodic information. [5].

In general, it is important to have a comprehensive strategy to reduce the impact of soil salinization, which is more often observed among agricultural and environmental problems.

Therefore, it is inevitable to change the current irrigation and crop management methods in arid zones.

RESULT

In the end, a digital salinization map classified by salinization degrees and areas was prepared.

Thus, based on the results of the project, the area of distribution of soils on the Salyan plain according to the degree of salinity was determined.

Table 4. Distribution of soils in Salyan region according to degree of salinization

S.s.	Salinity rates	Area (ha)	Area (%)
1	Unsalted	38783	24.2
2	Weakly salted	9295	5.8
3	Medium salted	30610	19.1
4	Severely saline	58816	36.7
5	Salty	22756	14.2
Total		160260	100

Table 5. Distribution of soils in Neftchala district according to the degree of salinization

S.s.	Salinity rates	Area (ha)	Area (%)
1	Unsalted	38763	26.7
2	Weakly salted	22358	15.4
3	Medium salted	26568	18.3
4	Severely saline	45731	31.5
5	Salty	11760	8.1
Total		145180	100

Table 6. Distribution of soils in the Salyan plain according to the degree of salinization

S.s.	Salinity rates	Area (ha)	Area (%)
1	Unsalted	77582	25,4
2	Weakly saline	31766	10,4
3	Medium salted	57422	18,8
4	Severely saline	104460	34,2
5	Saline	34210	11,2

Total	305440	100

Due to the fact that the main part of the irrigation and collector-drainage networks in the study area is of the soil channel and open type, along with the occurrence of high water loss, the rise of mineralized groundwater to the crop layer has caused repeated salinization of the surrounding soils.

At present, the development of agriculture without the establishment of a collector drainage network in the land areas newly involved in the crop rotation has also intensified soil salinization.

Continuous monitoring of soil salinization in current land use does not allow to control risks in salt-prone soils.

Collecting laboratory data by conducting field research to monitor soil salt quality over large areas requires a great deal of time and money.

There were positive results of the monitoring conducted using remote sensing tools. The joint performance of remote sensing data and laboratory analyzes ensured more accurate and prompt collection of monitoring results.

Application of such an advanced method not only reduces the difficulty of field research in large areas, but also minimizes the necessity of frequent trips to the regions.

Here, as a result of the preliminary analysis of remote sensing data, the areas where it is necessary to take soil samples are precisely determined.

Forecasting and monitoring of soil salinization using satellite data is digital besides actualizing the use of maps, it eliminates the additional loss of time of farmers and other users. The application of remote sensing technology plays an exceptional role in increasing productivity by providing the opportunity to ensure the appropriate selection of cultivated plant species by promptly obtaining information about the danger of soil salinization. notifies users of salinization in advance without going to large areas.The conducted research focused on determining the elements of salinization differential salinization in salinized and non-salinized areas.

Recently, the development of salinization maps of large areas using Remote Sensing and GIS modeling is very important for agriculture and environmental protection.

It is important to interpret the advantages of detecting changes in the fine details of the salinity environment by means of remote sensing.

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