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Monitoring of the Abrasion Processes (by the Example of Alakol Lake, Republic of Kazakhstan)

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ABSTRACT

The purpose of the study is to analyze the abrasion processes in the regions of dynamically changing Alakol lakeshores. Using the field method, methods of positioning by the GPS receiver and interpretation of remote sensing data, the authors determined that abrasion processes actively contributed to the formation the modern landscape, causing the occurrence of landslide processes due to trimming coastal cliffs. It influences the dynamic mode of coastline, which currently stands in the sea or in the form of capes in the areas of solid rock, or juts out into the bay with a beach by narrow pebble beaches. The results showed that the lakeshores retreated to 60-100 m (from 1990 to 2015). The suggested method of installation reefs may help to increase bio-productivity, to perform the functions of self-purification of sea water and to reduce the process of destruction of the shores of Alakol lake.

KEYWORDS
Abrasion, relief-forming processes, shores destruction, lakeside niche, submarine reef

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Introduction

Relief, especially its development, plays an important role in assessing the environmental safety of the surrounding space and management of the safe use of natural resources (Schultz, 2015; Velichko & Spasskaya, 2002). This role is reflected in multiple forms of the specific exogenous processes and phenomena changing the shape of the environment (Sharapov, 2013; Ermolaev, 2015). At the same time, great importance has dangerous relief-forming processes, having negative consequences, claiming the lives of people and causing serious damage

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(Veličko & Spasskaâ, 2011). Thus, the study of abrasion process threatening to settlements, to the normal functioning of industrial objects and engineering facilities in the regions of dynamically changing shores of Alakol lake is relevant in the context of modern research.

Literature Review

One of the modern scientific research directions of the processes occurring on the Earth's surface is the study of long-term changes of environment including abrasion processes by means and methods of RS (Whipple, Hancock & Anderson, 2000; Zobeck, 2003; Gaynullin, Sitdikov & Usmanov, 2014). Satellite information provides both operational control of seasonal changes in the Earth's surface, as well as the possibility of long-term research processes (Haines-Young, Green & Cousins, 2003).

Can note that abrasion refers to problems that require careful consideration of its causing prerequisites, monitoring of the coastline and shore protection works in places where this process is especially pronounced (Mitrofanova, 2002). Scholars agree that the most problematic forms of abrasion are lake terrace, cliff and niche (Sharapov, 2013; Kurdyukov, 1951).

Studies confirm development of process of retreat of the coastline, on the one hand, is determined by the natural conditions (Bird, 1985; Li & Gong, 2016), and on the other, can be a result of the human activities (Limber & Murray, 2011; Granja & de Carvalho, 1995).

At the same time, scientists argue that climatic conditions, mainly wind regime and unrest, have the greatest impact on the formation of the coast (Velichko & Spasskaya, 2002; Bai et al., 2011).

Hydrological feature of Alakol lake system, which located in the eponymous intermountain hollow in the south-east of Kazakhstan, are relic water bodies occupying reduced part of the ancient lake basin of tectonic origin (Kurdyukov, 1951). A.V. Sidorenko (1997) has pointed out that water conditions and sustainability of water ecosystems of lakes are mainly supported by the river network, which consists of rivers.

In this regard, it is important to conduct a comprehensive analysis of all relief-forming components in order to identify the causes of the abrasive processes in the selected area.

Aim of the Study

The aim of the study is to examine the abrasion processes in the regions of dynamically changing Alakol lakeshores.

Research questions

The research questions were as follows: What is the dynamics of Alakol lakeshores retreat? How does it affect the environmental change?

Method

The research methodology structured as on traditional as well as on innovative methods - cameral and field methods, methods of positioning by the GPS receiver, descriptive, comparative, interpretation of remote sensing (RS) data, cartographic works with application ArcGIS 10 software. In addition, the

results of previous research and the approved author's techniques of assessment and mapping of abrasion processes were used.

The main factors in research area selecting were an economically advantageous geographical position, especially the south-western and south-eastern coast of Alakol lake in terms of rapidly development, recreational activities; transport accessibility, the close proximity of cost-effective for field work and monitoring of abrasion processes.

Can add that according to the results of field research a supervised classification of satellite imagery was carried out. Moreover, the area of coastal retreat abrasion processes was defined. In this regard, we offered a number of suggestions and management activities of safe nature management.

Data, Analysis, and Results

Climate of research area is continental and dry, relatively cold, windy winter with less snow. The average annual temperature varies between 6,2-7,2 degrees, the absolute maximum temperature +42 in summer, -40 in the winter. Precipitation is unevenly distributed, depending on the terrain. In the south-western and south-eastern plains parts the average annual rainfall varies between 100-250 mm. Most precipitation falls in April-May and November-December.

Winds are causing severe unrest, it destroys in one place and builds coast, spit and in another. This geological structure (most parts of rocks are easily eroded) determines the mobility of coastline and the rapid pace of its development. Prevailing direction of winds in the research area north-east, south-east and north-west. Average annual wind speed 2-4 meters per second, and in the region of Dzhungar gate the strongest winds reach 70-80 meters per second. Hurricane-force winds in the northern and southern parts do not occur simultaneously and have opposite directions: in the northern part is dominated the south-east direction (evgey), in the south - the north-west (saikan) (Integrated studies of the tourism potential of Alakol basin for development of recreation and tourism. Research report on line MES (2012).

Specific feature of Alakol lake is the presence powerful underground supply by ground and artesian waters which formed in the mountainous areas and alluvial fans of rivers. The total inflow to the underground lake is (mainly in the Alakol lake) 0.8 km3 per year (Bexeitova, 2010).

The hydrographic network in research area is underdeveloped. The rivers Urdzhar, Katynsu, Emel flow into from northern and north-eastern part. Small rivers like Zhamanutkol, Rgayty, Zhamanty drain from the southern and south-eastern part, but their water don't reach to the lake, their stock is characterized by short-term spring floods. But a lot of temporarily existing watercourses, the original form of which - the erosion furrows, and after a period of time - gully erosion. Intensive gully erosion stimulates the abrasion and promotes rapid retreat of the coast.

Throughout in Alakol hollow developed the deflation of soils - one of the negative ecological and geomorphological processes, aided by both natural as well as relief-anthropogenic factors (Veselova, 2013).

Investigated the southeastern and south-western part of the Alakol cavity refers to the undifferentiated Quaternary aquifer system mainly alluvial deposits proalluvial.

Figure 1 shows the depth of the groundwater and the boundaries between areas with different depths. The lowest depth and close proximity of confined to the coastal part of the basin where it is located on. Kabanbai depth of 0-5 m. As the distance from the basin there is a gradual increase in depth. In the area. Koktuma depth to groundwater is 10-25 m. In terms of lithology water-bearing complex is represented by coarse sand, clay, detrital clay, loess and effusive rocks.

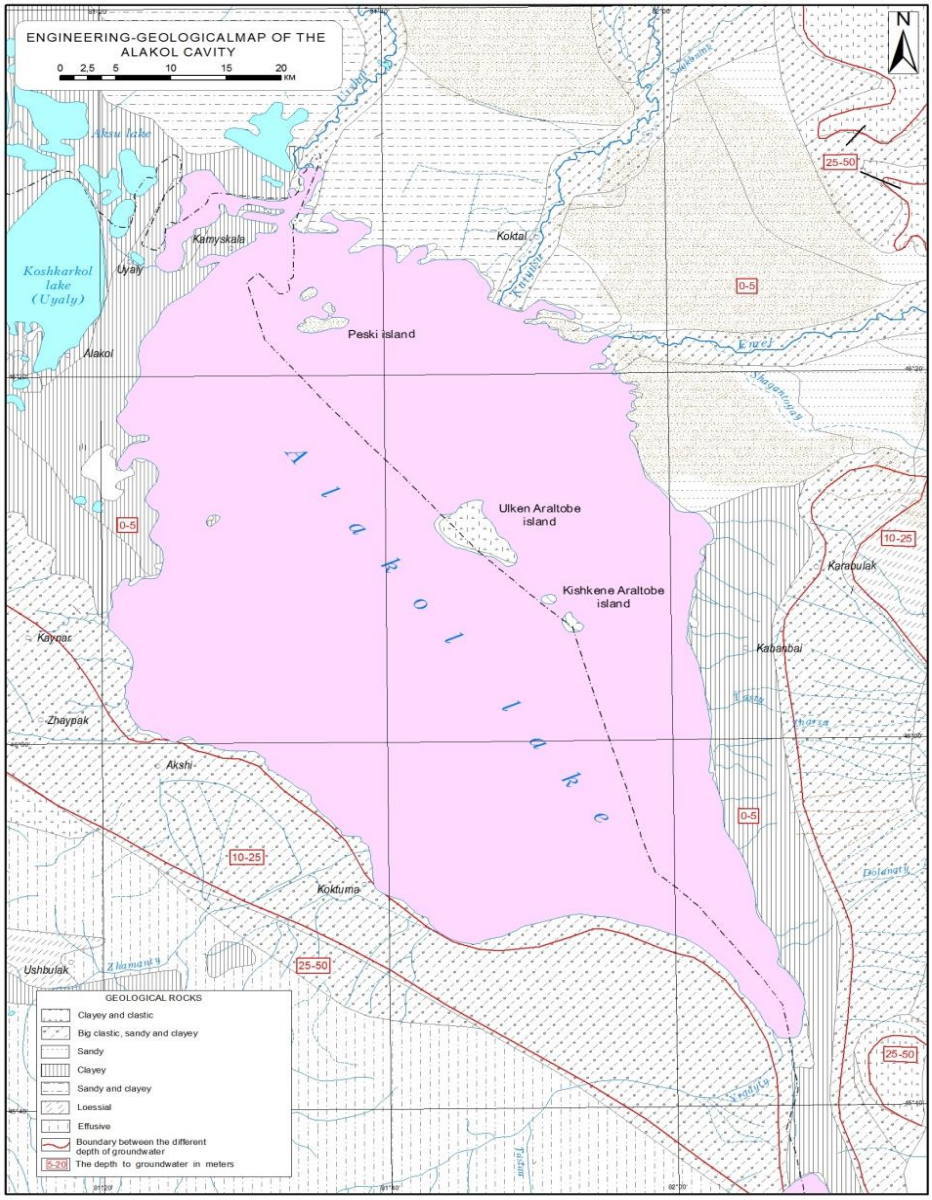


Figure 1. Engineering-geological map of the Alakol cavity

On the basis of geological maps of Quaternary deposits and field reconnaissance work of the working group, made up of the geological section of the coastal villages and Koktuma Kabanbai which is shown in Figure 2 in the section and in the photo clearly shows the boundaries of the terms of rocks with a loose mechanical structure, where abrasion resistance is directly depends on the lithology.

This geological structure and proximity of groundwater and groundwater (most easily eroded rocks) causes instability, mobility coastline and the rapid pace of its development (Kurdyukov, 1951).

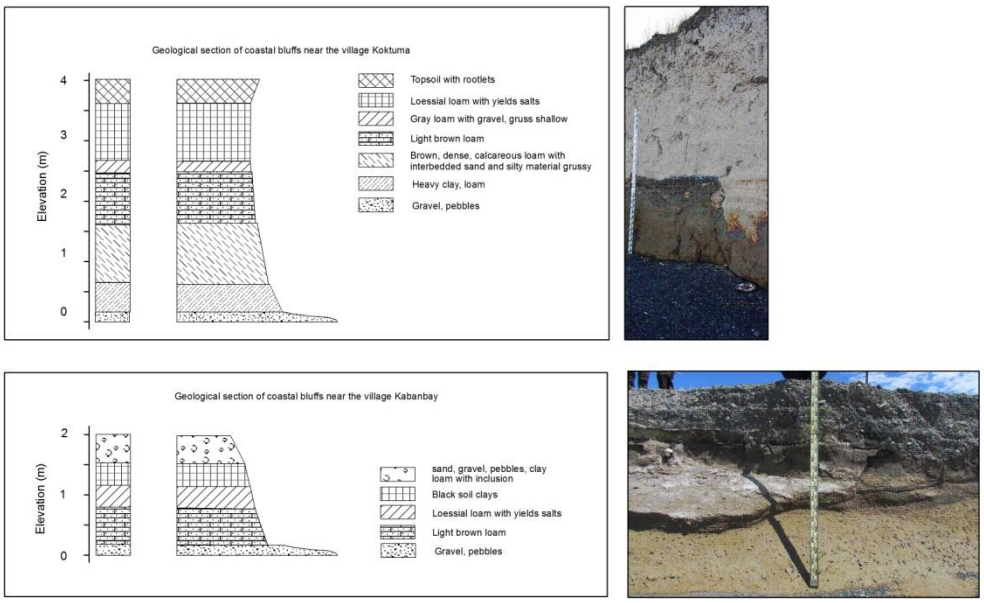


Figure 2. Geological section of costal bluffs near the village Koktuma and Kabanbay

Abrasive-accumulative processes developed in the coastal zone of Alakol lake have intensified currently on the background of the newest raising of the lake water level. The fluctuations of level reaching in a long-term section of 5-6 m, accompanied by significant changes in the coastline. The lake Alakol in the southeast of Kazakhstan has entered into a phase of next cycle of water rise. Recycling shores in various parts of the lake flows with different intensity depending on the direction of the resultant wave, parameters of the wave regime and geological structure of the slopes (Korovin, 1965).

In the last twenty years have been relocated 3 streets. If the water level will continue to rise, then under threat of flushing may be a local cemetery and railroad which are located 150 meters from the water's edge. In the village Kamyskala residential and administrative buildings in the last 50 years were already transported three times. The potential threat of flooding is not yet fully eliminated (Bedareva, 2000).

In the Figure 1, on the shore of the lake Alakol we can see boundaries of both denudational and accumulative lake processes. The height of the cliff is 3.5 m. The beach is 2.0 m wide folded pebbles. On the first terrace of the lake located pensions. At the edge of the ledge - destroyed houses, 70 meters off these homes are located new pensions. The gradual retreat of the cliff towards the

land increases the width of the accumulative foreshore lying at its foot (figures 3-5).

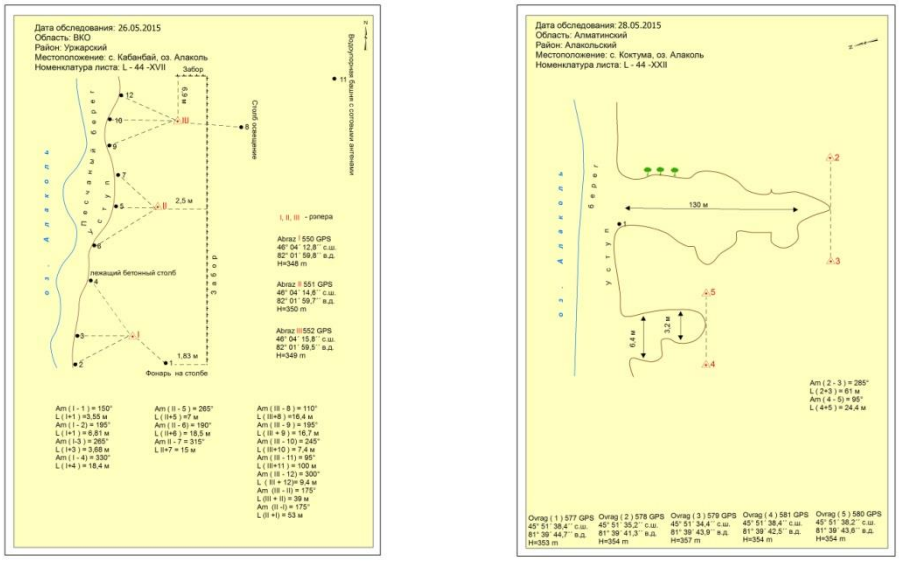
Figure 3. The formation of the cliff, niche (denudation) and the beach (accumulative) Lake Alakol, village Kabanbay.

Located on the lake terrace recreational, residential or industrial buildings were in the risk zone and the need to study coastal processes is obvious. Laboratory of Geomorphology and geoinformational mapping of Institute of Geography conducts monitoring abrasion processes of Alakol lake, by the example the villages Located on the lake terrace recreational, residential or industrial buildings were in the risk zone and the need to study coastal processes is obvious. Laboratory of Geomorphology and geoinformational mapping of Institute of Geography conducts monitoring abrasion processes of Alakol lake, by the example the villages

Figure 4. The coast niche Alakol lake, village Akshi

Figure 5. The village Akshi, Alakol lake, 1. terrace of lake, 2. scree, 3. low beach

Kabanbay and Akshi. During the field research were compiled passports, setting the vielbein by the profile (figure 6) and were examined destructive abrasion processes that negatively affect both on coastal strip and consequently on human economic activity (figures 7, 8).



a) **b)**

Figure 6. Setting the vielbein by the profile. (a) Kabanbai village, b) Koktuma village)

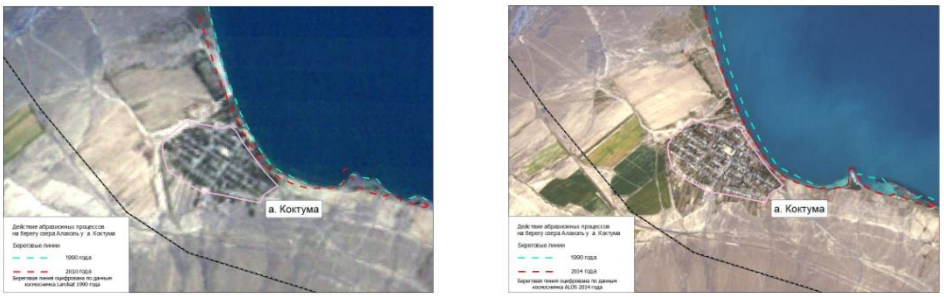
Figure 7. Destruction coast of Alakol lake and the negative impact of abrasion processes at village Kabanbay

Figure 8. The destruction of the coasts near the village Koktuma (dangerous approach to the line of inhabited constructions)

The accumulation space data of different spatial resolution for a certain period allow to estimate extent and trends of ongoing changes (Bexeitova, 2010).

In this regard, we collected the material by space images in 1990 Landsat 7 and ALOS in 2014, where dynamics abrasion processes from 1990 to 2014 was determined by geoinformational method, by the example of village Koktuma and village Kabanbay (figures 9, 10).

Coastlines have been digitized by the above mentioned space images for the given period and on the map we can see how the retreating coastline of Alakol lake for 25-year period in the village Koktuma within a radius from 60 to 100 meters and in the village Kabanbay dynamic range from 70 to 100 meters.



a) b)

Figure 9. Dynamics abrasion processes on the coasts of Alakol lake at the village Koktuma, a) Landsat 1990 y., b) ALOS 2014 y.

a) b)

Fig. 10. The development of abrasion processes on the coasts of Alakol lake at the village Kabanbay: a) Landsat 1990 y., b) ALOS 2014 y.

Discussion and Conclusion

Current relief-forming processes are reflected in many scientific works. For example, the research of O. Ermolaev (2015) confirms our thesis that modern exogenous processes develop in close depending on the nature of tectonic movements, structural and lithological conditions, topography, climate change and human activities.

The abrasion processes in the regions of Alakol lakeshores also were studied by A.H. Mitrofanova (2002). She determined that in the period 1963-1965 yy. stripe of retreat was 300-400 m and the intensity of the destructive processes was not less than 30 meters per year.

L.A. Bedareva (2000) observed that in February 2006 in the village Koktuma for three days were washed away by water 6 houses with farm buildings and 12 had been partially destroyed by hummocks. After the storm, about 20 meters of land remained under water. In summary, in the village Koktuma the street up to 300 m wide was eroded. Our submissions show that erosion continues.

It is pertinent to point out that the application of camera and field methods is one of the most common ways to examine the consequences of relief changes. For example, using the similar research methodology, F. Akijanova (2001)

determines the impact of desertification of the Kazakhstanian zone of the Caspian Sea on degradation of the many environmental components.

Can note that if in the near future is done nothing active steps to improve of activities for the conservation of coast of our unique lake, it may lose important recreational value for locals.

The regional administration allocated money for coast protection works. One pier which length is 168 meters is already constructed (figure 11). In the village Kabanbay breakwaters are also fitted (figure 12).

Figure 11. Pier to protect the coastline of Alakol lake, village Kabanbay

Figure 12. The breakwaters to protect the coastline of Alakol lake, village Kabanbay

To sum up, we have analyzed the scientific foundations for ensuring ecological and geomorphological assessment of abrasion processes, including methods of assessment and mapping. Furthermore, proposals for monitoring the abrasion processes of the Alakol lake were considered.

The results showed the dynamics for 25-year period in southeastern and southwestern coastlines. Thus, the lake shore retreated to 60-100 m. Therefore, we propose to revise the issue of the protection of the coast.

In contrast to our severe, the world's submarine reefs are located mainly at the sea coasts with warm climatic conditions. Nevertheless, we consider that the proposed method of installation reefs will help to solve the above problems of the Alakol lake because it aims at increasing the bio-productivity by creating an enabling ecosystems in the artificial reef, performing the functions of self-purification of sea water. Moreover, it will be helpful for reducing the process of destruction of the shores of Alakol lake and also for increasing of the beach area.

Implications and Recommendations

On the basis of analysis of international experience the authors have been offered other types of shore protection works. In particular, these are artificial submarine reefs, which should strengthen the coasts, increase the area of the beach, promote fishery production, and develop water types of tourism and recreation. Such constructions should improve the biological cleansing of water and the bottom.

Economic effects of the suggested model are also possible. For example, $1 invested to the industrial development of artificial reefs annually can bring about $130-150 dollars profit. In addition, new jobs are creates, the seaside towns and villages are revived, and highly profitable fisheries with large financial capital are created, and tourist industry are developed.

Disclosure statement

No potential conflict of interest was reported by the authors.

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