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ANTHROPOGENIC FACTORS CONTRIBUTING TO THE ECOLOGICAL CONDITION LANDSCAPES IN THE MINING ZONES OF IMERETI AND RACHA

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Abstract

A comprehensive landscape study was carried out in the coal mining area of Tkibuli-Shaori and the teschenite mining area in Kursebi. The article describes changes in the landscape, soil and vegetation and their specific ecological properties in the mentioned areas. A large scale map (1: 50 000) of Tkibuli Municipality has been designed with GIS by drawing on literature, expedition materials, satellite and aerial images and topographical maps. Zones of ecological stress have been revealed. Significant transformation of relief, intensification of geodynamic processes (landslides and mudflows) and groundwater contamination were identified as top risks related to coal mining. Open cast teschenite mining in Kursebi results in a high number of technogenic pits deprived of soil and vegetation and in low quality anthropogenic landscapes. The following anthropogenic impact zones can be distinguished: 1. A severe impact zone where vegetation and soil are completely destroyed and changes in micro-relief, and consequently in climate, trigger landscape transformation. 2. A zone adjacent to a mining site. 3. A transitional zone between post-mined and natural landscapes which is partially destroyed and altered.

Key words: Anthropogenic factor, Ecological condition, landscape, Mining Zone.

Introduction

The mining works carried out in ore mining complexes are geodynamic, geochemical, physical, technogenic and other kinds of reasons of the influence on the environment. Such activities cause dramatic changes in the environment of the ore mining areas in mountainous regions. The region of Imereti is under strong anthropogenic pressure. In this regard we should note the manganese ore in Chiatura, the coal ore in Tkibuli, the teschenite ore in Kursebi, the marble quarry in Salieti, the white and colour stone quarries in Eklari and etc. There is extremely hazardous situation on the territory adjacent to the arsenic ore in Lukhuni. The ecological assessment of the landscapes includes versatile studies of the landscapes, the analysis of their quantitative and qualitative characteristics, determination of the tendencies in the variation and development of the landscapes after anthropogenic impacts.

Materials and methods

During the studies we mainly used complex physical-geographical, cartographical, field and GIS analysis methods. We distinguished the morphological landscape units on the basis of the field materials obtained in 2016-2018 and the analysis of aerial and space photos and topographic maps. For the construction of the landscape map we used GIS technologies as ArcGIS and applied aerial photos from Google Earth.

Results and discussions

The main object of our landscape-ecological study was the Tkibuli-Shaori coal ore and the Kursebiteschenite ore in the mining industry regions of Imereti and Racha.

The Tkibuli coal ore was discovered in 1825 and its exploitation began in 1846. The active reserve of the coal is 307 million tons and its general geological reserve is approximately one billion tons. During the century and a half long history of coal mining its highest output was recorded in 1958 when 3014 tons of coal was mined out (Fig.1). It was 603 times more than the one in 1997 when the output of the ore mining was the lowest (5 thousand tons) [1]. It is obvious that during this long-term period (172 years) an anthropogenic impact on the environment was intense. Moreover, it is important to take into consideration

the physical-geographical conditions of the ore site as far as the seismic activity, complicated geological structure, steep sloping of the relief surface and air humidity in the region make the intensity of the impact on the environment higher.

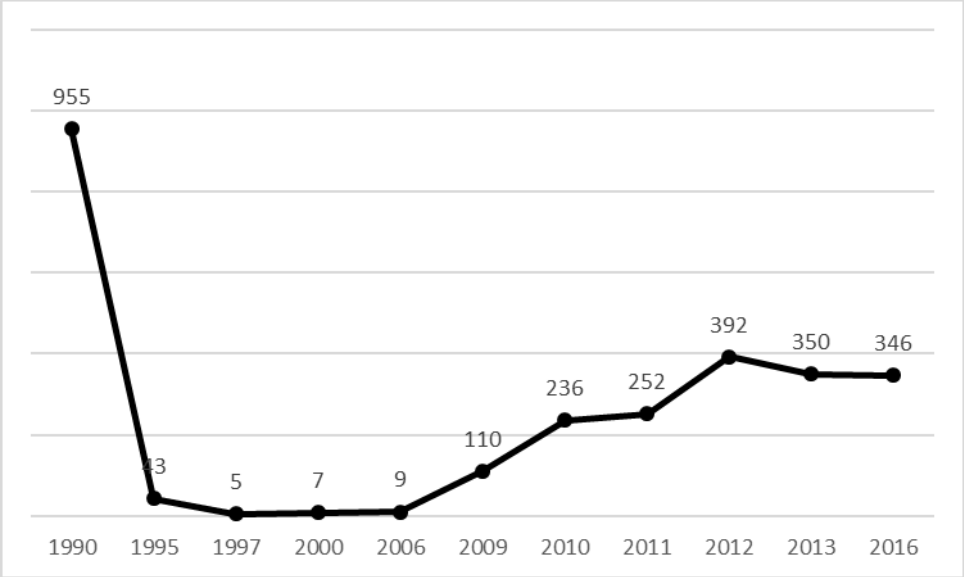

Fig.1. Coal mining output in Tkibuli coal ore

The Tkibuli-Shaori coal ore is situated on the territories of the municipalities of Tkibuli and Ambrolauri. Approximately 75% of the general reserve of different kinds of coal revealed on the territory of Georgia comes on the Tkibuli-Shaori coal ore. The Tkibuli part of the Tkibuli-Shaori coal ore, which includes the town of Tkibuli and its vicinities, is mainly characterized with hilly relief and is located on average at 700-800 m above sea level in the Tkibuli Hollow (in the north-east part), which covers the basin of the river Tkibula in its upper and middle reaches. The hollow is surrounded with the southern slopes of the Nakerala Ridge (the branch of the Racha Ridge). It is built of Jurassic sediments, Bajocian porphyritic suite, Bathonian slates, coal suite, Lower Cretaceous sediments.

The Shaori part of the Tkibuli-Shaori coal ore is situated in the Shaori Hollow of tectonic genesis. Its surface is located at 1000-1200 m above sea level. The hollow surface is less fragmented and its central part is occupied by the Shaori Reservoir nowadays.

The charcoal suite has precipitated parallel to the Nakerala Ridge and has 33-45° inclination and as it sinks deeper in the direction of the slope the inclination gradually decreases to 20-25° [2]. The charcoal-bearing horizons are situated at different depths from the surface, namely in the south-west of the vicinities of Tkibuli town the charcoal layers are observed on the surface, whereas on the surface of the Nakerala Ridge they are located at 1600 m depth and on the Shaori Hollow such horizons are observed at 300-700 m depth from the surface.

The study territory is mostly covered with forest flora with abundant tall timber terrace formations. Oak, hornbeam and chestnut trees are observed in the lowlands and in the midlands we meet beech and dark coniferous forests.

The relief mainly consists of low mountains, at some parts – with middle size mountains. It is characterized with hilly structural-erosive genesis, intensity of landslide-karst processes, mudflow jut cones, erosive hills, landslide forms, coal suites, transformed anthropogenic relief. The absolute altitudinal levels vary from 529 m (the southern part of the hollow) to 1570 m (the mountain Tskhrajvari). The climate is maritime subtropical damp with moderately cold winter and warm summer. The average annual temperature is 12°C; the annual quantity of precipitations is more than 1400 mm [3]. The bottom of the hollow is crossed by the river Tkibula and its numerous tributaries.

The landscape background is mainly presented with hilly erosive-denudational landscape with hornbeam and oak trees, oak and chestnut forests and evergreen undergrowth in the foothill and low mountains.

The Tkibuli part of the Tkibuli-Shaori ore, where the charcoal is mined, covers approximately 40 m^2.

In the past (the 40-s of the XX century) the charcoal was extracted from open cast mines in Tkibuli. Therefore, there are many small secondary artificial holes with the depths of 25-30 m and length of 12001500 m. The areas of each of them are 9 ha [4].

In the ore mining region of Tkibuli not only individual components of the nature are under anthropogenic pressure but the whole landscapes as well. In order to make the analysis of the interaction of the technogenic activities and nature and the assessment of the ecological state in the industrial complex we constructed a large-scale (1:50 000) landscape map (Fig. 2) in GIS technology. The map expresses the location of the modern landscapes and their spatial interrelation.

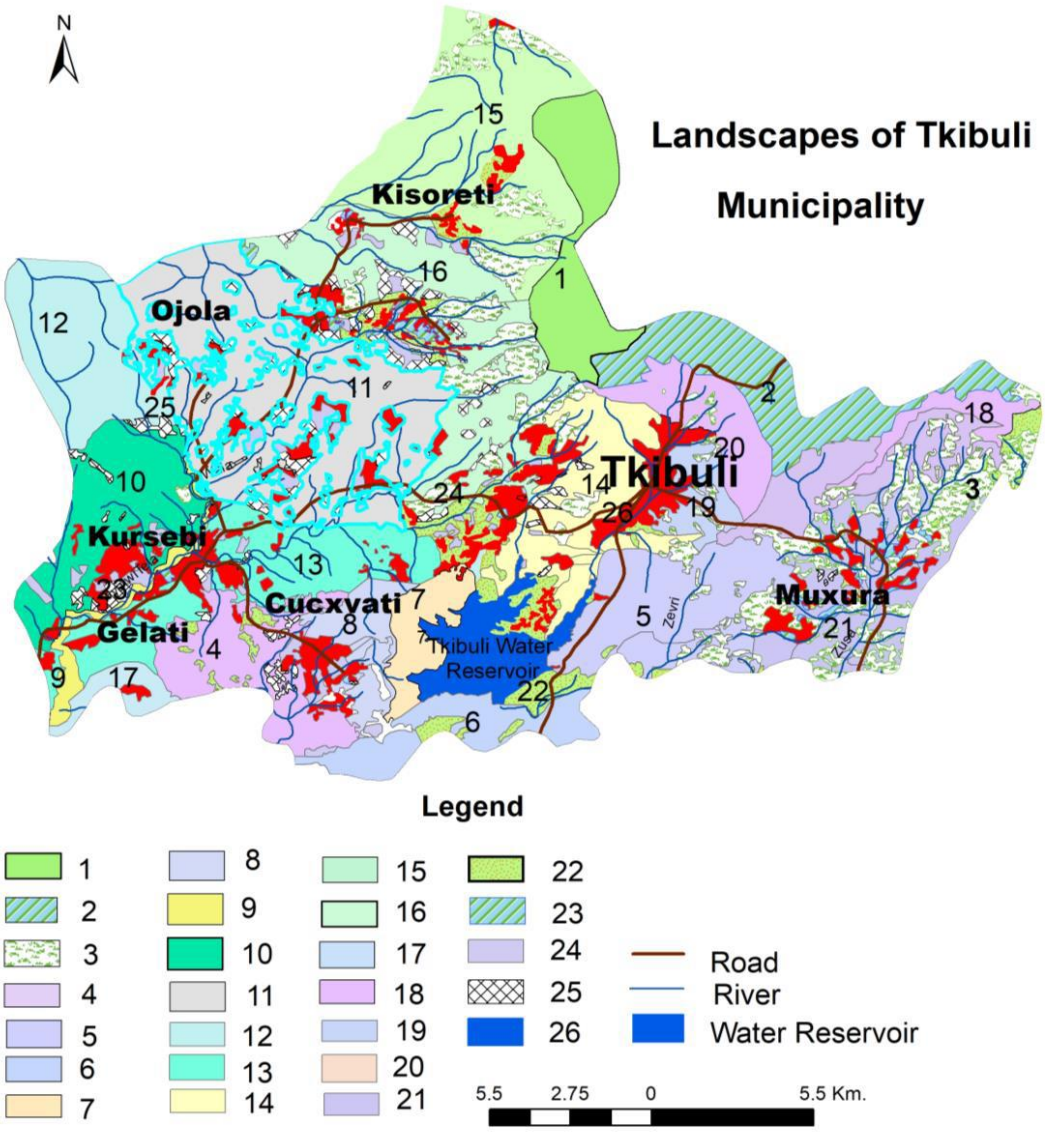

Fig. 2. Landscapes of Tkibuli Municipality [2, 5]

Landscapes: 1. The middle-size mountains with steep slopes and dark grey, at some places extremely washed off forest soils, beech and hornbeam trees; 2. The limestone cliffs; 3. The former forest sites, secondary meadows used as pastures; 4.The foothills with beech, oak and chestnut trees; 5. The low mountains with steep relief, at some places – collapsed reliefs, humus-carbonate soils; 6. The foothills with limestone quarries; 7. The hollow built of sandstones and slates in a charcoal suite, erosive and landslide-accumulative relief forms; 8. The quarries of facing stones (teschenite), yellow soil, agrolandscapes (orchards, maize fields, vegetable gardens) and populated landscapes; 9. The karst cavity with a low mountain relief; 10.The hilly relief with wide gorges, cliffs, landslide forms; 11.The steep relief with karst

forms; 12.The sloping valleys of the hollow with an artificial lake-reservoir, elements of Colchis forest, evergreen and deciduous undergrowth; 13.The low mountains with steep cliff relief with a coal suite, narrow and deep erosive gorges, river rapids and waterfall segments; 14.The low-mountain, extremely disintegrated erosive landscape relief with landslide phenomena; 15. The hollow with an anthropogenic relief with the quarries of building materials (teschenite, basalt, diabase, brick clay, etc.) and brown coal; 16.The cliffy slopes of the ridge with thick limestone layers; 17.The flat plateau of a ridge with numerous karst forms; 18.The ridge slopes built of limestone with a network of river gorges (Tkibula, Tskaltsitela, Chala, Lekhidari), with dark grey soil and chestnut and hornbeam trees; 19. The cavity with landslides and erosive, hilly-wavy relief with limestone around, abundance of beech and chestnut trees, Colchis undergrowth. 20. The limestone low mountains with beech and chestnut trees, brown forest soils. 21. Basin with landslide-erosive relief and the limestone cliffs, agrolandscapes (orchards, maize fields, vegetable gardens) and populated landscapes, humus-carbonate soils, oak and hornbeam trees; 22. Vegetable gardens; 23. Vineyards; 24. Fruit gardens; 25. Tea plantations; 26. Water reservoir.

As a result of the anthropogenic impact the ecological states of the landscapes are deteriorated due to landslides, torrents, erosive processes, forest clearing. The relief is greatly transformed and its surface is extremely inclined. At the same time the territory is distinguished with intense landslides that in their turn decrease the stability of the relief.

Taking into consideration the large-scale hazard and intensity of landslides in Georgia the areas of Tkibuli Municipality presented as Jurassic sediments and Tertiary clay rocks are characterized with considerable coefficient of damage (K0 0.5-0.7) and according to the coefficient of the damage caused by mudflow processes it belongs to the regions of major (0.5-0.3) and moderate (0.3-0.1) hazards. In the natural-territorial complex in the foothill of the southern slope of the Racha Ridge there is a high risk of probable mudflows and consequently, the coefficient of the probable damage of the territory is K0 0.5-0.8 [5].

The landslide processes are aggravated by the influence of technogenic factors. Its role is especially obvious in the development of anthropogenic landscapes, when almost every component creating the landscape undergoes considerable changes. On the low stability territories there are maximum load technical impacts. The technical influence on the relief nature causes disintegration in the natural surfaces and contributes to formation of new technogenic forms of the relief: anthropogenic-denudational pits, ditches, waste banks, mine dump. Besides, quite often there are funnel-form sloughs at the tops of abandoned quarries, which are caused due to the damage of the walls and cave-ins in the mines, etc. In the 70-s of the XX century the vertical bedding of the relief surfaces in the areas of mines “Nakhshira” and “Aghmosavlet 2” reached 90 cm on average and the maximum bedding exceeded two meters (Fig. 3). In certain areas the maximum vertical bedding of the surface caused by underground works during the whole period of their exploitation is 10-15 mm and the horizontal shift reaches 1.3-2.4 m [6].

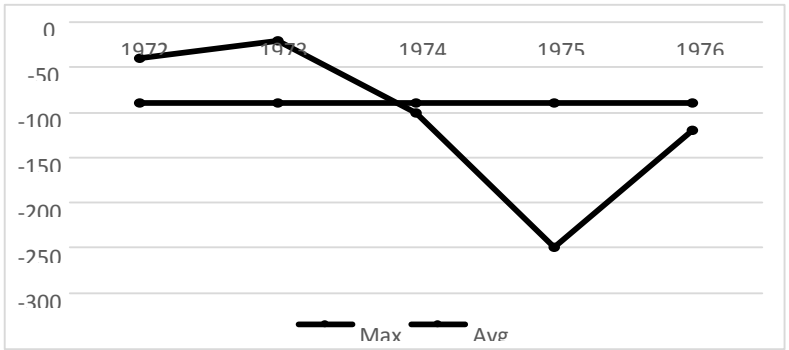

Fig.3. The vertical bedding of the relief surface in the areas of mines

Intense erosive processes are taking place on the rock refuses, which have 25-40° inclination. These processes are aggravated due to heavy rains, disintegrated rocks and steep sloping. The 10-20-year-old sloughs have already been covered with vegetation and most frequently cannot be distinguished from the natural forms of the relief.

The industrial explosions in the mines in seismically active regions are the reason for triggering local earthquakes and dynamic mining phenomena. The explosions resulted in seismic waves create additional

tension in the active foci zones. On the territory of Tkibuli, aggravated ecological state is characteristic of the foothill and lowland landscapes of the southern slope of the Racha Ridge, the southern slopes of the Nakerala Ridge in the midlands, the sources and confluence of the rivers Tskhrajvari, Mukhnariskhevi, Sabilasuri. Consequently, low stability of the landscapes is observed on the above mentioned territories.

Anthropogenic factors have significant impact on the development of karst processes. It causes formation of new fissures and activation of karst processes. The vegetation cover has considerably changed. In the river gorges there are thin lines of alder forests and willow and aspen trees. At some places the oak and hornbeam forests have degraded and are characterized with nature of derivatives presented as oriental hornbeam, dogwood, maple, medlar and etc. In comparatively well preserved places oak and hornbeam trees are presented. The process of mining works disturbs the regimes of underground and surface waters, which is the significant factor in creating landslides in the ore area. On the quarry slope the aquifer horizon is draining. Then it is followed by deformation and bedding of the cover layers and fissuring of the surface. As it makes favourable conditions for landslide formation, the surface water leakage accelerates the landslide movement.

As a result of a morphometric analysis of the relief of the Tkibuli Hollow, namely, calculating the areas of the reliefs, which have different inclinations, we determined that the most area – 48% is occupied by midstability (surface inclination – 15-45°) territories. The area is mainly occupied by the Lagori Mountains (745 m) in the west and the slopes of the Gormukhuli Mountain (992 m) in the south of the hollow. In the west it is presented as the gorge slopes of the rivers Tkibula and Satsiristskali. Comparatively less area – 22% is occupied by non-stable (surface inclination – more than 45°) territories. These are the northern and eastern parts of the Tkibuli Hollow (the limestone slopes of the Nakerala Ridge), which include the gorge slopes developed in the low and middle mountains. 30% of the area is covered by stable (surface inclination – 015°) territories, which are presented as the bottom of the Tkibuli Hollow, the lower reaches of the river Tkibula, populated areas: Tkibuli town, the territories of villages Satsire, Dzirovani, Dabadzveli and also Samtredia. These territories can be grouped as three types of areas: stable, mid-stable and non-stable.

In the conditions unsteady for the relief certain ecological problems have been arisen and they are considered the main ecological risk, which is hazardous for the environment. These are: fundamental changes in the relief, activation of geodynamical processes (landslides, mudflows), contamination of surface and underground waters (Fig. 4).

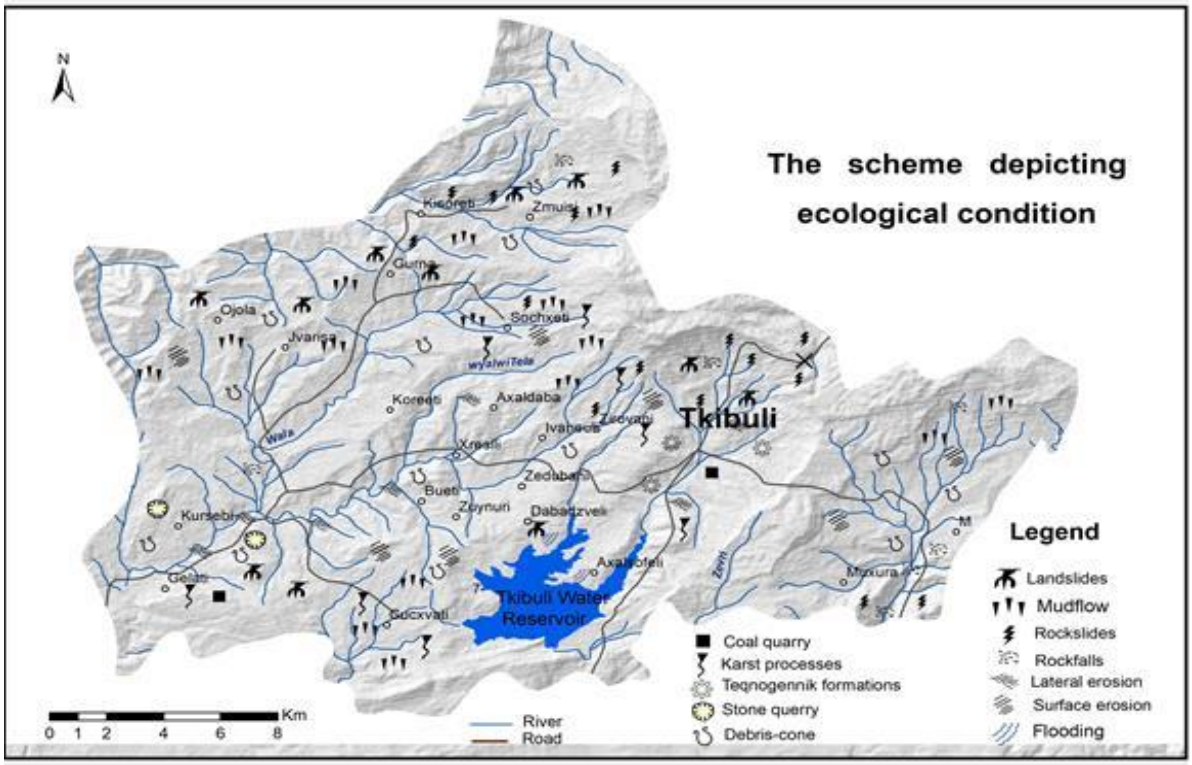

Fig. 4. The scheme depicting ecological condition of Tkibuli Municipality

The Kursebi teschenite ore where facing stone is extracted, is situated on the territory of village Kursebi in Tkibuli Municipality in the Kursebi Hollow (length: 3.5 km, width: 2-2.5 km). There is a vein of outcropped teschenite here. Its maximum thickness is 100 m. In the Kursebi Hollow the teschenite is extracted from an open cast mine. Therefore, the subtropical yellow, humus-carbonate type soil, which is covered with hornbeam, oak, chestnut and beech trees and with holly, azalea, hazel nut, hawthorn, etc. in the undergrowth, is being removed. Consequently, there are only left outcropped rocks, technogenic caves without any soil and vegetation cover and low quality anthropogenic landscapes (Fig. 5).

Fig. 5. Kursebi teschenite ore

On the basis of the large-scale landscape study of the territory of the Kursebi teschenite ore we distinguished following zones of anthropogenic impact: 1. the maximum anthropogenic impact zone, where the vegetation cover and soil are entirely destroyed. The microrelief is changed, consequently the microclimate and the whole relief have also changed; 2. The zone, which is located immediately in the area adjacent to the ore mining; 3. The transitional zone, which includes the territory between the ore mining area and natural landscape, though contains already affected and changed landscapes. Here, unlike the two former zones the degree of change in landscapes is insignificant and it is possible to restore the natural interaction between them. Thus, the main factor in the change in landscapes appears to be biogeomorphological factor, as far as first of all, the relief and soil-vegetation cover is changed here.

On the territory of Racha in Ambrolauri Municipality, a major problem is the Lukhuni arsenic ore, where extractions began in 1933 and the arsenic was processed from 1937 at the ore mill in village Uravi. In 1993 the industrial complex stopped functioning and nowadays on the mill territory 110 thousand tons of arsenicbearing material is stored and scattered. The general content of arsenic is 4-5 thousand tons. In "Mepischala" burial ground, allocated for 6000m^3 wastes, nowadays 600-700 tons of industrial waste brought from different parts of the mill is placed. The part of the cover of the burial ground is damaged and atmospheric precipitations are reaching inside. The torrents caused by precipitations fill the sedimentation chamber. Consequently, the arsenic-bearing material is flowing out of the burial ground and contaminating the environment. The industrial arsenic wastes mainly appear in the soil and water. The highest level of contamination is observed in villages Uravi and Likheti located in the gorge of the river Lukhuni. The arsenic content is considerably high 1500-29000 mg/kg on the territory of the mining-chemical factory in village Uravi. It is also high in the soil in the territory of the sarcophagus of the old mill. In the water of the river Lukhunistskali the arsenic content does not exceed the permissible concentration level and in the bed residuals the arsenic content is 18-200 mg/kg [7]. The contamination distribution area alongside the river gorge covers tens of kilometres and it reaches several kilometres perpendicular to the gorge. There is a great danger of contamination of the pastures and agricultural lands by the arsenic. It will make the food products useless and put the human health under danger.

Conclusions

Certain ecological problems at the Tkibuli Hollow, which were created in non-stable relief conditions during ore mining, mainly as an ecological risk hazardous for the environment, first of all are:

- A substantial change in the relief;
- Activation of geodynamical processes (landslides, mudflows).

Pollution of surface and underground waters is also a problem. The pollution areas become more hazardous in the conditions of active geodynamic processes in densely populated foothills and hollows. The exhausted mines are the reason for creating wide network of fissures, which in their turn are precondition for formation of landslides on the steep slopes and rock failures on the slanting slopes. On the southern slope of the Nakerala Ridge on the open cast mining territories new landslides are being formed and old fossilized landslide bodies are being activated.

The decrease in the forest and meadow landscapes as a result of technogenic impact contributed to dramatic intensification of exogenic processes (landslides, avalanches, earthfills), which in their turn caused displacement of huge soil masses on the steep slopes. It caused change in the tense state of the rocks, also decrease in the solidity of the rocks due to the removal of the slopes.

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C O N T E N T S