

## Ecological Problems of Karst Waters in Chiatura Municipality, Georgia

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**Abstract:** Karst waters in the world play an important role in water supply. Among them, the groundwater in Chiatura municipality (Georgia) is used as drinking water and is irreplaceable for the local population. Accordingly, it is important to assess their geo-ecological conditions and take care to maintain sustainability. The aim of the paper is to identify the hazards of pollution of underground waters in karst environment and to develop a scheme for their protection, which will take into consideration both the hydrogeological characteristics and the role of humans. To achieve this goal, the EPIK method was selected using of which an epikarst zone of the study area was studied in details, as well as the protective cover, infiltration conditions and frequency of karst network development, after which the conditions of karst waters in Chiatura municipality was assessed, their main pollutants were identified and the recommendations were prepared for their protection. The results of the study showed that the karst water pollution rate in Chiatura municipality is highest, where karst-fissured layers are represented and intensive extraction works are underway. The EPIK method is innovative in Georgia and was first introduced on the example of karst waters of Chiatura municipality.

**Keywords:** Karst waters; Cave; EPIK method; Pollution.

### 1. Introduction

It is stated that more than 20% of the Earth's surface is represented by karst terrain, while about 25% of the world's drinking water is accumulated in the karst water content rocks. Consequently, karst waters are in active use today; therefore, it is very important to identify and minimize their pollution risks.

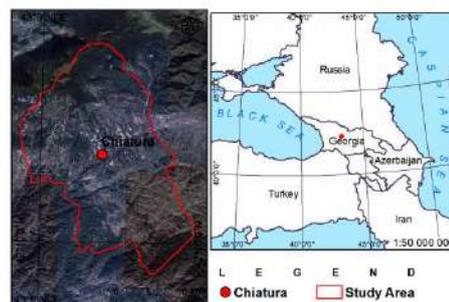
Manganese mining in Chiatura municipality begins in 1879 and has a long history. It was the mining works there that led to the creation of a settlement known as Chiatura, which grew with the development of this industry, and it gained the status of a city in 1921. At present, the extraction works are carried out by the company "Georgian Manganese" Ltd., the last is the largest manufacturer and exporter of high quality ferroalloys. Chiatura mining-enrichment plant extracts 1.3 million tons of manganese ore per year on average.

All this has a negative impact on the degree of suitability of karst waters in the study area, which is expressed by the strong turbulence characteristic of torrential rains in the vaucuse springs.

Chiatura municipality is a classic example of karst distribution. There are various morphological-genetic types of karst: covered, meadow, semi-meadow, uncovered, buried and remnant karst. There are all conditions for the intensive development of dry valleys, suction, sometimes collapsing type sinkholes, caves and wells. The most problematic among them is the buried karst, the formation of which has a long history from the past. Though today, as a result of human agricultural activities, systematic mining and irrational impact on the terrain, anthropogenic relief forms have been created, including karst burials with waste rocks. In addition, the living organisms inhabiting the cave are endangered; some habitats are lost, populations are reduced and karst underground waters are polluted, which has the function of drinking water for the local population [1].

### 2. Study Area

Chiatura municipality is located in western Georgia (fig. 1), which is represented by 1 city and 60 villages.



**Fig-1:** Geographical location of Chiatura municipality.

Chiatura municipality occupies a significant part of the Zemo Mereti plateau and an elevated part of the mountainous plain of Georgia. It geologically coincides with the intermediate massif between the Dzirula crystalline zone, Greater Caucasus and Lesser Caucasus folded zones, which is built of Paleozoic granitoids and

crystalline shales and is partially covered by weakly folded Meso-Cenozoic sedimentary rocks.

The climate in the municipality is marine, humid subtropical; winter is moderately cold and rainy, and summer is relatively dry and hot. The average temperature in January is + 2.4°C, and in July + 23.1°C; the absolute minimum of temperature is -20°C and the absolute maximum is +42°C, as for the amount of precipitation, it is 1,100 millimeters per year. The main river of the municipality is Kvirila; Colchis type deciduous forests are typical here. It should be noted that the main part of the forest is cut and little is left only on the steep slopes of the gorges [2, 14].

The karst terrain type is dominated among the types of relief presented in the study area. 110 caves have been discovered and studied here. They create an underground colorful world and are distinguished by unique properties. Their beauty, history and role in a healthy environment are invaluable. They are a shelter for many endangered living organisms, including the bones of fossil prehistoric animals, and also artifacts of prehistoric humans are kept in them. Archaeological excavations in the Dzudzuana cave, in the village of Mghvimevi, have uncovered 34,000-year-old flax thread, bradawl and other household items.

Although the region has great potential for tourism development, mining is still considered a leading activity today [2]. The municipality is famous for its mineral wealth. Here are villages, where two or more mineral resources are located. For example, the village of Mghvimevi is a place, where both manganese and quartz sand are mined. It should be noted that the epikarst is well developed in the given area as well; it is connected to the karst network from which three caves are distinguished: "Dzudzuana cave", "Chiatura 100" and "Mghvimevi". The presence of soil cover in the village of Mghvimevi is important and serves as a protection for karst underground waters [3]. However, in the conditions of intensive manganese extraction, the turbidity of drinking water in the rural area, especially during rains, creates a complex geo-ecological picture. Other villages are also facing this problem: Darkveti, Perevisa, Merevi, Rgani, Gundaeti, Salieta, Bunikauri and others (fig.2).

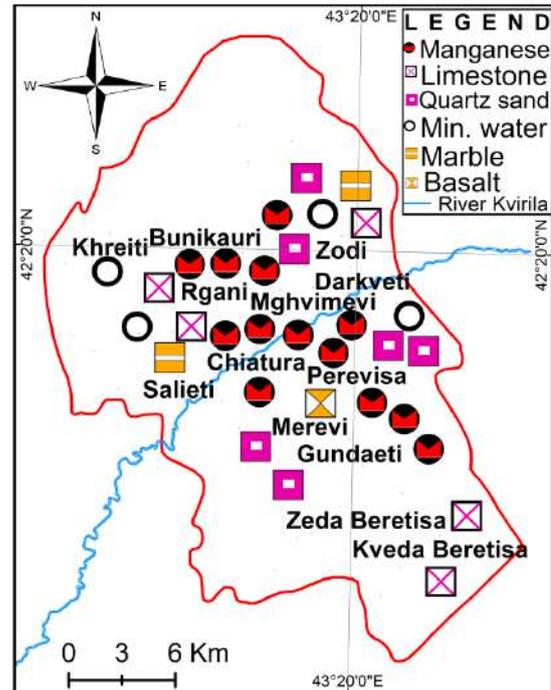


Fig -2: Map of mineral resources of Chiatura municipality.

Village of Bunikauri is located in the valley of the Kvirila River, at 760 meters above sea level. Manganese mining is intensive in the village. There are many speleothems in the territory of the village of Bunikauri including the Shvilobisa cave, Sakajkari cave, Cherula cave and Bunikauri karst shaft. Shvilobisa is one of the longest (1,000 m) sub-horizontal, watery tunnel-type caves in Chiatura Municipality. Through it flows a stream with a debit of 7-10 l/sec; the water level rises significantly during the rainfalls. The cave stream is used by the locals for drinking and it is important to protect its suitability [4].

### 3. Methodology and Discussion

Conditions of the karst waters of several villages (e.g.: Bunikauri, Rgani, Darkveti, and Mgvimevi) in Chiatura municipality were assessed using the EPIK method [5]. For the first stage, the research objects located in the gorge of the Kvirila River were selected. The Kvirila River, which is the main artery of the municipality, is in complex geo-ecological conditions; it is a left tributary of the Rioni River, and the latter is a Black Sea basin river. This is a confirmation to when local action leads to global consequences. For the second stage of the study, a detailed study of each parameter of the EPIK method was performed. Geomorphological map of Georgia was used to determine epikarst (E). To determine the conditions of the protective surface (P), both the soil types developed at the study area and the

geological characteristics of the karst water content layers were evaluated. Infiltration conditions (I) and karst network development (K) rate parameters were determined using ArcGIS and thematic maps [5, 13]. The issue of land use in Chiatura Municipality was studied in details for each settlement, which was rendered rating points according to the degree of pollution (table 1.)

**Table 1.** Land use ratings for the Hazard map (adapted from KAZAKIS et al.).

Land Uses	Hazard	Rating
Mineral extraction sites	Very High	4
Agriculture	High	3
Streets	Moderate	2
Forests	Low	1

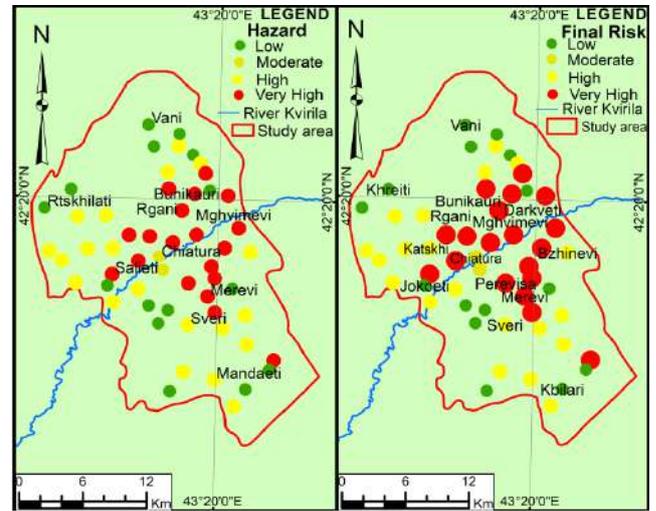
The pollution risk map depicts the areas in which it is most likely that groundwater will be polluted in Chiatura municipality, caused by human activities. The risk is very high, where high vulnerable zones and dangerous hazards come together [6]. For this case study, the risk map was evaluated by overlaying the vulnerability and hazard information, following Equation [7].

**4. Results**

The highest risk of contamination of underground karst waters was identified (fig. 3) in all villages, where intensive mining works are carried out, e.g. Darkveti, Mghvimevi, Rgani, Bunikaauri, Merevi, etc.. The highest risk of pollution was observed in 48% of the study area. 41% of the area is agricultural lands, due to intensive tillage conditions of which high risks of contamination were revealed (Katskhi, Sveri, Bzhinevi, etc.); The risk of moderate pollution is in the area, where roads are constructed or are being constructed, and covers minimum - 1.5% of the territorial area of the study area; and low risk of pollution is in the part of the area, where there are mostly forested zones (Vani, Jokoeti, Kbilari, Khreiti, etc.). The forest is especially well preserved in a sparsely populated area, on the southern slope of the Racha range, in the vicinity of the village of Khreiti. Restored forest massifs are also found in the areas of abandoned villages, e.g., village of Vani. Finally, the forest-covered area occupies 9.5% of the Chiatura municipality [8,14].

The karst relief in the Chiatura municipality constantly experience variability over time, both under the influence of natural factors and anthropogenic influence [9]. Due to intensive mining works, natural disasters have been intensified, creating life-threatening zones [10]. In addition, soil degradation is

one of the major problems in the region. It is therefore important to study the existing karst terrain using new modern research methods and to take care of the sustainable development of the region [11].



**Fig -3:** Hazard and Risk map of the study area.

**5. Conclusions**

The EPIK method is often used to assess the conditions of karst subsurface layers in different countries of the world. In the present study, the impact of land use on the degree of underground water pollution was revealed using the EPIK method [12]. As a result, during the assessment of karst underground water contamination risks in Chiatura Municipality it was revealed a very high vulnerability and moderate to high pollution levels associated with high quality of karstification and the presence of a thin layer of soil cover in the Chiatura structural plateau, which is also caused by the excavation of the terrain, the extraction works and the intensity of the soil cultivation [13, 14]. Similarly, high-risk water pollution zones correspond to high and very high vulnerability zones, where industrial activity is actively underway, as well as agricultural activities, also road infrastructure and urban development.

Underground karst waters of Chiatura Municipality are characterized by high vulnerability and obviously its protection is extremely important. Thus, recommendations are proposed to protect them in order to maintain the sustainability of the karst network system. Areas at high risk of contamination of underground karst waters should include a monitoring program of underground waters and should identify water compound substances over a certain period of time at the level of governmental institutions. Given that the highest rate of pollution in the region is due to

mining works, it is mandatory to tighten the law on issuing land use permits, in particular, to oblige companies to submit the necessary hydrogeological and environmental research findings and take into account in the working process for the purpose to maintain the environmental sustainability.

In the course of the research, the working team identified the diversity of cave systems formed in the karst terrain conditions of Chiatura municipality and developed five tourist routes to intervene in the ecological problems in the region, which serve to activate the tertiary sectors of modern economy.

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