
THE CHARACTERISTICS AND VALUES OF PROTECTED TECTONIC AND KARST LAKES IN ALBANIA

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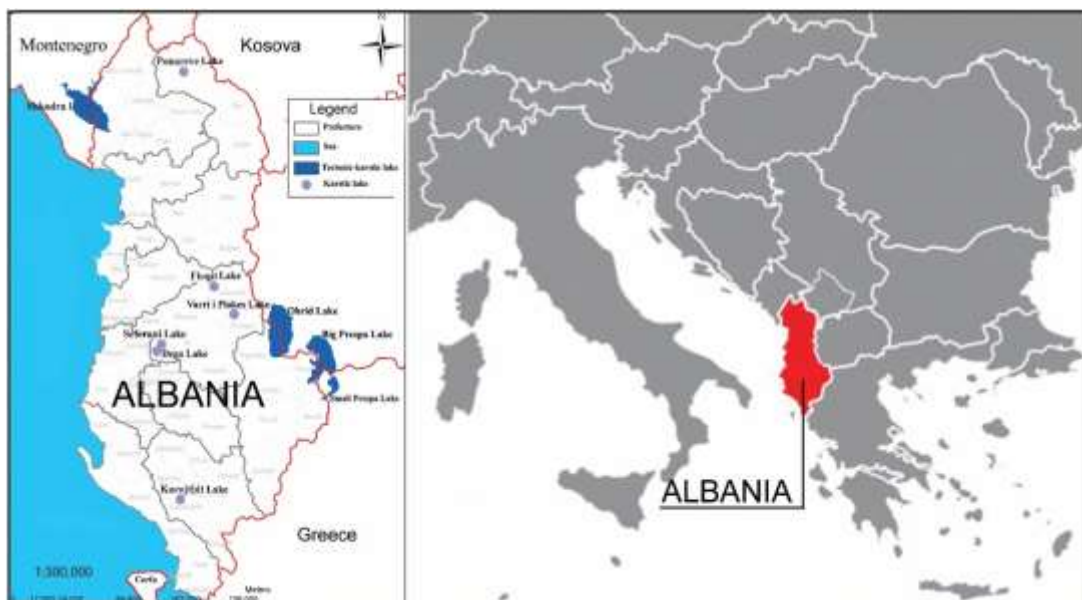
Abstract: Albania is located in the southeast of Europe, on the western part of the Balkan Peninsula, which is one of the richest countries in the world with water. Albania is a mountainous region, part of the Dinaric-Hellenic range, which in itself is part of the northern branch of the Mediterranean Alpine fold-thrust belt. The complex geological, structural, geomorphological, and climatic conditions of Albania result in the presence of different aquifers with very different hydrologic-hydrogeologic characteristics. Albania has a rich and complex continental hydrography system, composed of both surface and underground water, intensively recharged by high precipitations. The karstic water resource in Albania consists about 80% of the total groundwater resources. About one fourth of the discharge of the rivers of Albania is recharged by the karst waters. The karst landscape in Albania covers about 6750 km² consisting nearly 1/4 of the whole country's territory. In Albania, there are 23 karst regions, which composed of Mesozoic, especially Cretaceous limestone and dolomite, and other two karst regions developed in Perm-Triassic evaporate rocks, mainly gypsum. The geologic-tectonic factors and Mediterranean climate characterised of high precipitations and wide variation of temperature amplitude control the development of karst phenomenon, which favour intensive physical and chemical aeration of the rocks. Beside of many large karstic springs, in Albania there are totally 274 lakes, 94 of them have karstic origin, from which 84 lakes are located in Dumre gypsum plateau (dome) situated in the Central Albania. Three big tectonic lakes, namely Lake Shkodra, Ohrid Lake, Big Prespa and Small Prespa lakes are protected at International Level. All the lakes are transboundary ones: Shkodra lake is shared between Albania and Montenegro, Ohrid Lake is shared between Albania and North Macedonia, while both Prespa lakes, Big and Small, are shared between Albania, North Macedonia and Greece. Beside this, 6 small karst lakes, namely Lake of Ponareve, Kacojthi Lake, Lake of Floqi, Varri i Plakes Lake, Lake of Seferani and Dega Lake have the status of hydro monuments, the third category of Natural Monuments. All the mentioned lakes have distinct, scientific, geological, geomorphological, hydrological, didactic and economic value. The biggest lakes and their surrounding territory are some of the most attractive destinations for domestic and foreign tourists, also The main objective of this paper is to analyse and to present the necessity to digitalize the lake's data as a basis for the construction of the Map of Lakes of Albania; this will help the protected and the sustainable management of the lakes. For the digitalization of the protected karstic lakes, mainly is used the program Arc Gis 10.1. The scientific information about the lakes should seriously help the management of their big natural, economic, and tourist potential.

Keyword: Natural Monuments, Hydro monument, protected lakes, karst lakes, tectonic lake, Albania.

1. INTRODUCTION

Albania is location in Southeaster of Europe, in the Western part of the Balkan Peninsula (Fig. 1). Lakes are part of the continental hydrography and they differ according to their formation origin, elevation in m above sea level (m a.s.l.), type of water balance and of their importance as a very important element of the environment and human society. Albania has rich a hydrography; there are abundant surface and underground water resources. The hydrographical system belongs to the basins of Adriatic and Ionian Sea. Various tectonic, geological, geomorphological and climatical factors have influenced in creation of a dense hydrographical density. The lithological of the rocks in Albania is very diverse; the carbonate rocks consist about 24 % of the country's territory, the molasses consist about 15 %, the igneous rocks about 15 % and at about 40 % of it outcrop flysch and schist. The intergranular rocks, mainly of alluvial origin consist about 5 % of countries' territory (Qiriaz, 2017;2019; Eftimi, 2010).

Fig 1. Protected lakes in Albania



Albania has a typical Mediterranean climate, which is characterised by high yearly precipitation consisting about 1480 mm/year for the country territory, while the average annual temperatures vary from 14° C to 18° C (Qiriazi, 2019; Pumo et al, 1990). The large outcrop of carbonate rocks, the intensive movements of tectonic faults and the Mediterranean climate have controlled the intensive development of the karst forms, including also the formation of karst lakes. Apart from their unique natural values, karstic lakes have great economic importance too.

2. MATERIALS AND METHODS

In Albania there are over 247 natural lakes which have a total area of 460 km². The biggest lakes of Albania, namely Shkodra, Ohri and Prespa, which are also the biggest of the Balkans, they have tectonic-karstic origin. The big lakes are developed mainly on carbonate rocks, mainly limestone, while the small lakes are in limestone, but most of them are developed in evaporate formations. Generally, the water level of the lakes is related to the variation of the in the rainfalls. There are 94 karst lakes in Albania and 88 of them are located on Dumre plateau (Pumo et al, 1990, Qiriazi, 2019; Andreychouk at al. 2021). Protected karst lakes have special aesthetic, didactic and scientific values. More detailed information about the geographical position, height above sea level, temperature, mineralization, surface, transparency, etc. will influence to the interest of more in-depth studies as well as the increase of interest in the development of tourism in these areas. Four big transboundary lakes Shkodra Lake, Ohrid Lake, Prespa Lakes, as well as 6 small lakes like Floqi, Kacojthi Lake, Varri i Plakes, Lake of Ponareve, Seferan and Degas Lakes (Fig. 1) should be described in the following.

The **Lake of Shkodra** is the largest in Balkan Peninsula with an area of 369 km², from which 149 km² belong to Albanian territory and the rest belongs to Montenegro. From this lake issue Buna River, which flow into the Adriatic Sea. According to a hypothesis the lake area could have been an old sea bay of the Adriatic which was separated from it by river deposits (Pano, 2015, Qiriazi, 2017). One other hypothesis relates to the tectonic genesis of its formation and it is generally accepted by various researcher (Pumo et al 1990; Pano, 2016; Qiriazi 2017). The lake is a typical lowland lake, but mean elevation of the watershed is about 770 m a.s.l.

The western coastal lake area consists of limestone and is characterized by highyl erosive rocks, while the northern, eastern and southern lakeshore areas are characterized by low elevation plain morphology, having mainly accumulative nature. Shkodra Lake is supplied by rivers, streams, atmospheric precipitation and by underground springs. Several high energy rivers such as Drin, Moraça, Cemi, Perroi i Thate, Perroi i Vrakes, Perroi i Rrjollit flow from the North Albanian Alps. In periphery plain area of the Shkodra Lakes some big springs emerge such as Syri i Shegan, Syri Gjonit etc (Eftimi et al. 1985; Qiriazi 2017, 2019). Because of the intensive recharge of the lake by the surface and underground flow the lake waters are saturated with oxygen. Often due to the high turbidity of the lake water and of the development of microorganisms, lake water has low transparency, as well as green to dark blue colour. The lake level suffers large level fluctuations caused by the influence of the Buna and Drin rivers, as well as of high variability of the atmospheric precipitation, also (Pano, 2015).

Fig 2. Some protected tectonic-karst and karst lakes of Albania: A. Shkodra Lake; B. Ohrid lake; C. Big Prespa Lake; D. Small Prespa Lake; E. Seferani Lake; F. Dega Lake



Shkodra Lake is an important natural and climatic ecosystem. It is used for irrigation and fishing, but a distinguished rich fauna is developed there, and it serves also as a migration corridor of animals and aquatic fauna from the lake to the sea and vice versa (Stevanovic Z. et al. 2021, Qiriazi, 2017). There are 842 types of algae, 50 types of fish, 270 types of birds, including the curly pelican living in the lake (Akademia e Shkencave 2008, 2009). Shkodra Lake is an important European bird area, and is classified as a transboundary protected area and a Ramsar area

Ohrid Lake has a total area of 362.6 km², from which 111.4 km² belong to Albania and the remaining surface belong to North Macedonia. It is a tectonic-karstic lake and is the deepest lake in Balkan Peninsula (295 m) and one of the largest in Europe (Qiriazi 2019, Pumo et al 1990). Ohrid Lake is formed in the Tertiary period between 3-5 million years ago, and is one of the oldest lakes in the world (Matzinger et al, 2005). The high Mali Thate-Galichica karst mountain range separates the Ohrid Lake by Prespa Lake. It is a mountain lake with an average elevation of the watershed of 1157 m above sea level. The eastern and western lake-coasts consist of high mountains of carbonate

and less ultrabasic rocks, but the northern and the southern lake-sides consist of plain areas (Qiriazhi 2017, Pumo et al, 1990). The Ohrid lake collect the water of his watershed area, as well as that of the Prespa Lake watershed. The last is realised as a huge underground karst flow recharging a number of big karst springs issuing in the Ohrid lakeside, like St. Naum springs in North Macedonia and Tushemish springs in Albania (Eftimi and Zoto 1997, Eftimi et al. 2021, Matzinger et al., 2005). Around the Ohrid Lakeside are situated some important settlements like Struga city on the North, Pogradec and Saint Naum at the south, Lin Peninsula on the West and Ohrid city on the East, which represent important tourist destinations. The average temperature of the surrounding lake area is 15.6°C while water temperature is 17°C; this is an important indication for climate mitigating. The visibility of the water that ranges from 15 m to 20 m (Pano 2015; Qiriazhi 2019) is related to intensive groundwater drainage and the poverty of phyto and zooplankton. The lake water has low phosphates and nitrates, while the iron and magnesium is missing. Consequently, this lake is a perfect habitat of aquatic fauna with rare fish such as lake trout. Ohrid lake harbours a large number of endemic species plankton, fish etc (Matzinger et al., 2005). From 26 mollusc species, 24 of them are endemic (Qiriazhi 2017). In addition to the development of gastronomic tourism, the shoreline of Lake Ohrid offers good opportunities to development of blue and climatic or medical tourism. Mali i Thatë-Galicica karst massif, separating the lakes Ohrid and Prespa is another protected area with unique values too. Ohrid and Struga in the North of Ohrid Lake, Pogradec, and Saint Naum in the south are important tourist destinations for local and foreign tourists. Protection status of the lake is: UNESCO (World Cultural and Natural Heritage Site) from 1980, and “Cros-boundary Ohrid-Prespa Biosphere Reserve” from 2014. (UNESCO MAB).

Prespa Lakes. Big Prespa Lake has a surface of 285 km² and Small Prespa lake has a surface of 44 km²; Both lakes communicate through the Koula sluice constructed on 2005. Prespa lake recharge the Ohrid Lake through intensive karst underground flow; Prespa Lake loses the waters in Zaver swallow-hole and via underground karst flow discharges into Ohrid Lake. The water transparency is 15 m and the colour is dark blue. The average annual temperature of the lake waters is 1.9 °C higher than air temperature, which affects the warming climate (Pano, 2015). Along the lake-side there are good opportunities for the blue tourism development, as well as of gastronomic tourism too. Small and large Prespa has a rich and unique flora and fauna and are used for fishing and irrigation. There are about 132 bird species that create nest in Prespa Park, 18 fish species, 8 of them are endemic, and 25 bat species, 8 of which are endangered. In the Prespa area widespread karst rocks surrounding there are identified important karst phenomenon like the Tren Cave located on Small Prespa shore. Archaeological data prove its population since Neolithic period (Qiriazhi, 2002). There are also several natural monuments such as: Maligrad Island, Zaver swallow-hole, Mumje Tren Stones, Manastiri forest, Kallamasin Rid, and some other cultural monuments that offer opportunities of tourism development (Qiriazhi, 2002, 2017). Due to Devolli River diversion to Small Prespa lake in early 1978, the last one is transformed into a reed area and is experiencing the last stage of lake evolution; this part of the park is object of many natural and anthropogenic problems. Protection status: Ohrid-Prespa Transboundary Reserve (UNESCO MAB), Ramsar Site. IBA (Internationally Important Bird Area) a part of Galicica National Park- North Macedonia, Prespa National Park - Albania, and Prespa National Park Greece.

Lake of Ponareve is a Karstic-glacial Lake, located about 8 km from Bajram Curri at 130 m a.s.l. Its length is 200 m, its width is 165 m and its depth is several meters (Qiriazhi & Sala 2006). It has important scientific, hydrological, aesthetic and touristic values and can easily be visited using motorcar road Bajram Curri-Lekbibaj and pedestrian road to Maja e Hekurave (2500 m above sea level). This lake offers opportunities for camping and hiking too and it is a tourist destination under the development. **Lake of Kacojthi** is a karstic lake situated in South Albania and developed on Permo-Triassic gypsum deposits. It has an ellipse shape with a length of 100 m and a width of 60 m. In particular, there are large fluctuations of the lake level as a result of uneven seasonal precipitations. It has scientific hydrological, biological, aesthetic, didactic values and can be visited using Gjirokastër-Kolonjë road. **Lake of Floqi** is located near the homonymous village and is located at 700 m a.s.l. It is supplied by the waters of the karst spring which emerges from the contact between limestone and molasses (Qiriazhi & Sala 2006). It has scientific hydrological, didactic, touristic values and can be visited along Librazhd-Floq rural road. **The Lake of Varri i Plakes** is located near the village of Xhyre, Librazhd, at elevation 600 m a.s.l. It is recharged by some karst springs, issuing at the contact between Cretaceous limestones and the Tortonian molasses. It has scientific (hydrological, biological), didactic and touristic values and can be visited along the road Librazhd-Xhyre. **The lakes of Dumre** are located in central Albania, in the gypsum plateau of Dumre (Andreychouk et al. 2021). There are 88 karst lakes which total surface is about 14.2 km² and two of them, Seferani and Dega lakes have been known as hydro monuments. They haven't water flow and in during the many of them dry up; the rain is the only way for supply. Dumre Lakes have great fluctuation of their level, increased mineralization and low transparency. They are used for irrigation and fishing, but many tourist businesses have also been built near them. **Seferan Lake** is located near the village Seferan in Dumre and is located on gypsum deposits and consists of 4 small lakes. This lake is formed by the connection of several karst funnels, filled with water after the blockage with clay. It has an area of 87.5 ha, an

average depth of 4.5 m and is one of the deepest lakes of Dumre and his average level is about 124.01 m a.s.l. The lake ecosystem is rich, and has important scientific (hydrological, biological), aesthetic, didactic and ecological values. It can be visited using the rural road Cërrik-Belsh-Seferan. The water is taken for the irrigation of agricultural lands in the north of Seferaj through an artificial channel. In summer the area is 67 ha and in winter 87 ha, because of the use of water for irrigation. It has developed vegetation and offers picturesque views. **Lake of Dega** is located in the village of Fierza, on the plateau of Dumre, about 106 m above sea level. It is 1600 m long, about 300 m wide, 17.9 m deep, while the area is 37.5 ha. This lake stands among the most beautiful lakes in Dumre gypsum plateau (Qiriazhi & Sala 2006). The water temperature in winter is 7.8-8°C. Up to a depth of 15 m, the content of dissolved oxygen in water is 1.5 mg/l. Below this depth, hydrogen sulphide appears. It has scientific (hydrological, biological), aesthetic, didactic, ecological values and can be visited along the rural road Cërrik-Belsh-Liqeni i Dega.

3. RESULTS AND DISCUSSIONS

Typical karst lakes have noticeable fluctuations in their water level; during the dry season many small lakes they dry up. They are generally located at an altitude of 600 to more than 1000 m a.s.l. Four of six protected karst lakes are located in Elbasan County; one in Kukës, which has a double glacial-karst origin; the last in Gjirokastra County. Lake Seferan and Dega, which are part of the lakes of Dumre gypsum plateau and larger are visiting destination. There is a lack of data for Kacojthi and Varri i Plakes lake. All the small karst lakes are mainly visited following rural roads and offer opportunities for various sports and tourist activities. The three big tectonic-karst lakes have a large surface in general and are quite deep; they are transboundary lakes and are shared with Montenegro, Greece and North Macedonia. However, this has not become an obstacle for cooperation between the bordering states for their protection and sustainable management, collaboration which must be better planned and intensified in the future.

Table 1. Characteristic of Large Lakes in Albania

Name	Type	Area	Height (m) a.s.l.	Length (m)	Width (m)	Depth average (m)	Depth max (m)	Volume (m ³)	Watershed (km ²)
Shkodra Lake	plain	452	6.52	48	21	8	30	2.84.10 ⁹	5175
Ohrid Lake	mountainous	363	692	30.4	14.5	145	295	50.10 ⁹	2929
Big Prespa	mountainous	285	853	26.3	20.6	18	55	5.2.10 ⁹	1360
Small Prespa	mountainous	44	853	13	6	4.0	8.4	170.10 ⁶	189

Shkodra Lake is lowland, comparing it with other tectonic lakes which are mountainous. It is the largest with 453 km² and it has the largest watershed basin. Ohrid Lake is the oldest and deepest compared to other lakes. The Prespa Lakes are located at the highest altitude and they are lakes that communicate with each other.

Table 2: Characteristic of large lakes in Albania

Name	Ph (mg/l)	O ² -t (mg/l)	O ₂ (%)	Ca (mg/l)	Mg (mg/l)	Min (mg/l)	Transparency (m)	T Min °C	T max °C	Average T of water	Average of m ³ /sek
Shkodra Lake	8.19	8.74	43	40.18	7.14	221	4.2	6.8	25.9	18	32.0
Ohrid Lake	7.5	8.16	101	45.70	10.96	200-250	17.0	6.4	20	17	6.50
Prespa Lakes	8.1	8.30	94	53.62	6.08	200-250	4.9	4.8	21.9	13.5	12-16

The main topographic, and hydrological data of the three big lakes are summarised on Table 1, while in Table 2 are summarised some climate and hydrochemical data of the big tectonic lakes.

4. CONCLUSIONS

As a result of tectonics, geology, lithology and climatic conditions in Albanian territory, there are a large number of karstic and tectonic lakes. The biggest of them Shkodra, Ohri and Prespa Lakes are tectonic and transboundary lakes. The smallest where the largest part lies on the Dumre plateau. Lakes have great importance for nature but also

for various human activities. Through their unique values, they offer opportunities for the development of tourism. There is a lack of promotion of small karst lakes and information about their data their particular characteristics. The study of the lakes, especially of genuine karst lakes, the recognition of their values and features accompanied by good management and governance will offer more opportunities for economic development of the country.

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