



An Investigation of Tufa Microbialites in the Terrestrial Ecosystem of Adilcevaz (Bitlis) According to the Conservation Approach

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Abstract

Due to their rarity, scientific, and aesthetic value, or being a part of an important geological process, some natural formations (like calc tufa) on Earth have to be protected. While the formation and development processes of the microbialites in Lake Van continue, the microbialites in Adilcevaz remained outside the lake and became fossils. These structures are arranged approximately 200 m wide and 800 m long, reaching heights of 6 m in places. In this study, the area where the Adilcevaz tufa microbialites, surviving to the present day as a remnant of the level change stages of Lake Van as well as their aesthetic appearance and scientific importance, was evaluated according to the conservation approach. Phenomenology research design, one of the qualitative research designs, was used in the study. Although the research is basically a field study, secondary sources were used and face-to-face interviews were conducted. The semi-structured interview technique, one of the qualitative research techniques, was used for the interviews that were held with the participants on the basis of pre-prepared questionnaire forms. Following the interviews, the data were evaluated with descriptive and interpretive analyzes. As a result of the field observations and interviews, the area was suggested to be evaluated as a “natural monument” to protect it and carry out activities for tourism purposes. It is understood that the area has an important potential in terms of ecotourism, and should be proposed to be included in the UNESCO World Heritage List together with the Lake Van microbialites, the largest microbialites in the world.

Keywords Microbialite · Tufa · Nature conservation · Lake Van · Adilcevaz · Eastern Anatolia

Introduction

Microbialites were defined as “organo-sediments formed with the interaction between benthic microbial communities and chemical sediments” by Burne and Moore (1987). There are various debates about their formation even today. Based on the studies of Dupraz et al. (2011) in which they dealt with the formation stages, it can be said that microbialites are kinds of deposits formed both as a result of organic and inorganic developments.

The fact that microbialites are the oldest life forms according to their microbiological characteristics makes them an important subject of study for different disciplines.

Very few of the microbialites that were formed billions of years ago have survived today (in Western Australia, Canada, and South Africa). Since the surviving ones are few, the data regarding those formations is limited. This makes microbialites or stromatolites that have been formed recently and continue to be formed even more important. For that reason, Hoffman (1973) stated that “the interpretation of ancient stromatolites will continue to depend on the discoveries of their recent counterparts.” Therefore, in order to interpret microbialites or stromatolites of ancient times, it is necessary to preserve the recently discovered ones.

In general terms, the scientific importance of microbialites can be expressed as follows:

They help us understand how microbes contribute to globally important processes such as the carbon cycle. Cyanobacteria, found in microbialites and fulfilling many important functions, are a type of microbe capable of photosynthesis. Cyanobacteria take up water and produce oxygen during photosynthesis. Considering that microbialites are very ancient structures, many scientists have stated that

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Fig. 1 *Oxy-noemacheilus ercisianus* (on the left) inhabiting the microbialites of Lake Van (on the right). Source: Akkuş et al. (2021)

they contributed to the oxygenation of the early Earth and/or the formation of the atmosphere (Johnston et al., 2009).

Thanks to some properties of microbialites, it is possible to have information about the functioning of natural processes that develop on planets other than Earth. Lake Salda is the best example of this situation. It is known that NASA has carried out various studies on the microbialites in Lake Salda (in Southwestern Turkey), the exposed island of ancient microbialites, the alluvial fan, the newly formed microbialites, and their sedimentary surfaces (NASA, 2021).

Unique aquatic organisms are associated with microbialites. It has been determined that the microbialites in Lake Van are the habitat of a fish species. Discovered as a result of research, this fish has been shown to represent the *Oxy-noemacheilus ercisianus* population (Akkuş et al., 2021). This fish, which is a relatively recent discovery, is shown in Fig. 1. It is also known that microbialites are a food source and shelter for some aquatic species.

Microbialites are a subject of many different scientific studies. Early petrification, which is necessary for the accumulation and preservation of benthic microbial carbonates, is both a biological process and is dependent on the environment. Consequently, microbialite formation reflects not only the evolution of microbial mat but also long-term changes in

seawater and atmosphere that affect microbial metabolism and seawater carbonate saturation status (Riding, 2011).

Microbialites have survived to the present day because they have a durable structure similar to rocks. Fossilized microbialites (stromatolites) are among the oldest extant fossils (the earliest traces of life discovered in Western Australia). This shows that they are formations that have the potential to provide information about the natural environment billions of years ago.

Tufa microbialites in the terrestrial ecosystem in Adilcevaz, a district of Bitlis/Turkey, have not been given any protection status, although they have features needing to be protected in many respects. Accordingly, in this study, tufa microbialites in Adilcevaz, which are threatened by various factors, were evaluated within the scope of the conservation approach. The study aimed to reveal the scientific importance of the area where tufa microbialites are found and to determine its conservation status.

The elements threatening the site can be divided into two natural and human. It has been determined that the site has been damaged by external forces such as wind, rain, snow, etc. However, this is not a very advanced level of destruction. This situation can be seen as a threat arising from natural causes. The local people did not clearly understand these natural formations. Since tufa microbialites were perceived

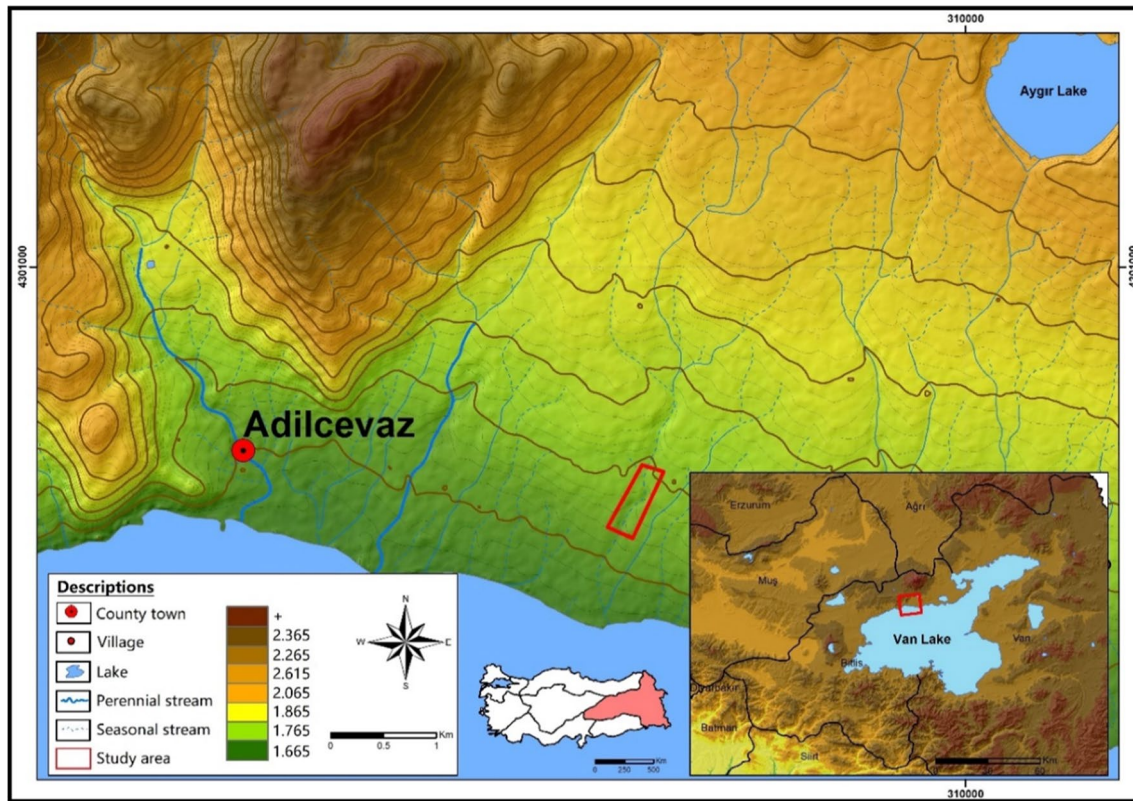


Fig. 2 Location of study area

as structures built by people in the historical period rather than natural formations, there were attempts to search for treasure in the field. This situation was learned at the end of the interviews. Therefore, it can be said that the site is also under threat from a human point of view.

The research problem is divided into two themes. The first is the problem caused by the fact that the area is not under protection, and the second is the problem caused by the inability to evaluate the potential of the area. Therefore, the research aims to draw attention to the scientific importance of the site where tufa microbialites are found. In parallel with this importance, it is among the objectives of the research to contact the necessary institutions and organizations to take the site under protection to ensure that the site receives a protection status appropriate to its nature and to reveal the tourism potential of the site and to determine in which status the site should be evaluated in this context.

The Adilcevaz Tufa Microbialites

The research area is located in Adilcevaz (Bitlis/Turkey), which is in the northern part of Lake Van. This lake is the fourth largest terminal lake in the world with a surface area of 3574 km² and a maximum depth of 450 m (Çukur et al.,

2014: 63). The study area is approximately 1.5 km inland from the shore point of Lake Van. Tufa microbialites are found on both slopes and sides of the Kazma Stream bed in the Cevizli neighborhood (Fig. 2). Since the creek has the characteristics of a seasonal stream, it remains dry for most of the year.

Yeşilova et al. (2019) investigated the ages of the tufa layers outcropping in the Adilcevaz district. In their aforementioned study, they stated that tufas were formed under humid and temperate climatic conditions in the contact zone between highly alkaline lake water rich in bicarbonate and carbonate ions and groundwater rich in calcium. The ages of the tufas examined in their studies were dated between 112.7000 and 19.3000 years.

Tufa microbialites constitute approximately 750-800 m long and 150 m wide of the stream bed. The heights of some of these natural formations reach 6 m (Fig. 3). In addition, most have survived to the present day almost intact, but some parts have been destroyed as a result of physical disintegration.

Today, there are residential areas in the western and southern parts of the land where the research area is located. In the eastern part, irrigated agriculture activities are carried out. Since the area corresponds to the stream bed, it is state-owned. Therefore, it does not constitute a problem



Fig. 3 Tufa microbialites up to 6 m

regarding its ownership. The map showing the functional land use of the immediate surroundings of the study area is shown in Fig. 4.

The most important feature that distinguishes the microbialites in Lake Van from the other microbialites of the world is their size. It has been confirmed by divers in the region that the microbialites in this lake are at an altitude of 30 or even 40 m. The distinguishing feature of tufa microbialites in the terrestrial environment is their shape. The size and shape of the microbialites in the lake, and especially the shape of the tufa microbialites on land (Fig. 5 and Fig. 6), arouse interest among people.

Microbialites are often found in ancient shallow marine environments and lakes. One of these is Lake Van, the largest soda lake in Turkey and the world. It was a shallow marine basin in the early Miocene and started to rise with the compression of the Arabian-Eurasian plates by neotectonic activities in the Middle Miocene (Yeşilova and Yakupoğlu, 2007). The location of the lake corresponds to the area called the Muş-Van depression. It is accepted that Lake Van in Quaternary was formed by the accumulation of waters as a result of the eruption of Mount Nemrut in the middle of the Muş-Van Depression and the Nemrut lava set forming a natural barrier (Erinç, 1953).

Lake Van has the largest known microbialites on earth. In order to investigate the relationship between the minerals and organic molecules that make up the Lake Van microbialites, Benzerara et al. (2006) carried out research using X-ray microscopy and high-resolution transmission electron microscopy. As a result of their research, they determined that microbial organisms played an important role in the formation of Lake Van microbialites.

Microbialites are seen in Lake Van, especially near Adilcevaz and Tatvan. The reason for their occurrence in these two particular locations was tried to be determined by Kempe et al. (1991). Accordingly, the reason for this is that the mountains to the north of Adilcevaz are composed of Miocene limestones and the calcified marbles partially buried under volcanic rocks have surfaced near Tatvan. These calcareous formations have made the waters in these locations more calcareous. Inorganic calcite precipitation occurs where calcium-rich groundwater seeps into the alkaline lake water.

The discovery of microbialites in Lake Van dates back to the 1970s. Degens et al. (1984) first noticed these formations in the south of Adilcevaz during their exploration of Lake Van. In 1989, Kempe et al. discovered two main areas where columnar microbialites were found. One of these two areas is Tatvan bay and the other is south of Adilcevaz (Kempe et al., 1991).

In 1989, S. Kempe et al. discovered two main areas where columnar microbialites were present. One of these two areas is Tatvan bay and the other is southern Adilcevaz (Kempe et al., 1991).

Since Adilcevaz is located in the coastal region of Lake Van, it was affected by the level changes that occurred in the past. Studies have shown that there was a period when Lake Van rose up to 1740 m (Görür et al., 2015). Researchers have detected these level changes from terraces at different heights and in different places around the lake. This shows that the lake has submerged almost all of today's district borders. According to the studies of Görür et al. (2015), the lake level moved between 1740 and 1710 m from 32000 to 21000 years ago. The reason for this mobility has been stated as climate and tectonic processes (mostly climate).

Methodology

The qualitative research method was used in this study. Data were obtained from observations, interviews, and written documents. Face-to-face interviews were conducted in accordance with the main theme of the research, and the content of the research was enriched by making use of written documents. Face-to-face interviews were carried out to evaluate the problems of the research area, the understanding of conservation, and its future, in

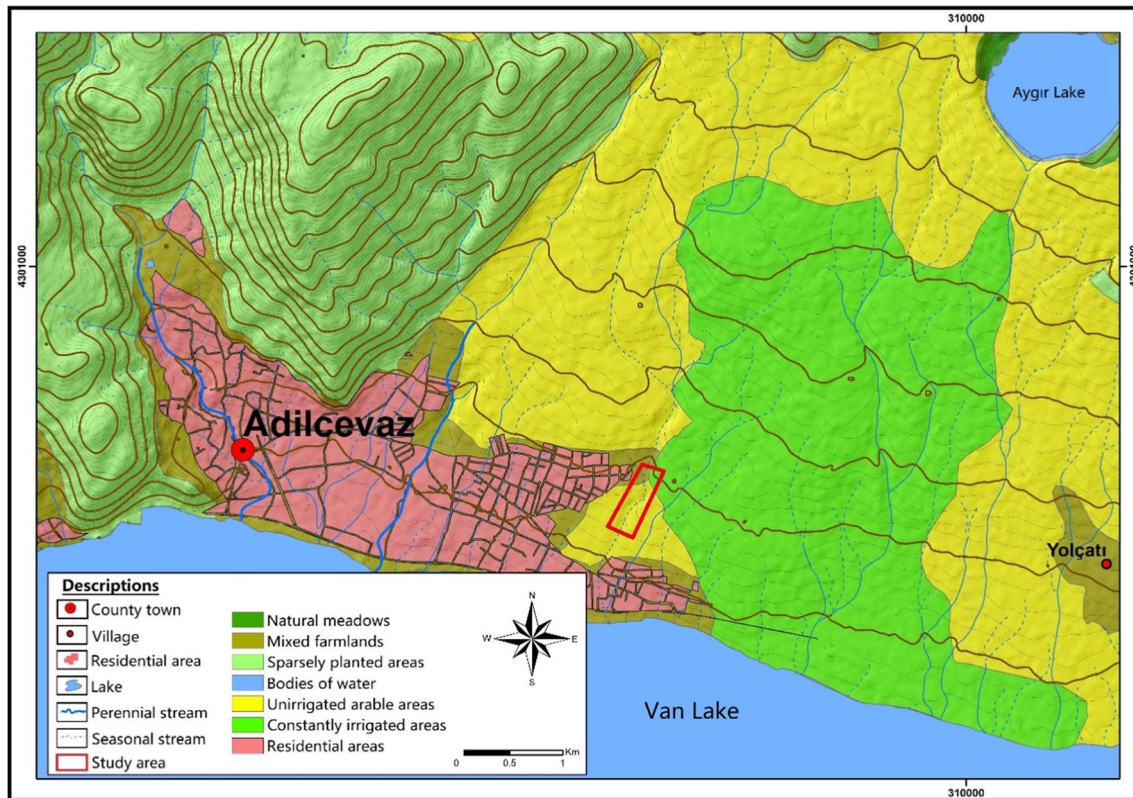


Fig. 4 Functional land use of the immediate surroundings of the study area

accordance with the main theme of the research. Interviews were conducted with the participants, who were determined according to the purposive sampling method, with the semi-structured interview technique.

Observations were made in the field with Cumali Birol, who played an important role in the discovery of the research area, and local people around the area were contacted. The information obtained was evaluated together with secondary sources. After the main topic of the research was created, interview questions were prepared and interviews were planned with five selected participants.

The sample consists of institutions and organizations within the scope of local governments in Bitlis and Adilcevaz. In this context, a total of five individuals including the mayor of Adilcevaz, the Governor of Adilcevaz, the Head of the Adilcevaz Culture, Art, and Tourism Association, the Dean of Bitlis Eren University Faculty of Arts and Sciences, and the Manager of Nature Conservation and National Parks Branch of Bitlis were determined as the sample and interviews were held.

The interview form consists of six questions. Appointments were requested from the persons who will be interviewed. None of the requested appointments were turned down. Audio recordings of the interviews were made with

the consent of the participants. Each of the interviews lasted approximately 40–50 min.

The questions asked in the interview are as follows:

1. Do you think that the area where tufa microbialites are found should be protected? If you think so, with which protection status should it be evaluated?
2. Why do you think the area where tufa microbialites are found should be brought in tourism?
3. In your opinion, with what method and technique should the area be transformed into a tourism destination?
4. Have you done anything for the natural formations in question? If yes, what kind of activities have you done so far?
5. What is the attitude of the management in activities related to the information, promotion, or protection of the area? What are your expectations from senior management in this regard?
6. In your opinion, are there any threats waiting for the area where these natural formations are located? If so, what are these?

Findings

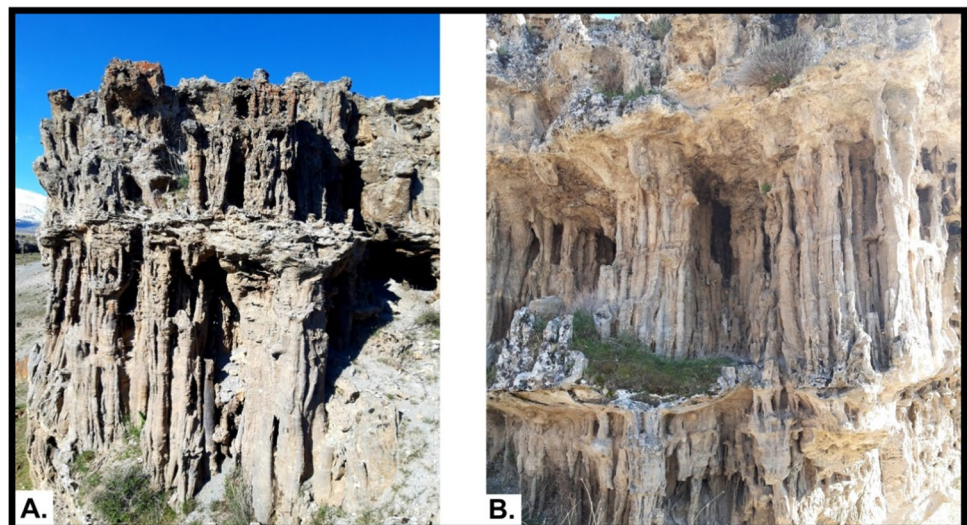
The fact that some natural formations on Earth are under threat due to various reasons necessitates the protection of these formations. Factors threatening these formations can



Fig. 5 Unique appearances of Adilcevaz tufa microbialites

sometimes be the result of human activities or natural conditions. The nature conservation approach can be thought of as an approach that has emerged against the aforementioned threats. Natural formations that need to be protected must have various characteristics. Natural structures that are rare, especially of scientific or aesthetic value, that are part of an important geological process, or that are of

Fig. 6 Unique appearances of Adilcevaz tufa microbialites: A. 2 m, B. 6 m. The head of the tufa microbialite row (A) in the eastern part of Kazma Creek. A view from the middle part of the tufa microbialite sequence in the eastern part of Kazma Creek (B)



biological importance as an important part of the ecosystem can be shown as exemplary structures to be protected.

All participants agree that the area should be protected. In addition to conservation, participants generally stated that the area should be brought in tourism. In short, the understanding of “both conservation and tourism” prevailed among the participants.

Participants think that bringing the area into tourism will provide income. Cumali Birol, head of the Adilcevaz Culture, Art, and Tourism Association, stated that “cultural interaction will be possible with tourism and such cultural interactions pose a great opportunity for small settlements like Adilcevaz.”

All of the participants agree that the area is scientifically valuable. Accordingly, all participants stated that sensitive work should be carried out while transforming the area where the natural structures are located into a tourism destination.

Important activities have been carried out since the day the research area was discovered. Adilcevaz District Governor İsmail Demir worked with special underwater photographers, especially for the microbialites in Lake Van, and exhibited these photographs at the district governor’s office. Governor Demir also underlined that there was a great interest in the exhibition. In addition, an exhibition on microbialites was opened for students at primary, high school, and university levels in the district governor’s office (Fig. 7).

Participants stated that an important step was taken in terms of bringing the modern microbialites of Lake Van into tourism. It was also stated by the participants that there is a diving school in the Adilcevaz district and this school will be operational in 2023 (Fig. 8).

The research area can be damaged due to some physical events in its natural process. However, since the area does



Fig. 7 Exhibition held at the Adilcevaz district governor's office. Cumali Birol gives a presentation on modern microbialites of Lake Van and tufa microbialites in the terrestrial environment of Adilcevaz

(A). Elementary school students listen attentively to the presentation (B). Group photos with some students and teachers after the presentation (C)



Fig. 8 Diving school presentation held in the Adilcevaz district governorship. Cumali Birol (on the left), who discovered tufa microbialites in the terrestrial environment of Adilcevaz, Adilcevaz District Governor İsmail Demir (on the right)

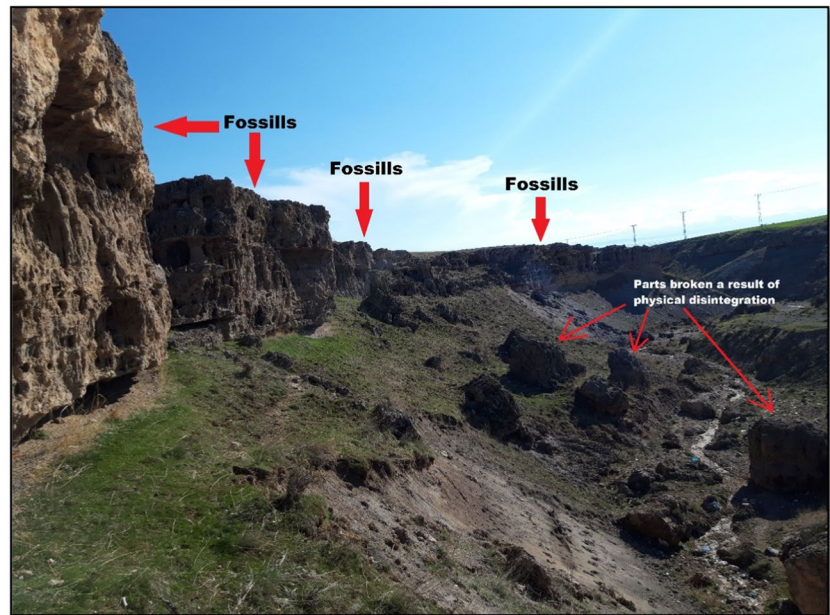
not have any protection status, it is obvious that it will be exposed to some external threats. In line with these concerns, the sixth and last question, one of the most important questions in the interview, was prepared for the aforementioned

concerns. The participants were asked whether there were any factors threatening the area that did not have any protection status. All participants except the mayor gave the same answer to this question. The answer given was “human.” It was stated that people came to this area in search of treasure and these searches caused some local damage.

It is also necessary to understand the factors that make people think that there are treasures in an area where such natural structures are located. There are two important reasons at this point. The first of these is Birol's statement, “When we reported the area to the press, we presented it as natural riches. People could not perceive this”. The concept of “natural riches” or “riches” in this expression was perceived by people as material wealth. The second reason is related to the formal appearance of these natural structures. The shapes of the tufa microbialites give the impression that they were handcrafted by humans in a historical sense rather than a natural structure. This situation created the perception that the area is a historical place and treasure searches were carried out in the region.

From the past to the present, natural or cultural values have been tried to be protected with various conservation approaches. Today, this understanding has developed in the form of protecting nature without spoiling it, without losing its natural characteristics, and ensuring its sustainability. Along with this, new conservation approaches have also come to the fore, and some of these approaches have emphasized the need for local people to be involved in the conservation process. Since the local people are ignored in the sole conservation approach, it is not possible to manage protection (Güneş, 2011). Therefore, it is necessary to carry

Fig. 9 Physical disintegration in the area where tufa microbialites are found



out conservation activities by involving the local people in the conservation process.

At this point, it is necessary to mention the internationally accepted classification of protected areas by the International Union for Conservation of Nature (IUCN), which was established to protect the diversity and integrity of nature and to ensure the equal and ecologically sustainable use of natural resources¹. The classification of protected areas specified by the IUCN is as follows:

- Category 1a: Strict Nature Reserve
- Category 1b: Wilderness Area
- Category 2: National Park
- Category 3: Natural Monument or Feature
- Category 4: Habitat/Species Management Area
- Category 5: Protected Landscape or Seascape
- Category 6: Protected Area with Sustainable Use of Natural Resources

Among the categories mentioned, the categories that may be suitable for the nature of the research area are Category 1a, Category 2, and Category 3. Category 1a is protected area managed for scientific purposes. Activities such as observational scientific research are permitted in an area in this category, but recreation and ecotourism activities are not allowed. In this context, tourism activities may be restricted if it is accepted as Category 1a. Category 1a can be evaluated within the scope of the “Nature Conservation

Areas” category in Turkey. The area where the Adilcevaz tufa microbialites are present meets the criteria. It is obvious that it is both a rare occurrence and exposed to danger. Accordingly, there are places where these formations are damaged as a result of physical disintegration (Fig. 9). However, the fact that the area is subject to restrictions on tourism activities makes it necessary to turn to another conservation approach for the research area.

Category 2 allows for environmentally and culturally appropriate spiritual, scientific, educational, recreational, and visiting activities that take into account the ecological integrity of a protected area. Tourism and recreation activities are given importance in protected areas within the scope of Category 2. However, activities such as tourism should be carried out in accordance with the nature of the area and in a way that the natural structures are not damaged. In order for an area to be protected within the scope of a national park, the area must be of a certain size which has been determined as at least 1000 hectares, excluding special cases and islands. The size of the research area has been determined as approximately 15 hectares. Therefore, it can be said that the size of the area is larger than the criteria required to be declared a national park.

Natural monuments protected within the principles of national parks are more flexible than national parks in terms of field size. Natural monuments fall under category 3. Accordingly, the field size for the natural monument should be small compared to the national parks, but large enough to ensure integrity in terms of protection. The research area is large enough to provide integrity in terms of protection. On the basis of national parks, recreational and visiting

¹ For detailed information on IUCN protection categories, see: <https://www.iucn.org/our-work/protected-areas-and-land-use>

activities are allowed in protected areas. If the research area is determined as a natural monument, people will be allowed to visit and activities in this direction can be carried out. In this context, the most appropriate conservation status for the research area is a natural monument.

Adilcevaz Tufa Microbialites as a Tourism Destination

Studies on microbialites offer the chance to develop activities such as congress tourism for the places that have these natural structures. Congress tourism can be an important center of attraction for tourism areas due to the cultural, scientific, and educational characteristics of cities or towns in some special cases. Especially cities or towns that are of scientific importance, which are the subject of many scientific studies or different disciplines, can be at the center of congresses to be held for scientific purposes.

In France, the M-fed (Microbialites: formation, evolution, diagenesis) organizes conferences on microbialites. At conferences, many different topics are discussed, from the formation processes to the fossil record of early and late microbialites. The formation, evolution, and diagenesis process of microbialites are discussed with up-to-date information in an open forum with the contributions of doctoral and postdoctoral researchers.

Scientists from different disciplines interact with the M-fed workshops. Scientists working in different disciplines such as microbiology, geomicrobiology, geochemistry, and sedimentology come together in this workshop. The first conference was held in Dijon, France (Microbialite Community, 2022).

Adilcevaz Tufa Microbialites Within the Scope of Ecotourism

Ecotourism aims to have as little impact on the natural environment as possible while being in harmony and peace with the environment. The International Ecotourism Society defines ecotourism as responsible travel to natural areas aiming to protect the environment and sustain the well-being of local people.

Considering the principles and objectives of ecotourism, Adilcevaz tufa microbialites as a tourism destination should be evaluated in this context in terms of its sensitivity to the natural and cultural environment. A tourism activity that takes into account the sensitivities of both the people of the region and this important natural formation will be beneficial in revealing the potential of the region.

In general, it is expected that the evaluation of Adilcevaz tufa microbialites within the scope of ecotourism will have the following benefits:

- Ecotourism provides first-hand experience with the natural environment. Seeing an important natural formation in its place, rather than just reading it in books or watching it only in documentaries, will add many different emotions and experiences to people.
- Since ecotourism considers the welfare of the local people, the local people will have more or less economic gains with the tourism activities carried out in the area.
- Ecotourism does not degrade, destroy, or harm natural resources. Therefore, these sensitive formations will be visited by conscious individuals.
- Ecotourism has an educational responsibility and satisfaction expectation, especially measured by educational criteria. So, the area where tufa microbialites are found will have the feature of a natural laboratory to be visited both in terms of scientific research and education.
- In ecotourism, there is no change or deterioration of the natural environment. It has the understanding to design and build as low-impact facilities as possible, even in the most extreme situations. In that case, when the area is transformed into a tourism destination, these sensitivities of ecotourism will be taken into account and necessary construction activities will be carried out without damaging these sensitive formations.
- The area where tufa microbialites are found should be protected. Ecotourism has the principle of providing direct financial benefits for conservation purposes. For this reason, ecotourism will be beneficial in keeping the area under protection.
- In ecotourism, there is a purpose to meet the needs of the local government and the people. There is also a responsible understanding that develops in cooperation with the local government and the public. A collaborative conservation approach with the responsibility of the local government and the public, as well as encouraging collaborative economic activities, will benefit both the natural formations in the area and the local people.
- Tourism activities can also create situations that harm sensitive formations in any area. However, in tourism activities within the scope of ecotourism, long-term follow-up and evaluation programs for the natural environment are supported in order to minimize the negative effects of tourism. Accordingly, the area will be under surveillance and any attempt to disrupt its natural structure will be prevented.

Despite its advantages, ecotourism activities that do not comply with its purpose and principles will definitely create negative results without good planning and management. In

a sensitive environment, they may even lead to the destruction of the environment. This will prevent the transfer of sensitive natural formations to future generations.

Adilcevaz Tufa Microbialites as a World Heritage with the Natural Values of Lake Van

World Heritage was established to promote cultural and natural assets with universal values, which are accepted as the common heritage of all humanity, to the world, to create awareness in society to protect this universal heritage, and to provide the necessary cooperation for the survival of cultural and natural values that are deteriorated or destroyed for various reasons (Ministry of Tourism, 2023). As of 2022, there are 19 heritage areas in Turkey, 17 of which are cultural and two of which are mixed.

Located on the shore of Lake Van, Adilcevaz has hosted many civilizations throughout history. Some castles, churches, and historical settlement ruins in the district are important structures that have survived to the present day. Especially the coastal part of Lake Van in Adilcevaz is very important. The district has the longest beach in the region. The beach is not the only factor that makes the coast of Adilcevaz district different from the coasts of other districts. Remains of historical castles and old settlements have also been identified off the coast of Adilcevaz.

In order to be included in the UNESCO World Heritage List, the areas should have a universal value and meet at least one of the ten selection criteria specified by UNESCO². Out of the ten criteria, areas meeting criteria 1–6 are accepted as “Cultural Heritage” while 7–10 are considered as “Natural Heritage.” In addition, the ones with both natural and cultural characteristics are considered as “Mixed Heritage.” Both the tufa microbialites on land and the microbialites off the Adilcevaz region of Lake Van have the potential to be considered a “Natural Heritage.”

Among the ten criteria determined by UNESCO for the World Heritage List, there are the criteria fulfilled by the research area and Lake Van. These are the 7th, 8th, and 10th criteria. The evaluated criteria are as follows:

a. Criterion (7): One of the most outstanding natural phenomena of Lake Van is that it has natural formations representing the largest microbialites in the world. Microbialites up to 40 m in size are unmatched in the world. Lake Van also has the distinction of being the largest soda lake in the world. Due to the recent withdrawal of the waters of Lake Van, many types of microbialites

have emerged in different parts of the Lake and at different times. Tufa microbialites in the terrestrial environment of Adilcevaz, besides their natural beauty, have aesthetic importance with their formal features. These natural structures on land attract attention with their formal appearances that are not seen anywhere else in the world. Having a highly unique structure distinguishes them from other fossil microbialites or tufa microbialites of the world.

- b. Criterion (8): The level of Lake Van, the world’s largest soda lake, has changed many times over the past years. These level changes have been the subject of many scientific studies, and the research on the terraces in the region has been decisive. However, the Adilcevaz tufa microbialites were the most concrete evidence of the level change in Lake Van. These natural formations are very important in terms of providing the opportunity to see the level change of the lake in the area. Adilcevaz tufa microbialites were discovered in 2017. It has not been the subject of any study since 2022. It is thought that scientific research on these natural formations will reveal a lot of information about the climate, vegetation, and geomorphology of the region’s past years. In this context, it is seen that the tufa microbialites in the terrestrial environment are precious natural formations that carry a lot of information about the past of both the world’s largest soda lake, Lake Van, and the region where it is located.
- c. Criterion (10): Besides having the largest microbialites in the world, Lake Van is a natural habitat for several important fish species. *Oxy-noemacheilus ercisanus*, known as Erciç Çöpçüsü, has been an important part of the lake ecosystem together with microbialites in Lake Van. It was stated by Akkuş et al. (2021) that the aforementioned fish population lives permanently in some of the unique microbialites of the lake, at a maximum depth of 13 m, approximately 500 m off the shore. *Oxy-noemacheilus ercisanus* was evaluated for the “Red List of Threatened Species” by the IUCN in 2013 and was later listed as “Endangered.” Microbialites and living things adapted to the life on them have become a rare example of natural life in the world in terms of being an important part of the lake ecosystem together with microbialites.

There are microbialites formed in different parts of the world in different geological pasts. These structures constitute the oldest life forms in the world. The oldest surviving life form belongs to the Archaean Period (3.6–2.5 billion years ago). These structures were inferred from the investigations of siliceous microfossils found in layered structures belonging to the Archaean Period. These microbial structures, found in sedimentary structures with silicon

² For more detailed information, see: <https://whc.unesco.org/en/criteria/>

dioxide composition dating back 3.5 billion years in Western Australia, are considered to be the oldest remnants of life on Earth (Schopf, 1993; Brasier et al., 2002; Konhauser, 2003; Allwood et al., 2007).

The oldest living remains discovered in Western Australia have been the subject of many scientific studies. In addition, the region is under protection. Shark Bay, located at the westernmost point of the Australian continent, attracts attention thanks to its islands and the land that surrounds it. The aforementioned region is included in the UNESCO World Heritage List. The most important feature of the region is that it has microbial structures containing the oldest living remains (Shark Bay World Heritage, 2022).

Lake Van has three extraordinary natural features. That is, it is the largest soda lake in Turkey and the world, the largest microbialite lake in the world, and the habitat of two important endemic fish, İnci Kefali (*Alburnus tarichi*) and Erciş Çöpçüsü (*Oxynoemacheilus ercisanus*). The fact that the İnci Kefali also hosts the original breeding migration gives the lake a different privilege (Sarı, 2008). In addition to these natural features, the lake preserves its mystery with historical ruins discovered in different places and at different times.

Conclusion

It is understood from the interviews conducted within the scope of the research that the biggest threatening element of the research field is human beings. It is important to protect the area where the Adilcevaz tufa microbialites are located, as well as to eliminate the dangers to which the area is exposed. The most important problem of the area is that it has not been taken under any protection status, which has caused this area to be exposed to external threats. The formal appearance of tufa microbialites gave people the impression that they were historical formations shaped by human hands rather than natural structures. As a result, there have been attempts to search for treasure in the research area.

Especially after the news by the written and visual media, attempts to search for treasure in the area show an important detail. The question “Is it correct to inform the press and announce this to the public before a building of natural or historical importance is taken under protection?” should be asked. At this point, it is understood that it is vital for the sustainability of a natural or historical area to be protected first and then announced to the press.

In the area where Adilcevaz tufa microbialites are found, the local people’s unawareness of the existence of the area has led to many problems. Within the scope of this research, interviews were also requested with the local people, but it was understood that the local people were not aware of the

existence of the area and at the same time they had no idea what such an area meant. This situation has led the public to consider the area as an ordinary place and as a result, causing problems such as environmental pollution.

If a certain area benefits people, it is expected that the negative activities towards the area will tend to decrease relatively. Because the benefit of the area will increase the sense of belonging in people. In this respect, if the area is brought into tourism and economic benefits can be obtained as a result, the sensitivities towards the area will also increase. In this case, a process for the benefit of both nature and human will have worked and naturally the understanding of protection will be deemed to have reached its main purpose. Another important issue in terms of reaching the main purpose of the conservation approach is the necessity of adopting a conservation approach that includes the local people. In cases where the local people are not included and ignored, the sense of belonging will disappear, and a process that is almost impossible to manage will emerge. In this context, it was deemed appropriate to take the area under protection within the scope of a “natural monument.” As a result of the universal value of the area, it was concluded that it should be included in the UNESCO World Heritage List.

In addition to their scientific importance, tufa microbialites are significant in terms of tourism, known as the smokeless industry. The more the scientific importance of a natural formation is, the more the interest in the location of that formation increases in direct proportion. These natural structures, with their previously unmatched morphological features, can encourage people to visit them. Travels can be made with the desire to see the area, which provides economic gain to the region. However, this potential could not be evaluated due to the fact that the area was not taken under protection and not promoted.

It is seen that the interest in microbialites is increasing day by day. With their unique formation and natural structure, they have the importance that should be the subject of scientific research. Microbialites serve as natural documents for different disciplines such as geography, microbiology, biology, and geology. Adilcevaz tufa microbialites are a laboratory for the aforementioned disciplines. These important natural structures need to be investigated by experts from different disciplines. In particular, mineralogical and microscopic studies are needed to enable a more detailed understanding of tufa formation and to explain the relationship between tufa and microbialites. Thanks to the scientific research to be made, thousands of years of information hidden in these structures will be revealed, and this will enable us to take a step further in understanding nature.

Both the tufa microbialites in the district and the historical remains under the waters of Lake Van show the stages of the level changes of Lake Van over thousands of years. All these values mentioned in Adilcevaz are natural and cultural

landscapes that show the extraordinary interaction between people and the environment. Evaluating the potential natural heritages in Adilcevaz and including them in UNESCO's World Heritage List will show that the interaction between humans and nature, together with the cultural values in the region, is an inseparable whole. Moreover, it will reveal the importance of the region more in terms of showing the reflection of this interaction process in a concrete way.

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Data Availability Data available on request from the authors.

Declarations

Conflict of Interest The authors declare no competing interests.

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