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Flood Control of Ulupinar Stream (Kemer/Antalya) and Evaluation of Geological Data

Sinan Emre ÇAKIR[1*] Mustafa Gürhan YALÇIN[1]

[1]*Department of Geological Engineering, Akdeniz University, 07058, Antalya, Türkiye*

Keywords

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Abstract

Antalya province, the study area, is located in the south of Türkiye, and it is one of the regions where flood disasters frequently occur, particularly due to excessive precipitation in the autumn and winter months. Therefore, it is extremely important to carry out the necessary engineering studies. Deluges and floods damage buildings, agricultural and residential areas, human life, and social and economic activities in the vicinity according to their flow rate. The study aims to evaluate the general geological structure of the region considering the reclamation of Ulupinar Stream in the Kemer district of Antalya, to determine a rock pit where resistant and impermeable rock material can be obtained to use in the construction of the masonry stone wall during the reclamation work, and also offer a reference study for future studies. The geological structure of the region was interpreted by using the general geological maps and studies conducted in the study area. The general geological map of the study area was edited and a generalized stratigraphic section was generated using geographical information system (GIS) methods and software. According to the results of the assessment of the studies and geological data on the flood control of Ulupinar Stream, which is one of the regions posing flood risk, the region was found to be a susceptible environment for flood considering the determining criteria such as the location of the basin and the average rainfall, and the reclamation of the stream has been suggested as part of the flood prevention plan. A rock pit where rock material can be obtained for constructing the masonry stone wall has been found 11 km from the region. The material in the rock pit is at a shallow depth and suitable for mining. All scientific studies related to the rock material and the rock pit determined in the study should be carried out before using the rock.

Cite

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Author ID (ORCID Number)

S. E. Çakır, 0000-0002-6384-5401
M. G. Yalçın, 0000-0002-8011-5371

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1. INTRODUCTION

In Türkiye, the Mediterranean, Black Sea, and Western Anatolia geographical regions are known to be susceptible to deluges and floods. The settlement type, distribution of the vegetation, and topography of these regions are observed to be compatible with the precipitation regime. Precipitation in these regions occurs under the influence of South, South-West, and North-West depression. In the Mediterranean and Black Sea Regions, the severity of depression precipitation increases since the range of mountains extend parallel to the coasts. Moreover, the melting of snow at high elevations, convective heavy rainfall in the inner regions, and the magnitude and frequency of floods in these regions affect the occurrence of floods in the spring (Demirbas, 2002).

Scientific studies have been made on medical geology, beach sands, and various river networks in the region (Yalcin M. G. et al., 2016; Cengiz et al., 2017; Unal et al., 2018; Yalcin et al., 2019). However, no study has been previously conducted on the study area. This emphasizes the originality of the study. The site location map (Figure 1) prepared in detail to be used in flood prevention studies of the Ulupinar Stream

*Corresponding Author, e-mail: sinanemrec@gmail.com

(Kemer/Antalya) is included in the study. The area indicated by the yellow line represents the risky area in the flood prevention study of the Ulupinar Stream in Kemer.

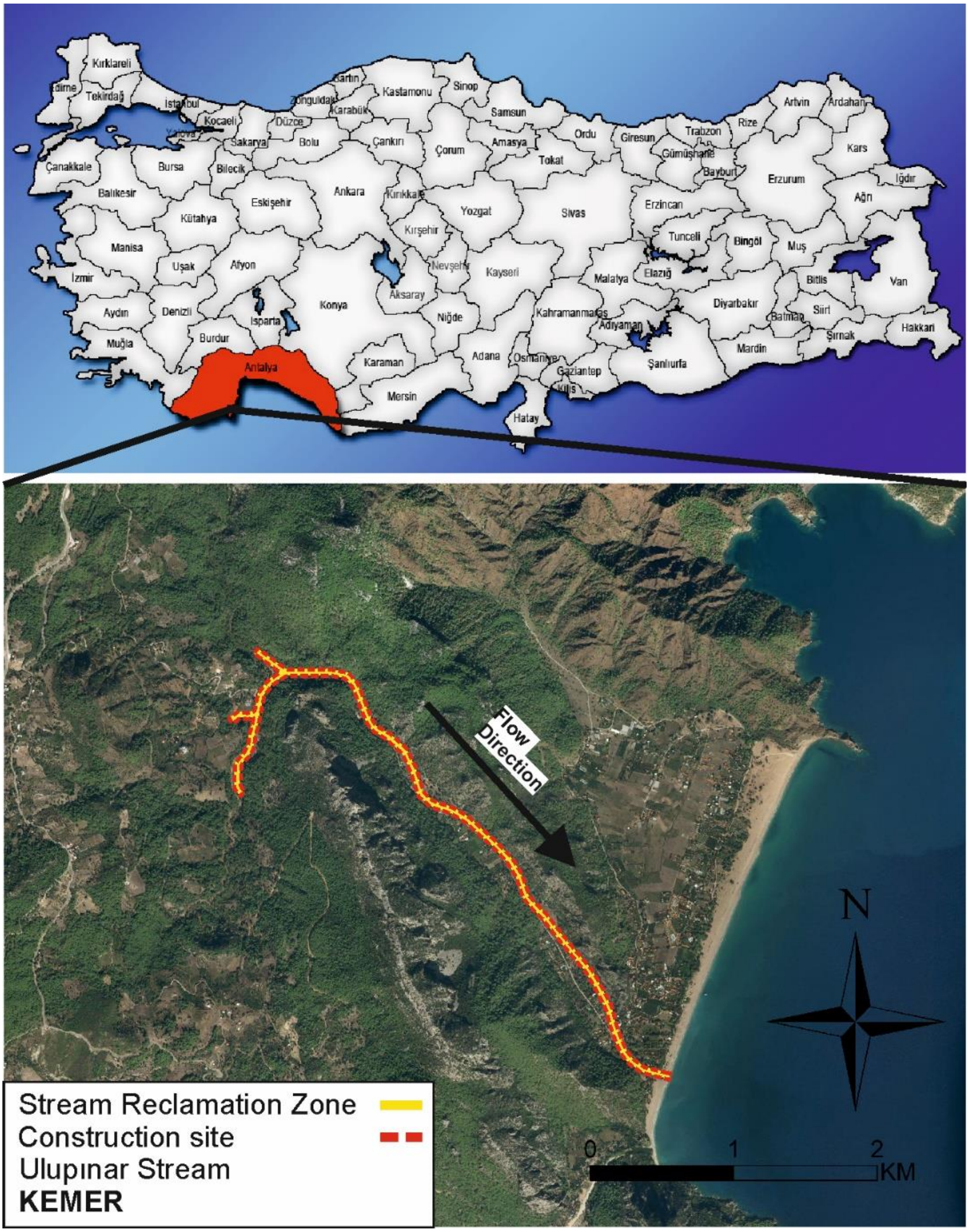

Figure 1. *Site location map*

The precipitation and temperature chart of Antalya (Figure 2) reveals that the amount of precipitation decreases very much and the temperature increases in the summer while it is warm and rainy in the winter. The temperature chart reveals that the average temperature in summer is above 25°C, the highest temperatures are observed in July (28.5°C) and August (28.4°C) while the lowest temperatures are observed in December, January, and February. The lowest average temperature has been measured in January (10°C). According to the precipitation chart, the amount of precipitation has been at the lowest level in summer while the amount of precipitation in winter has been higher compared to other months. The highest average precipitation (262.1 mm) has been observed in December (MGM, 2022).

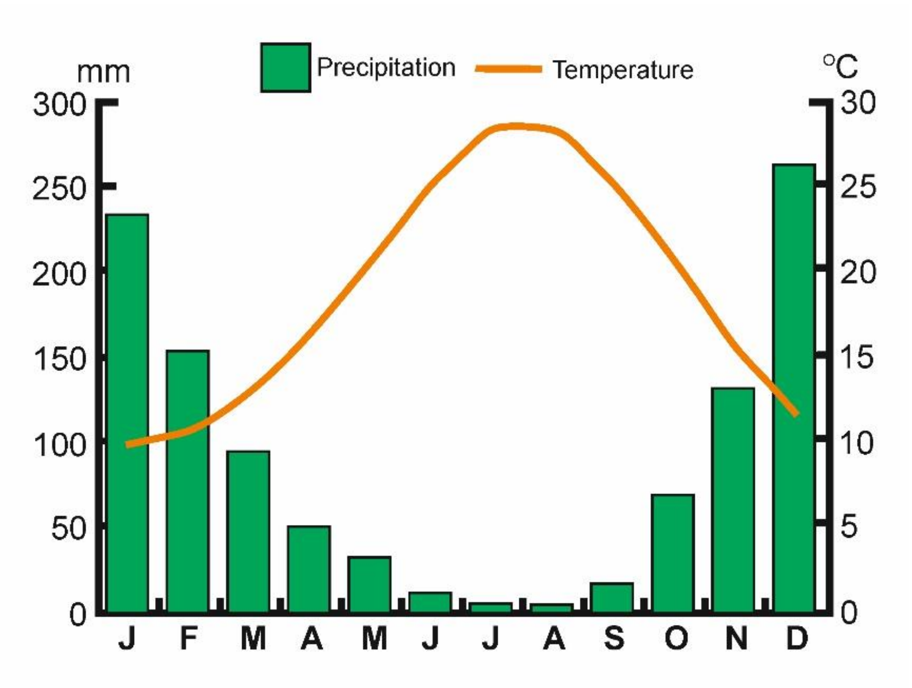

Figure 2. *Temperature and precipitation data of Antalya province for 1930-2020 (prepared using the 2022 dataset of MGM)*

Moisture added to the atmosphere with the evaporation in the Mediterranean creates unstable local precipitation around Antalya, especially in the summer. It is known that the humid air passing over the Mediterranean region creates heavy rainfalls due to factors such as the fact that the mountains extend parallel to the coast and the wind rises along the slopes. The fact that Antalya has heavy rainfalls creates flood risks and dangers.

Flood estimation studies are carried out using two methods before the occurrence of flood studies. These methods are as follows:

Deterministic (Analytical) Methods: Analytical relationships between the flood basins and climate parameters are established, and possible floods are estimated using these relationships (Yuksek et al., 2013).

Statistical Methods: Deluges and floods are examined as variables and possible floods are estimated using various probability distribution functions (Yuksek et al., 2013).

Flood risk assessment has been defined as the analysis of the most possible negative effects of the flood on people, buildings, agricultural areas, and infrastructure. The main purpose of flood risk assessment is to ensure human safety, support flood management and management decisions, and prevent damage to public and private sector infrastructure, and commercial and other economic activities (OSIB, 2015).

Deluges and floods occur at any time and place in nature due to usual or unusual meteorological events or due to climate change. However, artificial interventions performed by people play a significant role in causing destruction and human-life loss in settlements (Demircan et al., 2017).

Antalya has a high risk of deluges and floods due to heavy rainfalls; moreover, it is a suitable location for the formation of mineral deposits in terms of geological processes. In the region, quartzite, sand and gravel, manganese, lead and zinc, chromium mineralization and marble formation, as well as aluminum and barite mineralization, are observed (Yalcin F. et al., 2016; Tarinc et al., 2019; Ozer & Yalcin, 2020; Atakoglu et al., 2021; Atakoglu & Yalcin, 2021; MTA, 2022). Barite, lead, and zinc deposits, which are above the mining limit, are generally located in the Alanya and Gazipaşa districts in the east of Antalya. The region has barite deposits containing $BaSO_4$ with almost 95-100% purity (Kursun & Yalcin, 2020).

In areas such as the Ulupinar Stream, where the flow rate is high and the height and strength of the stream slope are low, it poses a flood risk due to heavy rains in cases where the gutter is insufficient. This causes material and moral damages, particularly in settlements such as greenhouses, agricultural fields, roads, and households. In order to prevent the flood risk, it is aimed to raise the stream slope by constructing an appropriate engineering structure and making it resistant to flow, thus reducing the damage it will cause. Therefore, a geological study was conducted before the project to meet the impermeable and stable rock material required for the construction of the flood prevention structure for the stream from a rock pit closest to the study area.

The general geological map and generalized stratigraphic section of the study area were generated using a geographical information system (GIS) software (ArcGIS 10.0.4), drawing software (Corel Draw 7.0), and 1:25,000 scale geological map data of the General Directorate of Mineral Exploration and Research.

2. MATERIAL AND METHOD

Geological units in the region are listed from the oldest to the youngest as follows (Figure 3):

Carbonates and Clastic Rocks - Carboniferous (p2): Tectonic slices of Hocalar and Sinat Mountain Nappes, which are examined in the regions can be examined as part of the Bolkar Mountain Unit and are located on tectonic slices belonging to the Bozkır Union. The outcrops of the Hocalar Nappe in the Hadim region consist of the Zindancık meta-olistostrome, which is thought to be Triassic-aged and contains meta-shale slate, meta-sandstone, and phyllite and includes Late Devonian, Late Permian, and Carboniferous limestone olistoliths, and Kayraklitepe quartzites, which cover it conformably (Ozgul, 1976).

Sandstone and shale limestone are identified as Middle-Upper Triassic (t2-3) age while the Middle-Upper Triassic aged sediments are identified as Sapadere formation. The name of radiolarite member was used for red-brown radiolarite, cherts, and shales in the formation (Ozgul, 1984a, 1984b).

Carbonates and Clastic Rocks - Triassic (t): The formation, which is represented by Megalodon limestones to the south of Anamas Mountain, was named by Gutnic et al. (1979). The unit consists of a thick-medium layer, light gray, pink, gray, cream, and dirty yellow limestones with plenty of megalodons. There is dolomitic limestone at the base and sand-clay limestones at the upper level. It has abundant algae and gastropod traces and stromatolite layers. Leylek limestone, which is compatible with Üzümdere formation on top, is approximately 250 meters thick and found to be of Rhaetian age. Shallow carbonate is the unit that deposits in the shelf environments and has a regressive feature at the top (Gutnic et al., 1979).

Neritic Limestone - Jurassic-Cretaceous (jka): The formation, which was named by Senel (1984), consists of neritic limestones. In the study area, several small crops with block appearance belonging to Tekedagi formation, which is the typical formation of Tahtalıdağ nappe, have been outcropped. The unit consists of limestones with medium-thick stratification, occasionally massive, beige, cream, gray, and white color, recrystallized limestones, and dolomitic limestones. Local dolomitizations are observed widely in the unit. The lower relationship of limestones in small cubes is observed to be tectonic while the upper relationship is not observed in this area. The unit in the area has a thickness of a few tens of meters. The Jurassic-Cretaceous formation was deposited in offshore platforms.

Dunite - Mesozoic (y1): Bolkar Mountain Unit, which was named by Ozgul (1976), contains Permian-Cretaceous aged rocks. It starts with the upper Permian carbonate rock and schist; the lower Triassic shale is compliant with the sandstone and marble intercalation. Middle Triassic diabase cuts these units and is all covered incompatibly by Jurassic-Cretaceous carbonate rocks. These units have been eroded by Cretaceous ophiolites (Yalcin & Temur, 2006).

Unseparated Quaternary Sediments (Qa): Quaternary alluvial sediments consist of loose, slightly round, or angular sand, gravel, and silt fillings. They are easily uncompacted dispersible rocks. The alluvium is observed along the stream valleys. Alluvial series, which are the cover layers, consist of limestones, metamorphic base, and clastic units (Cobanoglu et al., 2007).

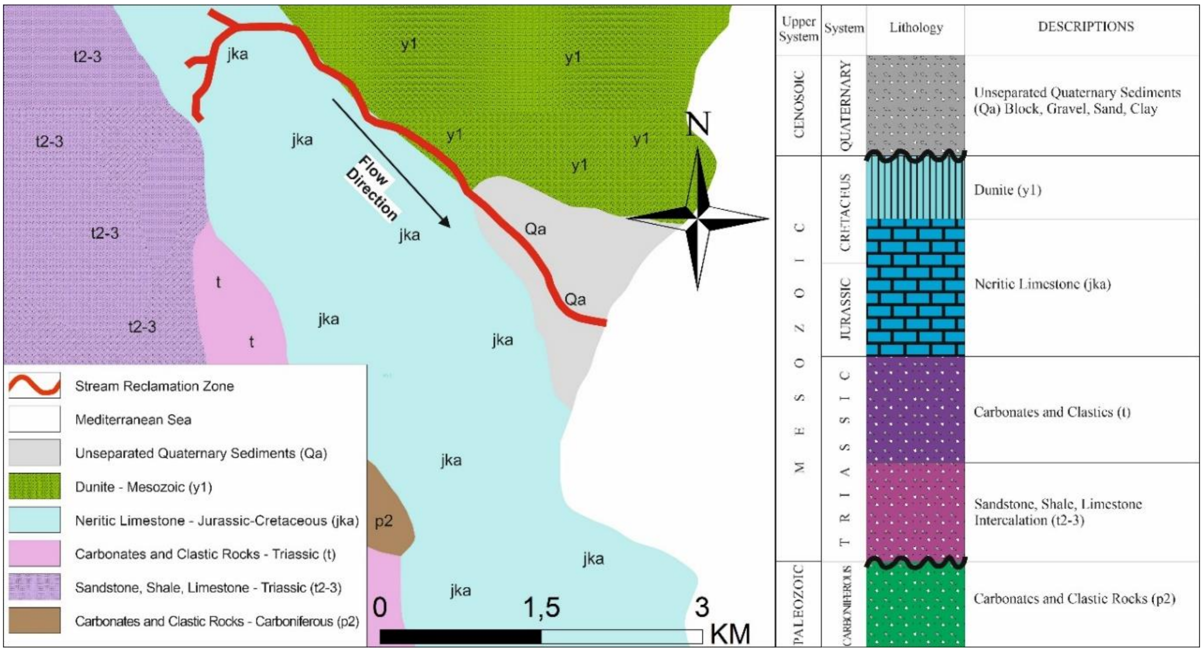

***Figure3. a)** Geological map of Ulupinar Stream and vicinity in Cirali Neighborhood of Kemer (prepared by editing the data of MTA (Akbaş et al., 2011)), **b)** Generalized stratigraphic section of Ulupinar Stream in Cirali Neighborhood of Kemer (prepared by editing the data of MTA (Akbaş et al., 2011))*

Photographs indicating the land and flow directions in the area are presented in Figure 4. Considering the geological map, stratigraphy, and general geology of Ulupinar Stream/Kemer and its vicinity, it is usually observed that there are carbonates and clastic rocks, sandstone-shale-limestone intercalation, limestones, and alluvial sediments in the study area. Since the geological units in the area will create a susceptible environment for deluges and flooding, research studies have been carried out to determine a rock pit of stable and impermeable rock material to be used in the construction of masonry stone wall for the reclamation of the stream and prevent the material and moral damage due to floods.

***Figure 4.** Photographs and flow directions in the study area of Ulupinar Stream in Kemer*

3. RESULTS AND DISCUSSION

Considering the geological data of the Ulupinar Stream and its vicinity covered by the study area, it was determined that it generally posed a flood hazard under heavy rainfall or precipitation conditions. Therefore, the reclamation of the Ulupinar Stream/Kemer was decided against flood hazards. The rock pit for the rock material required for the flood prevention measures in line with the data obtained from the General Directorate for State Hydraulic Works was determined, and the required filling volume was calculated.

The rock pit where rock material required for the construction of various flood protection and prevention structures on the course of the Ulupinar Stream/Kemer can be obtained is located 11 km southwest of the region. It is public property in the north of the Kilise location. It was found that 106,090 m^3 of rock material can be obtained with a mining depth of 4 meters. The site was investigated in terms of the required rock materials and the nature, reserve, and ground of the examined rock pit and its distance to the structure are given in the following tables (Table 1, 2).

The rock pit is located in the area covered by the 1:25.000 scale topographic map sheet of ANTALYA P24-b3. The rock pit, which is located approximately 1 km southeast of the Dükmendibi Neighborhood, is located on the western slopes of the Orta Hill in Kiliseyaka Location (Figure 5).

Figure 5. *Images of Rock Pit*

Table 1. *Details about the Rock Pit, its reserve, and distance to the construction site*

NAME OF THE AREA	DISTANCE TO STRUCTURE (m)	ROAD STATUS	AREA OF THE ROCK PIT (m^2)	MINING DEPTH (m)	RESERVE OF THE ROCK MATERIAL (m^3)	AMOUNT OF MATERIAL NEEDED (m^3)
ROCK PIT	11,000	Earth road has to be improved	26,524	4	106,096	67,000

Table 2. *UTM Coordinates of the Rock Pit (ITRF96-6°)*

POINT	Y= (EAST) E	X= (NORTH) N
1	271578.73	4030194.04
2	271665.18	4030175.23
3	271580.29	4029961.54
4	271458.93	4030010.62

All scientific studies should be carried out for the rock material to be extracted from the proposed rock pit before use.

4. CONCLUSION

Considering the geological and stratigraphic properties of Ulupinar Stream/Kemer, it was thought that there might be flood risk and it might damage farming and residential areas. Therefore, the reclamation of the stream was suggested. According to the results of the investigations, the researchers found that there were Upper Triassic Period Formations, Upper Cretaceous Period Formations, Quaternary Period Formations, Upper Cretaceous Formations (Bey Daglari Autochthon), and Quaternary Formations in the study area. Quaternary unseparated sediments, quaternary travertine, beach sand formations, limestone-shale intercalation, alluvial range, neritic and pelagic limestones, carbonates, and clastic rocks were also observed in the study area and its vicinity.

The geological map and stratigraphic section of the study area, Ulupinar Stream/Kemer and its vicinity, were generated. The rock material required for the construction of flood protection and prevention structures was investigated. Examining the geological maps and ambient conditions of the study area, it was first determined that the environment was susceptible to floods; thus, the reclamation of the stream was suggested by constructing a masonry stone wall using impermeable and strong rocks extracted from the rock pit.

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