MICROZONING OF IRGILLI MUNICIPAL AREA BASED ON TECTONIC, HYDROGEOLOGICAL AND GEOTECHNICAL PARAMETERS

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Abstract - Geological and geotechnical studies, decisive on land use and development plans, are the basic stage of a modern urbanization. Microzonation studies for development plans are crucial for safe environment and sustainable development. This study is focused on settlement suitability of Irgıllı (Denizli) Municipal area. The area is on an alluvium plain where is located on south of Lake Işıklı and surrounded by active fault lines. Some geotechnical tests and hydrogeological studies have been performed and the area was classified in terms of settlement characteristics. According to results of this study, it is determined that the southern part of the area is more suitable to settlement than the northern part.

Index Terms - Microzoning, geotechnics, active tectonics, Irgilli, SW Turkey.

I. INTRODUCTION

Turkey is one of the most active earthquake regions in the world. The early experiences show that many of the buildings were destroyed or damaged in the earthquakes because of improper geological and geotechnical site/soil conditions. In settlement site selection projects, geological and geotechnical studies to guide development plans and construction are one of the first and most basic stages of modern urbanization. Especially during earthquakes, the vital data that enables the hazard and risk analyzes resulting from the complex dynamic forces for the ground-structure interaction are obtained from these studies. In order to establish reliable ground, structure and environment relations before the urbanization, microzonation studies are carried out to analyze the ground engineering features and the potential hazards and risks of local and environmental disasters [1]. Microzonation is a multidisciplinary study aimed at identifying the disaster risks of non-urbanized and urbanized areas, and strategies and priorities in urban regeneration planning studies [2], [3]. Microzonation studies have been conducted especially in numerous cities where earthquakes are expected [4], [5]. In this context, studies were published by the Disaster Risk Management Institute and the Ministry of Public Works and Settlement General Directorate of Disaster Affairs titled "Microzonation for Municipalities: Handbook" and "Microzonation for municipalities: Scientific endowment" [6], [7] [8], [9], [10].
In this study, geological and geotechnical surveys supported by detailed geological surveys and field and laboratory tests of Irgilli settlement areas under earthquake risk were evaluated and the settlement suitability of the site was evaluated. In order to do it, the tectonical and hydrogeological parameters were also considered.

II. SITE SETTINGS AND METHODS

The study area is located in Denizli Province at SW Turkey where is highly industrialized. The area has a very high seismic activity and horst-graben system (Figure 1).

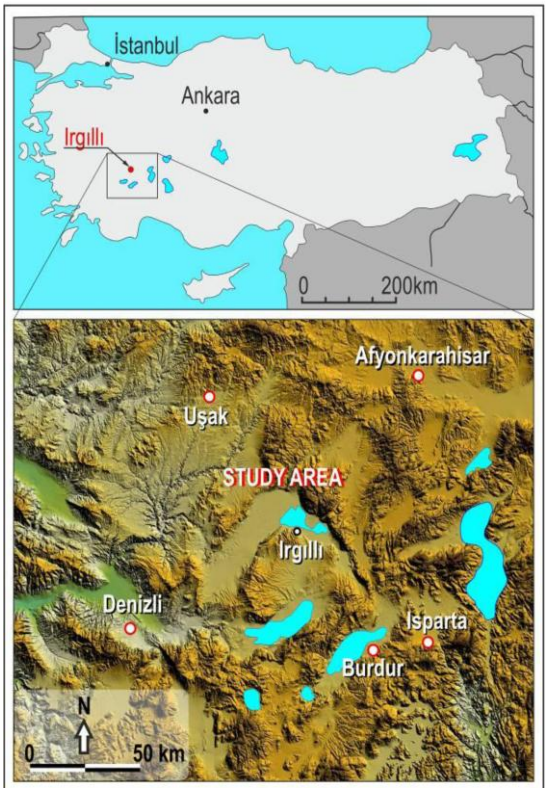


Figure 1. Location map

A. Geology

The metamorphics exposed in the study area represent the cover schists at the upper levels of the Menderes metamorphics. Menderes massifs are overlain by Lycian nappes composed of crystallized

limestones/marbles with tectonically thick bedded Mesozoic ages and recrystallized pelagic limestones and phyllites as old as Lower Eocene [11] (Figure 2). Tectonic settlement over the Menderes Massif of Lycian Nappes occurred in the Middle Eocene [11].

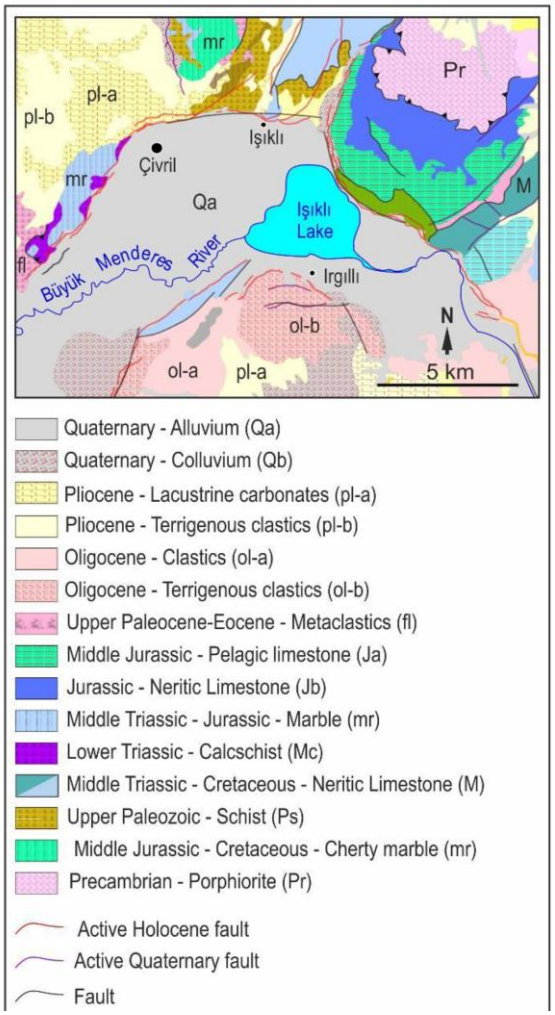
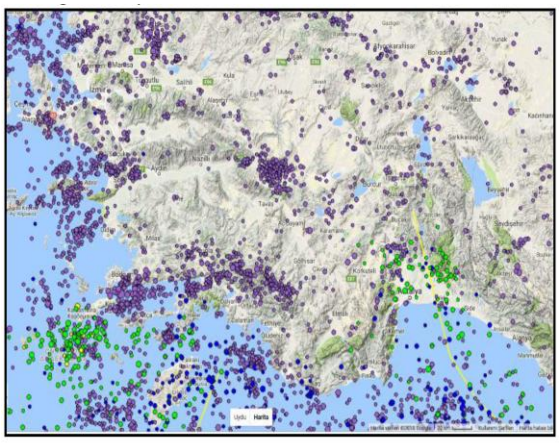


Figure 2. Geological and tectonical map of the study area

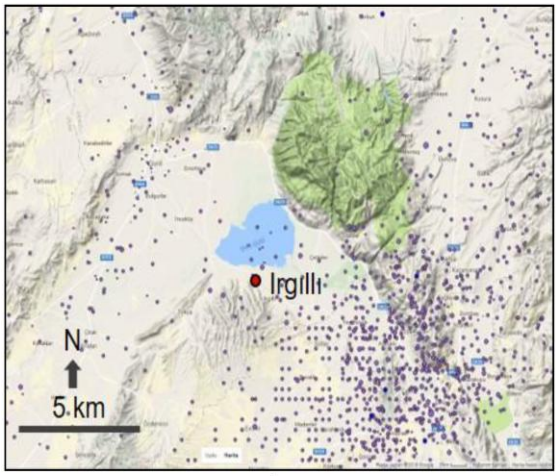
B. Tectonics

The study area and the Western Anatolian Region is one of the most seismically active (Figure 3) and fastest expanding regions of the world. The amount of opening is about 35 mm/year in the N-S direction [12]. In general, this direction of opening in the region under the effect of a tensile stress in the NNE-SSW direction is also compatible with the direction of the T axis, which is the result of the focal mechanism solutions of the earthquakes.Block-faulting tectonics, which constitute the main fracture systems in the study area, are related to the neotectonic development of Western Anatolia. The Aegean region is currently under active NE-SW stress deformation. The Anatolian plate bounded by the North Anatolian Fault and the East Anatolian Fault between the Arabian and Eurasian plates is escaping from the Bitlis-Caucasus zone to the Aegean region. At the same time, the influence of the roll-back of the African-Mediterranean lithospheric crust dipping northward under the Anatolian plate along the Cyprus-Aegean continent, pulls the western Anatolian region to the south and expands in the NE-SW direction.

The tectonic movements have led to develop the horst-graben systems in the area.



-a-



-b-

Figure 3. Earthquake records in Western Turkey (a) and in the study area (b) since 1970 (IRIS)

C. Hydrogeology

During this study and before, drilling data and water levels in observation pits for various purposes show that groundwater is closer to the surface in the northern parts of the study area. It can also be clearly seen from the locations of natural resources. That is, as approaching towards the lake, the depth of the underground water level decreases and is reaches to zero at the lake edge and equals to the lake edge (Figure 4).

The groundwater depth is shallowest in the northern part of the study area (observation point 1-2.4 meters); and the deepest is 10 meters to the east (drilling water purpose) at the further south (well #20). The direction of groundwater flow is generally from south to north

(Figure 4). The distance between the isohydrouhids (equi-elevation curves) opens up towards the northern plains. That is, as you approach the edge of the lake, the hydraulic gradient decreases.

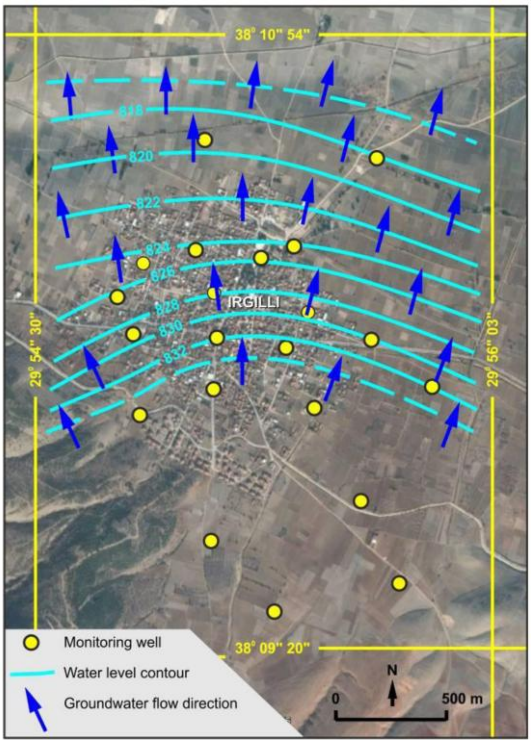


Figure 4. Groundwater table map (2002)

D. Engineering Geology

In order to put forward the geotechnical properties of the municipal area, twenty four geotechnical boreholes have been drilled. The disturbed and undisturbed samples have been collected at several levels of the boreholes. Menard presiyometre tests were carried out at various levels of drilling. Underground water level measurements have been made in the drilling wells and areas where there may be a groundwater problem from geotechnical aspects have been identified. In addition, twenty observation pits were opened for various observations and tests [13]. Since the site contains block- and gravel-sized material, the undisturbed samples could not been taken from all observation wells. Liquid limit, plastic limit, sieve analysis tests were carried out on spoiled samples. As a result of these experiments, soil classes were determined according to the consistency indices of the soils and the combined soil classification. Due to soil characteristics, the classification of some soil samples were made according to the results obtained from the sieve analysis. Untreated samples were taken mainly for direct shear test and triaxial pressing test. However, undisturbed samples could not be obtained at the amount of triaxial compression strength due to the soil conditions. Therefore, only shear tests were performed to determine the mechanical properties of the soils in the laboratory environment.

Atterberg limits were determined on the samples taken from all observation pits opened. It is seen that the liquid limit values vary between 22.0% (9 point observation point) and 46.0% (1 point observation point). In plastic limit tests, the values range from 15.0% (observation point 5) to 28.0% (observation point 16). The plasticity index values were ranging from 1 to 15. The natural unit weight of the obtained samples was found to be 17,3 kN/m^3 minimum and 18,9 kN/m^3 maximum. The natural water contents change between 17.1% (observation point 4) and 36.6% (observation point 1).

The soil types found in the study area are mainly sandy, gravelly soils and rock. The sand soils include silt and clay and have outcropped in northern part of the area. Gravelly soils are also very common in the area. The rocks are observed at southwest of the municipal area (Figure 5). The most problematic soils are sandy soils and have liquefaction potential.

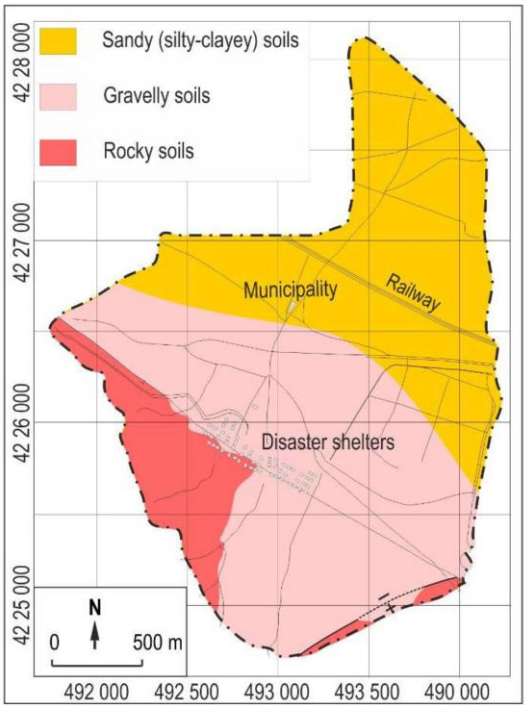


Figure 5. Soil types in the study area

III. RESULTS AND DISCUSSION

The parameters described above are dominant when the study area is evaluated for urbanization suitability. In the recent geological and geotechnical studies, it is expected that the areas should be classified as "suitable", "suitable with precaution" and "not suitable" in Turkish Building regulations. As it can be understood from the description, geological and geotechnical areas are not suitable for zoning but there is absolutely no permission for urbanization in unfavorable areas.

The Irgilli settlement area generally presents a morphological structure increasing in height from

north to south. In parallel to this, a small transition from the north to the blocks in the size of the block is seen in the same direction, and rock units appear in some sections. Rock and coarse grained units generally provide a more appropriate foundation for the construction. On the contrary, fine grained units generally exhibit a lower bearing capacity. It is observed that the low modulus of elasticity and the limit pressure are lower in the northern sections and increase towards the south. If the slope is too high, the urbanization is classified as “unsuitable”, although it is geologically appropriate.

In the light of all these evaluation criteria, the area is classified as "suitable", "suitable with precaution" and "not suitable” for urbanization and it is shown in Figure 6.

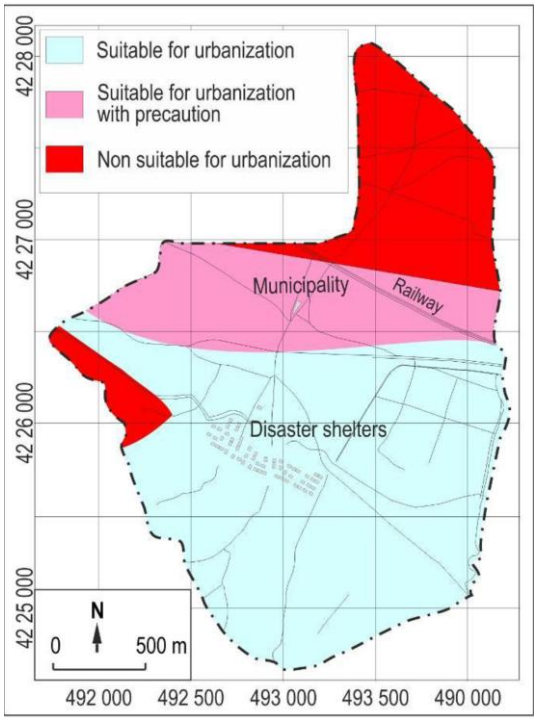


Figure 6. Settlement suitability map

The northern sections of the survey area are classified as "not suitable", while the southern sections are designated as "not suitable". The section between these two sections is a transitional zone is called "suitable with precaution" where detailed geotechnical study have be made before the construction and/or the necessary geotechnical precautions should be taken if necessary. Although a narrow area in the western-southwest part of the study area is a rocky ground, "settlement is defined as “inappropriate area". The reason is the high slope inclination in this area.

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