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Hydrological investigation of Antalya basin (Turkey) concerning the inflow into the Mediterranean Sea

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Abstract

A hydrological study is carried out of the Antalya travertine basin in Turkey concerning the inflow into the Gulf of Antalya into the Mediterranean Sea, respectively. The demand for water (for drinking, industrial and irrigation purposes etc.) in the Antalya basin is increasing. E.g. the city of Antalya will require about $150 \cdot 10^6$ m³ water in the year 2020 (KARAGÜZEL, SCHOLZ AND EBEL 1999). To be able to determine the water need, geological, hydrological, hydro geological and hydro chemical investigations in the Antalya basin are needed. Especially measurements of precipitation, water levels (volumes) of the lakes, discharges of the distributaries and the irrigation channels in the whole catchment area are necessary. Water-quality analyses show that groundwater has been and is being contaminated by sewage discharge, industrial and other activities that create an ever-expanding impact to the available aquifer (KARAGÜZEL AND IRLAYI 1998).

On the basis of the present research an integrated, e.g. EU-founded research project is needed. Project co-ordinator will be Süleyman Demirel University (SDÜ) which is located at the centre of the research area. Turkish and German universities and the public sector institutions will be the partners of the project. In this paper the status of the present research and the ongoing research activities are presented.

Introduction

As stressed in long term development plans of Turkey and other global conferences, i.e. Rio Conference, the optimum management of water resources is extremely important. This environmental subject, which is closely related to the future living conditions of the people of Turkish and Mediterranean countries, is also seriously concerned by Turkish Government.

Two of the largest fresh water lakes of Turkey, along with others, are located in the Lake district of Turkey. In addition, many rivers reaching the Mediterranean originates from that area. The good management of these water resources has vital importance, and this necessitates continuous updating of the relevant data and adding new tools of management. By the research effort, it is expected that better understanding of the current and future environmental conditions of the water resources will be obtained and decision models to be developed for sustainable use of this vital resources of the benefit of the region, of Turkey and of mankind.

The Lake District of Turkey and the Antalya Basin

From the point of water resources, the Lake district of Turkey is one of the richest regions of the country. In the region, many lakes such as Egirdir (see Fig. 1), Beyşehir, Burdur, Akşehir and so on, and large aquifers such as Isparta, Yalvaç, Gelendost, Akşehir, Atabey, Senirkent, Yılanlı, Bucak, Antalya Travertine Basin and so on are present.

The surface water resources have been employed for multipurpose utilisation, namely drinking, irrigation, hydroelectric energy production and tourism purposes. The new water exploitation projects are also being planned for further use. However, there exists a potential of overexploitation of those resources. In addition, the industrial and agricultural activities in the fresh water basins continues to negatively affect the water quality and to deteriorate the ecological balance.

Therefore, the aims are establishing a co-ordination of the multipurpose use of the resources in an optimal way and to alleviate the harmful environmental and ecological impacts. In addition, considering the richness of the water resources of the region, a co-ordinated use of them will allow the excess water to be shared by the middle east and Mediterranean countries.

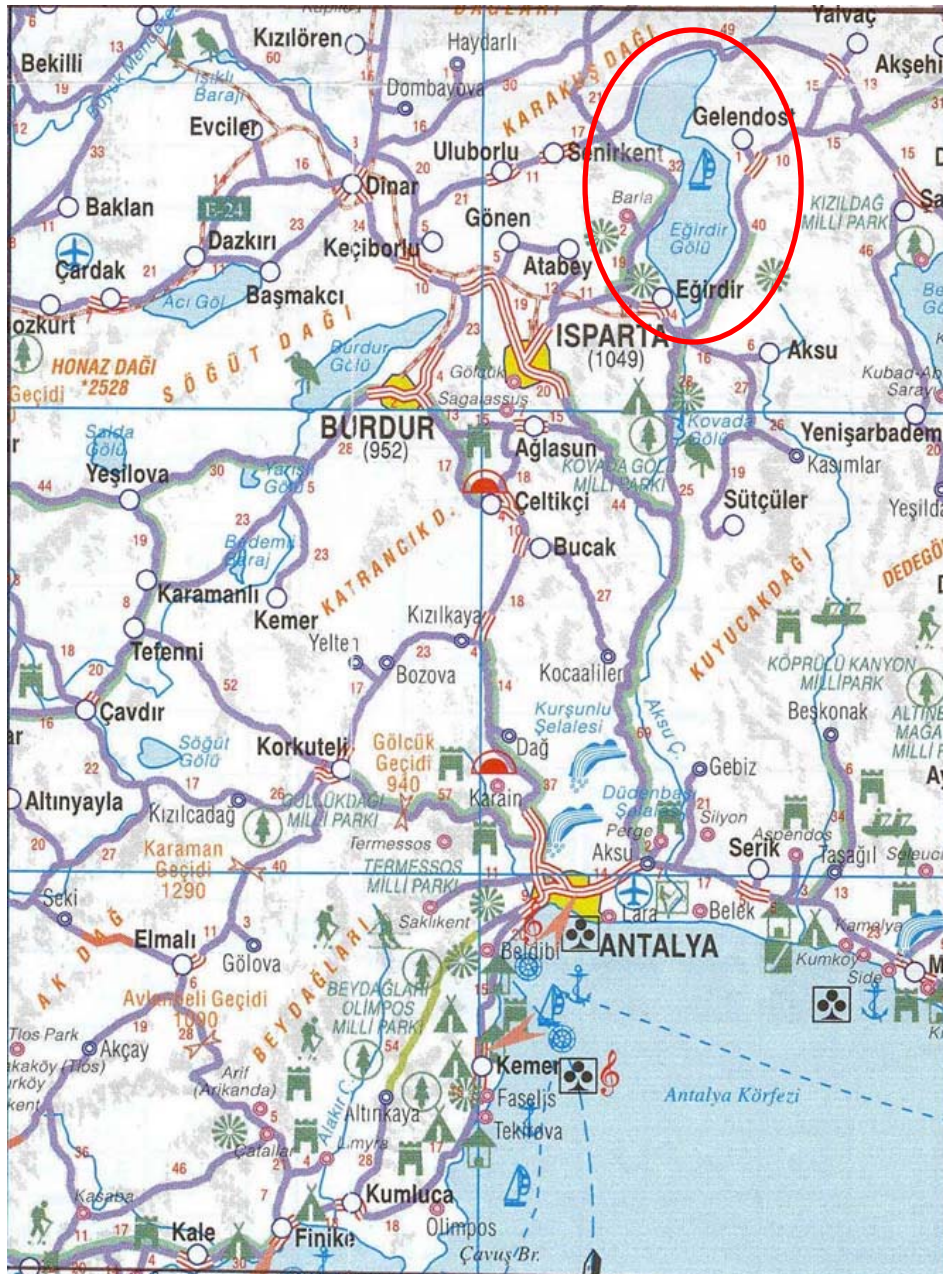


Fig. 1: Gulf of Antalya, Eğirdir lake in Southwest Turkey

The Antalya basin is subdivided into Manavgat, Köprüçay and Aksu sub-basins in the western Taurides Mountains. A map with parts of the investigation area, including Antalya and Lake Eğirdir, is shown in Fig. 2.

In the Northwest is an outcrop of Mesozoic limestone with dark grey to black colour and massive and crystalline in texture. It contains karstic landforms such as sinkholes, dolines, poljes and uvalas. In the East are a Molasse series (Miocene) of deposits of approximately 120 m, which consists of successive layers of loosely cemented gravels, limestones, sandstones and marls. In the North and Southwest are allochthonous units overthrust upon the Mesozoic limestones. They create an impermeable cover over the Karstic limestone. A large area of 630 km² is covered by Antalya Travertine, which can be divided into three plateaus. The elevation difference between these plateaus can reach up to 100 m (KARAGÜZEL, SCHOLZ AND EBEL 1999).

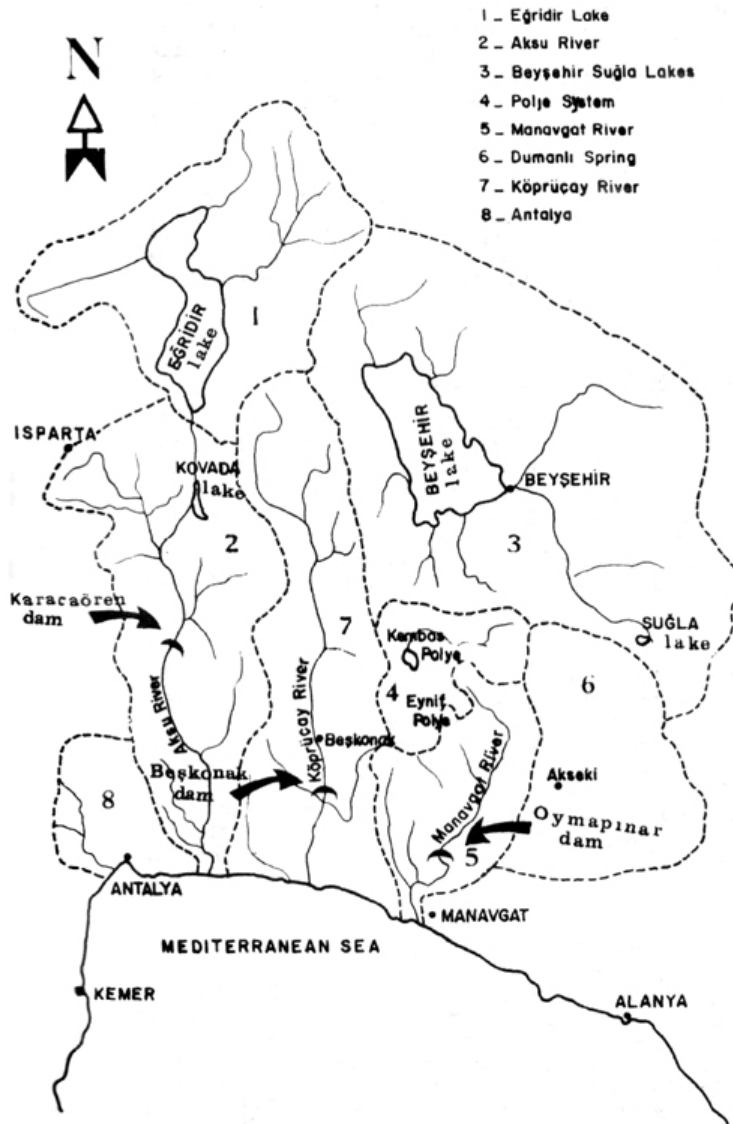


Fig. 2: Catchment basins in the investigation area in Southern Turkey

The area, where Taurid Range mainly is made of ophiolitic complexes, thrust over massive carbonate formations with karstic cavities. Agricultural basins, including shallow lakes are located within these tectonically broken limestone masses. For physical and socio-economic identity of the region some statistical information's are given in table 1 and 2:

Table 1: Main physical features of sector concerned

| | Egirdir Lake | Burdur Lake | Beyşehir Lake | Akşehir Lake | Eber Lake | Salda Lake | Acı Lake | Gölcük Lake | Kovada Lake |
|----------------------------|--------------|-------------|---------------|--------------|-----------|------------|----------|-------------|-------------|
| Surface (km ²) | 480 | 200 | 656 | 105 | 126 | | 153 | | 8.5 |
| Topog. high (m) | 916 | 854 | 1120 | 958 | 967 | 1139 | 836 | 1378 | 903 |
| Depth (m) | 5-10 | 110 | 70 | 3-5 | | > 200 | | ≅35 | 3-4 |
| Quality of water | fresh | brackish | fresh | fresh | fresh | brackish | brackish | fresh | fresh |
| Management | | | | | | | | | |
| Irrigation | + | | + | + | | | | + | |
| Domestic water | + | | + | | | | | | |
| Energy | + | | | | | | | | |
| Industrial raw material | | | | | | + | + | | + |
| Tourism | + | + | + | + | + | + | + | + | + |
| Aquatic prod. | + | | + | + | + | + | | + | + |

Table 2: Main socio-economic features of sector concerned

| | Isparta | Burdur | Afyon | Antalya | Konya* | Toplam | Türkiye | %-Ratio |
|--|---------|---------|---------|---------|----------|-----------|-----------|---------|
| Cultivated area | 1354084 | 1350804 | 3072938 | 3332255 | 10564210 | 19674291 | 174480913 | 11.28 |
| Irrigated area | 342959 | 471692 | 693855 | 1038656 | 2685206 | 5232368 | 36741577 | 14.24 |
| Not Irrigated area | 1011125 | 879112 | 2379083 | 2293599 | 7879004 | 137739336 | 10.48 | |
| Unused potentially productive land | 110831 | 124610 | 670875 | 361096 | 1248508 | 2515920 | 21606845 | 11.64 |
| Montana or forest land | 1503680 | 1156960 | 2972086 | 3444926 | 5394505 | 14472157 | 113403340 | 12.76 |
| Population of provincial and district centre | 229796 | 129112 | 306209 | 602194 | 963128 | 2230439 | 33411252 | 6.68 |
| Population of villages | 204975 | 125787 | 432770 | 530017 | 789530 | 2083079 | 23061783 | 9.03 |

* Only a small part of Konya province is included in the area.

Background

Since the potential of ground and surface water resources which are distributed unevenly is not known sufficiently following problems reach serious dimensions gradually:

- The usage water resources for domestic, industrial, irrigation, energy, sea products, sport and tourism affects each other in negative directions.
- Irrigation of agricultural lands using ground and surface water resources in the region is not carried out in unbalanced way.
- Unconscious usage of pesticides and fertilisers and fish breeding works spoils the water quality in the lakes. In addition to this, the waste water which are not filtered adequately by settlements (KARAGÜZEL, TASDELEN, ÖZKUL AND BILGIN 1995) and solid waste not stored properly by industrial enterprises in the basins give way to the pollution of the water resources.
- The usage of lake water for irrigation and energy cause the decrease in the food (flora and fauna) of fish. This situation of the lakes gets poor from aquatic products point of view.
- The scale of the possible problems related to the excessive usage of the lake water, pollution, sediment deposition velocity and shallowness in years of 2010 is not known.

In relation to the planned research project, but directed to various purposes, the following work have been and are being carried out by different institutions and universities:

- Elements of natural and artificial recharge and discharge of lakes
- Surveys of groundwater in the basins
- Determination of water quality
- Report of hydrology of Egirdir Lake
- Basemetry of Egirdir Lake
- Geologic maps of the region scaled 1/25 000

- Statistical reports of marine products
- MSc and PhD studies of Turkish and German universities
- Compilation of a GIS-based database

Data and Database

Information related the geography within the boundary of Lake District area which is the subject of the investigations will be collected in a database. The geographical information of settlements, population, agricultural fields, vegetation, animal breeding, industrial organisations, peaks, streams, plains and water reservoirs will be found in the database. Also a compilation of a GIS-based database is needed.

The geological properties have to be known from the underground and surface water potential interbasin hydrogeological relations and to establish water quality point of view. Geological maps and sections have to be prepared by using earlier works made in the basins subject to the study. Subsurface and surface geology will be explained by a revised map, sections, block and panel diagrams prepared as a result of the works made by different research institutes and organisations. All kinds of geological properties; mineralogy, petrography, stratigraphy, tectonics, mineral deposits industrial raw materials, geochemical etc. will be stored in the database. By using the information, various geological maps will be digitalized. So, all information will be related to solve all kinds of geological problems of the area accessible very quickly and evaluated.

From designate potential of the water sources (underground and surface) of the Lake District, study of the basin relations and to determine and observing the water quality point of view, the importance of the hydrogeological works is important. Hydrogeological studies of the plains and neighbouring basins in the basin discharge area is unavoidable due to mutual water trade and water quality point of view.

An abundant source of groundwater can be found in the aquifer under the plains where the urban areas are located. As urban areas above aquifers create the danger of pollution of groundwater, pollution studies are vital for groundwater management and public health. For the future watershed management a high quality groundwater model is needed.

Age determination will be made by using natural ^{210}Pb and ^{137}Cs and sedimentation speed of the Lake District sediments will be obtained. Since the sediments are like the memory of the artificial and natural events of the past, provided the pollutants analysed along the depth of the sediments organic pollutants will be based on a chronological age. ^{210}Pb determinations will be made by using sediment samples. Either ^{210}Pb to be separated by radiochemical methods will be measured in determinations or sediment samples will be counted directly by utilising gamma spectroscopy methods.

For the present and the proposed situations irrigation water drawn from the lakes will be determined in a sensitive way and these will be taken an input for the development of water management models. Nowadays some water related projects affect the country economy in a serious way. In spite of this, they also affect the

environment and the society in great dimension. Therefore, these studies must be based on the reliable hydrologic studies. The aim of the agriculture is to improve the production per unit area. In order to get the aim, effective irrigation is essential. For this reason great amount of water supply and irrigation structures are needed for agricultural lands. Since the irrigation water is supplied by only a single water resource, usage of water must be optimum in order to use the water resource at optimum level.

Water Level Fluctuations

Further more an analysis of the water volume and level fluctuations of all lakes in the basin, e.g. Egirdir Lake is needed. Egirdir Lake is located near the city of Isparta in the south west of Turkey (see Fig. 1 and 3).



Fig. 3: Lake Egirdir

It has a major importance in the region for drinking water, irrigation, hydro energy, fishing and tourism. Water fluctuations on the lake level have been recorded for a long time (see Fig. 4). The natural inflow parameters of the lake are surface and subsurface flows and the direct rainfalls on the lake. The natural outflow parameters can be listed as evaporation, shallow holes and a discharge channel in the south end of the lake. Artificial outflows are originated from drinking water, irrigation and hydro energy requirements.

The level fluctuations of the lake have been found occurring as long term repeats and annually. Annual level changes are in the range of 30 to 50 cm and the periodical

changes reach up to 4 meters. These fluctuations basically depend upon arid and rainy periods. The changes in the lake level are greatly affected by artificial inflows resulted from several reasons (KARAGÜZEL, TASDELEN AND AKYOL 1995).

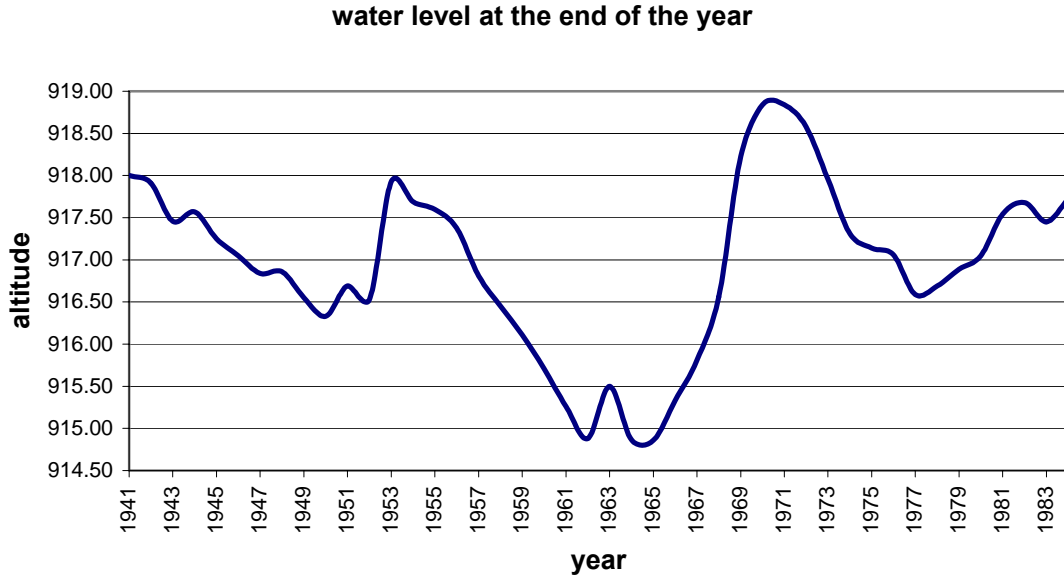


Fig. 4: Fluctuation of the water level of Lake Egirdir

In order to analyse these fluctuations, the water budget has to be calculated. The results show that the groundwater outflow is greater than the groundwater inflow. Because the Egirdir Lake is very shallow a sustainable water management is needed. The risk of drying out the Egirdir lake by misuse is high because the equilibrium is very sensitive. The total outflow of the Antalya basin into the Gulf of Antalya respectively the Mediterranean Sea has changed. These changes will also affect the future sea level of the Mediterranean Sea.

Fields of Investigations

Chemical, Hydrological, Hydrogeological and computational facilities of Engineering and Architecture, Aquatic Products and Agricultural Faculties of Süleyman Demirel University (SDÜ), Computer and Chemical Engineering of Bilkent University, Remote Sensing and Geographic Information Systems (GIS) facilities of SDÜ. and Anatolian Universities will be utilised. The Research Center for Water and Environmental Engineering (fwu) of the Faculty of Civil Engineering, Siegen University (Germany), will provide the educational and consulting support.

In addition, observation stations, water chemistry laboratory and drilling equipment and facilities of State Hydraulics Works (DSY) (UNITED NATIONS 1983) and Mining Technical Exploration Institute and finally chemical, biological and botanical laboratory facilities of Marine Products Research Institute will be utilised.

Conclusions

The Lake District area has rich water resources in the country. The Süleyman Demirel University, (co-ordinator of the project), is located in the centre of the investigation area. Whenever needed, required laboratory and other technical equipment that belong to the partner institutions will be available for the investigation. Personnel's of the partners and students of the universities will work for the investigation when required.

Presently unirrigated agricultural lands are able to be irrigated after the completion of the investigations, leading to an increase in the agricultural productivity and hence to opening of new work areas, as well as to an increase in the average income of the region.

Another possible social benefit namely prevention of migration to urban areas, will result due to opening of new agricultural work areas. Achieving an optimum use will prevent the waste of water resources. Possible industrial and urban sources of surface waters and groundwater pollution will be identified and various measures of protection and premeditation will be put into action.

Further investigations of Antalya basin and the Lake District of Turkey concerning the inflow into the Mediterranean Sea are of very high importance.

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