Water Receding in Burdur Lake and Solution Proposals / Burdur Gölü'nde Su Çekilmesi ve Çözüm Önerileri

NURFEDDIN KAHRAMAN

Bilecik Şeyh Edebali University, Faculty of Arts and Sciences,
Department of Geography, Bilecik - TURKEY
nurfeddin.kahraman@bilecik.edu.tr

Abstract

Burdur Lake has gone through a rapid receding in the water level since Burdur earthquake on May 12, 1971. The lake cannot be fed at a sufficient level due to various reasons such as ponds established on the streams flowing to the lake and drawing underground water in the basin with drilling at extreme levels.

Burdur Lake, one of the important wetlands of Southwest Anatolia, is an example to oligotrophic lakes. As there is no outflow, the water cycle is realized with influx and evaporation. For this reason, the lake has a high level of salinity.

The water level in the lake increases in rainy periods and decreases in drought periods. At the end of every increase period following water drawback, generally the lake water cannot reach the previous rise level. As a result of these drawbacks and rises, instability of the lake coast line can cause fatal consequences for living species on the coastline.

Although certain projects have been implemented for continuity of the lake ecosystem in Burdur Lake, no positive result has been obtained from these projects that have provided solutions for the basin.

The visible problem of Burdur Lake is that it cannot be fed at enough level. The purpose of this study is to flow water from Karakuyu Lake which is located within the borders of Afyonkarahisar to Burdur Lake by benefitting from height difference and thus to provide a solution offer for the rapid water drawback in the lake. We think that it may be possible with additional measures to be implemented at Burdur Basin.

Site observations, flow values for Karakuyu Lake and Suçıkan spring in Dinar and meteorological data provide results that support our opinion in this regard.

Keywords: Burdur Lake, lake level, lake ecosystem, Karakuyu Lake, Suçıkan spring

Özet

Burdur Gölü, 12 Mayıs 1971 tarihinde meydana gelen Burdur depreminden beri, su seviyesinde hızlı bir çekilme süreci yaşamaktadır. Göle ulaşan akarsular üzerinde kurulan göletler, havza içinde yeraltı suyunun sondajlarla aşırı miktarda çekilmesi gibi nedenlerle adı geçen göl, yeterince beslenememektedir.

Güneybatı Anadolu'nun önemli sulak alanlarından olan Burdur Gölü, oligotrofik göllere örnek oluşturur. Dışa akışı olmadığı için su döngüsü, sızma ve buharlaşma yolu ile gerçekleşir. Bu nedenle göl suyunda tuzluluk oranı yüksektir.

Göldeki su seviyesi, yağışlı dönemlerde yükselme, kurak dönemlerde ise çekilme göstermektedir. Çekilmeyi takip eden her yükselme devresi sonunda, genellikle göl suyu bir önceki yükselme seviyesine ulaşamamaktadır. Bu yükselme ve çekilmelere bağlı olarak göl kıyı çizgisinin duraysızlığı, kıyı kuşağında yaşayan canlı türleri için ölümcül sonuçlar doğurabilmektedir.

Burdur Gölü'nde, göl ekosisteminin devamlılığı için bazı projeler uygulanmış olmasına rağmen, bugüne değin havza içi çözümler sunan bu projelerden olumlu bir sonuç alınamamıştır.

Burdur Gölü'nün görünürdeki sorunu, yeterli beslenememesidir. Bu çalışmanın amacı, yükseklik farkından yararlanarak Afyonkarahisar il sınırları içindeki Karakuyu Gölü'nden Burdur Gölü'ne su akıtılması ve böylece gölün su seviyesinin hızlı düşüşüne bir çözüm önerisi getirmektir. Burdur Havzasında yapılacak ek önlem çalışmaları ile, bunun mümkün olacağını düşünmekteyiz.

Saha gözlemleri, Karakuyu Gölü ve Dinar'daki Suçıkan kaynağına ait akım değerleri ve meteorolojik veriler, bu konuda düşüncemizi destekler sonuçlar ortaya koymaktadır.
Anahtar Kelimeler: Burdur Gölü, göl seviyesi, göl ekosistemi, Karakuyu Gölü, Suçıkan kaynağı

1. Introduction

Demand for fresh water reserves in the world is rapidly increasing depending on population growth and developing technology. On the other hand, the rainfall level that is included in the hydrological cycle after evaporating from the earth's surface and feeds terrestrial water environments as rainfall products is at a fixed level at global scale. Use of this water, reserves of which we consider to be fixed, has a great importance for the future of human beings and the earth's ecosystems. Considering the current developments, it will be inevitable that water related problems from different locations of the world will cause more serious challenges in near future.

The region of lakes in Southwest Anatolia (Fig. 1), mainly Burdur basin, is an example to regions where water problem is growing day by day. Burdur Lake that covers the bottom of the basin is experiencing a rapid downfall in water level as a result of evaporation, influx and extreme level of water loss as well as insufficient feeds. Water level measurements have been made in the lake since the beginning of 1960. The lake reached its highest level in May, 1970 since then with 857.44 m and as from that time, it constantly decreased and reached 842.87 m level in September, 2012.

Burdur Basin has emerged as a pull apart type basin with neo-tectonic movements that began in the Upper Miocene and has acquired its current position throughout the geomorphologic development. Burdur Lake has been formed as a result of sedimentation of this basin depending on the same tectonic mechanism of the Northeast section in the Lower Quaternary.

Water of Burdur Lake, en example to oliographic lakes, includes 22 g dissolved solid per liter. Dissolved solids include chlorides, sulphate and carbonates as well as trace amount of arsenic. The lake ecosystem is distinctive just as the chemical structure of water. The lake has been exposed to extreme pollution with urban and industrial waste waters along with pollutants from agricultural irrigation in recent years.

Life in the lake has developed on the coast line that received plenty of daylight, that is relatively rich in nutrients and that provides a more vivid water circulation due to characteristics of water. Frequent fluctuations and gradual decrease in the lake water level depending on seasonal changes pose threat against life on the coastline. Plants that try to cling to life in shallow waters on the coastline are weak types roots and support systems of which has not developed. In case of low water, their vital functions are damaged (Photo 1). Changes in the water level of the lake in this respect cause fatal consequences for these plants and other species that lead their lives depending on them.

Receding in the water level that has been observed for over forty years in Burdur Lake has accelerated since the beginning of 1990s. Water receding has brought many problems, mainly damages in the lake ecosystem and salination on the coastline. All of the opinions that have been expressed to solve such problems until now provide in-basin suggestion offers. Problems of the basin that has been opened for agricultural production and settlement since the Neolithic period have emerged due to disruption of the natural balance in itself. Possible in-basin measures will be

limited due to settlements in the basin, agricultural production areas and investments in industry, transportation and water facilities.

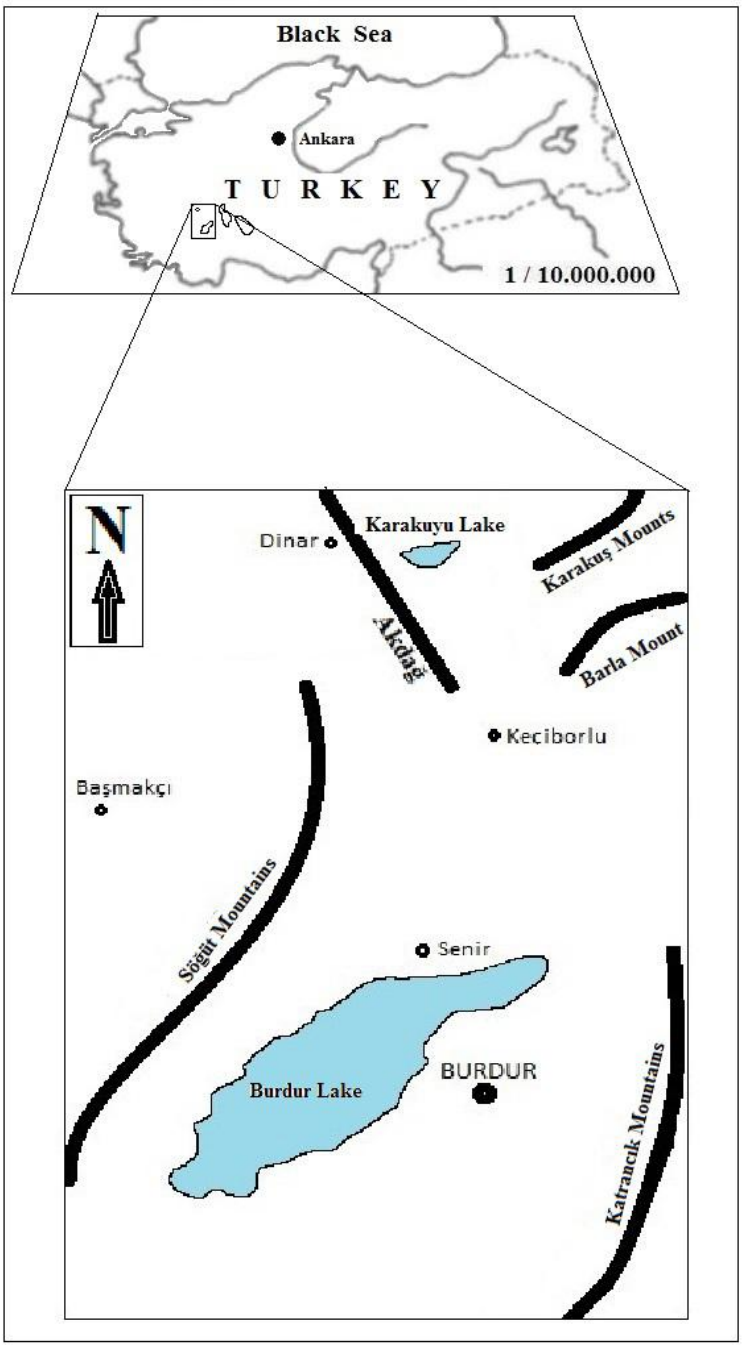

Fig. 1: Location map of Burdur and Karakuyu lakes.

Photo 1: Tangles that dried as a result of drawdown in Çendik Beach on the Southeast coastline of Burdur Lake.

1.1. Purpose

Despite the negative developments underlined above, supply of the water need of Burdur Lake and its ecosystem from outside the basin comes to the forefront as a possible suggestion. Water support from Karakuyu Lake in the North of Burdur Lake is considered possible in this respect. Such measure would create a condition that would provide a slight balance although it cannot completely prevent the decrease in the water level of Burdur Lake.

1.2. Material and Methodology

Water reports for the years 2007-2008 for Karakuyu Lake, flow values for Dinar Suçıkan spring and measurement results of Burdur Lake obtained from the General Directorate of State Hydraulic Works constitute the priority data used in this study. Furthermore, climate data obtained from the General Directorate of State Meteorological Service, core results of drilling operations around Burdur Lake obtained from the Regional Directorate of State Hydraulic Works of Isparta, satellite images and literature studies compiled from works by different researches that indicate the condition of the lake in the recent years constitute our reference sources. The indicated data and results obtained from the aforementioned sources have been tried to be evaluated with the site observations that we conducted in the region.

2. Generalgeomorphological - Hydrographic Characteristics of Burdur and Karakuyu Lake Basins

Basins where Burdur and Karakuyu lakes are located are depressions that have emerged as a result of the neo-tectonic movements dominant in the region. Karstification is also effective in formation of these depressions.

The basin where Burdur Lake is located has indicated subsidence through the Quaternary and thus, the lake level has gradually lowered. Subsidence plays a role in that the lake basin has not been disappeared by being filled out although it has been exposed to significant levels of sedimentation. Burdur Lake is surrounded by slopes comprised of Pliocene lake reservoirs that are not suitable for direct formation of aquifers.

There is no high flow water resource, except for Koca Pınar spring located in the West of Senir town, at any point of the slopes of Söğüt Mountains comprised of ophiolites, Eocene flysh series and Oligo-Miocene old conglomerates surrounding the basin in the West. Burdur urban water is provided from Koca Pınar spring located near the coastline of Burdur Lake.

The geologic-tectonic structure in the Northeast section provides a similar condition. Two relatively powerful springs located close to each other in the Western sloped of Yortmadere valley that descends onto Burdur Basin from the Western extensions of the Barla Mountain used to supply water for sulphur facilities in past and meet the water need of Keçiborlu pond now after decommissioning of these facilities.

Burdur Quaternary basin is connected to Tefenni Basin with Karaçal Strait in the Southwest. Bozçay, coming through this strait from Tefenni basin is the most important stream that feeds Burdur Lake. However, it will not be possible anymore to feed the lake from this section with the dam constructed on Karaçal Strait.

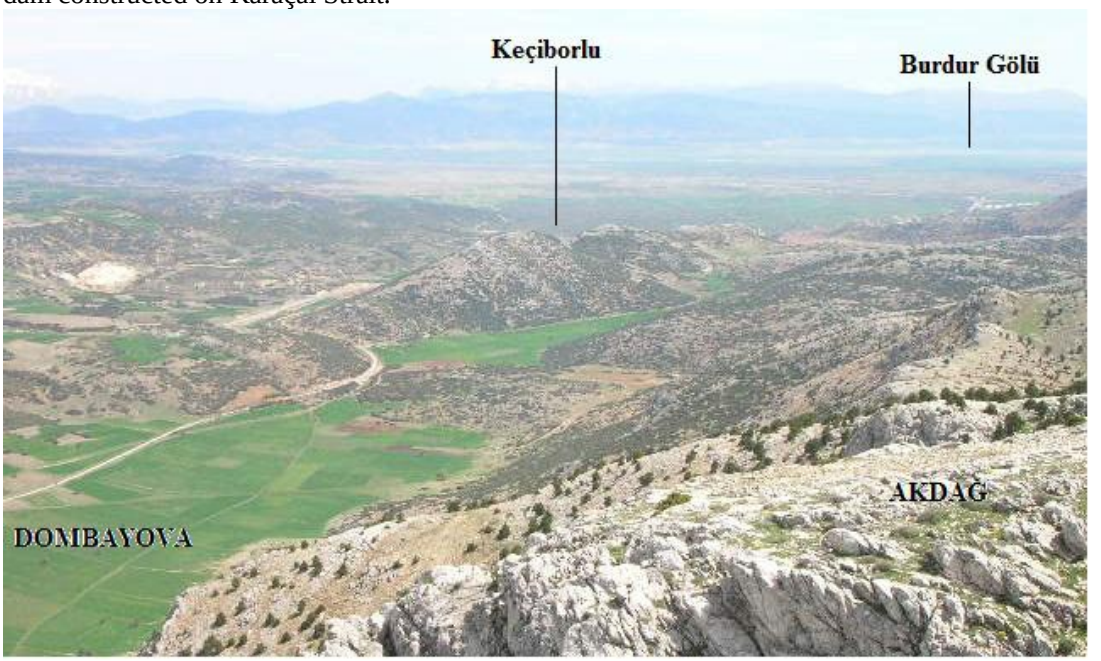

Photo 2: View from Akdağ summit of the borderline that distinguishes Burdur and Dombayova depressions and the hanging valley in the North of Keçiborlu.

Karakuyu Lake is located in the middle sections of Dombayova. Dombayova has occurred after sedimentation of the Southern section of Sandıklı Plain due to neo-tectonic movements. The borderline that distinguishes these two depressions follows the district borders of Dinar and Sandıklı. Dombayova plains gradually contract in the South and lead away from Burdur Basin with a borderline in the North of Keçiborlu. There is a valley canal hanging in the West section of this borderline (Photo 2). The height of the bottom of the valley canal where the highway and the railway pass through today is between 1108-1110 m. The height difference is over 30 m

between the upper sections and the bottom of the Eastern slope of the valley. There is not any stream located in the surrounding area that could possibly split such valley. Terrace sets in the lower levels of the valley slopes indicate that this valley canal was used by a stream in the Quaternary. It is understood that before the tectonic subsidence described above, Dombayova waters used to follow this valley canal and flow in Burdur Lake. Traces that correspond to the fault steeps of the last phases of the described subsidence are clearly monitored in the sections of the slopes behind Uluköy, Akça, Burunkaya and İncesu villages that border Dombayova in the East. A volcanic ash cone has also been formed depending on the fault located on the slope in the East of Akçaköy.

Terrace set formations from the previous levels of the lake were not observed around Karakuyu Lake. This indicates that the lake was formed in the Quaternary and did not make any changes in the levels in following periods. Dombayova depression is bordered with Akdağ mass in the West. Waters submerging from numerous dolines formed under the slopes of this mountain before the surrounding area of Karakuyu Lake was set by DSİ rise to the surface from the karst springs under the Western slopes of Akdağ. The most important spring among them is Suçıkan spring rises from the slope behind the district center of Dinar

Photo 3: Lake patterns that indicate decrease of water level in time on the slopes of Üveyik Tepe on the Southwest coastlines of Burdur Lake.

3. Reasons For Decrease in Water Level of Burdur Lake

a. Decreases have been observed in the water level since the emergence of the lake depending on the settlement with subsidence of the basin bottom where Burdur Lake is located (Photo 3). It is understood from old traces around the lake that the water level also increased between drawdown periods. The Roman Era sepulcher in the Beşiktaş rock on the coastline between Pamuklu plain and Karakent village in the Southwest of the lake is submerged

comparing to the water level of the lake in 1970s. The concerned sepulcher could have been constructed in the beginning of the Christian era (Ramsay 1960).

b. Irrigation purpose dams and ponds constructed on the straits emerging from the mountain slopes surrounding the Burdur closed basin prevent the lake from being fed at a sufficient level. Total water amount held at 19 dams and ponds constructed on the basin streams is approximately 202 hm^3 (Ataol 2010).

c. Underground waters drawn by extreme and uncontrolled drilling on Burdur basin are used as irrigation water with traditional methods. For this reason, these waters that are not lost with underground evaporation get involved in evaporation more when they are brought to the surface. It is required to know the number of drilling operations and the amount of drawn water to accurately indicate the total water amount drawn by drilling in Burdur basin. The estimated annual amount is about 42 hm^3. Waters that are transferred to underground aquifers by infiltration from Burdur Lake replace the waters drawn by drilling. The water loss of the lake by this means is 30 hm^3 annually.

It is inevitable to use drilling waters in Burdur basin. Even drinking and potable water of the city used to be provided from drilling operations in Çine Plain before İnsuyu Cave for long years. Drilling waters also meet a significant deficit in agricultural irrigation.

d. Natural or human induced drying of wetlands that emerged for natural reasons at different heights in the basin played a significant role in the emergence of water problem. The lake formations that used to cover Çine Plain before İnsuyu Cave in the East of the basin (1200 m), lakes Bereketli in the South section (1423 m), Gençali in the West (1131 m) and Pınarbaşı in the Tefenni plain bottom are example to dried lakes. Also the swamps around Kovanlı (870 m) and Özarmut (859 m) in the Southwest of Burdur Lake have dried as a result of extreme drawing of underground water with drilling. Yarışlı Lake (910 m) in this section has started to look similar to the playa formations as it did not receive sufficient amount of water.

e. As Burdur Lake does not have open drainage, the water level in the lake depends on feeding and evaporation. The region receives 433 mm of rainfall annually according to the rainfall averages of Burdur and Tefenni meteorology stations. The annual average potential evaporation in the basin is 1359 mm according to the data from Burdur Meteorology Station.

According to the calculations made by Ataol (2010) in the light of data from Burdur Meteorology Station between 1965 - 2008, the water inlets and outlets of Burdur Lake are summarized in the below chart:

Chart 1: Water inlet and outlet of Burdur Lake according to average rainfall and evaporation values for 1965 - 2008.

WATER INCOME (hm3)		WATER OUTLET (hm3)	
The sum of the annual rainfall of the lake	: 61	Evaporation from the surface of the lake	: 149
Reaching water the lake by streams	: 78	Infiltration	: 30
Total	: 139	Total	: 179

f. The annual average amount of water that flows with streams on Burdur basin is approximately 269 hm^3. However, it does not provide a significant contribution for feeding the lake as 202 hm^3 of this water is held at dams and ponds as described above.

There are opinions suggesting that Burdur Lake loses water with leakage (Sungur 1978). Despite the lack of concrete evidence for such water loss of the lake, this assertion should be researched into. Because, the bottom of the depression where Burdur Lake is located has been fragmented in a rhomboidal pattern with fault lines developing in different directions. Water

leakage is possible from the weak lines of the faults to deeper levels. For this reason, a detailed hydrogeologic study is required about Burdur basin.

There are high leakage capacity Mesozoic old limestones that are mostly suitable for karstification under the Quaternary terrestrial filings on the bottom of the basin. Thickness of the terrestrial fillings covering the limestone formations differ from one point to another. According to drilling results, while main rock form limestone is reached at 26 m around Keçiborlu in the Northeast of the basin, 32 m around Senir town, 16 m around Aşağı Müslimler village in Southwest and 21 m at Düğer village, thickness is high in the impermeable fillings comprised for materials such as marl and clay in the East-Southeast section. Clay and gravel interchanges are significant from the levels near the bottom in drillings exceeding 100 m in this section (Fig. 2).

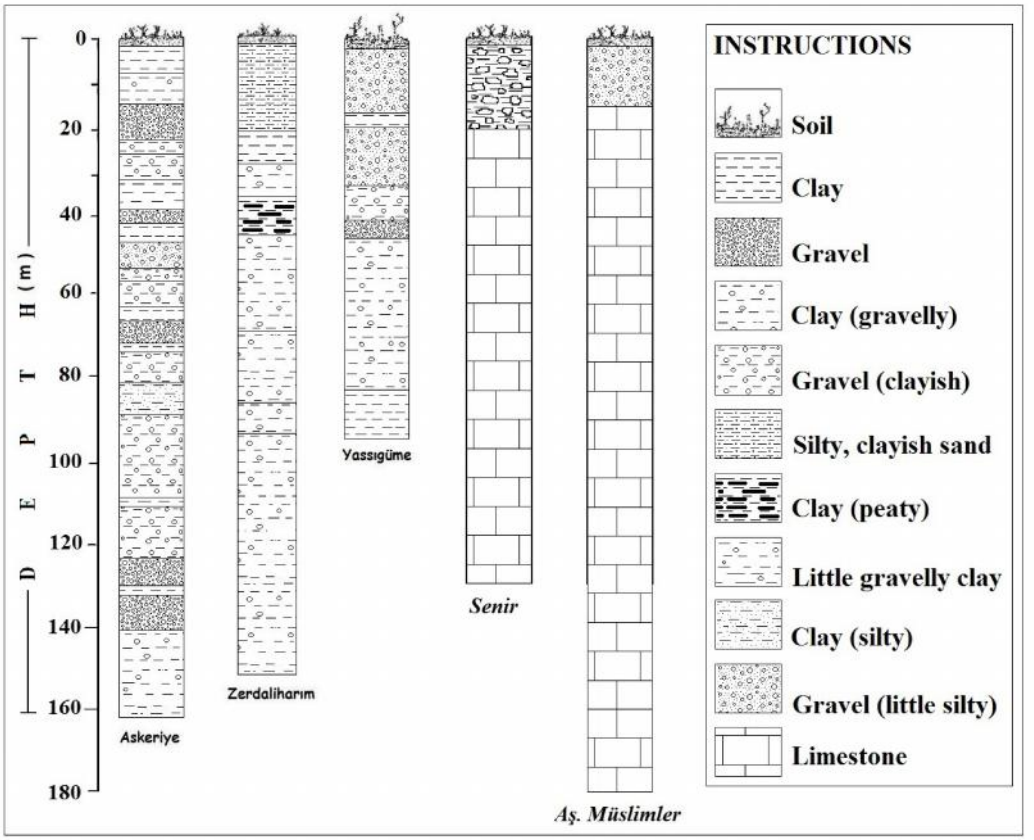

Fig. 2: Drilling cores in Burdur Quaternary basin.

Burdur Lake concavity has been filled with materials brought by straits from the slopes comprised of marl, silt, clay, sand and gravel reservoirs of old Pliocene Burdur lake from the East-Southeast. For this reason, the lake face has moved to West-Northwest and leaned on the Eastern slopes of Söğüt Mountains where limestone is dominant on lithologic terms. This condition may have caused underground galleries and water leakages along the West-Northwest coastline of the lake.

4. Water Report For Karakuyu Lake

Karakuyu Lake is located in the Southern section of Dombayova that constitutes the South section of Sandıklı depression. The lake and its surroundings were declared "Wild Life

Protection Area" in 1994. Karakuyu Lake, covering an area of approximately 1099 hectares, is fed by seasonal straits from Eldere spring in the East (called Kocapınar or Ulupınar in the area), underground and seasonal straits from the surrounding mountain slopes. The most important strait of them, Kumalar Streamlet originates from the Southeast sections of Sandıklı Plain and pours into Karakuyu Lake in the South of Karakuyu town.

According to measurements of Regional Directorate DSİ of Isparta, Karakuyu Lake receives 87 hm^3 water in total annually from Eldere spring. Considering waters from rainfall, underground feeding and other resources, it is understood that the lake has a water inlet of about at least 100 hm^3 annually. Ministry of Forestry and Water Affairs General Directorate of Nature Conservation and National Parks describe Karakuyu Lake "with rich water resources".

March-April months constitute the period in which Eldere spring flow value reaches the highest point. Flowrate is 6 m^3/sn in these months. The lake should receive 180 hm^3 annually according to these flow values. However, summer is drought except for sudden rain showers observed in certain years in the region. For this reason, flow values decrease in summer also in Eldere spring.

It was observed that no significant change occurred in the water level of Karakuyu Lake during the site studies conducted between 2006-2008. This condition is also related to underground feeding of the lake apart from Eldere springs.

According to the date from General Directorate of DSİ, the water inlet and outlet of Karakuyu Lake are as follows:

Chart 2: Water inlet and outlet of Karakuyu Lake for 2007 - 2008.

WATER INCOME	(hm^3)	WATER OUTLET	2007	2008 (hm^3)
Eldere (Kocapınar) source	86	Given water to Dinar hpp	25.7	17.95
Kumalar stream and others streams	20	Sinkhole	8.44	5.72
Rainfall	30	Water rights	4.77	7.10
		Pumping	2.15	3.43
		Evaporate	6.79	8.27
TOTAL	130 (hm^3)	TOTAL	47.19	42.47 (hm^3)

In the chart, the annual average water outlet of Karakuyu Lake for 2007-2008 is 45.87 hm^3. It is observed that there is a difference over 80 hm^3 between water inlet and outlet.

5. Water Streaming From Karakuyu Lake to Burdur Lake:

Comparing Burdur and Karakuyu basins, while Burdur basin has a deficit of up to 40 hm^3 in terms of annual water report, an excess amount of annual 80 hm^3 is available in the water report of Karakuyu Lake. We assume that while a portion of this water is provided to the surrounding facilities and operations, an important part moves underground by leaking. The limestone slopes bordering Dombayova in the East and the West cover a very large area. There are numerous sinkholes under the limestone sloped of Akdağ in the Western section. Although Karakuyu Lake has sets before these slopes, water loss is possible from the sinkholes, fractures and break systems in leakages mainly comprised of colluvial fillings. Whatever the reason for water loss, it is understood that Karakuyu Lake has excess water. The surface level of the lake is 1009 m. The water level of Karakuyu Lake decreases in the periods of summer drought. However, such decreases do not reach levels to effect the lake ecosystem as in Burdur Lake.

We mentioned above that the Western section of the border line distinguishing Burdur and Karakuyu lake basins is cut by a hanging valley. The highest point on the bottom of this valley is 1110 m. The bottom of Dombayova descends to the North at a 1% slope towards Karakuyu Lake at 1009 m level. From the indicated border line, the area descends at a 1.1% slope towards Burdur Lake surface of which is located at 850 m height. The 1009 m level, which is the level of Karakuyu Lake in the section sloping towards Burdur Lake corresponds to the vocational high school in the district center of Keçiborlu. It will be possible to drain excess water of Karakuyu Lake to Burdur Lake without any energy consumption with a water distribution tunnel to be dig from a certain point on the Dombayova bottom to this level (Fig.3).

As can be understood from Chart 1, the annual water deficit of Burdur Lake is approximately 40 hm³. According to our evaluations, more water than this Fig. is available in Karakuyu Lake. Under the light of these evaluations, in case of implementation of such project:

- As no water will be drawn by pump from Karakuyu Lake, the lake level will be maintained in accordance with natural developments in every period of the year.

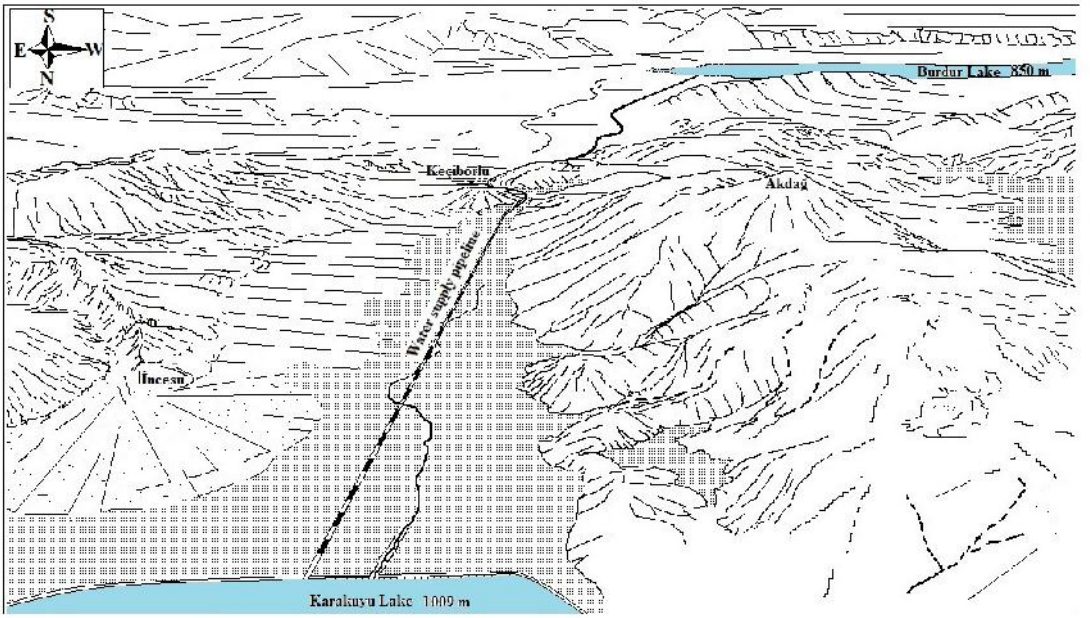

Fig. 3: Burdur and Karakuyu lakes and water pipeline.

- It will be possible to provide more energy from Dinar hydroelectric power plant by establishing more hydroelectric power plants within the 14 km distance from Keçiborlu central area and Burdur Lake and no other significant cost will occur apart from the water distribution tunnel to be used for streaming the water.

- The bottom level of Burdur Lake is at the lowest level in terms of underground water plate in the section between the provinces of Antalya, Isparta, Afyonkarahisar and Denizli in Southwest Anatolia. The direction of the movements of underground waters in the waterlogged zone underground is determined by underground galleries formed by karstification, cave systems and tectonic origin weak lines rather than topographic conditions.

Lower bottom level of Burdur Lake compared to other basin and canal bottoms in the surrounding area causes the lake to play the role of a bottom line for the surrounding sites. For this reason, decreases in the level of Burdur Lake may cause decreases in the level of Karakuyu Lake as in other basin and canal bottoms. Therefore, the level of the underground water plate in

Burdur Lake and other depending sites nearby will be balanced as much as possible with such a project.

- Water need of Burdur in case of possible problems (earthquake, drought etc.) can be fulfilled by transferring the water from Karakuyu Lake to the urban water depots of Burdur when required without the need for any energy consumption with this project.
- Although water characteristics of Burdur and Karakuyu lakes are different (Turna et al. 2005), other streams and waters coming with the surface flow to feed Burdur Lake will help maintaining the water characteristics and the ecosystem of this lake.

6. Additional Measures To Be Taken In Burdur Basin

It is required to take the following in-basin additional measures, some of which were previously suggested by certain researchers, as well as transfer of water from Karakuyu Lake to Burdur Lake at a level not to disrupt ecologic balances to prevent shrinking of Burdur Lake with water drawdowns and to save the lake ecosystem:

1. Regaining the lake environment with setting operations in certain lake areas in Burdur basin that were previously dried and eliminated. Therefore, creating the local bottom water levels around these lakes. For example, the Southern section of Çine Plain around İnsuyu Cave at a higher level than the Burdur Lake basin bottom line, former lake areas such as Karaevli, Bereket, Çorak (Bayındır), Gençali and other former lake areas around Yarışlı, Pınarbaşı, Hasanpaşa on the bottom of the basin should be met with lakes again.
2. A regional scale water management plan that covers the entire area should be arranged in the region of lakes without delay. Therefore, all kinds of lack of control in terms of water should be eliminated and strict inspections should be conducted to establish new drilling operations by imposing regulations on the operations conducted to provide underground water. A water network should be established in the area with the help of pipelines, tunnels, galleries and channels similar to an electrification network and water from excess areas should be transferred to the areas in deficit of water.
3. To minimize the loss from evaporation, modern technologies should be applied in all water distribution operations and systems similar to the Roman water channel systems should be established. For this reason, realization of water distribution lines entirely with underground systems will decrease water loss due to evaporation.
4. Operations should be conducted to diminish evaporation from the surface of Burdur Lake.
5. Agricultural irrigation with traditional methods, especially released water method, should be prohibited in Burdur basin and the entire region. Systems such as drip irrigation that diminishes water loss due to evaporation should be encouraged in this respect.
6. Although it is important to have water available in a region, it is much more important how to use that water. For this reason, training about water usage should be provided for local people in all agricultural production levels.

7. Conclusion

Burdur basin used to be described as a wetland in the ancient age. Burdur Lake, subject to gradual water receding today, used to tend to inflate at a level to bother the surrounding settlements at the date of 1971 Burdur earthquake.

Similar information from the remote or recent past indicates that Burdur Lake did not suffer from water related problems. It is understood that drying the secondary lake areas in the basin and construction of dams and ponds on the straits feeding the lake caused water receding in the lake to reach a serious level. It seems hard to provide solutions from the project that have been implemented until today in the basin. Therefore, feeding Burdur Lake by draining water from

Karakuyu Lake that is fed by rich water resources in the near North comes to the forefront as a possible solution. In case such solution is put into implementation, the distinctive Burdur Lake ecosystem will be maintained.

References

Ataol, M. (2010) Burdur Gölü'nde seviye değişimleri. Coğrafya Bilimleri Dergisi. S.8. s. 77-98.

Ramsay, W. M. (1960) Anadolu'nun tarihi coğrafyası (çev. M.Pektaş). Milli Eğitim Bakanlığı yay. İstanbul.

Sungur, K. A. (1978) Burdur, Acıgöl depresyonları ve Tefenni ovasının fiziki coğrafyası. İst. Üniv. Yay. No: 2397. İstanbul.

Turna, İ. İ., Gülle, İ., Güçlü, S. S. (2005) Burdur Gölü'nün su kalitesi, planktonu ve verimlilik düzeyi. I. Burdur Sempozyumu. s. 518-524.