
ASSESSMENT OF WATER AND WASTEWATER POTENTIAL OF BURSA CITY

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Abstract: Urban growth is increasing the demand for freshwater resources and water is of significant importance for cities. Many fast growing megacities are facing serious water-related problems including pollution, eutrophication, missing wastewater treatment and perhaps most importantly, a severe scarcity of clean water. In the entire urban world, water resources are used in an inefficient way. Bursa is one of the wealthiest cities in terms of its supply of drinking and general purpose water in Turkey. Apart from rich freshwater resources Bursa has also thermal water springs. Bursa can be a sample city with its environmentally respectful water management system and foresighting in terms of water resources and wastewater treatment facilities. In this paper, Bursa a metropolitan city located in South Marmara Region of Turkey and which has come into prominence with wealthy water resources was evaluated in terms of water consumption and water resources. Several recommendations were scrutinised in order to protect current water capacity and proper usage of water for a planned and well-designed water management of the city. Wastewater treatment facilities were also stated within the frame of the paper. This paper concludes by suggesting ways of enhancing the resources of water and wastewater services in Bursa.

Keywords: Water management, Water resources, Wastewater, Bursa

Bursa İlinin Su ve Atıksu Potansiyelinin Değerlendirilmesi

Öz: Kentsel büyüme tatlısu kaynaklarına olan ihtiyacı artırmaktadır ve su kentler için dikkate değer bir öneme sahiptir. Hızlı büyüyen mega kentlerin pek çoğu kirlilik, ötrofikasyon, atıksu arıtımı eksikliği ve belki de en önemlisi temiz su eksikliği gibi ciddi su ile ilgili problemlerle karşı karşıyadır. Dünyanın tüm kentsel kısımlarında su kaynakları verimsiz bir yolla kullanılmaktadır. Bursa, içme suyu ve genel kullanım suyu temini açısından Türkiye'nin en zengin kentlerinden biridir. Tatlısu kaynaklarının dışında Bursa kenti termal su kaynakları açısından da zengindir. Bursa, su kaynakları ve atıksu arıtım faaliyetleri açısından çevreye duyarlı su yönetim sistemi ve ileri görüşlülüğü ile örnek bir şehirdir. Bu çalışmada, Türkiye'nin Güney Marmara Bölgesi'nde bulunan ve zengin su kaynakları ile önem arz eden bir metropolitan kent olan Bursa su tüketimi ve su kaynakları açısından değerlendirilmektedir. Çalışma kapsamında atıksu arıtım faaliyetleri de belirtilmiştir. Çalışma sonucunda Bursa'daki su kaynaklarının ve atıksu arıtım servislerinin geliştirilmesi ile ilgili çözüm önerileri verilmiştir.

Anahtar Kelimeler: Su yönetimi, Su kaynakları, Atıksu, Bursa

1. INTRODUCTION

World water reserves are steadily declining. According to the studies, in 10-15 years, many cities will be faced with the threat of drought, and this situation will pose a serious threat to small regions that have less than 1000 m³ of water (Sivanappa,2006; Goel and Patel, 2006).

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Although covered with water three quarters of the world, the appropriate amount of fresh water for human use is very limited. The total amount of freshwater on Earth about 35 million km³ (ie 2.5 % of the total water on Earth) and only 0.3 % is composed of freshwater resources which are suitable for the ecosystem and human use (Figure 1). The remaining freshwater, were tapped mostly poles, glaciers located in high mountains and under ground reservoirs.

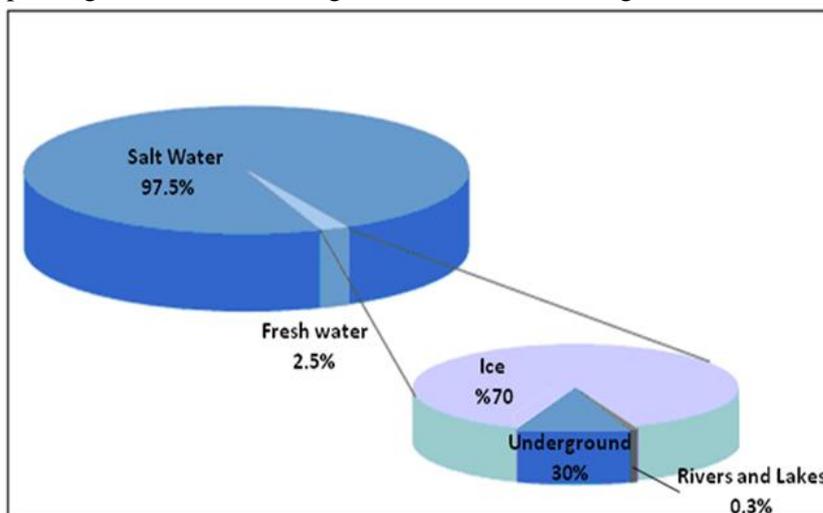


Figure 1.
Water Distribution on the World

The general objective of this study was to assess and review the existing water and wastewater services and to identify priority areas, that can help in developing strategies and programs for improving quality of the water supply services in case of Bursa city.

2. TURKEY'S WATER POTENTIAL

Contrary to the general perception, Turkey is neither a country rich in freshwater resources nor the richest country in the region in this respect.

Turkey is situated in a semi-arid region, and has only about one fifth of the water available per capita in water rich regions such as North America and Western Europe. Water rich countries are those which have 10000 m³/year. This is well above the 1500 m³/year in Turkey.

One of the global scale environmental pollution problems of Turkey is temporospatial uneven distribution of water resources among the regions. Water resources of Turkey aren't located in the right place at the right time to meet present and anticipated needs of the region. Certain regions of Turkey such as the Black Sea region have ample but unusable freshwater, while some of the highly populated and industrialized regions such as the Marmara and the Aegean regions lack sufficient fresh water.

Water potential of Turkey was shown in Figure 2. According to hydrometeorological data during 1951-2000 annual average rainfall depth was 643 mm/year and it corresponds 501 km³. 55% of rainfall (274 km³) backs to atmosphere by evaporation, ~14% (69 km³) of feeds groundwater and 31% (158 km³) of reaches sea and lake by flow (MFWA, 2008). 28 km³ (~41%) of 69 km³ water which feeds surface waters and groundwaters backs to the surface water by fountains.

41% (28 km³) of water fed subsurface and ground water includes into surface water by fountains. Total annual flow is 186 km³ (158+28 km³). In addition, ~ 7 km³ of water comes into country from neighboring countries. Therefore gross surface water potential reaches to 193 km³. In assuming the groundwater feeds (41 km³), renewable water potential of country could be estimate as 243 km³/year.

Within the scope of technical and economical conditions, surface water potential which will be consume for several purposes is 98 km³ including domestic run off (95 km³) and flows from neighboring country (3 km³). Annual draw-off groundwater potential was estimated as 14 km³ (~34% of total) technically and economically. Therefore, current available surface and grounwater potential can be assumed as 112 km³, and 40 km³ of available water potential (~36% of total) is used already (Ayaz, 2010).

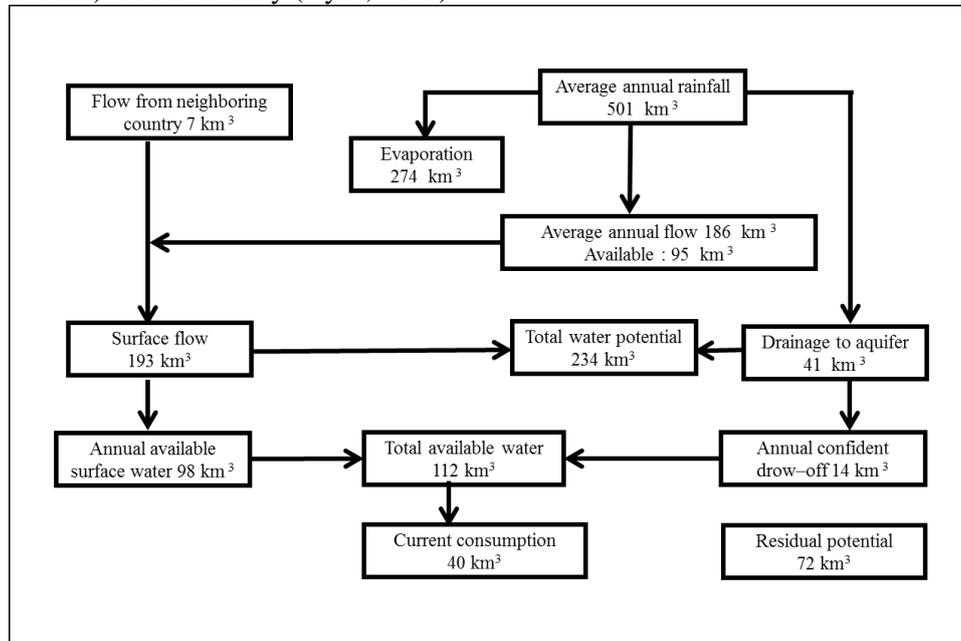


Figure 2.
Water Potential of Turkey (Ayaz, 2010)

Municipal water use accounts for about 15% of total water use in Turkey, compared to 75% used by agriculture and 10% by industry. Total water withdrawals for all uses accounted for only 17% of total available water resources in an average year (average 1977-2001). Municipal water use thus accounted for only about 3% of available water resources. However, water availability is highly seasonal and there is not a uniform water distribution throughout the country. Local and regional water scarcity occurs despite ample average water availability (RTMD, 2001)

Located in northwestern Anatolia, within the Marmara Region Bursa is the fourth most populous city in Turkey with a population of 2842547 and one of the most industrialized metropolitan centers in the country (TSI, 2016). Its surface area is 10891 km² and altitude is 155 m. Bursa exerts a significant impact upon the national economy of Turkey as being a centre of both agricultural and industrial production. According to the industrial activities, it takes part in the second order after İstanbul and 13th order in the Turkey's general situation. It is known with many sectors such as textile, automotive, manufacture, agriculture based industry and food, furniture and machine-metal. The sectoral distribution of industry in Bursa (in 2000) is as follows: service is 40%, agriculture is 33% and industry takes part 27% (CCIB, 2003).

As being one of the most important and agricultural center of Turkey, during the past two decades, substantial migration into the region has increased drastically. Huge population masses migrated and settled in Bursa as a result of various wars beginning from the end of the 19th century. The migration from rural to urban areas of about 1.4 million people per year shows adverse effects, which are felt heavily in Ankara, Bursa, İstanbul, İzmir, Adıyaman, Antalya, Diyarbakır, Batman and İçel (OECD, 1996).

Bursa is one of the wealthiest cities in terms of drinking and general purpose water resources in Turkey. The water of Bursa may be grouped into two as drinking and general use

and as thermal springs. Despite the rich resources of water, Bursa is facing some problems along with the increasing urbanization and industrialization.

3. POPULATION AND WATER DEMAND

The increase in the population of the cities also causes the increase in the total water for adequate municipal supply (Falkenmark and Widstrand, 1992; Posteli et al., 2006 ; McDonald et al., 2011; Bhatia and Falkenmark, 1993). This total municipal water demand growth is not just because of the increase in urban population, but also because of a tendency for economic development. This economic development also increases the fraction of the urban population that uses municipal supply rather than other sources such as local wells or private water vendors (Bartlett, 2003; Howard and Bartram, 2003).

Municipal supply is generally cleaner and safer than other water sources, so actually, increasing access to municipal supply for the world's poor is one of the Millennium Development Goals (Howard and Bartram, 2003). Furthermore, economic development which brings urbanization increases water use per capita (Posteli et al., 1996). The overall increase in total municipal water demand causes cities to search for new adequate, relatively clean water sources, leading to the creation of sometimes quite complex systems of urban water infrastructure (Alcott et al., 2013; Brown et al., 2009; Chau, 1993; McDonald et al., 2014)

The average water consumption per capita is 158 L/day in Bursa City. However, because of the 30% of water loss within the distribution network, gross water consumption per capita is accepted 226 L/day (BUWSA, 1992, Akal Solmaz et al., 2003). Distribution of water demand by year in Bursa City is given in Figure 3.

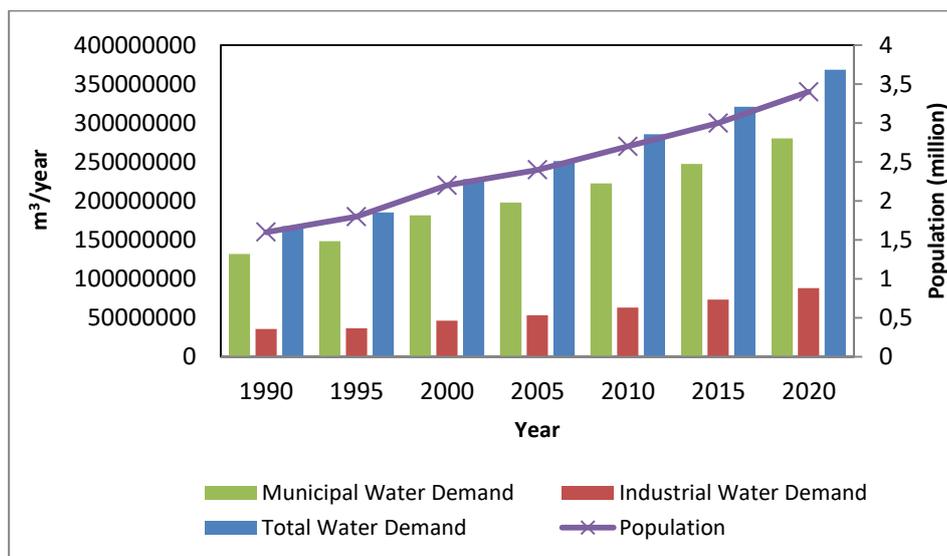


Figure 3.
Distribution of Water Demand by Year in Bursa City

4. CURRENT SITUATION OF WATER RESOURCES IN BURSA

Bursa is one of the few cities owing both superficial and underground water resources. The city's water supply is provided by three sources. These are superficial water resources, (Nilüfer Creek, Doğancık Dam), groundwater services and fountains. Due to the data of 2004, water supply system is 5845000 m³/day from Nilüfer Creek, 360000 m³/day from groundwater services, 1277000 m³/day from fountains and totally 7482000 m³/day (Yalılı and Akal Solmaz, 2004). The annual water resources capacity and percentage distribution of water resources of Bursa City is given in Figure 4 and Figure 5, respectively.

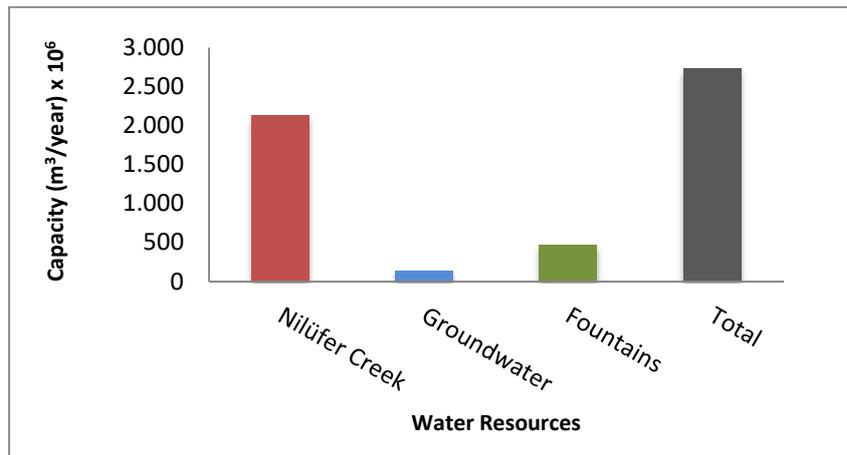


Figure 4.
Annual Water Resources of Bursa

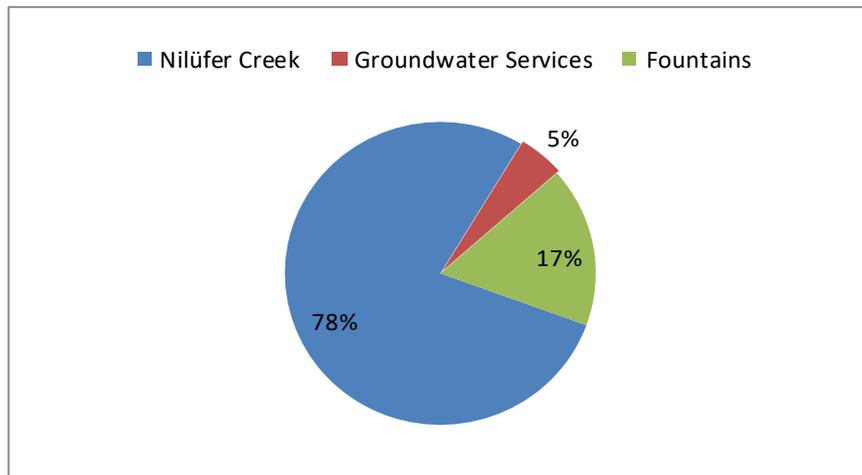


Figure 5.
Percentage Distribution of Water Resources of Bursa City

As it is shown in Figure 5, Nilüfer Creek which is one of the most important river of Marmara Region has a great importance as a source of drinking water. Also Nilüfer Creek is faced to discharge of wastewater from all kind of industries, as a result of discharges, Nilüfer Creek consists of serious pollution.

Nilüfer is a subbasin of Susurluk Basin, that has a flow potential of 5.43 km³/year and has also 3% of the water potential of Turkey's rivers. Figure 5 shows the location of Bursa in Turkey Map.

According to Water Supply Master Plan Report of Bursa City, four dams are planned to be constructed namely Doğancı (S. Saygı), Nilüfer, Çınarcık and Gölbaşı Dam for drinking water supply. Doğancı (S. Saygı) Dam is the major drinking and domestic water resource of city. The height of Doğancı Dam is 65 m and the body of dam consists of rock and soilfill. Although it is an open system and it interacts with many environmental factors, the quality of water is suitable for Quality Criteria of intracontinental water resources classes which are given in Water Pollution Control Regulations (WPCR) since its location is far away from industrial and municipal area. Nilüfer Dam which is consists of rock fill has a 72.5 m height and supplies drinking and domestic water demands of city. Çınarcık and Gölbaşı Dams are serving for other purposes apart from drinking and domestic water uses.



Figure 6.
The Location of Bursa in Turkey Map

Bursa and Çayırköy Plains can be assumed as the groundwater potential of Bursa City. Bursa Plain has annually 147.8 hm^3 recharge and discharge capacity. 80% of this capacity (118.2 hm^3) is used by Bursa Municipality and several enterprises as drinking and domestic water. In addition, Bursa Plain water reserves are assigned to discrete cooperatives for irrigation purposes. The annual recharge and discharge capacity of Çayırköy Plain is 10.1 hm^3 and 70% of this capacity is used. The major use areas of the reserves of Çayırköy Plain are irrigation and drinking water purposes (GDSHW, 1994).

As a result of climate change, permanent drought or water stress can be seen in some regions even in a water abundant city such as Bursa. The groundwater resources were used in 2014 when there was a water scarcity throughout the city.

5. WASTEWATER INFRASTRUCTURE OF BURSA CITY

5.1. Sewerage Collection System

While the majority part of the city has already had a separate sewerage system which collects storm water and sewage with different pipe lines, separate collector systems are under construction in some parts of the city. The length of sewerage system in Bursa City center including Osmangazi, Yıldırım, Nilüfer, Gürsu and Kestel Districts is about 2762000 km. BB (concrete pipe), BA (concrete pipe) and HDPE (high density poly ethylen) types of pipes have been used in the system. Diameters of concrete pipes vary between $\text{Ø}300$ and $\text{Ø}2000$ mm. Cast manhole covers are used. Bursa City Center and the municipal adjacent areas of Bursa Metropolitan Municipality have 1061000 km stormwater collector systems. The stormwater system project of the other areas have been completed, and the system will be constructed within the program. The diameters of stormwater collection pipes varies between $\text{Ø}400$ and $\text{Ø}1600$ mm (BUWSA, 1992).

5.2. Municipal Wastewater Treatment

In Bursa, 5 wastewater treatment plants (WWTP) namely Western, Eastern, Çalı, Kayapa and Hasanağa have been operated by Bursa Water and Sewerage Administration General Directorate (BUWSA). The percentage of wastewater from urban area is treated by Western and Eastern WWTP is 95%. In Eastern WWTP, municipal wastewater from Osmangazi and Yıldırım districts are treated with capacity of $240000 \text{ m}^3/\text{day}$ while Western WWTP treats municipal wastewater from Nilüfer with capacity of $87500 \text{ m}^3/\text{day}$. Domestic wastewater from

Gürsu and Kestel, industrial and domestic wastewaters from Kestel Organized Industrial District and domestic and industrial wastewaters from Kestel and Barakfakih Organized Industrial District are treated together by wastewater treatment plant operated by Green Environment Treatment Plant Management Cooperative, which is an association of the relevant municipality and the companies located in region. The capacity of Karacabey and Çalı WWTP are 9600 and 1000 m³/day, respectively. In addition, two domestic wastewater treatment plants have been operated in Hasanağa and Kayapa Housing Development Administration of Turkey (TOKI) districts. Three more wastewater treatment plants have been planned to be constructed for the areas with a population of over 2000, namely Akçalar, Gölyazı ve Badırğa areas (Ayaz,2010).

5.3. Industrial Wastewater Treatment

There are seven (7) Organized Industrial Districts (OIDs) namely, Chamber Of Commerce and Industry (CCI), Demirtaş, Nilüfer, Gürsu, Kestel, Hasanağa, Bursa Leather OIDs located within the Bursa City. Totally 1256 companies which are operating in packaging, electronics, food, chemical, paint, furniture, machinery, metal, automotive, textile and leather areas (MSIT, 2016). Table 1 shows information about organized industrial districts of Bursa city center.

The industrial wastewater discharges of CCI, Demirtaş, Nilüfer, Hasanağa and Bursa Leather OIDs are being treated through the wastewater treatment plants within their districts. Wastewater from Kestel OID and Gürsu is being treated by Green Environment Treatment Plant Management Cooperative. There are 27 industrial enterprises which have their own wastewater treatment plants outside of organized industrial districts. Capacity of these plants varies between 40 and 22500 m³/day (Ayaz, 2010).

Table 1. Current state of OIDs of Bursa

OID name	Company number	Units	Capacity(m ³ /day)	Discharge Environment
CCI	220	P,C,B	96000	Ayvalı Stream
Demirtaş	429	P,C,B	70000	Nilüfer Creek
Nilüfer	320	P,C	792	Ayvalı Stream
Gürsu	76	P,C,B	59000	Deliçay Creek by DSI south channel
Kestel	80			
Hasanağa	79	P,C,B	1000	Hasanağa Stream
Bursa Leather	52	P,C,B	4000	Nilüfer Creek

P: Physical, C: Chemical, B: Biological

6. CONCLUSIONS

Bursa is a water rich city with high capacity of surface waters and groundwaters except from other thermal water resources, and the unique city possesses these speciality. Prescinding the high water capacity of Bursa, an evaluation has been done in terms of potable water and water resources. As a result of the study, it has been concluded that water resources meet the demand of the city within the 20 years time. However, being a migration-receiving city in case of an unexpected increase in population, the planned water resources should be put into use gradually, water treatment plants should be built, and the deficiencies of distribution systems should be completed.

Reclamation and reuse of treated wastewaters have become a significant component of municipal, regional and national water management. The United Nations is compelling the countries to develop new water management strategies due to the threat of water shortage within 10 years. Wastewater reclamation and reuse topics are gaining importance, against limited water resources and increasing water demand, not only in dense population cities but also in rural areas as well.

Bursa is a metropolitan where dense industrial facilities take place and also rich for agricultural activities that it is one of the major cities which meets the food demand of Turkey.

230 792 m³/day industrial wastewater is being discharged into the surface waters after being treated in Bursa. Hence, treatment of wastewater should be carried and controlled carefully in order to reuse it in agricultural irrigation. Water Pollution Control Regulations Technical Methods Declaration- Appendix 7 (20 March, 2010; no: 27527) should be considered while treatment of wastewaters for purposes of agricultural irrigation reuse.

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