PREFACE

MENA Region represents a geographical space including Turkey, Jordan, Egypt, Tunisia and Morocco. These countries share similarities in terms of aridity and scarcity of water, and suffer from climate change that has induced periodic severe drought periods in some countries like Morocco. The increasing demand on water due to economic development, abusive usage of resources and anthropogenic pollution generated by domestic, industrial and agricultural activities tend to be alarming for certain countries with low potential of water. To tackle the problem in its entirety, management strategies based on real investigation and best fitting models are required in terms of saving, protecting and managing the clean water.

The EXCEED Swindon project aims to highlight this issue in order to tackle it through exchange of experiences and joint research projects involving experts and researchers from the respective countries.

After the workshop held in Cairo, April 2017 under the title "***Solutions to Water Challenges***", this workshop held in Marrakech November 3-8, 2017 aimed to pursue this under the title "***Water Use in MENA Countries***". The choice of Marrakech was appropriate, since this city is located in an arid region of Morocco and relies on water drawn from hundred kilometers away, and from aquifers loaded through melting snow from the Atlas Mountains nearby and drawn through an ancient and ingenious system of connected wells *"Khattarat"*.

The workshop was attended by 51 participants from all associated countries. It was inaugurated by the welcome speech given by Prof. Dahchour on behalf of the organizing committee, and the words pronounced by Prof. Dichtl and Prof. Haarstrick on behalf of this DAAD project.

The first day was dedicated to three sessions on **water and wastewater management** and one session on **groundwater.** In the second day, sessions dealt with **water and wastewater treatment, water quality models and irrigation issues.** The third day was dedicated to the evaluation of the workshop, distribution of greeting certificates for the three major works and presentations, followed by the distribution of certificates to participants. The fourth day was reserved for field visit of the wastewater treatment plant and an excursion to the Berber villages of *Eurica and Sete Fatma* for appreciation of the natural sceneries of High Atlas Mountains and of the local and endemic products.

In conclusion, the workshop covered the management of water issues from different viewpoints and experiences from several countries in the MENA Region. It was an opportunity to bring together researchers from the entire MENA Region, to whom the gratitude of the workshop chair people is warmly delivered.

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THE CHALLENGE OF MANAGEMENT OF WATER IN MOROCCAN CITIES

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Keywords: Morocco, water scarcity, water management, wastewater, drinking water

Abstract

Water resources in Morocco are under serious threat due to climate change, abusive use and increase of pollution potential of water resources, including surface and groundwater resources. Northern part of the country is well fed (up to 1,500 mm precipitation per year) compared with the south (100 mm). However, Morocco is self-sufficient in water resources and their management. The impact of the constraining factors tends to shift the situation to critical limits of 550 m^3 by 2020 instead of 1000 m^3 few years ago. This situation has pushed the authorities to work out new strategies aiming to increase the availability of water, to improve its quality and to protect it from pollution. Different governmental authorities are involved to supervise production, quality control and distribution to consumers in the framework of new law of water that considers water as public domain and precious commodity. Access to drinking water tends to reach 100% as well as sewerage network in rural and urban zones. Private sector is involved in the main cities, and the prices practiced are calculated according to economic social level of life of the population and to give up with the free access to this commodity.

1 Introduction

In Morocco, water resources are under serious threat due to climate change, abusive use and increase of pollution generated by various domestic, industrial and agricultural activities. Rainfalls are not regular and unequally distributed geographically and temporally. Northern part is well rain fed (up to 1,500 mm/yr) compared to the south (100 mm/yr), with a national average of 450 mm/yr, due to different factors including latitude, closeness to the sea (ocean) and altitude. Besides of this variability, it has been noticed a decreasing tendency of rainfalls since 1970s [1].

Potential of water resources includes surface and groundwater resources. The annual amount mobilized is estimated to 21 BCM (billion cubic meter) including surface water (16 BCM) and groundwater (5 BCM). Surface and groundwater water sources are mainly confined in the northern part of the country, where the main basins and rivers are encountered (Figure 1).

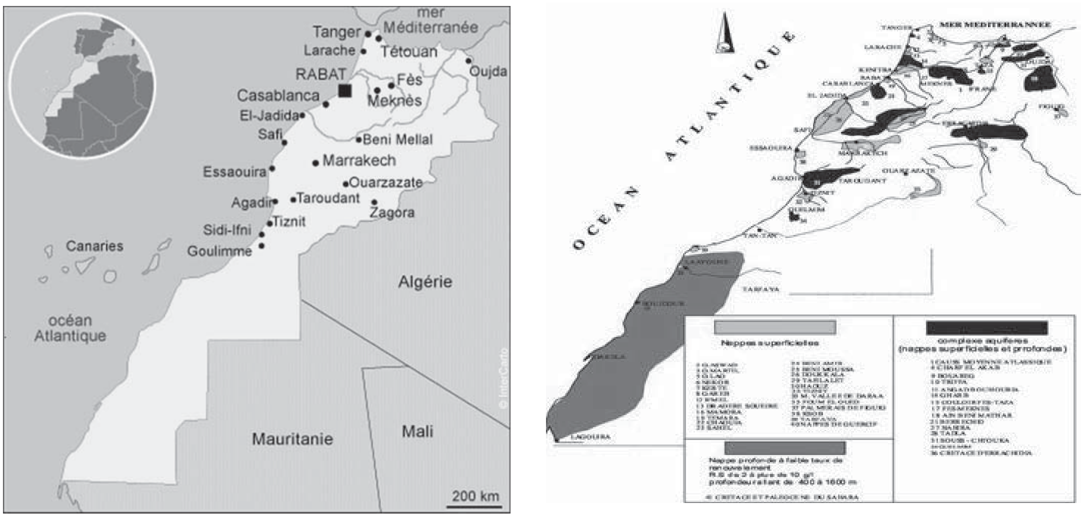

Figure 1: Main Rivers, basins and groundwater resources in Morocco

Four main basins represent 70% of surface water resources. However, Morocco is self-sufficient in water resources. Their irregularity, the tendency of a prevailing drought and management tend to shift the situation to critical limits of 720 m^3 or below by 2020.

Focus on this situation reveal that the available water varies between 180 m^3 per capita per year for the areas deficient in water resources (Souss-Massa, Atlas South, Sahara) and 1,850 m^3 per capita per year for areas rich in water resources such as the basins of Loukkos and Tangiers, and the Mediterranean coast (Table 1) [2].

Table 1 Repartition of potential of water in the main basins

Main basin	Surface water (%)	Groundwater (%)	Total
Loukous	23.10	11.20	25.90
Sebou	27.6	17.80	25.70
Oum Errabia	20.70	18.20	20.20
Bouregreg and coast of Casablanca	4.70	5.10	4.70
Tensift and coast of Essaouira	4.70	10	5.70
Sous massa	3.80	12	5.40

2 National Strategies to Tackle the Problem of Water Scarcity

2.1. Agriculture as driving factor for water storage

This situation has raised concerns among the authorities since the early 1960s, where the strategy of 1 Million ha was launched to store water and to provide the required amount for agriculture and drinking water. This has been beneficial for Morocco, since the number of dams has increased from 1 in 1960 to 114 in 2006. This has increased the storage capacity by the factor of 11. However, the successive periods of drought (from 1980 to 1985, from 1991 to 1995, and from 1998 to 2001) have contributed to the depletion of groundwater potential due to the excessive use as supplemental resource for agriculture [3]. Nowadays, the main part of water resources is provided as surface waters (16,109 m^3), regulated partly by 128 dams and 1,100 km pipelines.)

Management of water in irrigated areas was put under the supervision of seven regional ORMVAs (agencies in charge of improvement and development of agriculture in irrigated zones) under the authority of the ministry of agriculture.

Increase of the demand on water for different purposes associated with the risk of scarcity has pushed the government to improve the management of this commodity. Thus, the first law on this issue was issued in 1995 (law 10/15, OB 1995), accompanied by the creation of river basin agencies (RBA). This legislative framework intends to identify the users and the intervening partners to limit the responsibilities. The principles governing this law are (1) to consider water as public domain and recognition of the economic value of water by adoption of the principles operator payer and polluter payer, (2) to regulate development, distribution and sale of drinking water, (3) to improve water use in agriculture, and (4) to protect water resources from pollution. With regard to different international organizations, this law was an important step towards rationalization, securing and providing access for and reducing disparities between rural and urban zones. The execution of this strategy is scheduled over the next coming years until 2030. The main goals are expressed in terms of [2]:

Efficiency

- Saving 2 BCM/yr in irrigation by conversion to drip by drip system,
- Saving 0.4 BCM /yr by improvement of the yield in agriculture,
- Saving 0.2 BCM/yr by improvement of the network of drinking water.

Development of the supply

Mobilization of 1.7 BCM of surface water by:

- 60 new major dams,
- 1,000 small dams,
- North-South transfer: 0.8 BCM,
- Desalination of sea water,
- Reuse of treated wastewater,
- Harvesting rainwater.

Protection and preservation of water resources

- Reduction in levies and building control,
- Artificial recharge of groundwater,
- Protection of the water quality,
- Implementation of sanitation programs and wastewater treatment,
- Prevention and combat against Industrial pollution,
- Implementation of the national plan of household and similar wastes.

Reducing vulnerability to climate change

- Identifying vulnerable sites to floods (400 sites),
- Strengthening forecasting and warning,
- Combat against the effects of drought (diversification of sources of water supply).

Regulatory reforms and institutional

- Review of the law 10-95. It has been reviewed and enriched to adapt to new requirements for the development of water resources.

Infrastructure and capacity building

- Development of applied science and research,
- Capacity building and training,
- Development of information systems.

Moroccan authorities have been aware of these issues and conducted an efficient strategy for water management. The first dam was built under the protectorate in 1929. The water policy was boosted under the reign of Hassan II (1960s). Nowadays, mobilized water exceeds 17.5 BCM/yr, retained by more than 135 dams, 6 desalination plants, and 130 wastewater treatment plants.

3 National Water Quality Protection Plan (NWQPP)

Management of water does not rely on the efficiency of its mobilization and usage only. Measures for its protection have to be conducted. In this context, the national water quality protection plan (PNAL) was launched in 2005 to cope with the expected shortness in water supply by providing alternative resources and to ensure a better quality of water. Actually, drought in Morocco has become more prevalent in the past decade and is predicted to be more sever due to the expected decrease of 4% over the next 20 years [4].

The actual total volume of sewage discharged in Morocco was estimated at about 0.6 BCM/yr. 48% of these waters are discharged into rivers or applied to land; the rest is discharged into the sea. This amount is expected to reach 0.9 BCM/yr. The pollutant load from wastewater is estimated to 131,715 tons of organic load, 42,131 tons of nitrogen, and 6,230 tons of phosphorus annually. On the basis of an average 30 to 60 m^3/yr of wastewater production per capita, a population of 1 million inhabitants and a rate of irrigation of 10,000 m^3/ha, this amount of wastewater would be sufficient to irrigate 3,000 to 9,000 ha land [5].

On another hand, social issues, concerning water distribution and consumption among villages, meet some constraints and are causing instability and conflicts in the region [6]. The insufficient amount of water is also affecting progressively current and future generations of farmers by limiting the variety of crops, which they are able to grow in certain regions, as well as by forcing them to conserve the water they do have [7].

4 Pollution of Water

Pollution of water was reported to be higher in the cities compared to rural zones [5] (Table 2).

Table 2: Water pollution according to the size of the agglomeration

Parameters	Small Villages < 20,000 inh.	Medium-sized Cities 20,000 – 1 Million inh.	Large Cities > 1 Million inh.	National average
BOD_5 (mg/L)	400	350	300	350

Therefore, in order to protect water resources and to reduce the pollution, the NWQPP intends to improve sewage collection (80% by 2020), to treat both industrial and domestic wastewater, to reduce the pollution amount by 60% until 2020, and to increase its reuse while providing alternatives to save freshwater resources.

Biotechnologies for urban wastewater treatment were introduced in Morocco since 1950s in some medium and small settlements, including activated sludge, trickling filter and biodisc treatment facilities. Some of them were not operating regularly due to problems of maintenance, the high-energy consumption, and the reluctance of decision makers to provide additional funds. Until 1993, there were 55 wastewater treatment plants serving small settlements and medium-sized cities. Only 18 of them were operating regularly, while 31 plants were out of service, and the remaining 6 were not connected to the sewerage for various reasons [8].

In 2016, the rate of treated wastewater has reached 71% (instead of 5% in 1999) in 113 treatment plants. The sewer network has attained 10,000 km with a flux of 500,000 m^3/d [9].

5 Management of Drinking Water

The main producer of drinking water in Morocco is the National Office of Water and Electricity (ONEE) created in 1972. The current water production exceeds 55 m^3/s. ONEE is also in charge for distribution of water in the cities via its regional agencies. Since the mid-1990s, in the big cities such as Casablanca, Rabat, and Tangier, the distribution is delegated through concessions to the private sector (Lydec in 1997, Redal in 1998 and Amendis in 2009). These concessions cover fairly the needs of 40% of the population. At present time, 95% of the population is provided with drinking water in urban zones and 91% in rural zones [9].

The control of water distributed is basically under the supervision of ONEE. The main laboratory was created in 1968. Private companies involved in the distribution perform some complementary analyses. Some urgent analyses are performed by mobile laboratories at different locations when necessary. The control of drinking water covers more than 4,600 sampling points and 70,000 samples/yr. The main assignments of the laboratory are:

- Control of the quality of water produced and distributed,
- Performance of assays and analyses required for projects related to drinking water,

- Control of the pollution of drinking water,
- Offer of assistance to other institutions involved in drinking water issues.

More than 200-trained technicians supervised by more than 50 highly qualified engineers ensure the different tasks of the control, using modern equipment, including liquid and gas chromatography, mass spectrometry, and atomic absorption spectrometry. The number of analytical methods used exceeds 460 to determine more than 300 parameters in water.

6 Costs of Water Management

In order to recover the costs of water provision, Moroccan government has granted autonomy to public urban water supply agencies and concessions to private sector in the main cities of Casablanca, Rabat, and Tangier. The case of Casablanca provides an example how the urban water sector may be organized. Similarly, the use of a revolving fund providing loans to urban users both for water metering and renewing installations is an innovative way participating users to urban water conservation [10].

Pricing applied by regional public agencies and private sector vary from region to region. Bills are expressed in sections according to the volume consumed. The more the consumption is, the higher the bill. Differences between the prices of sections vary from equal to three fold. Some users have preferential prices, such as public baths and public fountains. For hotels and industries, the prices are higher. Prices tend to increase due to introduction of some taxes (solidarity tax and tax to support investment in rural zones [11].

7 Conclusions

Geographic position of Morocco is characterized by aridity and an irregular variation of rainfall. This situation is made sever by the prevailing climate change and repeated periods of drought. Water resources are becoming scarce that pushed the government to apply different strategies aiming at mobilization, protection and supply of water to consumers. A new water law has been enacted, précising the role of the partners involved in different sectors associated with water. Mobilization of water resources has been improved to achieve 17 BCM/yr. Sewer network has been extended to cover nearly all rural and urban zones. The number of wastewater treatment plants is increasing to serve the main urban and rural settlements. In rural zones, water management is supervised by basin agencies, while drinking water is under autonomous institutions and private companies. The control of water quality is ensured at sampling points and before supply to the consumers.

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REVITALIZATION OF HISTORICAL BEYKOZ-ONÇEŞMELER WATER SYSTEM IN ISTANBUL, TURKEY

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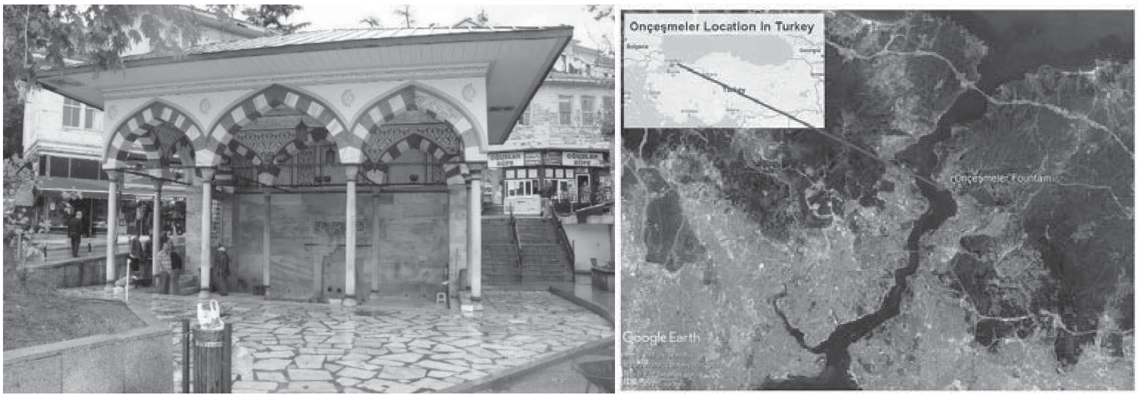
Keywords: Water heritage, historic constructions, Onçeşmeler Fountain, Istanbul

Abstract

Beykoz-Onçeşmeler is one of the best historical water fountains of Istanbul that was built during the Ottoman era of Turkey in 1746. This historical water system and its masterpiece water fountain survived until today. The fountain was built on a spring that actually discharges water collected from precipitations of Beykoz-Forestry region. The fountain structure is very important in terms of architecture and in historical perspective. People of Beykoz District in Istanbul have raised public awareness for protection and sustainability of this historical water system, therefore, Istanbul Great Metropolitan Municipality supported this research to investigate the hydrological properties of the water system to revitalize it according to its historical conditions. In the last couple of years, flow rates of the Onçeşmeler reduced significantly. A wastewater collection tunnel passed thorough Beykoz District along the Istanbul Straight at the depth of -5 m elevation below sea level. The tunnel was blamed to drain the groundwater that supplies water of the Onçeşmeler along the tunnel's outer face. In this study, it was aimed to investigate the hydrological and hydrogeological properties of this historical water system in order to understand the relationship of the climate conditions, land use changes, and the wastewater tunnel passing underneath the water system with water of the Onçeşmeler fountain. At the end of the study, it was found out that the tunnel construction caused to increase hydraulic conductivity of the formation around the tunnel perimeter. Groundwater started flowing along the tunnel to follow this newly formed higher hydraulic conductivity zone along the tunnel instead of flowing towards the Onçeşmeler as it was used to flow formerly. This is especially true in dry and average seasons, however, in wet seasons, since groundwater levels are high, water is abundant to flow towards the Onçeşmeler as well as along the tunnel. Therefore, the effect of the tunnel is seen only in dry and partially in average seasons but not in wet seasons. The change of the precipitations, land use change, and other hydrological factors are not very effective in reducing the Onçeşmeler fountain.

1 Introduction

Supplying water to Istanbul has been a problem throughout history. During the Byzantine period (364 - 378), two aqueducts and a big underground reservoir were constructed to bring water to the city [1]. During the Ottoman Empire, 16 water ways totaling 130 km and 33 aqueducts supplied water to a population of 150,000 - 200,000 people [2]. Onçeşmeler water fountain is one of the unique historical structures built in 1746 to supply water to the Beykoz District of Istanbul [3]. In Ottoman culture, water was being supplied to the squares of the districts via fountains to have people access good quality spring water for free of charge. Most of the fountains are generally piece of the art and reflect the architecture characteristics of their time. In this perspective, the Onçeşmeler fountain is a good example, which is among the iconic historical structure of Beykoz with its unique architectural structure and modest identity (Figure 1). It is among the rare fountains of Istanbul and reflects its baroque style characteristics [4].



(a) (b)

Figure 1: (a) *Onçeşmeler Water Fountain; (b) Location of Onçeşmeler Water System in Istanbul*

The Onçeşmeler fountain is technically a spring water (groundwater) emerging from the rocks (aquifer), on which a natural reservoir was carved into the rocks at the back of the fountain structure. The water collected in the reservoir freely flows out of ten nozzles made of bronze. Therefore, the structure is called as Onçeşmeler that literally means in Turkish "Ten-Fountains" (Figure 2).

Istanbul sets a good example of challenges faced with in water supply in heavily populated cities, where illegal settlements on watershed zones pose a threat to scarce water resources. Problems caused by lack of implementation of regulations could be compensated by engineering solutions. The Onçeşmeler fountain has been supplying spring water to the square of the Beykoz. Since it was built but in the last couple of years it was faced with the danger of getting dried or decreased its water level. This situation took the people's attention and several protests took place to save the Onçeşmeler fountain and to urge water authority of Istanbul Great Metropolitan Municipality (IGMM) to find the cause of the problem and to take necessary measures to solve the problem.

This study aimed to investigate those reasons that cause the flow reduction or even drying of the historic fountain and to find possible solutions to revitalize and make it available for public usage again. Possible reasons for reduced flow rates are (i) climate change and reduced recharge due to less rainfall compared with historical situation, (ii) new illegal groundwater wells opened in the area that interfere with the source of Onçeşmeler water, (iii) land use changes because of increasing urban area and decreasing forest area, and (iv) groundwater loss due to the tunnel construction of "Kavacık-Paşabahçe-Beykoz Wastewater Tunnel" passing underneath the recharge area of the fountain. This tunnel is suspected to create a loose-cracked formation around the tunnel peri-