



Sustainability of water supply management for Erbil City in the context of sustainable development agenda

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ABSTRACT

Conserving water and providing for the future generation is one of the most important principals established on the agenda concerning sustainable development goals. The aim of the paper is to evaluate the sustainability of the quantity and quality of water sources for Erbil City, as well as their safety and security based on the standard limitations. Therefore, the study computed the adapted scale of measuring water quantity and the demand of water and then evaluated the collected data from the water directorates related to both surface water and groundwater for the studied area. The study focused on the management of water supply and main factors that affected the lack of the sustainability. The next step was the planning of appropriate solution for those problems, such as avoiding drilling of illegal groundwater wells and managing water sector that made the poor water management as well. The use of additional surface water accomplished with the construction of extra water treatment plants was seen as an alternative to consuming groundwater. Reusing of processed sewage for various consumption and recharging of groundwater was considered as sustainable strategy and management for the water field in Erbil City.

1. Introduction

In general, surface and groundwater have a crucial role in water supply system, and it is used for irrigation purposes as well. Recently, Erbil City, which is in the northern part of Iraq that is considered to be rapidly expanding area due to increasing population number, faced the economic problems. However, it is necessary to monitor and better manage the sources of water and provide water for following years (Mustafa et al., 2021). The impact of climate change and sustainability of both groundwater and surface water resource is important. The requirement for groundwater studies are necessary for sustainable management of water resources and it is also

important for considering the climate change and its variability for a long periods in order to better manage the underground system that has increased due to the required demand (Nanekely et al., 2017; Mustafa et al., 2021). However, groundwater is a vital source for agricultural, domestic, and industrial purposes in almost every country. The demand for water increases due to population growth, therefore the problems concerning groundwater sources should be taken into account (Hawez et al., 2020). Meanwhile, the water demand in Erbil City has also increased due to population growth. In addition, the percentage of domestic wells represent 40 % of water supply system in the city (Wali and Alwan, 2016). Mostly, Erbil City uses groundwater for irrigation,

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industrial, and other daily activities (Wali and Alwan, 2016). Moreover, the groundwater quality depends on the composition of the aquifer recharge and interactions between both material and the groundwater. It is obvious that clean water is used for many activities based on WHO recommendation which states that about 80 % of all the diseases in human beings are caused by water (Toma et al., 2013; Mustafa et al., 2021).

There are numerous studies on the sustainability of the water resources. Halim et al. (2010) studied the causes of spreading disease through water among people, factors affecting the sustainability of water resources, are the increase in population and the climate change pressure. Vishwajit and Sumit (2012) did the investigation on sustainability of sources, and the study conducted by Toma et al. (2013) was on groundwater quality in Erbil City. Jadoon et al. (2015) studied water quality in Erbil City, also the article of Ahmed and Miran (2016) explained the sustainability for water sources in Erbil City. Moreover, Bapper and Younis (2016) evaluated the water quality in Erbil City as well.

On the other hand, there is also the study of Dizayee (2018) on groundwater level in Erbil Basin, and Qurtas (2018) determined the recharge of Erbil groundwater. Mawlood and Omer (2019) used Kriging Method to estimate the depth of the Erbil groundwater. Later, Mawlood (2019) did the investigation on groundwater sustainability for the studied area. Mahmood and Omar (2019) studied the amount of water supplied for population of the selected area. Then, Hawez, et al. (2020) published the study on quality of the groundwater for the cities in the Kurdistan Region Governorate. The presented study tried to evaluate the problems in water resources management in the future, and also determine the basic plan to face the water sector problems. The major problem was lowering groundwater table due to numerous illegal wells, and then developing the projected sources of surface water for better management of water resources. Water demand for domestic uses has reached more than (320,000 m³/day), while, the demand for agricultural and industrial uses in the city has not been computed yet (Shekha, 2008). Furthermore, Shareef and Muhamad (2008) reviewed a number of studies on water quality in Erbil Governorate. Al-Ansari (2013) studied water resources development in Koya City. In another research, Hameed (2013) studied water harvesting for Erbil Governorate by using geographic information system (GIS) and remote sensing. Saeedrashed and Guven (2013) estimated the geomorphologic parameters by using GIS for Lower Zab River-Basin. In addition, Mawlood and Hussein (2016) discussed water management system for Mala Omer in Erbil City. Tinti (2017) studied water resources management for Kurdistan Region of Iraq. According to Dizayee (2018), there were many illegal wells in the central sub-basin of Erbil. Al-Kubaisi et al. (2019) described water balance for the central basin of Erbil area. Additionally, Hiscock

et al. (2002) stated that providing future sustainable groundwater development would need a common understanding of each individual based on information and education that promoted cooperation and responsibility of each person. Consequently, the objective of the present research was to assess the management and sustainability of the quantity and quality of water sources in Erbil City.

2. Materials and methods

2.1. Study Area Location

Erbil Province is the capital of Kurdistan Region of Iraq, and is located on the north-east of Iraq, which covers about 197 km² with the elevation of the 414 m above sea level (Mahmood and Omar 2019; Mustafa et al., 2021). It is surrounded at the north-west by the Greater Zab River and at the south-east by the Lesser Zab River. Boundaries extend from longitudinal 43°15' E to 45°14' E and from latitude 35°27' N to 37°24' N, Figure 1. Mainly, the sources of water in the city belong to two types, which are surface and groundwater sources. The Greater-Zab River is the chief surface water source for water supply in Erbil City (Aziz and Mustafa, 2019). Three water treatment-plants (named Ifraz 1, Ifraz 2, and Ifraz 3) exist on the Greater-Zab River, Figure 2. The other source is groundwater which supplies water throughout drilled wells for the consumers. This study is highly focused on the sustainability of the groundwater management for the selected area based on the provided data obtained from government organizations and previous investigations.

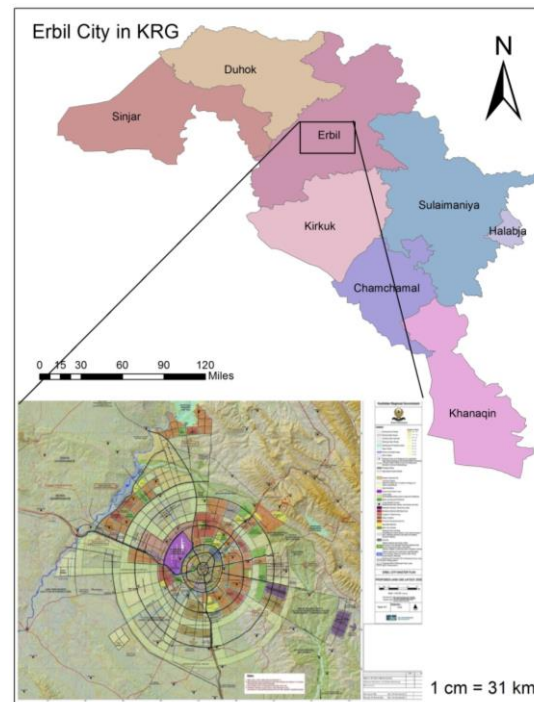


Figure 1. Study area location created by GIS (Arc Map 10.4)



Figure 2. Location of water treatment plants on Greater-Zab River (Omar, 2020)

According to Al-Kubaisi, (2019), that the Erbil basin is a plain divided into three sub-basins, Kapran, the central basin which includes Erbil city, and Bash Tapa basin. It is also bounded on the Greater-Zab and Lesser-Zab Rivers from the northwest and southeast, respectively.

2.2. Water Supply Estimation (Quantity and Quality)

Generally, the estimation of the quantities of the water sources for Erbil City that depend on the groundwater from pumping of water in the wells was investigated. Omar (2020) reported that the amounts of drinking water for Erbil City during 2014 to 2018 were:

- (139,036,720) m³/year (2014),
- (143,472,095) m³/year (2015),
- (158,069,446) m³/year (2016),
- (164,331,177) m³/year (2017),
- (172,687,525) m³/year (2018).

The presented data was obtained from the series of 60 sets of monitoring of the production wells, and it represented the average monthly amount of supplied water to the consumers in Erbil City. Therefore, the number of inhabitants obtained from the Central Statistical Office (CSO) was estimated at 1,365,000 with the annual calculated growth rate of 3.5 % (Mahmood and Omar, 2019).

On the other hand, the determination of water quality for the water sources in Erbil City was based on the previous studies. Aziz (2004) studied the seasonal variation of water and wastewater for the study area. The author obtained the samples from well No.3 in Iskan Quarter. Toma et al. (2013) investigated water quality for the six groundwater wells in various quarters (Ronaky 1, Tayrawa 1, Badawa 13, Azadi 8, Rizgari 1, and Ankawa 9) in Erbil City, and explained that the quality of water was suitable for drinking purposes. Ground water wells are illustrated in Figure 3.

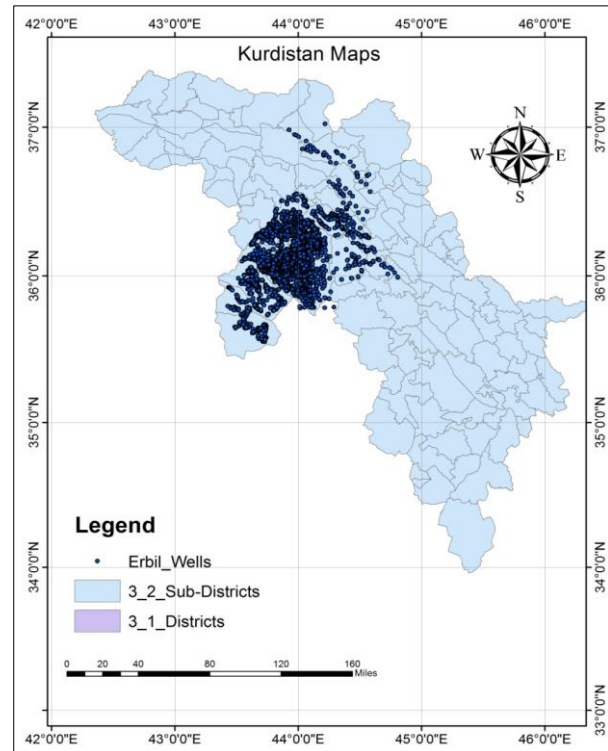


Figure 3. Groundwater wells in Erbil City

Moreover, the water quality for fifty groundwater wells within Erbil City were tested by Daham et al. (1998). In addition, the study observed a high pH, turbidity, total hardness, and alkalinity of water in Erbil City. Similarly, in both Bakhtiari and Ainkawa quarters, five groundwater wells tested by Jadoon et al. (2015). The authors reported that the water quality from a number of groundwater wells was subjected to contaminants such as high concentration nitrates and pathogens (Hawez et al., 2020; Mustafa et al., 2021).

2.3. Sustainability of the Water Resources Management

In general, there are a lot of points that should be considered. During this study, it is observed that the water management is very poor that may cause the depletion in groundwater table in the study area because there are a number of illegal wells without recording, Figure 3. In spite of this, the actual number of the drilled wells is higher than the recorded wells as it is pointed out by Dizayee (2018). Therefore, most of the drilled wells were dried and the people faced the draught problem in the area. Second point, about the surface water which directly converted water from the existence Ifraz Water Treatment Plants on Greater Zab River to Erbil City for water consumption purposes (Aziz and Mustafa, 2019). Table 1 illustrates the details of Ifraz 1, Ifraz 2, and Ifraz 3 Water Treatment Plants.

Groundwater is the main source of water for drinking and irrigation purposes, and it is also a unique resource,

Table 1

Detail of the Water Treatment Plants on Greater-Zab River (Omar, 2020)

No.	WTP	Constructed year	Location of distributions	Discharge (m ³ /day)	Location of WTP
1	Ifrac 1	1968	Erbil city	34,000	Ifrac village
2	Ifrac 2	1983	Erbil city	44,000	Erbil city
3	Ifrac 3	2007	Erbil city	216,000	Ifrac village

widely available and providing security against droughts. It is linked to surface water resources and the hydrological cycle. Meanwhile, this source is reliable supply, uniform quality, temperature, relative turbidity, and pollution free, however, the minimal evaporation losses are attributed to making groundwater source more attractive when compared to other sources Menon (2007).

In the current study, the approximate quantity of groundwater water wells was calculated. The data for 1,100 wells were used (General Directorate of Water and Sewerage in Kurdistan Region-Iraq, 2020):

- The estimated rate of well drainage for each well = 25 m³/hr.
- The average number of operating hours for each well = 15 hours
- The produced water from wells = 412,500 m³/day.
- Total discharges for the Ifrac 1, Ifrac 2, and Ifrac 3 Water Treatment Plants is 294 m³/day, Table 1.
- The total quantity of available water for Erbil City is approximately equal to 706,500 m³/day.

The rate of losses is about (15 %) (General Directorate of Water and Sewerage in Kurdistan Region-Iraq, 2020). Thus, the remaining net quantity (85 %) is 600,525 m³/day. Average daily water consumption in Erbil City is nearly 380 liters/person/day (General Directorate of Water and Sewerage in Kurdistan Region-Iraq, 2020; Mustafa et al., 2021).

2.4. Quality of Water

In general, polluted surface water source cannot be used for the purpose of drinking and daily consumption because it contains some pollutants that do not conform with the drinking water standards. Often the percentage of turbidity, suspended matter and bacteria in the surface water source is more than the permissible limit for drinking water. According to Iraqi Standards, the turbidity should be less than 5 NTU (Abbawi and Hussein, 1990). Previous studies showed that the turbidity is around 100 NTU, and during rainfall times more than 1,000 NTU (Omar, 2020). Therefore, surface water filtering through the filtering plants is necessary in order to reach a degree that matches the drinking water standards.

Hearing that the running water is clean, the percentage of dissolved oxygen increases with the circulation of the water waves, and it is possible that some materials settle

at the bottom of the river, and the water can be used for irrigation, for fish farming and for construction in general, but the problem of bacteria and rust remains and the water needs to be filtered and sterilized for the purpose of its use for drinking and household consumption (Aziz, 2006; Davis and Cornwell, 2008; Aziz et al., 2017). In addition, the groundwater quality depends on the result of the hydrogeology of the location, the rock composition, weathering in the source area, and composition of the mineral sediments that are the basic factors controlling the chemical composition of the water. Also, the water from Bakhtiari formation and recent deposits has in general good quality, as well as the waters from shallow wells, located near cities and villages, which are mostly contaminated, due to free seepage of sewage water (Stevanovic and Iurkiewicz, 2009).

3. Results and discussions

Usually, the average daily consumption per person in the city can be found by dividing the amount of water used for all purposes in the particular area (such as daily consumption of people, washing, irrigation of gardens, industries, markets, departments, schools, places of worship ... etc.) by the number of population in that area. This indicates that everyone has the right to consume the quantity specified by the concerned departments. For example, Directorate of Water in Erbil City provides an amount of 380 liters/person/day (General Directorate of Water and Sewerage, Kurdistan Region-Iraq, 2020). Therefore, any use of more than the specified amount available for each person leads to a decrease in the quantity for another person (or other people). For example, a person builds a garden next to or opposite his house and irrigates the garden with potable water, and on the other hand, there are other houses that do not reach them with the water intended for them. Washing cars in front of houses and garages is the other example of wasting water. This is a transgression on the rights of others. It should be noted that due to excessive use of drinking water.

The current study verified that the Erbil City directly provided its required quantity of water, about 85 %, from the Greater-Zab River. This water is provided by the Directorate of Water in Erbil City throughout water treatment plants, which are responsible for the acquiring the required amount of water for each inhabitant. Some of the groundwater that is pumped out from the wells is subjected to pollution via nitrates and pathogens. This

water source also has a higher nitrate and E.coli level than the water that comes from the Ifraz water treatment plants. However, when the pathogen (coliform, and E.coli) amounts increase, the potential for creating higher levels of disinfection by-products also exist which is also a water quality concern. Meanwhile, Erbil continually imports this treated water by Ifraz Water Treatment Plants which contains disinfection agent (Mustafa et al., 2021). Chlorine gas is used for disinfection process in the Ifraz water treatment plants. The chlorine can react with naturally occurring materials in the water to form unintended by-products which may lead to health risks according to (Jadoon, 2015). It should be mentioned that the local authorities with the Directorate of Water Resources and Irrigation in Erbil City should set a monitoring network that would be required to observe the groundwater fluctuations and to avoid drilling extra illegal wells in the region, and to control water resources management for Erbil City.

Additionally, it is recommended to use further surface water for water supply in Erbil City, instead of using groundwater. Providing treated wastewater for irrigation, washing, construction, and recharging groundwater is another sustainable solution and management for water in Erbil City. According to Shareef and Muhamad (2008) Water contamination is a serious problem, also population and industry are trying to make greater demands on the water resource, that demand the problem escalates. Based on Shekha's (2008) study, about 20 % of the world's population lacks in safe drinking water and a half of the world's population lacks adequate sanitation.

4. Conclusions

Based on the results it can be concluded that the Erbil City requires appropriate water management system because the sustainability of the water management can play a fundamental role to maintain the source for the future challenges and for the future generation, as it is clear. The rapid growth of the global population and their activities cause the decrease of amount of water and increase of its demand. The study highly recommended to consider the sustainability of the water supply system. If this issue is not taken into consideration, the draught will cause irreparable problems. It is suggested to use more surface water via construction further water treatment plant, instead of using groundwater wells. Reusing of treated wastewater for irrigation, washing, construction and recharging groundwater can be seen as a sustainable plan and management for the water sector in Erbil City.

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Održivost upravljanja snabdevanja vodom u Erbilu u kontekstu održivog razvoja

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INFORMACIJE O RADU

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Erbil

Snabdevanje vodom

Kvalitet

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Održivost

Upravljanje snabdevanjem vodom

IZVOD

Jedan od najvažnijih principa zastupljenih na dnevnom redu po pitanju održivog razvoja jeste raspodela vode i snabdevanje budućih generacija. Cilj rada je procena održivosti količine i kvaliteta izvora vode za Erbil, kao i njihova sigurnost i bezbednost na osnovu standardnih ograničenja. Prvi korak je bio izračunavanje količine i potražnje vode na osnovu prilagođene skale, a zatim su proučavani podaci dobijeni od direkcija za vode koji se odnose na površinske i podzemne vode za ispitivano područje. Ispitivanje je bilo usmereno na upravljanje vodosnabdevanjem i glavne faktore koji su uticali na nedostatak održivosti. Sledeći korak je bio razmatranje odgovarajućeg rešenja za te probleme, kao što je izbegavanje bušenja ilegalnih bunara podzemnih voda i bolje upravljanje vodoprivrednim sektorom. Upotreba dodatnih površinskih voda dobijenih nakon izgradnje dodatnih postrojenja za prečišćavanje vode se može smatrati alternativom za potrošnju podzemnih voda. Ponovno korišćenje prerađene kanalizacijske vode za potrošnju i dopunjavanje podzemnih voda se takođe može smatrati održivom strategijom za snabdevanje vodom u Erbilu.