WATER MANAGEMENT SYSTEM AND ITS RELATED ENVIRONMENT IN MALA OMER CATCHMENT AREA IN ERBIL GOVERNORATE/ KURDISTAN REGION OF IRAQ

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Abstract: In the future, societies will face hard challenges to meet global water needs and sustain the environment. The present study was conducted to evaluate water management system and its related environments in Mala Omer. Data were collected and information abstracted using site visits and interviews .The average annual rainfall is 518.5mm, and only 18.7% recharged into the ground. Seventy-five wells were observed to abstract water for different purposes. Groundwater suffered huge depletion in water level between years 2000 and 2014. Water resources are largely gone unmanaged and inadequate capacity of management's impacts was clearly evidenced on the longevity of water supply services.

Keywords: Mala Omer, water management and environmental aspects, hydrology, Water Balance.

1. INTRODUCTION

Humankind cannot survive more than few days without water. No developments and human achievements would have been achieved without water [1]. Peri-urban water management in developing countries is an issue of serious concern and lacks sustainable solutions [2]. Aligned with growth of civilization and population, the required amount of water for human survival increases; however, the water management is complicated.

The water resources management has traditionally given priority to infrastructural development, with limited considerations of economic instruments and social and environmental factors [3]. Delivering adequate water for social, economic and environmental requirements is often understood as the preserve of the 'water sector', which is expected to provide the appropriate infrastructure and channel water in the right direction [4]. Yet, in reality, water cuts across all social, economic and environmental activities. As such, it cannot be confined to one sector; and also its governance requires cooperation and coordination across diverse stakeholders and sectoral 'jurisdictions' extends beyond a narrow sectoral focus [4]. It is crucial to integrate environmental and water sectoral policies [5] aligned with challenges imposed by increasing demands and growing water quantity and quality concerns [3], as well as international, sub-regional and local specificities [6], circumstances and required legal and regulatory frameworks [7]. Decision makers should start considering issues as appropriate institutional frameworks, implementation of demand management practices, protection of natural resources, participation from the affected sectors and stakeholders, and improving management capacity [7].

There are some problems with water in Asian countries, in general. The water problems in Asia's cities are similar. These include sources and uses of raw water, the large proportion of water loss in distribution networks, intermittent supply, and the quality of tap water. In some cities, the excessive use of groundwater resources has caused serious environmental problems, including rapid depletion of groundwater, deterioration of water quality, and land subsidence. Many cities suffer from inadequate sewerage networks and wastewater treatment systems while a large majority still depends on septic tanks and other on-site sanitation facilities. As a result, pollution loads in freshwater bodies and groundwater sources have increased substantially [8].

Efforts have been attempted to solve these problems. Some studies had a great success in achieving their goal while others were not as successful as required. [8]. On the other hand, there are several instances water crises. In India, a severe drought has been sweeping it the Bundelkhand region, since 2003. It has let loose a severe livelihood crisis. Loss of agriculture is a foremost issue that is considered [9]. Similarly, these problems exist in Kurdistan Region of Iraq (KRI). Therefore, the present study examines the current situation of research area, Mala Omer, regarding water management and the related environment.

2. METHODOLOGY

2.1 Research Location and Catchment Area

Mala Omer community is the selected site to be investigated regarding water management and its related environmental concerns. It is located in the KRI in the North-Northeast of Erbil Governorate, Dashty Hawler District, and it belongs to Kasnazan sub-district. It extends between latitudes 36°17' 0" and 36°19' 0" N and longitudes 44°6'30" and 44°11' 0" E as shown in Fig.1.

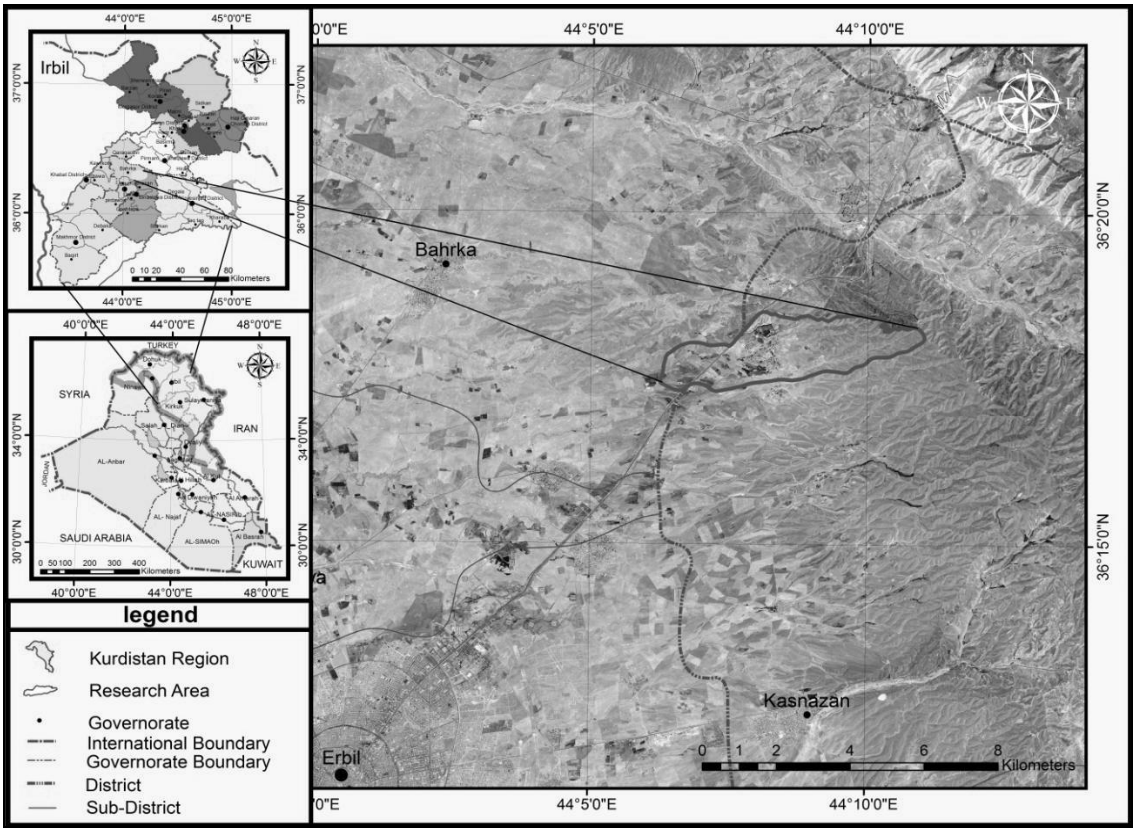

Fig.1. Location map of the research area regarded Kurdistan Region of Iraq.

Despite being a small area it characterized by it is variety of characters and it faces a rapid population growth. Research area has no limited identified borders. Therefore, the catchment area of the research area was determined through the drainage areas of the land surface that contribute to particular edges on the Hydro Network. The topography of the research area differs from one point to another and faces huge elevation changes since the lowest and highest points range are between (548 and 901 m) a.s.l.

Geologically, the studied area is located within Zagros mountain belt according to the physiographical distribution of Iraq [10]. The studied area is located at the northern part of foothill zone, where the high mountain chain is in northwest and southeast directions. In the same direction and between these mountains, there are narrow and subsequent valleys and plains, includes Mala Omer valley [11]. Mala Omer valley is one of erosional valleys along the southern limb of Pirmam anticline. This valley was divided into many small consequent seasonal brands like wady Kandak, wady Showk.

2.2 Data Collection and Analysis

In terms of information collection a number of sources were used, including written material, interviews with stakeholders and field inspections.

The sources of water were determined by personal interviews with Mala Omer water wells operators and private owner wells. Global Positioning Station (GPS) was used to determine wells location, and then, Geographical Information System (GIS) was used to determine the location, climate interpolation, distance measurement between wells, and land use. Penman-Monteith equation was used to determine evapotranspiration consumption and then [12]; they were rechecked using Crop-Water Program. Soil Conservation Service Method (SCSM) was used for runoff determination. Thereafter, water that is recharged into the ground was determined by simple mathematical calculations. Future water table drawdown was forecasted in Microsoft Excel. Exponential equation was used for population growth rate forecast. In addition, Cooper-Jacob method was used for pumping test analysis and compared with geological formation layers properties [13-16].

3. RESULTS AND DISCUSSION

3.1 Water Distribution System (WDS)

The water distribution systems used within the research area are mainly through direct pumping and also pumping from storage water tanks.

There are about 5,000 meters of old water distribution pipes within the research area. The system misses valves manholes, in general, especially, in case of old water distribution pipes that cause delay in identifying the leakage and broken pipes that lay under houses and causes mixing of wastewater with drinking water. In addition, improper design and pipe erection methods cause traffic disruption [17].

There is no equity in water distribution among served number of families provided with water ranges between (75 - 312) liters per capita per day. There are families does not have enough water, because of insufficient pressure in water that make it difficult to reach them. In addition, operation and maintenance costs for water network maintenance are also insufficient and not provided on time to cover the required maintenance.

The water distribution tariffs recently started to be required by consumers. Until the end of 2014, there were no water costs payments by consumers. Every year, the required amount of water is increasing, but wells' yield is decreasing. Therefore, wells have become unable to provide the required water; thus, new water pipe was driven from Pirmam to the research area passing through the main old road of research area. This includes a 200 mm ductile pipe and connected to the existed main pipes that are 100 mm in diameter. Thus, consequently, that pipe to be connected to the existed wells and storage tanks within the research area that have a total capacity of 220 m^3 [17].

Research area, like all other areas within KRI, faces a rapid development in population growth and land use change that affected the hydrology and environment. This increased the pressure on water resources within the research area and led to degradation in the quality and quantity of the water and livelihood.

The population of the research area was about 3,000 individuals in 1997 [18] and it was about 11,655 by the end of 2013 [17]. Based on the conducted questionnaire, people who live in Mala Omer are not all from Mala Omer, but have come from other parts and villages of KRI. The percentage of people who were born and lived in Mala Omer is 52%, and those who came from other parts, the remainder 48%. It is also worth mentioning that large numbers of those born in Mala Omer are grandsons of others who came in a long time ago to settle in Mala Omer.

To have a proper sustainable water management, the population growth for the next decade is forecasted using exponential equation; it also could be forecasted using many other methods like rational method, arithmetic method, decline rate of growth and many other methods.

Exponential Function
Continuous Change Model [19]

$A(t) = Pe^{rt}$

$r = 7.98\%$

The estimation is increasing and the population will reach about 20,375 people by 2020 and that number will be increased to 45,250 by 2030. The population of Mala Omer is facing a big increment in population, which is estimated to be 7.98%. It is extreme when compared to Erbil population incremental rate, which equals 2.32% using same exponential equation depending on Erbil population data [20].

This difference in the population increase is due to the location of the research area, which is close to Erbil city that made people settle to the research area. Therefore, the government should take serious actions to balance the development in urbanization. It should also control the population growth by considering that all parts of the KRI require to be planned on basis of providing the same welfare and entertainment. Hence, people can obtain their life requirements equally. According to this basis, the design rate of increment for the future same of Erbil city should be considered to provide water for future.

3.2 Groundwater condition

Total reliance on ground water for water provision is pragmatic within the present context of strained surface-water resources [4]. Besides easily obtaining water by drilling new water wells in the research area, along with water quality (derogation) and volume (depletion) protection initiatives were not considered as well. Groundwater production is based on the amount discharge from the wells. For the studied area, Fig.2. shows and identifies the number of wells and the position of every well with global coordination.

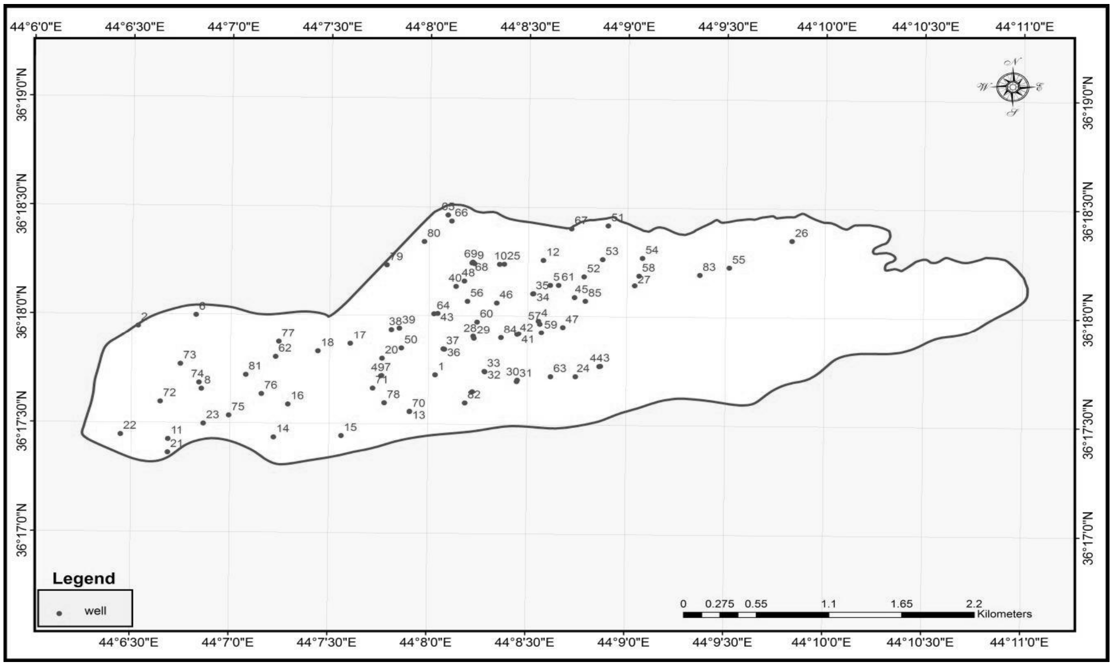

Fig. 2. Number and global coordination of the research area wells.

Eighty four wells were observed in the research area. Nine of the wells are now dried while Seventy-five wells were used to abstract water from the groundwater. This is a large number of wells to be existed in a small area, which is barely 9.326 km^2, and it is being used in unmanaged ways that have caused a lot of problems in water resources in the research area. The evidences of water wells' distribution that have been detected within the research area, exhibited that there are about 8, 11 and 27 wells alongside each other in about equal to and less than 75, 100 and 200 m, respectively.

Almost all wells were in operation. Hence, this caused interference in radius of influence [21]. Thus, the areas of influence had interfered with each other affected the wells' efficiency [22]. On the other hand, the drawdown of the wells affected the pumping tests that have been conducted for production wells [21]. This is because after analyzing the results of well pumping tests, it has been found that the tests are conducted as single well test without providing the data of the surrounded wells that have to be considered. Besides, the conducted pumping tests are almost taking data measurements after a reasonable drawdown and that affects the drawing on semi-log paper and affecting the results [22].

Moreover, the pumping well test results, of determining aquifer parameters, are not equivalent to the aquifer formation layers, which are mainly consist of clay, sand and gravel. The transmissivity of such aquifer is relatively high [23], while well test results showed very small values of transmissivity and different well efficiency values, range between 98% and 142% within the research area. These values cannot be relied on for aquifer assessment and groundwater productions. Furthermore, correct well test data are essential for well efficiency, aquifer properties and other required important hydrogeological information. In order to assess the capacity of aquifer wells production, whether it is useful to construct hydraulic wells or not and whether for the short and long-term conditions, therefore, well-field must be designed when groundwater is abstracted [24]. It is also important to take the main aspects into consideration, including production capacity [25] and allowable drawdown [24], within the aquifer of the research area. It is vital to construct minimum number of wells for water production, which, in turn, minimize the drawdown caused by surrounded wells and maximize capacity of wells, and as a result minimizing costs of pumping. According to the present study findings, it has been experienced that the problem of failing to supply water from aquifer with current water management and wells constructed within the research area.

In addition, the construction of water wells within the household has its direct exposure to water contamination and biological bacteria from cesspool tanks aligned with improper waste water and solid waste management [24]. The quantity of water was continuously decreasing in efficiency until it became unable to provide the required water, due to improper planning and water losses through inadequate water network and leakages. The water is pumped out of the well at too high rate, in such an extensive number, in addition to insufficient water wells screening and casing that caused water not flow through the geologic formation fast enough[26], to keep the well filled at a required level. Beside over pumping of groundwater would cause significance land subsidence [25] and contamination movement fastening increases towards wells.

Accordingly, it is indispensable to eliminate the number of existed wells to the minimum number of wells. Aquifers with high transmissivity can provide the high rates of discharge [24] aligned to high discharge that results in increasing the drawdown, and thus, decreasing well efficiency that should be kept in ranges equal to or greater than 70% [27]. Thus it is easier also to control wellhead protection zone area that should be provided to protect against contamination.

It is crucial to have accurate information to set the efficiency in the allowable ranges. On this basis, obtaining the discharge depended on the allowable drawdown keeps the efficiency in the permitted range. Then determine number of wells which provide the required yield in the allowable drawdown.

Even though, the groundwater protection is complex, it should have a potent coordination and commitment on multidisciplinary institutional level and regulatory requirements, environmental and socio-economic impacts as well as its technical requirements [28].

3.3 Groundwater Level

Due to the huge pressure and topography of the research area, the groundwater level faced an extensive lowering of the water table based on the available data for monitoring wells within the research area and surrounded it [29]. Ground water table has been dropped down significantly in 2014, compared to 2000. The ground water level in several places has been dropped by almost 80 m in depth in less than two decades [29]. The drawdown is expected to deplete about 69 m between 2014 and 2030. This is a big threat because it will have huge impacts in the near future. The reasons for this depletion are the reliance of unmanaged use of groundwater and lack of water planning that affected the water losses in the system. This requires strategic protection plans in order to be sustained.

3.4 Water Balance

3.4.1 **Climate Elements, Evapotranspiration, and Runoff**

Catchment area is un-gauged and its climate elements have been resulted from interpolation of the climate elements between Salahaddin and Hawler (Erbil) stations of twenty one years between (1993-2013) using program Arc GIS 10.2[30]. See table 2.

Climate change is a central external driver that affects water demands for all uses directly. Its mitigation and controlling factors is crucial [4]. The amount of evapotranspiration in the research area is increasing until reaching its maximum in July and that amount is decreasing after that. This flowing in temperature is related to temperature of the area. The mean temperature riches it’s maximum to 39 °C in July (table 2), and therefore, evapotranspiration is maximized to more than 250 mm. see table (2).

The SCSM was used for runoff calculation that was developed by US Army Corps of Engineers, uses the following equations:

$$Pe = (P-0.2S)^2/(P+0.8S) \quad (1)$$

$$S = (25400/CN)-254 \quad (2)$$

where:

Pe: Depth of direct surface runoff in [mm]

P: Depth of rainfall in [mm]

S: is maximum potential difference between rainfall and runoff in mm, starting at the time when the storm begins.

CN: Curve number varying from zero to 100. When CN= 100, S=0 and Pe= P

CN can be obtained from special tables, in which, the values apply to antecedent rainfall condition II (Table 1) for soil type (A), which is an average value for annual floods. According to above factors, SCSM classifies soil into four hydrological soil groups (A, B, C, and D) for condition II, correction factors for other antecedent rainfall conditions should be done using special equation [31].

$$CN = (4.2\,CN2/(10-0.058(CN2))) \quad (3)$$

$$CNIII = (23CN2/(10+0.13(CN2))) \quad (4)$$

Condition I: Moisture content from wilting point to about lower plastic limit. For this study, September, October and November considered as condition I, where the soil is dry and it is the beginning of rainfall.

Condition II: Average value for annual floods, where the soil is almost wet. For this study, December, January and February were considered as condition II.

Condition III: The soil is almost at high moisture content and soil potential for infiltration is at low, so runoff increases. For this study, March, April and May considered as Condition III [31].

Table 1: Antecedent rainfall conditions, CN and correction factors.

Type of land use	Area (km^2)	Area (%)	CNII	Weighted CNII
Commercial	0.022	0.24	89	0.21
Agricultural	2.933	31.45	67	21.07
Pond	0.029	0.31	0	0
Streets	0.255	2.73	98	2.68
Gardens	0.283	3.04	64	1.94
Non-cultivated areas	4.859	52.10	49	25.53
Residential	0.945	10.13	77	7.80
Total	9.326	100		59.23

Table 2: Mean monthly climate elements values of the research area.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evaporation (mm)	42	52	103	135	232	319	349	320	236	158	73	50
Relative Humidity (%)	72	70	61	56	41	32	32	32	36	47	60	67
Daylight (hours)	5	5	6	7	9	12	11	11	10	8	6	5
Wind speed (m/sec)	2	2	3	3	3	3	2	2	2	2	2	2
Vapor pressure (mbar)	8	7	9	11	12	13	15	15	13	11	9	7
Rainfall (mm)	104	92	79	58	21	2	1	0	4	33	49	76
Maximum temperature (°C)	10	12	16	21	29	34	39	38	33	27	18	13
Minimum temperature (°C)	3	4	7	12	17	23	26	26	21	16	9	5
ET_o (mm)*	39.4	48.5	78.6	57.9	21.4	2.4	0.8	0.0	4.0	32.5	49.0	44.2
Evaporation (mm)*	41.7	52.1	78.6	57.9	21.4	2.4	0.8	0.0	4	32.5	49.0	49.7
Runoff (mm)*	19.6	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7

Means actual available rainfall water for evaporation and evapotranspiration, and the remained of precipitation, evapotranspiration and evaporation then available for runoff.

3.4.2 Current Water Consumption in the Research Area

The amount of the consumed water in the research area is frequently difficult to be accurately estimated. This is due to the absence of any measuring meters, storage tanks with specified times and also missing records of daily amount abstracted from wells; because the main source of water is ground-water wells for supplying water for domestic purposes, agricultural and commercial purposes .

For domestic water supply within the research area there are about 28 wells for water supply for public and 18 of them are operated by government and the other are personnel by public people. For commercial purposes, six wells are operated, two of them for Bafrin apartments and four wells for Khanzad hotel. The other remained 41 wells are used for agricultural, gardens watering and for livestock requirements. Most of abstracted water is for domestic uses followed by agricultural and commercial uses [12].

The difference between water precipitation, evapotranspiration, evaporation, and runoff is estimated to be recharged into aquifer as shown below:

Aquifer Recharge = Rainfall – (Evapotranspiration + Evaporation + Runoff).

Aquifer Recharge = 903812.8 m^3

Aquifer Recharge = (903812.8 /4834598.4) *100% = 18.7% of precipitation

The annual water abstraction was estimated to be ((3642m^3/day)*365day =1329298 m^3)

Then, the water balance condition in the research area is calculated as: see Fig. 3.

ΔS = 4,834,598.5 + 19,000 – 3,057,356.5 – 488,265.3 – 385,163.8 – 1,329,298

ΔS = -406485 m^3

Where 19,000 m^3 are water brought by trucks to the research area.

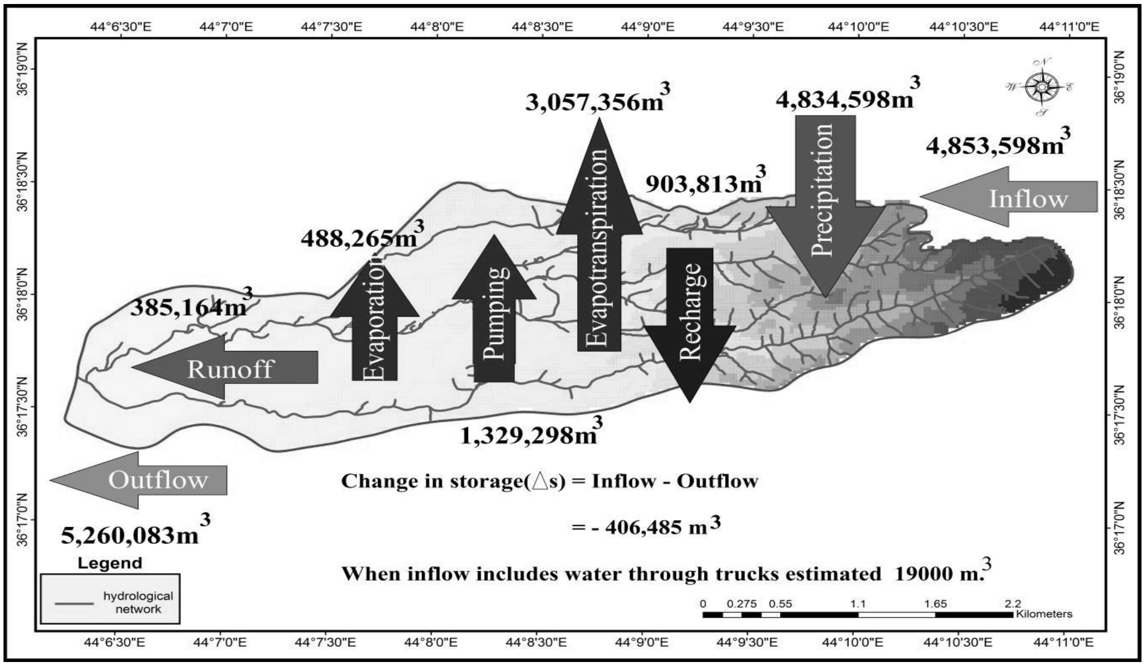

Fig.3 . Estimated amounts of water reach and leave research area in m^3/year.

This deficit is equal to 0.31 of the water abstraction which is estimated to 1329298 m^3. Therefore eliminating equivalence rate of pumping of the total wells the watershed balance will be satisfied. In addition it will restrict the groundwater drawdown of the research area.

Worth to mention that the availability of daily climate data could have a significance improvement to the calculation of runoff amounts.

3.4 Waste Management

Waste management still improper and harms the natural resources which is also dangerous. Inadequate collection, recycling or treatment and uncontrolled disposal of waste in dumps lead to severe hazards, such as health risks and environmental pollution.

Waste management needs more effective plans for collecting, monitoring, and disposal of the waste. It should include all improvements in waste management in a way to reduce discharge of wastes to water and environment. Current waste approaches do not consider all elements of waste cycle. Proper control at the source of the problems is a key to acceptable management of the waste problems.

The United Nations Environmental Program recognized the importance of Integrated Waste Management [32]. This requires synergy between economic development, social equity and the environment. Focus on, increasing covering degree of the municipal waste collecting system for population, as well as quality management system corresponding to optimum prices. Reducing the amount of waste stored; Increasing the amount of recycled waste; Setting up of some efficient structures for integrated waste management.

4. CONCLUSIONS

From the present study, it was concluded that the water management strategies implemented within the research area were inadequate, and water supplied to the community was in continuous deterioration. Many gaps are existed within the information management system, and what made it more complicated, was the variety of institutions in charge of water and water management with no clear responsibilities.

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СИСТЕМА ЗА УПРАВЛЕНИЕ НА ВОДИТЕ И СВЪРЗАНИТЕ С НЕЯ ФАКТОРИ ВЪВ ВОДОСБОРА НА МАЛА ОМЕР, ОБЛАСТ ЕРБИЛ/ КЮРДИСТАНСКИ РЕГИОН НА ИРАК

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Резюме. В бъдеще, съвременните общества ще се изправят пред все по-трудни предизвикателства за да успеят да отговарят адекватно на нарастващите потребности от вода и необходимостта от устойчиво използване на ресурсите. Настоящото изследване има за цел оценка на системата за управление на водите и свързаните с нея фактори в Мала Омер – територия, в която тези проблеми се поставят все по-остро. Представените данни са обобщена информация от проведени различни теренни посещения и интервюта. Средната стойност на годишните валежи в тази област е 518.5 mm, като само 18.7% достигат подземните водни тела – основен водоизточник за различни цели, експлоатиран чрез 75 броя кладенци. Но проведените анализи показват значително намаляване на водните нива на подземните води между 2000 и 2014 г. Водните ресурси са до голяма степен управлявани неефективно, а водоснабдителните услуги, предоставени на населението са остарели и с неадекватен капацитет за съвременните нужди.

Keywords: Мала Омер, управление на води и влияние на околната среда, хидрология, воден баланс.

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