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Research Article

Assessment of water suitability of the Lower Zab River for agriculture in two regions of Altun Kupri and Dibis, Iraq

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Abstract
This study was conducted to evaluate the water suitability of the Lower Zab River for the purpose of agriculture on sampling in all seasons in two stations of theAltun Kupri and Dibs regions, Kirkuk Governorate. The results of the Piper classification showed that the waters of the Lower Zab River in both regions are alkaline in nature, due to the influence of the original rock components of the region on the water quality. The Stiff Diagram of the study area based on the contents of water ions showed water quality with a carbonic formation. The water quality of the Lower Zab River in the Altun Kobri and Dibs districts is alkaline nature water containing moderate Ca and Mg ions and small percentages of Na and K ions with a predominance of bicarbonate ion. The river waters fall within the field C2 -S1 based on the Richard classification i.e. river water is suitable to irrigate crops.

Keywords: Water quality, Lesser Zab, Index, Piper classification.

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Introduction

Hydrochemistry focuses on verifying the chemical composition of surface waters and their interaction with the terrestrial environment of the area they pass through. It represents the complete interaction between the hydrological, chemical, physical and biological factors of the watershed ecosystems, in addition to anthropological effects resulting from the dumping of various types of waste (Carol et al. 2012). Water pollution is the increase of some elements that leads to a change in the quality of water and the loss of water suitability for irrigation of crops. Because it causes an imbalance in the ecological balance, the quality of water depends on the geology of the watershed area and several climatic factors. The pollution of water sources is one of the most prominent and complex environmental problems. Lavon defined water pollution as any change that occurs in the natural, chemical and biological properties of water due to a change in its condition directly or indirectly so that the water becomes unsuitable for natural uses (Rasul 2013).

The pollution of Iraqi waters is one of the major problems that have emerged and started to increase, which need serious thinking to find ways to reduce it effects especially. The Zab River is the main source of drinking water in Kirkuk governorate, and most of the water projects and complexes in the governorate (the Hawija district projects) depend on it. The Kirkuk Unified Water Project is the main project for feeding water in the Kirkuk governorate in addition to agricultural uses. Its water depends on the melting of snow and the rainfall, and its level fluctuates depending on climatic conditions too. Its water level reaches its highest level in spring due to snow melting and decreases in summer. The maximum and minimum mean monthly river discharges are 480m3/s during April and 55m3/s during September. While the average monthly discharge amounted to 191.2 cubic m/s (Table 1).

This study aims to determine the quality of the Zab River water and compare it with the Iraqi specifications and the World Health Organization. In addition, its suitability for agricultural uses and impact on the pollution of the Tigris River will be assessed by examining the chemical and physical properties of the water.

Materials and Methods

This river is one of the main tributaries of the Tigris River. Most of its catchment area is located in Iraq of about 49562km2, representing 81% of the total catchment area and the remaining area is located within the Iranian Borders .The river's length is about 400km, of which 33km extends along the Iraqi-Iranian Borders. The river joins the Tigris River at a point located 220km north of Baghdad City. The average annual inflow of the river as it joins with the Tigris River is 7.9 billion m^3, 66% of this annual inflow is from the catchment area within Iraq and 34% of the catchment area located within Iran. Two sites were studied on the lower Zab River, the first in the Altun Kupri area, located in the northwestern part of the Kirkuk governorate (N35.7°60´53´´, E44.1°41´89´´), about forty kilometers away from Kirkuk and fifty kilometers away from Erbil, and the second site is the Debs region (N 35.6°84´47´´, E 44.0°70´72´´), about 25 kilometers north of the Hawija district, between the Kirkuk triangle from the east and the Makhmur district from the west, and Hawija district from the south.

The sampling bottles were washed before filling at each site. During filling, the bottles were placed under the water's surface at a depth of 30cm. The filling was carried out in the direction of the flow of water. The distance between sites was about 11-12 km. According to standard methods, the samples were transferred to the laboratory for chemical analysis. The physical measured parameter were temperature, pH, electrical conductivity EC, and TDS (Yahya Dhannoun & Jumaa Mahmood 2014). The studied water chemical parameters were **c**alcium (Ca^{+2}), magnesium (Mg^{+2}), Sodium (Na^{+}), sulfate (SO_4^{-2}), chloride (Cl^{-1}) nitrate ($NO3^{-1}$), and bicarbonate (HCO_3^{-1}).

Water quality classification: Several classifications have been proposed to assess the quality of water for irrigation purposes, by measuring the mineral content and soil quality and irrigated plants. The Piper method was used to classify the waters quality of the Lower Zab River, where water is classified according to seven categories (A, B, C, D, E, F, and G). Stiff Diagram was also used in this study to classify water quality. The value of the SAR was calculated according to the equation (Saeed 2009) of SAR= $Na^{+2}/ (Ca^{+2}+Mg^{+2})/2)^{0.5}$.

Results and discussion

The results showed that the temperature in both sites ranged 17.0-24.3 (Table 2), and this change may be attributed to no difference in water depth between the studied sites (Lambert 1997). The pH of the river water ranged between 7.6-8.15 (Table 2). The Lower Zab River water is low alkalinity and there is no problem with its use for irrigation (Hammoud 1996). Electrical conductivity (EC) of the river water ranged 304.33-388.5µSiemens cm^{-1} (Table 2), and these values are proportional to the total dissolved salts, ranging between 206-264mg l^{-1}. Based on the American Salinity Laboratory for irrigation water, the river water in both regions is classified into medium-saline water (0.25-0.75mmose/cm^{-1}) (Al-Tammie 2015). It is not suitable for all crops, as this water will affect salt-sensitive crops. Therefore, the selection of crops with medium resistance to salinity with a moderate increase in irrigation water should

Table 1. Monthly mean discharge of the Lower Zab River based on historical records.

Monthly mean discharge, m^3/s											
Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.
67.1	115.9	177	224	349	276	480	296	127	71	60	55

Table 2. The physical and chemical measurements of the Lower Zab River waters in the Altun Kupri (A) and Dibs (D) regions.

Parameters	Unit	Winter A	Winter D	Spring A	Spring D	Summer A	Summer D	Autumn A	Autumn D
pH		7.6	7.99	7.95	7.95	8.15	8.00	7.8	7.71
Temp.	Cº	17	17.83	19.33	19	20	24.33	19	21.33
HCO_3^{-1}	mg l^{-1}	100	120	110	122	121	143	133	150
PO_4^{-3}	mg l^{-1}	0.08	0.13	0.11	0.12	0.14	0.11	0.134	0.18
NO_3^{-1}	mg l^{-1}	10.96	5.96	9.71	10.10	13.3	4.48	15	5.09
Ca^{+2}	mg l^{-1}	54	43	44.66	48	55	44	55	47
Mg^{+2}	mg l^{-1}	19.95	17.09	18.26	21.35	20.2	15.43	14.02	13.58
K^{+1}	mg l^{-1}	1.55	2.15	2.266	2.2	2.55	1.24	2.45	1.433
Na^{+1}	mg l^{-1}	8.5	7.60	8.63	7.3	8.1	5.5	6.09	5.4
SO_4^{-2}	mg l^{-1}	43.5	29.5	27	36	55	18.26	30.5	19.66
Cl^{-1}	mg l^{-1}	14	11.33	10.33	13.5	17.94	10.66	11.3	10.66
TDS	mg l^{-1}	245	206	244.66	264	250	231	220	221
EC	$cm^{-1}\mu$	355	304.33	363.66	388.5	360	340	322	325.33
SAR	Mg l^{1-}	0.11	0.12	0.12	0.10	0.10	0,11	0.11	0.13

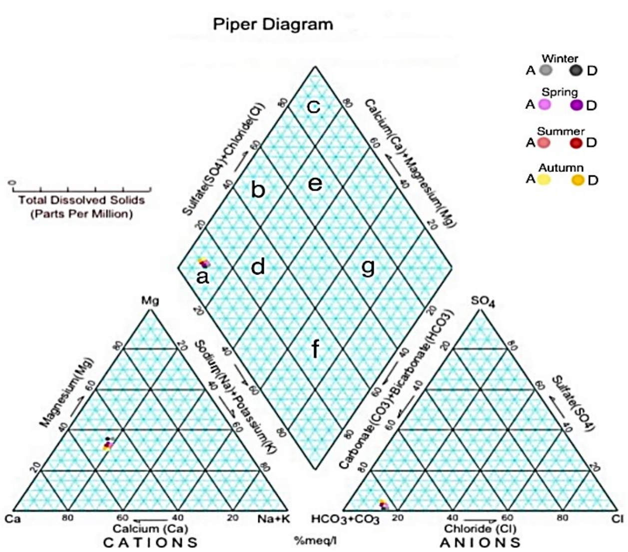

Fig.1. Water quality according to Piper classification divided into six sections according to Langguth (1996).

be given to prevent the salts accumulation in the soil. Total dissolved solids (TDS) of river water ranged 206-264 (Table 2), and the highest value was in the Dibs area in the spring. The reason is the adoption of surface irrigation even in the cultivation of grain and human consumption resulting from the villages located around the river (Shukri et al. 21011).

Water chemical parameters: Calcium (Ca^{+2}) and Magnesium (Mg^{+2}) ions are released from the melting of minerals and rocks (Dvorak 2014). In this work, the calcium value of water was between 43–55ppm, and magnesium between 13.58-21.35ppm. Sodium (Na^{+}) values ranged 5.4-8.63mg.l^{-1}. The higher sodium concentration in the irrigation water causes a high sodium adsorption rate. It exposes the irrigated soils to cause a reduction in plant growth when its concentration exceeds 300mg.l^{-1} (Al-Tammie 2015). Therefore, river water is considered in both two regions are safe to use in all seasons. The potassium ion is found in low concentrations in natural waters (1.24-2.55ppm).

The main source of sulfate (SO_4^{-2}) ions in river water is sedimentary rocks (gypsum and anhydrides), igneous rocks and water precipitation (Al-Tammie 2015). Also, bacteria produce sulfate by decomposition organic matter in sediments in water reservoirs such as lakes (Saeed 2009; NPCA 2014). The results showed that the sulfate ion in the two study areas was 07.1-89.1ppm (Table 2). This high amount may be attributed to waste discharge that increased its concentration. The chloride ion (Cl^{-1}) is characterized by its high solubility in water. It enters the surface water through atmospheric deposition processes (Mahmoud 2010). Its values in the current

Table 3. Piper chart division by Langguth 1996.

Primary title	Secondary title	Class
Normal earth alkaline water	With prevailing bicarbonate	A
	With prevailing bicarbonate and sulphate or chloride	B
	With prevailing sulphate or chloride	C
Earth alkaline water with increase portion of alkali	With prevailing bicarbonate	D
	With prevailing sulphate and chloride	E
Alkaline water	With prevailing bicarbonate	F
	With prevailing sulphate and chloride	G
Alkaline water	With prevailing bicarbonate	F
	With prevailing sulphate and chloride	G

Table 4. Water quality standards and their compatibility with the waters of the Lower Zab River**.**

water quality standards		
Water quality for irrigation of agricultural land based on electrical conductivity values according to L.A (Richods 2012).		
Electrical conductivity values µS / cm	water class	Samples
100> E.C <250	Low salinity water	
250> E.C <750	Medium salinity water	Altun Kupri (A) and Dibs district (D)
750> E.C <2250	High salinity water	
2250> E.C <5000	Very high salinity water	
Surface, ground, and irrigation water quality depending on electrical conductivity according to Don 1995.		
Electrical conductivity values µS / cm	water class	Samples
<250	Excellent	
250-750	good	Altun Kupri (A) and Dibs district (D)
750-2000	allowed	
2000-3000	Doubtful	
>3000	Not suitable	
Water quality for irrigation based on the values of SAR according to Hamza 2011.		
SAR	SAR	dangerous
S1	<10	There are no dangerous effects of sodium
S2	10-18	A markedly high risk of sodium in soils with fine tissue while it can be used for soil sandy good permeability
S3	18-26	Dangerous effects can be expected in most types soil
S4	>26	Generally unsatisfactory for irrigation

study ranged 10.33-17.94ppm (Table 2). In the summer, the higher limit was in the Dibs district due to pollution from sewage and agricultural wastewater (Mahmoud 2010). The minimum was recorded in the Altun Kupri station in the spring, which may be losing its concentration due to physical, chemical and biological activities and the minimum was within the Iraqi and World Health Organization parameters, which amounted to 120mg/liter (Al-Tammie 2015).

The nitrate ($NO3^{-1}$) values ranged between 4.48-15mg in the current work. l^{-1} (Table 2), and the higher value was recorded in the Altun Kupri in the Autumn. This higher value is attributed to agricultural activities or draining untreated sewage water containing detergents to irrigate crops or from wastewater seepage into the river. The minimum nitrate was found on the Dibs site in the summer. The concentrations were within the Iraqi and World Health Organization parameters (50ppm) (Al-Tammie 2015). In the current work, the bicarbonate (HCO_3^{-1}) values were 100-150mg.l^{-1} (Table 2). It is the predominant negative ions in the waters of the Lower Zab River and its percentage varies according to the water source (Mahmoud 2010). In addition,

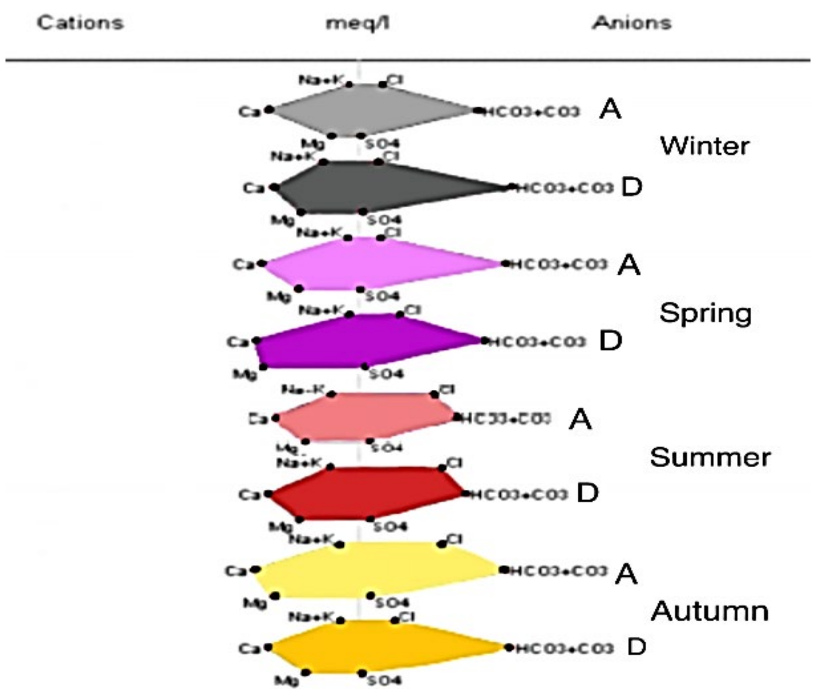

Fig.2. Stiff diagram of the water quality of the Lower Zab (Module 1999).

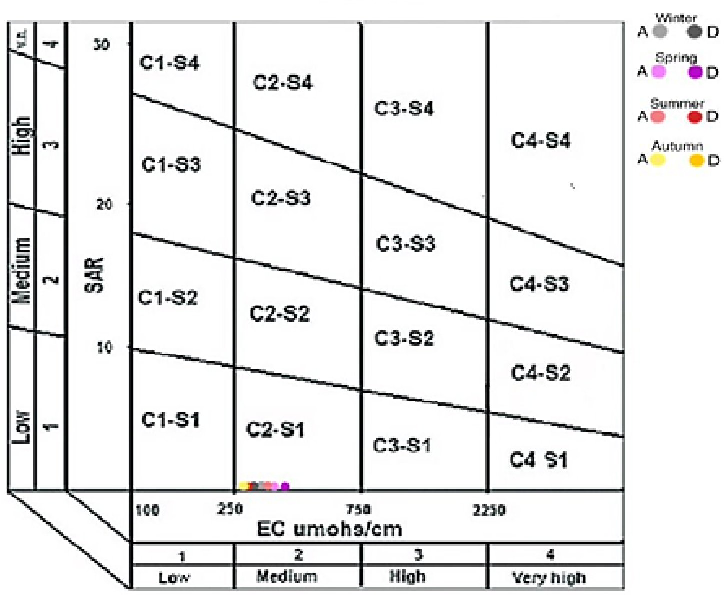

Fig.3. Distribution of the study models according to Richard classification.

aquatic plants affect the amount of carbon dioxide to stabilize carbon (Al-Tammie 2015).

Water quality indices: The suitability of water for different uses needs their requirements (Healey 2014). Determining water quality is useful in diagnosing sources of water pollution and their possible use (Pennsylvania Integrated Water Quality 2014). This study showed the differences in water quality due to human activities and pollution in the two studies sites.

In the piper method, water quality is classified according to seven categories (A, B, C, D, E, F, G) (Table 3). The main positive ions (Ca^{+2}, Mg^{+2}, Na^{+1}, and K^{+1}), the main positive and negative ions (SO_4^{-2},

HCO_3^{-1}, and Cl^{-1}) are illustrated in a piper diagram. The piper diagram of the waters of the Zab River is shown in Figure 1. Bicarbonates are dominant components originating from rocks of the area, making it alkaline water containing calcium ions (Ca^{+2} and Mg^{+2}) and small percentages of sodium ions, Na and K with a predominance of bicarbonate ions.

The stiff diagram consists of a scale to determine the concentrations of positive and negative ions (Fig. 2). The bicarbonate ions are the predominant negative ions, next the chloride ion, then followed by the sulfate. As for the positive ions, the calcium and magnesium ions predominate, then the sodium and potassium ions. This result shows the study area belongs to a region with a carbonic formation.

The waters of the Lower Zab River are mainly used to irrigate field crops. Classification based on Richard's classification depends on two factors that affecting on the quality of irrigation water i.e. the total salinity represented by EC and SAR which is one of the important hydrochemical factors that have a detrimental effect on the soil. Figure 3 shows that the waters of the study area are within the C2-S1 class. In the Lower Zab River, it was found that the water quality depending on EC values according to L.A. (Table 3). All samples for seasons and both sites had medium salinity, and based on the EC values according to Don (Table 3), the water quality for irrigation in the two sites and in all seasons have suitable quality. Based on the Richard classification, all study models were within the type S1 and according to SAR (Table 3), the water and its sodium content do not have any serious effects to use for irrigation.

Conclusion

The water quality of the Lower Zab River in the Altun Kobri and Dibs districts is alkaline nature water containing moderate Ca and Mg ions and small percentages of Na and K ions with a predominance of bicarbonate ion. The river waters fall within the field C2 -S1 i.e. river water is suitable to irrigate crops.

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