Water quality assessment of Rawanduz River and Gali Ali Beg stream by applied CCME WQI with survey aquatic insects (Ephemeroptera)

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Abstract

The population of Ephemeroptera was studied in three selected stations of Rawanduz River (Gali Ali Beg water fall, Rawanduz River and after the junction of these two waters) during the three seasons of spring, summer and autumn in 2016. In addition,sixteen physicochemical parameters (pH, EC, turbidity, DO, BOD_5, NO_3, TDN, TDP, HCO_3^-, Hardness, Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, SO_4^{2-}, Na% and SAR) of water in these stations were estimated and used to calculate the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI). Eleven species of aquatic insects were identified,which belong to four families of the order Ephemeroptera. Three of the studied species are described for the first time. According to water quality index, the water was ranked as poor for drinking and marginal for irrigation purposes.

Key words: Water Quality, Rawanduz River, Ephemeroptera, CCME WQI.

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تقييم جودة مياه نهر رواندوز وجدول كلي علي بيك بواسطة مؤشرنوعيةِالماءِ CCME المطبق مع مسح الحشرات المائية (Ephemeroptera)

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الخلاصة

تمت دراسة سكان رتبة Ephemeroptera في ثلاث محطات مختارة من نهر رواندز (شلال كلي علي بيك ونهر رواندز وبعد التقائهم) خلال ثلاثة مواسم ؛ الربيع والصيف والخريف من عام 2016. بالإضافة إلى ستة عشر خصائص فيزيائية كيميائية (الرقم الهيدروجيني ، التوصيل الكهربائي ،عكرة ، أوكسجين المذاب، الطلب على الأكسجين الكيميائي الحيوي، النتراتإجمالي النيتروجين المذاب، إجمالي الفوسفات الذائب، بيكربونات، العسرة ، أيون الكالسيوم، المغنيسيوم أيون، أيون الصوديوم، أيون البوتاسيوم، أيون الكلوريد، أيون الكبريتات. نسبة الصوديوم ونسبة امتصاص الصوديوم (SAR) من المياه في هذه المحطات والتي تم حسابها من قبل مجلس وزراء كندا لمؤشر جودة المياه في البيئة (CCME WQI). تم التشخيص أحد عشر نوعا من الحشرات المائية التي تنتمي إلى أربع عائلات من رتبة Ephemeroptera. ثلاثة أنواع من الحشرات تم وصفها لأول مرة. وفقًا لمؤشر جودة المياه ، احتلت المياه المرتبة السيئة بالنسبة للشرب وهامشية لأستعمال الزراعي.

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Introduction

Rivers are the human's most important freshwater resources. Social, economic and political development has been largely linked to the availability and distribution of freshwater in river systems. River systems can be considered as the arteries of the land that supply life and give water to an abundance   of   organisms   [1]. Referring to the quality of water required for human use (i.e. drinking, agricultural and industrial purp oses), the term water quality was used. This term is completely human for all aquatic organisms or ecosystems [2].

Generally, several researches used the Canadian Water Quality Index to assess the quality of local water [3- 8]. Water quality is important to preserve human health and the health of the ecosystem. Current concern for the quality of the environment is therefore focused on water. Freshwater is a resource that is essential for agriculture, industry and even human life; without adequate quantities and   quality   of   freshwater,   sustainable   development   will   not   be   possible[9]. It is necessary to use the numerical index as a tool for assessing water quality. An index is a number, usually without dimensions, expressing the relative magnitude of a certain complex phenomenon or condition [10]. Water quality depends on recharged water quality, atmospheric precipitation, inland surface water, interaction time with rock water, mineral weathering, process of ion exchange and geochemical sub-surface processes. Temporary changes in the source and nature of recharged water, along with hydrological and human factors, can cause periodic changes in the quality of groundwater and surface water [11].
Several health stressors that significantly deplete biodiversity affect aquatic ecosystems. In the future, biodiversity loss and its effects for aquatic ecosystems are predicted to be greater than for terrestrial ecosystems [12]. Several factors related to water quality, stream morphology and food availability and quality affect aquatic insect communities [13]. Immature mayflies are important components of freshwater aquatic assemblies due to their high abundance and wealth and their role in the trophic chain [14].Several previous studies about mayfly in the local area, covered by the present study,were published [15- 25].

This study aimed to evaluate water quality of Rawanduz River for drinking and irrigation purposes by using the Canadian water quality index CCME WQI as well as surveyingthe community of benthic insect,particularly those of the order Ephemeroptera.

Materials and methods

1. Description of the study sites

In the present study, three sampling sites were selected(Figure-1), which are situated within Soran District in Erbil, Kurdistan Region of Iraq. The sites are marked as Rawanduz River (Site 1), Gali Ali Beg water fall (Site 2) and the junction of these two waters (Site 3).
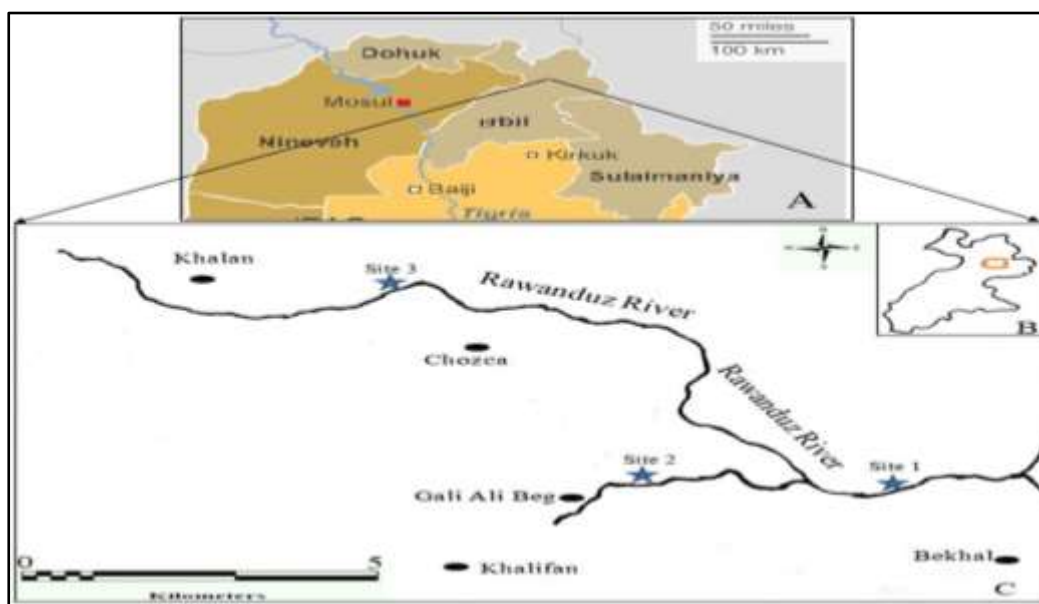

Figure 1- A: Map of northern Iraq. B: Erbil Governorate. C- Studied sites.

2. Samples collection and analysis

During this study,samples from three sites were collected for the analysis of sixteen physicochemical parameters, namely, pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), nitrate (NO_3^-), total dissolved nitrogen (TDN), total dissolved phosphate (TDP), bicarbonate (HCO_3^-), Hardness, Calcium ion (Ca^{2+}), Magnesium ion (Mg^{2+}), sodium ion (Na^+), potassium ion (K^+), chloride ion (Cl^-), sulphate ion (SO_4^{2-}). For these measurements, along with those of sodium percentage (Na%) and sodium adsorption ratio (SAR), samples were collected from the water bodies for three seasons [spring, summer and autumn] during 2016 with three replications using previously described procedures [26- 29]. In addition, the samples of aquatic insects were collected from each site by collecting the rocks by using Surber sampler with an area of 1 m^2. After collecting the samples, they were preserved in vials with ethanol 70%. Then the insects were isolated to the main taxonomic groups and the results were expressed as individual/m^2 [27]. Compound microscope was used for identification of aquatic insects using the adequate references [30- 32]. Statistical analysis was performed using Statistical Package for Social Science (SPSS, version 21). All data were treated with one way Analysis of Variance (ANOVA).

3.   Calculation of WQI

The Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) was used for the evaluation of water quality of Rawanduz River. The CCMEWQI includes three factors [33].

F1 (**scope**) represents the percentage of parameters that are out of their objectives (failed variables).

F1= (

F2 (frequency) represents the percentage of the tests that do not meet the objectives (failed tests).

F2=)

F3 (Amplitude) represents the amount by which failed test values do not meet their objectives. F3 is calculated in three steps:

i. The number of times an individual concentration is greater than (or less than when the objective is a minimum) the objective is called an "excursion" and is expressed as follows. If the test value must not exceed the objective:

Excursion= ()-1

For cases where the test value must not fall below the target:

Excursion i= ()-1

i.   The collective amount by which individual tests are out of compliance is calculated by summing the individual test excursions from their goals and dividing them by the total number of tests (both those meeting goals and those not meeting goals). This variable, referred to as the standard sum of excursions, or nse, is calculated as:

nse=

ii. F3 is then calculated by an asymptotic function that scales the normalized sum of excursions from goals (nse) to yield a range between 0 and 100.

F3= ( )

Once the factors are obtained, the index itself can be calculated by summing up the three factors as if they were vectors. Therefore the sum of each factor's squares is equal to the index square. This approach treats the index as a three-dimensional space defined along one axis by each factor. With this model, the index changes in direct proportion to changes in the three factors.

The CCME Water Quality Index (CCME WQI):

CCMEWQI =)

The divisor 1.732 normalizes the resulting values to a range between 0 and 100, where 0 represents the "worst" water quality and 100 represents the "best" water quality. Once the CCME WQI value has been determined, water quality is ranked by linking it to one of the following categories:

WQI values	Description
95-100	**Excellent:** water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.

80-94	**Good**: water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
65-79	**Fair**: water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
45-64	**Marginal**: water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
0-44	**Poor**: water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

The assignment of CCME WQI values to these categories is called "categorization" and represents a critical but somewhat subjective process. The categorization is based on the best available information, expert judgment and water quality expectations of the general public. The categorization presented here is preliminary and will undoubtedly be modified as the index is further tested [33].

Results and Discussion

To understan the quality of Rawanduz River and its characteristics, several physic-chemical parameters were selected, while statistical analysis (mean and standard error) of parameters for the studied sites and seasons are listed in Tables-(1 and 2).

The pH value of the water system is one of the important indicators of water quality and the level of pollution in the water body [34]. The pH value for the studied sites and seasons ranged from 7.49 to 7.83 and 7.37 to 8.08 respectively, which indicates that the water is slightly alkaline in nature; all the water samples are within permissible limit prescribed by the WHO [35]. Statistically, there were significant differences ($p \leq 0.05$) in pH values between the seasons.

The values of EC ranged from 293 µS.cm^{-1} at site 1 to 346 µS.cm^{-1} at site 2. There were significant differences recorded among study sites. These variations are related to climate, soil, geological origin, and ionic salt content [36]. While, during the study period, the values of EC ranged from 232 to the 406 µS.cm^{-1}. The minimum value was recorded in summer season and the maximum in autumn.This may be related to the input of allochthonous organic materials from the catchment area d uring rainfall which lead to increased EC values [37]. Other factors can include thelow content of some variables during summer season such as HCO_3, Na%, NO_3 and turbidity.

Turbidity refers to clarity of the water. The larger amount of suspended solids in the water, the more turbid it appears, the higher the turbidity will be. The values of turbidity for the sites ranged from 20 NTU at site 1 to 55 NTU at site 2. This may be attributed to sewage water discharge of Khalifan subdistrict into Gali Ali Beg waterfall. Also turbidity can be caused by clay, silt, organic and inorganic matter, and microorganisms [38]. However, turbidity during the studied seasons ranged from 9 to 63 NTU, with the maximum value being recorded in autumn. There was a significant difference among turbidity values of studied sites and seasons. The DO value ranged from 6.59 to the 7.94 mg.l^{-1}, and site 3 statistically ($p \leq 0.05$) differed from other sites. However, for the seasons, maximum level of DO was observed in autumn, reaching a value of8.21 mg.l^{-1}.This may be associated with a low water temperature and a rainfall dilution effect [39].The minimum DO value wasabout 6.34mg.l^{-1}, which was recorded in summer.

The magnitude of BOD_5 is influenced by several factors. In this study, BOD_5 levels fluctuated among all sites and ranged from a minimum of 5.32 mg.l^{-1} at site 3 to a maximum of 7.85 mg.l^{-1} at site 2. This is related to the increase in the rate of decomposition of organic matter [40], in addition to the increase in water temperature in summer season.

Nitrate is an essential source of nitrogen available for plants.Nitrate values of the present investigation ranged from 11.40 to 13.03 mg NO_3-N.l^{-1}. The maximum value was recorded at site 2 and coincided with the high TDN value at this site. This could be attributed to the process of nitrification [41]. On another hand, TDN concentrations in the studied sites ranged from 60.45 to 57.68 µg. l^{-1}. The highest value was recorded at site 2, coincided by the highest value of NO_3^- at the same time. This could be

attributed to the process of nitrification [41]. TDN's maximum value was in spring, while significant differences among the studied sites and seasons were also observed.

TDP concentration in all studied sites showed a little variations with non-significant differences (p>0.05)among studied sites. In addition, no significant differences (p>0.05) were observed between spring and autumn. The maximum value of TDP was at site 3 which reached to 3.21 µg. l^{-1} and the minimum at site 1 which was about 0.77 µg. l^{-1}. Meanwhile, the summer value of TDP was the lowest, which was about 0.45 µg. l^{-1}. The higher phosphate levels during the summer were reported to be associated with the death and decomposition of residues of organisms [42].

The results of HCO$_3$ revealed significant differences (P≤0.05) between site 1 and the other sites. However, for the studied seasons the maximum value was 191.54 mg CaCO$_3$.l^{-1} in autumn and the minimum was 119.53 mg CaCO$_3$.l^{-1} in summer, while significant differences among the seasons were also observed. This could be related to the ionic soil composition, buffering capacity and rainfall [43]. Total hardness is commonly associated with high concentrations of calcium and magnesium salts that are considered to be the most common ions causing water hardness [27]. Concerning the total hardness for sites, the values were within the range of219- 287 mg CaCO$_3$.l^{-1}, while for the studied seasons hardness levels ranged from 207 mg CaCO$_3$.l^{-1} in spring to 285 mg CaCO$_3$.l^{-1} in autumn. This may reflect the combination of many factors, such as biological activity, rainfall, flow rate and differences in catchment areas [44].

Calcium and magnesium ions were among the cations measured during the present study. The concentrations of calcium and magnesium at the studied sites ranged from 26 to the 34 mg.l^{-1} and 35 to 42 mg.l^{-1}, respectively. For the studied seasons, the concentrations of calcium and magnesium ranged from 21 to the 35 mg.l^{-1} and 28 to 50 mg.l^{-1}, respectively. The dominance of magnesium ion over calcium ion was recorded throughout the study, which might be due to the geological formation of the area, sincethe dolomitic limestoneswere reported to be behind the higher levels of magnesium [45].

The concentrations of Na$^+$ and K$^+$ in the studied sites ranged from 6.45 to 9.37mg.l^{-1} and 1.59 to 2.33 mg.l^{-1}, respectively. However, for the studied seasons, the levels of Na$^+$ and K$^+$ ranged from 4.33 to 7.84 mg.l^{-1} and 0.99 to 1.72 mg.l^{-1}, respectively. This is probably related to seasonal changes and biological activation in addition to anthropogenic inputs into the water body [46]. Statistically, there were significant differences between the studied sites and seasons for both Na$^+$ and K$^+$.

Chloride is widely distributed in nature, generally in its commonly   known forms (NaCl, KCl and CaCl$_2$), and the presence of chloride in natural waters can be attributed to the di ssolution of salt deposits [47]. The highest level of Cl$^-$ was 16 mg.l^{-1} at site 2 while the lowest level was 12 mg.l^{-1} at site 1. For the studied seasons, the concentration of Cl$^-$ ranged from 10 to 17 mg.l^{-1}.

Sulphate ion concentration ranged from a minimum value at site 1,which reached to 808 mg.l^{-1}, to a maximum value of 894 mg.l^{-1} at site 3. It was shown that sulphate level in water systems depends on the solubility of gypsum in water and on atmospheric sulphur, which can beoxidized to sulphate and eventually deposited in water with precipitation [48]. For the studied seasons, the levels of sulphate ion ranged from a minimum value of 821 mg.l^{-1} to a maximum of 881 mg.l^{-1}. This variation in sulphate ranges can be related to rainfall and industrial breakdown of sulphur - containing organic matter [28]. Statistically, significant differences (p≤0.05) were observed among sulphate levels in the studies seasons. These values were lower than those previously described[49]during their study on Greater Zab River, in which they attributed the high sulphate concentration to agricultural activities and sewagewater discharge into the river.

According to a previous criteria [50], the presently studied waters were classified, based on %Na, as Excellent (<20 %) for irrigation purpose, because the sodium percentage ranged from 7% to 12%. There were also significant differences (p<0.05) amongthe studied sites and seasons.

Moreover, based on Sodium Adsorption Ratio (SAR), the studied waters were also classified as excellent for irrigation purpose according to previous methodology [50]. The results of SAR revealed that the highest value was 1.59 meq.l^{-1} at site 2 and the lowest value was 1.09 meq.l^{-1} at site 1. For the seasons, levels of SAR ranged from 0.87 meq.l^{-1} in spring and 1.24 meq.l^{-1} in summer. There were significant differences in levels of SAR among both sites and seasons.

Table-3 shows the results of WQI. For this study, WQI values for drinking purposes were 36.06 and 44.99, which was ranked as poor water based on drinking water standards[51]. Water quality of this rank is described as almost always threatened or impaired; conditions usually depart from natural

or desirable levels. While, for irrigation purpose, the values of WQI were 60.50 and 62.63. The water quality was classified as marginal for irrigation purpose; water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.

As illustrated in Table- 1, the total density of aquatic insects for the studied sites ranged from 99 to 206 Ind./m^2 .The maximum value of insects was found at site 3, whichmay be due to the nutrient availability. However, for the seasons, the values ranged from 89 to 275 Ind./m^2. Summer season shows largest populations of aquatic insects and this may be related to the organic matter availability and water temperature. During the study, the communities of aquatic insects were surveyed, especially those of the order Ephemeroptera.Table- 4 shows the phylum, class, order, family, and genus/species levels of classification of the aquatic insects. Eleven species of aquatic insects were identified, belonging to four families of the order Ephemeroptera. Three of the studies species are described for the first time in Iraq, as in the following:

☐   ***Baetis bicaudatus:*** Gills on segments (1-7), 2 tails (middle one wanting), No dark band on tails, Metamorphosis, wing pads present, Gills with simple lamella (Plate 1).

☐   ***Baetis intercalaris:*** Gills on segments (1-7), Mandible without tusks, Claws on all legs similar, Gills of single lambella. Three tails. Middle tails shorter than outer tails, Metamorphosis wing pads present (Plate 2).

Caenid robusta: First pair of gills is reduced to tapering filaments; second one forming a large flap which covers the rest. Sides of pronotum flaring outwards as they approach the anterior margin. More than a row of cockade-like scale in the band that runs along the underside of the gill-cover. A central light running from the top of the head across the pronotum to the fore part of the mesonotum (Plate 3).
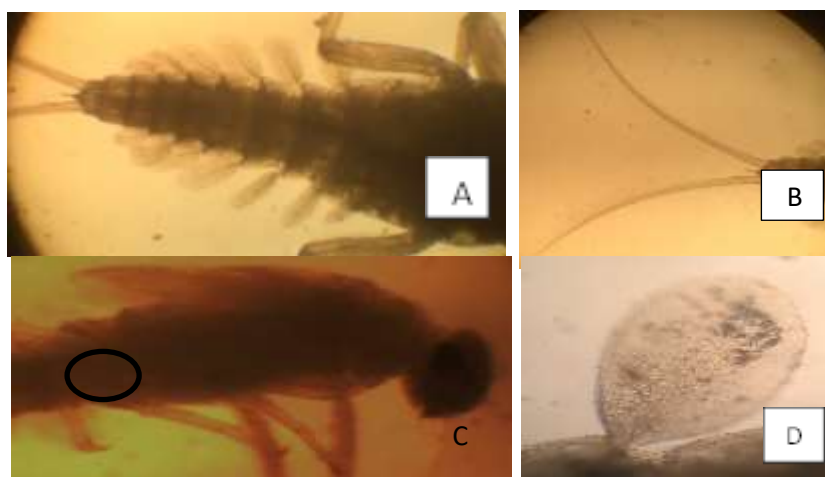

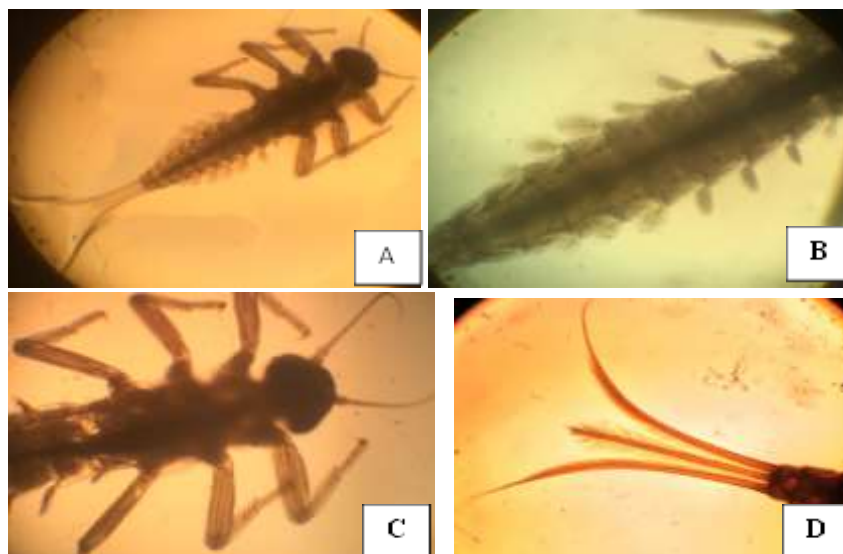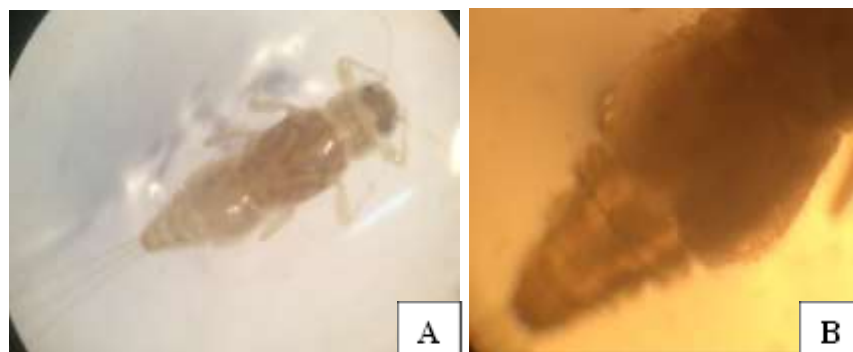Plate 1-***Baetis bicaudatus*** A. gills (4X), B. tails (4X), C.wing pad (4X), D. gill (10X).

Plate 2-***Baetis intercalaris*** A. whole body (4X), B. gills (10X), C. claws (10X), D. tails (10X).

Plate 3: *Caenid robusta* A. whole body (2X), B. gills (4X).

Table 1- Mean ± SE values of physical and chemical parameters and aquatic insects of the samples collected from the studied sites.

Parameters	Site 1	Site 2	Site 3
pH	7.49 ± 0.01^a	7.76 ± 0.07^b	7.83 ± 0.09^b
EC (µS.cm^{-1})	293 ± 0.62^a	346 ± 1.17^c	327 ± 1.12^b
Turbidity (NTU)	20.0 ± 0.04^a	55.0 ± 0.36^c	45.0 ± 0.47^b
DO (mg.l^{-1})	7.77 ± 0.21^a	6.59 ± 0.37^a	7.94 ± 0.69^b
BOD$_5$ (mg.l^{-1})	6.72 ± 0.42^b	7.85 ± 0.04^c	5.32 ± 0.16^a
NO$_3^-$ (mg NO$_3$-N.l^{-1})	11.4 ± 0.21^a	13.0 ± 0.36^c	12.0 ± 0.15^b
TDN (µg.l^{-1})	57.6 ± 0.53^a	60.4 ± 0.32^c	59.1 ± 0.12^b
TDP (µg.l^{-1})	0.77 ± 0.05^a	1.03 ± 0.06^a	3.21 ± 2.54^a
HCO$_3$ (mg CaCO$_3$.l^{-1})	192 ± 0.90^b	133 ± 5.486^a	141 ± 0.931^a
Hardness (mg CaCO$_3$.l^{-1})	219 ± 2.96^a	287 ± 12.4^b	232 ± 4.93^a
Ca^{2+} (mg CaCO$_3$.l^{-1})	34.0 ± 0.40^b	27.0 ± 0.39^a	26.0 ± 0.47^a
Mg (mg CaCO$_3$.l^{-1})	35 ± 0.259^a	42.0 ± 0.88^b	37.0 ± 0.49^a
Na (mg.l^{-1})	6.45 ± 0.24^a	9.37 ± 0.13^c	7.58 ± 0.44^b
K (mg.l^{-1})	1.78 ± 0.12^a	2.33 ± 0.15^b	1.59 ± 0.08^a
Cl (mg.l^{-1})	12.0 ± 0.11^a	16.0 ± 0.23^c	14.0 ± 0.21^b
SO$_4$ (mg.l^{-1})	808 ± 2.71^a	834 ± 19.8^{ab}	894 ± 34.8^b
% Na	8.00 ± 0.29^a	12.0 ± 0.11^b	11.0 ± 0.45^b
SAR (meq.l^{-1})	1.09 ± 0.93^a	1.59 ± 0.01^c	1.36 ± 0.05^b
Aqu. Insects (Ind./m^2)	172 ± 0.57^b	99.0 ± 0.11^a	206 ± 1.52^c

Table 2- Mean ± SE values of physical and chemical parameters and aquatic insects of the samples collected according to seasons.

Parameters	Spring	Summer	Autumn
pH	7.66±0.01[b]	7.37±0.03[a]	8.08±0.07[c]
EC (µS.cm^{-1})	295±5.19[b]	232±20.1[a]	406±1.21[c]
Turbidity (NTU)	35.0±0.69[b]	9.00±0.22[a]	63.0±2.14[c]
DO (mg.l^{-1})	7.60±0.16[b]	6.34±0.21[a]	8.21±0.06[c]
BOD$_5$ (mg.l^{-1})	1.41±0.05[b]	2.15±0.09[c]	1.18±0.01[a]
NO$_3^-$ (mg NO$_3$-N.l^{-1})	12.5±0.13[b]	11.3±0.06[a]	13.7±0.09[c]
TDN (µg.l^{-1})	49.0±0.34[c]	36.2±0.12[a]	43.0±0.26[b]
TDP (µg.l^{-1})	0.51±0.003[b]	0.45±0.02[a]	0.51±0.01[b]
HCO$_3$ (mg CaCO$_3$.l^{-1})	144±0.39[b]	119±0.20[a]	191±0.39[c]
Hardness (mg CaCO$_3$.l^{-1})	207±0.54[a]	215±0.73[b]	285±3.00[c]
Ca^{2+} (mg CaCO$_3$.l^{-1})	21.0±0.76[a]	35.0±0.61[c]	31.0±0.60[b]
Mg (mg CaCO$_3$.l^{-1})	28.0±0.69[a]	38.0±0.24[b]	50.0±0.53[c]
Na (mg.l^{-1})	4.33±0.12[a]	5.67±0.01[b]	7.84±0.19[c]
K (mg.l^{-1})	0.99±0.01[a]	1.17±0.05[b]	1.72±0.05[c]
Cl (mg.l^{-1})	10.0±0.04[a]	16.0±0.63[b]	17.0±0.92[b]
SO$_4$ (mg.l^{-1})	821±1.13[a]	847±1.79[b]	881±0.60[c]
% Na	8.00±0.21[b]	7.00±0.20[a]	9.00±0.11[c]
SAR (meq.l^{-1})	0.87±0.01[a]	0.94±0.005[b]	1.24±0.02[c]
Aqu. Insects(Ind./m^2)	89.0±2.30[a]	275±2.88[c]	113±1.73[b]

Note: Values in each rows with different letters are significantly different at P<0.05. Values in rows with same letters are not significantly different.

Table 3- Water quality indices calculated using mean values of sites and seasons.

CCMEWQI

	Sites	Seasons	Rank	Description
Drinking	36.06	44.99	poor	**(CCME WQI Value 0-44) – Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.**

Irrigation	62.63	60.50	**Marginal**	**(CCME WQI Value 45-64) – Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.**

Table 4- List of aquatic insects recorded during the study and their classification.

Taxa	Spring			Summer			Autumn		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Phylum Arthropoda									
Class Insecta									
Order Ephemeroptera									
Family Baetidae									
Baetis bicaudatus (Dodds, 1923)	5	2	7	9	4	11	1		
Baetis intercalaris (McDunnough, 1921)	4	3	8	8	6	12			1
Baetis rhodani **(Pictet, 1845)**	6	1	3	1		2	1		
Baetis tricaudatus **(Dodds, 1923)**	1		1	9	7	10	11	9	10
Baetis vernus **(Curtis, 1834)**	5		4	5	4	5		1	
Family Caenidae									
Caenis horaria **(Linnaeus, 1758)**	4	4	6	20	13	17	7	4	4
Caenis macrura **(Stephens, 1835)**	3		2	1	1	6	6	2	4
Caenis meosta **(Bengtsson, 1917)**	6	4	10	23	12	30	11	13	15
Caenis robusta (Eaton, 1884)				3	2	5			
Family Heptageniidae									
Subfamily Heptageniinae									
Rhithrogena **sp.**				18	6	21	3	1	9
Family Oligoneuriidae									
Lachlania **sp.**				1		3			

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