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Biodiversity of Aquatic Insects in Relation to Physio-chemical Parameters of Shekh Turab Stream

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ABSTRACT

Ecological integrity and their properties of any aquatic environment are important to monitor its stability and any change to the ecological system. The current work was undertaken to study the community of aquatic insects and physio-chemical variables of the Shekh Turab stream in periods extended for two months, one in July and the other in November 2017. The aquatic insects' samples collected from five sites with three replications/site. The physio-chemical parameters of water were water temperature, air temperature (˚C), pH, electrical conductivity EC (µS.cm-1), total dissolved solid TDS ($mg.l^{-1}$), dissolved oxygen DO ($mg.l^{-1}$), BOD5 ($mg.l^{-1}$), alkalinity ($mg\ CaCO3.l^{-1}$), bicarbonate HCO3 ($mg.l^{-1}$), total hardness ($mgCaCO3.l^{-1}$), calcium ($mg\ Ca2+.l^{-1}$), magnesium ($mg\ Mg2+.l^{-1}$), nitrate ($mg\ NO3\text{-}N.l^{-1}$), chloride ($mg.l^{-1}$), sodium ($mg.l^{-1}$), potassium($mg.l^{-1}$) and sulfate ($mg\ SO4.l^{-1}$). The correlation between physio-chemical parameters and different biological taxa were statistically tested. The correlation analysis showed significant relationship. In phylum Arthropoda, a total of 5 insect species belonging to 2 orders; Ephemeroptera and Diptera depicted the Shesk Turab stream macroinvertebrates. Depending on Shannon-Weiner index, species diversity varied from 0.365 to 0.755 at site 4 and 2 respectively.

Keywords: Macroinvertebrate insects, benthic biodiversity, relationships, lotic water ecosystem, Physio-chemical parameters.

1. Introduction

There are over 751,000 known insect species, which is about 75 percent of all known animal species on Earth. Some of them are living in water ecosystem as benthic macroinvertebrates and they can be used for water quality monitoring [1]. Despite the fact that most insects live in inland water; for instance, (swamps, ponds, lakes, springs, rivers and streams) these are referred to as water insects [2]. Approximately 3% of all insect species have water phases in some inland water biotopes; insects can account for more than 95% of the complete macroinvertebrates population [3]. Biosocial methods have recently been replaced or compensated for physical and chemical factors in evaluate water qualities [4]. Furthermore [5], concluded that the role of biota is usually the last point of water degradation and contamination and are therefore significant indicators of a healthy ecosystem. The biodiversity is the variety of living forms in a certain area and represented by the number of existing species. It is indicated that anthropogenic contamination and environmental stress will reduce the biological productivity of the wetland communities which will led to changes in their communities, reduction of their optimal nutritional activities, reduction in the richness and abundance of the endogenous species [6]. However, highlighted five major impacts affecting on biodiversity in water general: (I) the fluctuation of the water levels; (II) The overexploitation; (III) water contamination; (IV) destruction of the habitat; (V) and the effect of the invasive species [7]. Biodiversity implies the organisms that reside in a region, plus the ecological factors that are essential to maintain them, but also the relationship between these two factors that can be translated into the water system's capacity to support different forms of living organisms [8]. The use of aquatic insects as biological indicators is supported by the fact that they are usually stable in time and place; thus, appearing the variations of the ecosystem had gone through [9]. Aquatic insects are used to evaluate the "healthy status" of a stream, and also determined water quality by characterized by finding sensitive as well as tolerance organisms [10]. In various researches, aquatic insects were used to assess the biological-ecological integrity of the lotic water environment. They estimated the biological integrity and to validate the Index of Biological Integrity based on macroinvertebrate assemblages in rivers [11,12]. Conditions of aquatic ecosystems can be evaluated to assess the degradation of freshwater ecosystems, hence the current work has been completed to estimate the aquatic insects' diversity in relation to physical and chemical characteristics of Shekh Turab stream in Erbil province.

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2. Materials and Methods

2.1. Study Site

Erbil is the capital city of Kurdistan and is situated in northeastern Iraq (figure 1A). It is bordered to the north-east and south-east the Upper and Lower Zabs. It is located between longitudinal 43º 58¯ to 44º 03¯ E and from latitude 36º 09¯ to 36º 14¯ N [13]. Climate in the region is regarded a broad daily and annual temperature variation. The climate of the area is nearer to the sort of Iran-Turan. The average annual precipitation exceed 1000mm [14]. Shekh Turab stream located about 20 km from the east of Erbil city, Kurdistan Regional of Iraq. The stream is mainly used for irrigation and drinking purposes. The riparian areas are occupied by residence and therefore it is exposed to domestic waste and agricultural runoff. The locations of the sampling sites are shown in figure 1B.

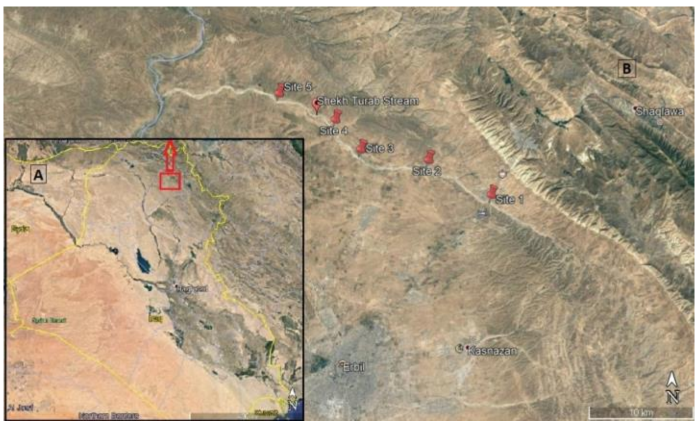

Figure 1: A- Map of Erbil province within Iraq, B- Map of studied sites within Erbil province (Shekh Turab Stream) [15]

2.2. Sample Collection and Analyses

Five sites were homogenously distributed in the studied Shekh Turab stream. Water samples were taken in July and November 2017, when the responses of the systems to nutrient enrichments were more significant and growth and decay rates of macrobenthic species were at the highest [16]. From upper stream (site 1) to downstream, each site was located 7 km from each other except site 4 was located 6 km from site 3. Temperature measured using alcohol thermometer, pH, EC (µS.cm-1) and total dissolved solids was directly measured with portable equipment (pH-EC-TDS meter, HI 9812, Hanna instrument), dissolved oxygen (mg.l^{-1}), BOD5 (mg.l^{-1}), alkalinity (mg CaCO3.l^{-1}), HCO3 (mg.l^{-1}), total hardness (mgCaCO3.l^{-1}), calcium (mg Ca2+.l^{-1}), magnesium (mg Mg2+.l^{-1}), nitrate (mg NO3-N.l^{-1}), chloride (mg.l^{-1}), sodium (mg.l^{-1}), potassium (mg.l^{-1}) and sulfate (mg SO4.l^{-1}) were estimated according to [17]. Aquatic macroinvertebrate insect samples were collected at each site by gathering the rocks using Surber sampler [18]. The benthic invertebrate has been separated for the primary taxonomic group, and conserved in 4% formalin vials [19]. Most samples were taxonomically identified at the generic level and some participants at the species level through the taxonomic key of [20-22]. The Tukey HSD multiple comparison test was used for the significant differences of means of physio-chemical variables between sites (one-way ANOVA; $P < 0.05$). Pearson correlation coefficient analysis was performed to find out the relation between physio-chemical parameters versus taxonomic levels of diversity of aquatic insects. The aim was to find the strength of association between the two sets of variables [23]. All statistical analyses were carried out using SPSS (version 19) and using a significant level of 0.05.

2.3. Biological indices

a- Species Richness: Species richness is a measure of the amount of species contained in a sample. This specific measure of species richness is known as D, the index of the Menhinick [24].

$$D = S/\sqrt{N}$$

Where S is equal to the amount of distinct species in the sample, and where N is equal to the complete amount of individual sample organisms.

b- Species diversity: Species diversity differs from species richness by taking into consideration both the number of species current and species dominance or evenness in relation to each other. Shannon index was calculated as a measure of species diversity, H. [25].

$$\boldsymbol{H} = \sum (\boldsymbol{Pi}) /\ln \boldsymbol{Pi}/$$

Where: Pi is the proportion of the total number of individuals in the population that are in species "i".

c- Simpson dominance index: Simson's Index is regarded as a dominance index because it weighs towards the most prevalent species ' abundance.

$$\mathbf{Ds} = \sum_{i=1}^{S} (\mathbf{ni}(\mathbf{ni}-\mathbf{1})/\mathbf{N}(\mathbf{N}-\mathbf{1}))$$

Where: ni is the number of species and N complete amount of species in the ith species [26].

3. Results and Discussion

All the variables studied includes water temperature, air temperature, pH, EC, total dissolved solid, dissolved oxygen, BOD5, alkalinity, HCO3, total hardness, calcium, magnesium, nitrate, chloride, sodium, potassium and sulfate shows significant at different sites in the two different months (Table 1 and 2). Air and water temperatures varied between 12.40 Cº to 35.45Cº and 7.20 Cº to 26.30 Cº respectively. The pH values ranged from 7.89 to 8.38, this implies water samples are almost sub-alkaline in nature. The present results indicate a comparative coincidence with pH values of surface water which lie within the range of 6.5 to 8.5 [27]. The values of Electrical Conductivity varied between 977 to 1198 µs/cm. The values of total dissolved solid (TDS) changed from 624 to 766 mg/l respectively. In drinking water, the most desirable limit for TDS is 500 mg/l according to WHO standard and all samples go beyond this limit [27].

Do and BOD findings have never reached critical information in most of this study, indicating excellent circumstances of water quality. The smallest concentration of DO was 5.7 mg/l in accordance with WHO norms and is deemed good to sufficient for human consumption and most aquatic biota [28]. A low alkalinity value was 113.0 mg CaCO3/l while an elevated alkalinity value was 178 mg CaCO3/l. (15) reports that sewage contamination and other pollution sources and its decomposition appear to be a probable cause of the peak alkalinity in water. Lowest value of calcium was 48 mg/l at site 4 in July and maximum value was 139 mg/l at site 1 in July, values for Ca^{+2} agree with (10 and 23). All Ca^{+2} values are within acceptable limit which is 200 mg/l according to the Iraqi Standard [27]. The minimum 19.0 mg/l and maximum 51 mg/l values for Mg^{+2} were recorded at site 1 and site 3 in July respectively. Values for Mg^{+2} were acceptable according to Iraqi standard [27]. Total hardness for this survey varied from 249 mg CaCO3/l in November at site 1 and 438 mg CaCO3/l in July at site 1. This value was unacceptable because the maximum limit is 200 mg/l according to WHO standard [27]. Total hardness increases in water because pollution of surface water with industrial and domestic wastes and nature of salts content of the soil [27]. Current water samples indicate that the sodium ion value ranged from the minimum value of 29.3 mg/l the highest value of 37.4 mg/l. These findings acquired agree with the outcomes of [29]. Both sodium and potassium demonstrate resemblance in the timing of rise and reduce, according to the findings of [29]. Chloride values were unstable through the study period. In July, the greater value 45 mg/l was calculated at site 1, while the smallest value 28 mg/l was recorded at site 1 in November. All values for chloride were within the acceptable range according to Iraqi standard [27]. The most abundant form of nitrogen compounds was nitrate and the highest value was 23 mg/l in the course of this study, however, it still complies with the suggestions of the WHO [27]. The possible sources of nitrate in the surface water of Shekh Turab water system are mainly from the atmosphere, surface runoff, sewage discharges, agricultural fertilizers and organic wastes [27]. With respect to the study area's sulfate content, they show differences within 236 – 1054 mg/l. Aquatic insects are excellent indicators of water quality because they are influenced by the water body's physical, chemical and biological factors. They have little mobility and they are sensitive to local pollution [30].

Table 1: Physio-chemical parameters of Shekh Turab stream in July 2017 (numbers are mean ± SE).

Sites	1	2	3	4	5
Water temperature (˚C)	23.9 ± 0.05^{a}	24.5 ± 0.20^{a}	24.5 ± 0.30^{a}	26.3 ± 0.25^{b}	24.5 ± 0.20^{a}
Air temperature (˚C)	32.5 ± 0.40^{a}	32.3 ± 0.20^{a}	34.6 ± 0.30^{b}	35.45 ± 0.15^{b}	35.15 ± 0.35^{b}
pH	7.89 ± 0.07^{a}	8.00 ± 0.06^{a}	8.07 ± 0.07^{a}	8.11 ± 0.02^{a}	8.15 ± 0.12^{a}
EC (µS.cm-1)	1198 ± 18.50^{b}	1155 ± 34.50^{ab}	1176 ± 3.50^{ab}	$1159\pm5.50a^{b}$	1127 ± 2.50^{a}
TDS ($mg.l^{-1}$)	766 ± 11.84^{b}	739 ± 22.08^{ab}	752 ± 2.24^{ab}	$741\pm3.52a^{b}$	721 ± 1.60^{a}
DO ($mg.l^{-1}$)	6.2 ± 0.20^{a}	6.6 ± 0.40^{a}	5.7 ± 0.30^{a}	6.35 ± 0.05^{a}	6.05 ± 0.05^{a}
BOD_5 ($mg.l^{-1}$)	2.15 ± 0.65^{a}	2.45 ± 0.55^{a}	1.55 ± 0.15^{a}	2.10 ± 0.30^{a}	1.10 ± 0.10^{a}
Alkalinity (mg $CaCO_3.l^{-1}$)	178 ± 2.50^{a}	175 ± 1.50^{a}	178 ± 5.50^{a}	171 ± 1.00^{a}	171 ± 4.24^{a}
HCO_3 ($mg.l^{-1}$)	217 ± 3.05^{a}	213 ± 1.83^{a}	227 ± 4.29^{b}	209 ± 1.22^{a}	213 ± 0.19^{a}
T. Hardness ($mgCaCO_3.l^{-1}$)	438±12.00c	342±12.00a	411±1.00bc	405±1.00b	408±0.50b
Ca^{2+} (mg $Ca^{2+}.l^{-1}$)	139±5.50c	76±8.40a	105±14.80b	48±1.50a	113±1.50bc
Mg^{2+} (mg $Mg^{2+}.l^{-1}$)	19±3.60a	48±9.36b	51±6.48b	36±10.56ab	27±2.88ab
NO_3-(mg NO_3-$N.l^{-1}$)	19±0.20c	18±0.28c	17±0.20b	16±0.08a	16±0.18a
Chloride ($mg.l^{-1}$)	45±1.00b	36±0.00a	36±2.00a	39±3.00ab	40±2.00ab
Na^{+} ($mg.l^{-1}$)	30.1±0.01b	29.3±0.01a	31.3±0.26cd	31.2±0.01c	31.5±0.02d
K^{+} ($mg.l^{-1}$)	2.4±0.02b	2.3±0.01a	2.4±0.02b	2.5±0.01c	2.9±0.01d
SO_4^{2-} (mg $SO_4.l^{-1}$)	236±4.00a	264±4.00b	362±2.50c	353±7.50c	369±3.50c

Note: Values in each row with different letters are significantly different and values with same letters are not significantly different.

Table 2: Physio-chemical parameters of Shekh Turab stream in November 2017 (numbers are mean ± SE)

Parameters	Site 1	Site 2	Site 3	Site 4	Site 5
Water temperature (˚C)	12.1±0.10a	7.2±5.45a	13.68±0.02a	12.6±0.06a	13.9±0.05a
Air temperature (˚C)	12.4±0.03a	17.5±0.03c	15.3±0.10b	14.7±0.24b	19.2±0.11d
pH	8.36±0.03c	8.15±0.01a	8.22±0.05ab	8.38±0.06c	8.35±0.02bc
EC (µS.cm-1)	1015±4.50b	985±5.00a	994±5.00ab	1015±15.00b	977±2.50a
TDS ($mg.l^{-1}$)	640±6.40ab	629±1.80a	6.33±0.30ab	650±9.60b	624±3.20a
DO ($mg.l^{-1}$)	9.5±0.50d	7.9±0.10cd	6.5±0.50ab	6.2±0.20a	8.2±0.60cd
BOD_5 ($mg.l^{-1}$)	1.8±0.25bc	2.1±0.11c	1.6±0.05ab	1.2±0.05a	3.6±0.05d
Alkalinity ($mgCaCO_3.l^{-1}$)	131±0.50d	125±0.50c	119±0.50b	122±1.5bc	113±2.00a
HCO_3 ($mg.l^{-1}$)	159±0.45d	153±0.03c	145±1.22b	146±0.61b	138±2.44a
T. Hardness ($mgCaCO_3.l^{-1}$)	249±1.00a	255±1.00a	283±1.00b	254±2.50a	251±7.00a
Ca^{2+} (mg $Ca^{2+}.l^{-1}$)	59±0.80c	63±0.40d	53±0.80a	57±0.40bc	56±0.40b
Mg^{2+} (mg $Mg^{2+}.l^{-1}$)	25±0.18ab	24±0.01a	36±0.24c	26±0.96b	25±0.44b
NO_3-(mg NO_3-$N.l^{-1}$)	23±0.06a	22±0.06a	21±0.02a	12±9.00a	20±0.08a
Chloride ($mg.l^{-1}$)	28±0.40a	32±1.60ab	29±1.00ab	34±0.00b	30±0.00a
Na^{+} ($mg.l^{-1}$)	35.4±0.26a	35.9±0.26a	36.9±0.26b	37.4±0.26b	36.9±0.26b
K^{+} ($mg.l^{-1}$)	2.3±0.00a	2.3±0.04a	2.7±0.33a	2.8±0.02a	2.3±0.01a
SO_4^{2-} (mg $SO_4.l^{-1}$)	966±13.44a	995±0.00a	1054±2.42b	1052±16.36b	997±9.60a

Note: Values in each row with different letters are significantly different and values with same letters are not significantly different.

Among aquatic insects identified in the studied area (Table 3), Baetiserhodani, Caenimacrura, Caenismeosta, Caenistardata of the order Ephemeroptera, and Stimulium of order Diptera of Phylum Arthropoda were discovered to be abundant in the Shekh Turab stream. The variety of aquatic insects at site 5 in July-2017 may be due to the existence of phytoplankton and algal blooms, because they are food resources for macroinvertebrates. They provide them with shelter and nesting grounds for breeding [31]. It was observed that a number of aquatic insects in the studied area in July were more than in November. Biological diversity of the water system develops in response to the hydrological regime, physical and chemical characteristics and biological interactions (Table 4). Thus the Shekh Turab's complete environment is the consequence of interaction between a number of parameters including water temperatures and nutrients, some of which play a significant part in determining the structure and function of the water ecosystem [32]. There are important relationships among the water characteristics and aquatic diversity. The nature of the lower substrates is one of the most important environmental parameters for influencing the biodiversity of the stream [33]. Different variables have been known to affect the density and abundance of water insects, but the most significant variables are water temperature and dissolved oxygen in the study region

Table 3: Aquatic insects that recorded in Shekh Turab stream in July and November, 2017.

	July					November				
Taxa	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**
Phylum Arthropoda										
Class Insecta										
Order Ephemeroptera										
Family Baetidae										
***Baetisrhodani* (Pictet, 1845)**		4			1		2			
Family Caenidae										
***Caenismacrura*(Stephens, 1835)**	4	6	11	6	9	1		2		3
***Caenismeosta* (Bengtsson, 1917)**	21	18	26	22	33	2		4	1	10
***Caenistardata*(McDunnough, 1931)**	2	1		2	3					
Order Diptera										
Family Simuliidae										
Subfamily Simuliini										
***Simulium* sp.**							8			
Total	27	29	38	30	46	3	10	8	1	13

Table 4: Pearson correlation coefficient between water parameters, (Shannon index and Taxa richness).

Water parameter	H	P-Value	S	P-Value
Water temperature	0.666*	0.050	-0.647*	0.043
PH	-0.438	0.238	0.592	0.072
EC	0.602	0.086	-0.545	0.104
TDS	0.611	0.081	-0.545	0.104
DO	-0.447	0.228	0.484	0.256
BOD5	-0.165	0.671	-0.418	0.229
Alkalinity	0.654	0.056	-0.534	0.112
HCO3	0.651	0.058	-0.549	0.100
T.H	0.674*	0.047	-0.599	0.067
Ca	0.409	0.275	-0.391	0.264
Mg	0.413	0.269	-0.366	0.299
NO3	-0.530	0.142	0.661*	0.037
Cl	0.677*	0.045	-0.474	0.166
Na	-0.724*	0.027	0.508	0.134
K	0.102	0.794	-0.461	0.180
SO4	-0.676*	0.046	0.572	0.084

* Correlation is significant at the 0.05 level (two-tailed).

In the Shekh Turab water there were several variables responsible for more aquatic ecosystems, including water temperature, EC, TDS, DO, alkalinity, hardness and other ions. Periphyton development in relation to geology and velocity parameters was investigated in New Zealand [34]. The nature of the underlying substratum of Shekh Turab stream is another one, too important factors affects the variety water insects. Species variety ranged from 0.365 to 0.755 bits/ind according to the Shannon-Weiner index. The highest diversity value recorded at site 2 whereas the minimum diversity calculated at site 4 (Table 5).

Table 5: Diversity and other indices of aquatic insects in the study stations of Shekh Turab stream.

	Site 1	Site 2	Site 3	Site 4	Site 5
Number of taxa	3	5	2	3	4
Taxa richness / Menhinick's index	0.866	0.6875	0.5725	0.774	0.5725
Shannon-Wiener diversity (H)	0.653	0.755	0.622	0.365	0.68
Simpson dominance	0.476	0.537	0.519	0.284	0.582

In general, sites diversities 1, 2, 3 and 5 were greater; this can be ascribed to greater human activity at site 1 sewage disposal containing more water nutrients and other ions used as food from phytoplankton cells and aquatic insects dominated at this site. Organically enhanced environments have a reduced diversity, with some dominant species, according to [35]. Meanwhile, [36] wrote that, in many instances, diversity at intermediate polluted locations is greater than at clean locations. Menhinick's richness index disclosed the largest richness calculated in site 1 and the lowest in locations 3 and 5, which likely linked to the amount of taxa recognized in each site for the region studied. Taxa dominance in this study ranged from 0.284 at site 4 to 0.582 at site 5.

4. Conclusion

From the results throughout this study, a total of 3 families representing 2 orders were recorded in this survey. Caenis macrura and Caenis meosta were present in the large amount of individuals at all sampling sites. This indicates the richness and diverse group of aquatic insects in the study area. It reinforces to the fact that the habitat quality is most suitable for insects to breed and multiply under the natural ecosystem. Furthermore, the river's environmental factors had directly and/or indirectly affected aquatic insect assemblages, showing that aquatic insects were useful indicators of water quality in the Shekh Turab Stream. All sampling stations in the study came out as moderately polluted by indication of diversity index.

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