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INFLUENCE OF DETERIORATING WATER QUALITY ON CLADOCERAN ASSEMBLAGE IN IKPOBA RIVER, EDO STATE, NIGERIA

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ABSTRACT

The study of water quality using cladocerans as bioindicators to access the deterioration of water in Ikpoba river Benin City, Edo State was carried out for a period of 6 months (December 2017 – May 2018). Water samples were collected monthly from station 1 (control) and stations 2, 3, and 4 (perturbed locations) for analysis of physicochemical parameters and zooplankton collection. Samples were analysed using standard procedures and an atomic absorption spectrometer. At a significant level of $P<0.05$, alkalinity, dissolved oxygen, biological oxygen demand, and ammonium concentration were significantly different across the study stations. The dissolved oxygen content in the water was very low and this was probably as a result of effluents discharged into the river at the sampled stations. Seasonal variation of the parameters was determined across the stations. Twenty-three taxa were identified as belonging to five families and a total of 150 individuals were encountered. The general diversity using the Shannon Weiner index showed diversity in decreasing order of station 4>2>1>, margalef’s species richness index revealed that station 3 was the most species-rich. There was a poor correlation between the cladocerans and the physicochemical parameters analysed. Regulatory measures should be taken to prevent deterioration of water quality and to enhance the survival of the aquatic ecosystem.

Keywords: Distribution, anthropogenic activities, abundance

INTRODUCTION

Water is important to the existence of all living organisms; however, this valued resource is additionally being vulnerable as human populations grow and demand more water of prime quality for domestic functions and economic activities (UNEP, 2000). There are varied scientific and economic facts that pollution will cause severe decrease in productivity, deterioration of water quality and even death of aquatic organisms (Garba et al., 2008; 2010).

The quality of any body of surface or spring water may be a operate of either or each natural influences and human activities. Most rivers in African nation ar heavily exploited for water provides for each domestic and industrial uses, fisheries exploitation, transportation, irrigation, electricity generation and recreational activities. In several instances, waste water is discharged into rivers leading to its deterioration and associated consequences. Researchers have wanted to link sure species or practical cluster of species with specific environmental characteristics so as to measure the results of sure activities within the aquatic scheme (Parmesan et al., 2006, Primo et al., 2015). These species or cluster of species are termed bioindicators. they're living organisms used for accessing surrounding health and biographic changes going down within the environment (Rawtani et al., 2016). One vital cluster of bioindicators in aquatic ecosystems are cladocerans.

Cladocerans are a gaggle of small crustaceans normally referred to as water fleas. they're primarily fresh little sized branchiopod crustaceans inhabiting oceanic, littoral and benthonic zones (Fryer, 1987). Cladocerans occupy a key position within the aquatic organic phenomenon, the intermediate link between primary and secondary productivity and conjointly function as model species in the environment as a result of their high sensitivity to water quality (Siciliano et al., 2015). The aim of this analysis is to see the water quality of the stream through assessment of the physicochemical properties in respect to the abundance and distribution of cladocerans within the water body.

MATERIALS AND METHODS

Study Area

The study area is located within the rainforest belt of Edo state, Southern Nigeria. It lies between the latitude of 6°13'35.53"N and a longitude of 5°46'33.54"E (Fig. 1). The climate is warm and wet throughout the year. It is characterized by the sub-equatorial type of climate marked by two dominant seasons, which are rainy and dry with harmatan inbetween. The mean annual temperature ranges from 22°C to 31°C while the annual minimum and maximum relative humidity are 69% and 96% respectively.

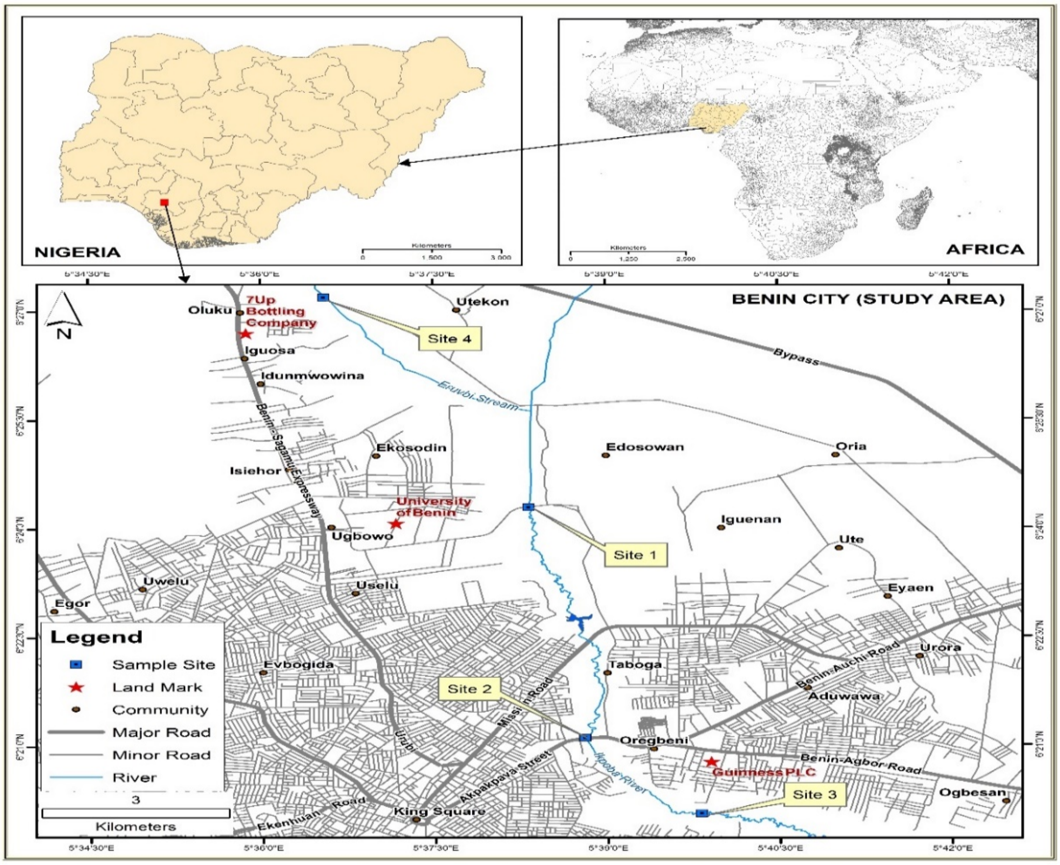

Fig. 1: Map of Study Area indicating Study Stations.

Sampling and Collection

Water samples were collected from four (4) stations: Stations 1 (Ugbowo) serves as the control while stations 2 (Ikpoba slope), stations 3 (Oregbeni community) and stations 4 (Iguosa/Oluku community) are the perturbed stations with anthropogenic activities.

Water samples were collected for six (6) months (December to May). The sampling stations were visited monthly for the study period. Surface water samples for physicochemical analysis were collected by immersing a litre plastic bottle below the water surface and allowing it to fill before removing it from the water while water samples for dissolved oxygen (DO) and biological oxygen demand (BOD) determination were collected using 250ml reagent bottles (transparent for DO and amber for BOD) with stoppers. The water sample for dissolved oxygen determination (DO) was immediately fixed by adding 1ml each of Winkler's solutions A (Manganous sulphate) and B (Potassium hydroxide in Potassium iodide), and the stopper quickly replaced.

Zooplankton collection

Quantitative method of sampling zooplankton was employed. This method was carried out by filtering 500 litres of water through *55μm* hydro-bios plankton net with the aid of a 20 liters bucket sampled randomly 25 times at each station. The zooplankton samples were stored in plastic bottles and 5% formalin was added to the sample. Each plastic bottle was properly labelled indicating the stations and date of collection. This procedure was repeated throughout the sampling period. A total of 24 samples were collected during the duration of sampling. In the laboratory, cladocera specimens were sorted under an optical microscope (model 570) X10 magnification. Counting was done using a gridded petri dish under a dissecting microscope. cladocerans were picked by a micro pipette and carefully placed on a glass slide and covered with a cover slip prior to viewing. Specimens were viewed and identified under an Olympus compound microscope with the objective lens of X10. Photographs of the specimen observed under the microscope was taken with a digital camera. Identification of the specimen was done with the identification key of fresh water zooplankton by Jeje and Fernando, 1986. The specimens were identified up to the species level.

Laboratory Analysis

Water samples were taken the laboratory for physicochemical parameters analysis using various analytical methods (Table 1).

Table 1. Analysis methods used for physicochemical parameters.

Physicochemical parameters	**Analysis method**
pH	pH meter
Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS)	Conductivity meter
Temperature	Thermometer
Turbidity	Turbidity meter
Transparency	Secchi disc
Nitrate (NO_2), Nitrite(No_3^{2-}), Phosphorus (P), Ammonium(NH_3)	UV-Visible Spectrophotometer ASTM D1209
Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD)	Titration Sawyer and McCarty, 1978

Statistical Analysis

The descriptive statistics of the physicochemical parameters of water samples were expressed as mean, standard error and range. Analysis of Variance (ANOVA) was done using Excel 2013 to test for significant difference across the study stations at a probability level of 0.05. Where there was a significant difference ($P<0.05$), Duncan Multiple test was done to establish the definite location of the significant difference (Ogbeibu, 2014).

RESULT AND DISCUSSION

The results of physicochemical characteristics of the water from Ikpoba River at the different sampling stations and cladoceran species composition and distribution are summarized in table 2 and table 3. These show the major descriptive statistics such as the mean, standard deviation, minimum and maximum monthly values for each parameter analysed for the different stations. The distribution of cladoceran species according to their families is represented in figure 1. The diversity indices of cladocerans encountered in the study and the correlation matrix for the physicochemical characteristics and cladocerans are shown in table 4 and 5 respectively.

Table 2: Surface water physicochemical status of study stations from December 2017- May 2018

Parameters	Station 1 Mean ±SD	(Min-Max)	Station 2 Mean ±SD	(Min-Max)	Station 3 Mean ±SD	(Min-Max)	Station 4 Mean ±SD	(Min-Max)	*P* value	Limits FMEnv r 2002	Limits WHO, 2004
Air temperature (°C)	$27.50^{A} \pm 1.225$	(26-29)	$28.5^{AB} \pm 0.837$	(27-29)	$29.17^{AB} \pm 0.983$	(28-30)	$29.333^{AB} \pm 1.033$	(28-30)	$P < 0.05$	-	25
Water temperature (°C)	26.25 ± 1.084	(25-28)	27 ± 1.095	(26-28)	26.83 ± 0.983	(26-28)	27.333 ± 1.211	(26-29)	$P > 0.05$	35	40
Water level (m)	$13.17^{A} \pm 1.438$	(11-15.5)	$4.17^{B} \pm 0.408$	(26-28)	$8.42^{C} \pm 0.492$	(8-9)	$3.767^{B} \pm 0.294$	(3.5-4.1)	$P < 0.01$	-	-
Water velocity (m/s)	$2.37^{C} \pm 0.896$	(1.4-4)	$0.17^{A} \pm 0.408$	(0.57-0.004)	$0.73^{B} \pm 0.545$	(0.2-1.5)	$3.128^{AC} \pm 1.224$	(1.73-5.1)	$P < 0.05$	-	-
Transparency (m)	$8.58^{A} \pm 1.429$	(6.5-10.50)	$2.62^{B} \pm 1.350$	(1.2-4)	$7.33^{A} \pm 1.033$	(6-9)	$3.77^{B} \pm 0.294$	(3.5-4.1)	$P < 0.01$	-	-
Ph	$5.66^{A} \pm 0.403$	(5.1-6.200)	$6^{AB} \pm 0.0894$	(5.9-6.1)	$6.33^{B} \pm 0.0816$	(6.2-6.4)	$5.817^{AB} \pm 0.279$	(5.5-6.2)	$P < 0.05$	6.5-8.5	6-8
EC (uS/cm)	$10^{A} \pm 0$	(10-10)	$18.33^{A} \pm 7.528$	(10-30)	$58.33^{B} \pm 7.528$	(50-70)	$38.33^{C} \pm 11.69$	(30-60)	$P < 0.01$	-	1000
TDS (mg/l)	$5.3^{A} \pm 0$	(5.3-5.3)	$9.72^{B} \pm 3.990$	(5.3-15.9)	$30.92^{C} \pm 3.99$	(26.5-37.1)	$20.32^{D} \pm 6.196$	(15.9-31.8)	$P < 0.01$	500	2000
Turbidity (NTU)	$11^{A} \pm 1.265$	(10-13)	$15.83^{B} \pm 2.927$	(12-19)	$29.67^{C} \pm 7.581$	(22-41)	$12.67^{D} \pm 4.59$	(5-18)	$P < 0.01$	5	5
Alkalinity (mg/l)	$8.83^{A} \pm 2.563$	(6-12)	$10^{A} \pm 3.742$	(5-14)	$26.17^{B} \pm 13.63$	(12-42)	$25^{B} \pm 7.694$	(15-36)	$P < 0.05$	-	100
DO (mg/l)	$5.13^{A} \pm 0.599$	(4.3-5.8)	$4.25^{D} \pm 1.828$	(0.8-5.6)	$1.32^{C} \pm 1.713$	(0.4-4.8)	$1.2^{B} \pm 0.724$	(0.4-2.2)	$P < 0.05$	7.5	≥6
BOD_5 (mg/l)	$2.4^{B} \pm 1.090$	(1.2-4.2)	$3.88^{A} \pm 0.962$	(2.4-4.9)	$7.95^{B} \pm 4.297$	(2-12.3)	$10.27^{A} \pm 7.384$	(1.7-21.5)	$P < 0.05$	-	40
Nitrate-N (mg/l)	2.60 ± 0.390	(2.19-3.12)	3.18 ± 0.465	(2.4-3.81)	3.12 ± 1.018	(2.1-4.85)	2.368 ± 0.237	(1.91	$P > 0.05$	10	50
Nitrite-N (mg/l)	0.016 ± 0.0074	(0.01-0.03)	0.02 ± 0.007	(0.014-0.032)	0.0235 ± 0.0112	(0.013-0.041)	0.0335 ± 0.0181	(0.019-0.067)	$P > 0.05$	1	-
Phosphate-P (mg/l)	0.69 ± 0.191	(0.55-1.02)	0.84 ± 0.175	(0.63-1.08)	0.73 ± 0.168	(0.55-0.98)	0.76 ± 0.21	(0.6-1.12)	$P > 0.05$	<5	-
Ammonium (mg/l)	$3.13^{AB} \pm 0.478$	(2.60-3.79)	$4.21^{AB} \pm 0.382$	(3.68-4.65)	$3.75^{AB} \pm 1.341$	(2.48-5.9)	$2.80^{B} \pm 0.312$	(2.32-3.17)	$P < 0.05$	<10	-

Table 3: Species composition and distribution of Cladocera in Ikpoba River

TAXA	Station 1	Station 2	Station 3	Station 4	Total
Alona eximia	17				17
A.cambouei	1				1
A. davidi	1	1	1		3
A.monacantha			1	1	2
A. guadrangularis	2	3			5
A.rectangula	5	1	1	1	8
Leydigia macrodonta				1	1
Pseudochydorus globusus	1				1
Alonella excise	6	2	1		9

Chydorus parvus		3			3
C. pubescena	1	3	2		6
C. sphaericus		8	1		9
Pleuroxus similis	1	2			3
Dunhevedia crassa	2				2
Simocephalus vetulus			1		1
Echinisca rosea				1	1
Grimaldina brazzai			5		5
Macrothrix goeldi	1		3	2	6
Macrothrix spinosa			1	5	6
Moinodaphnia macleaya			17	5	22
Moina micrura			17	14	31
M. reticulate				3	3
Diaphanosoma excisum				5	5
Total number of individuals	**38**	**23**	**51**	**38**	**150**
Taxa (S)	10	8	12	10	
Shannon-Wiener index	1.802	1.862	1.793	1.907	
Evenness	0.551	0.804	0.501	0.673	

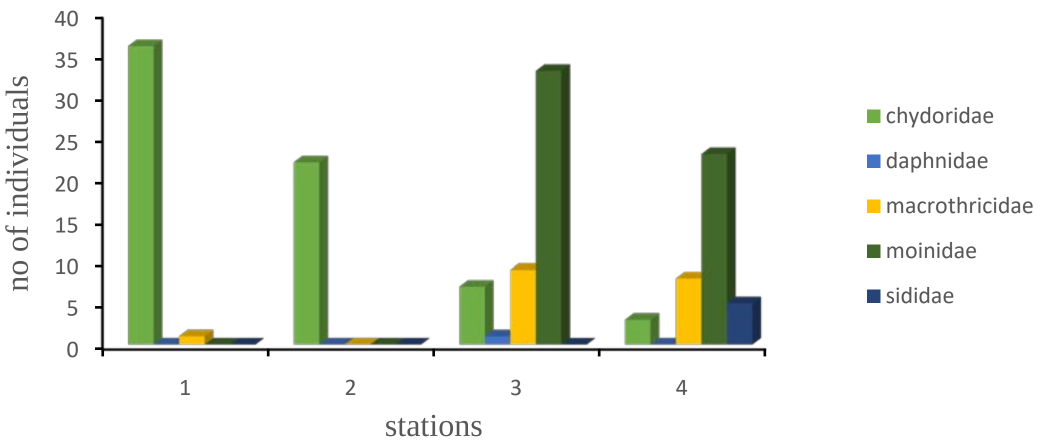

Figure 1: Distribution of the number of individuals in each family across the four stations

Table 4: Diversity indices of the cladocerans recorded

Diversity Indices	Station 1	Station 2	Station 3	Station 4
Taxa(S)	10	8	12	10
Individuals	38	23	50	39
Dominance	0.251	0.191	0.239	0.199
Shannon-H	1.802	1.862	1.793	1.907
Eveness-e^H/S	0.551	0.804	0.501	0.673
Margalef's	2.749	2.233	2.798	2.474
Simpson 1-D	0.748	0.809	0.761	0.801

Sixteen (16) parameters were examined namely air temperature, water temperature, water depth, water velocity, pH, transparency, total dissolved solids, dissolved oxygen, biological oxygen demand and ammonium among others. These physicochemical parameters have striking relevance on the life of aquatic organisms (Hynes, 1970) in triggering different responses on several species. Water temperature is inherently influenced by substratum composition, turbidity, vegetation cover, run-off, inflows and heat interchange with air (Umeham, 1989). The water temperatures were similar throughout the stations sampled as there was no significant difference (P> 0.05) across the stations sample. The dry season water temperature was higher than those recorded during the wet season, and this is typical of most tropical waters (Awachie, 1981).

Dissolved oxygen is of principal importance because it is critical to the survival of most forms of aquatic life besides being the most reliable measure in assessing the trophic status and the extent of eutrophication (Edmondson, 1966). Tropical aquatic ecosystem should have a dissolved oxygen concentration of at least 5mg/l in order to support organisms (Jha *et al*., 2008). In this study, station 1 recorded a mean DO concentration of 5.13mg/l, station 3 and 4 recorded 1.32mg/l and 1.2mg/l respectively. The low DO concentrations recorded at stations 3 and 4 could be attributed to the presence of high concentrations of degradable organic and inorganic matters which result in a tendency to be more oxygen demanding thereby making oxygen less available to desirable organisms. This is in agreement with the observations made by Ogbeibu and Edutie (2002) who reported a similar DO range of 1.84- 5.22mg/l in Ikpoba River. A higher dissolved oxygen concentration was obtained in the dry than wet season which is in agreement with the study carried out by Arazu and Ogbeibu

(2017) who reported that the DO was higher in dry season than wet season and the higher values of DO was recorded in non-organically polluted areas. The five days biological oxygen demand (BOD_5) is the most widely used parameter in evaluating of organic pollution of surface waters. It is the amount of dissolved oxygen taken up by aerobic micro-organisms to degrade oxidizable organic matter present in streams. BOD concentration was highest (25.5mg/l, March) in station 4 and lowest (1.2mg/l, January) in station 1.

pH ranged between 6 and 9. Most freshwaters are relatively well buffered and more or less neutral. The pH of wastewater needs to remain between 6 and 9 to protect and be beneficial to organisms (USEPA, 2004), and also 7 for drinking water (WHO, 1996). Aquatic organisms are very sensitive to the pH changes in its environment because their metabolic activities are pH dependent. In this study, a mean pH range of 5.66 (in station 1) to 6.33 (in station 3) was obtained which indicates that the water was slightly acidic. The pH falls within the permissible limits of WHO.

Transparency is one of the important physical properties of water indicative to the degree to which sunlight can pass through water. Higher values of transparency were recorded in station 1 and the least transparency was recorded in station 2 as a result of the activities such as the disposal of waste from abattoirs that flows into the water. The mean values of turbidity in the sampled stations were 11 NTU in station 1, 12.67 NTU in station 4, 15.83 NTU in station 2 and 26.67 NTU in station 3. The turbidity value was higher in station 3 (41 NTU) and the lowest value (10 NTU) in stations 1 and 4 respectively. There is a high significant difference ($P < 0.01$) among the four stations sampled. The occurrence of high turbidity which exceeds the 5.00 NTU Standard limit of WHO is an indication that the river water is not safe for drinking.

Conductance is a measure of the ability of water to conduct an electric current and has been used for assessing the tropic status of water bodies (Shastree *et al*., 1991). Electrical conductivity indicates the quantity of dissolved salts in water. Values of conductivity recorded for stations 1 and 2 were close and similar but different in the range of the values recorded for stations 3 and 4 (which were also similar). The mean conductance value was lowest (10µS/cm) in station 1 and highest (58.33µS/cm) in station 3. The highest conductivity observed in station 3 favoured its cladoceran species richness as indicated by Margalef's index of species richness. This study agrees with report from Arazu and Ogbeibu (2017) that the higher conductivity in a station indicates a higher species richness. There is a high significance difference ($P< 0.01$) across the stations.

Total Alkalinity (HCO_3) is a measure of buffering capacity of water and is important for aquatic life in a fresh water system. The mean total alkalinity ranges from 8.83 mg/l to 26.17mg/l. The HCO_3 was highest (42 mg/l, February) in station 3 and lowest (5.0, May) in station 2. Alkalinity was higher during the dry season than in the wet season. This conforms with the study carried out by Ikhuoriah *et al,* (2016) on the physico-chemical properties of River Ossiomo which reported that higher levels of alkalinity were recorded in dry season than wet season. There was a significant difference ($P< 0.05$) observed across the stations.

Nitrates are a form of nitrogen found in several different forms in aquatic ecosystem. These forms of nitrogen include ammonia (NH_3), Nitrites (NO_2) (USEPA, 2012). Nitrate is less toxic than the other forms nitrogen as a result, the nitrate concentration in surface water is usually low but can reach high levels from agricultural runoff or from effluent discharge, contamination by humans or animal wastes (CCME, 2007). Nitrate values were 1.91±2.61 in station 4, 2.19±3.12 in station 1, 2.1±4.85 in station 3 and 2.4±3.81 in station 2. The higher rates of nitrates observed in station 2 and 3 were as a result of the discharge of effluents and human sewage. The mean values of nitrites were 0.016mg/l, 0.02mg/l, and 0.023mg/l and 0.034mg/l. The concentration of nitrite was higher during the dry season as compared to the wet season.

Fauna Composition

An important characteristic of a water body is its biological diversity. Odiete *et al*, (2003) reported that chemical measurements reflect water quality at a given time while biological assessment reflects conditions that have existed in a given environment over a long period of time.

Twenty three species of Cladocera were found in this river during the study. It comprises of 5 families which include Chydoridae (represented by *Alona monacantha*, *A. davidi*, *A. rectangula*, *A. quadrangularis*, *A. cambouei*, *A. eximia*, *Leydigia macrodonta*, *Chydorus parvus*, *C. pubescena*, *C. sphaericus*, *Pleuroxus similis*, *Alonella excisa*, *Dunhevedia crassa*, *Psuedochydorus globosus*), Daphnidae (represented by *Simocephalus vetulus*), Sididae (represented by *Diaphanosoma excisum*), Macrothricidae (represented by *Macrothrix goeldi*, *Macrothrix spinosa*, *Echinisca rosea*, *Grimaldina brazzai*), and Moinidae (*Moina micrura*, *M. reticulata*, *Moinodaphnia macleayi*). Members of the family Chydoridae were found across the four stations sampled with more species found in station 1.

Abundance and Diversity

From the 5 families encountered in this study, the family Chydoridae was the most diverse with a total of 14 species. The families Moinidae and Chydoridae were the most abundant with 68 and 56 individuals respectively. The family Daphnidae was the least diverse with only 1 species and 1 individual. The calculated diversity indices using Shannon's index revealed that station 4 (1.907) was most diverse followed by station 2 (1.862). Simpson's index which takes into account both richness and diversity showed that station 2 (0.809) had the greatest diversity followed by station 4 (0.801) and the least diverse was station 1 (0.748). Margalef's richness indices which takes into account the relationship between the number of species 'S' and the total number of individuals observed 'N', revealed that station 3 (2.798) was the species richest station followed by station 1 (2.749).

Correlation of Cladocera with Physicochemical Parameters

The study revealed that water temperature was positively and significantly correlated with air temperature. Alkalinity showed positive correlation with air temperature, water temperature, electrical conductivity, total dissolved solids and turbidity. Dissolved oxygen showed a negative correlation with electrical conductivity, total dissolved solids, turbidity and alkalinity. Nitrite was positively correlated with turbidity. Nitrate was positively correlated with air temperature and alkalinity. Phosphorus was positively correlated with nitrate. Ammonium was negatively correlated with water velocity and positively correlated turbidity and nitrite. Cladocera showed a poor correlation with the physicochemical parameters analysed. No linear relationship was observed between the biological and physicochemical parameters.

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Table 6: Correlation matrix, Test of relationship between the physicochemical parameters and cladocerans at the study stations using Pearson's correlation

Note: The bold values are strongly correlated, + values are positively correlated, - values are negatively correlated, P<0.05=significant, P>0.05= not significant.

Where: WT-Water Temperature, AT-Air Temperature, WL-Water Level, WV-Water Velocity, Transp-Transparency, pH- Hydrogen ion concentration, EC- Electrical conductivity, TDS-Total Dissolved Solid, Turb-Turbidity, Alk-Alkalinity, DO-Dissolved Oxygen, BOD-Biological Oxygen Demand, NO_3-Nitrite, NO_2-Nitrate, P-Phosphorus, NH_4-Ammonia, Clad-Cladocera.

	AT	WT.	WL	WV	Transp.	pH	EC	TDS	Turb	Alk	DO	BOD	NO_3	NO_2	P	NH_4	Clad
AT	1																
WT.	**0.7810**	1															
WL	-0.4831	-0.4694	1														
WV	-0.1014	0.0052	0.1005	1													
Transp.	-0.2066	-0.2869	**0.8123**	0.1800	1												
pH	0.3074	-0.0242	-0.1665	-0.4000	-0.0722	1											
EC	**0.5110**	0.2196	-0.2590	-0.0359	0.0497	**0.5362**	1										
TDS	**0.5110**	0.2196	-0.2590	-0.0359	0.0497	**0.5362**	1.0000	1									
Turb	0.3911	0.0242	-0.0228	-0.4497	0.2133	**0.5339**	**0.7488**	**0.7488**	1								
Alk	**0.7952**	**0.5569**	-0.2940	0.1026	0.0149	0.3478	**0.6900**	**0.6900**	**0.5170**	1							
DO	-0.3839	-0.2026	0.3178	-0.0823	0.0620	-0.2798	**-0.8402**	**-0.8402**	**-0.5200**	**-0.6282**	1						
BOD	0.2014	0.1935	-0.3735	0.2048	-0.1531	-0.1632	0.3635	0.3635	0.0961	0.2528	**-0.5698**	1					
NO_3	0.2472	-0.0394	-0.1063	-0.5312	-0.2015	0.3390	0.0973	0.0973	**0.5497**	0.1528	0.1070	-0.2879	1				
NO_2	**0.6181**	0.3398	-0.3416	0.2599	-0.2196	0.2925	0.3630	0.3630	0.0738	**0.6674**	-0.2193	0.1102	0.0810	1			
P	0.3971	0.1082	-0.2140	-0.0982	-0.3069	0.3510	0.0617	0.0617	0.0997	0.3423	0.1872	-0.2129	0.4609	**0.7591**	1		
NH_4	0.2450	-0.0162	-0.1059	**-0.5857**	-0.2077	0.3562	0.0914	0.0914	**0.5528**	0.1362	0.1192	-0.2791	**0.9914**	0.0566	0.4375	1	
Clad	0.0374	-0.0475	0.0632	0.0576	0.1714	0.1842	0.1589	0.1589	-0.0679	0.2258	-0.0960	-0.1881	-0.3620	0.2904	0.0948	-0.3736	1