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Water Quality and Macroinvertebrate Diversity Indices of Water Receiving Cassava Effluents

Akawo, O. N., Akuaka, G. O., Odita, G. N. and Osagiede, L. A.
Biology department, Federal College of Education (Technical) Asaba.

Abstracts:- This study focused on the community of macroinvertebrates and their distribution in the Adofi River receiving cassava effluents. Samples for physicochemical analysis of water parameters and macroinvertebrates were collected bi-monthly for three months at three different stations (I, II, III) in Adofi River. The results of the physicochemical analysis did not reveal any significant difference in the values of the parameters measured between the three stations at (*p≤0.05*). The macroinvertebrate community recorded in Adofi River was low and was dominated by Odonata.The principal coordinate analysis revealed that Odonata and Coleoptera positively impacted Station III along the principal axis 1. The dominance of Odonata and coleoptera in River Adofi, as well as the absence of pollution sensitive EPT-groups, indicated that fermentation of cassava in Adofi river is a serious Stressor to the Environment, therefore creating an urgent need for water managers to develop strategies to improve the water quality of Adofi River as well as manage itsfisheries potential.

***Keywords**:- Adofi, River, Physico-Chemical, Diversity, Index.*

I. INTRODUCTION

Macro-invertebrates are an important component of the stream and river systems and play crucial roles in maintaining the structural and functional integrity of freshwater ecosystems. Theyare, however, affected by certain environmental conditions such as water temperature, dissolvedoxygen, flow velocity, bottom sediment, and water chemistry. The use of aquatic macroinvertebrates to monitor changes in the aquatic environment particularly the inland freshwater systems has gained much accolades, as it has been reported, that changes in community structure of aquatic macroinvertebrates, reflects state of the surrounding environment (Arimoro and Ikomi, 2008; Adu and Oyeniyi, 2019). The introduction of wastewater generated from anthropogenic activities around the watershed back into the streams and rivers without proper treatment poses a significant threat to the survival of aquatic, human and other water-dependent lives (McGoff et al, 2013). Macroinvertebrates demonstrates varying degree ofresponses to the presence of pollutants or stresses in the environment, based on their ability to tolerate varying degree of aquatic pollutants. This attribute makes them very effective in monitoring the presence or otherwise of pollutants in the aquatic environment.

Adofi River which is located in Delta State, Nigeria, has not only been a source of water for domestic, recreational, and agricultural use for the communities located around its banks but also a place of ancestral worship for many generations. Despite the importance of this water body, very few studies exist on the ecological status; this includes those provided by Iloba and Akawo (2013), Arimoro et al (2009). Given this premise, this study beamed its focus on the macroinvertebrate community and the physicochemical parameters of Adofi River. In Nigeria, changes in land-use and other anthropogenic activities which causes harmful effects on water quality, stream habitat and aquatic invertebrate's biodiversity depending on the type, concentration and duration of exposure have threatened the ecological integrity of many river systems. The outcome of this study to a large extent will be used to estimate the fishery potential of Adofi River and also its suitability for use as source water for domestic, agricultural, recreational, and industrial use. This study can also help to provide baseline information needed to develop a river remediation plan in the future.

Description of Study Area.

Adofi River is a first-order river flowing from Ejeme in Aniocha South Local Government, through Utagba-uno and Ossissa in Ndokwa West and East Local Government areas of Delta state respectively. The river provides water for both domestic and agricultural use to the inhabitants of the surrounding communities. It lies within the dense and thick tropical rainforest, at a terrain elevation estimated at 22m above sea level. The vegetation here consists of floating plants such as *Pistia spp., Azolla africana, and Nymphacealotus.* The submerged plants *include Vossia cuspidate, Ludioigia Spp., Salvinia nymphelluda, Hydroles glabra, and Pyereus lanceotus.* Fishes found in this river include *Tilapia Spp., Malopterurus electricus,* e.t.c. Anthropogenic activities include fishing, washing of clothes, bathing, fermentation of cassava, lumbering, e.t.c.

Description of Sampling Sites.

In other to ensure that a wide range of the river system is covered in this study, sampling was done at three different points, located at Ejeme-Aniogor, Utagba-Uno (Etua), and Ossissa, representing stations 1, 2, and 3 respectively.

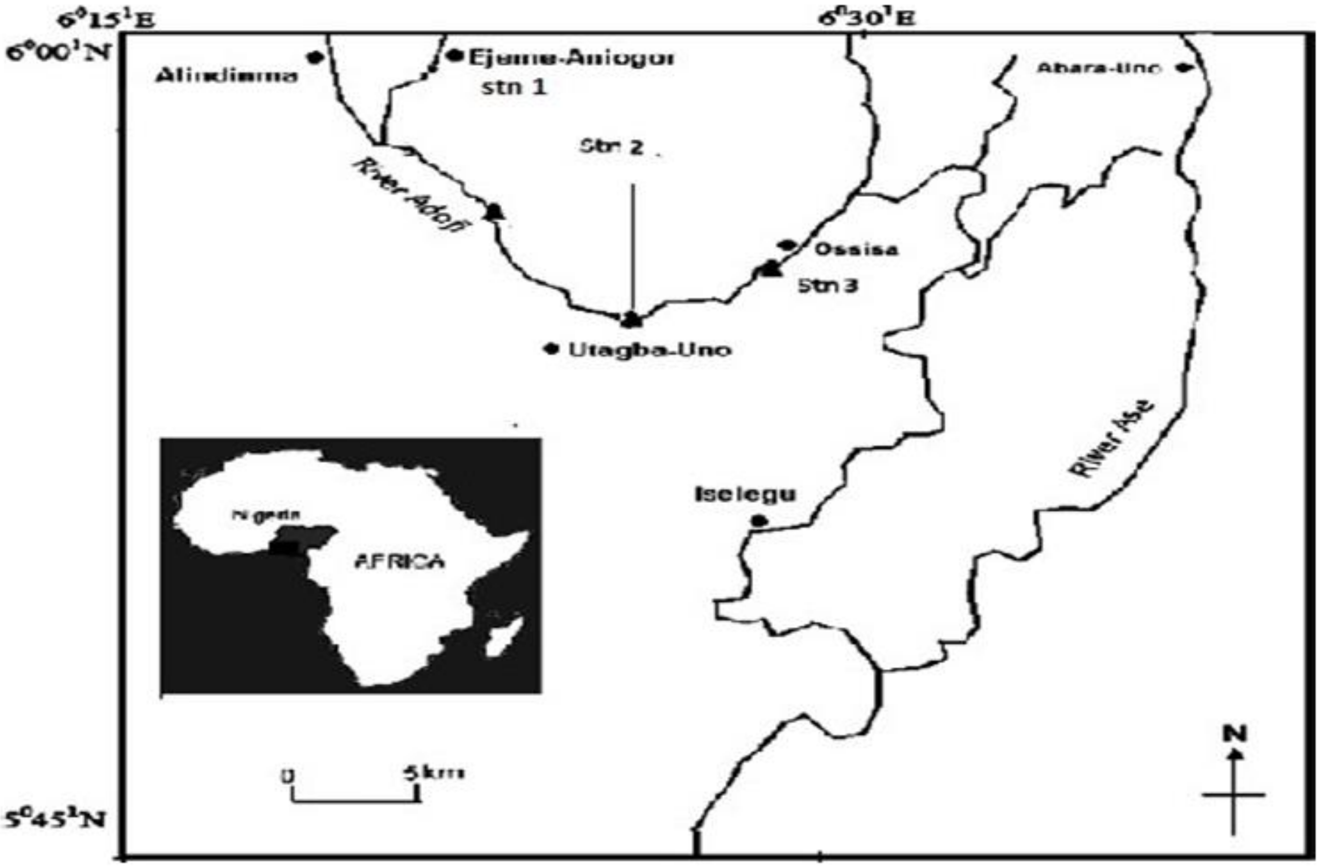

Fig.1: Map of Adofi River showing the study stations (modified from Arimoro, 2011).

II. SAMPLING METHOD

The stations were bi-monthly for three months between 9.00 am – 12 pm, to collect water samples for Physico-chemical parameters and macro-invertebrate samples.

Physico-Chemical Analysis of Water Sample.

Water samples for physico-chemical parameters at the three stations was collected monthly for six (6) months in a 2litre plastic container, stored in an ice chest and transferred to the laboratory of Biology department, Federal College of Education (Technical) Asaba, where it was analyzed, using standard methods according to APHA (1995). Air and water temperature were measured in-sittu, using environmental thermometer.

Macro-invertebrate sample:

The "kick sampling technique" described by Lenat *et al* (1981), adopted by Ikomi and Arimoro (2005) was used in collecting macroinvertebrates from the bank root biotope of each station. In this method, the substratum and the emergent vegetation was vigorously disturbed by kicking towards upstream. The disturbed animals from the streambed were washed by the current and a D-frame net of mesh size (154cm) held downstream was used to collect them. Collected samples were preserved with 10% Formalin. In the laboratory, sampleswere washed in a 600micro meter mesh sieve to remove formalin, invertebrates were picked from the substrate with the aid of an illuminated 10x magnifier, and then the entire sample was enumerated and identified to the lowest practical taxon under a binocular dissecting microscope. Identification was done using keys and references: Hawking (2000) and Theischinger (2001). **Statistical Analysis:** Factor analysis was applied to physical (air and water temperature and transparency), chemical (conductivity, pH, alkalinity, dissolved oxygen, sulphate, nitrates, and total phosphorus), and macroinvertebrate abundance that was assessed throughout the observation. (Hammer et al. 2001)

III. RESULTS

Table 1: Mean± Standard Deviation Values of Some Physico-Chemical Parameters of the Stations ofRiver Adofi, from March to August 2019 (minimum and maximum values in parenthesis).

Parmeters	Stn 1	Stn 2	Stn 3	F	p
Air temp	22.5±0.89 (21-23.5)	20±1.90 (18.5-23.5)	21±2.68 (18-24)	2.457	0.1194
H20 temp	19.3±0.75 (18-20)	17.75±2.16 (15-21)	20.17±2.42 (16-23)	2.442	0.1208
Ph	7.02±0.40 (6.58-7.65)	6.86±0.55 (6.09-7.73)	6.71±0.43 (6.32-7.51)	0.6484	0.5369
D.O	1.92± 0.38 (1.6-2.6)	1.90±0.4 (1.4-2.4)	1.77±0.88 (0.8-3.2)	0.113	0.8939
B.O. D	1.93±1.37 (0.2-4.0)	2.08±2.27 (0.4-4.8)	1.47±0.92 (0.2-3.0)	0.3727	0.6951
Alkalinity	11.83±2.23 (10-15)	10.5±3.62 (5-15)	11.12±3.19 (7-15)	0.2834	0.7572
TDS	0.15±0.08 (0.1-0.3)	0.15±0.09 (0.1-0.3)	0.17±0.08 (0.1-0.3)	0.0652	0.9371
Conduc	12.3±2.39 (9.4-15.6)	10.85±0.71 (10-11.8)	10.22±0.70 (9.5-11.4)	3.055	0.0771
Nitrate	3.34±1.37 (2-5.1)	3.08±0.78 (2.04-4.05)	2.50±1.33 (1.29-4.4)	0.7761	0.4778
Phosphate	0.47±0.85 (0.09-2.21)	0.24±0.31 (0.08-0.86)	0.41±0.42 (0.06-0.95)	0.274	0.7689
Sulphate	167.20±47.22(120.4-220.19)	173.18±32.98 (137.09-215.4)	158.29±59.2 (99.45-254.7)	0.16	0.8649

Air Temperature (°C).

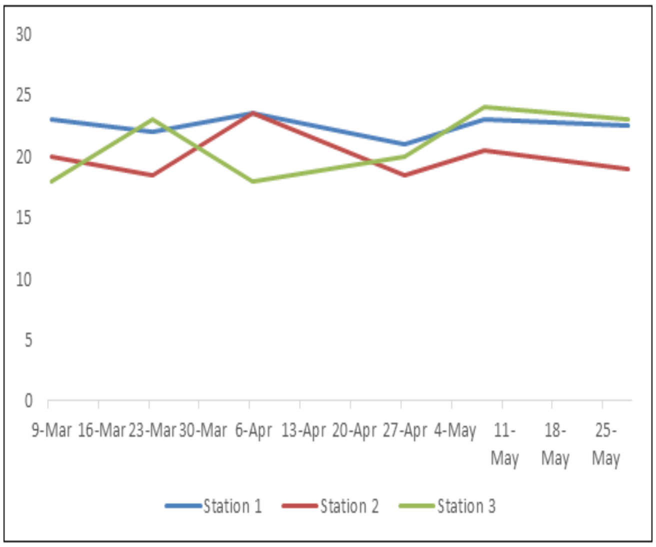

Fig. 4.1.1: Graph revealing Variations in Bi-monthly Air Temperature

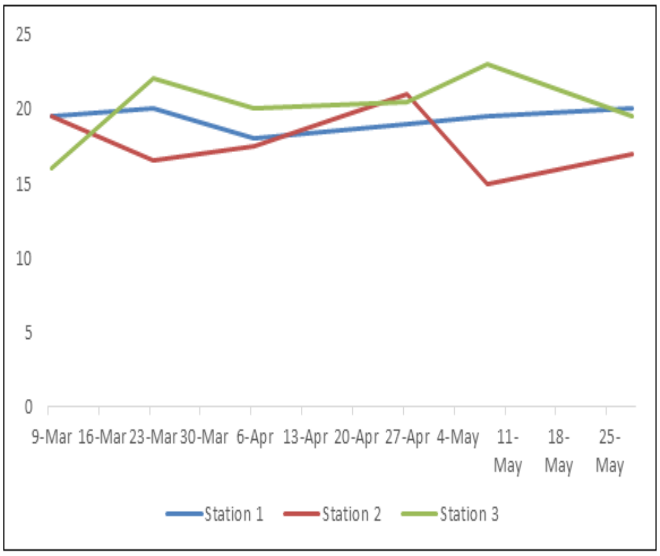

Fig. 4.1.2: Graph Showing Variations in Bi-monthly Water Temperature Values

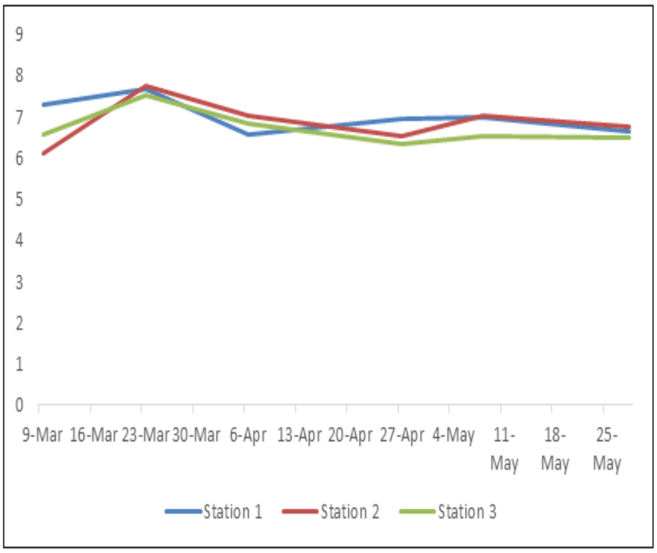

Fig. 4.1.3: Graph Showing Variations in Bi-monthly Hydrogen-ion Values

Fig. 4.1.6: Graph Showing Variations in Bi-monthly Dissolved Oxygen Values

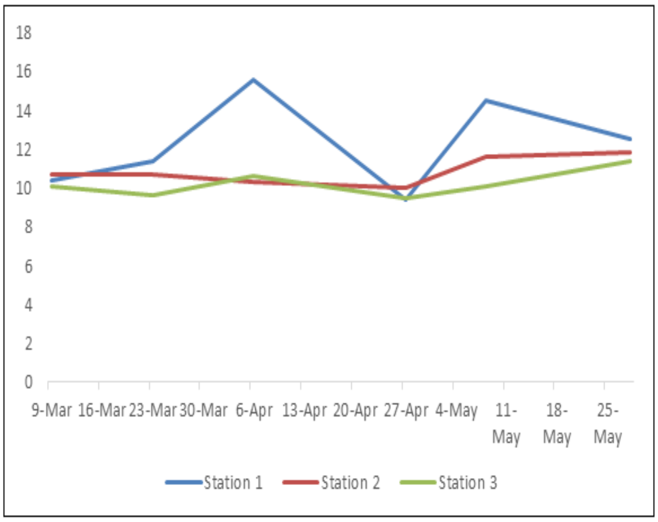

Fig. 4.1.4: Graph Showing Variations in Bi-monthly Water Conductivity Values

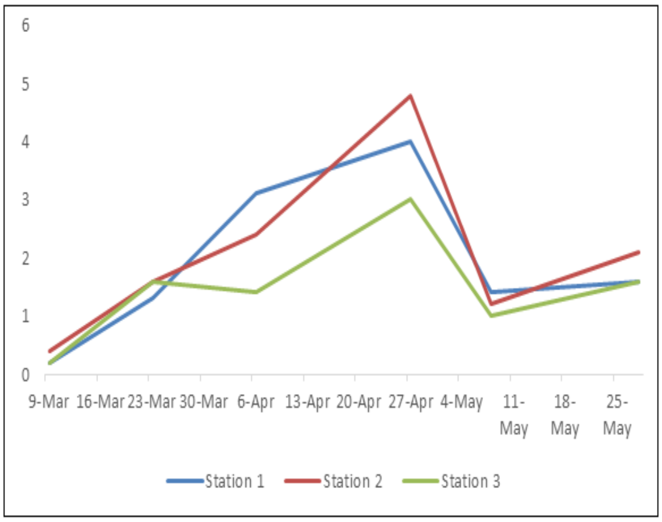

Fig. 4.1.7: Graph Showing Variations in Bi-monthly Biochemical Oxygen Demand Value

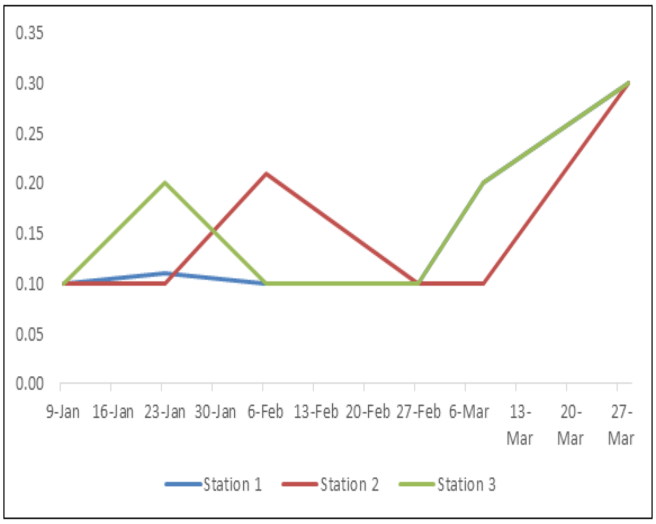

Fig. 4.1.5: Graph Showing Variations in Bi-monthly TDS Values

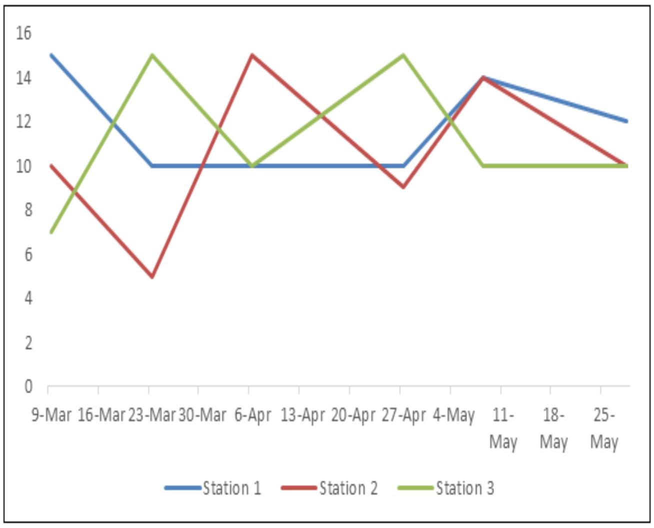

Fig. 4.1.8: Graph Showing Variations in Bi-monthly Alkalinity

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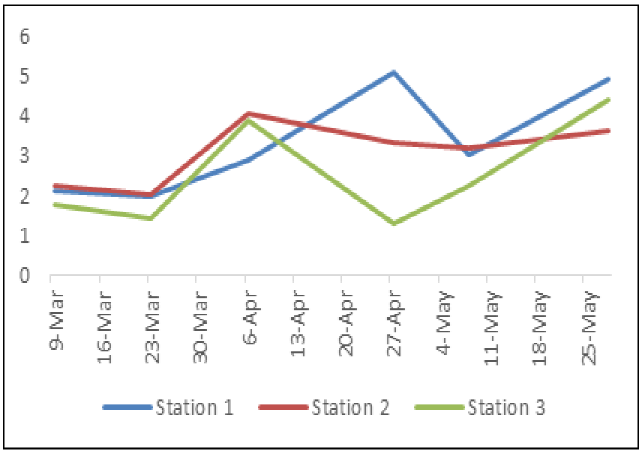

Fig. 4.1.9: Graph Showing Variations in Bi-monthly Nitrate Values

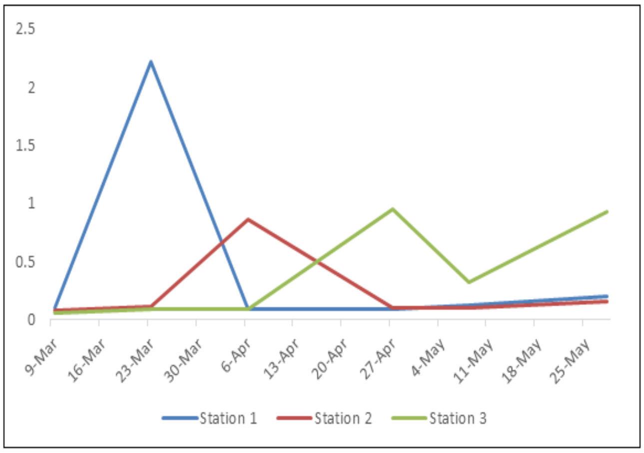

Fig. 4.1.10: Graph Showing Variations in Bi-monthly Phosphates Values

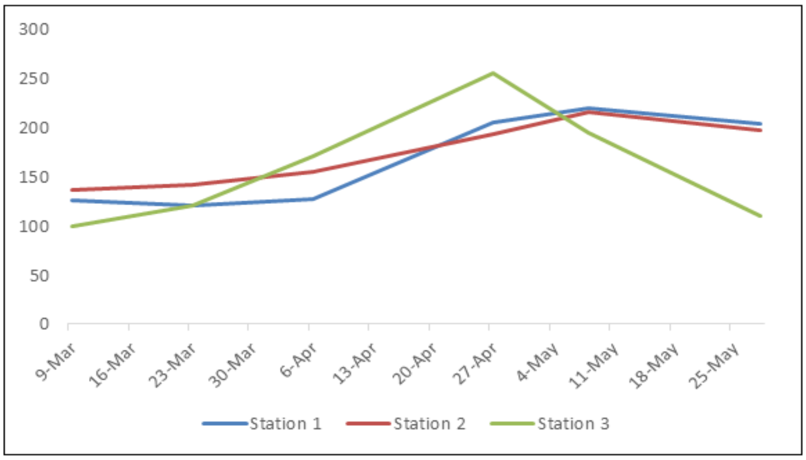

Fig. 4.1.11: Graph Showing Variations in Bi-monthly Phosphates Value

Table 4.2.1: Distribution of Macroinvertebrates in Adofi River

Taxa	Family	Station1	Station 2	Station 3	Total
Gastropoda	*Planorbidae*	−	+	+	**3**
	Pleuroceridae	+	+	+	**17**
Hemiptera	*Notonectidae*	+	−	−	**8**
	Gerridae	+	−	+	**8**
	Corixidae			+	**1**
	Nepidae	+	+	+	**24**
		+	+	+	**16**
Coleoptera	*Gyrinidae*	+	+	+	**7**
	Psephinidae	+	−	+	**3**
	Elmidae	+		+	**3**
	Halipidae	−	+	+	**3**
Arachnida	*Pisauridae*			+	**1**
Diptera	*Chironomidae*	+	+	+	**21**
Odonata	*Gomphidae*	+	+	+	**22**
	Aeshnidae	+	+	+	**60**
	Cordulegastridae	+	+	+	**51**
Oligochaeta	*Lumbricidae*	−	+	+	**5**
Total		*77*	68	108	**253**

Macroinvertebrate community structure and Abundance

Macroinvertebrate community structure and abundance of River is such that, Odonata dominated the environment with about 123 individuals, with Aeshnidae as the most abundant, and the Gomphidae the least abundant family. The Aeshnidae is quickly followed by the Hemiptera, while the Arachnids were the least abundant group with only one family, Pisauridae, and represented by one individual. Of the 253 individuals recorded, 77, 68, and 108 individuals were recorded in station 1, station 2, and station 3, respectively. Most macroinvertebrate order except Hemiptera and Diptera, were most abundant in station 3, while station 1 was dominated by Hemiptera and Diptera. However, in the entire stretch of the river, the Odonata dominated the macroinvertebrate abundance in the river as shown in figure 4.2.1 below.

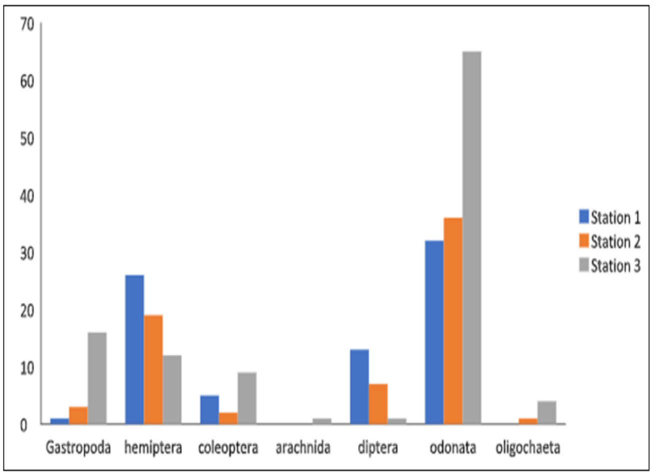

Fig. 4.2.1: Distribution and Abundance of Macroinvertebrates in Adofi River

Table 4.3.1: Diversity Indices of Macroinvertebrates in Adofi River.

Station 1	Station 2	Station 3	
Taxa_S	5	6	7
Individuals	77	68	108
Dominance_D	0.3196	0.372	0.405
Simpson_1-D	0.6804	0.628	0.595
Shannon_H	1.266	1.23	1.248
Evenness_e^H/S	0.7092	0.5705	0.4979
Margalef	0.9209	1.185	1.281
Equitability_J	0.7865	0.6867	0.6416

Diversity indices values recorded during this study were particularly low, especially with regards to species richness and diversity. Margalef's index obtained ranged between 0.9209 – 1.281. These values are indicative of serious impairment of the aquatic environment potentially from organic sources. Shannon index did not also fare any better, with a value range between 1.23 in station 2, to 1.266 in station 1.

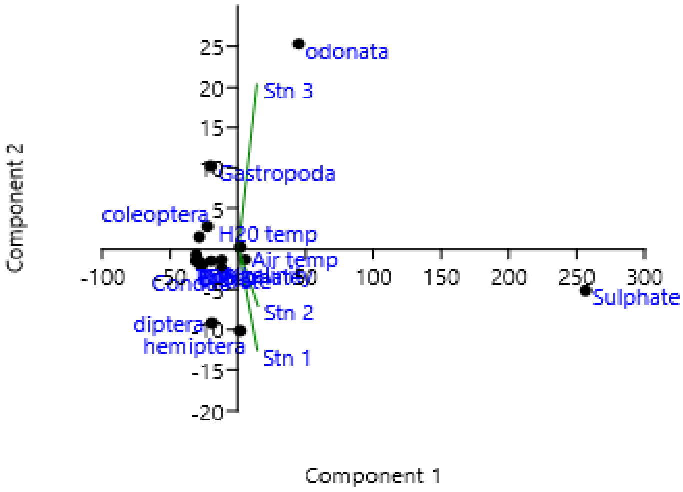

Fig. 4.2.2: PCA Scatter Plot

The PCA analysis showed that River Adofi environment showed greater variation along axis-1, with D.O, B.O.D, Alkalinity, T.D.S, Conductivity, Nitrate, Phosphate, Gastropods, Coleoptera, Arachnida, Diptera, and Oligochaete been responsible for the negative variation recorded while Sulphate and Odonata, were responsible for the significant positive variations recorded. The variations in axis-2 were less than 5%.

IV. DISCUSSION

This study recorded a total of seventeen (17) taxa, from sixteen (16) families belonging to the following genera: Gastropoda, Hemiptera, Coleoptera, Arachnida, Diptera, Odonata, and Oligochaeta. This number is smaller than those reported for river systems in the study environment by Arimoro et al (2008) and Iloba et al., (2018). Water quality, food availability, presence and abundance of predator species as well as the degree of effective competition are factors that control the abundance and distribution of macroinvertebrates' fauna in the aquatic environment. The Odonata, although with three families, are the most abundant with (133) individuals. The abundance of Odonata could be as a result of the fact that they were the first to colonize the habitat, hence multiplied successfully in the environment before other groups arrived. This corroborates Braccia et al., (2007) who reported that Odonata is early colonizers of new lenthic habitats. Bernath et al., (2002) also reported that turbidity serves as distant visual cues to adult Odonata in detecting polarization and reflecting the light of suitable habitat to oviposit. Although turbidity was not measured in River Adofi during this study, the high Value of TDS recorded could have increased the turbidity of this River and influenced the abundance of Odonates in the River. This agrees with the positive correlation between TDS and Odonata in this study. The high turbidity associated with most stagnant vernal pools might have guided the colonial Odonates to colonize this water body earlier before other groups arrived and hence given them an advantage over others in dominating the habitat. Another factor that may have contributed to the dominance of Odonates is habitat stability particularly in station 3 where their numbers were particularly higher. This conforms with

Biber (2002), who stated that Odonate species are sensitive to habitat disturbance. Hemipteran abundance could be linked to the abundance of food. Corixidae feeds on periphyton, chironomids, and Oligochaetes which are almost abundant under high nutrient conditions (Lock et al, 2013). This condition is true for this study and explains the low number of Oligochaetes and chironomids particularly in station 3, where the numbers of predator species like Odonata and Hemiptera were highest. The presence of Coleoptera, Particularly *Gyrinus* might be an indication that the water body is pollution-free, corroborating Arimoro et al, (2007) who reported that the presence of coleopteran in an aquatic system along with other less tolerant species such as the EPT species and Odonata is an indication of clean water conditions. According to Ibemenuga and Nzekwe (2017), in the Amaku stream, Streams are classified into unpolluted (BODs <1.0m g/l), moderately polluted (BODs, between 2–9 mg/l), and heavily polluted streams (BODs >10.0 mg/l). With BODs <1.0m g/l recorded in thisstudy, it is safe to refer to the Adofi river as a moderately polluted water body. The slightly acidicpH, Low value of dissolved oxygen, as well as high nitrate presence in Adofi River, are all indicative of a deteriorating environment resulting from many years of fermentation of cassava in the river,aligning with the reports of Arimoro et al, (2007) and Ibemenuga and Nzekwe (2017). However, Lenat et al., (1980) reported that Margaleff's water quality index with values less than three (3) indicates poor water conditions. Margaleff's index value for this study was less than 3 in this study for all stations and was particularly less than 1 in station 1. This is an indication of very poor water conditions. The preponderance of Diptera in this station also gives further credence to this claim, as Diptera and Oligochaetes have been known to tolerate poor waterconditions.

V. CONCLUSION

The results of the study show that Adofi River water is highly acidic due to the release of hydrocyanic acid into the river as the cassava ferments. The BOD, nitrate, and TDS values are also very high leading to depletion of dissolved oxygen (DO) needed for the survival of aquatic life as indicated by the low DO values recorded in this study. The absence of the EPT group of Macroinvertebrates from the samples collected and the presence of pollution indicative species(Diptera &Oligochaeta) as well as low values of both Shannon and Margaleff's indices of diversityare conclusive evidence that cassava fermentation in Adofi River is a stressor on the water quality.

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Conflict of Interest
The authors declare no conflict of interest regarding the publication of this manuscript.

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Table 5.1: Pearson correlation analysis between physic-chemical parameters and Macroinvertebrates communities of Adofi River.

Correlation	Air temp	H20 temp	pH	D.O	B.O.D	Alkalinity	TDS	Conduc	Nitrate	Phosphate	Sulphate	Gastropoda	Hemiptera	Coleoptera	Arachnida	Diptera	Odonata	Oligochaeta
Air temp		0.63747	0.58163	0.84845	0.92154	0.048327	0.92681	0.45101	0.73131	0.2447	0.81187	0.84845	0.59348	0.79224	0.92681	0.59348	0.85597	0.77239
H20 temp	0.53918		0.78091	0.51408	0.28408	0.58914	0.43572	0.91153	0.63123	0.39277	0.1744	0.51408	0.76905	0.15478	0.43572	0.76905	0.50657	0.59014
pH	0.61089	-0.33739		0.26683	0.49683	0.62995	0.34519	0.13062	0.14968	0.82632	0.6065	0.26683	0.011855	0.62613	0.34519	0.011855	0.27434	0.19077
D.O	0.23581	-0.69129	0.91344		0.23001	0.89678	0.078363	0.39744	0.11714	0.90685	0.33968	9.00E-06	0.25497	0.35931	0.078363	0.25497	0.007518	0.076058
B.O.D	-0.12293	-0.90208	0.71062	0.93544		0.87322	0.15164	0.62745	0.34715	0.67684	0.10967	0.23001	0.48498	0.1293	0.15164	0.48498	0.22249	0.30606
Alkalinity	0.99712	0.6015	0.54909	0.16143	-0.19784		0.97514	0.49933	0.77963	0.19637	0.76354	0.89678	0.64181	0.74391	0.97514	0.64181	0.9043	0.82072
TDS	-0.11471	0.77478	-0.85656	-0.99243	-0.97176	-0.03904		0.47581	0.19551	0.82849	0.26132	0.078363	0.33333	0.28094	9.00E-06	0.33333	0.070845	0.15442
Conduc	0.75938	-0.13853	0.97903	0.81137	0.55237	0.70785	-0.73346		0.2803	0.69571	0.73712	0.39744	0.14247	0.75675	0.47581	0.14247	0.40496	0.32139
Nitrate	0.40964	-0.54741	0.97249	0.98312	0.85497	0.33928	-0.95321	0.90463		0.976	0.45682	0.11714	0.13783	0.47645	0.19551	0.13783	0.12466	0.041087
Phosphate	0.92703	0.81564	0.26944	-0.1458	-0.48609	0.9528	0.26616	0.45999	0.037683		0.56717	0.90685	0.83818	0.54754	0.82849	0.83818	0.89933	0.98291
Sulphate	-0.29123	-0.96271	0.57949	0.861	0.9852	-0.36294	-0.91693	0.40129	0.7534	-0.6287		0.33968	0.59465	0.019628	0.26132	0.59465	0.33216	0.41574
Gastropoda	-0.23581	0.69129	-0.91344	-1	-0.93544	-0.16143	0.99243	-0.81137	-0.98312	0.1458	-0.861		0.25497	0.35931	0.078363	0.25497	0.007518	0.076058
hemiptera	0.59604	-0.35486	0.99983	0.92086	0.72359	0.53343	-0.86603	0.97506	0.97666	0.25146	0.59456	-0.92086		0.61428	0.33333	9.00E-06	0.26249	0.17891
coleoptera	0.32058	0.97059	-0.55409	-0.84491	-0.97944	0.3915	0.90419	-0.37286	-0.73277	0.65238	-0.99952	0.84491	-0.56949		0.28094	0.61428	0.35179	0.43537
arachnida	-0.11471	0.77478	-0.85656	-0.99243	-0.97176	-0.03904	1	-0.73346	-0.95321	0.26616	-0.91693	0.99243	-0.86603	0.90419		0.33333	0.070845	0.15442
diptera	0.59604	-0.35486	0.99983	0.92086	0.72359	0.53343	-0.86603	0.97506	0.97666	0.25146	0.59456	-0.92086	1	-0.56949	-0.86603		0.26249	0.17891
odonata	-0.22432	0.69978	-0.90857	-0.99993	-0.93955	-0.14977	0.99381	-0.80441	-0.98089	0.15747	-0.86694	0.99993	-0.9162	0.85117	0.99381	-0.9162		0.083576
oligochaeta	-0.34996	0.60024	-0.95544	-0.99287	-0.88664	-0.27791	0.97073	-0.87526	-0.99792	0.026844	-0.79424	0.99287	-0.96077	0.77513	0.97073	-0.96077	0.9914	