BIO-EVALUATION OF THE ECOLOGICAL HEALTH STATUS OF PETROLEUM EFFLUENT RECEIVING WATER FROM ELEME RIVER, NIGERIA

ABSTRACT

The ecological Health Status of Eleme River receiving treated petroleum effluent wastes from Eleme Petroleum Refinery Company was evaluated using a combined approach of biological methods; petroleum effluent bioindicators, functional diversity and community assemblage metrics, and physicochemical methods; TPH, nutrients, turbidity, DO, pH, Heavy metals, and total dissolved solids analysis. This was carried out, knowing that effluent discharges change the biodiversity of aquatic macroinvertebrates, particularly insects, reduce their functional roles, and change their physicochemical requirements. The River was divided into 3 stations; upstream (receiving point), midstream, and downstream, with each station further divided into 3 sampling points. The collection of macroinvertebrates was done, using handnets and Eckman's grab from floating vegetation, logs, and sediments. The samples were placed in a 4-L bucket containing 70% ethanol and 5% glycerin and transported to the Entomology Research Laboratory, Department of Animal and Environmental Biology, the University of Port Harcourt for sorting and identification. Composite water samples were taken for analyses of physicochemical properties using standard devices and methods. Results obtained indicated that out of 18 species encountered, 12 were monitor indicators, 5 were facultative tolerant indicators and none were sensitive indicators. Five species (taxa) occurred at both up and mid-streams and seven occurred downstream. Daphnia barbata and macrobranchium sp., occurred commonly in the three stations. The insect indicators encountered were seven, all of the downstream, and were dominated by insects belonging to the order: Hemiptera. Three functional groups; Detritivorous, collector-herbivorous, and predators were encountered with detritivorous being dominant. The TPH, nitrate, phosphate, copper, and nickel concentrations in all sampling stations were above the intervention limits of the World Health Organization (WHO). Concentrations of physicochemical properties except DO and pH were higher downstream. Shannon-Weiner index showed that the absence of species belonging to Ephemeroptera, Plecoptera, and Trichoptera in all stations indicated that Eleme River has a poor ecological health status.

Keywords: Ecological Health, bioindicators, functional diversity, petroleum effluents, physic-chemicals.

INTRODUCTION

Eleme River is a freshwater body and a branch of Imo River; situated at Aleto and Agbonchia communities, in Rivers State, Nigeria. Eleme is an oil-producing area, hosting two of Nigeria's four petroleum refineries whose treated effluent wastes are usually discharged into the river. Petrochemical wastes discharged into rivers are highly toxic (Abduli et al., 2006) and usually modify the physical and chemical components of the receiving water bodies.

Some of the waste effluents are persistent in the water bodies and lead to instability, disorder, harm, or discomfort to both physical systems and living organisms inhabiting the ecosystem (Dawodu et al., 2015). Kuehn et al (1995), pointed out a positive correlational relationship between fish health and the aromatic hydrocarbons from petrochemical waste effluents, while Sangodoyin (1991) stated that such waste effluents affect the biodiversity of aquatic flora and fauna.

The impact of petrochemical waste effluents on the physicochemical and heavy metals of receiving water bodies has been described. Kanu and Achi (2011) reported an increase in the physicochemical properties of the Eleme river while Gbarakoro et al. (2020) stated that though variations in such parameters occur they were within World Health Organization (WHO), (1990) and Nigeria Federal Ministry of Environment (1991) permissible limits. Parameters such as Electrical conductivity, turbidity, TSS, TDS, calcium hardness, COD, and BOD were pointed out as above permissible limits with pH values showing alkaline upstream and slightly acidic downstream (Gbarakoro, et al., 2020). Gheorghe, et al., (2017) reported that petrochemical effluent wastes increased heavy metal levels in water bodies which caused its bioaccumulation in aquatic organisms.

The discharge of petrochemical effluent wastes and its attendant changes in the stability of the water body constitute a disturbance of the ecosystem. Pickett and White (1985) defined disturbance as any relatively discrete event in time that disrupts an ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment.

The discrete event of petrochemical effluent waste discharge into the Eleme river can be assessed using indicators principally physicochemical and biological indicators in rivers (Kambwiri et al., 2014). The use of biological indicators for the evaluation of the ecological health of rivers and their landscapes is the best method because it provides complete spatial-temporal integration of knowledge of freshwater ecosystems and their landscapes (Uherek et al., 2014). Abel (2002) stated that the method can reveal the occurrence of ecologically-significant environmental changes and provide needed data for further investigation. Tagliapietra and Sigovini, (2010), stated that biological indicators particularly benthic communities are suitable for use because they provide information on environmental conditions either due to two factors; i. sensitivity of single species to environmental changes (indicator species)

ii. possession of features that enable them to integrate environmental signals over a long period. They listed out the features as exposure to chemical contaminants that accumulate in the sediment; low dissolved oxygen levels that often occur near the bottom surface; and limited mobility that restricts their ability to avoid adverse conditions. The physicochemical approach is vested with limitations such as the restriction of data to the moment of sampling without taking cognizance of the patchy distributions of chemicals in the environment in long term (Resende et al., 2010). It is time-consuming and expensive for most developing countries (Deborde et al., 2016), and often limited to suspect compounds, priority pollutants, or major components of a mixture.

Biological indicators such as benthic macroinvertebrates which have high efficacy for bio indication of ecosystem health have been used for evaluation (Zerniawska-Kusza, 2005; Abdelfattah et al., 2022; Abdelfattah and El-Shamy, 2022). Okiwelu (1996) stated that insects are effective bioindicators for monitoring landscape changes because of their abundance, species richness, ubiquitous occurrence, and importance in the function of natural ecosystems. Uwaigbae et al (2020) observed that insects provide information on the habitat and aquatic ecosystem integrity due to their sensitivity to pollution. The determination of the ecological health status of freshwater bodies in the tropics, particularly Nigeria and Eleme to be specific has been restricted to the physicochemical approach. The available literature on the use of the biological approaches is limited, therefore, the present study, used both approaches to ascertain the ecological health status of the Eleme river. The use of a combined approach to obtain information on the causes of degradation and the consequent effect on the aquatic ecosystem has been suggested (Carmen, 1988; James and Daniel, 1981). We applied biological evaluation methods as contained in Elios and Chilima, 2017, and the functional diversity index.

MATERIALS & METHODS

DESCRIPTION OF STUDY AREA

The area was divided into three sampling stations; the upstream station was located at 04^{0} 48^{1} 46.2^{II} N and 07^{0} 06^{1} 45.3^{II}. It is the receiving point of the treated petrochemical effluent waste discharge from the petrochemical company. This station is also stressed by mechanical in-stream sand mining, and there is virtually no vegetation cover. The midstream station is located 1.5km from the upstream on 04^{0} 48^{1} 29.8^{II}N and 07^{0} 06^{1} 38.6^{II}E. Vegetation cover is absent, and manual in-stream sand mining operations are occurring in this station. Both stations are contained in the Aleto Eleme section of the river and have deeper depths.

Station 3 is downstream located at the Agbonchia section of the river where there are vegetation cover and no in-stream sand mining operations. The depth is shallow and the station which lies on a coordinate of 04^{0} 05^{1} 20.2^{II}N and 06^{0} 53^{1} 54.4^{II}E is about 2km from station 2.

Each station was divided into three sampling points which serve as replicates in a completely Randomized Design.

COLLECTION OF BIOLOGICAL MATERIALS

Biological materials used for the analysis of environmental health status were collected from the three sampling stations, using Eckman's grab and hand net devices. The devices were used to sample randomly from the sediments, logs, and vegetation cover. The Eckman's grab which measures $225cm^3$ was used in a wooden canoe to collect biological materials from about 15 to 28cm depth and sieved through a 0.5mm mesh size net and immersed into the water to wash off unwanted particles. The biological materials were collected from an upstream and mid-stream and preserved in a 4-liter bucket with 70% ethanol and 5% glycerin.

Floating vegetation and logs at the river banks and channels were searched and dislodged, and hand nets were placed underneath for the collection of biological materials. Unwanted materials collected alone were sieved and removed, and the biological materials were placed in a 4-L bucket containing 70% ethanol and 5% glycerin. All the biological materials were stained with 0.1% Euson red stain and transported to the Entomology Research Laboratory, Department of Animal and Environmental Biology, University of Port Harcourt.

SORTING AND IDENTIFICATION

The sorting technique used enhanced easy sorting; which consists of picking up from the sieve material all the animals that were alive at the moment of the sampling (Tagliapietra & Sigovini, 2010). Sorting and identification were carried out under a binocular dissecting microscope.

Identification was conducted using standard keys, illustrations, and typed specimens (Dudgeon, 1999), in which small samples were spread onto Petri dishes and carefully examined to identify the species. Biological materials (macroinvertebrates) were picked and placed in different containers according to the main taxonomic groups; oligochaetes, crustaceans, and insects. The containers were labeled according to the sampling stations with identified species counted and grouped according to their functions, indicator ability, pollution tolerance, species richness, and abundance. This was used to determine pollution indicators, community assemblage metrics, and functional diversity.

DETERMINATION OF PETROLEUM EFFLUENT INDICATORS

Three categories of effluent indicators were determined by counting the taxa or species that were encountered in the three respective sampling stations of the river sections. Species counted for each section were recorded as tolerant to the habitat-specific concentration of the stressor. Those species which were somewhat tolerant as they occur at one sampling station but were absent at another station were counted and called Facultative indicators. Those taxa that usually occur at freshwater bodies but are absent in the studied sites are observed to be sensitive to the stressor and called sensitive indicators.

DETERMINATION OF COMMUNITY ASSEMBLAGE METRICS

The total number of individuals in taxa (abundance) that belong to three orders of insects; Ephemeroptera, Plecoptera, and Trichoptera, and those that belong to the family Chironomidae were counted and analyzed using EPT Metrics. Individual macroinvertebrates belonging to three subcommunities; oligochaetes, Insects, and crustaceans were counted and recorded according to their respective habitat types; upstream, midstream, and downstream to determine their abundances. The abundances obtained were subjected to assemblage or biodiversity analyses using metrics such as Simpson's, Shannon-Weiner, and Margalef richness indices to determine the significant differences between the habitat types on one land, and between subcommunities on the other land.

FUNCTIONAL DIVERSITY INDEX

Organisms that perform the same or similar functions in the water body encountered were assembled and used to assess the level of functional performance of the water body.

PHYSICOCHEMICAL EVALUATION OF ECOLOGICAL HEALTH STATUS OF ELEME RIVER, NIGERIA.

Physico-chemical materials used for the evaluation of the ecological health status of the Eleme river were collected from the sampling stations, using standard devices and methods. Composite water samples from stations were collected and analyzed. For pH, temperature, and conductivity, calibrated handheld pH electronic meter (D1-4337), digital thermometer, and electronic conductivity meter model (H_1-4103) respectively were used.

Turbidity was determined by Nephelometric turbidity meter (NTU), while Total Dissolved Solids (TDS) and total suspended solids (TSS) were determined by Calibrated handheld Electronic TDS meter (D4-7103) and gravimetric method, respectively.

The titrimetric method with $AgNo_3$ was used to determine chloride concentration while calibrating a handheld electronic TDS/Salinity meter (D4-7103) for salinity, and ASTMD3875 for alkalinity. Dissolved oxygen (DO) was determined by calibrated handheld HACH Electronic DO meter, Total Petroleum Hydrocarbon (TPH) by Flame Ionization Detector (FID) - Gas Chromatograph with Agilent 7890N. Heavy metals (Lead, copper, and nickel) by calibrated Atomic Absorption spectrophotometer (AAS) and non-metals (Nitrates & Phosphates) by calibrated HACH 3900DR spectrometer.

The values obtained from the analyses were subjected to Hierarchical Cluster Analysis by Jaccurd Similarity Index to determine the similarity between the three habitat types, and Principle Component Analysis (PCA) to determine the relationship between the parameters and insect distribution.

RESULTS

Petroleum Effluent Sediment Indicators

Three key performance indicators of taxa were encountered in the study; indicators of taxa that were tolerant of the effluents; indicators that were somewhat tolerant and tolerated certain levels of effluents which are referred to as facultative tolerant indicators; and indicators that were sensitive to the effluents and were not encountered but usually occurred in unpolluted ecosystems.

Petroleum Effluent Tolerant Indicators

Five taxa of macroinvertebrates; *Paranais sp., Nais sp*. (oligochaetes), *Daphnia barbata; Macrobrachium sp., and Sudanonautus africanus africanus* (crustaceans) were encountered. They tolerated the effluent wastes received by the Aleto section of the Eleme River at the sediments (Table 1).

Seven insect taxa; *Lethocerus indicus, Naucoris sp., Leptonea sp., Aphelocheirus grik, Dytiscus sp., Chironomus sp.*, and *Dragonfly* nymphs, and three crustacean taxa; *Daphnia* *sp*., *Macrobrachium sp*., and *Apus sp*., tolerated the effluents at the vegetation cover and water column and were encountered during the study (Table 1). Out of the twelve (12) petroleum effluent indicators encountered in the study, five taxa occurred at both the up-and mid-streams, and seven occurred downstream (Table 2). Two taxa; *Daphina barbata* and *Macrobranchium* (Crustacean group) occurred commonly in the samples collected from the three stations.

Seven species of insect indicators encountered were collected from the downstream, and they were dominated by insects that belong to Hemiptera (bugs); *Leptonea sp; A.grik, L.indicus, Dytiscus sp*; and *Naucoris sp*. The other two taxa (species) collected were *Chironomus sp* (Diptera: Chironomidae), and *Dragonfly* nymphs (Odonata: Lebillulidae). (Table 2). Insect-Indicators were all collected from the vegetation cover following a loosening, and oligochaetes were collected from the sediment samples.

Facultative Effluent Tolerant Indicators

In the sediment samples, five taxa or species; *Diplonychus rusticus, Ophidonais sp., Chaetogaster sp., Aeolosoma hemprichi,* and *Elseniella tetrahedral* were encountered. Four taxa apart from the insecta; *D.rusticus* were absent in the sediment samples collected from the upstream but occurred at the midstream, indicating their somewhat tolerant characteristics (Table 3).

Pollution Sensitive Indicators

None of the species belonging to the EPT orders were encountered at either the Aleto receiving point of the effluents or the Agbonchia downstream end of the river (Table 1). Out of 18 species encountered, 12 tolerated the petroleum effluent waste, and only 5 species were somewhat tolerant. Among the insects, hemipterans (bugs) dominated with 5 species, while one species each was recorded in Coleoptera, Diptera, and Odonata.

Functional Diversity

The detritivorous trophic group dominated the sediment samples among the oligochaetes and crustaceans encountered while the herbivorous trophic group, particularly collectors dominated among insects. The predator trophic group represented by *Chaetogaster* (Oligochaeta) and *L.indicus* (Insecta) were also encountered.

Community Assemblage Metrics

The result of statistical analyses of the Simpson index, Shannon-Weiner diversity index, and Mergalef richness index showed that diversity was more unmined and low at the Mechanical habitat types (Table 5).

Table 1: Physicochemical Parameter Values of Petroleum Effluent Receiving Eleme River.

Values of Range, Mean, Standard Error of Physicochemical Parameters of Eleme River

Parameters				WHO Standard Limit 2016 Edition
	Upstream	Midstream	Downstream	
Temperature (^{0}c)	30	28.0-28.4	27.5-28.0	27.5-29.1
		28.13±0.13	27.77±0.15	28.13±0.49
Salinity (mg/L)	600	20.0-22.1	21.7-23.4	25.0-28.1
		21.1±0.61	22.47±0.50	26.7±0.91
pH	6.5-8.5	6.63-6.68	6.71-6.79	6.34-6.40
		6.65±0.01	6.75±0.02	6.37±0.02
Dissolved oxygen (mg/L)	7.5	5.4-5.8	5.0-6.1	4.02-4.51
		5.63±0.12	5.63±0.33	4.35±0.17
Total suspended solids (TSS) mg/L	30	8.8-20.3	17.9-18.6	20.8-22.4
		19.53±0.43	18.20±0.21	21.57±0.46
Turbidity (NTU)	15	13.8-15.5	11.5-15.8	14.3-16.7
		14.7±0.49	14.1±1.32	15.7±0.72
Nitrate (NO^{3-}) mg/L	10	10.5-12.4	11.3-14.8	15.6-17.5
		11.27±0.58	12.67±1.08	6.33±0.59
Phosphate (PO_4^{3-}) mg/L	0.1	0.259-0.271	0.212-0.288	0.37-0.383
		0.266±0.004	0.260±0.024	0.377±0.004
Copper (Cu) mg/L	1.5	0.25-0.31	0.24-0.29	0.31-0.35
		0.29±0.02	0.27±0.01	0.33±0.01
Lead (Pb) mg/L	0.05	0.021-0.025	0.023-0.031	0.029-0.034
		0.023±0.001	0.027±0.004	0.031±0.002
Nickel (Ni) mg/L	0.03	0.114-0.19	0.115-0.122	0.131-0.142
		0.116±0.001	0.119±0.002	0.137±0.003
Total Petroleum Hydrocarbon (TPH)	0.01	5.78-7.37	4.6-7.08	9.47-13.51
mg/L		6.66±0.47	5.84±0.72	11.34±1.18
Total Dissolved Solids (TDS)	2000	44.30-46.00	47.00-48.00	48.3-52.0
mg/L		45.37±0.54	47.40±0.80	49.60±1.02

Table 2: Categories of Petroleum Effluent Indicators Taxa (species) Encountered at Eleme Branch of Imo River During the Period of Study.

Taxa (species)	Group	Tolerant Indicators (TI)	Facultative Moderately Tolerant Indicators (MTI)	Sensitive Indicators (SI)
Nais sp.		E		
Paranais sp.	olig	E		
Ophidonais	och		E	
Chaetogaster sp.	aet		E	
Aeolosoma hemprichi	es		E	
Elseniella tetrahedra			E	
Apus sp.	cr		E	
Daphnia barbata	us	E		
Macrobrachium sp.	ta	E		
Sudanonautus	ce			
Africanus africanus	a	E		
Lethocerus indicus		E		
Naucoris sp.	in	E		
Leptonea sp.	se	E		
Aphelocheirus grik	ct	E		
Dytiscus sp.	s	E		
Chironomus sp.		E		
Dragonfly nymphs		E		
EPT species				
NE				

Legend: TI = Tolerant Indicators
MTI = Moderately Indicators (Facultative)
SI = Sensitive Indicators
E = Encountered
NE = Not Encountered

Table 3: Petroleum Effluent Indicators Encountered at the three study stations of Eleme River During the Period of Study.

Taxa	Upstream	Midstream	Downstream
Nais sp	E	E	NE
Paranais sp.	E	E	NE
Daphnia barbata	E	E	E
Macrobrachium sp.	E	E	E
Sudanonautus africanus africanus	E	E	NE

Leptonea sp.	NE	NE	E
A.grik	NE	NE	E
L.indicus	NE	NE	E
Dytiscus sp.	NE	NE	E
Chironomus sp.	NE	NE	E
Dragonfly nymphs	NE	NE	E
Naucoris sp.	NE	NE	E

Table 4: Petroleum Effluent Facultative Indicators Encountered at the Stations During the Period of Study.

Vegetation	Sediments		
Taxa	Upstream	Midstream	Downstream
Diplonychus rusticus	E	NE	NE
Ophidonais sp.	NE	E	NE
Chaetogaster sp.	NE	E	NE
Aeolosoma hemprichi	NE	E	NE
E.tetrahedra	NE	NE	E
Apus sp.	NE	NE	E

Table 5: Impact of Sand mining on Species Richness of Macroinvertebrates at Eleme River, Rivers State, Nigeria

Phylum or class	Diversity Group	Species (Taxa)	Order	Family	Common name	Up-stream	Mid-Stream	Down Stream
Annelida	OLIGOCHAET (MEIOBENTHIC)	1. *Ophidonais sp.*	Naididae			-	+	-
		2. *Nais sp*	Naididae			+	+	-
		3. *Paranais*	Naididae			+	+	-
		4. *Chaetogaster*	Naididae			-	+	-
		5. *Aeolosoma sp*	Naididae			-	+	-
		6. *Eiseniella tetrahedra*		Lumbricidae	Square tailed worm	-	+	-
Sub-Total						2	6	8
Arthropoda	INSECTA (AQUATIC ENTOMOFAUNAL	1. *Diplonychus rusticus*	Hemiptera	Belostomatidae		+	-	-
		2. *Lethocerus indicus or americanus*	Hemiptera	Belostomatidae	Giant water bug	-	-	+
		3. *Naucoris sp*	Hemiptera	Naucoridae	creeping water bug	-	-	+

		4. *Leptonea sp*	Hemiptera	Hydropsychidae		-	-	+
		5. *Aphelocheirus grick*	Hemiptera			-	-	+
		6. *Dystiscus sp.*	Coleoptera	Dytiscidae	Predacious diving beetle	-	-	+
		7. *Chironomus sp.*	Diptera	Chironomidae	Midges	-	-	+
		8. *Dragonfly* nymphs	Odonata	Libellulidae		-	-	+
Sub-Total						1	-	7
Crustacea	CRUSTACEA	1. *Daphnia barbata*		Brachiopoda	Water flea	+	+	+
		2. *Apus sp.*		Brachiopoda	Triops or Tadpole	-	-	+
		3. *Macrobrachim sp*		Malacostraca	Shrimp Crayfish	+	+	+
		4. *Sudanonautus africanus*		Malacostraca	Freshwater crab	+	+	+
Sub-Total						3	3	4
Grand Total						6	9	11

Table 6: Diversity indices of the Habitat-types

Diversity indices	Habitat-types		
	Mechanical	**Manual**	**Unmined**
Taxa_S	6	9	11
Individuals	11	121	46
Dominance_O	0.273	0.166	0.124
Simpson_1-D	0.727	0.835	0.876
Shannon-H	1.509	1.904	2.214
Evenness_e^H/S	0.754	0.746	0.832
Brillouin	1.160	1.782	1.903
Menhinick	1.500	0.818	1.622
Margalef	1.803	1.668	2.612
Equitability_J	0.842	0.866	0.923
Fisher_alpha	3.487	2.248	4.580
Berger-Parker	0.438	0.223	0.196
Chao-1	9	9	11.5

Table 7: Percentage abundance (%) of invertebrate groups collected from the study sites

Phylum	1	% abundance	2	% abundance	3	% abundance	Total	% abundance
Annelida	10	12.5	115	38.08	0	0	125	26.60
Arthropoda	69	86.25	186	61.59	88	100	343	72.98
Mollusca	1	1.25	1	0.33	0	0	2	0.43
Total	80	100	302	100	88	100	470	100

Table 8: Percentage abundance of arthropod classes Encountered during the study

Phylum	1	% abundance	2	% abundance	3	% abundance	Total	% abundance
Annelida	4	5.80	0	0	42	47.73	46	13.41
Arthropoda	65	94.20	186	100	41	46.59	292	85.13
Mollusca	0	0	0	0	5	5.68	5	1.46
Total	69	100	186	100	88	100	343	100

The TPH, Nitrate, Phosphate, copper, and Nickel concentrations in all the sampling stations were above the intervention limits of the World Health Organization (WHO) (Table 4). The salinity and nitrate of the upstream that received the effluent waste discharge were less in concentration with mean values of 21.1 0.61mg/L, and 11.27±0.58mg/L, respectively. The station also contained the least concentration of Lead (0.023±0.001mg/L) and Nickel (0.116±0.00mg/L) (Table 4). The least concentration of TPH was recorded at mid-stream with a mean of 5.84±0.72mg/L.

The highest concentrations of physicochemical properties were recorded downstream: salinity (26.7±0.91mg/L), turbidity (15.7±0.72ntu), Nitrate (16.33±0.59mg/L), Phosphate (0.377±0.004mg/L), Copper (0.33±0.01mg/L), Lead (0.031±0.002mg/L), Nickel (0.137±0.003mg/L) and TPH (11.34±1.18mg/L) (Table 3). Downstream recorded the least concentrations of Dissolved Oxygen (4.35±0.17mg/L) and pH (6.37±0.02). Both suspended and dissolved solids were high in the station with mean values; of 21.57±0.46mg/L (TSS) and 49.60±1.02mg/L (TDS).

DISCUSSION

The absence of EPT species in all stations of the Eleme river investigated is an indication of Ecological poor health status. This is because species of EPT orders occur in good healthy water bodies and are usually sensitive to pollution and cannot inhabit polluted water ecosystems. The collaborative reports of Barman (2014) and Elias and Chilima (2017) that organisms belonging to the Ephemeroptera (Mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) are sensitive to pollution and typically occur in good quality water.

The number of taxa (species richness) and their individuals (species abundance) occurring in an ecosystem indicates the ecological health status of the ecosystem. An ecosystem richer in species and having high abundance is adjudged to be healthier, while otherwise is unhealthy and data (Burman, 2014) collected to reveal the effects of pollutants or changes in the ecosystem are used to assess anthropogenic impacts on the ecosystem. In this present study, most of the species encountered are tolerant to the petroleum effluent waste discharged into the water body. The collection of a high level of tolerant taxa is an indication that the Eleme river is ecologically poor in health. In fact, out of 18 species encountered, 12 (66.67%) are in the tolerant category.

The high number of taxa of oligochaetes and insects particularly Hemipterans (bugs) that dominated the sediments and vegetation, respectively, showed that these groups of species have a high tolerance for petroleum effluent wastes. The high number of oligochaetes collected from the mid-stream over the upstream implies that though both streams are poor in ecological health, that of the upstream is poorer (Table 2). Moreso, the occurrence of E.tetrahedra which usually occur in good freshwater in the mid-stream showed that the mid-stream is a little bit healthier. This agrees with the report that some genera of Lumbriculidae are associated with a water body that has good water quality (Fend, and Lenat, 2007).

Cheimonopoulou, et al. (2010) stated that the main river reaches of the Greek river possess moderate water quality, while downstream mainly contained poor water quality, due to its dominance by pollution-tolerant macroinvertebrate taxa. This was also observed in our study, as the absence of insect species at both up-and mid-streams, and its dominance by pollution-tolerant species downstream is an indication of poor-quality water. The non-availability of vegetation habitat at both up-and mid-streams is responsible for the absence of petroleum effluent waste-tolerant insect species. Payakka and Prommi (2014) argued that the presence of riparian vegetation and a suitable substrate increases insect taxa and abundance in aquatic habitats because vegetation may protect from predators, food for the insects, sites for oviposition, and source of respiratory oxygen. This situation may have prevailed at a very reduced rate downstream and was completely absent at both up and midstream of our study sites.

The high level of TPH recorded downstream is an indication that the downstream is more impacted by petroleum effluent waste. The reduction in the TPH level upstream (point of effluent entry) is due partly to an increase in the volume of water and water flow (current) caused by sand mining. This led to the flow of the pollutant downstream where there is less mixing of water. The presence of insect taxa that belong to three orders (Hemiptera, Odonata, and Diptera) of tolerant species downstream, indicates that the downstream is more impacted, and contain ecologically unhealthy water (poor quality water). These species; Dragonflies (Odonata), Bugs (Hemiptera), and Chironomus sp; (Diptera) have been described as pollution-tolerant species that occur in polluted water (Barman, 2014). Our study agrees with the description.

Natural stream water contains a dissolved oxygen range of 5-13mg/L, and less than 1.0mg/L for nitrates (Barman, and Gupla, 2015). However, in this present study, the DO range is 4.35-5.63mg/L. The low DO, and pH, high nitrates and phosphates recorded in our study; particularly in the downstream is an indication of poor water quality. This agrees with the report that such a situation can cause a reduction in water quality (Payakka, and Prommi, 2014), especially as it does not favor the assemblage of Trichoptera which is a pollution-sensitive group whose assemblage is favored by high values of DO and low levels of nitrate (Barman, and Gupta, 2015).

The high level of TPH triggered by the petroleum effluent wastes caused a variation in the levels of some physicochemical properties which consequently cause a poor ecological health status of the Eleme water body of Aleto and Agbonchia.

Living organisms contribute immensely through their functions to their communities and ecosystems. In our study three groups of functional diversities were encountered; predatory, detritivorous, and collectors. The abundance of detritivores; oligochaetes and crustaceans, including Daphnia sp indicates that decomposition or degradation is ongoing in the ecosystem at the sediment levels in the midstream. The reduced number of detritivores upstream is an indication that decomposition is slow and inefficient when compared with the midstream.

In the downstream, the collector-functional group is abundant showing that filterer-detritivorous activities are also ongoing.

The inducement of the dominance of decomposers comprising detritivorous and collectors functional groups over the predatory functional group by petroleum effluent wastes is in good faith for the sediments and water at midstream and downstream, respectively. It will naturally, though at a longer time degrade the pollutant. This responsibility is lacking in the upstream, but at the midstream, it is performed by Oligochaetes and Crustaceans, while the insects carry it out downstream.

This agrees with the report that the abundance of a functional group in an ecosystem indicates the different quality of the water body (Barman, 2014) and provides information on the state of ecosystem functionality (Paraschiv *et al*., 2013). Ecosystems dominated by predator insects are usually not good while those dominated by the collector-insect functional group are better ecosystems (Barman, 2014) as it will help in natural recovery.

CONCLUSION

The absence of insect species belonging to the orders; Ephemeroptera, plecopteran, and Trichoptera indicate that the Eleme river is polluted, however, the dominance of collector-functional groups is an indication that the ecosystem is undergoing natural recovery. The study also shows that Eleme river contains petroleum effluent tolerant indicators.

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