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Ecological studies on benthic fauna from Alaro Stream in Ibadan

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Abstract
Distribution and abundance of the benthic fauna as indicators of the degree of pollution was studied. The physical hydrological factors like temperature, water current velocity, water width and depth was determined while benthic fauna were collected at the four study sites in Alaro Stream for five weeks between December 2003 and January 2004. The results showed that there was varying diversity in the number of different genera of benthic fauna at the different sites in Alaro Stream during the sampling period. *Limnae* (87.9%) had the highest number among the benthic fauna while the other benthic fauna encountered included *Chironomus* (6.5%), *Eristalis* (4.1%), *Rana* (0.8%), *Corixa* (0.5%) and *Ambrysus* (0.2%). There was recovery through self-purification from the point of effluent discharge as indicated in the increasing biodiversity downstream.

1. Introduction

Growth of industries and increase in pollution has made inland water to become the recipient of organic matter in amounts exceeding their natural purification capacity [1]. This changes the good quality of the water body making it unfavorable for aquatic organisms [1]. Several studies on aquatic ecosystem impairment have been reported in Nigeria [2-7].

It has been observed that the amount of pollutants contributed by a small -scale industry may be equal to that contributed by the sewage from a large city [8]. The nature and quantity of wastes differ from industry to industry depending on the nature of raw materials, process used, products manufactured and any by-products produced [9]. Some effluents are bound to be produced as long as industrial production continues [8]. Ogbeibu and Ezeunara [10] have reported that these industrial effluents finally end up in the aquatic ecosystems as allochthonous inputs from surface runoffs or through direct discharge from waste-generating industries.

Ford [11] asserts that aquatic pollution is any alteration of chemical, physical or biological quality of water which results in unacceptable depreciation which adversely affects its subsequent beneficial uses. Temperature is one of the factors that affect the survival and adaptability of aquatic organisms. Rates of chemical and biological reactions double for every 10°C increase in temperature [12]. This means that aquatic lives will utilize two times as much oxygen at 30°C as they would do at 20°C. Oxygen requirement of aquatic forms is more critical when temperature is high than when temperature is low. Temperature greatly influences metabolic and physiological activities and life processes such as feeding, reproduction, growth, movement and distribution of aquatic organisms. Boyd [12] and Odiete [1] reported that oxygen content of water decreases with rise in temperature and vice - versa.

Dejoux *et al* [13] reported that organic wastes mineralize in the receiving water bodies and the resulting nutritive elements stimulate plant production leading to eutrophication. Pollution through organic eutrophication affects photosynthesis which is the primary means of food production that sustains the aquatic animals. Odiete [1] has asserted that the decomposition process of organic matter utilize oxygen, thereby reducing the minimum dissolved oxygen required by the aquatic animals. A rapid influx of extra nutrients upsets the balance and throws the ecosystem into a chaotic proliferation of blue-green algae, which cuts out the light supply to the deeper regions of the water such that the plants below the surface die and decay. This leads to a further increase in nutrient level and then growth rate until sheer space becomes a limiting factor. The algae bloom represents a massive accumulation of organic matter as competition for light kills the lower layers of the algae bloom, saprophytic fungi and bacteria are stimulated to grow. These absorb oxygen and so deoxygenate the water thereby killing fish and other aerobic benthic fauna [14].

According to Odiete [1], sewage decreases the number of benthic invertebrates and also promotes the growth of benthic algae; settlement of silts and other solids at the bottom of the stream can smother or quench bottom line. Most benthic fauna feed on the debris that settle at the bottom of the water and in turn serve as food for variety of fishes. Thus, benthos plays a vital role in the nutrient circulation in aquatic environment. They accelerate the breakdown of organic matter into inorganic forms while some of the macrobenthos also act as indicators of pollution and other human-induced stress factor [15].

Case history of oil spills in Nigeria reveal that the effects of spills on the aquatic environments linger in the littoral vegetation, soils and river bottom sediments long after the degradation of oil from water. In the early 1970s, measurements of pollutants residues in aquatic organisms were recognized to be a valuable addition to analyses of water and sediments [16] [17].

Benthic macro-infauna species are important as food for economically important fish and shellfish species in most aquatic environment where they are the major secondary producers. Impacted changes in the water quality are reflected in the biotic community structure, with the most vulnerable dying. While the most sensitive species act as indicators of pollution [18] [19] [11]. Studies in water quality management have dealt with the use of macro-invertebrate in evaluating the impacts of specific pollutants in aquatic environments [18] [20] [21] [22][23] [24] [25].Self-purification studies of Ogunpa carried out by Ajayi and Adelaye [2] revealed the relative ease with which the stream recovered from pollution stress.

The stress, demands and hazards of Alaro stream, are brought about by the continuous disposal of wastes into it, while rapid industrialization could account for effluent discharges into it [26].

This study is aimed at sampling benthic fauna and measuring the physical parameters (Temperature, water current velocity, depth and width of the stream) at four different sites for five weeks with a view to measuring the distribution of benthic fauna as well as assess the abundance and diversity of the biota which are the indicators of the degree of pollution at the different sites in Alaro Stream in Ibadan.

2. Materials and Methods

2.1. Study Area

Alaro stream is located in Oluyole local Government Area of Ibadan, Oyo State of Nigeria. Like other streams it is characterized by unidirectional flow of water. The current velocity varies with the climatic condition of the year; it is usually higher in the rainy season and lower during the dry season. The study sites are located within Oluyole industrial estate between latitude 7^o 21’N -7^o 22’N and longitude 3^o 50’-3^o 52’E.Alaro stream flows into Oluyole in a west –south east direction from its source at Agaloke near Apata in Ibadan. It joins river Ona at the south east end of a meat processing factory as its main tributary.

Sampling of benthic fauna and the measurement of physical parameters were done at four different sites in Alaro stream, Ibadan, once a week for a period of five weeks (December to January).

Site 1 was taken as the "control point" and assumed to be relatively unpolluted. The substratum of site 1 was characterized by sand and stones of diameter between 0.2m - 0.8m. Site 2 had muddy substratum with smaller stones of diameter between 0.1m - 0.2m. The substratum of site 3 was embedded with stones of 0.1m - 0.2M in diameter, and covered with algae bloom. In Site 4, the substratum was sandy and covered with algae bloom.

2.2. Temperature

For temperature, the mercury in glass thermometer (50°C) was used. Air temperatures were first taken by avoiding direct sunlight. Water temperatures were taken by inserting the thermometer in water at 2cm below the water surface and allowing to stabilize for about two minutes before readings were taken.

2.3. Water Current Velocity

Current velocity was measured with a float in water, a stopwatch and a measuring tape. The tape was laid down along the bank of the stream, the float was placed in the water at point O metres, the length of time it took the float to travel a distance of 2. 6 metres was measured with the stop watch.

The current velocity was calculated as:

$$\frac{\text{Distance Covered (Metres)}}{\text{Time Taken (Seconds)}} = \text{M/s}$$

2.4. Water Depth

For water depth, measurement was taken with a long pole and a measuring tape. The pole was dipped into the middle of the stream and the point where the water stopped was marked and measured with the measuring tape.

2.5. Stream Width

This was taken with a measuring tape. The tape was held across one side of the stream and measurement was taken from the other end.

2.6. Sampling Benthic Fauna

A metal shovel-shaped material with diameter of 0.6 meters was used to scoop the stream substrate. Some of the macro-benthos was hand-picked. Other benthic invertebrates were extracted by wet-sieving. Extracted benthic fauna were placed in bottles of water containing 4% formalin solution and then the bottles were corked tightly.

In the laboratory, the benthic fauna were sorted using a shallow white tray, while a dissecting microscope was used to observe some of the organisms and identified using an identification key by Miles, *et al* [27].

3. Results and Discussion

3.1. Temperature

Table 1. *Temperature variation at the study sites*

Period	PARAMETER	Site 1	Site 2	Site 3	Site 4
Week1	H_2O TEMP. (°C)	27	26	25	28
	AIR TEMP. (°C)	30	29	26	30
Week 2	H_2O TEMP. (°C)	30	29	28	27
	AIR TEMP. (°C)	32	32	30	29
Week 3	H_2O TEMP. (°C)	27	29	29	28
	AIR TEMP. (°C)	29	32	32	29
Week 4	H_2O TEMP. (°C)	26	27	29	28
	AIR TEMP. (°C)	28	29	32	30
Week 5	H_2O TEMP. (°C)	25	27	25	26
	AIR TEMP. (°C)	26	29	27	28

The lowest mean temperature of surface water (27^0C) was recorded in site 1, while the highest mean surface water temperature of 27.6^0C was recorded in site 2. Slingsby and Cook [28] had extensively discussed temperature differences at water sampling sites influenced by organic pollution which showed higher temperatures than others due to decomposition.This is corroborated by Brinkhurst [29] in his discussion on organic pollution and other authors [5][7][30][31] who made similar observations. During the same period of study, atmospheric temperatures were generally higher than aquatic temperatures as shown in Table 1.

3.2. Water Current Velocity

Table 2 shows the variations in the current velocity of the stream throughout the sampling period. Site 1 had the highest water current velocity (0.26m/s) during the sampling period while the lowest current velocity of 0.14m/s was recorded in Site 4.Similar observations had been asserted where hydrophytes limited the water current velocity depending on their abundance as well as nature of the shoreline and substratum [32].

Table 2. *The variations in the water current velocity (m/s) at the study sites during the study.*

Period	Site 1	Site 2	Site 3	Site 4
Week1	0.26	0.25	0.22	0.19
Week 2	0.19	0.17	0.16	0.14
Week 3	0.20	0.20	0.19	0.16
Week 4	0.24	0.20	0.22	0.17
Week 5	0.20	0.19	0.22	0.17

3.3. Water Depth and Width

Table 3 shows the variations in both width and depth during the sampling period. From the data obtained, there was gradual reduction in both width and depth of Alaro stream during the sampling period. The reduction in depth and width could be due to gradual deposition of organic debris on the substratum and along the shoreline arising from human activities from the catchment hydrology as corroborated by other authors and studies that found similar results [14][15][25] [32].

Table 3. *Variations in the depth (metres) and width (metres) of the stream.*

Period	Parameter (M)	Site 1	Site 2	Site 3	Site 4
Week1	H_2O Depth /H_2O Width	0.35 /2.00	0.39/ 1.90	0.23 /5.95	0.36/ 5.11
Week 2	H_2O Depth /H_2O Width	0.32 /1.70	0.35 /1.50	0.20 /5.88	0.32 /5.70
Week 3	H_2O Depth /H_2O Width	0.30 /1.50	0.34 /1.40	0.19 /5.86	0.30 /5.60
Week 4	H_2O Depth /H_2O Width	0.28 /1.30	0.33 1.40	0.18 /5.85	0.28 /5.40
Week 5	H_2O Depth /H_2O Width	0.29 /1.40	0.33 /1.40	0.18/ 5.85	0.29 /5.40

3.4. Benthic Fauna

Table 4 shows the diversity in genera and number of benthic fauna at different sites during the 5 weeks sampling period at Alaro stream, Ibadan.

There was diversity in the number of different genera of benthic fauna at the different sites in Alaro stream. Site 3 had the highest number (717) of benthic fauna during the sampling period. Among the benthic fauna, *Limnae spp* had the highest number (663), and this was recorded in site 3. Throughout the sampling period, *Rana spp* was found only in Site 1 possibly due to its favourable nature to the species given its moderate temperature and high water current velocity that favors oxygenation of the water and conveyance of food particles [32][33][34].During the 5 weeks sampling period, *Corixa spp* was encountered three times, while *Ambrysus spp* was encountered twice. These variations in species abundance may be due to niche structuring that affects species availability, predators such as fish that consume them and their ability to migrate before the sampling [33][35].

Table 4. *Abundance of benthic fauna at different sites*

Genera	Sites	Wk1	Wk2	Wk3	Wk4	Wk5	Total
Rana	1	2	1	3	1	2	9
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	Total	2	1	3	1	2	9
Limnae	1	0	0	0	0	0	0
	2	6	22	16	16	26	86
	3	233	137	105	101	87	663
	4	33	43	36	36	36	184
	Total	272	202	157	153	149	933
Eristalis	1	0	0	0	0	0	0
	2	7	9	5	4	6	31
	3	1	3	4	4	0	12
	4	0	0	0	0	0	0
	Total	8	12	9	8	6	43
Chironomus	1	0	0	0	0	0	0
	2	3	0	0	2	0	5
	3	20	6	0	2	8	35
	4	5	8	6	5	4	28
	Total	28	14	6	9	12	69
Corixa	1	0	0	0	0	0	0
	2	0	0	0	0	2	2
	3	0	2	1	0	0	3
	4	0	0	0	0	0	0
	Total	0	2	1	0	2	5
Ambrysus	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	1	1	0	0	2
	4	0	0	0	0	0	0
	Total	0	1	1	0	0	2
Grand total		310	232	177	171	171	1061

4. Conclusion

The average water temperature in the study falls within the range found in the tropics (23^0C- 29^0C) as corroborated in other studies. Thus mean surface water temperature of 27.0^0C - 27.6^0C were recorded for all the sampled sites. The highest mean surface water temperature (27.6^0C) recorded in site 2 can be attributed to influx of effluents at the site that contributes to decomposition that gives off the heat. The lower air temperatures recorded during the sampling period were associated with the cold harmattan wind in December 2003 and January 2004 that is commonplace in the ecological zone.

Chironomus, Limnaea and *Corixa* were the benthic fauna that tolerated water of poor quality at the effluent discharge point as shown by their abundance. The presence of *Rana sp.* in site 1 (the control site) and its absence from the other sites could be due to the low level of organic decomposition and aerobic conditions at the control site. Increase in the number of benthic fauna in site 2 could be attributed to the influx of nutrients from the organic decomposition of the effluents.

The increase in the number of the pollution-tolerant *Chironomus* and *Limnaea* and a marked reduction in other benthic fauna can be attributed to the fact that these organisms thrive in conditions of active decomposition of organic matter where oxygen level is very low. It has been shown that *Chironomus* can survive anoxic conditions for several a long period that can span up to several weeks. Site 4 can be described as the point where there is recovery from pollution stress due to the increase in biodiversity from sites 2 to 4 due to natural self-purification.

This study contributes to further understanding of the effects of physical hydrology on the abundance of benthic fauna in a tropical stream ecosystem. The study found a decrease in the water depth and width of the stream which is attributable to organic deposition as a result of human activities such as industries that discharge untreated wastes into the stream and through storm run-offs from the catchment hydrology. It can be concluded that effluent discharge Alaro stream in Ibadan has negatively impacted on the faunal diversity and physical hydrology of Alaro Stream. It is therefore recommended that organic wastes should be treated before being discharged into receiving streams and a monitoring program for physical hydrology and species diversity should be established for streams and rivers in Ibadan, Nigeria.

References

[1] Odiete, O.W.: Environmental Physiology of Animals and Pollution Diversified Resources Publishers.61-70 (1999).

[2] Ajayi, S.O., Adelaye, S.A.: Pollution studies on Nigerian rivers I. Bull. Chem Soc. Nigeria. 2, 77-82(1977)

[3] Mombeshora, C., Osibanjo, O., Ajayi, S.: Pollution studies on Nigerian rivers. Toxic heavy metal status of surface waters in Ibadan city, Environment International. 5, 49-53 (1981).

[4] Ajao, E.A.: The influence of Domestic and industrial Effluents on the population of sessile and Benthic Organisms in Lagos Lagoon, PhD Thesis, University of Ibadan, Ibadan.1-411 (1990).

[5] Ogbogu, S.S., Hassan, A.T.: Effects of sewage on Physico-chemical variables and Ephemeroptera (Mayfly) larvae of a stream-reservoir system. Journal of Aquatic Sciences. 11, 43-55 (1986).

[6] Oben, B.O.: Limnological Assessment of the impact of Agricultural and Domestic Effluents of three man-made Lakes in Ibadan, Nigeria, Ph.D. Thesis, University of Ibadan, Nigeria.(2000).

[7] Ogbogu, S.S.: Assessment of Water Quality and macroinvertebrates abundance in Opa Stream-Reservoir system, Ile-Ife Global Journal of Pure and Applied Sciences.7, 517-521 (2001).

[8] Agarwal, S.K.: Pollution Ecology. Hinanshu Publication, Udapur, India.1-222(1991)

[9] Ademoroti, C.M.A.: Environmental Chemistry and Toxicology. Foludex Press Ltd, Ibadan, Nigeria. 1-215 (1996).

[10] Ogbeibu, O., Ezeunara, P.U.: Ecological impact of brewery Effluent on the Ikpoba River using the fish community as bio-indicators of pollution, Journal of Aquatic Sciences. 17, 35-44 (2002).

[11] Ford, J.: The effects of chemical stress on aquatic species composition and community structure. In: Levin, S.A, Harwell, J.R. Kelly and K.D. Kindall (Eds), 1989.

[12] Boyd, C.E.: Water Quality in Warm Water fish ponds, Craft Master Printer, Inc Opelika, Alabama.25-34(1979)

[13] Adamson, R.G.: Pollution: An Ecological Approach. T - Best Publishers, Canada. (1979)

[14] Egborge, A.G.M.: Water Pollution in Nigeria: Biodiversity and Chemistry of Warri River.1-331(1994)

[15] Ajao, E.A., Fagade, S.O.: A study of sediment communities in Lagos Lagoon, Nigeria. Journal of Oil and Chemical Pollution. 7, 85-105 (1991)

[16] Philips, D.J.: Quantitative Aquatic Biological Indicators. Applied Science Publishers, London.1-488(1980).

[17] Obeng, L.: Man's impact on tropical rivers. In: Lock, M.A. and Williams, D.D (Ed), *Perspectives in running water biology.* Plenum Press, New York. 259-310(1981).

[18] Winner, R.W., Boesel, M.W., Farrell, M.P.: Insect community structure as an index of Heavy metal pollution in lotic ecosystems. Canadian Journal of Fisheries and Aquatic Science. 37, 647-655(1980)

[19] Rosenberg, D.M., Danks, H.V., Lemhkuhi, D.M.: Importance of insects in Environmental Impact Assessment. Environmental Management.10, 773-783.

[20] Dills, G., Rogers, D.T.: Macroinvertebrate community structure as indicators of acid Pollution. Environmental Pollution. 6, 239-262(1974).

[21] Scrimgeour, C.J.: Effect of bleached Kraft Mill Effluents on macroinvertebrates and fish populations in weed beds in a New Zealand lake. New Zealand Journal of Marine and Freshwater Research. 23,373-379(1989).

[22] Quinn, J.M., Hickey, C.W.: Effects of sewage waste stabilization lagoon effluents on Stream invertebrates. Journal of Aquatic Ecosystem Health. 2,205-219 (1993).

[23] Monda, D.P., Galat, D.L., Finger, S.E.: Evaluating ammonia toxicity in sewage effluent to stream macroinvertebrates: A multi-level approach. Archives of Environmental Contamination and Toxicology. 28, 378-384(1995).

[24] Ort, M.P., Finger, S.E., Jones, J.R.: Toxicity of crude oil to the Mayfly, *Hexagenia bilineata* (Ephemeroptera: Ephemerida). Environmental Pollution. 90,105-110 (1995).

[25] Matagi, S.V.: The effect of pollution of benthic macroinvertebrates in a Ugandan Stream. Archives of Hydrobiology.137, 537-549 (1996).

[26] Odiete, R.A.: The implications of rapid urbanization: some considerations of the Warri example. BSc Essay submitted to University of Ibadan, Geography Department.1-65(1972).

[27] Miles, P.M., Miles, H.B., Gratiam, V.E.: Tropical freshwater Ecology.1-250(1970)

[28] Slingsby, D., Cook, C.: Practical Ecology. Cambridge University Press.1- 213 (1986)

[29] Brinkhurst, R.O.: Organic pollution. In: Pollution: causes, effects and control (Ed), Harrison. R.R. The Royal Society of Chemistry, London. p 103(1990).

[30] Cole, G.A.: Textbook of Limnology. The C.V. Mosby Company.1-283(1975).

[31] Pennak, R.W.: Freshwater Invertebrates of the United States. Second Edition, John Wiley and Sons, New York. (1978).

[32] Hynes, H.B.N.: The Ecology of running waters. University of Toronto Press. (1970).

[33] Odum, E.P.: Fundamentals of Ecology.W.B.Saunders Ltd, Philadelphia.1- 610(1971).

[34] Nigerian Environmental Study Action Team (NEST).The perspective in Environmental Management. In: Proceedings of Nigerian Environmental Study Action Team (NEST) from 1991 to 1995.1-169 (1995).