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Heavy Metal Composition in Industrial Effluent on Alaro Stream Benthos.

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Abstract: An assessment of the impact of industrial effluents from Oluyole industrial Area on Alaro stream and a pond, was carried out in August – November, 2002. The heavy metal concentrations of the stream and pond and effluents were investigated to determine their effects on the water quality, the distribution and abundance of benthos in the stream and a pond. The major components of the benthic community in the stream and the pond were dominated by *Monhystera* and *Chironomus,* which were known to be pollution stress tolerant. The mean heavy metal concentration ranged between : As (0.40 – 1.60), Cd (0.65 – 1.60), Cu (1.0 – 11.60), Pb (0.50 -1.60), Hg (0.40 – 1.63), Ni (0.40 – 2.00),and Zn (0.10 – 2.20).

Key words: benthos, effluent, heavy metal, pollution.

INTRODUCTION

Water is a very valuable but finite natural resource on which life depends for survival. All facets of the hydrological cycle are utilized by man for multifarious purpose for his survival and comfort in domestic and commercial water supply, agricultural food production, fishing, energy generation, transportation, industrial and recreational activities (Aina, E.O., 1990).

The history of water pollution problem dates back to the 19^{th} century when outbreaks of cholera epidemic and other water-borne diseases, occurred in Europe as a result of gross organic pollution of river with raw human wastes. Rapid industrial and technological developments of the mid-nineteenth century in Europe further compounded the water pollution problems (Aina, E.O., 1990). Aquatic ecosystems are still suffering from the large amount of hazardous compounds introduced into them by man. The presence of heavy metals in aquatic environment may render it unsuitable for some fauna and flora, and the potential risk of bioaccumulation along the food chain cannot be over emphasized. Take for instance, many industries discharge raw, untreated and highly toxic wastes (effluents) into open gutters, drains, streams, ponds, cannals, river, etc. Effects of this act have almost rendered many of our surface water system unsafe for domestic, agricultural, recreational and other beneficial uses, destroys life, poisons the natural ecosystems and even threat to human life. Little wonder that water-related disease such as diarrhoea, cholera, typhoid fever, hepatitis, dysentery, guinea worm, poliomyelitis, skin diseases are rampant in the country, both in the urban and rural communities. Though, most importantly children who normally have low immunity, and rural populace with poor healthcare facilities, are particularly vulnerable victims of these epidemics.

MATERIAL AND METHODS

Study Area:

Ibadan the capital of Oyo State is the largest urban center in West Africa. Based on the 1991 provisional census data, it has a built up area of 240km^2 and a population of 1,991,367 (Ogbuagu, H.D., 1999). Oluyole Industrial Estate is one of the industrial layouts of Ibadan. It is located on latitude $7^0 19^1 10^{11}$N –$7^0 23^1 36^{11}$N and longitude $3^0 50^1 33^{11}$E – $3^0 55^1 16^{11}$E. It is about 1.5km away from Mobil filling station along Ring Road – Challenge expressway in Ibadan Southwest Local Government Area.

The industries: SUMAL, 7UP, bottling company and INTERPACK are situated about 80m away from Alaro stream – a tributary of RIVER Ona. ISO-GLASS is located about 250m away from the Alaro stream. SUMAL, 7UP, and INTERPACK, discharged their effluents collectively through an underground pipe which possibly joins Alaro stream somewhere further down stream. A small pound is situated about 4m from ISO-GLASSS (Fig.1).

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During the raining season, the stream is known to overflow some of its banks along its flow route. The water is more turbid in the raining season than dry season, possibly due to runoff and other discharges. The stream is characterized by pungent smell in the dry season and occasional complete dryness of the stream has been observed, most importantly during severe dryness or longer dry months. The bed of the stream consists of sand and gravels upstream, while sand, silts, gravels and rocks characterized the down stream. Refuse dumps with human faeces and farmlands bordered the sides of the downstream and farmland upstream. The pond on the other hand is a stagnant pool of clear or transparent water, which Usually flows on the road during the raining season. The pond is characterized by vegetation growing round it, pondweeds growing in some portions of the pond. Nefarious odour oozes out occasionally from the pond. The bed of the pond consists of sand, silt and generally muddy dark-coloured sediment with decaying vegetable matter. Total dryness of the pond was observed during the course of this study.

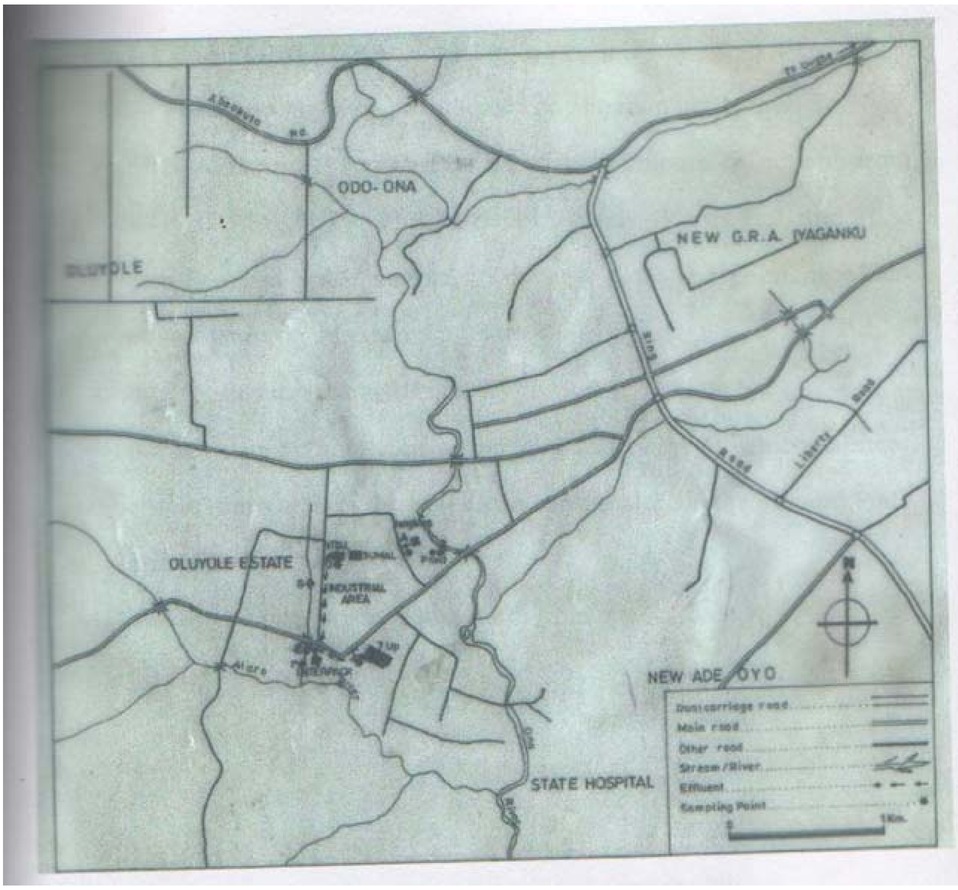

Fig. 1: Extract map of Ibadan metropolis showing sampling points.

Sampling Sites:

The sampling sites as indicated on the map (fig.1) are:

- Sites A, C and D – represent the direct effluents collections from ISO- GLASS, 7UP, and SUMAL respectively.
- Site E – mid down stream, 15m away, from the point at which effluent enters Alaro stream.
- Sites F – down stream.15m away from site E.
- Sites G – upstream, 30m away from the point which effluent enters Alaro stream. It serves as a control site for the stream.
- State B – a pond which is about 4m from site A.

Analysis of Metals in Effluents and Water:

A representative of each of well-mixed sample (100ml) was transferred into a beaker and 5ml of concentrated HNO_3 was added.

The solution was evaporated to near dryness on a hot plate, making sure that the sample did not boil. Heating was continued with addition of acid, until digestion was completed. (Light coloured residue obtained). 2ml concentrated HNO_3 was added to dissolve the residue. The residue was washed with distilled water and filtered to remove silicates and other insoluble materials. The volume of solution was adjusted to 100ml in a volumetric flask. A sample solution and blank sample were analyzed for total heavy metals using BUCK 200 Atomic Absorption Spectrophotometer from the institute of Agricultural Research and Training, (IAR& T) Moore Plantation, Apata, Ibadan Oyo State, Nigeria.

Collection of Sediments for Benthic Organisms:

Sediments were collected with shovel at a depth of about 10 – 15cm at sites B, E, F and G. The sediments from each site were sieved with 0.5mm and 1mm sieves over running water and organisms retained were taken as the benthos for the sites. The organisms were preserved in 5% formalin. Benthos were identified using the method provided by Needham and Needham, Durad and Leveque (Duran, 1980; Needham, 1969).

Statistical Analyses:

1. Shannon Weiner's species diversity index was used to estimate the diversity benthic organisms sampled. Shannon Weiner's index =

$$H^1 = \sum^s i=1 \ (P_i) \log_2 P_i \text{ or } H^1 = \sum^s_i =1 \ [P_I * 3.321928 \log_{10} (P_i)]$$

Where H = index of species diversity in bits per individual or decits
S = number of species
P_i = proportion of total sample belonging to 'I' species
$P_{i\,=}$ n/N
2. Margalef' index of diversity for the sites richness (Margalef, 1961).
I =S – I/LogN
Where I = Margalef' index
S = number species
N = total number of individuals
3. Correlation coefficient of the heavy metals in the sites was used to determine the relationship between variables (Ikporukpo, E., 1994).

RESULTS AND DISCUSSION

Heavy Metal Studies in the Surface Water and Effluents:

The lowest and the highest range of heavy metal concentrations recorded in the surface water and the effluents, from August-November (Table 1), were:

Arsenic (As) – Arsenic ranged between 0.40 and 1.60 mgl^{-1} in site E and C in the months of November and October respectively. As showed a perfect negative significant correlation with Cu (r=-1.00, p<0.05) at site E.

Cadmium (Cd) – Ranged from 0.65mg^{-1} and 1.60 mgl^{-1} in site A and C respectively in the most of month of October. Cd showed a strong negative significant correlation with Ni (r=-0.92, p>0.05), and with Zn(r=-0.89,p=0.05) in site E.

Copper (Cu) – This ranged between 1.00 mgl^{-1} in site G and 11.60 mgl^{-1} in site D in the months of August and November respectively. A strong negative significant correlation of Cu with Pb (r=-0.93,p<0.05) was obtained in site G.

Lead (Pb) – Lead concentrations ranged between 0.50 Mgl^{-1} and 1.60 Mgl^{-1} at site D, E and C, in the months of November and October respectively.

Mercury (Hg) – ranged between 0.40 mgl^{-1} in site D and 1.63 mgl^{-1} in site C in October and November respectively.

Nickel (Ni) – Nickel concentration in the samples ranged between 0.40 mgl^{-1} in site E and 2.00 mgl^{-1} in site F in November.

Zinc (Zn) – ranged between 0.10 mgl^{-1} and 2.20 mgl^{-1} in site E and D respectively in the month of November.

Table 1: Heavy metal concentration of the effluent, Alaro stream, and a pond in August-November.

		Effluent	Pond	Effluent		Alaro stream		
Parameters (Mgl^{-1})	Month	A (Mgl^{-1})	B (Mgl^{-1})	C (Mgl^{-1})	D (Mgl^{-1})	E (Mgl^{-1})	F (Mgl^{-1})	G (Mgl^{-1})
ARSENIC	AUG	1.2	0.8	1.42	1.05	1	1.2	0.8
(As)	SEP	1.12	0.95	1.4	1.02	1	1.24	0.8
	OCT	0.72	0.8	1.6	0.83	0.85	0.8	0.92
	NOV	-	-	1.1	1.2	0.4	1.4	1
CADMIUM	AUG	1	0.8	1.44	1.2	0.9	1.2	0.86
(Cd)	SEP	1.15	0.93	1.43	1	1	1.2	0.85
	OCT	0.65	0.7	1.6	0.9	0.7	0.8	0.87
	NOV	-	-	1.3	0.8	1.4	1.2	0.8
COPPER	AUG	1.2	2.2	1.42	1.4	1.2	1.8	1
(Cu)	SEP	1.4	1.28	1.6	1.5	1.23	1.6	1.1
	OCT	2.6	2.4	3.6	2.8	2.6	2.4	2.6
	NOV	-	-	7.4	11.6	7.6	0.4	8.2
LEAD	AUG	1.18	0.84	1.38	1	1.2	1.2	0.85
(Pb)	SEP	1.15	0.98	1.43	1.1	1.17	1.2	0.83
	OCT	0.7	0.8	1.6	0.8	0.8	0.8	0.9
	NOV	-	-	0.75	0.5	0.8	0.7	0.5
MERCURY	AUG	1.2	0.8	1.42	1.05	1	1.26	0.8
(Hg)	SEP	1.19	1.15	1.45	1.15	1.06	1.28	0.87
	OCT	0.63	0.65	1.63	0.65	0.83	0.75	0.8
	NOV	-	-	0.71	0.4	0.8	0.73	0.5
NIKEL	AUG	1.2	1.2	1.4	1.3	1.2	1.3	1
(Ni)	SEP	1.3	1.2	1.6	1.4	1.2	1.5	0.9
	OCT	1.23	1.2	1.81	1.2	1.23	1.2	1.2
	NOV	-	-	1.4	1.4	0.4	2	1.6
ZINC	AUG	1.2	1.4	1.5	1.4	1.25	1.75	1.2
(Zn)	SEP	1.38	1.25	1.62	1.42	1.23	1.55	1
	OCT	1.21	1.22	1.8	1.19	1.2	1.2	1.22
	NOV	-	-	0.25	2.2	0.1	0.3	0.2

The range of heavy metals averagely in all the sites were above FEPA and WHO standard. Though, moderately low values were obtained in site G (which was devoid of the effluents). Anthropogenic sources may have contributed to occasional high values recorded in these sites (Table 1). The high concentration of heavy metals in the effluent sites than the stream and the pond, may imply that metal levels in the water depend on the composition of effluents discharging or entering the water (stream and pond).

The toxicity and other effects of heavy metals to aquatic life are significantly modified by numerous biological and abiotic factors such as: water, temperature, pH, Eh, Phosphate concentration, suspended solids presence of other substances and toxicant, organic content, duration of organism exposure, speciation (Bryan, 1985; McGeachy, 1990; Sanders, J.G., 1986).

Table 2: Monthly collections for quantitative count of benthos from Alaro stream and pond.

	OCT				NOV			
	B	E	F	G	B	E	F	G
NEMATODA								
Monhystera spp	5	1	1	6	-	-	-	1
Diplogasteroides spp	-	-	2	1	-	-	-	-
ANNELIDA								
Tubifex spp	7	-	1	3	-	2	6	2
Earthworm spp	-	-	-	-	8	-	-	-
INSECTA								
Chironomus spp	4	1	6	3	-	-	4	2

Studies on the Diversity and Distribution of Benthic Organisms:

A total of 66 benthic organisms were identified and recorded during the last two months (October and November) of the study period (Table 2). These organisms include 2 genera of nematoda, 17 (25.76%); 2 genera of annelida, 29(43.94%) and 1 genera of insecta, 20(30.30%). Site G recorded the highest number of individual benthos of 28 (36.84%); this was followed by site B, 24 (31.58); site F, 20 (26.31%);and the least in site E,4 (5.26%).

The Shannon Wiener's index of species diversity showed that annelida with 0.09 was the most diverse in site B. Nematoda with 0.92 and 0.54 had the highest diversity in sites F and G respectively. Site E recorded no species diversity. Margalef's index of diversity for the study sites showed that site E with 3.32 was the most diverse site, followed by site B with 2.49, site G with 2.39 and site F with 2.31 was the least diverse site. These results supported Margalef's (1961) observation that the biodiversity of a place (habitat) cannot be measured only by the numerical abundance of one or two species, but by the stability and fitness of various species in such a place. Site B, G and F might have showed more numerical abundance of organisms of the same species than site E but not various species as found in site E. The extremely low numerical abundance of the benthos in the stream and the pond may be in support of observation made by Ajao, (1990), that most effluents are not composed of a single toxic substance, therefore, the potential interaction of the pollutants in either a synergistic or an antagonistic manner may have affected the benthos population greatly in the stream and pond.

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