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Full Length Research Paper

Studies on the effect of abattior and industrial effluents on the heavy metals and microbial quality of Aba river in Nigeria

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Levels of lead, iron, zinc, copper, arsenic, cobalt, chromium, manganese, mercury and cadmium, as well as the microbial profile were determined in water samples from Aba River. Physico-chemical examinations revealed that manganese (0.03 mg/l), zinc (4.81 mg/l) and copper (0.19 mg/l) were below the maximum allowable levels set by the United States Environment Protection Agency (USEPA), while lead (0.064 mg/l), iron (0.81 mg/l), arsenic (0.1 mg/l) chromium (0.006 mg/l) and mercury (0.009 mg/l) were high but not significantly. The implication is that waste assimilation capacity of the river is high, a phenomenon attributable to dilution, sedimentation and depuration. Quantitative examinations of the microorganisms present revealed that as many as 2.05 x 10^8 viable bacterial (cfu/ml) were present. The predominant bacterial forms include *Staphylococcus* species, *Streptococcus faecalis*, *Escherichia coli*, *Salmonella* species, *Bacillus* and *Clostridium* species implying that the abattoir wastes discharged into the river may have had a significant impact on the river ecosystem.

Key words: Waste assimilation, effluent, low level metals, pollution.

INTRODUCTION

Aba River is an important economic river in Nigeria. Aba town lies between latitude 50 03'N to 50 07' and longitude 70 17'E to 70 24'E in Abia State of Nigeria. The river is used for various human activities including car washing and fishing. People living within the upstream vicinity draw water from the river for drinking. The river originates from the northern Ngwa hinterland of Aba and stretches down to Cross rivers state where it empties with its creeks into the Atlantic Ocean. The river receives wastes from the industries and abattoirs sited along its course.

Effluent discharges into receiving waters and the cumulative hazardous effects on the environment have received much attention due to rapid industrialization in modern society. Industrial and abattoir wastes containing high concentration of microbial nutrients would obviously promote an after growth of significantly high Coliform type and other microbial forms, both in the effluent and the receiving waters (Ezeronye and Amogu, 1998). Process water from cosmetic, detergent and textile industries contain a lot of heavy metals, which when in super-abundance causes a disruption in the ecological balance. Moreover, allochthonous and autochthonous influences could make concentration of heavy metals in the water high enough to be of ecological significance. Furthermore, bio-concentration and magnification could lead to toxic levels of these metals in organisms, even when the exposure level is low.

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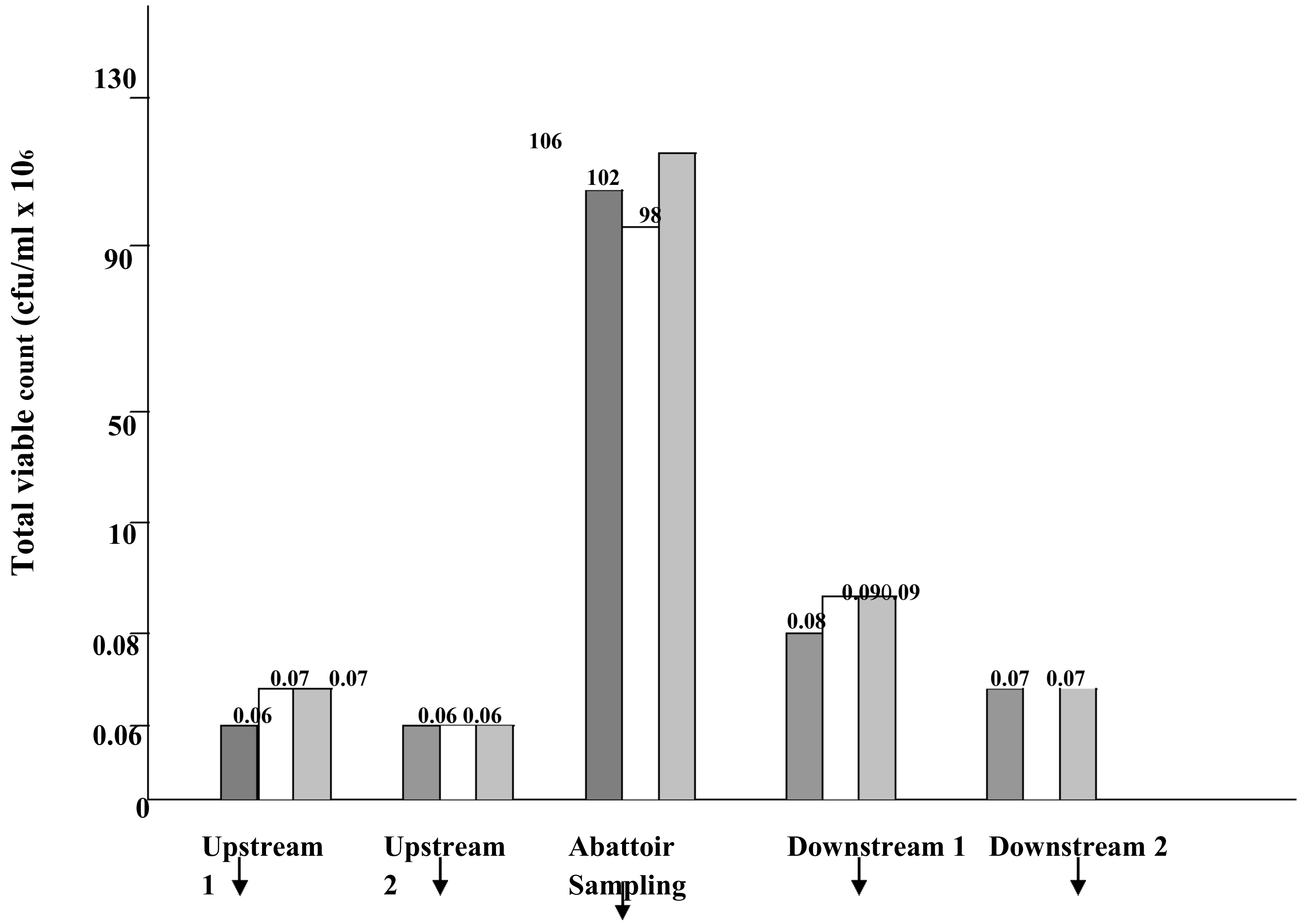

Figure 1. Total viable of micro-organisms isolated from Aba river in dry season.

The proven toxicity of high concentrations of heavy metals in water to organisms and wild life poses the problem of ultimate disequilibria in the natural ecological balance (Babich and Stoczky, 1985) Under such conditions the toxicity of a moderately toxic metal could be enhanced by synergisms and organisms population may decline (Laws, 1981). Apart from destabilizing the ecosystem, the accumulation of these toxic metals in the aquatic food is a potent threat to public health. The Mina Mata Bay epidemics in Japan remain a classic example. This work was carried out in order to establish the existing levels and assess the pollution profile, as well as to examine the assimilative capacity of the water body in Aba River. Similar studies have been conducted in the Lagos Lagoon, Igboba River in Benin and in Niger/Delta River all in Nigeria (Okoye et al., 1989; Kakuku, 1985). The data could be helpful in defining future waste management practices in the area in terms of quantity of waste to be discharged. This work could be of relevance to the Federal Environmental Protection Agency (FEPA) in the enactment of environmental protection laws in Nigeria.

MATERIALS AND METHODS

Sampling

Five different water samples were each collected with 1-liter sterile polyvinyl chloride (PVC) plastic water bottles at a depth of 1 meter below the water surface from the five designated sampling points in Aba River. At each sampling point, three water samples were drawn at random from three points and pooled. Dry season (November/December to March) samples were collected in January while Rainy season (March/April to December) samples were collected in July. The time for the collection of the two seasons' samples was 11.00 am in the morning. The samples were subsequently placed on ice in a cooler and transported to the laboratory for analysis. The importance of samples collection at the upstream and downstream points was for comparative studies.

Physicochemical analysis

Determination of heavy metals in the water samples was done using the Atomic Absorption Spectrophotometer (AAS, Unican lab. Services, York Street, UK) as described in the manufacturer's instruction manual.

Table 1. Seasonal mean values of the heavy msetal levels in surface sediments of Aba river.

	EPA MAXIMA[a]	Up stream 1	Up stream 2	Abattoir	Down stream 1	Down stream 2	Total	Mean
Pb								
Dry Season		0.04	0.12	0.08	0./08	0.06	0.38	0.08±0.03
Rainy Season	0.05	0.04	0.08	0.04	0.04	0.06	0.26	0.05±0.02
Fe								
Dry season		0.82	0.96	0.88	0.84	0.84	4.34	089±0.06
Rainy season	0.1	0.84	0.68	0.68	0.88	0.64	3.72	0.74±0.12
Zn								
Dry season		3.80	6.80	6.40	4.20	4.20	25.4	5.08±1.40
Rainy season	5.0	3.64	4.62	6.48	3.80	4.20	22.7	4.55±1.14
Cu								
Dry season		0.18	0.24	0.24	0.20	0.18	1.04	0.24±0.03
Rainy season	1.0	0.08	0.20	0.12	0.18	0.12	0.7	0.14±0.05
As								
Dry season		0	0.12	0.06	0.06	0.04	0.28	0.06±0.04
Rainy season	0.05	0	0.04	0.02	0.04	0.04	0.14	0.03±0.02
Mn								
Dry season	0.65	0	0.12	0.06	0.06	0.04	0.28	0.02±0.02
Rainy season		0	0.04	0.02	0.04	0.04	0.4	0.03±0.02
Hg								
Dry season		0.01	0	0	0.02	0.02	0.05	0.01±0.02
Rainy season	0.002	0	0	0	0.02	0.02	0.04	0.01±0.03

Key: All values are in mg/l
Co, Cr and Cd were not detected in all the samples for both seasons
a: source; EPA (1976) (EPA

Table 2. Seasonal total viable count (10^6cfu/Ml) Of microorganisms Isolated From Aba river.

PLATES	UP STREAM 1	UP STREAM 2	ABATTOIR	DOWN STREAM 1	DOWN STREAM 2	TOTAL	MEAN
(i)							
Dry season	0.06	0.06	102	0.08	0.07	102.28	20.5
Rainy season	0.06	0.06	109	0.07	0.07	109.25	54.6
TOTAL	0.12	0.12	211	0.16	0.12	211.5.52	75.1
MEAN	0.06	0.06	105	0.08	0.06		37.6
(ii)							
Dry season	0.07	0.06	98	0.09	0.07	98.28	19.7
Rainy season	0.06	0.07	104	0.07	0.06	104.26	20.9

Table 2. contd.

TOTAL	0.13	0.12	202	0.16	0.13	202.54	40.6
MEAN	0.06	0.06	101	0.08	0.66		20.3
(iii)							
Dry season	0.07	0.06	106	6.09	0.06	106.29	21.3
Rainy season	0.06	0.07	90	0.75	0.07	90.26	18.1
TOTAL	0.12	0.12	196	0.16	0.13	196.54	18.1
MEAN	0.06	0.06	98	0.08	0.07		19.7
GRAND TOTAL	0.12	0.12	203	0.16	0.13	617.59	
GRAND MEAN	0.06	0.06	101	0.08	0.07	205.86	

Key: Each value represents the mean of three replicates. 106 dilution factor was used for the upstream 1, 2 and downstream 1 and 2 water samples but values were converted to a common dilution factor (106).

Microbiological analysis

Direct microscopic examination of each water sample was done by the standard microbiological procedures (International Commission on Microbiological Specification for Foods (ICMSF, 1988) before culturing the samples on appropriate media. The total viable count (TVC) of mesophilic aerobic bacteria was determined by the pour plate technique. Serial (10- fold) dilution of each sample was done prior to inoculation on plate count Agar (Merck) and incubation at 25°C for 48 h. The microbial load (cfu/ml) of each sample was estimated by the method of Yongming et al. (1996).

Bacterial colonies (representing the most numerous colonial types) were picked at random from plates containing the highest countable dilution. Bacterial isolates were characterized by the methods of Harrigan and McCance (1976) and Speck (1976). Identification was based on Bergey's Manual of Systemic Bacteriology (Krieg and Holt, 1984). The ability of the organisms to produce oxidase, catalase, coagulase and metabolize glucose by both fermentation and oxidation were tested. Sugar fermentation assays and the ability of the isolate to utilize exogenous nitrate were also carried out. In addition the ability of the organisms to produce indole-methyl red and utilize nitrate was determined. Lipase hydrolysis, lecithinase and proteinase activities were also carried out.

RESULTS

The result obtained from the analysis of the physicochemical quality of the water samples are presented in Table 1. The range of mean values of the metals for both seasons are: Pb (0.05- 0.08 mg/l); Fe (0.7-0.9 mg/l); Zn (4.6-5.1 mg/l); Cu (0.1-0.2 mg/l), As (0.14-0.06 mg/l); Mn (0.02-0.03 mg/l); Cr (0.004-0.008 mg/l) and Hg (0.008-0.01 mg/l). The concentrations of the heavy metals were observed to be higher between the upstream 2 and Downstream 1.

Results of microbiological analysis of the various samples are shown in Table 2. The mean total viable count for the bacterial colonies ranged between 0.059 x 10^6 to 1.01 x 10^8 cfu/ml (Figures 1 and 2). The highest bacterial count was observed at the abattoir site followed by the downstream 1 (Figures 2 and 3) in the dry season. The abattoir site recorded the highest number of microorganisms isolated, followed by the downstream 1. The same pattern was observed for rainy seasons sample as represented in Figure 3. *Bacillus* species were predominant while Vibrio species were the least in number among all the isolates. Amongst the Gram-positive bacteria isolates were *Streptococcus faecalis, Staphylococcus* spp, *Clostridium* and *Bacillus* spp. All the organisms isolated were coagulase positive with the exception of *Clostridium* species.

DISCUSSION

The average levels of manganese (0.03 mg/l), zinc (4.81 mg/l) and Cu (0.19 mg/l) determined were below the United States Environmental Protection Agency maximum in marine waters (USEPA, 1976) and are comparable to those obtained in the Niger Delta waters (Kakuku, 1985). cobalt and cadmium were below detectable limits. Levels of Pd (0.06 mg/l), Fe (0.81 mg/l), arsenic (0.1 mg/l), chromium (0.01mg/l) and mercury (0.01 mg/l) were high but not significantly (p 0.05). The metal average seasonal levels are presented in Table 3. Analysis of variance (ANOVA) did not reveal significant spatial variations in the levels of any of the metals, neither did the least significant difference (LSD) show any significant seasonal variations (p 0.05). Anderson

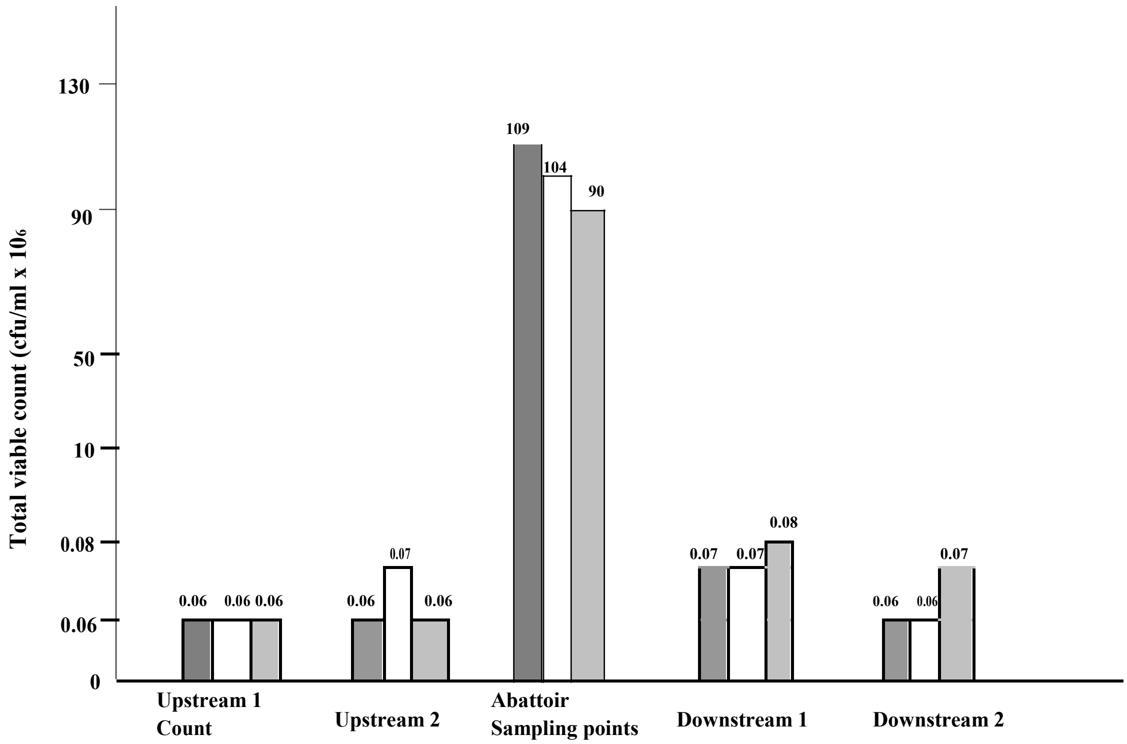

Figure 2. Total Viable count of organisms isolated from Aba river in rainy season.

Table 3. Faecal microbial count (10^4cfu/ml) of dry and rainy season water samples.

	Up stream 1	Up stream 2	Abattoir	Down stream 1	Down stream 2	Total	Mean
Escherichia coli							
Dry season	0.06	0.05	0.01	0.09	0.09	0.30	0.06
Rainy season	0.04	0.04	0.09	0.06	0.04	0.27	0.05
Salmonella spp							
Dry season	0.03	0.06	0.07	0.04	0.04	0.02	0.05
Rainy season	0.03	0.03	0.05	0.03	0.03	0.17	0.03
Streptococcus faecalis							
Dry season	0.03	0.02	0.03	0.02	0.02	0.12	0.02
Rainy season	0.04	0.02	0.03	0.02	0.02	0.01	0.03
Shigella spp							
Dry season	0.09	0.06	0.01	0.03	0.03	0.22	0.04
Rainy season	0	0	0.09	0	0	0.09	0.05
Vibrio spp							
Dry season	0.08	0	0	0	0.08	0.16	0.03
Rainy season	0	0	0.06	0	0	0.06	0.01
Clostridium spp							
Dry season	0.02	0.03	0.01	0.05	0.03	0.14	0.03

Table 3. contd.

Rainy season	0.02	0.02	0,08	0.03	0.12	0.17	0.03
Other Organisms							
Staphylococcus spp							
Dry season	41	40	43	32	26	182	36
Rainy season	39	37	40	26	22	164	33
Bacillus spp							
Dry season	41	40	44	38	33	196	39
Rainy season	38	36	41	36	32	183	37

Key: The faecal organisms originally of (10^2 dilution factor) were converted to (10^4) which is the dilution factor for other organisms.

(1987) reported that the toxicity of heavy metals occur when present in superabundance. In addition, the fundamental problem with heavy metals according to Chapman (1996) is that some of them are needed by microorganisms in trace amounts, when present in excess they denature enzymes thus inhibiting the microbial metabolism.

High lead levels in Aba River could be traced to urban and industrial wastes and high petrol-lead used by vehicles in Nigeria (Arah, 1985; Arah, 1987). Wastes management in urban and industrial centers in Nigeria, such as Aba has remained very unsatisfactory. Inflow waters to the Aba River have been found polluted with untreated industrial wastes, which are carelessly discharged, directly, or indirectly into the river. One other important source of industrial lead pollution is the expired motor batteries. Lead and other pollutants, whether in the air, or on land, ultimately end up in the aquatic systems.

There was no correlation between the individual organisms in Table 2 and the heavy metals while the correlation analysis between the heavy metals and total count of microorganisms did not reveal significant effect (p 0.05). The result indicated some variations in the bacterial population of the station in the two sessions. These variations suggest the impact of human activities and natural changes. The low bacterial count at the upstream 2 when compared to the other sites may be due to reduced human activities, sedimentation and depuration. The relatively high coliform counts at the abattoir may be connected with high rate of cattle defecation near the site. The introduction of wastes from the abattoir and the surface run-off into the site during the rains is also a contributory factor. The presence of *Escherichia coli, Streptococcus. faecalis* and *Shigella* spp in this study give credence to these findings. In addition the presence of *Clostridium* spp in all the sites further confirms the human faecal contamination of these sites. Costridium spp have been shown to be better indicator of human faecal contamination in tropical surface waters (Fujioka and Shizumura, 1985). The isolation of E. coli throughout the sites is an indication of recent human contamination. The presence of *Bacillus* and *Clostridium* species, which are mostly soil inhabitants, showed contamination from overland run-off. The presence of Salmonella and Shigella species at most of the sites and Vibrio species at the abattoir and the coliform counts of all the sites not falling within internationally recommended standard is of public health concern (Ezeama and Nwankpa, 2002).

The low levels of metals determined could be ascribed to dilution, sedimentation and depuration. Although the water flow in Aba River is limnethic in some area with little or no upwelling during the rainy season, immense volumes of fresh water passes through the river. The Aba River forms the major outlet for water draining a vast watershed, hence the influx has force and short residence time in the river. The short residence time of the influx means that most of the input materials are discharged along with the water. Slow flow conditions enhance sedimentation, especially in the presence of high levels of iron and manganese in the system as observed from the analysis of sediments (Okoye et al., 1989). This sedimentation would likely become the more important mechanism for removing heavy metals and other pollutants from the water at low tide and during the dry season when the influx of fresh water is very minimal. Thus the cumulative impact is that heavy metal levels are kept low in spite of high fluxes from industrial and urban wastes, including the immense urban run-off.

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