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Full Length Research Paper

Chemical and silt-induced eutrophication syndrome at Otamiri River, Owerri, Nigeria

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Partially eutrophicated site (A) and free-flowing site (B) of Otamiri River in Owerri, Nigeria, separated by a barricade were evaluated to determine their relative pollution status. Microbiological analysis using membrance-filtration techniques detected high presence of *Salmonella* spp., *Vibro* spp., *Staphylococus aureus* and faecal *Streptococci*. Aerobic bacterial counts of 5.0 x 10^5 cfu/100ml were obtained from site B and 4.5x 10^3 cfu/100ml from site A. The physico-chemical analysis revealed high conductivity of 178 umhoo/cm with total dissolved solids (TDS) of 89.0 mg/L at site B and 52 umhoo/cm with TDS of 26mg/L at site A. Recovery of $PO4^{3-}$, SO_4^{2-}, $N0^{3-}$, was obtained, though more at site A than Site B, indicating pollution. Statistical analysis revealed significant differences ($P \leq 0.05$) in pollution indices obtained between sites A and B. The barricade encouraged siltation and nutrient accumulation at site A creating an eutrophic environment that further complicated a desperate pollution status of the river due to indiscriminate dumping of refuse. This river serves as drinking water source to many inhabitants of Owerri municipality with villages beyond. Government effort to protect it from over pollution is therfore highly desired.

Key words: Eutrophication, pollution, Otamiri River, Owerri, Nigeria.

INTRODUCTION

Domestic and industrial discharges into surface water bodies vary in nature, quality and quantity, thus contributing significantly to chemical, biological and physical pollution of these water bodies (Okafor, 1985). Most of these pollutants enter the streams and rivers and are transported downstream passing through regional and international water bodies carrying with them wastes whose quality and quantity are yet to be determined. Though rivers and streams are continually renewed from the underground stream (USEPA, 1990) they are seldom pure. This is because, our manner of indiscriminate waste disposal at the domestic and industrial levels directly or indirectly (through run-offs) into surface waters, are likely to overwhelm the dilution power of such water bodies, consequently making them sources of all sorts of diseases whose causative agents may be contained in the waste (Blum et al., 1987). The resultant water-borne diseases like cholera, typhoid, dysentery and intestinal parasitic infections have remained a scourge to mankind especially in developing countries where adequate public health services are not available (Craun, 1976; Eden, 1977). In addition to promoting the seeming increase in prevalence of human-related water-borne diseases, waste accumulation also adversely affects the aquatic biodiversity. This is so since other organisms associated with the waste also play important roles in maintaining the different trophic levels in the aquatic ecosystem (USEPA, 1990).

Eutrophication may result if sufficiently large amounts of nutrients through wastes are added over a long period to surface waters (Prescott et al., 2002). At the same time, siltation resulting from blockage or basal river flow with erection of a barricade to mimic water fall for improved water flow may enhance nutrient accumulation in certain sections of the river creating a eutrophic environment. The Otamiri River originates from a forest

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Abbreviations: TDS, Total dissolved solids; **DO,** dissolved oxygen; **BOD,** biochemical oxygen demand; **TCBS,** thiosulphate citrate bile sucrose agar.

north of Owerri Municipality and flows southwards through the Owerri metropolis before emptying into other water bodies in the Rivers State of Nigeria. Owerri itself is the capital and administrative headquarters of Imo State with a dense population and a previously reported high incidence of diseases including sexually transmitted diseases (Anyanwu et al., 1996). Information on other possible sources or health hazards like the Otamiri River that is barricaded at a point to increase the water flow are however scanty. The threat of water pollution to man's existence has informed the adaptation of strategies aimed at its control and one of such strategies according to Imhoff (1995) is the provision of information on the quality and quantity of contaminants in a water body. The aim of this study therefore is to provide information on Otamiri River, a water body that is assaulted on different fronts, yet it is used by several residents of Owerri municipality in Nigeria. The river is a source of drinking water as well as a source of water for various activities including laundry, domestic use and also a recreational resort to young boys and girls that continually swim in it.

MATERIALS AND METHODS

Sample collection sites

Samples were collected from two sites of the river viz:-

Site (A): The eutrophicated area of the river located about 50 m upstream of the barricade;

Site (B): The free-flowing areas near the Owerri - Aba Road Bridge, about 100 m downstream of the barricade.

Collection of samples

Samples for analyses were in each case collected in duplicates. For bacteriological analyses, sterile Durham bottles as described by Nwanebu and Nwabueze (2004) were used. The bottles were unscrewed one meter below the surface of the water, facing the mouths in upstream direction and corked when filled while still under water. Similarly, as described by Nwanebu (2003), 4-liter capacity plastic containers were used to collect samples for physico-chemical analysis while transparent, amber-coloured 250 ml capacity bottles were used to collect samples for dissolved oxygen (DO) and biochemical oxygen demand (BOD).

Sample collection for analyses of the zooplankton and phytoplankton was carried out using cone-shaped, silk plankton net as recommended by Okafor (1985). In the free-flowing, navigable part of the river (site B), the net was used by sinking it beneath the surface of the water and towing it against the water current, on foot. Water samples from the impeded part of the river (Site A) were collected in buckets and sieved through the net. One set of the duplicate phytoplankton samples was fixed with 4% formalin and taken to the laboratories for immediate analysis. Samples for bacteriological analysis were transported to the laboratory using a mobile cooler equipped with ice pack and were analyzed within 2 h of sample collection.

Bacteriological analysis

The Millipore membrane technique as applied by Nwanebu (2003) for the examination of water and waste water was adopted for the isolation of bacterial flora. A 25 ml portion of 10-fold serial dilution of the samples were sieved through the sterile membrane filter measuring 47 mm in diameter in the system aided by a hand vacuum pump. The treated filter was then asceptically removed from the Millipore system and placed on soaked pad of Millipore membrane media or solid media in plastic petridishes. Cultures of the filtration on membrane Lauryl sulphate Broth (MLSB; Oxoid and BDH) were incubated at 37°C for 4 h and then, 44.5°C for 20 h as described by Blum and co-workers (1987) for faecal coliform isolation. Nutrient agar medium was used for isolation of aerobic heterotrophic bacteria while total coliform isolates were obtained using MF-Endo agar medium. KF- streptococcus agar was used for faecal streptococci while thiosulphate citrate bile sucrose agar (TCBS) was used to isolate *Vibro* species as recommended by Kampelmacher and co-workers (1971). The enumeration of *Salmonella* species was carried out using the bismuth sulphate agar method (Nwanebu, 2003) while *S. aureus* population enumeration was carried out using Baird Parker medium (Nwanebu and Nwabueze, 2004). Media preparations were according to manufacturer's instructions and incubation generally, except for faecal coliform, was at 35 -37°C for 24 h.

Bacterial counts

Bacterial colony counts of 30-200 were accepted for further investigation. In some cases, averages of duplicate plates within this range were accepted. Those outside this range were rejected and serial dilution of sample repeated to obtain acceptable values. All the counts obtained were averaged to produce counts per 100 ml. Typical bacterial isolates were identified as described by Cruickshank et al. (1982). Biochemical tests using sugars such as glucose, maltose, lactose, sucrose, mannitol, and fructose were carried out. Methyl red, and Vogues- Proskauer tests were adopted in the differentiation of enterobacteriaceae. Gram staining, motility and catalase production tests were also utilized to further identify the isolates (Cruickshank et al., 1982).

The physico-chemical qualities of the water samples were determined by the standard methods for the examination of water and waste water as described in Nwanebu (2003). The temperature was measured on the spot using a mercury thermometer while the pH was determined with a Pye Unicam pH meter. Calcium and Magnesium were determined utilizing the Direct Reading Engineering Lab. I Dr-EL / 5 Hach kit (Hach Company, Colorado, 1981). Hach kits were also used to measure concentrations of sulphate and nitrate based on the turbidimetric method using Sulfa var 4 sulphate reagent and Cadmium reduction method respectively. Stannous chloride and ammonium molybdate methods were used to evaluate phosphate concentration. The Nitric acid-perchloric acid digestion method was applied for the analyses of metals. DO and BOD were measured as reported in Cruickshank et al. (1982).

RESULTS AND DISCUSSION

The results of the bacterial quality and quantity of the studied sites are recorded in Table 1. The results of the physico-chemical analyses are as recorded in Table 2.

The bacterial quality of Otamiri River was investigated in the month of February 2008, by which time, part of the river was already partially eutrophicated with much siltation, nutrient/waste accumulation and overgrowth of weed, while a bed of water was maintained underneath. The total aerobic count at site B was observed to be higher than that at site A probably because eutrophication

Table 1. Bacterial quality of sampled sites.

	Site A	Site B
Total aerobic heterotrophic count	*$4.5 \times 10^3 \pm 707.11$	*$5.0 \times 10^5 \pm 2.8 \times 10^4$
Total coliform count	$1.7 \times 10^3 \pm 424.26$	$1.1 \times 10^3 \pm 2.83 \times 10^2$
Faecal coliform	$2.7 \times 10 \pm 2.83$	$2.1 \times 10^2 \pm 28.28$
Faecal Steptococci	$2.1 \times 10 \pm 2.83$	$1.0 \times 10 \pm 7.14$
Total *Salmoaella*	*$1.7 \times 10 \pm 2.83$	*$2.0 \times 10^2 \pm 14.14$
Total *Vibrio*	$1.2 \times 10 \pm 2.83$	$1.2 \times 10 \pm 1.41$
Staphylococcus aureus	*$2.0 \times 10^2 \pm 14.14$	*$5.5 \times 10^4 \pm 2.83 \times 10^3$

Values are means f duplicates ± standard deviation.

Key: A = Partially eutrophicated area; B = Non-eutrophicated area; *Significant differences at $p \leq 0.05$.

Table 2. Physicochemical parameters of sampled sites.

Parameter	Site A	Site B
Appearance	Clear	Clear
pH	6.3 ± 0.0	6.6 ± 0.14
Temperature (^{O}C)	25.0 ± 0.0	27.4 ± 0.14
Conductivity (umhos/cm)	*52 ± 2.83	*178±4.24
Total dissolved solids (mg/L)	*26 ± 1.41	*89.0± 0.00
Total hardness solids (mg/L)	6.0 ± 0.28	4.0 ± 0.28
Dissolved oxygen solids (mg/L)	*5.3 ± 0.28	*7.5 ± 0.35
B.O.D. solids (mg/L)	*4.3 ± 0.14	*1.5 ± 0.14
Calcium hardness solids (mg/L)	*2.4 ± 0.14	*1.6 5 ± 0.07
Magnesium solids (mg/L)	0.88 ± 0.01	0.58 ± 0.06
Chloride solids (mg/L)	0.53 ± 0.03	0.5 ± 0.00
Salinity solids (mg/L)	0.95 ± 0.01	1.35 ± 0.04
Carbonate solids (mg/L)	-	-
Bicarbonate solids (mg/L)	24.0 ± 2.83	36.0 ± 0.71
Phosphate solids (mg/L)	*38.2 ± 0.28	*15.2± 0.42
Sulphate solids (mg/L)	*24.8 ± 0.14	*7.5 ± 0.14
Nitrate solids (mg/L)	*44.3 ± 0.14	*10.8± 0.28
Nitrite solids (mg/L)	1.5 ± 0.42	0.4 ± 0.14
Potassium solids (mg/L)	*2.1 ± 0.14	*1.15± 0.07
Iron solids (mg/L)	*1.5 ± 0.14	*0.08± 0.02

Values are means of duplicates ± standard deviation.
*Significant differences at $p \leq 0.05$.

has occurred at site A. The phenomenon has been reported to support less growth of aerobic bacteria due to establishment of anaerobic environment by the photosynthetic action of overlaying weeds (Okafor, 1985; Chorst, 1975). Nevertheless, the population of the coliforms, viz; faecal coliform as well as faecal streptococci, seemed more tolerant to the harsh environ-ment and the partially eutrophicated site A was noticed to have higher isolates of these organisms than site B. Run-offs into this river from a government-owned abattoir located about 100 meters on a slope off the bank of the river and emptying into the river about 20 m upstream of site A, may have greatly contributed to its load of coliforms (Okafor, 1985).

Conversely, the increased presence of *Salmonella* and especially, *Staphylococcus aureus* population at site B, much higher than isolated from site A, may be due to the observed higher presence of human activities at site B. The situation is in accordance with other reports (Yoshpe-Purer and Golderman, 1987; Favero et al., 1964) who attributed increased bacterial presence notably *S. aureus* populations to the presence of human activities especially, those involving body contacts. Activities such as swimming, washing of vehicles and domestic wares were observed to take place daily at site B unlike site A which was virtually abandoned.

The analysis of the river at these sites did not reveal any common trend in pollution status between the two sites with regard to physicochemical parameters. The analysis showed that while site A had low conductivity the much more free-flowing site B with bustling human activities, justifiably had higher conductivity level. Such trend in the level of conductivity has been reported for effluent-receiving water bodies (USEPA, 1990). The levels or the TDS being directly related to conductivity levels at both sites were as expected in view of both the pollution and the unhealthy human activities that take place at site B. Similarly, the higher levels of magnesium and calcium hardness at site A must have been responsible for high total hardness obtained at that site. Such trend in the magnesium and calcium hardness affecting the total hardness has been reported elsewhere (Nwanebu and Nwabueze, 2004).

The lower temperature at site A may be due to the siltation and grass that covered the surface of site A, drastically reducing the effect of the sun on the underlying water at site A. This corroborates the reports of Dupree and Hurner (1984), and Okpokwasili and Ogbulie (1993), who associated high absorbing particles as objects in water to affect light penetration and hence, temperatures for rivers and lakes. The temperature at site B remained high since the site was totally exposed to direct sunrays, human activities notwithstanding. Even though site B had high level of dissolved oxygen, the lower level of DO noted at site A may be attributed to increased growth of aerobic bacteria in the presence of large organic matter, prior to onset of anaerobiosis (Okafor, 1985; Dupree and Hurner, 1984). Conversely, the levels of anions, PO_4^{3-}, SO_4^{2-}, NO^{3-}, NO^{2-} and the elements, potassium and iron, were much higher at site A than site B and were likely to be consequent upon the eutrophication phenomenon observed (Prescott et al., 2002; Okafor, 1985). High levels of cow dung and wastes from the nearby abattoir resulting in high PO_4^{3-}accumulation may have helped to activate the partial eutrophication phenomenon observed. Generally, analyses of Otamiri River showed clear evidence of pollution at both sites. The accumulation of chemicals invariably complicated the siltation at site A which was a consequence of a built-in barricade leading to the ob-served partial eutrophication. Unfortunately, inhabitants of Owerri still depend on this river for drinking purposes in the face of frequent pipe-borne water short-age. A fresh look at the implications of this barricade and the need to check the unhealthy dumping of wastes into the river, even by government agencies, is recommended.

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