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Full Length Research Paper

Pollution studies on harbours and jetties in Nigeria

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The distribution of bacteria in the surface waters and sediment of selected harbours and landing jetties in the city of Port Harcourt was investigated. Nine water and sediments samples were allocated on each trip and cultured for various organisms on the rainy and dry season. The total heterotrophic count of the water sample in the dry season ranged between 33 ± 7.4 and 62 ± 6.1 and between 38 ± 7.1 and 62 ± 19 CFU/ml in the rainy season. In the case of sediment samples, the THC of the dry season ranged between 31 ± 8.1 and 54 ± 20 CFU/g, while the count in the rainy season ranged between 24 ± 1.9 and 54 ± 19 CFU/g. Of the *Vibrio* species isolated, 3 (60%) were found to be *Vibrio cholerae*, while 2 (40%) were *Vibrio parahaemolyticus*, four isolates were also identified as *Salmonella* species. The high distribution of the bacteria which is of public health importance in the harbours/jetties, indicates pollution. Physiochemical parameters such as alkalinity, dissolved oxygen, temperature, pH, conductivity, total dissolved solids, salinity, chloride, biochemical oxygen demand (BOD) and heavy metal were investigated and showed significantly high values, which indicates pollution of the harbour.

Key words: Bacteria, Port Harcourt, *Vibrio*.

INTRODUCTION

A harbour is a place of shelter for ships; it deepens a channel leading to the river so that ships will not run around. Harbours are central point for development and commercial activity but have the reputation of being some of the most polluted (Walmsley, 1999). It is amazing, how people live along side serious pollution sources and not notice. Harbours, around the world have traditionally been regarded as 'appropriate for insanitary conditions' (Ravikumar, 1992, 1994). GESAMP (1990) defines pollution as the introduction by man, directly or indirectly of substances or energy into the marine environment (including esturaries) resulting in such deleterious effects as harm to living resources, hazards to human health and hindrance to marine activities. Contamination, on the other hand, is the presence of elevated concentration of substances in the environment above natural background level for the area and the organism. Some major examples of contaminants, which have been identified by Clark (1986) are suspended solids, biodegradable organics (proteins, carbohydrates and fats) pathogens and nutrients (nitrogen, phosphorous and carbon). The presence of suspended solids in water gives rise to turbidity (Metcalfe and Eddy, 1991). Suspended solids may consist of clay, silt, airborne particles, colloidal organic particles, plankton and other microscopic organisms. Turbidity can bear an indirect relationship with the health aspects of water quality (WHO, 1984a,b). The sources of pollution at harbours and landing jetties include organic waste, litter, petroleum hydrocarbon and toxic chemicals (Murkerjee, 2001). Contaminated cleaning water can be washed down into the harbour via drainage systems, even when no chemicals are used. Mukerjee (2002) stated that the cleaning of harbour might be contaminated with oil debris, heavy metals or sediments from the surface harbours. No matter how carefully regulated and managed wastes are within a harbour, there will always be risks of accidental illegal discharges from ships, port operations and other non-port related discharges. The following are liable to cause contamination or pollution of aquatic environment and hazard to public health: Oil,

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Abbreviations: TSS, Total suspended solids; **DO,** dissolved oxygen; **BOD,** biochemical oxygen demand; **DCA,** desoxycholate citrate agar; **APW,** alkaline peptone water; **TCBS,** thiosulphate citrate bile salts sucrose; **THC,** total heterotrophic count.

garbage, sewage, ballast, dredging and disposal, detergents, antifouling paints, biocides and bleach (MCS, 1998).

MATERIALS AND METHODS

Area of study

The work was carried out using a harbour and two landing jetties located in the city of Port Harcourt; they include Abonema wharf, NPA harbour and Nembe waterside. Each location was made up of three sampling stations viz: Stations 1, 2 and 3. Abonema wharf and Nembe waterside are jetties for local transport and journeys outside Port Harcourt using diesel and petrol engine boats. They are also fishing and settlement area for many people. Additionally, Nembe waterside witnesses a lot of activities as a result of a large number of people that patronize a popular market, the Creek Road Market, located behind the jetty, where a lot of buying and selling is done for food and crude products.

Sample collection and preservation

Surface water samples were collected at three sites along the course of the river. Two litres of sterile water containers were used to collect samples. Prior to collection, containers were prewashed with detergents, rinsed with distilled water, soaked with absolute alcohol and allowed to dry. All samples were collected between 11.00 am and 1.00 pm and at low tide. Containers for metal analysis were sterilized using the method of Mombershora et al. (1981). Water samples were preserved in the refrigerator.

Physioco-chemical analysis of samples

The following physical and chemical analyses were carried out on the water sample: Temperature, pH, conductivity, alkalinity, total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chloride and total hardness.

Microbiological analysis

Heterotrophic plate count was performed using the pour plate method; serial ten-fold dilutions of the sample were prepared using sterile normal saline as diluents. Nine milliliters of normal saline was dispensed into each tube and sterilized by autoclaving. After cooling, one milliliter of the water sample was transferred with the aid of a sterile pipette into nine milliliters normal saline to obtain 10^{-1} dilution. This was well mixed manually using the same sterile pipette; 1 ml of the mixture (10^{-1} dilution) was transferred into the second tube (10^{-2} dilution). The same procedure was repeated until 10^{-7} dilution was prepared.

An aliquot (0.1) of the suitable dilutions 10^{-4} to 10^{7} was aseptically transferred into sterile petri dish and cooled sterile nutrient agar was added. The mixture was allowed to solidify and then incubated at 37°C for 48 h. Bacterial colonies on each plate was counted and multiplied by the reciprocal of the appropriate dilution.

Isolation of *Salmonella* sp. and *Vibrio* sp.

Selenite F broth is an enrichment medium which enhances the isolation of *Salmonella* species from sample. Hundred milliliters of Selenite F was prepared according to manufacturer's procedure. Thereafter, 9 ml aliquot was dispensed into screw-capped bottles and sterilized by heating to boiling. Screw caps were tightened and allowed to cool, after which 1 ml of the water sample or one gram of sediment was transferred using sterile pipette into the first tube and ten-fold serial dilutions were made. Tubes were incubated for 18 – 24 h at 37°C. An aliquot (0.1 ml) of the growth in Selenite F broth culture was transferred into prepared desoxycholate citrate agar (DCA) plates and was incubated for 18 – 24 h at 37°C. Colonies with black center were counted and cultural characteristics of colonies were observed. *Vibrio* spp. were isolated by preparing 100% of alkaline peptone water (APW), and were dispensed into tubes and sterilized at 121°C for 15 min and allowed to cool after which 1 ml of water sample was transferred into the first tube and ten-fold serial dilution was carried out. Tubes were incubated for 6 – 8 h after which 1 ml was transferred from tubes to already prepared thiosulphate citrate bile salts sucrose (TCBS) agar plates and were incubated for 24 – 48 h. Yellow and blue-green colonies were counted.

RESULTS AND DISCUSSION

The results in Figures 1 - 10 shows the influence of physiochemical parameters on selected harbours and jetties in Port Harcourt, Nigeria. Analysis of variance data confirms that there is significant difference ($P \leq 0.05$) between Abonnema, NPA and Nembe stations except in January where there is no significant difference ($P \leq 0.05$) between the means. The temperature observed ranged from 27.0 to 31.0°C as observed in Figure 1. Temperature plays a major role in microbial interaction in aquatic environment (Alabaster and Lloyds, 1980). The aquatic organisms are adapted to such changes in temperature and can even withstand changes outside this range. There was no significant difference between NPA and Abonema stations in the months of September, October and November but they differed significantly ($P \leq 0.05$) with Nembe intervals. The results in Figure 2 shows the effect of pH on selected harbours and jetties, there was no significant difference ($P \leq 0.05$) between the stations in all the months with respect to pH. It was observed that the means at significant levels differed significantly throughout the stations in July, September and November, but no mean difference was observed in October between NPA and Nembe watersides. From the study, the pH is within the range for water quality, the permissible limit of pH is 6.5 – 9.0 (Standards for water Quality), which confirms that the water is suitable for aquatic life; for drinking, standard limit of pH is 6.5 – 8.5. This confirms that the harbour water is unsuitable for drinking (Zhou et al., 1994).

Results in Figures 3 - 10 show the values of DO, BOD, chloride/salinity and alkalinity during rainy and dry seasons. For DO as depicted in Figure 3 and confirmed by the analysis of variance, no significant mean difference between the three stations was observed during the two seasons. With respect to alkalinity shown in Figure 5 with its corresponding two way analysis of variance, the data obtained showed that there is no significant difference between the three stations although there is mean significant difference ($P \leq 0.05$) between the three

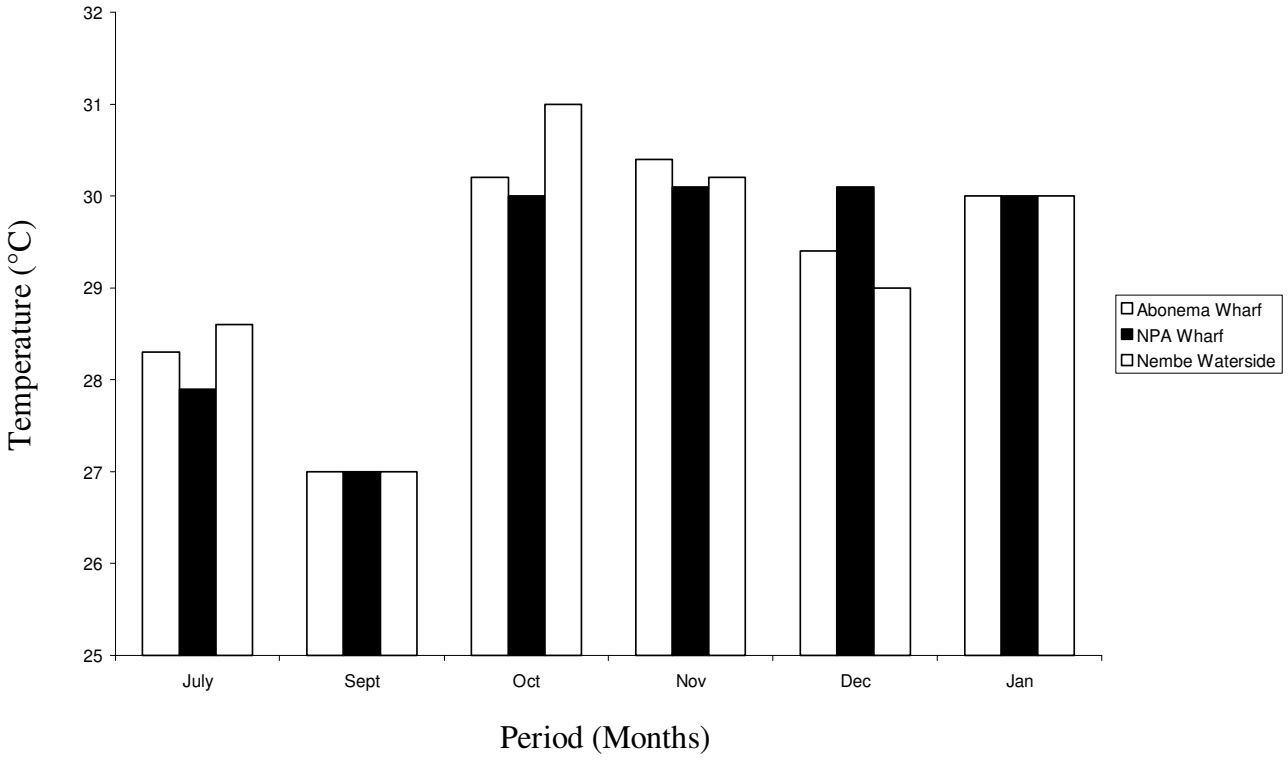

Figure 1. Temperature profile of the different stations.

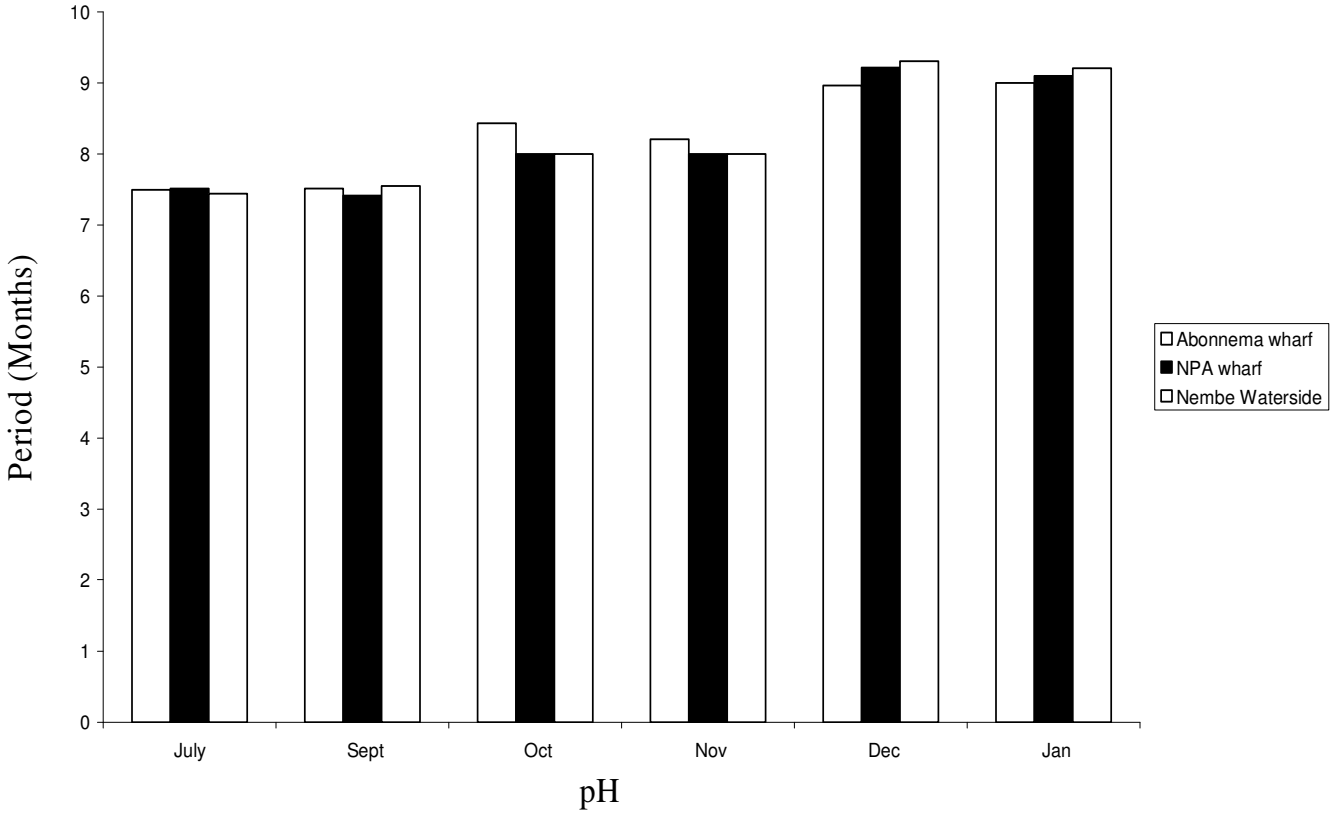

Figure 2. pH profile of different stations.

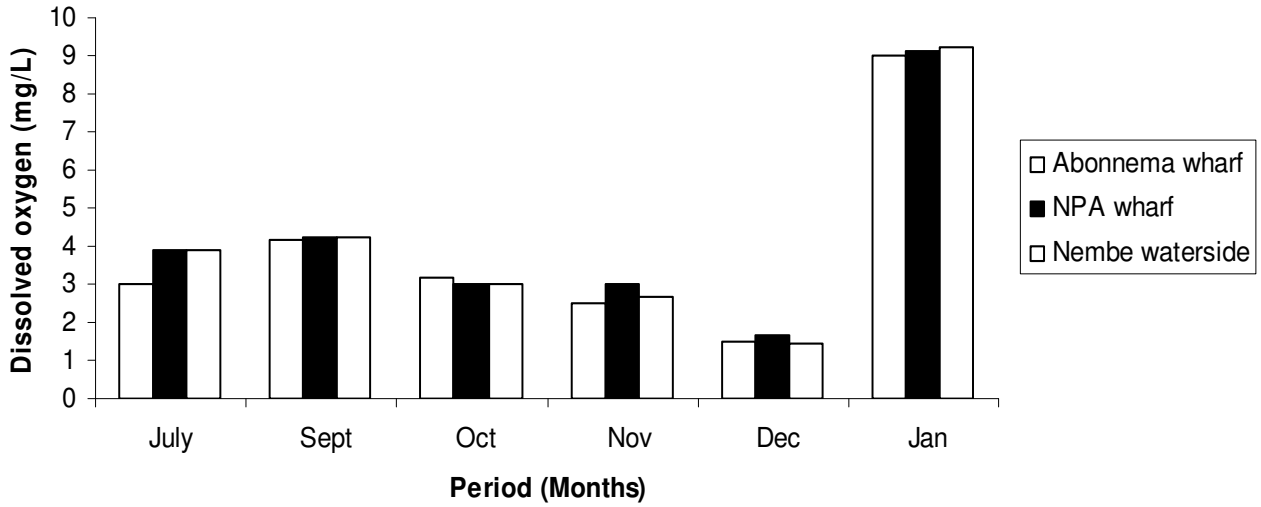

Figure 3. Dissolved oxygen profile of the different stations.

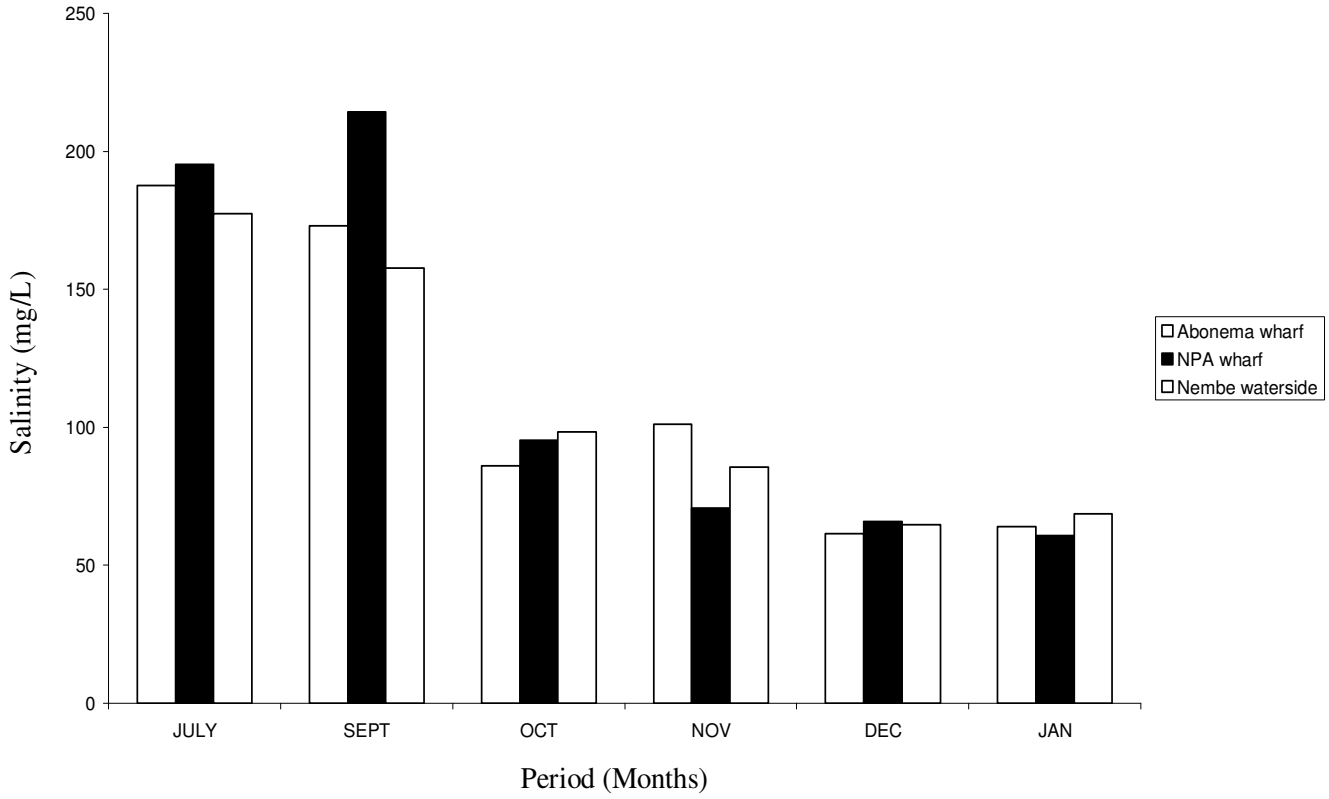

Figure 4. Salinity profile of the different stations.

stations in all the months except January where no mean difference was observed between NPA and Nembe waterside. In Figure 10, no significant difference ($P \leq 0.05$) was observed within the stations in the analysis of variance with respect to conductivity but their mean significantly ($P \leq 0.05$) differed in all the months with respect to conductivity. The observed seasonal fluctuation in BOD depicted in Figure 7 may be due to high heterophonic activities within these sites (Odokuma and Okpokwasili, 1993). The difference observed in DO may be due to solubility of oxygen in water; at high temperature the solubility of oxygen decreases, while at lower temperature it increases. Moreso, fluctuation may be due to effluents which enhances the depletion of dissolved

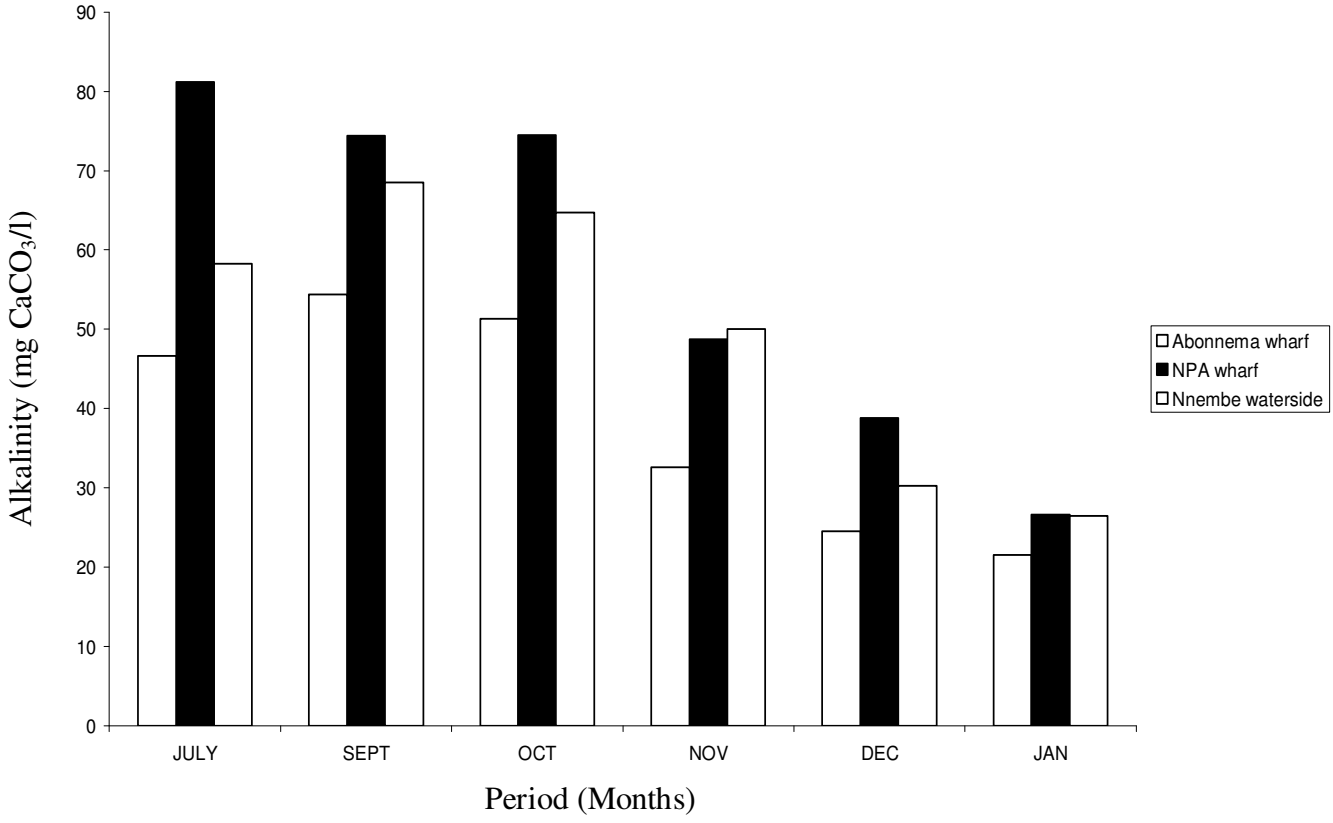

Figure 5. Alkalinity for the different locations.

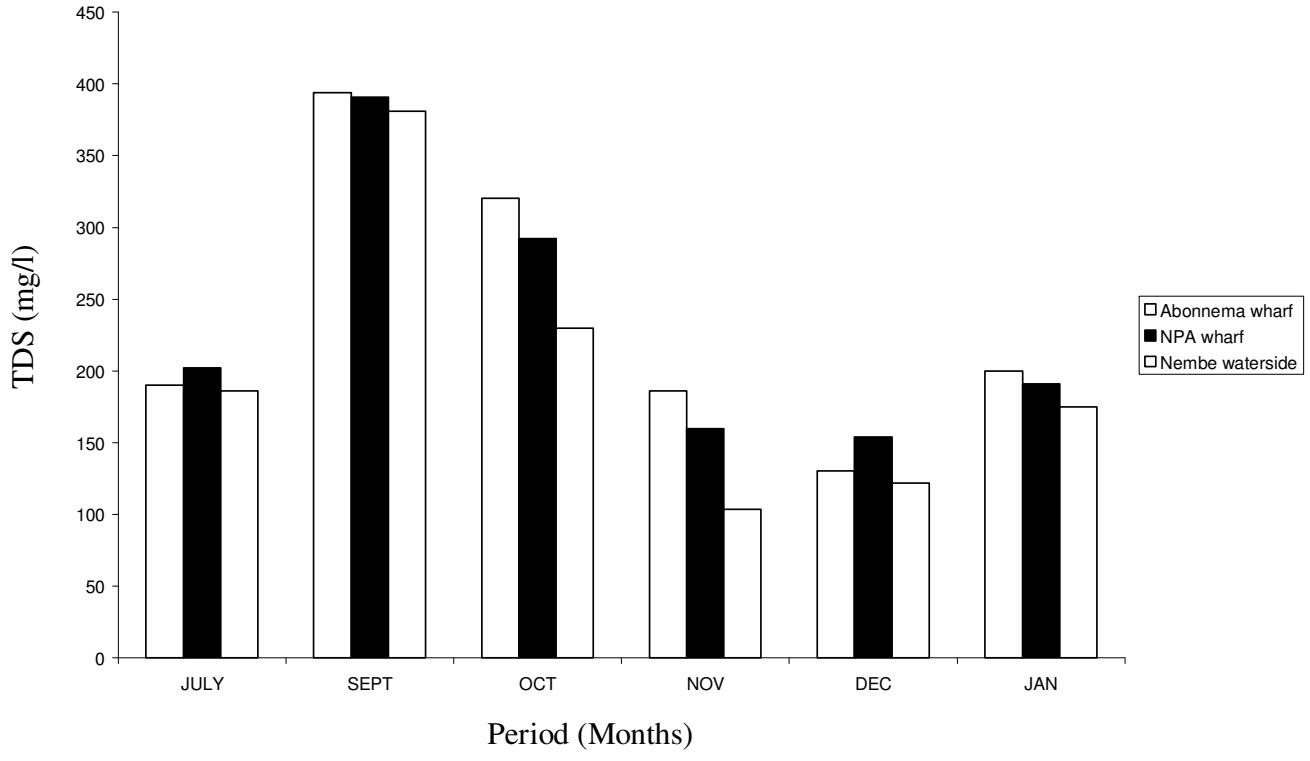

Figure 6. Total dissolved solids of the different locations.

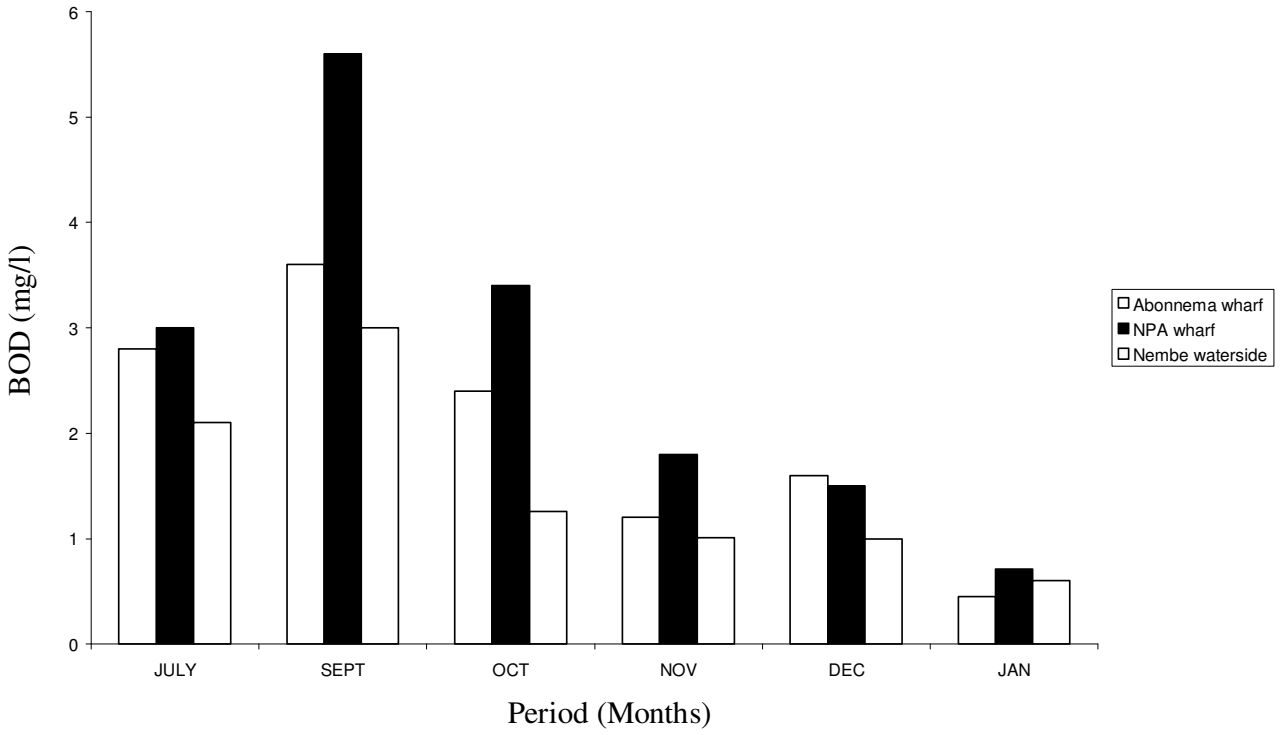

Figure 7. Biochemical oxygen demand of the different stations.

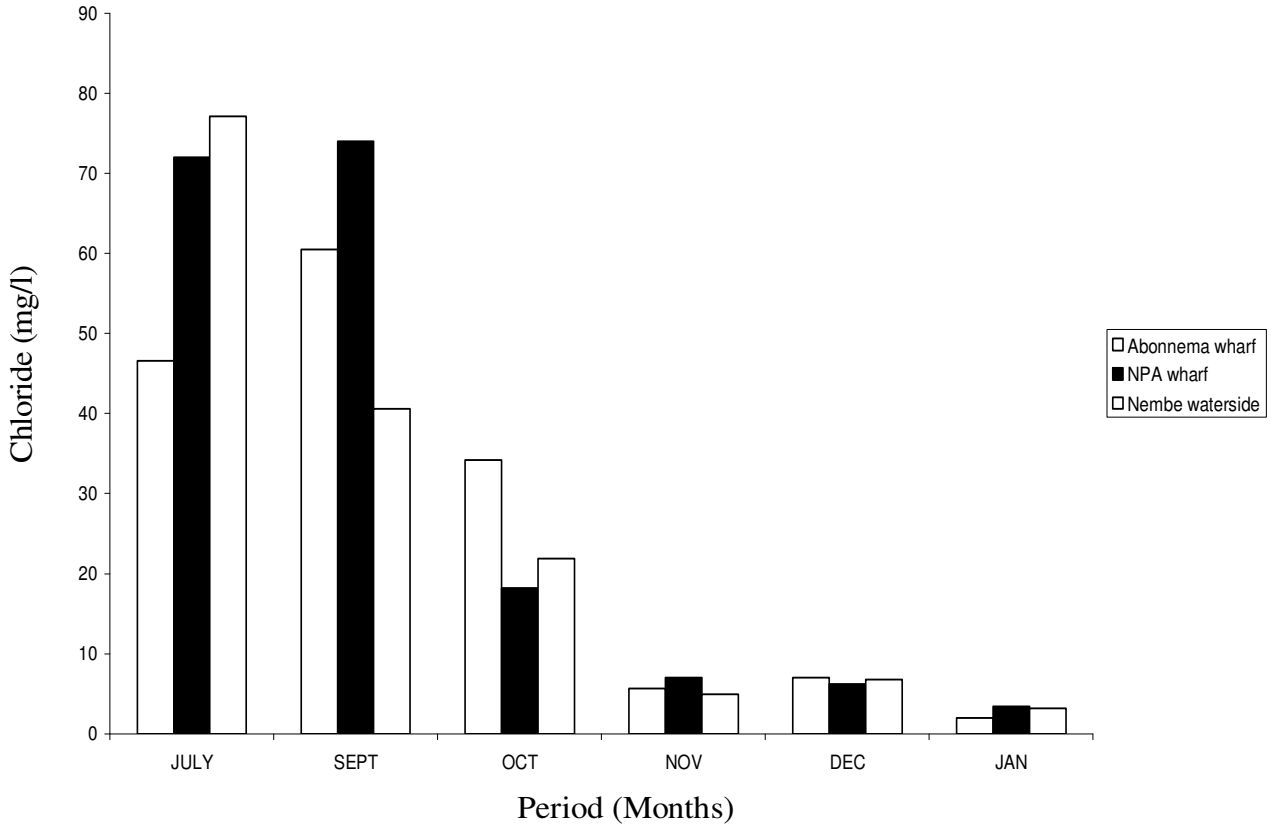

Figure 8. Chloride profile for the different stations.

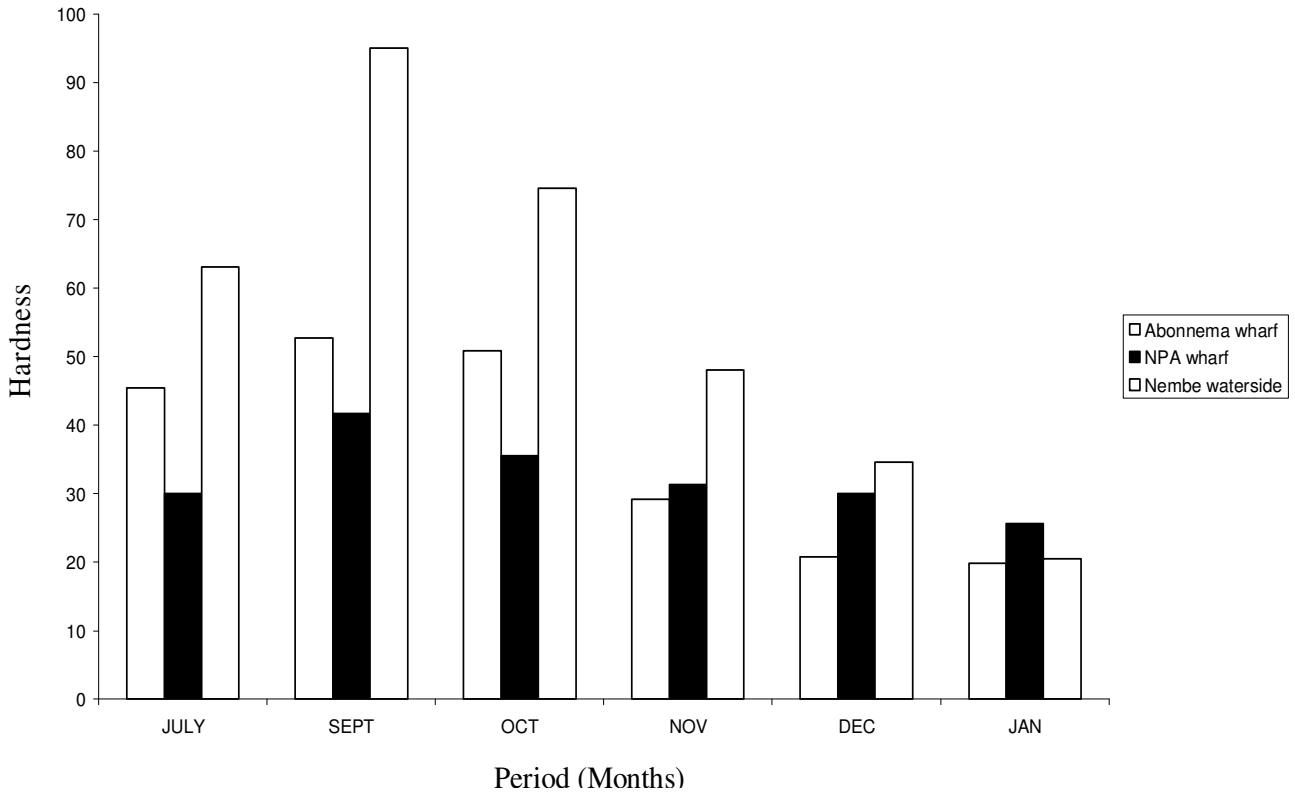

Figure 9. Hardness of the different stations.

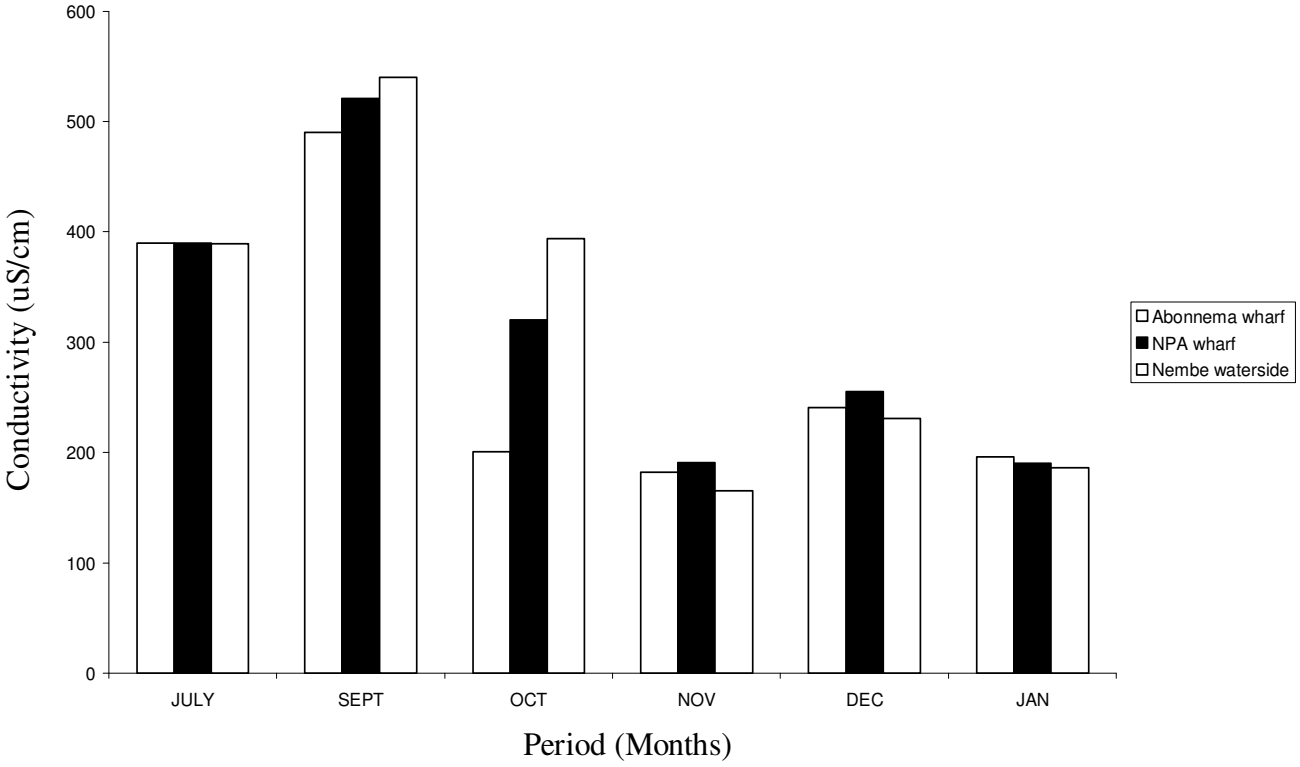

Figure 10. Conductivity of the stations.

oxygen at these sites (Plummer, 1978 and Okpokwasili et. al. 1995).

The fluctuation of alkalinity and hardness of the harbour water during the rainy season over that of the dry season was attributable to inputs of industrial effluents during the rainy season, increased dilution during this season and subsequent increased soil erosion and surface runoff, thus, invariably leading to increase in bacterial numbers (Wilter et al., 1990). Heavy metal analysis of harbour waters revealed varying concentrations of copper, lead, zinc, iron and cadmium. Their proportion decreased following the trend Fe > Pb > Cu > Cd > Zn. The concentrations of these heavy metals were higher in the dry season than in the rainy season and more sediment was found in the surface samples. The levels for sediment decreased in the following trend Fe > Mn > Cd > Zn > Ni > Pb > Cu. The concentration of zinc in the tap water can be considerably higher than in surface water owing to its leaching action from galvanized pipes, brass and other zinc alloys. Zinc imparts to water an undesirable astringent taste and in concentration which is in excess of 5 /ppm. The presence of copper in the harbour water supply, although not constituting a hazard to health, may interfere with the intended domestic uses of water. Copper stains cloths and plumbing fixtures. Lead monitoring is important because of its toxicity to human health. Lead is a cumulative poison; most lead used in compound form like paints and petrol additives are lost to the environment, eventually ending up in the aquatic environment (Jun et al. 1994).

Microbiological results

Total and coliform count is usually used as an index of pollution from domestic waste. Total coliform was high at NPA 2, Nembe 2 and ABO 2, which are the busiest station where a lot of activities take place. Total heterotrophic count (THC) were higher in Nembe waterside than Abonema and NPA wharfs. This may be due to disposal of offals and condemned fish at the harbour and disposal of municipal waste, raw sewage, runoff from the sale of petroleum products at the harbours and jetties. These results are consistent with previous studies (Machiwa, 1992). Bacteriological investigation revealed the following bacterial genera viz: *Shigella* sp., *Alcaligens* sp., *Bacillus* sp., *Serratia* sp., *Proteus* sp., *Staphylococcus* sp., *Vibrio* sp., *Pseudomonas* sp., *Escherichia* sp. and *Salmonella* sp. These bacterial isolates agreed with those reported for water and sediment by Timoney et al. (1978). Out of the five *Vibrio* spp. isolated, 3 (60%) were found to be *Vibrio cholerae*, while 2 (40%) were *Vibrio parahae-molyticus*. The presence of these microorganisms in the harbour water and its environment indicates pollution and represents a threat to the public health of the populace.

The organisms could have been discharged into the environment via human beings with disease or from human carriers which may cause diseases that vary in severity from mild gastroenteritis to severe and sometimes fatal dysentery, cholera or typhoid (Mukejee, 2002).

Conclusion

The harbour/jetty environment from the work carried out is found to be polluted with organisms which pose serious threat to public health and financial losses on account of fish quality making. It is necessary for the harbour master to accord a high priority or monitoring water quality for signs of feacal pollution and ensure that sewage and gray waste from harbour complex are adequately treated and safely disposed and residents living within and along the jetties are advised to use alternative/pipe borne water for domestic purposes (Okpokwasili et. al.1995).

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