

Studies on the Effect of Municipalwaste and Industrial Effluent on the Pollutant Levels of River Challawa, Kaon State, Nigeria

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Abstract: Levels of Copper (Cu), Cobalt (Co), Zinc (Zn), Iron (Fe), Lead (Pb), Manganese (Mn), Chromium (Cr), as well as pH, redox potential (Eh), Dissolved Oxygen (DO), Total Dissolved Solid (TDS), temperature, nitrate, sulphate and phosphate were determined in River Challawa, Kaon State, Nigeria. These parameters were simultaneously monitored. Physio-chemical examination revealed that the levels of pH (6.81 ± 0.10 and $10.23 \pm 0.32 \text{ mg L}^{-1}$), Eh (-46.3 ± 1.34 to $-87.2 \pm 1.54 \text{ mV}$), TDS (40.3 ± 3.24 to $70.1 \pm 8.40 \text{ mg L}^{-1}$), temperature (8.2 ± 0.14 to $12.8 \pm 0.24 \text{ }^\circ\text{C}$), sulphate (22.6 ± 0.21 to $43.5 \pm 0.31 \text{ mg L}^{-1}$) and nitrate (1.11 ± 0.02 to $4.04 \pm 0.03 \text{ mg L}^{-1}$) were below the maximum permissible limits set by WHO and FEPA for drinking water and aquatic ecosystem. Concentration of heavy metals; Cu, Co, Zn, Fe, Pb, Mn and Cr were significantly above the maximum allowable levels set by United State Environmental Protection Agency (USEPA) and WHO levels for drinking water and for protection of aquatic ecosystem. The levels of DO and phosphate in the water samples exceeded the Nigeria Federal Environmental Protection Agency (NFEPA) tolerance limits for drinking water and water meant for domestic uses. This may have deleterious effect on aquatic ecosystem and the health of the rural dweller that use the river water directly for domestic purposes without treatment.

Key words: Effect, municipal waste, industrial effluent, River Challawa, Kaon

INTRODUCTION

The problem of pollution is attracting the attention of people around the world. With increased urbanization and industrialization, there has been a rapid increase in the municipal water (Sewage water + Industrial effluents), which in turn has intensified the environmental pollution. The disposal of industrial effluents and municipal wastes is therefore a major problem for big cities.

Industrial discharge is a major component of water pollution, concentration of oxygen demand and nutrient loading of the water bodies, promoting toxic algal blooms and leading to a destabilization of the aquatic ecosystem (Morrison *et al.*, 2001; WRC, 2000; DWAF and WRF, 1995). The problem is compounded in areas where wastewater treatment systems are simple and not efficient, as is the case of Challawa industrial area where effluent from industries are discharged into river challawa, with little or no treatment.

River challawa is an important river in Kaon State, Nigeria. The river is used for various human activities including washing, fishing, farming and drinking. The domestic water supply for this area comes from river Challawa. Some peasant farmers along the course of the

river also use water from the river to water their food crops especially vegetables during the dry season. The river receives municipal waste and wastewater from industries sited along this area.

Effluent discharged into receiving waters and the cumulative hazardous effects on the environment have received much attention due to rapid industrialization in modern society. Industrial and municipal waste containing high concentration of microbial nutrients would obviously promote an after growth of significantly high coliform bacteria's. Both in the effluent and the receiving water (Ezeronye and Amogu, 1988).

High or low pH values in a river affect aquatic life and impair recreational uses of water (DWAF and WRC, 1995; Ezeronye and Amoye, 1988; Larger and Smith, 1975). A change in pH from that normally encountered in unimpacted streams affects the biota (Larger and Smith, 1975). For example, different organisms flourish within different ranges of pH. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals.

This research was carried out in order to assess the pollutant profile of the water body in river challawa, Kaon State, Nigeria.

MATERIALS AND METHODS

Sampling points: Measurement points from the sampling sites have been designated PS, 1 and 4 m and these points reflect different activities along the watercourse of river challawa. Point PS was located at the inlet of the discharged of waste effluent into river challawa. Point 1 m was the point located approximately 100 m after the effluent discharged point into river challawa. Point 4 m was located 400 m downriver from PS.

Sample collection: Water samples were monitored through regular weekly grab sample collections for 8 weeks. Grab samples were collected thrice a week at specified periods.

Water samples were collected in plastic containers previously cleaned by washing in non-ionic detergent, rinsed with tap water and later soaked in 10% HNO₃ for 72 h and finally rinsed with deionised water prior to usage.

During sampling, sample bottles were rinsed with sampled water three times and then filled to the brim at a depth of one meter below the water surface from the three designated sampling points in river challawa. At each sampling points, three water samples were drawn at random from three points and pooled. The samples were transported to the laboratory immediately and stored in the refrigerator at about 4°C prior to analysis.

Determination of pH, Eh, temperature, dissolves oxygen and total dissolved solid: pH, redox potential Eh, dissolved oxygen DO, total dissolved solids TDS, temperature and heavy metals concentration. Standard methods were followed in determining the above variable (USEPA, 1991).

All field meters and equipment were checked and calibrated according to the manufacturers specifications. The pH meter was calibrated using buffers of pH 4.0, 7.0 and 10.0; (HACH, 1997). Total Dissolved Solid (TDS) meter was calibrated using the potassium chloride solution provided by the manufacturer (HACH, 1997). Dissolved Oxygen (DO) meter was calibrated prior to measurement with the appropriate traceable calibration solution of (5% HCl) in accordance with the manufacturers instruction.

In-situ measurements for some of the parameters pH, Eh and temperature (°C) were measured using WTW pH Electrode SenTix 41. Dissolved oxygen was measured with Jenway Model 9070 waterproof DO meter while TDS was determined by using a C0150 conductivity meter.

Analysis of nitrate, sulphate and phosphate: The concentration of sulphate, nitrate and phosphate were determined using a DR/2010 HACH Portable Data

Logging Spectrophotometer. The spectrophotometers (HACH DR2010) were checked for malfunctioning by passing standard solutions of all the parameters to be measured; Blank samples (deionized water) were passed between every three measurements of effluent samples to check for any eventual contamination or abnormal response of equipment.

The concentration of phosphate in the samples were determined using the ascorbic acid method by reacting it with added reagent containing molybdate and an acid to give a blue coloured complex (Standard Methods, 1976; DWAF, 1992).

Nitrate as N was determine by the cadmium reduction metal method 8036 (Standard Methods, 1976; DWAF, 1992). The cadmium metal in the added reagent reduced all nitrate in the sample to nitrite. While sulphate was determined by using Sulfa Ver methods 8051 (Standard Methods, 1976; DWAF, 1992).

Heavy metals analysis: Heavy metal (copper, cobalt chromium, iron, zinc, manganese and lead) were determination using Atomic Absorption Spectrophotometer (AAS, Unicom 969). The water samples were digested as follows. One hundred cm³ of the sample were transferred into a beaker and 5mL concentrated HNO₃ Were added. The beaker with the content was placed on a hot plate and evaporated down to about 20mL. The beaker was cool and another 5mL concentrated HNO₃ was also added. The beaker was covered with watch glass and returned to the hot plate. The heating was continued and then small portion of HNO₃ was added until the solution appeared light coloured and clear. The beaker wall and watch glass were washed with distilled water and the sample was filtered to remove some insoluble materials that could clog the atomizer. The volume was adjusted to 100cm³ with distilled water (Radojevic and Bashkin, 1999). Determination of heavy metals in the water samples was done using Atomic Absorption Spectrophotometer (AAS, Unicom 969) as described in the manufacturers instruction manual.

Data analysis: Results were subjected to analysis of variance using the general linear models (Proc GLM) procedure of the statistical analysis system program package. Proc Univariate procedure was carried out on residuals to support the assumptions of normality made by the researchers. Where a significant Fisher test was observed, treatment means were separated using the Least Significant Difference at p < 0.05.

RESULTS AND DISCUSSION

The results of the study are presented in Table 1, Fig. 1 and 2, respectively. The pH values varied between

Table 1: Concentrations of pH, Eh, DO, TDS and Temperature in River Challawa, Kaon State, Nigeria between the periods of September to December 2005

Sampling points	pH	Eh (m v ⁻¹)	DO(mg L ⁻¹)	TDS (mg L ⁻¹)	Temperature (°C)
PS	10.23 ^a ±0.32	-87.2 ^a ±1.54	5.67 ^a ±0.54	70.1 ^a ±8.40	12.8 ^a ±0.24
1 m	8.12 ^b ±0.21	-57.2 ^b ±1.52	6.67 ^b ±0.43	50.0 ^b ±5.20	10.2 ^b ±0.14
4 m	7.11 ^c ±0.10	-46.3 ^c ±1.34	7.55 ^c ±0.14	40.3 ^c ±3.24	8.2 ^c ±0.14

The values given in the table above are means of replicate values (n= 24). Within columns, means with different letters are statistically significant, p<0.05. PS: Point Source (point of immediate discharge of effluent into River Challawa), 1m: 100 meter (after point of discharge of effluent into River Challawa) and 4m: 400 meter (downriver from point source)

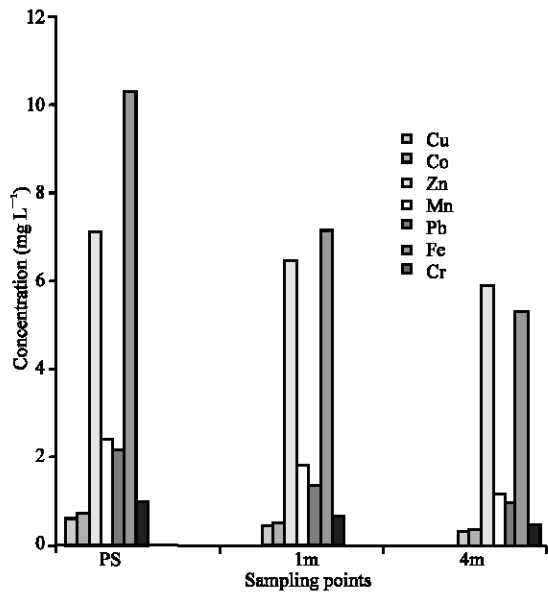


Fig. 1: Concentration of heavy metals in River Challawa

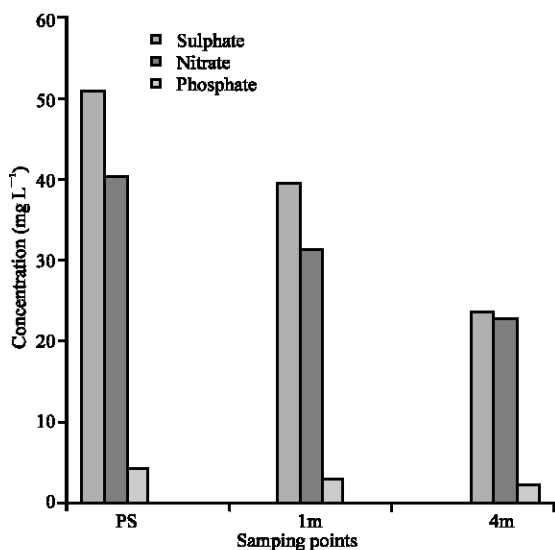


Fig. 2: Concentration of anions in River Challawa

6.81±0.10 and 10.23±0.32 mg L⁻¹ in river Challawa as shown in Table 1. Generally the pH values were basic. The pH value at Point Source (PS) was slightly above WHO and FEPA standards of 7.5-8.5 for drinking water. The mean pH values recorded for point 1 and 4m in this study

were within the stipulated Nigeria FEPA pH tolerance limit of between 6.0-9.0 for drinking water and water meant for full contact recreation (DWAf, 1996b; Anthony, 1997). The EU also sets pH protection limits of 6 to 9 for fisheries and aquatic life (Chapman, 1996). The pH obtained from the sampling point (1 and 4 m) fell below this range. Base on these guidelines, the pH of the river water would not adversely affect its use for domestic or recreational purposes.

Redox potential (Eh) of the water sample shown in Table 1, ranged from -46.3±1.34 to -87.2±1.54 m v⁻¹. Lowest Eh value was that of sample from Point Source (PS), while the sample of point 4m has the highest Eh value of -46.3±1.34 mg L⁻¹. This negative values shows that the environment is a reducing environment.

Dissolved Oxygen (DO) values ranged from 5.67±0.54 to 7.55±0.14 mg L⁻¹ as presented in Table 1. levels of DO from point source (PS) was lowest 5.67±0.54 mg L⁻¹ and point 4m was highest 7.55±0.14 mg L⁻¹, all the values obtained were above limits set by WHO of 3 mg L⁻¹ for drinking water. The dissolved oxygen values were not within the safety limits for maintenance of aquatic life of 5.00 mg L⁻¹ (Symonds *et al.*, 1981).

The Total Dissolved Solids (TDS) values of the samples ranged from 40.3±3.24 to 70.1±8.40 mg L⁻¹ (Table 1). The lowest value was found in point 4m while the highest value was found in Point Source (PS). The TDS value at Point Source (PS) was slightly above WHO and FEPA standards of 50 mg L⁻¹ for drinking water. While TDS values from point 1m and 4m were within the permissible limits set by WHO.

Temperature values for water samples are presented in Table 1, which ranged from 8.2±0.14 to 12.8±0.24 °C. the highest value was found in Point Source (PS) while the lowest value was found in point 4m. The temperature values were within the permissible limits of 12°C for drinking water set by WHO.

The values of pH, total dissolved solids and temperature decrease with distance from point source up to a distance of about 4m, while redox potential and dissolved oxygen increase with distance from point source up to a distance of a about 4m. The finding is in line with what (Symonds *et al.*, 1981; Ademoroti, 1996; Rand *et al.*, 1979) reported that a low DO usually depict a high TDS values. The results of DO and TDS values also emphasized this fact. From Table 1, an increased in TDS

correspond with a decreased in DO. Results of statistical analysis indicated that variations among points were statistically significant in all the parameters determined above ($p < 0.05$).

Sulphate levels in all the water samples studied varied from 22.6 ± 0.21 to 43.5 ± 0.31 mg L⁻¹ between the sampling points (Fig 1). Levels of sulphate in the river slightly decrease downriver from Point Source (PS) and none of the water samples from river exceeded the 200 mg L⁻¹ WHO maximum permissible levels for drinking water that may give rise to Methaemoglobinemia.

Nitrate levels in the water samples varied between 1.11 ± 0.02 to 4.04 ± 0.03 mg L⁻¹ for all sampled points (Fig. 1) Nitrate toxicity increases the risk of anaemia in infant and pregnant women and formation of carcinogenic nitrosamines (Bush and Meyer, 1982) The WHO guideline for domestic water supply states limit of 45 mg L⁻¹ for Nitrate levels. The South Africa guideline for domestic water supply (DWAF, 1996b) states limit of 6 mg L⁻¹ as safe limits for babies. None of the samples from the river exceeds these limits. Thus, nitrate concentration is not considered to pose a problem for the domestic use of water from the river. The levels of phosphate in the water samples ranged from 0.54 ± 0.02 to 1.56 ± 0.04 mg L⁻¹ (Fig 1). These values already exceeded the South Africa guideline for phosphate in water system of 5.0 ug L⁻¹ (Morrison *et al.*, 2001; DWAF, 1996b) that will reduce the likelihood of algae growth and would cause eutrophication in the river. Anion levels in the water samples showed a decrease in concentration with distance from point source up to 4m, this decrease might be ascribed to dilution, sedimentation and depuration due to immense volume of fresh water passing through the river.

Heavy metal contents of water samples from River

Challawa: The average heavy metal content of water samples from river Challawa are given in Fig. 2.

Copper: The average values of copper content of water samples from river Challawa was 0.32 ± 0.02 to 0.57 ± 0.05 mg L⁻¹ respectively between sampling points. These results show that Cu content of river Challawa was above the WHO limit of 0.05 mg L⁻¹ and Maximum Contaminant Level (MCL) of 0.052 mg L⁻¹ for drinking water (WHO, 1984; Shivkumar and Bikshman, 1995) analyzed the surface water and subsurface ground water content. The concentration of copper content was 5 to 10 times above the permissible limits.

Cobalt: Mean levels of Cobalt in river Challawa ranged from 0.37 ± 0.01 to 0.66 ± 0.04 mg L⁻¹ between sampling

points. These values exceeded the 0.05 mg L⁻¹ WHO maximum permissible values of cobalt for drinking water and the 0.1 mg L⁻¹ WHO highest desirable values for water meant for the same purpose (Fatoki *et al.*, 2003). The implication of this is that the water from the river may have taste and other aesthetic problem (Fatoki *et al.*, 2003).

Zinc: The mean values of zinc ranged from 5.86 ± 0.41 to 7.13 ± 0.56 mg L⁻¹ between the sampling points. The highest value was found in Point Source (PS) while the lowest value was found in point 4 m. All of these values fell above the 5.0 mg L⁻¹ highest desirable level for zinc in drinking water (WHO, 1984). However, these zinc levels in the river may be of a problem for the use of aquatic ecosystem, as their levels exceeded the 5.0 mg L⁻¹ target water quality range for zinc in water for the use of aquatic ecosystem (WHO, 1984). The high values of zinc might be attributed to municipal waste and discharged of wastewater from industries sited along this area in to river.

Manganese: Mean levels of Manganese in the water samples varied between 1.16 ± 0.11 to 2.39 ± 0.14 mg L⁻¹. The highest value was found in Point Source (PS) while the lowest value was found in point 4m. Levels of manganese obtained for the river samples are above the 0.05 mg L⁻¹ manganese in water meant for aquatic ecosystem (WHO, 1984), this gives cause for alarm, therefore, the river will not be suitable for the maintenance of aquatic ecosystem. The high values of manganese The high values of manganese might be attributed to municipal waste and discharged of wastewater from industries sited along this area in to river.

Lead: The mean levels of lead in the river samples ranged from 0.09 ± 0.01 to 2.15 ± 0.04 mg L⁻¹ between the sampling points. The levels of lead obtained for the river samples were above the WHO limit of 0.05 mg L⁻¹ and Maximum Contaminant Level (MCL) of 0.052 mg L⁻¹ for drinking water (WHO, 1984; Salido and Jones, 1999). Consequently, the direct use of water for drinking from this river by rural dwellers without treatment could be detrimental to human health.

Iron: Mean levels of iron in river Challawa ranged from 5.32 ± 0.21 to 10.28 ± 0.31 mg L⁻¹ between the sampling points. The values of iron were above the limits set by FEPA and WHO of 0.3 mg L⁻¹. The high values of iron might be attributed to municipal waste and discharged of wastewater from industries sited along this area in to

river or due to its abundance in the earth crust. The implication of this is that the water from the river may have taste and other aesthetic problem (Fatoki *et al.*, 2003).

Chromium: Chromium levels in river challawa varied from 0.45 ± 0.01 to 0.97 ± 0.31 mg L⁻¹ between the sampling points. The highest value was found in Point Source (PS) while the lowest value was found in point 4m. All of these values fell above the 0.05 mg L⁻¹ highest desirable level for chromium in drinking water (WHO, 1984). Levels of chromium in the river may give cause for concern presently, bio-magnification of it in the river with time may lead to serious condition as chromium is extremely toxic and the primary use of water high in chromium could cause adverse health effects to consumers such as renal disease and cancer (Salido and Jones, 1999).

The concentration of heavy metals in the water from river challawa decrease with distance from point source up to 4m, this decrease might be ascribed to dilution, sedimentation and depuration due to immense volume of fresh water passing through the river. These high values of heavy metal in the water samples might be attributed to the municipal discharged of wastewater from industries sited along this area into river.

CONCLUSION

The major source of surface water pollution is injudicious discharged of untreated industrial effluent and municipal waste directly into surface water bodies, resulting in serious surface water pollution. This loss of water quality is causing health hazards and death of human beings, livestock, death of aquatic lives and crop failure. The high levels of heavy metals, DO, phosphate obtained in this study may in addition to affecting the health of the aquatic ecosystem in the river, have a deleterious effect on the health of rural dwellers downriver that use the water from the river for domestic purpose without treatment. The wastewater treatment plants in these industries need to be upgraded to improve their treatment performance.

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