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An Assessment of the Impact of Point Source Pollution from a University Sewage Treatment Oxidation Pond on a Receiving Stream-A Preliminary Study

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Abstract: The treatment performance of the sewage treatment oxidation pond of a Nigerian University was assessed in terms of pH, electrical conductivity, biochemical oxygen demand (BOD_5) and nutrient removal from the influent. These parameters were simultaneously monitored in the receiving stream, influent and effluents. Significant pollution of the receiving stream was indicated for BOD_5, nitrate, phosphate, suspended solids and pH. The levels of these parameters in the sewage effluent exceeded the Nigerian Federal Environmental Protection Agency tolerance limits for the effluents to be discharged through public sewers into a stream. In addition, the levels of some trace metals: Pb, Fe, Mn, Zn and Cd were also determined in the influent, effluent of the oxidation pond and the receiving stream. High mean levels of Pb, Zn and Fe were observed in the receiving stream and exceeded the WHO guideline levels for drinking water and for protection of aquatic ecosystem. This unfortunately, may affect the 'health' of the aquatic ecosystem in the receiving stream and the health of the rural dwellers who use the stream water directly for domestic purposes without treatment.

Key words: Oxidation pond, sewage, trace metals, eutrophication, stream, point source pollution

INTRODUCTION

Sewage discharge is a major component of water pollution, contributing to oxygen demand and nutrient loading of the water bodies, promoting toxic algal blooms and leading to a destabilized aquatic ecosystem[1-3]. This problem is compounded in areas where wastewater treatment systems are simple and not efficient, as is the case of the Obafemi Awolowo University sewage treatment oxidation pond.

The oxidation pond was built as an aerobic and anaerobic pond system in which the sewage treatment occurs naturally without added chemicals. This is unfortunate, since the problem of too high an inflow load results in a poor level of sewage purification and consequently results in the pollution of the receiving stream.

The receiving stream originates from Adefarakan hills in Ile-Ife. It is a tributary to a major Opa river (Fig. 1) and some communities downstream use water from this stream for a variety of purposes like fishing, recreation and drinking without prior treatment and it is of great importance that the stream remains in a 'healthy' state. In addition there is an Abattoir located along the course of this river that utilizes raw water from the adjacent Opa river for washing of slaughtered cattle parts prior to their sale to consumers. Some peasant farmers along the course of the receiving stream also use water from the stream to water their food crops especially vegetables during the dry season.

However, fears have been raised that, due to the continual discharge of effluent from the oxidation pond, the receiving stream could be excessively polluted. Untreated domestic waste or raw sewage wastewater is usually gray brown, odiferous and relatively dilute (99% water). Some of the important constituents of domestic and raw sewage wastewaters that are targeted for removal through treatment are total suspended solids (TSS), biochemical oxygen demand (BOD), nutrient-nitrogen (NO_3^-) and phosphorous (PO_4^{3-})[4].

High or low pH values in a river have been reported to affect aquatic life and alter toxicity of other pollutants in one form or the other[1,5,6]. Low pH values in a river for example impair recreational uses of water and affect aquatic life. A decrease in pH values could also decrease the solubility of certain essential elements such as selenium while at the same time low pH increases the solubility of many other elements such as Al, B, Cu, Cd, Hg, Mn and Fe[1,6]. High pH values affect the toxicity of some pollutants e.g. at high pH values (pH>8.5) free ammonia (NH_3) is more toxic to aquatic biota than when it is in the oxidized form (NH_4^+)[5].

High nitrate concentrations are frequently encountered in treated wastewater, as a result of

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ammonium nitrogen (which is prevalent in raw waste) being totally or partially oxidized to nitrate by microbiological action[7]. High nitrate levels in waste effluents could also contribute to eutrophication effects, particularly in freshwater[1,7,8]. Various workers have reported that the potential health risk from nitrate in drinking water above threshold of 45 mg L^{-1} may give rise to the condition known as methaemoglobinemia in infants and pregnant women[9-12]. Nitrate in waste effluents can originate from domestic and agricultural wastes especially from nitrogen-containing fertilizers.

Furthermore, phosphates in sewage effluents arise from human wastes and domestic phosphate-based detergents. Unfortunately, phosphate anions are not desirable in receiving waters because they act as the most important growth-limiting factor in eutrophication and result in a variety of adverse ecological effects[8, 12-14].

Biochemical oxygen demand (BOD) measures the amount of oxygen required by bacteria for breaking down to simpler substances the decomposable organic matter present in any water, wastewater or treated effluents. It is taken as a measure of the concentration of organic matter present in such water. The greater the decomposable matter present, the greater the oxygen demand and the greater the BOD value[14-15]. It is an important parameter for river and industrial waste studies and control of waste treatment plants.

EC of water is a useful and easy indicator of its salinity or total salt content. Wastewater effluents often contain high amounts of dissolved salts from domestic sewage. Salts such as sodium chloride and potassium sulphate pass through conventional water and wastewater treatment unaffected[1,5]. High salt concentrations in waste effluents however, can increase the salinity of the receiving water, which may result in adverse ecological effects on aquatic biota[7].

The accumulation of metals in an aquatic environment has direct consequences to man and to the ecosystem. Metals like Zn, Pb an Cd are common pollutants which are widely distributed in aquatic environment. Their sources may be atmospheric deposition[16]; domestic effluents[17,18]; urban storm water runoff[19] and soil heaps[20]. Extensive literature on the aquatic toxicity of Zn and especially its toxicity to fishes has been reviewed[21]. It is unusual in that it has low toxicity to man, but relatively high toxicity to fish[21].

Cadmium has been found to be toxic to fish and other aquatic organisms[22]. Toxicity effect of cd in man includes kidney damage[23] and pain bones[24]. The mutagenic, carcinogenic and teratogenic effects of cadmium have also been reported in literature[25-27]. The major effect of the presence of Fe and Mn in domestic water is aesthetic because of the colour[18].

Lead is a potentially hazardous element to most forms of life and is considered toxic and relatively accessible to aquatic organisms[28]. Lead is bioaccumulated by benthic bacteria, fresh water plants, invertebrates and fish.[29]. The chronic effect of Pb on man includes neurological disorders, especially in the foetus and in children.

The pH of water body determines the chemical species of many metals and thereby alters the availability and toxicity in their aquatic environment[29]. Metals such as Cd, Pb, Mn and Zn are most likely to have increased detrimental environmental effects as a result of a lowered pH[29].

In this study, an attempt was made to assess the levels of some water quality parameters-pH, BOD, nitrates, phosphates, electrical conductivity, total solids, suspended solids and some trace metals in the sewage treatment oxidation pond of Obafemi Awolowo University, Ile-Ife Nigeria and the impact of discharges from the oxidation pond on the receiving stream. Interest on these parameters stems from the realization of their aforementioned undesirable consequences and has prompted several statutory bodies such as the World Health Organization to set up stringent guidelines for their control in surface waters and wastewater[30]. The study would no doubt give an indication of the impact of pollution from the sewage treatment oxidation pond on the receiving stream. Peoples' health downstream is at stake and so are our water resources and ecosystem health.

MATERIALS AND METHODS

Study area and sampling points: Measurement points from the sampling sites have been designated S1 to S6. Sample SR represents the reference point upstream before discharge of the effluent into the stream and serves as control.

The Obafemi Awolowo University campus has two oxidation ponds X and Y lying side by side (Fig. 1). They were constructed in 1967 and became operational in 1968. They are located in the Southwestern part of the University and drain wastewater and sewage from the students' hostel and the academic area (about 27,000 people). Each of the ponds is 150x32x1.5 m. A 10 m wide dyke separates them. Only one pond receives influents at a time and wastewater and sludges are retained in the pond for about two weeks during which algae, bacteria and other organisms act on them. Wastes are conveyed to the ponds through sewers made of concrete pipes and there are manholes at some points along the channels to change the direction of the sewers.

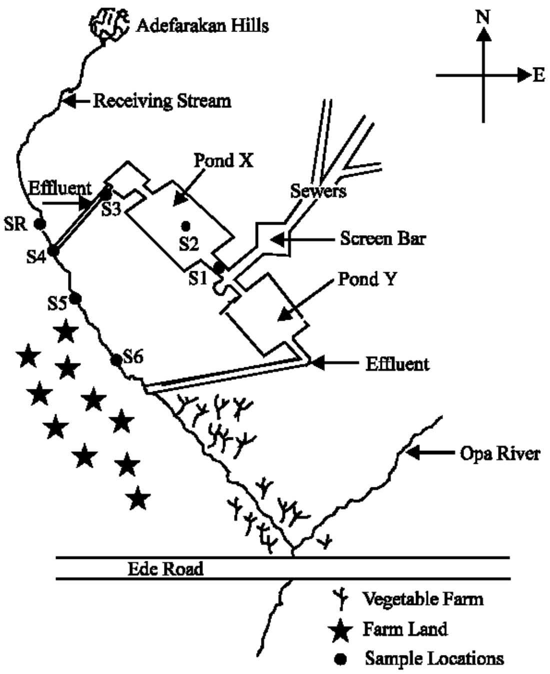

Fig. 1: A sketch diagram of the study area (not drawn to scale)

Pond X is the one that was in use at the time this study was conducted; hence samples were collected from this pond and the receiving river as indicated on the sketched diagram of the study area. Each of the ponds has a discharge channel through which effluents are discharged into a nearby receiving stream. This stream feeds Opa river directly.

Site S1 was located at the inlet of the sewage treatment oxidation pond where influent samples were collected. Site S2 was located on the oxidation pond while Site S3 represents the effluent discharge point from the oxidation pond before entry into the receiving stream. The qualities of influents and effluents were measured at these three points to determine the efficiency of the oxidation pond in removing those aforementioned parameters, from the influents. At Site (S3), the effluent used to be treated with hydrated calcium hypochlorite before its discharge into the receiving stream. This practice has stopped since about seven years ago now and this makes the present study very urgent and necessary. S4 was a sampling point located at the merging point of the effluent from the oxidation pond and the receiving stream to investigate the impact of the effluent on the river. Sites S5 and S6 were points approximately 20 and 100 m downstream the oxidation pond effluent discharge point on the stream. Samples were taken from these sites to further assess the impact of the effluent discharge on the receiving stream.

Sample collection: Water samples were collected in plastic containers previously cleaned by washing in non-ionic detergent, rinsed with tap water and later soaked in 10% HNO_3 for 72 h and finally rinsed with deionised water prior to usage.

During sampling, sample bottles were rinsed with sampled water several times and then filled to the brim. The samples were transported to the laboratory immediately and stored in the refrigerator at about 4°C prior to analysis. pH and electrical conductivity analyses were carried out immediately after sample collection. Nitrate and phosphate levels were determined colorimetrically after filtration of samples. Fresh standards were prepared for these parameters during every measuring event that is not more than a week.

Blank determination was also performed and results presented in this study were adjusted for blank measurement.

Determination of pH, electrical conductivity, BOD, (NO_3^-), (PO_4^{3-}), suspended solids and total solids: The pH was measured immediately after sample collection using a digital pH meter model H18519 (Hanna Instrument). Calibration of the electrode with 2 buffer solutions of pH 4 and 7 was done prior to its use for pH measurement of the samples.

Electrical conductivity was carried out using a METTLER TOLEDO MC 126 conductivity meter, which was calibrated with conductivity standard (METTLER TOLEDO conductivity standard 1413 $\mu S\ cm^{-1}$) at 25°C.

The Fiske and Subbarow method[31] was adopted for the colorimetric determination of available phosphate. A standard curve of (PO_4^{3-}) was prepared by diluting 0.2, 0.4, 0.6, 0.8 and 1.0 mL of 0.001 M KH_2PO_4 measured into separate test tubes with 4.8, 4.6, 4.4, 4.2 and 4.0 mL of distilled water respectively. To each of the test tubes was added 1.0 mL of 5N H_2SO_4 and then 1 mL ammonium molybdate solution. Finally, 0.3 mL of Fiske reagent (1.0 g of Fiske reagent in 6.3 mL distilled water) was added and mixed thoroughly and allowed to stand for colour development. A blank containing distilled water, instead of the standard 0.001M KH_2PO_4 was also treated as above. Optical density measurements were taken at 660 nm using a UV/visible spectrophotometer (Camspec model M301, Cambridge, UK). 1.0 mL each of the water samples was then similarly treated without standard 0.001M, KH_2PO_4 and the optical density measurements were also taken like before. The phosphate concentrations in the samples were extrapolated from the standard curve constructed.

Concentrations of nitrate in the samples were determined using standard methods[32]. Total and suspended solids were determined by the filtration, drying and weighing method. A cellulose acetate membrane filter and clean dried vitrosil crucibles were used. The temperature of drying was 105°C[13].

The BOD determination of the sample in mg L^{-1} was carried out using the standard methods[33]. The dissolved oxygen content was determined before and after incubation. Sample incubation was for 5 days at 20°C in BOD bottles and BOD_5 was calculated after the incubation period.

Trace metals analysis: The nitric-perchloric-hydrofluoric acid digestion method described by[34] was adopted. Ten milliliter of water sample was taken for analysis in a Teflon beaker (previously soaked in 10% nitric acid for 72 h and rinsed with de-ionized water) and 30.0 mL of concentrated HNO_3 was added and the sample was evaporated to dryness on a hot plate in a fume cupboard. This was allowed to cool and 5.0 mL of conc. HNO_3, 2.0 mL of 60% perchloric acid $HClO_4$ and 6.0 mL of 40% HF were added. The mixture was evaporated to dryness at a temperature not exceeding 280°C. Furthermore, 2.0 mL of HNO_3 and 2.0 mL of $HClO_4$ acids were added and evaporated to ensure that silicon and fluoride were removed. Again, the beaker was cooled and 20.0 mL of 5% v/v HNO_3 was added to dissolve the salts. The solution was transferred to a 100.0 mL standard flask and made up to mark with de-ionized water washings from the digestion beaker.

A blank experiment was carried out for background correction using de-ionized water and following the procedure described above without the sample. Solution of the worked up samples were run on a Chemteck (UK) flame AAS at the Centre for Energy Research and Development at the Obafemi Awolowo University, Ile-Ife, Nigeria.

The instrument was operated as per the instrument handbook and the data were acquired on a Gateway 2000 PC system using the Alphaster software. Measurements were done at 214, 228, 279, 283 and 248 nm for Zn, Cd, Mn, Pb and Fe, respectively. All the chemical analyses were done in triplicate.

For the quality control, water samples were spiked with a known amount of standard Pb, Mn, Fe, Zn and Cd, respectively and the recoveries of the elements were measured using the above standard procedure[34].

RESULTS AND DISCUSSION

The results of the study are presented in Table 1 and 2, respectively. The pH values varied between 5.95 and 6.32 in the influent and effluent from the oxidation pond and between 5.23 (S5) and 5.88 (S6) in the receiving stream, respectively as shown in Table 1a and b. Generally the influent, effluent and the receiving stream were acidic, the influent (S1) having the highest pH. The mean pH values recorded for the influent and effluent in this study is within the stipulated Nigerian FEPA pH tolerance limit of between 6.0-9.0 for effluents to be discharged through sewers into a stream (Table 3). The pH values from the point of discharge of effluent into the receiving stream and downstream (S4-S6) (Table 1), fell below the WHO pH range of 7.0-8.5 and the water quality range of 6.5 to 8.5 for drinking water and water meant for full contact recreation, respectively[29, 35]. According to the WHO guidelines the pH values obtained for the stream make it unsuitable for potable water and recreational purposes. The EU also sets pH protection limits of 6 to 9 for fisheries and aquatic life[36]. The pH obtained in the stream (S4-S6) fell below this range. Therefore, the parameter does gives cause for concern and it would adversely affect aquatic life and the use of the stream for fisheries.

The electrical conductivity (EC) values were 890 and 527 µS cm^{-1} for the influent (S1) and effluent (S3), respectively. The EC value was 279 µS cm^{-1} at the point of discharge of effluent into the receiving stream (S4) and decreases downstream. Electrical conductivity of water which is a useful indicator of its salinity or total salt content is high in the influent and effluent of the oxidation pond compared with values recorded for the receiving stream. This result is not unexpected since water effluents from domestic sewage often contain high amounts of dissolved salts[5]. The results of EC in Table 1a show a general removal of salts contributing to conductivity from influent (890 µS cm^{-1}) to effluent sample (527 µS cm^{-1}). A decrease of EC from S1 of 890 to S2 of 693 µS cm^{-1} (sample collected on the oxidation pond 30 m away from the influent point) is an indication of the effectiveness of the oxidation pond in removing dissolved salts from the sewage to an extent. The values of EC in the receiving stream varied between 159.5 µS cm^{-1} at SR (reference point) and 279 µS cm^{-1} at S4 (point of discharge of effluent into the stream). The continuous decrease in the value of the electrical conductivity downstream from the point of discharge of effluent into the receiving stream may have resulted from dilution as the effluent mixes with fresh water.

The biochemical oxygen demand (BOD) of a system is usually increased by the addition of both organic and inorganic substances to the environment. In general, organic contaminants entering the systems from municipal sewage treatments plants or as raw sewage are some of the major sources of organic wastes entering our waterways. These organic materials eventually are broken

Table 1: Electrical conductivity, BOD, nutrient, suspended and total solids from the sewage treatment oxidation pond and the receiving stream

Samples	pH	Electrical conductivity (EC) (µS cm^{-1})	BOD_5 (mg L^{-1})	(NO_3^-) (mg L^{-1})	(PO_4^{3-}) (mg L^{-1})	Total solid (mg L^{-1})	Suspended solid (mg L^{-1})
(a) Influent and effluent form the oxidation pond							
S1	6.32	890	98.85 (±11.85)	2.24 (±2.41)	7.74 (±1.24)	900.00 (±8.12)	500.00 (±7.10)
S2	5.95	693	55.35 (±0.03)	1.99 (±0.81)	7.89 (±1.59)	800.00 (±0.21)	300.00 (±4.51)
S3	6.03	527	31.64 (±5.20)	2.53 (±1.20)	3.32 (±0.24)	500.00 (±9.21)	200.00 (±3.11)
Overall mean (±SD)	6.10 (±0.19)	703.33 (±175.22)	61.95 (±34.09)	2.25 (±0.27)	6.32 (±2.60)	733.33 (±230.94)	333.33 (±173.20)
(b) Receiving river							
S4	5.90	279	11.07 (±0.01)	2.54 (±0.52)	2.52 (±0.10)	400.00 (±13.91)	300.00 (±10.11)
S5	5.23	221	7.12 (±1.32)	2.46 (±1.44)	1.57 (±0.72)	200.00 (±4.8)	100.00 (±7.12)
S6	5.88	211	10.55 (±0.53)	2.43 (±0.33)	1.08 (±0.20)	100.00 (±14.5)	98.62 (±10.89)
SR	6.67	159	1.74 (±0.16)	5.41 (±0.20)	0.84 (±0.03)	96.67 (±20.09)	20.00 (±2.00)
Overall mean (±SD)	5.92 (±0.59)	217.63 (±48.99)	7.62 (±4.29)	3.21 (±1.47)	1.50 (±0.74)	199.18 (±304.71)	129.66 (±142.36)

Table 2: Levels of some trace metals (mg L^{-1}) from the sewage treatment oxidation pond and the receiving stream

Samples	Pb	Mn	Fe	Zn	Cd
(a) Influent and effluent form the oxidation pond					
S1	0.17 (±0.01)	0.13 (±0.01)	9.20 (±0.30)	0.11 (±0.01)	<0.001
S2	0.16 (±0.01)	0.19 (±0.20)	9.20 (±0.40)	0.19 (±0.20)	<0.001
S3	0.17 (±0.20)	0.09 (±0.10)	6.90 (±0.40)	0.11 (±0.01)	<0.001
Overall mean (±SD)	0.17 (±0.01)	0.14 (±0.05)	8.43 (±1.33)	0.14 (±0.05)	<0.001
(b) Receiving river					
S4	0.18 (±0.002)	0.14 (±0.01)	7.10 (±0.20)	0.13 (±0.01)	<0.001
S5	0.16 (±0.04)	0.15 (±0.01)	7.80 (±0.30)	0.14 (±0.01)	<0.001
S6	0.20 (±0.01)	0.11 (±0.01)	7.60 (±0.30)	0.11 (±0.10)	<0.001
SR	<0.0080	0.04 (±0.01)	1.80 (±0.30)	0.12 (±0.011)	<0.001
Overall mean (±SD)	0.134 (±0.09)	0.11 (±0.05)	6.08 (±2.86)	0.13 (±0.01)	<0.001

Table 3: Some ** FEPA limitation guidelines for effluents discharging through public sewers into Stream

Parameters	Tolerance limits for effluent (mg L^{-1})
pH	6.0-9.0
BOD	50
Total solids	2,500
Suspended solids	50
Lead	0.1
Manganese	5.0
Iron	20
Zinc	-
Cadmium	-

** FEPA-Nigerian federal environmental protection agency

down by bacteria, which require oxygen for decomposition process. Since there is a large amount of organic matter to be broken down, the bacteria remove large quantities of dissolved oxygen from the system hence the BOD increases. As additional material is added, more oxygen is removed and thus decreasing the oxygen level further[37]. The BOD_5 obtained in this study was highest for the influent (S1) 98.85 mg L^{-1} and decreases from this point to 31.64 mg L^{-1} at S3 (Table 1a). This result indicates some purification and effectiveness of the oxidation pond in the removal of biochemical oxygen demanding substances from the effluent before they enter the stream. The BOD_5 values of water samples from the receiving stream (Table 1b) varied between 7.12 mg L^{-1} (S5) and 11.07 mg L^{-1} (S4). Generally, the BOD_5 levels recorded in the river water are higher than the EU guidelines of 3.0-6.0 mg L^{-1} for the protection of fisheries and aquatic life[36]. The overall mean BOD_5 found for the influent and effluent from the oxidation pond (61.95 mg L^{-1}) (Table 1a) is higher than the 50 mg L^{-1} tolerance level stipulated by FEPA for effluents to be discharged through sewers into a stream (Table 3), this is unfortunate since continuous discharge of the effluent has impacted the receiving stream to some extent and this may have negative effects on the quality of the fresh water and can as well cause harm to the aquatic life especially fish downstream[1]. The BOD_5 (1.74 mg L^{-1}) reported for the reference sample (SR) is expectedly low since this sample serves as control.

Level of phosphate in the influent (S1) was 7.74 mg L^{-1} and increases slightly in the oxidation pond sample (S2) to 7.89 mg L^{-1} but reduces to 3.32 mg L^{-1} in the effluent (S3). The high value of phosphate in sample (S2) is expected, as there was a prolific algal growth on the oxidation pond during sampling. The high nutrient value obtained on this site explained the growth of blue-green algae on the oxidation pond. This is unfortunate as the blue-green algae could release toxic cyanotoxins into the receiving water causing death of farm livestock[38]. Phosphate levels varied from between 2.52 and 0.84 mg L^{-1} in the receiving stream (Table 1b). These values already exceeded the South African guideline for (PO_4^{3-}) in water systems of 5.0 µg L^{-1}[1,6] that will reduce the likelihood of algal growth and would cause eutrophication in the stream especially in the larger Opa river situated down stream (Fig. 1). This phenomenon was experienced on Opa river as at the time this study was conducted. This is unfortunate as incidence of eutrophication could adversely affect the use of this river for recreational purposes as a large area of this Opa river downstream was covered by macrophytes.

Nitrate concentrations in both influent and effluent are 2.24 and 2.53 mg L^{-1}, respectively. In the receiving stream, the level of nitrate varies between 2.43 and 5.41 mg L^{-1}. From Table 1b levels of nitrate in the receiving stream slightly decrease downstream from the point of discharge of the effluent and none of the water sample from the receiving stream exceeded the 45 mg L^{-1} WHO maximum permissible level for drinking water that may give rise to methaemoglobinemia. However, the mean nitrate level in the effluent was 2.25 mg L^{-1} (Table 1a), which exceeded the 1.5 mg L^{-1} South African guideline for nitrate in sewage effluent[39]. Levels of nitrate reported in this study in addition to the phosphate levels can cause eutrophication and may pose a problem for other uses[8].

The high level of total solids (900.00±8.12-500.00±9.2 mg L^{-1}) and high suspended solid values of (500.00±7.10-200.00±3.11 mg L^{-1}) obtained for the influent and effluent, respectively support some of the high values obtained for other parameters determined in this study. The bulk of the wastewater in the study area contains human excreta, urine and other semi solid wastes. Although total solids obtained in this study are below the 2,500 mg L^{-1} FEPA tolerance level for sewage to be discharged into a stream, the suspended solids levels are higher than the tolerance limit value of 50 mg L^{-1} (Table 3).

The percentage recoveries obtained for the cations investigated in this study varied between 78.6±3.5% for zinc and 82.5±2.6% for Pb, which validate the experimental procedures used for the chemical analysis. The detection limits of these elements in mg L^{-1} were Pb, 0.0080; Mn, 0.013; Zn, 0.005; Cd, 0.001 and Fe, 0.1020.

The results of trace metals measurements in the influent and effluent from the oxidation pond together with those of receiving stream are presented in Table 2a and b.

The mean levels of Pb in the influent and effluent varied between 0.16 and 0.17 mg L^{-1} whereas in the river water Pb levels ranged from <0.0080 to 0.20 mg L^{-1}. The overall mean level of Pb is 0.17 mg L^{-1} obtained for the influent and effluent (Table 1a) is above the 0.1 mg Pb L^{-1} FEPA limitation guideline (Table 3) for the discharge of effluent from the public sewer into a stream. Also, levels of Pb obtained for the stream samples with the exception of the reference sample (SR) were above the WHO limit of 0.01 mg L^{-1} and maximum contaminant level (MCL) of 0.015 mg L^{-1} for drinking water[30,40,41]. Consequently, the direct use of water for drinking from this stream and the adjacent Opa river downstream by rural dwellers without treatment could be detrimental to human health. Furthermore, levels of Pb obtained for the stream water are above the 100 μg L^{-1} Pb level that may result in possible neurological damage to foetuses and young children[18], all these give cause for concern.

Mean levels of Mn in the influent and effluent varied between 0.09 and 0.19 mg L^{-1} and between 0.04 and 0.15 mg L^{-1} in the receiving stream . There are however no Mn FEPA limitation guidelines for the discharge of sewage effluents into a stream. Happily, levels of Mn obtained for the stream samples are below the 0.18 mg L^{-1} Mn in water meant for aquatic ecosystem use[18], this gives no cause for alarm, therefore, the stream will be suitable for the maintenance of the aquatic ecosystem.

Mean levels of Fe in the receiving stream ranged from 1.80 to 7.80 mg L^{-1}, while in the influent and effluent, the levels ranged between 6.90 and 9.20 mg L^{-1}. The FEPA limitation guideline of 20 mg Fe L^{-1} (Table 3) was met by the effluent discharged to the receiving stream, but unfortunately the samples of water from the stream exceeded the 1.0 mg L^{-1} WHO maximum permissible value of Fe for drinking water and the 0.1 mg L^{-1} WHO highest desirable value for water meant for the same purpose[18, 35]. The implication of this is that the water from the river may have taste and other aesthetic problems[18].

The mean values of Zn ranged from 0.11 to 0.19 mg L^{-1} in influent and effluent and from 0.11 to 0.14 mg L^{-1} in the receiving stream. All of these fell below the 5.0 mg L^{-1} highest desirable level for Zn in drinking water[30,35,40], hence use of such water for domestic purposes may not pose any danger base on this criterion. However, these Zn levels in the stream may be of a problem for the use of aquatic ecosystem, as their levels exceeded the 2 μg L^{-1} target water quality range for Zn in water for the use of aquatic ecosystem[18].

Cadmium levels in the influent, effluent and the receiving stream were very low and occurred below the detection limit of 0.001 mg L^{-1}. This may not pose problem for now from domestic and aquatic ecosystem considerations. The WHO level of cadmium in drinking water is 0.01 mg L^{-1} (Maximum allowable concentration) while the MCL of Cd in drinking water is 5 μg L^{-1},[30,41,42], cadmium level in water for aquatic system is 0.15 μg L^{-1} in soft water and 0.25 μg L^{-1} in moderately soft water[18]. Although levels of Cd in the river may not give cause for concern presently, bio-magnification of it in the stream with time may lead to serious conditions as cadmium is extremely toxic and the primary use of water high in Cd could cause adverse health effects to consumers such as renal disease and cancer[24,43].

Although the levels of the heavy metals investigated in this study did not conform to a definite pattern in the influent, effluent and the receiving stream, the high levels of some of the metals in the stream give cause for concern because the people's health and the 'health' of the ecosystem are at stake. Generally, the sources of metal pollution in the stream may be diffuse, which include agricultural runoff and point sources from the sewage treatment oxidation pond, as well as some natural sources.

The impact of point source pollution from a University sewage treatment oxidation pond on a receiving stream was assessed in this study. Significant pollution of the stream was indicated for pH, BOD_5, nitrate, phosphate and suspended solids due to point-source discharge. The high levels of Pb, Zn and Fe obtained in this study may in addition to affecting the health of the aquatic ecosystem in the receiving stream, have a deleterious effect on the health of rural dwellers downstream that use the water from the stream for domestic purposes without treatment. The sewage treatment oxidation pond is still in a 'shambolic state' and seems to do very little in the way of treatment. It therefore needs to be upgraded to improve its treatment performance since the oxidation pond in its present state is obviously not efficient enough.

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