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Impacts of industrial effluent and dumpsite leachate discharges on the quality of groundwater in Oyo state, Nigeria

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Abstract

The quality of groundwater at Oluyole and Ona Ara local government were studied to reveal the impacts of industrial effluent discharge into Ona River (Oluyole) and dumpsite leachate discharge into Eku River (Ona Ara). Considering the mean levels in the upstream and downstream regions at both locations, all the physico-chemical parameters studied on the groundwater samples fell within the ranges quoted for Ibadan, Lagos, Kaduna, and Warri groundwater, and the levels of zinc and copper were found to be below the World Health Organisation (WHO) acceptable level and WHO maximum permissible levels. A higher mean value, recorded at the downstream region for oil and grease (2.21mg/l) at Oluyole was partly due to the quality and handling of bailers used by the residents. The dumpsite leachate and industrial effluent were also analysed for the same parameters as for the groundwater samples. Comparisons made on the results obtained for some parameters inferred that the dumpsite leachate and the industrial effluent were but not only the sources of pollutants in the groundwater.

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Introduction

Water pollution is a major problem in the global context, and it has been suggested that it is the leading worldwide cause of deaths and diseases (World Resources 1998). Pollution of water bodies is caused by human activities, and can be harmful to animals and plants that depend on them. Different kinds of pollutants affect human beings unknowingly because the chronic effects are not dramatic compared to the acute menaces. Human activities during the last century have polluted most of the groundwater in Nigeria (Osibanjo 1994). Rainwater on its way down to Earth also brings number of air pollutants, which mix with water on the ground and pollute it. Pollution of soil, groundwater, and surface water often happens as a result of spills and leakages of pollutants, as well as regular discharge from processing activities (NORAD 1996). In particular, both surface water and groundwater have been contaminated by industrial, commercial and household discharges, thus creating the potential for considerable health risks for the urban population (Ojo 1995). While liquid with lower density than water will float on top of the water table, liquid of higher densities than water will sink through the groundwater, down to the lower regions of the groundwater reservoir. Generally, about 80% of groundwater in non-industrialized areas satisfies WHO limits (Osibanjo 1994), but the level of compliance could be as low as 40% in some cases. In Nigeria, surface and groundwater sources are not clean after all; they have been grossly contaminated by Oxygen demanding organic matter, toxic and hazardous substances including heavy metals, and pesticides. It is the purpose of the present paper to assess the impacts of industrial effluent and dumpsite leachates discharges on the qualities of groundwater along the course of Ona and Eku Rivers located at Oluyole and Ona Ara local government respectively.

Materials and methods

Study areas

Ona and Eku are Rivers systems in Oyo state. Located in Ibadan southwest of the state, Ona River is bigger, longer and more prominent than Eku River. Ona River receives discharge of industrial effluent from industries located at Oluyole industrial estate. Eku River originates from Aba Epo in Ona Ara local government of Oyo State and flows through the thick forests of Idi Ose, Aperin, and finally into Omi. Eku River used to be clean until influx of leachate runoffs from a dumpsite located at Aba Epo polluted it.

Sample design

The two rivers were used as reference points, and samples were collected upstream (USGW) and downstream (DSGW) along the river courses. Water samples from three different wells, located along the river courses were collected each at the upstream and downstream region. The selection of these wells was influenced by proximity to the river course. The design was to enable the determination of the pollution potential of the effluent and leachate discharges. Using the upstream region as the background conditions, the variation and impact of the effluent and leachate downstream were evaluated.

Sample pretreatment and analysis

Water samples for heavy metal determination were acidified in pre-cleaned plastic containers on the field. Each sample was collected in an acid-cleaned polypropylene bottle, which was rinsed three times with the sample water prior collection. Samples for nutrients were filtered with Whatman GF/C, 1.2 mm pore size filters immediately to remove any large particles, and bacteria. Poisoning with mercuric chloride (1 drop saturated solution per 100mL of sample) was also used to further aid in the preservation of the samples. Oxygen was fixed according to Winkler's method using Manganus sulphate and alkaline Potassium iodide. The samples were kept in an ice cooler during transport back to the laboratory, and upon arrival they were refrigerated at 4 °C and analysed within 1 week. Except for nitrate determination that was carried out using phenoldisulphonic acid spectophotometric method (Michael 1950), APHA-AWWA-WPCF method (2005) was used for all the parameters studied on water samples.

Results and discussion

The mean concentrations of the studied parameters in the upstream groundwater (USGW), downstream groundwater (DSGW), and effluent / leachate (as the case may be) for the study areas are as presented in figures 1, 2, 3, and 4. At Oluyole, the general physico-chemistry of the groundwater recorded higher values for temperature (30.2^oC), chemical oxygen demand - COD (21mgO_2/l), total hardness (73mg$CaCO_3$/l), and total alkalinity (79mg$CaCO_3$/l) in the downstream region (fig. 1). These levels are higher than their respective values in the upstream region. Of the anions studied, only the phosphate (1.04mg/l) was found to be higher in the downstream region (fig. 1). Total solids, total suspended solids, and total dissolved solids were found to be higher downstream with mean values of 950mg/l, 18mg/l, and 932mg/l respectively.

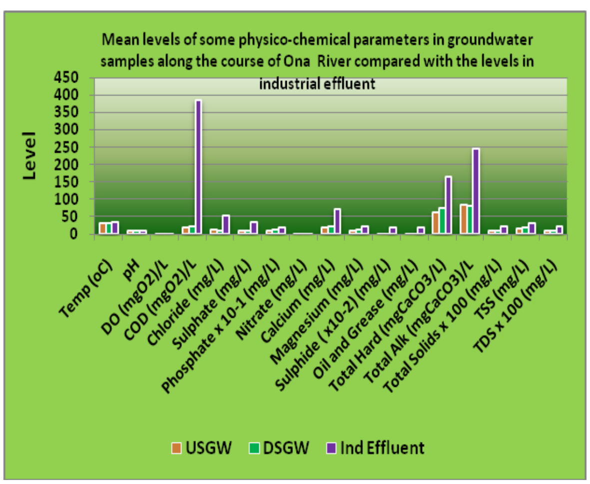

Fig. 1. Mean levels of some physico-chemical parameters in groundwater samples along the course of Ona River compared with the levels in industrial effluent.

Though there were little or no significant differences in the mean levels of heavy metals at both regions, all the metals were found to be higher in the downstream region, with Zn (0.54μg/ml) and Ni (0.003μg/ml) recording the highest and lowest mean levels respectively (fig. 2). The raw industrial effluent was found to be higher in temperature (32^oC), COD (385mgO_2/l), total hardness (165mg$CaCO_3$/l), and total alkalinity (245mg$CaCO_3$/l) when compared to their respective mean levels upstream and downstream (fig. 1). Of all the parameters studied, only pH (6.9), dissolved oxygen – DO (1.4mgO_2/l), and nitrate (1.81mg/l) recorded lower mean values in the industrial effluent, when compared to their respective mean levels upstream and downstream.

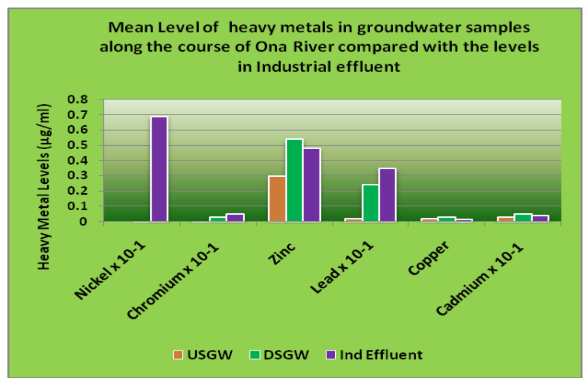

Fig. 2. Mean levels of heavy metals in groundwater samples along the course of Ona River compared with the levels in industrial effluent.

At Ona Ara, the general physico-chemistry of the groundwater recorded higher values for temperature (31.5^oC), chemical oxygen demand - COD (34mgO_2/l), total hardness (87mg$CaCO_3$/l), and total alkalinity (104mg$CaCO_3$/l) in the downstream region (fig. 3). These levels are higher than their respective values in the upstream region. Mean levels for chloride (14mg/l) and nitrate (1.30mg/l) in the downstream region were found to be lower that their respective levels in the upstream region (fig. 3).

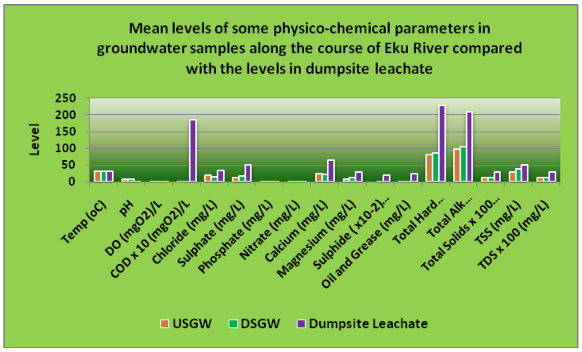

Fig. 3. Mean levels of some physico-chemical parameters in groundwater samples along the course of Eku River compared with the levels in dumpsite leachate

Total solids, total suspended solids, and total dissolved solids were found to be higher downstream with mean values of 1300mg/l, 38mg/l, and 1262mg/l respectively (Fig. 3).

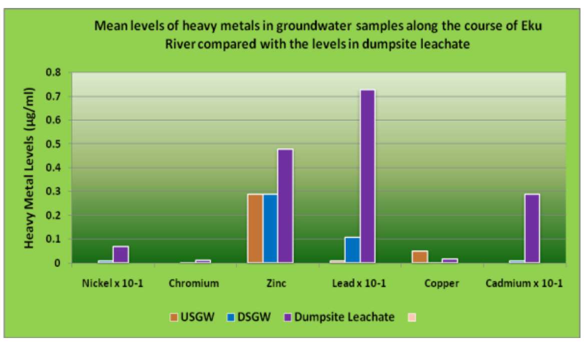

Fig. 4. Mean levels of heavy metals in groundwater samples along the course of Eku River compared with the levels in dumpsite leachate.

Of the heavy metals studied, only Cu was found to be lower in the downstream region. Zn (0.29µg/ml) was observed to be at par in both regions (fig. 4). The raw leachate was found to be higher in temperature COD (1870mgO_2/l), total hardness (228mg$CaCO_3$/l), and total alkalinity (209mg$CaCO_3$/l) when compared to their respective mean levels upstream and downstream (fig. 3). Of all the parameters studied, only pH (4.7), dissolved oxygen – DO (1.8mgO_2/l), and nitrate (1.21mg/l) recorded lower mean values in the industrial effluent, when compared to their respective mean levels upstream and downstream.

Considering the mean levels in the upstream and downstream regions at both locations, all the physico-chemical parameters studied on the groundwater samples fell within the ranges quoted for Ibadan, Lagos, Kaduna, and Warri groundwater (Osibanjo 1994); and the levels of zinc and copper were found to be below the WHO acceptable level (WHO-AL) and WHO maximum permissible levels (WHO-MPL) (table 1). The mean levels for total alkalinity at both locations were in agreement with the mean value (79.3mg/L) quoted for some groundwater in Ibadan (Dawodu and Ipeaiyeda 2008). A higher mean value, recorded at the downstream region for oil and grease (2.21mg/l) at Oluyole was partly due to the quality and handling of bailers used by the residents. The relatively high value of COD (385 mgO_2/L) recorded for the raw effluent at Oluyole showed that the effluent was rich in organic load. The high levels of total dissolved solids (1950mg/l) and oil and grease (18.2mg/l) in the effluent indicated that the effluent contributed significantly to the higher levels of these parameters downstream (Fig. 1).

Table 1. Groundwater Quality in Nigeria (Osibanjo 1994).

Parameter	Ibadan	Lagos	Kaduna	Warri	WHO-AL	WHO-MPL
pH	5.5 – 7.7 (6.7)	2.6 – 8.0 (5.8)	6.5 – 7.9	3.6-6.5	7.0-8.5	6.5-9.2
Total Solids (mg/l)	104 – 1956 (750)	93 – 1303 (429)	113 – 1230 (416)	101-1459	500	1500
TSS (mg/l)	ND – 66 (14)	ND – 55 (7.9)	8 – 659	13-954	-	-
T Hardness (mg/l)	11 – 221 (182)	4 – 390 (88)	30 – 350 (105)	6-128	100	500
Sulphate (mg/l)	4 – 23 (40.3)	22 – 400 (168)	10 – 117 (38)	2-108	200	400
Oil & Grease (mg/l)	-	0.09-0.398	<0.1 – 9.3 (1.1)	<0.10-1.8	0.01	-
Fe (mg/l)	-	0.01 – 13.9	0.25 – 160	0.50-30	0.10	1.0
Mn (mg/l)	-	0.01 – 0.97	0.1 – 5.44	<0.01-0.40	0.05	0.50
Zn (mg/l)	-	ND – 6.27	0.08 – 1.90	0.01-0.80	5.0	15.0
Cu (mg/l)	-	-	0.01 – 0.40	0.01-007	0.50	1.5

(Mean values in bracket)

The level of heavy metals in the raw effluent showed that the effluent was not high in heavy metals. This suggests other sources of heavy metals (petroleum seepage/leakage and agricultural run-offs) that may likely impact Oluyole groundwater. However, nickel, zinc and lead were of considerable levels in the effluent sample. The general trend of metal levels in the effluent was zinc > nickel > lead > copper > chromium > cadmium; and the levels of these metals comply with the FEPA standards.

Except for COD, pH, and oil and grease, the variations in the general physico-chemical parameters between the upstream and downstream groundwater samples were found to be slight at Ona Ara. However, akin to the observed variations at Oluyole, the groundwater at Ona Ara was found to be slightly higher in general physico-chemistry at the downstream region than the upstream region. The high levels of most of the parameters studied on the leachate indicated that the effluent contributed significantly to the higher levels of these parameters downstream (figure 3). At the two location, the mean values for lead (Pb) in the downstream regions were found to be slightly higher than the mean value quoted (0.0049µg/ml) for groundwater in Ibadan, south-western Nigeria (Abiola 2010). However, the levels of heavy metals at both locations were also found to be lower than some groundwater sampled around battery factory in Ibadan (Dawodu and Ipeaiyeda 2008). Other physico-chemical parameters were within the ranges quoted for groundwater in Ibadan metropolis (Nkolika and Onianwa 2011).

Conclusion

The impact of discharge into water body on the quality of groundwater was evident at the two locations, considering the differences in the mean levels of some physico-chemical parameters monitored in the upstream and downstream regions. Comparisons made on the results obtained for some parameters inferred that the dumpsite leachate and the industrial effluent were, and not only the sources of pollutants in the groundwater. Waste management has been a very serious problem in urban centres as discharge of industrial effluent and dumpsite leachate into water bodies has been seen to cause problems through pollution of land, surface water, and groundwater resources nearby. Developing countries like Nigeria have not been able to address these problems due to weak enforcement of environmental policies binding on industries, and inadequate adherence of urban residents to proper waste management system. The effects of pollutant discharge into water bodies can be devastating to the environment, the people and animals that depend on that source of water. There is therefore a great need to preserve and protect these resources for sustainable use by mankind. This however, must go beyond the mere safe disposal or recovery of wastes that are generated, and seek to address the root cause of the problem by attempting to change unsustainable patterns of production and consumption. This implies the application of the integrated life cycle management concept, which presents a unique opportunity to reconcile development with environmental protection.

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