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Physicochemical Analysis of Groundwater in the Vicinity of an Industrial Area: a Case Study of Mopin Community, Ota, South-Western Nigeria

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Abstract- The physicochemical characteristics of groundwater in Mopin Community, Ota in South-western Nigeria were assessed to ascertain the quality and possible effects of the effluents from neighbouring Industrial Estate. This analysis was important because the contamination or pollution of a water source especially used for domestic and drinking purposes will be detrimental to the health of the consumers of such water. Measures of gross organic pollution; BOD, COD, TDS amongst others were determined. Four groundwater samples were collected within the months of October, 2010 to June, 2011 from hand dug wells in residential buildings that are in proximal locations to the industrial effluents discharge point and flow path and analysed in triplicates. Heavy metal levels were also analysed using AAS machine after sample digestion. It was observed that the effluents has little or no impact on the groundwater quality as indicated by the average COD value recorded which was lower than the average COD levels of the effluents.

Keywords- *Groundwater, Effluents, Chemical Oxygen Demand (COD)*

I. Introduction

Groundwater refers to water collected under the Earth's surface [1]. Water that forms on the earth surface continues to travel downwards due to gravity until a zone comes where it is saturated with water. A major source of potable drinking water is groundwater especially in rural areas since digging of wells is relatively cheap and clean. However, with the recent trend in civilization and urbanization, more and more industries are established. These industries use water and some chemicals in their manufacturing processes and then channel their liquid wastes (effluents) back to water sources without proper treatment which in turn results in the pollution of groundwater. Oftentimes, the effluents are left to flow through the soil surface or not neatly dug and constructed passage ways or channels. This in effect promotes groundwater pollution. At the time of this investigation, a major source of potable drinking water in Mopin community was groundwater from locally dug wells as borehole wells are more expensive. It is therefore imperative that the physicochemical characteristics of the groundwater source in this community be assessed as it is domicile in an industrial area.

II. MATERIALS AND METHODS

The water samples were collected from locally hand dug wells of four residential buildings at locations in close proximity to the effluents discharge point and flow route and labelled GWR-1 to GWR-4. The samples were collected as grab samples at each sampling point in polyethylene bottles that have been previously cleaned by washing in non-ionic detergent, rinsed with tap water, soaked in 10% nitric acid for 24hours and finally rinsed with distilled water. GWR-1 to GWR-4 for BOD and DO determination were collected in previously cleaned BOD bottles. These samples for DO determination were pre-treated by adding 1ml each of manganous sulphate and alkali-iodide-azide reagent to fix oxygen present in the samples respectively while others were stored in a refrigerator at about 4^oC prior to analysis. Same was done for the effluents samples.

The groundwater samples were analysed for pH, alkalinity, chloride, total hardness, calcium and magnesium hardness, nitrate, phosphate, sulphate, chemical oxygen demand (COD), BOD, DO and heavy metals (Pb, Zn, Cd, Cu, Co, Cr and Ni). The parameters were determined using the same methods of analysis described in an earlier research by different authors [2] in line with APHA methods of analysis [3].

III. RESULTS AND DISCUSSION

Table 1 shows the results of the groundwater analysis. The physicochemical data of the effluents has been documented earlier [4]. pH range of the studied ground water samples is in the range of 5.9 – 6.9. The ground-water samples had an average pH of 6.40±0.42 and judging from water chemistry which identified a pH of 4.3 as that which separates alkalinity from acidity, the water source can be said to be alkaline. This pH value is also slightly below WHO [5] and USEPA [6] standards (6.5-9.5 and 6.5-8.0) for water quality (Table 2). According to NIS (2007) [7], acceptable pH range for drinking water is 6.5 – 8.5. Going by this, GW2 is suitable for drinking.

Earlier studies on ground water in this study area documented similar results [2]. Contrary to these observations, a study [8] reported a pH value range of 6.8-7.8 for groundwater in Okhla Industrial Area.

Alkalinity in groundwater is mainly derived from the dissolution of carbonate minerals and CO_2 present in the atmosphere and soil above the water table [9]. The alkalinity levels of the ground water samples ranged from 5.0 – 45.0 mg/L with average level of 21.53±16.82. These values are low when compared with alkalinity range of 150 – 289 mg/L reported by some researchers [10]. Though there are no specific limits for alkalinity in groundwater, alkalinity in large amounts imparts bitter taste to water and may cause eye irritation in human. The chloride concentration of the ground water sampled was in the range of 19.28 to 70.16mg/L and of a mean value of 37.54±23.55mg/L. These values were far below the maximum permitted limit of 250mg/L [4,6] for water quality and below optimum value (750mg/L) for domestic water supply. Similar results were documented by Etim and Onianwa (2013). Chloride is an important quality that affects the aesthetic property of water including taste and renders it unsuitable for drinking purpose if present in high concentrations. The average level of total hardness of studied ground water samples is 32.75±13.50mg/L and is less than the maximum permitted limit of 150mg$CaCO_3$/L. It therefore means that the water samples are soft since water sources with hardness>50 mg$CaCO_3$/L are considered soft, 50 - 100 mg$CaCO_3$/L moderately soft, 200 - 300 mg$CaCO_3$/L as hard [11].

BOD, COD and DO are parameters that indicate the level of gross organic pollution of a water source. The ground water samples had mean BOD value of 2.58±0.47mg/L, with values ranging from 2.15 to 3.02mg/L. The DO levels ranged from 4.28 to 7.72mg/L with mean value of 6.18±1.80 and COD mean value of 64.79±28.05mg/L. A comparison of average DO level of the ground water samples with water quality standards shows that the water source met with the standard limit of 5.5 – 9.5mg/L (CQC, 1999) [12]. Similarly, the COD values observed in this study were all within the desirable limit as the permissible limit of COD for drinking water is 255mg/L [4]. The average value of TDS in the groundwater samples of Mopin community was 127.5±23.63mg/L, with individual values ranging from 110 to 160mg/L. According to NIS 554: 2007 and IS: 10500 standards [13], the desirable limit of TDS is 500mg/L. Thus groundwater samples TDS value is within the desirable limit and as such potable. A high TDS value imparts a peculiar taste to water and reduce its portability. The nitrate, phosphate and sulphate mean values observed in this study were 8.04±7.00mg/L, 0.14±0.09mg/L and 8.05±12.70mg/L. These values were well below the WHO and USEPA recommended standard limits. Nitrate concentration above the recommended value of 10mg/L is dangerous to pregnant women and could cause blue baby diseases to infants. Heavy metals levels were of the decreasing order; Pb> Zn> Cr> Ni> Cu> Co> Cd. All results obtained in this study showed that the effluents had no effect on the physicochemical and heavy metal levels.

TABLE I. LEVELS OF PHYSICOCHEMICAL PARAMETERS HEAVY METAL IN MOPIN GROUND WATER

Parameters	GW1	GW2	GW3	GW4	Mean±s.d
pH	6.4	6.9	5.9	6.4	6.40±0.41
Alkalinity (mg/L)	5	45	17.98	18.12	21.53±16.82
Chloride (mg/L)	21.34	70.16	19.28	39.4	37.54±23.55
Total Hardness (mg/L $CaCO_3$)	26.5	51.5	20.27	32.72	32.75±13.50
Calcium (mg/L)	7.42	12.85	5.48	7.72	8.37±3.15
Magnesium (mg/L)	2.02	4.87	1.67	3.36	2.98±1.46
BOD (mg/L)	3.02	2.95	2.21	2.15	2.58±0.47
COD (mg/L)	102.72	40.92	46.51	69.02	64.79±28.05
DO (mg/L)	5	4.28	7.72	7.72	6.18±1.80
TDS (mg/L)	130	110	160	110	127.5±23.63
TS (mg/L)	371.33	480.32	523.13	269.31	411.02±114.06
Nitrate (mg/L)	0.63	3.49	14.12	13.92	8.04±7.00
Phosphate (mg/L)	0.21	0.02	0.12	0.21	0.14±0.09
Sulphate (mg/L)	27	ND	3.02	2.18	8.05±12.70
Zn(mg/L)	0.238	0.06	0.026	0.16	0.121±0.10
Pb(mg/L)	ND	0.62	0.046	0.36	0.257±0.29
Cr(mg/L)	ND	0.01	0.044	0.082	0.034±0.04
Co(mg/L)	0.031	ND	ND	ND	0.008±0.02
Cd(mg/L)	0.009	ND	ND	ND	0.002±0.01
Ni(mg/L)	0.054	ND	0.034	0.018	0.027±0.02
Cu(mg/L)	0.029	ND	0.036	0.038	0.026±0.02

TABLE II. A COMPARISON OF GROUNDWATER DATA WITH WATER QUALITY STANDARDS

PARAMETERS	GW	NIS	WHO	CQC	USEPA
pH	6.40±0.41	6.5 – 8.5	6.9-9.5	6.5-9.0	6.5-8.0
Alkalinity (mg/L)	21.53±16.82	-	-	-	-
Chloride (mg/L)	37.54±23.55	250	250	250	250
Total Hardness (mgCaCO$_3$/L)	32.75±13.50	150	500	-	-
Calcium (mg/L)	8.37±3.15	-	-	-	-
Magnesium (mg/L)	2.98±1.46	0.20	-	-	-
BOD (mg/L)	2.58±0.47	-	-	-	-
COD (mg/L)	64.79±28.05	-	-	-	-
DO (mg/L)	6.18±1.80	-		5.5-9.5	-
TDS (mg/L)	127.5±23.63	500	< 1200	500	500
TS (mg/L)	411.02±114.06	-	-	-	-
Nitrate (mg/L)	8.04±7.00	50	50.0	-	10.0
Phosphate (mg/L)	0.14±0.09	-	-	-	-
Sulphate (mg/L)	8.05±12.70	100	500	500	-
Zn(mg/L)	0.121±0.10	3.0	0.01	0.03	0.12
Pb(mg/L)	0.257±0.29	0.01	0.01	0.017	0.003
Cr(mg/L)	0.034±0.04	0.05	-	0.05	0.10
Co(mg/L)	0.008±0.02	-	-	0.05	-
Cd(mg/L)	0.002±0.01	0.003	0.003	-	0.002
Ni(mg/L)	0.027±0.02	0.02	0.02	0.025	0.05
Cu(mg/L)	0.026±0.02	1.0	-	0.024	0.009

IV. CONCLUSION

The physicochemical characteristics of groundwater in Mopin community, Ota, South-western Nigeria was analysed in this study. Mopin Community is surrounded by an Industrial estate that discharges its liquid wastes through poorly channelled gutters. Hence this study was done to assess the quality of groundwater which is a major source of potable water in that Community and to ascertain the possible effect of the effluents on the water quality. Earlier documentation on the effluent characteristics showed that the effluents were at least partially treated. The results of this study revealed that all parameters were well within or below standard limits. Therefore, it can be concluded that the water source is fit for consumption for both man and livestock and also for domestic purposes in Community investigated.

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