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Full Length Research Paper

Groundwater quality around new cement factory, Ibese, Ogun State, Southwest Nigeria

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Assessment of physicochemical parameters and trace metals were carried out in groundwater of Ibese town and environs, Southwest Nigeria. The mean value of pH, electrical conductivity (EC), total dissolved solid (TDS) and alkalinity (HCO_3^{2-}) are 5.90 ± 0.32, 1328.00 ± 676.26 μScm^{-1}, 664.00 ± 353.58 mgL^{-1} and 94.00 ± 18.55 mgL^{-1}. The chloride concentration was found to be higher than World Health Organization (WHO) recommended limit of 250 mgL^{-1} in drinking water in majority of the samples. The suitability of the water for irrigation was established using sodium adsorption ratio (SAR) which ranges from 2.61 to 11.56. Concentration of heavy metals [Lead (Pb), Manganese (Mn), Nickel (Ni) and cadmium (Cd)] was determined using atomic absorption spectrophotometer and most of them are below detection limit of the instrument. It was concluded that the alkalinity was as a result of water-rock reaction, and treatment to remove high chloride concentration is required before consumption. The establishment of Dangote cement factory in the area should facilitate the provision of potable water for the inhabitants by the company as part of community service.

Key words: Ibese, groundwater, cement, heavy metals, sodium adsorption ratio.

INTRODUCTION

Groundwater and surface water are important source of water supply in the world which is needed for human survival and industrial development. The ground and surface water chemistry is controlled by the composition of its recharge components as well as geological and hydrological variations within the aquifers (Shahnawaz and Singh, 2009). Polluted groundwater and surface water sources are the cause for the spread of epidemic and chronic disease in human beings. Industrialization and increase in population are responsible for depletion of our groundwater sources (Khodapanah et al., 2009). Improved knowledge is required for understanding and evaluating the suitability of groundwater for different purposes. The knowledge of water-rock interaction as well anthropogenic influence is necessary for eventual utilization and management (Todd, 1995; Kelly, 1940).

Groundwater quality comprises physical, chemical and biological qualities of groundwater (Oluseyi et al., 2011). Temperature, turbidity, colour, taste and odour make up the list of physical water quality parameters. Since most groundwater are colourless, odourless and without specific taste, the concern is the chemical qualities. Naturally, groundwater contains mineral ions and these ions slowly dissolve from soil particles, sediments and rocks as the water travels along mineral surfaces in the pores or fractures of the unsaturated zone and the aquifer.

Some dissolved solids may have originated in the precipitation water or river water that recharges the aquifer. However, human activities can alter the natural composition of groundwater through mining activities, disposal or dissemination of chemicals and microbial matter at the land surface and into soils or through injection of wastes directly into groundwater.

Cement industries are generally associated with high dust emissions into atmosphere. Emitted dusts are naturally eliminated as deposits to the earth surface through dry or wet deposition in rainfall (Olaleye, 2005;

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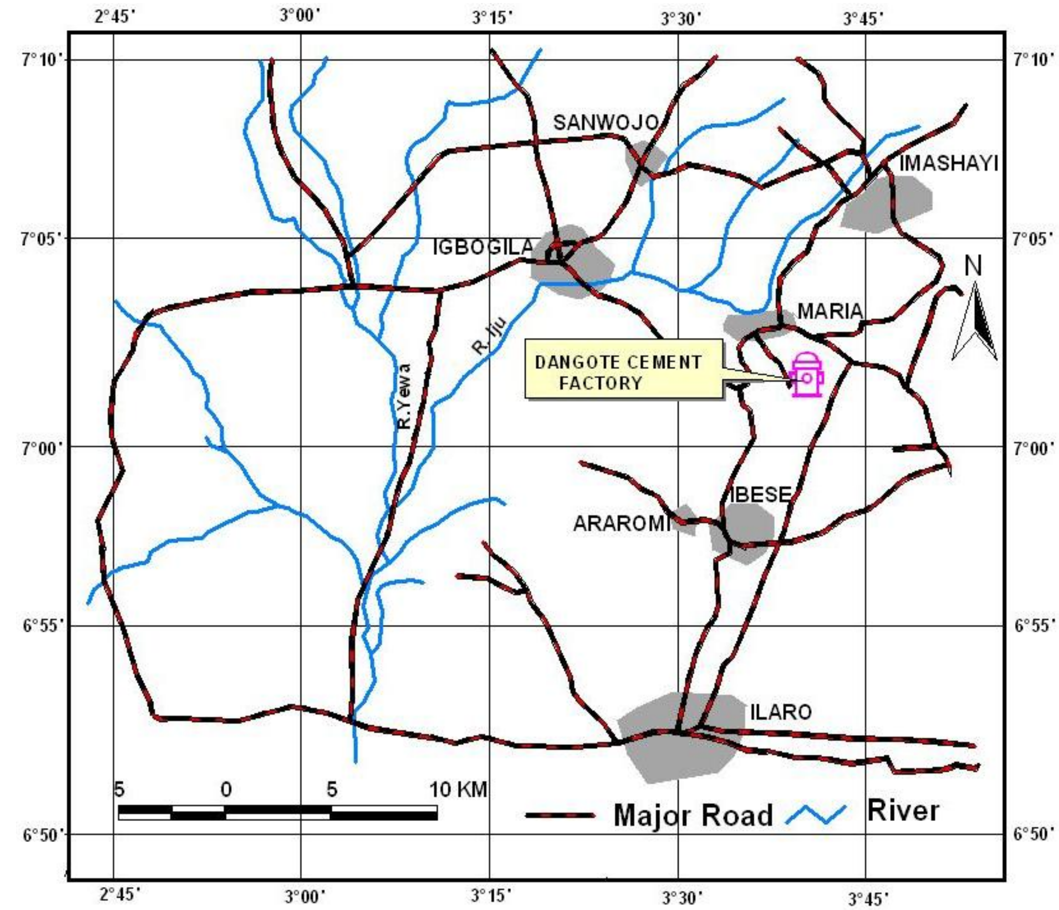

Figure 1. A map showing the sampling locations.

Asubiojo et al., 1991). The damaging consequences of the released dust particles for the soil, flora and fauna of the cement factory neighborhood could be considerable (Akeredolu, 1989) and the damaging effects of dust fall, which is characterized by enriched toxic heavy metals such as Arsenic (As), Lead (Pb), Nickel (Ni), Chromium (Cr), Copper (Cu), Zinc (Zn), Manganese (Mn) and Cadmium (Cd) (Adejumo et al., 1994).

A cement factory (Dangote Cement) was situated at Ibese but under construction as at the period of sampling (October/November, 2010) and commenced production by the end of 2011 (Figure 1). The aim of the present study is to determine physicochemical parameters and heavy metal concentration in groundwater of Ibese and environs to serve as baseline data against which future changes will be compared.

MATERIALS AND METHODS

Study area

Ibese is located in Egbado (Yewa) North of Ogun state Southwest Nigeria. It lies on latitude 6° 58′ 0″ N and longitude 3° 2′ 0″ E. The inhabitants are mainly farmers and traders. A cement factory (Dangote Cement) was situated at Ibese but under construction as at the period of sampling (October/November 2010) and commenced production by the end of 2011. The study area consists of Ibese, Imasayi, Sawonjo, Maria and Igbogila which are located few kilometers downstream to the cement factory.

Geology of the study area

The geology of Ibese and environs consists of Ewekoro formation which is marine and Paleocene age. It consists of a limestone unit several meters in thickness which is overlain by a shale unit almost three times as thick as the lime stone.

Method

Water samples were collected from 25 wells around Dangote cement factory, Ibese, Ogun State, Southwest Nigeria in September, 2010. Plastic bottles were used for the collection and kept in the ice, while samples meant for metal analysis were preserved by the addition of concentrated nitric acid (5 ml to 1 L of water). Parameters like pH, temperature, electrical conductivity (EC) and depth were measured on the field. The pH, conductivity and total dissolved solid (TDS) were measured with pH-conductivity-TDS meter (COMBO HI model 98130). The redox potential (RP) and temperature were measured using RP-meter

Table 1. Range of physicochemical parameters from all locations.

Parameter	Ibese	Sawonjo	Maria	Imasayi	Igbogila	Mean ± SD	WHO
pH	6.42	6.1	5.5	5.7	5.8	5.90 ± 0.32	6.5 - 8.5
Temp (°C)	28.06	30.1	29.3	28.7	29.2	29.07 ± 0.68	-
EC (µSCm^{-1})	1130	2570	520	1320	1100	1328.00 ± 676.26	-
TDS (mgL^{-1})	560	1320	260	660	520	664.00 ± 353.58	-
RP (mV)	39.53	70	20.8	25.2	58.5	42.81 ± 18.93	-
Depth (m)	22	9.5	10.7	30	8.5	16.14 ± 8.47	-
HCO_3^{2-} (mgCaCO$_3$L^{-1})	120	90	110	70	80	94.00 ± 18.55	-
DO (mgL^{-1})	1.14	5.2	6.1	3.4	2.2	3.61 ± 1.84	-
Cl^- (mgL^{-1})	350	270.5	275.2	120.92	280.71	259.47 ± 75.12	250
NO_3^- (mgL^{-1})	6.49	5.2	7.2	4.2	5.1	5.64 ± 1.07	50
PO_3^{2-} (mgL^{-1})	0.41	0.32	0.75	0.62	0.42	0.50 ± 0.16	-
SO_4^{2-} (mgL^{-1})	9.03	10.3	15.21	10.52	10.63	11.14 ± 2.12	250

Table 2. Concentration of metals in groundwater of the study area.

Parameter	Ibese	Sawonjo	Maria	Imasayi	Igbogila	Mean	WHO
Na (mgL^{-1})	7.65	35	7	30	35	22.95 ± 12.87	200
K (mgL^{-1})	0.34	11.7	5.45	2.26	11.62	6.27 ± 4.69	-
Ca (mgL^{-1})	3.9	17.3	9.4	12.7	20.1	12.68 ± 5.73	-
Mg (mgL^{-1})	0.29	6.23	4.96	4.51	4.79	4.16 ± 2.02	-
SAR	5.28	10.2	2.61	10.24	9.92	7.65 ± 3.14	-
MH	6.92	26.48	34.54	26.21	19.24	22.68 ± 9.25	-
%Na	65.59	0.66	46.44	65.21	65.19	48.62 ± 25.07	-
Pb (mgL^{-1})	ND	0.01	0.01	ND	ND	0.01 ± 00	0.01
Mn (mgL^{-1})	0.03	0.01	0.05	0.01	0.01	0.02 ± 02	0.5
Ni (mgL^{-1})	ND	ND	ND	0.01	ND	0.01 ± 00	0.02
Cu (mgL^{-1})	ND	0.01	ND	0.01	ND	0.01 ± 00	2
Cd (mgL^{-1})	ND	ND	ND	ND	ND	ND	0.03

(Thermo Orion model), while the dissolved oxygen (DO) was measured using DO-meter (HACH model). Anions like SO_4^{2-}, PO_4^{3-} and NO_3^{2-} were determined using ultraviolet (UV)-Visible Spectrophotometer (Camspec model). Turbidimetric method was used for SO_4^{2-} determination, Vanado-Molybdo-Phosphoric acid method was used for PO_4^{3-} determination, while Salicylate method was used for NO_3^{2-} determination. The Cl^- concentration was determined by Mohr's method, while HCO_3^{2-} was determined by titration against 0.01 M H_2SO_4 using mixed indicator (Bromocresol green-Methyl red solution). Ethylene diamine tetraacetic acid (EDTA) titration was used for Mg^{2+} and Ca^{2+}, while Flame Photometer was used for Na^+ and K^+ concentration determination. The heavy metals (Cd, Pb, Ni, Mn and Cu) were determined using atomic absorption spectrophotometer (Bulk Scientific Model).

RESULTS

The results of the physicochemical parameters from Ibese, Sawonjo, Maria, Imasayi and Igbogila are shown in Table 1. The concentration of heavy metals (Pb, Mn, Ni and Cd), essential elements (Sodium (Na), Potassium (K), Magnesium (Mg) and Cu) as well as calculated percent (%) Na, sodium adsorption ratio (SAR), Magnesium hazard (MH) are shown in Table 2.

DISCUSSION

The range of pH values (5.5 to 6.42),which are below 6.5 to 8.5 recommended by World Health Organization (WHO) in drinking water as shown in Table 1 indicated that, all the groundwater collected from the study areas are slightly acidic. Acidic water as recorded from groundwater of the study area can cause corrosion of water pipes and can affect gastrointestinal tract when consumed which can lead to diarrhea. Longe and Balogun (2010) reported pH range of 5.30 to 7.07 in groundwater of Lagos, Nigeria, while Obiefuna and Orazulike (2011) reported pH range of 6.5 to 7.8 in groundwater from Yola area, Northwestern, Nigeria. The closeness of the value may be due to similarity in geology

Table 3. Salinity and alkali standard (Sadashivaiah et al., 2008; Richards, 1954).

EC	SAR	Class
100 - 250	<10	Excellent
250 - 750	10 - 18	Good
750 - 2250	18 - 26	Doubtful
>2250	>26	Unsuitable

of Lagos and the study area which are all sedimentary and coastal in nature. Water temperature is the most important factor of the water which has a great deal of influence on various chemical and biological reactions taking place in water. The temperature ranges recorded in groundwater in the present study are 28.06 to 30.1°C. Rahim and Hussain (2011) reported temperature ranges of 28 to 30°C in groundwater of Beed city, Maharashtra, India. The sulphate concentration ranges from 9.03 to 15.21 mgL^{-1} which are within normal range recommended for drinking water by WHO. Oluseyi et al. (2011) reported mean value of 84.63 mgL^{-1} in groundwater of Ewekoro cement factory environment.

Close relationship exists between groundwater quality and land use (Orebiyi et al., 2010). Various land use activities can result in groundwater contamination. Potential sources of groundwater pollution include solid waste landfills, on-site excreta disposal systems, cemetery and animal wastes resulting from human activities among others. In Ibese and environs, the sources previously mentioned could be responsible for concentration of sulphate, phosphate and nitrate recorded in the area because the environment is rural and agricultural based. Nitrate concentration ranged between 4.2 to 7.2 mgL^{-1} which were all within WHO acceptable limit of 50 mgL^{-1} in drinking water. This implies that all the agricultural and anthropogenic activities in the area do not affect the groundwater sources. High nitrate concentration causes met-hemoglobinemia with the symptoms of paleness, bluish mucous membranes, digestive and respiratory problems (McCasland et al., 2007). If leachate is released from landfill or open dumpsites to the surrounding soil without proper collection and treatment, it could contaminate groundwater resources (Somjai and Suporn, 1993). Studies have shown that leachates cause an increase in dissolved inorganic substances such as chloride sulphate, bicarbonate, sodium and potassium of groundwater (Zanoni and Fungaroli, 1973).

The chloride content ranges from 120.92 to 350 mgL^{-1} with the values higher than 250 mgL^{-1} recommended by WHO recorded in Ibese, Sawonjo, Maria and Igbogila. The values recorded from Imasayi may be due to location which is less water-logged like others. Similarly, wells in Imasayi are deeper than those from other locations. Excess salt increases the osmotic pressure of the soil solution that can result in a physiological drought condition. Shahidullah et al. (2000) reported no chloride toxicity in groundwater from Phulpurthana, Mymensingh district of Bangladesh. Ramkumar et al. (2009) reported chloride in the range of 5.3 to 51.9 mgL^{-1} in groundwater of Vedaraninyan, India and reported the groundwater to be of NaCl types which indicate the influence of sea water in the wells. Similarly, the high level recorded in Ibese environs is likely due to saline intrusion because of the coastal nature of the area. The concentration of HCO_3^{2-}could result from dissolution of CO_2 gas likely formed by anoxic biodegradation of organic matters in domestic sewage, wastes water and landfills. Jun-Yan (2010) reported higher value in groundwater of Nandong, China. The EC ranges from 520 to 1320 μScm^{-1}. Gbadebo et al. 2010 reported the mean value of 349 ± 9.74 μScm^{-1} in groundwater of Agbara area of Ogun State, Nigeria, while Khodapanah et al. (2009) reported conductivity value of 350 to 23600 μScm^{-1}. The value found in the present study indicated that 20% of all the wells were above 2,250 μScm^{-1} as unsuitable according to Sadashivaiah et al. (2008). The large variation in EC is mainly attributed to lithologic composition and anthropogenic activities prevailing in the area. Normally, irrigation water with an EC of < 700 μScm^{-1} causes little or no threat to most crops, while EC > 3000 μScm^{-1} may limit their growth (Tijani et al., 2005).

The sequence of mean concentration values of cations in groundwater of the study area is Na > Ca > K > Mg as shown in Table 2. The Ca^{2+}, Mg^{2+}, HCO_3^{2-} and pH are primarily controlled by water-rock interaction in the area (Adedeji and Ajibade, 2005). The suitability of groundwater for irrigation is contingent on the effects on the mineral constituents of the water on both the plant and soil. Salts can be highly harmful as they can limit the growth of plants physically, by restricting the uptake of water through modification of osmotic processes. Salinity, sodicity and toxicity generally need to be considered for evaluation of the suitability for irrigation (Todd, 1995). Parameters such as EC, %Na, MH and SAR, were used to assess the suitability of water for irrigation.

The Na and alkali hazard in the use of water for irrigation is determined by the absolute and relative concentration of cations and is expressed as the SAR. The SAR was calculated from: SAR = Na / (Ca+ Mg) / 2. The values obtained from this study range from 2.61 to 11.56. Richards (1954) stated that if SAR <10 (Excellent), 10 to 18 (Good), 18 to 26 (Doubtful), >26 (unsuitable) as shown in Table 3. Fifty-seven percent (57%) of the groundwater samples in the study area are excellent for irrigation, while 43% are good for the same purpose. Na^+ was the most dominant among the major cations with mean values of 19.04 ± 12.62, while K^+ has the least mean values of 4.72 ± 4.66 mgL^{-1}. This trend is similar to what was reported by Khodapanah et al. (2009). Similarly, Mitra et al. (2007) reported an average Na concentration of 18.8 mgL^{-1} in groundwater of Northwest

Honshu Island, Japan. The Na in irrigation waters is expressed using the following equation: %Na = (Na + K) / (Ca + Mg + Na + K) * 100 where all the ionic concentrations are expressed in mg/L. High percentage of Na^+ with respect to Ca^{2+}, Mg^{2+} and Na^+ in irrigation water, causes deflocculating and impairing of soil permeability (WHO, 2008). The range of $\%Na^+$ in groundwater of the study area is 0.66 to 65.49 %. Locations with %Na greater than 60% are not suitable for irrigation. Majority of the heavy metals were not detected in groundwater of the study area. Pb concentrations are below detection limit in Ibese, Imasayi and Igbogila, while other heavy metals (Pb, Mn, Ni and Cd) are within the range recommended by WHO in drinking water.

Conclusion

Most of the physicochemical parameters examined in groundwater of Ibese and environs showed that they are suitable for drinking. The concentration of Ca^{2+}, Mg^{2+}, HCO_3^{2-} and pH are due to water-rock reaction and most of the heavy metals analyzed were not detected before the commencement of Dangote cement factory in the area. The chloride content which was higher in concentration than WHO recommended limit in drinking water can be removed by using reverse osmosis because direct removal may be too expensive. Also, for agricultural purposes, like irrigation, groundwater samples from the study area are equally suitable. We advise that the company should provide boreholes for the people as part of community service as soon as possible to guide against unforeseen situation of contamination in order to safeguard the health of people living in the area.

REFERENCES

Adedeji A, Ajibade IT (2005). Quality of well water in Ede area Southwestern Nigeria. J. Hum. Ecol. 17:223-228.

Adejumo JA, Obioh OOJ, Akeredolu FA, Olaniyi HB, Asubiojo OI (1994). The atmospheric deposition of major, minor and trace elements within and around three cement factories. J. Radioanal. Nucl. Chem. 179:95-204.

Akeredolu FA (1989). Atmospheric Environment Problems in Nigeria: An overview. Atmos. Environ. 23(4):783-792.

Asubiojo O I, Aina PO, Oluwole AF, Arshed W, Akanle OA, Spyrou NM (1991). Effects of Cement production on the elemental composition of soils in the neighborhood of two cement factories. Water Air Soil Pollut. 58:819-828.

Jun-Yan YJ (2010). Effects of land use on hydrochemistry and contamination of Karst groundwater from Nandong underground river system, China. Water Air Soil Pollut. 210:123-141.

Kelly WP (1940). Permissible composition and concentration of irrigation waters. Proceedings ASCE 66:607.

Khodapanah L, Sulaiman WNA, Khodapanah N (2009). Groundwater quality assessment for different purposes in Eshtehard distric, Tehran, Iran. Eur. J. Sci. Res. 36(4):543-553.

Longe EO, Balogun MR (2010) Groundwater quality assessment near a municipal landfill, Lagos, Nigeria. Res. J. Appl. Sci. Eng. Technol. 2(1):39-44.

McCasland M, Trautman NM, Robert RJ, Porter KS (2007). Nitrate: Health effects in drinking water. http:// pscp.ccc.cornell.edu/facts slides-self/facts/nit-heef-grw85.aspx.

Olaleye VF (2005). Chthofaun survey of rivers within Ewekoro cement manufacturing operational areas. Biodivers. Conserv. 14:2171-2184.

Oluseyi T, Olayinka K, Adeleke I (2011). Assessment of groundwater pollution in the in the residential areas of Ewekoro and Shagamu due to cement production. Afr. J. Environ. Sci. Technol. 5(10):786-794.

Orebiyi EO, Awomeso JA, Idowu OA, Martins O, Oguntoke O, Taiwo AM (2010). Assessment of Pollution hazard of shallow well water in Abeokuta and Environs, Southwest, Nigeria. Am. J. Environ. Sci. 6(1):50-56.

Rahim A, Hussain S (2011). Assessment of groundwater quality of Beed city, Maharashrata India. Orient. J. Chem. 27(3):1273-1275.

Ramkumar T, Venkatramanon S, Mary AI, Tamilselvi M, Ramesh G (2009). Hydro-geochemical Quality of Groundwater in Vedaranniyan Town, Tamilnadu, India. Res. J. Earth. Sci. 1(1):28-34.

Richards LA (1954). Diagnosis and improvement of saline alkali soils: Agriculture. Handbook 60, US Department of Agriculture, Washington D.C. Vol. 160.

Sadashivaiah C, Ramakrishnaiah RC, Ranganna G (2008). ‘Hydrochemical Analysis and Evaluation of Groundwater Quality in Tumkur Taluk, Karnataka State, India”. Int. J. Environ. Res. Public Health 5(3):158-164.

Shahnawaz MD, Singh KM (2009). Groundwater quality of Piro and Jagdishpur Blocks Bhorps district, a middle gangatic plain. Intl. J. Pharma. Qual. Assur. 1(1):9-10.

Somjai K, Suporn KTI (1993). Monitoring and evaluation of shallow well water quality near a waste disposal site. Environ. Int. 19:579-587.

Todd DK (1995). Grounddwater Hydrology. John Wiley and Sons Inc. New York.

Tijani MN, Balogun SA, Adeleye MA (2005). Chemical and Microbiological Assessment of water and Bottom-sediments Contaminations in Awba Lake (U.I), Ibadan, SW-Nigeria. Mater. Geo-environ. 52(1):123-126.

WHO (2008). Guidelines for drinking water quality. 3rd Ed. Health criteria and supporting information, Geneva.

Zanoni AE, Fungaroli AA (1973). Potential for groundwater pollution from the land disposal of solid wastes. Crit. Rev. Environ. Sci. Technol. 3:225-260.