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Groundwater Quality in Sewage Receiving Areas of Eneka and Atali Igwuruta, Rivers State, Nigeria

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Abstract

Chemical investigations were carried out on groundwater at the proximity of sewage receiving areas of Eneka and Atali, Igwuruta in Rivers State in order to assess the level of pollution of the aquifer of the area. Investigations revealed the mean values of the following parameters: Temperature, 24.2.-27.0^{0}C; pH,5.57-7.01; dissolved oxygen,5.91-6.73mgl^{-1}; electrical conductivity,35.07-207.25μScm-^{1}; total suspended solids, 28.67-825.00mgl^{-1}; total dissolved solids,16.67-98.00mgl^{-1}; salinity,0.01-0.10mgl^{-1};sulphate, 0.001-04 mgl^{-1}; BOD$_5$ 0.001-3.30 mgl^{-1}; COD, 0.001-6.387 mgl^{-1}; oil and grease, 0.001-0.02 mgl^{-1}; ammonia, 1.029-1.63 mgl^{-1}; calcium, 0.75-8.97 mgl^{-1}; copper, 0.001-1.81 mgl^{-1}; zinc, 0.042-0.20 mgl^{-1}; iron, 0.48-1.013 mgl^{-1}; lead, 0.194-0.4 mgl^{-1}; silver, 0.016-0.051 mgl^{-1}; chromium, 0.001-0.67 mgl^{-1};nickel, 0.184-0.69 mgl^{-1} and vanadium, 0.006-0.08 mgl^{-1}. The results when evaluated were found to be within Nigeria's Federal Environmental Protection Agency (FEPA) standard except for iron, lead and chromium for which values were a bit higher than the acceptable limits. Also cadmium had a concentration value of 0.08 mgl^{-1} for Eneka dumpsite which is above FEPA standard of 0.01mgl^{-1}.The study emphasized the need for protection of the groundwater to meet the needs of population growth and urbanization in the study area.

KEYWORDS: Sewage, dumpsite, groundwater, Eneka, Atali, Pollution, chemical.

Introduction

The pollution of groundwater is a case of major concern mainly because of the health implications on humans. Wastes dumped undergo some bacteria and chemical actions along with the effect of sunlight and rainfall. They are known to have found their way into the groundwater aquifer, and if not checked may result into extensive contamination of the groundwater. Most industrial effluents contain non-biodegradable toxic and hazardous wastes. These wastes pose high health risk on sea creatures on which most rural population especially in the riverine areas depend on for their livelihood. These problem calls for scientific investigation in order to improve the quality of both the surface water and groundwater in the study area to meet the rapid needs of ever-growing population, urban development, as well as agricultural irrigation. (Ibe and Duruike,1991; Pipkin, 1999; Ojelabi *et al*; 2001).

Surface and groundwater can be contaminated because groundwater movement is usually slow hence, polluted water may go undetected for a long time. Most contamination is discovered only after drinking water has been affected and people become ill. By this time, the volume of polluted water may be very large, and even if the source of contamination is removed, the problem is not solved. It is worthy of note that once the source of groundwater contamination has been identified and eliminated, the most common practice is simply to abandon the water supply and allow the pollutants to be flushed away gradually. This is the least costly and easiest solution but the aquifer must remain unused for many years. To accelerate this process, polluted water is sometimes pumped out and treated. Following removal of the contaminated water, the aquifer is allowed to recharge naturally or, in some cases, the treated water or other freshwater is pumped back. This process is costly, time-consuming, and it may be risky because there is no way to be certain that all of the contamination has been removed. Clearly, the most effective solution to groundwater contamination is prevention (Lutgens and Tarbuck,1998; Odomelam, 1999; Ibe *et al.*, 2002; Egereonu and Nwachukwu, 2005).

The objective of this study is to delineate pollution level of the groundwater of the study areas and highlight the groundwater quality of the sewage receiving areas.

Materials and methods

Sampling and sample preparation

Water samples were collected from wells in Eneka and Atali in Igwuruta LGA as shown in Fig. 1 during the dry and rainy seasons from 2005 to 2006 with the use of thoroughly washed plastic bucket. Precaution was taken by washing the bucket and rinsing thoroughly with deionized water before each dip. For the metallic ion determination 100cm^3 of each water sample was pre-concentrated by heating in a vacuum until the sample was reduced to 25cm^3. This was acidified with few drops of 2M HNO_3 for stability of the ions and preserved in plastic bottles for Atomic Absorption Spectroscopy (Franson, 1995; Vogel, 1989).

The metallic ions in the samples were determined using the Atomic Absorption Spectrophotometer, Unicam model 911. Total dissolved solids (TDS), chloride, nitrate, sulphate, phosphate, biochemical oxygen demand and chemical oxygen demand were determined by standard methods (Franson, 1995; IITA, 1990; Vogel, 1989; HMSO, 2000), while the total suspended solid was by the filtration method (IITA, 1990). The temperature, pH and electrical conductivity (EC) were determined *in situ* with the mercury-in glass thermometer, Phywe analog pH meter and conductivity meter (model H1 9813) respectively.

Stock solutions from which working standards were prepared as reported by Franson, (1995). Standard calibration graphs for the elements were prepared following procedures of Ibe *et al.*, (2002) and Standard Methods for Examination of Water and Wastewater reported by Franson, (1995). The oil and grease were determined by the Department of Petroleum Resources (DPR, 2002).

Results and Discussion

Tables 1 and 2 are the mean values of the different parameters of the groundwater samples. For water to be potable, the concentrations of substances must not exceed the level set by the World Health Organization (WHO, 1984) and the Federal Environmental Protection Agency (FEPA,1991). The pH of groundwater in Igwuruta has a range of 6.46-6.55 with a mean value of 6.51 in Eneka and a range of 5.56-5.60 with a mean value of 5.57 in Atali in the dry season. For the rainy season, the pH ranged from 6.50 - 7.11 in Eneka with a mean value of 6.66, while a range of 6.94 - 7.07 was obtained in Atali and a mean value of 7.01.

The electrical conductivity is dependent on the amount of dissolved materials and is the ability of a substance to conduct an electric current at a specified temperature, usually 25ºC. The electrical conductivity (EC) in the study area has a range of 30.50-37.40 µScm-^{1} with a mean value of 35.07 µScm-^{1} in Eneka and a range of 30.40-90.40 µScm-^{1} with a mean value of 70.40 µScm-^{1} in Atali in the dry season. In the rainy season, a range of 33.30-290.0 µScm-^{1} and a mean value of 101.00 µScm-^{1} in Eneka and a range of 63.5-351.0 µScm-^{1} and mean value of 207.25 µScm-^{1} in Atali samples.

The chloride values in the dry and rainy seasons are very negligible. The dissolved oxygen range between 6.55 and 6.86mgl^{-1} with a mean value of 6.73 mgl^{-1} in Eneka, while in Atali samples a range of 5.38-6.53 mgl^{-1} and a mean value of 5.88 mgl^{-1} was reported for the dry season. For the rainy season, a range of between 4.84 and 6.39 mgl^{-1} with a mean value of 5.91 mgl^{-1} was found in Eneka samples and a range of between 5.44 and 6.38 mgl^{-1} with a mean value of 5.88 mgl^{-1} in Atali samples. The total suspended solids ranged from between 14.00 and 245.00 mgl^{-1} in the rainy season with a mean value of 83.25 mgl^{-1} in Eneka and a range of 240 - 825 mgl^{-1} with a mean of 432.50mgl^{-1} in Atali. The values are within the FEPA limit of 500 mgl^{-1} for potable water.

The total dissolved solids (TDS) ranged between 14.00 and 18.00 mgl^{-1} with a mean value of 16.67 mgl^{-1} in Eneka and a range of 14.0-47.0 mgl^{-1} with a mean of 34.33 mgl^{-1} in Atali during the dry season. In the rainy season values ranged between 16-00-136.00 mgl^{-1} with a mean value of 47.75mgl^{-1} in Eneka and a range of 31.00-165mgl^{-1} with a mean of 98.00 mgl^{-1} in Atali. There is a linear relationship between TDS and EC in this study. This is expected because the greater the TDS the greater the EC (Todd, 1980). The values are within the FEPA limit of 1,000 mgl^{-1} for potable water.

Values of phosphate, nitrate and sulphate in Eneka and Atali in the dry and rainy seasons are within the FEPA permissible limit for potable water. Values of lead ranged between 0.001 and 1.083 mgl^{-1} with a mean value of 0.43 mgl^{-1} in Eneka and ranged between 0.001 and 5.83 mgl^{-1} with a mean of 0.194 mgl^{-1} in Atali in the dry season. In the rainy season however, lead values ranged between 0.00 and 0.001mgl^{-1} in Eneka and Atali samples. Values of lead are within the FEPA permissible limit of 0.05 mgl-$^{1.}$ Value of calcium, copper, zinc, iron, silver and nickel are within the FEPA limit both in the dry and rainy seasons, except for chromium and cadmium where values exceeded the FEPA limit in both the dry and rainy seasons for Eneka and Atali samples; whereas mean chromium level of Atali samples (0.001mgl^{-1}) was below the stipulated 0.05 mgl^{-1} FEPA limit during the rainy season. Ammonia values in the dry and rainy seasons in both study areas exceeded the FEPA limit for potable water. This could also be due to the effect of anthropogenic activities. The biological oxygen demand $(BOD)_5$ and the chemical oxygen demand (COD) in both seasons in the study area are within the WHO permissible limit of 6.00mgl^{-1} and 10.00 mgl^{-1} respectively. The chemical oxygen demand (COD) is used to provide a rapid measure of organic concentration. Values of oil and grease in both seasons are within the FEPA permissible limit of 1.00mgl^{-1}

Conclusion

The physicochemical analysis of groundwater samples from Eneka and Atali in lgwuruta, Rivers State of Nigeria was carried out in the light of Federal Environmental Protection Agency water quality criteria. Although many of the parameters determined were within the FEPA and WHO safe limits, the groundwater samples were found to be inadmissible for human consumption due to the presence of high levels of cadmium. It is recommended therefore that sewage dumpsites should be sunk far away from boreholes. It is also essential to measure and monitor levels of pollution due to environmental and other anthropogenic impacts on a continuing basis. This is for the protection of the groundwater to meet the rapid population growth and rate of urbanization.

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Table 1: Comparison of the Levels of Physico-chemical Parameters of Groundwater from Eneka and Atali, Rivers State in the Dry Season, 2005 with FEPA and WHO standards.

	Eneka		**Atali**			
Parameters	**Range**	**Mean**	**Range**	**Mean**	**FEPA (1991)**	**WHO (1984)**
Temp. (°C)	24.00-24.50	24.2	26.00-26.50	26.33	25	25
pH	6.46-6.55	6.51	5.56-5.69	5.57	6.5-9.2	6.5-8.5
Elect. Cond. (μS cm-[1])	30.50-37.40	35.07	30.40-90.40	70.40	na	na
Diss. Oxygen (mgl^{-1})	6.55-6086	6073	5.38-6.53	5.88	na	na
Chloride (mgl^{-1})	0.0-0.01	0.01	0.0-0.01	0.01	na	250
Total Sus. Solids(mgl^{-1})	13.00-49.00	28.67	0.0825	825	500	na
Total Diss. Solids (mgl^{-1})	14.00-18.00	16.67	14.047.0	34.33	1000	1000
Phosphate (mgl^{-1})	0.0-0.001	0.001	0.01-07	0.04	na	250
Nitrate (mgl^{-1})	0.0-0.001	0.001	0.44-10.56	3.96	10	45
Sulphate (mgl^{-1})	0.001-1.071	0.67	0.001-1.00	0.67	400	250
Pb^{2+} (mgl^{-1})	0.001-1.083	0.42	0.001-0.583	0.194	0.05	0.05
Ca^{2+} (mgl^{-1})	0.316-1.00	0.75	0.895-16.00	8.97	150	na
Cu^{2+}(mgl^{-1})	0.67-1.05	0.87	1.66-2.09	1.81	1.5	1.5
Zn^{2+} (mgl^{-1})	0.125-0.275	0.20	0.086-0.145	0.12	1.5	1.5
Fe^{2+} (mgl^{-1})	0.233-0.836	0.48	0.157-1.516	1.013	1.00	0.3
Ag^{2+} (mgl^{-1})	0.011-0.055	0.03	0.011-0.055	0.040	0.05	0.05
Cr^{6+} (mgl^{-1})	0.001-1.50	0.58	0.250-1.250	0.67	0.05	0.05
Ni^{2+} (mgl^{-1})	0.001-0.071	0.67	0.001-1.143	0.69	0.184	0.184
Cd^{2+} (mgl^{-1})	0.001-0.198	0.08	0.001-0.120	0.043	0.01	0.005
NH_3 (mgl^{-1})	1.210-2.140	1.63	0.726-1.580	1.23	0.5	0.5
BOD_5 (mgl^{-1})	0.0-0.001	0.001	1.64-2.00	1.84	6.0	6.0
COD (mgl^{-1})	0.0-0.001	0.001	2.73-4.12	3.33	10.0	10.0
Oil and Grease	0.0-0.001	0.001	0.001-0.011	0.0036	1.0	1.0

na = Not available

Table 2: Comparison of the Levels of Physico-chemical Parameters of Groundwater from Eneka and Atali, Rivers State in the Rainy Season, 2006 with FEPA and WHO Standards.

	Eneka		Atali			
Parameters	**Range**	**Mean**	**Range**	**Mean**	**FEPA (1991)**	**WHO (1984)**
Temp. (^oC)	25.00-26.00	25.5	26.00-27.00	26.50	25	25
pH	6.50-7.11	6.66	6.94-7.07	7.01	6.5-9.2	6.5-8.5
Elect. Cond. (μS cm^{-1})	33.30-290.00	101.00	63.5-351	207.25	na	na
Diss. Oxygen (mgl^{-1})	4.84-6.39	5.91	5.44-6.38	5.91	na	na
Chloride (mgl^{-1})	0.01-0-10	0.025	0.01-0.20	0.10	na	250
Total Sus. Solids (mgl^{-1})	14.00-245.00	83.25	240-825	432.50	500	na
Total Diss. Solids (mgl^{-1})	16.00-136.00	47.75	31.00-165.00	98.00	1000	1000
Phosphate (mgl^{-1})	0.001-9.00	0.008	0.02-0.04	30.04	na	250
Nitrate (mgl^{-1})	0.001-9.00	2.32	1.32-1.76	1.54	10	45
Sulphate (mgl^{-1})	0.001-9.00	0.75	3.00-9.00	6.00	400	250
Pb^{2+} (mgl^{-1})	0.0-0.001	0.001	0.0-0.001	0.001	0.05	0.05
Ca^{2+} (mgl^{-1})	0.067-17.77	4.789	0.99-11.67	4.789	75	na
Cu^{2+} (mgl^{-1})	0.001-0.152	0.001	0.00-0.001	0.001	1.5	1.5
Zn^{2+} (mgl^{-1})	0.001-0.152	0.042	0.001-0101	0.051	1.5	1.5
Fe^{2+} (mgl^{-1})	0.211-1.158	0.685	0.474-0.526	0.051	1.0	0.3
Ag^{2+} (mgl^{-1})	0.001-0.059	0.016	0.012-0.082	0.051	0.05	0.05
Cr^{6+} (mgl^{-1})	0.001-0.20	0.061	0.00-0.001	0.001	0.05	0.05
Ni^{2+} (mgl^{-1}) Cd^{2+} (mgl^{-1})	0.001-0.30 0.001-0.037	0.184 0.006	0.133-0.367 0.056-0.083	0.25 0.007	0.184 0.01	0.184 0.005
NH_3 (mgl^{-1})	0.466-3.076	1.469	0.851-1.208	1.029	0.5	0.5
BOD_5 (mgl^{-1})	2.140-5.620	3.30	1.360-4.790	3.075	6.0	6.0
COD (mgl^{-1})	4.560-10.36	6.387	3.410-8.020	5.715	10.0	10.0
Oil and Grease	0.001-0.80	0.20	0.001-0.40	0.02	1.0	1.0

na = Not available