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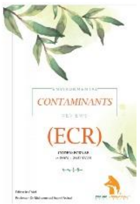

RESEARCH ARTICLE

EVALUATION OF TOXIC ELEMENTS IN GROUNDWATER IN THE INDUSTRIES AREA OF NNEWI NORTH SOUTH-EASTERN NIGERIA

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ABSTRACT

Due to the unregulated flow of industrial wastes into the environment, industrial pollution is a major environmental issue in South-eastern Nigeria. It became critical to examine the influence of industrial activity on groundwater quality for home use. Following conventional protocols, twenty-two groundwater water samples were obtained inside the study region. Atomic Absorption Spectroscopy, method was used to determine the chemical compositions of all the samples collected. Groundwater Quality index was employed to evaluate the laboratory result. Potential Toxic Element concentrations in Groundwater for Cr, Fe, Ni, As, Cd, Hg and Al ranged from (0.00 to 0.83ppm, 0.32 to 0.56ppm 0.10 to 0.38ppm, 0.00 to 0.32ppm, 0.00 to 0.01ppm, 0.13 to 0.35ppm, and 0.00 to 1.21ppm) respectively. The various guidelines for water quality and the index revealed that the groundwater was contaminated, basically from anthropogenic sources. It´s recommended that the groundwater should be treated before consumption.

KEYWORDS

Industrial Pollution, Groundwater, Spectroscopy, Toxic Element

1. INTRODUCTION

Groundwater is one of the most importance sources of water supply for domestic uses. Groundwater quality is however affected by the characteristics of the environment of circulation and occurrence. Groundwater is invariably exposed to anthropogenic and industrial pollutants through indiscriminate disposal of waste into surface water and soil environment (Egbunike and Okpoko, 2018). This waste that is directly discharged into the surface water and soil environment contains Potential Toxic Elements (PTEs) that percolates through the soil profile and flow from the streams to reaches the groundwater (Ifeanyichukwu et al., 2020). PTEs are metals and metalloid such as Cr, Ni, As, Fe, Cd, Hg, Al and Pb which when found in water and soil in an amount beyond a certain threshold, can be hazardous to human health. Due to rapid industrialization and urbanization of Nnewi and environs, adequate monitoring and control of industrial wastes is required. Nnewi has been dubbed the "Japan of Africa" due to its diverse manufacturing industries, which include automobiles, automobiles, plastics, paints, and agricultural products. Because these industrial operations pollute the environment, environmental contamination from industrially discharged effluents is an emerging problem in Nnewi town. As a result, the focus of this research is on the analysis of Potential Toxic Elements (PTEs) in groundwater in the Nnewi industrial region.

2. DESCRIPTION OF THE STUDY AREA

The research area is in Anambra state's Nnewi North LGA, some 22 kilometers southeast of Onitsha. It lies within latitudes 5^{0} 58^{I}N and $6^{0}30^{I}$N, and longitudes $6^{0}52^{I}$E and $6^{0}57^{I}$E. The elevation ranges from 105 to 300 meters above sea level. Its business nature has an impact on its rapid urbanization and social position. It is divided into four autonomous quarters: Otolo, Uruagu, Umudim, and Nnewichi (Figure 1). The research area is approximately 128km2, with a population estimate of 121,063 people (Nigerian population commission, 2018). The predominant climatic conditions in the area are characterized by two major regimes: rainy and dry seasons. The wet season runs from April to September, and the dry season is from October to March. The average annual temperature in the area is 25.5°C.

2.1 Geology and Hydrogeology of the Area

Two formations underpin the studied area: Eocene Nanka Sands Formations and Quaternary Ogwashi-Asaba Formations (Nwajide, 2013; Reyment, 1965). The Formation is made up of a thin band of claystone, siltstone, and shale. The porosity and permeability of the units are both high. The Ogwashi-Asaba Formation is beneath the Nanka Sands. This is accomplished through the intercalation of lignite and clays.

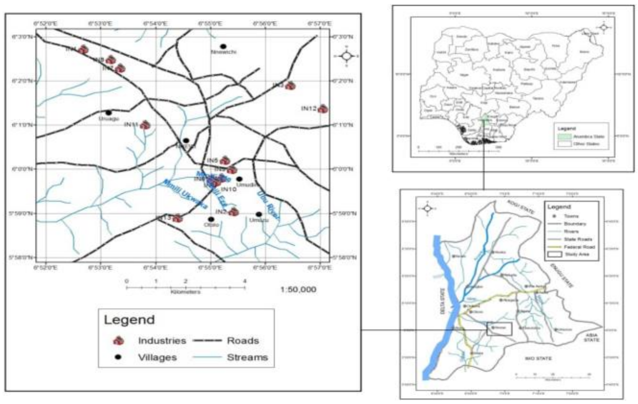

Figure 1: Map of Study Area Location and Accessibility (Source NGSA 2018)

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3. METHODOLOGY

During the dry season, twenty-two (22) groundwater samples were obtained from boreholes in the research region (figure 2). The content of PTEs such as chromium, nickel, arsenic, iron, lead, cadmium, mercury, and aluminum in water samples was determined using a Varian AA240 Atomic Absorption Spectrophometer (AAS). The groundwater analysis results were compared to WHO criteria and the Nigerian Standard for Drinking Water Quality (WHO, 1996; NSDWQ, 2015).

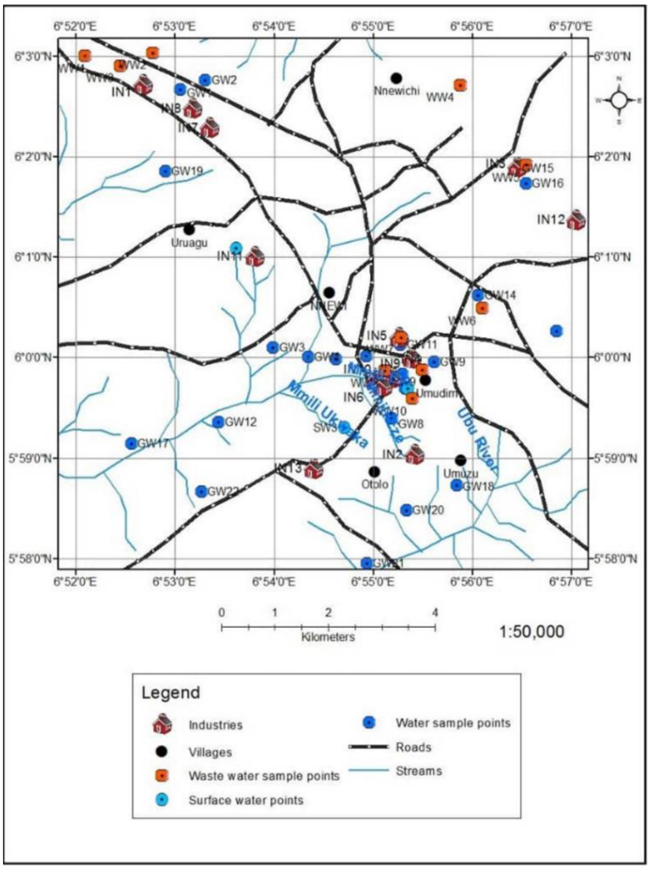

Figure 2: Water sample location map of the study area

3.1 Groundwater Quality Index (GWQI)

The term "groundwater quality index" refers to a rating technique that offers the composite influence of specific water quality criteria on the overall quality of water for human consumption. The following equation was used to calculate the quality of groundwater. for the GWQI

$$GWQI = \sum SIi = \sum(Wi \times qi) = \sum[(wi \sum wi\ i \equiv 1\ n) \times (Ci\ Si \times 100)] \qquad (1)$$

Where Ci represents the concentrations of each parameter and Si represents the limit values, wi represents the given weight based on its relative importance in the overall quality of water for drinking purposes (Table 1) and qi represents the water quality rating. Wi is the relative weight, and SIi is the ith parameter's sub-index.

Table 1: The following is a list of characteristics, weight factors, and limit values for the water quality index.

S/No	Units	Parameter	Weight (w_i)	Relative Weight (W_i)	Standards
1	ppm	Fe	4	0.125	0.3
2	ppm	Cr	4	0.125	0.05
3	ppm	Ni	4	0.125	0.02
4	ppm	As	4	0.125	0.01
5	ppm	Cd	4	0.125	0.003
6	ppm	Hg	4	0.125	0.001
7	ppm	Al	4	0.125	0.2
8	ppm	Pb	4	0.125	0.01
			$\Sigma w_i = 32$	$\Sigma W_i = 1$	

4. RESULT

The result of the PTEs in groundwater analysis of the study area is summarized in (Table 2)

Cr: The concentration of Cr in groundwater varied from 0.00 to 0.83ppm respectively in the study, with values above the permissible guideline of 0.05ppm. In most groundwater locations, the high values are traces to inadequate waste disposal practice from industries manufacturing automotive, fertilizer, paints and metal processing (Shivam and Shriram, 2020). Health effects of Cr toxicity may result as cancer (NSDWQ, 2015).

Ni: The primary source of Ni in groundwater is from wastes from electroplating, mining, agricultural chemicals and fertilizers leaching from metals in contact with water, such as pipes and fittings, also from dissolution from nickel ore-bearing rocks. Ni values range between 0.10 to 0.38 which exceeded the recommended guidelines of (WHO, 2011 and NSDWQ, 2015). This could be connected with wastes from fertilizer, automotive and batteries manufacturing industries in the study area.

As: As occurs as trace element in most rocks but can be released into the groundwater as a result of human activities such as mining, industrial effluent from smelting of metals and pesticides. As was not detected in most of the groundwater location apart from GW3, GW5, GW6, GW13, GW14, GW15, GW19 and GW22, which exceeded guidelines limit of 0.01ppm. This could be traced to waste from automotive, PVC pipes and Agro chemical producing companies in the study area. Arsenic pollution in drinking water is toxic at low level and known to be carcinogenic (EPA, 2001).

Cd: The major source of Cd to groundwater is from industrial waste from cell batteries, mining and fertilizers. The concentration of Cd in the study area varied from 0.00 to 0.01ppm. Reason for high values of Cd above the guideline value of 0.003 is due to poor wastes disposal from battery and fertilizer producing industries to the environment. High concentration of cadmium in the groundwater is toxic and can affect the kidney when taken (Imasuen and Egai, 2013).

Fe: Fe in groundwater occur naturally, from weathering of iron and manganese bearing minerals and rocks. Industrial effluent, acid-mine drainage, sewage and landfill leachate may also contribute Fe to local groundwater (EPA, 2001). Fe concentration in the study is above the recommended guideline of 0.3. This could be traced to the geology of the study area, which is are iron rich sedimentary rocks. At low concentration, Fe is not considered a health risk. Groundwater with a high concentration of iron may cause the staining of plumbing fixtures or laundry (WHO,1996).

Hg: Hg can occur naturally in groundwater, usually in low concentration, elevated Hg in groundwater may be as a result of chemical spills, or by industrial improper disposal of materials containing Hg (EPA, 2001). Hg concentration in the study area varied from 0.13 to 0.35ppm. All locations have the value for Hg concentration above the recommended guideline value of 0.006ppm. this can be attributed to effluents for automotive, battery and paint manufacturing industries in the study area. Health implication of drinking water contaminated with Hg is renal failure and neurological changes (WHO, 2011).

Al: Al infiltrate groundwater into naturally through the weathering of rocks and minerals also anthropogenic associated with industrial processes, play significant role such as aluminum production (EPA, 2001). The concentration of Al in the study area ranged from 0.00 to 1.21ppm, with locations (GW5, GW7, GW8, GW9, GW10 GW11, GW14, GW15, GW18, GW19, GW20, GW21 and GW22) exceeding the recommend limit of (WHO, 2011). This could be traced to effluents, and solid waste from cables, automobile, automotive, and aluminum roofing industries in the study area. High concentration of Al in the groundwater causes neuro degenerative disorders (NSDWQ, 2015).

Table 2: Dry season heavy PTEs in groundwater

SAMPLE	**Cr**	**Ni**	**As**	**Fe**	**Cd**	**Pb**	**Hg**	**Al**
LOCATION	ppm	Ppm	Ppm	ppm	Ppm	Ppm	ppm	ppm
GW1	0.66	0.09	0.00	0.35	0.027	0.07	0.72	0
GW2	0.18	0.34	0.00	0.32	0.002	0.01	0.25	0
GW3	0.00	0.16	0.08	0.46	0.022	0.14	0.16	0
GW4	0.00	0.30	0.00	0.41	0.028	0.26	0.35	0
GW5	0.89	0.08	0.03	0.37	0.053	0.22	0.22	0.013
GW6	0.00	0.22	0.12	0.38	0	0.12	0.01	0
GW7	0.44	0.38	0.00	0.42	0	0.22	0.25	1.272
GW8	0.30	0.04	0.00	0.41	0.061	0.47	0.33	0.827
GW9	0.53	0.35	0.00	0.45	0.045	0.35	0.29	0.777
GW10	0.82	0.22	0.00	0.52	0	0.20	0.23	0.803
GW11	0.75	0.33	0.00	0.56	0.062	0.07	0.15	0
GW12	0.00	0.18	0.00	0.42	0.008	0.22	0.05	0.763
GW13	0.00	0.20	0.04	0.39	0.003	0.30	0.23	0
GW14	0.00	0.34	0.32	0.48	0.002	0.07	0.26	0.012
GW15	0.45	0.19	0.08	0.37	0.002	0.38	0.16	1.208
GW16	0.59	0.35	0.00	0.39	0.004	0.18	0.18	0
GW17	0.66	0.10	0.00	0.38	0.003	0.13	0.33	0
GW18	0.00	0.38	0.00	0.46	0.008	0.15	0.25	0.14
GW19	0.45	0.28	0.13	0.45	0	0.09	0.17	0.284
GW20	0.83	0.23	0.00	0.47	0	0.23	0.13	0.832
GW21	0.19	0.19	0.00	0.41	0	0.35	0.35	0.732
GW22	0.56	0.25	0.01	0.52	0	0.03	0.16	0.802
MINI	0.00	0.10	0.00	0.32	0.00	0.03	0.13	0.00
MAXI	0.83	0.38	0.32	0.56	0.01	0.38	0.35	1.21
WHO (2011)	0.05	0.07	0.01		0.003	0.1	0.006	0.001
NSDWQ	0.05	0.02	0.01	0.3	0.003	0.01	-	0.2

Table 3: Result of the dry season groundwater based on drinking water indices

Index method	**Category**	**Degree of pollution water class**	**Number of locations**	**Percentage of sample (%)**	**Samples**
GWQI	< 50	Excellent water	0	0	
	50 – 100	Good water	0	0	
	100.1 -200	Poor water	0	0	
	200.1 -300	Very poor water	1	4.6	GW6
	> 300	Water unsuitable for drinking	21	95.4	GW1, GW2, GW3, GW4, GW5, GW7, GW8, GW9, GW10, GW11, GW12, GW13, GW14, GW15, GW16, GW17, GW18, GW19 GW20, GW21 &GW22

5. CONCLUSION

A safe source of drinking water is critical to human survival. However, in most poor nations (including Nigeria), a considerable proportion of the population lacks access to safe drinking water. When the calculated indices were compared to the criteria, it was discovered that groundwater is contaminated, primarily from anthropogenic sources (industrial waste). As a result, it is suggested that groundwater be treated before consumption. To minimize potentially harmful cumulative effects, it is advised that groundwater be treated before drinking. To protect human health, improved waste disposal methods and regular monitoring of harmful substances in groundwater in the research area should be implemented.

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