

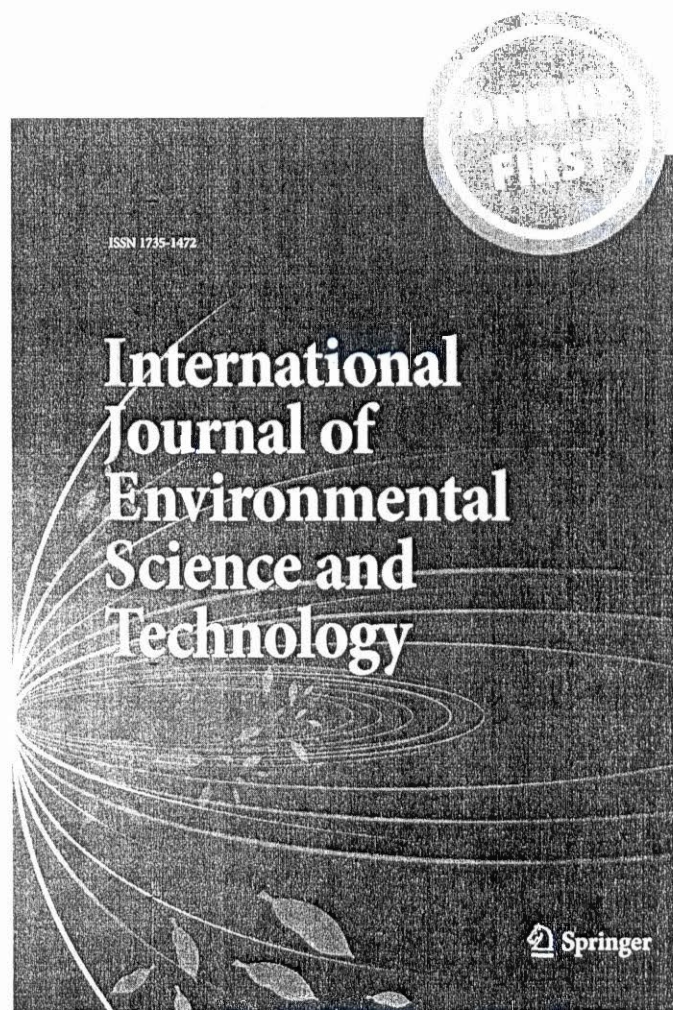
*Geochemical and quality assessment of
groundwater in some Nigerian basement
complex*

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Table 5 SAR hazard of irrigation water

	SAR	Notes
None	<3.0	No restriction on the use of recycled water
Slightly to moderate	3.0-9.0	From 3 to 6 care should be taken to sensitive crops From 6 to 8 gypsum should be used. Not sensitive crops Soils should be sampled and tested every 1 or 2 years to determine whether the water is causing a sodium increase
Severe	>9.0	Severe damage. Unsuitable

Table 6 Summary of trace elements in groundwater

Trace elements (µg/l)	Min	Max	Mean	SD	Median	EPA (2012)		WHO (2012)	% above standard
						MCLG	MCL		
As	<0.5	9.4	2.97	2.97	1	0	10	10	
B	<5	413	25.72	73.86	8			2400	
Ba	5.48	909.76	79.32	153.29	37.26		700	700	2
Be	<0.05	0.37	0.2	0.21	0.12			12	
Cl	<0.05	0.56	0.17	0.16	0.1	5	5	3	
Co	<0.01	7.5	1.37	2.08	0.44				
Cr	<0.02	5.17	1.01	1.13	0.6				
Cr	<0.5	30.8	5.32	6.39	2.4		50	50	
Cu	0.1	86.6	10.07	17.58	1.65	1300	1000	2000	
Li	<1	6.5	1.38	1.06	1				
Mn	<0.05	326.1	59.8	86.01	28.64		50		12
Mo	<0.1	24.8	3.45	7.25	0.2			70	
Ni	<0.2	15.7	2.15	3.23	1			20 ^a	2
Pb	<0.1	20.5	4.15	5.38	1.4	0	10	10	12
Sr	0.11	7.78	0.94	1.29	0.77	6	6	6	2
S	<0.5	20.9	5.65	7.66	2.24	50	50	40	
H	<0.01	0.14	0.03	0.03	0.02				
U	<0.02	1.85	0.16	0.32	0.05			30	
V	<0.2	15.3	1.27	2.55	0.6				
W	<0.02	2.27	0.62	1.1	0.09				
Zn	1.8	302.9	39.17	53.26	17.8		5000	1000	

^a National primary drinking water standard

Goering 1991). The inorganic compounds are more toxic than the organic compounds (Stemmer 1976). Soluble antimony salts can cause gastrointestinal mucosa and trigger sustained vomiting after oral uptake. Other effects include abdominal cramps, diarrhea and cardiac toxicity (Elinder and Friberg 1986).

Barium is not considered to be an essential element for human nutrition (Schroeder et al. 1972). At high concentrations, barium causes vasoconstriction by its direct stimulation of arterial muscle, peristalsis as a result of the violent stimulation of smooth muscles and convulsions and paralysis following stimulation of the central nervous system (Stoekinger 1981). The prevalence of dental caries has also been linked to high dose of barium. Death may occur in a few hours or a few days depending on the dose

and solubility of the barium salt. The health effect of excess nickel in water includes skin irritation and hypersensitivity. It can also be carcinogenic (WHO 2005).

Manganese is an essential element for man. Excess intake of Mn in water can lead to neurological effects (Canavan et al. 1934; Cook et al. 1974; Roels et al. 1999; ATSDR 2000). Exposure to high levels of manganese can also lead to a disease called manganism which is characterized by a Parkinson-like syndrome including weakness, anorexia, muscle pain, apathy, slow speech, monotonous tone of voice, emotionless masklike facial expression and slow clumsy movement of limbs.

The pollution index was used in this study to evaluate the degree of trace metal contamination in water samples (Subramani et al. 2010; Todd 1980; U.S. Environmental

Fig. 7 Plots of pollution index against sample locations

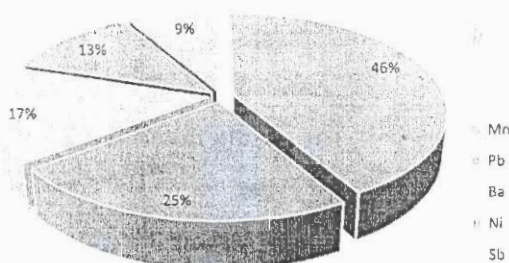
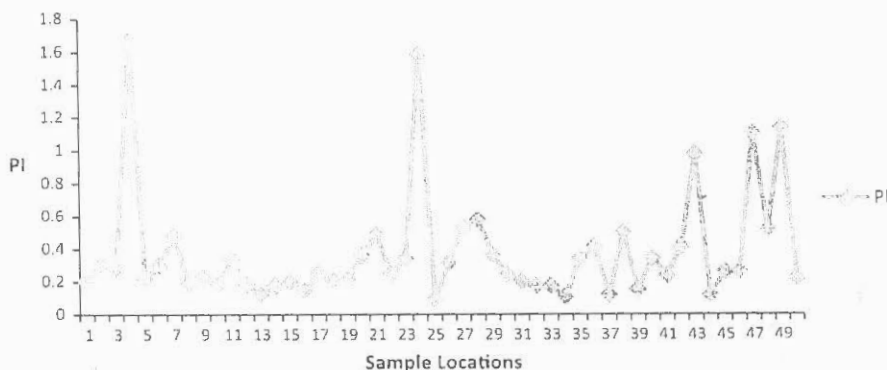


Fig. 8 Percentage of contaminated trace elements

Protection Agency 2002, 2008, 2009). The tolerable level is the element concentration in the water considered safe for human consumption. The tolerable level given by Wilcox (1948) and U.S. Environmental Protection Agency (2012) was used for water, and the pollution index can be calculated by the formulae:

$$PI = \frac{\text{Heavy metal concentration in water/Tolerable level}}{\text{Number of heavy metals}} \quad (4)$$

The PI among all sites varied from 0.09 to 1.76 with a mean value of 0.37 (Fig. 7). Water sample with pollution index >1 is regarded as being contaminated although the water is generally contaminated as much as there is any kind of contamination in it. Eight percentage of the water samples which include W4, W24, W47 and W49 showed pollution index above 1 (Fig. 7).

Mn contributed the highest percentage (46%) to the pollution index. This was followed closely by Pb which contributed 25%. Ba, Ni and Sb contributed 17, 13 and 9%, respectively (Fig. 8). These trace elements just like major elements were from both geogenic and anthropogenic origin.

Conclusion

Fifty samples from hand dug wells and boreholes were collected within Ijebu Igbo and its environs, southwestern Nigeria. The purpose was to establish preliminary baselines

for constituents in the groundwater and also to determine the quality for both drinking and irrigation purposes.

The pH and TDS of groundwater showed that the water varied within slightly acidic to basic and fresh, respectively. Ca, Mg, Si and S were all within recommended standard for both drinking and irrigation purposes. Al, Fe, Na, K and P were above the EPA 2012 recommended standard for drinking water in 79, 23, 3, 37 and 6% of the water samples, respectively.

There is involvement of silicate weathering in the geochemical processes, which contributed mainly calcium, magnesium and potassium ions to the groundwater. $Na^+ + K^+$ contributed more to water chemistry than $Ca^{2+} + Mg^{2+}$. The high concentration of Fe, Al, Na, K and P which were above recommended standards could also be linked to anthropogenic sources which include waste dumpsites, agricultural activities and sewage that are common in the study area.

SAR in water samples ranged from 0.12 to 10.43 and can be classified as excellent and good for irrigation. MAR varied between 0.89 and 87.94%. The values obtained in only 22% of the water samples were <50% considered suitable with no hazardous effects to the soil. The values obtained for the SSP parameter ranged between 62.79 and 90.32%. Seventy-eight percentage of the water samples fall within fair classification of 80%, and the remaining samples fall within poor (>80%) for the purpose of irrigation. Kellys ratio (KR) obtained for the water samples was 0.008–0.08 meq/L. The values obtained were lower than the permissible limit of 1.0 for all the samples. Water samples were also above 15% recommended standard for irrigation water based on Na%.

Trace element analysis showed that the concentration of Te and Ti was below detection limit for all the samples. As, B, Cd, Cr, Cu, Mo, Ni, U and Zn though present in water were below recommended standards for all the samples. Ni and Sb exceeded recommended standard only in sample W24, and Ba exceeded recommended standard in W20 with value as high as 909.76 ppb. Mn and Pb were higher

than recommended standard in 12 % of the samples. The pollution index varied from 0.09 to 1.66 with 8 % of the water samples showing pollution index above 1.

Generally, groundwater in the study area is suitable for both domestic and irrigation uses except samples W4, W24, W47 and W49. However, since heavy metals are not biodegradable, they tend to bioaccumulate and biomagnify in the body and eventually become harmful to human health.

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