Original Research Article

Application of Hazard Quotient (HQ) for the Assessment of Potential Health Risk of Groundwater Users Around Uyo Main Dumpsite

ABSTRACT

The present work aims at assessing the hazard quotient (HQ) in the groundwater samples collected around Uyo main refuse dumpsite. For calculating the HQ, 18 parameters, namely, temperature, pH, TDS, TSS, BOD, COD, nitrate, ammonia, Cu, Ni, Pb, Cd, Cl, total phosphate, sulfate, EC, DO and turbidity were considered. The HQ for pH(1.0 – 1.1), temperature(1.2), TDS(0.0), TSS(0.4 – 0.5), BOD(0.5 – 1.0), COD(0.1), nitrate(0.0 – 0.6), Cu(0.7 – 0.8), Ni(0.2), Pb(5 – 16), Cd(3.0 – 10), Cl(0.3 – 0.4), phosphate(1.4 – 1.9), sulfate(0.0), EC(0.1), DO(1.6 – 1.9) and turbidity(0.2). The HQ of temperature, pH, DO, phosphate, Pb, and Cd in water samples were all greater than unity and thus posed a potential health risk for human oral consumption. The present study revealed that groundwater around Uyo village road waste dumpsite poses a health risk to groundwater resource users due to groundwater contamination by the leachate. Monitoring of this site is recommended as well as research by biomedical experts to reveal the rigorous adverse impacts that physio-chemical, and heavy metal contamination of groundwater might induce in humans, particularly among individuals in vulnerable populations. Also, the local authorities should be made aware of such health risks and provide potable water facilities either by treating the water or find alternative sources for drinking.

Keywords: Groundwater, Physicochemical, Heavy Metals, Hazard Quotient

1. INTRODUCTION

Groundwater is one of the main sources of fresh water for drinking, irrigation, and industrial uses in most communities around the world. It is an important renewable resource with several merits over surface water. Groundwater is typically less polluted compared to the surface water because of its self-cleansing ability and ease of treatment [1]. One of the leading causes of groundwater pollution in urban areas is contamination by leachate emanating from municipal solid waste dumpsites. Several reports in different parts of the world have reported a large number of organic, inorganic and microbiological pollution in groundwater [2], [3], [4], [1], [5], and much resources have been allocated to remediate the problems.

Access to safe clean water and acceptable sanitation is a fundamental right and a condition for basic health [6]. Lack of safe drinking water and inadequate sanitation measures lead to a number of diseases such as cholera, dysentery, salmonellosis and typhoid, and every year millions of lives are claimed in developing countries. Diarrhea is the main cause for the death of more than 2 million people per year world-wide, mostly children under the age of five. It is a symptom of infection or the result of a combination of a variety of enteric pathogens [7]. Water-borne pathogens infect around 250 million people each year resulting in 10 to 20 million deaths world-wide [8]. This highlights the potential of infection due to water - borne pathogens.

In most developing communities, there are imbalances in the provision of some basic amenities such as individual toilets, security, drinking water, play area for children, power transformer, work out space, roads, citizen service centres, water harvesting, public libraries, animal shelter, theatre and skill development centre because of the politics of the days. Nevertheless, where population density is high, pollution may result because water resources are often located in close proximity. The situation may be aggravated by the hydrogeology of the area, which permit easy mobility of the pollutants into the groundwater. Lack of proper solid waste disposal systems threatening water resources in urban areas [9].

There has been an increasing concern about the environment in which man lives. Solid wastes, amount of rubbish, garbage and sewage are being produced everyday by our urban society. In an attempt to dispose of these materials, man has carelessly polluted the environment. Some component of these wastes including food, paper, metals, polythene bags, zinc and lead containing materials etc consume oxygen thereby changing the redox potential of the liquid present [10], which may cause health issues to surface and groundwater resource users. Leachate migration from landfill site can pose a high risk to surface and groundwater resource users if not properly managed. This may be due to surface run-off of precarious substances or leachate percolation which may be the source of large outbreaks of disease [11].

Human health risk assessment has been defined by United States Environmental Protection Agency as the process of estimating the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environmental media, now or in the future. Health risk assessment involves identifying the potential of a risk source to introduce risk agents into the environment, estimating the amount of risk agents that come into contact with the human-environment boundaries and quantifying the health consequence of exposure [12].

To fulfill the health risk assessment, generally, four steps must be followed: hazard identification, dose-response assessment, exposure assessment and risk characterization [13]. Health risk assessment has drawn a lot of attention from many scientists across the world, and many assessments relating to drinking purpose and human health have been reported. Human health risk assessment is an effective approach to determine health risk levels posed by various contaminants [14]. This method has been applied to assess the potential adverse health effects exposing to contaminated water [15], [16], [17], [14], [18], [19], [20]. Ingestion is considered to be the primary route of exposure to chemical contaminants in drinking water.

Uyo main refuse dumpsite in Uyo local government area is the site being engulfed by gully erosion several years ago, and was adopted by the Akwa Ibom State government as erosion control measures to reclaim the site. Today environmental quality around Uyo village road main dumping ground is affected by landfill leachate, foul odours, unsightliness and attraction of vector that are of interest to public health. Several health related issues have been reported by the residence living around the municipal solid waste dump site. In the present study, considering the gravity of the situation, hazard quotient was used to assess the potential health risk of groundwater users around Uyo main refuse dumpsite.

2.0 MATERIALS AND METHODS

2.1 STUDY AREA

The study was carried out at Uyo Village Road in Uyo local government area. Uyo is the capital city of Akwa Ibom State, Nigeria. It's situated at 5.03° North latitude, 7.93° East longitude and 196 meters elevation above the sea level. The average annual temperature in Uyo is 26.4 °C. The rainfall here averages 2509 mm. Fig. 1 show the map of the study area.

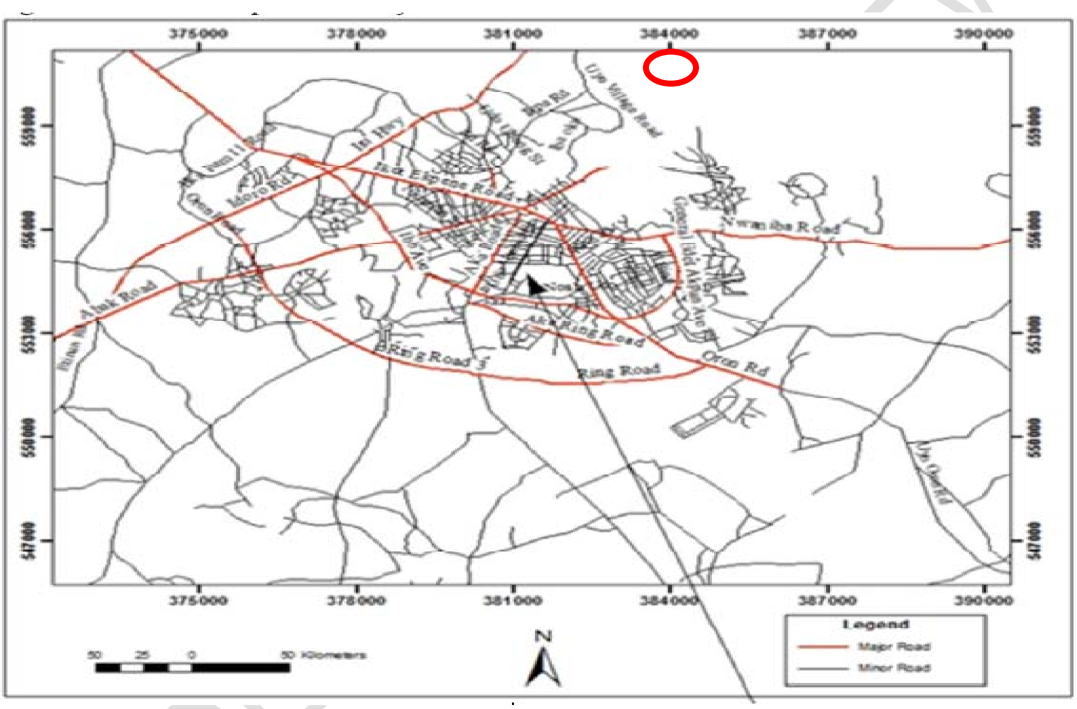

Fig. 1 Map of Uyo Urban Showing the Study Area

Uyo Village Road Waste Dumping Site

2.2 Samples Collection

Four borehole water samples were collected around the municipal solid waste dumping site. 1 litre capacity containers were used to collect the groundwater samples for laboratory analyses (plate 1). Site specifications for sampling points are presented in Table 1.

Plate 1. Borehole Water Samples

Table 1: Site Specification for Sampling

S/N	Sampling Location	Latitude and Longitude	Notation
1	Borehole Number 1	5.0498556° N; 7.9337177° E	SP1
2	Borehole Number 2	5.0417077° N; 7.9333278° E	SP2
3	Borehole Number 3	5° 2’ 27’ N; 7° 56’ 0” E	SP3
4	Borehole Number 4	5° 3’ 1” N; 7° 56’ 2” E	SP4

NB: SP - Sampling Point 1, 2, 3 and 4.

2.3 Sample Preservation and Analysis

The samples were stored in refrigerator at 4 ^{0}C pro-to analysis. The adopted methods of analyses for the examination of all parameters were in accordance with American Public Health Association [21] standard recommendation.

All samples were analyzed for selected physical, chemical and heavy metals parameters. Table 2 shows the methods of analysis of different parameters of the water samples.

Table 2: Methods of Analysis of Different Parameters in Groundwater Samples

Parameters	Instrument used to identify the parameters
pH	Electronic pH meter
Temperature (°C)	Thermometer
Turbidity (NTU)	Turbidity meter
DO (mg/l)	DO meter
COD (mg/l)	Open reflux method
BOD (mg/l)	Winkler's method
Electrical Conductivity (µs/cm)	Conductivity meter
TDS (mg/l)	TDS meter
TSS (mg/l)	TSS meter
Chloride (mg/l)	Titration
Sulphate (mg/l)	Titration
Nitrate (mg/l)	Spectrophotometer method
Ammonia (mg/l)	-
Total Phosphate (mg/l)	-
Lead (mg/l)	Absorption Spectrophotometer
Cadmium (mg/l)	Absorption Spectrophotometer
Nickel (mg/l)	Absorption Spectrophotometer
Copper (mg/l)	Absorption Spectrophotometer

2.4 Risk Assessment on Human Health

Exposure of human being to physicochemical and heavy metals could occur via three main pathways, these are: direct ingestion, inhalation through mouth and nose, and dermal absorption through exposure to the skin. However, ingestion pathway is the most significant for drinking water [22], [23].

Risk characterization for this study was quantified by potential non carcinogenic risks, reflected by the hazard quotient (HQ). The (HQ) is calculated using the following equation [16], [24].

Hazard Quotient (HQ) =

$$\frac{\text{Exposure Concentration}}{\text{Reference Concentration (RfC)}} \qquad (1)$$

Where:

Exposure concentration: Per unit amount of a chemical or other hazardous substance representing a health risk in an environment in mg/l or ppm.

Reference concentration (RFC): An estimate of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Its unit is also in mg/l or ppm. RFC values employed in this study were obtained from [25], [26].

Health Risk assessment of the toxicants was interpreted based on the values of HQ. A hazard quotient less than or equal to 1 indicates that adverse effects are not likely to occur, and thus can be considered to have negligible hazard.

If the hazard quotient is greater than 1, the adverse health effects are possible.

3.0 RESULTS AND DISCUSSION

Table 3: Present the summary of health risk assessment for exposure to physico-chemical and some heavy metals properties in water around the Uyo municipal solid waste dumpsite.

Table 3 Health Risk Assessment for Exposure to Physico-chemical and Some Heavy Metals Properties in Borehole Water around Uyo Main Refuse Dump Site

parameters	HQ @SP1	HQ @SP2	HQ @SP3	HQ @SP4
pH	1.1	1.0	1.0	1.1
Temperature	1.2	1.2	1.2	1.2
Turbidity	0.2	0.2	0.2	0.2
DO	1.6	1.9	1.9	1.6
COD	0.1	0.1	0.1	0.1
BOD_5	1.0	0.5	0.5	0.6
EC	0.1	0.1	0.1	0.1
TDS	0.0	0.0	0.0	0.0
TSS	0.5	0.4	0.4	0.4
Cl	0.3	0.4	0.4	0.4
Sulphate	0.0	0.0	0.0	0.0
Nitrate	0.0	0.6	0.5	0.5
Ammonia	-	-	-	-
Phosphate	1.9	1.5	1.4	1.6
Pb	5.0	11.0	15.0	16
Cd	3.0	6.7	10.0	6.7
Ni	0.5	0.5	0.5	1.0
Cu	0.8	0.8	0.8	0.7

HQ @ SP1, 2, 3 and 4: Hazard Quotient for Borehole No. 1, 2, 3 and 4

The hazard quotient of temperatures in borehole water samples SP1, SP2, SP3 and SP4 was 1.2, this is greater than unity. The same applies to pH for boreholes SP1 and SP4 with the giving a hazard quotient of 1.1. Thus, the hazard quotient is greater than unity which poses a health risk to ground water users.

For turbidity, the calculated hazard quotient was 0.2 for SP1, SP2, SP3 and SP4 which is far less than 1, which makes turbidity a no-risk physiochemical parameter in boreholes water around municipal solid waste dumpsite. Turbidity has no direct health impact but can harbor microorganisms protecting them from disinfection and can entrap heavy metals and biocides. This can bring problems in water treatment process and can also be a potential risk of pathogen in treated water [25].

Dissolved oxygen had hazard quotient of 1.6, 1.9, 1.9 and 1.6 for boreholes water samples SP1, SP2, SP3 and SP4. This poses a great risk or hazard since it is greater than unity. Dissolved oxygen concentrations indicate whether aerobic or anaerobic conditions exist in groundwater, and therefore provide useful information to assess the potential for biodegradation or biotransformation of chemical of potential concern.

COD poses no long term health effect as its entire calculated hazard quotient values in this study are below unity. BOD_5

also poses no long term health risk as all the values of hazard quotient in this study fall below one except borehole sample (SP1) recorded 1 unity.

Hazard quotient EC(0.1), TDS(0.0), TSS(0.4 – 0.5), Cl(0.3 - 0.4), sulphat(0.0) and nitrate (0.0 – 0.6). These calculated hazard quotients were less than 1, which makes them no-risk physicochemical parameters in drinking water quality.

There is no reference concentration for ammonia in drinking water even though it is highly toxic and lethal to aquatic species even at low concentrations.

Phosphate in water around municipal solid dumping site had a hazard quotient of 1.9, 1.5, 1.4, and 1.6 for boreholes water sample SP1, SP2, SP3 and SP4 which make it risk physicochemical parameter in ground water. This may be due to some observed emission from mixed waste.

Pb had hazard quotient of 5, 11, 15 and 16 for boreholes SP1, SP2, SP3 and SP4). Thus, from the results of this study, Pb poses a high risk of contamination for human health exposure to the water. Pb may causes cancer, interference with vitamin D metabolism, affect mental development in infants, toxic to the central and peripheral nervous systems on the health status of local surface and groundwater resource users in the host communities as reported by [25]. It may also cause anemia, brain damage, anorexia, mental deficiency, vomiting and even death in human beings [27], [28], and is toxic even at lower concentrations.

CONSENT

It is not applicable

The hazard quotient values for cadmium in all the sampling points were all greater than unity. They were 3.0, 6.7, 10.0, and 6.7 for borehole SP1, SP2, SP3 and SP4, respectively. These poses high risk of contamination for groundwater resource users. Cadmium has been reported to cause agonistic and antagonistic effects on hormones and enzymes leading to lots of malformations like renal damage [29], [30], and are toxic to the kidney [25]. Nickel recorded 1.0 for SP1, while other sampling point were less than unity.

4.0 CONCLUSION

Borehole water samples around Uyo main refuse dumpsite were studied. The results show that hazard quotient for pH, temperature, dissolved oxygen, phosphate, Pb and cadmium were above unity. This represent a human health risk exposure to the water through drinking. This confirms that boreholes around Uyo main dumpsite are contaminated by leachate which calls for more monitoring. The results of the study can be used beneficially and applied to monitoring and educating the local inhabitant who generally directly drink groundwater. In order to reduce more risk, the local authorities should be made aware of such possible health risks and provide potable water facilities either by treating the water or find alternative sources for drinking. Continuous monitoring and further studies of the area are also recommended to ascertain long-term effects. Further investigation is also recommended for seasonal variability of toxic metals in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

ETHICAL APPROVAL

It is not applicable.

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