International Journal of Engineering Applied Sciences and Technology, 2020
Vol. 5, Issue 1, ISSN No. 2455-2143, Pages 690-695
Published Online May 2020 in IJEAST (http://www.ijeast.com)

IMPACT OF REFUSE WASTE DUMP ON SUBSURFACE WATER QUALITY OF THE ALLUVIAL DEPOSIT OF UPPER BENUE RIVER ADAMAWA STATE, NORTH-EAST NIGERIA

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Abstract— **subsurface water quality of the alluvial deposit at Kwanan Kuka Bus stop along the Upper Benue River flood plain was investigated through strategic sampling and standard laboratory methods. The refuse waste dump was also investigated concerning heavy metals concentrations. Heavy metals and physicochemical properties of groundwater were thus evaluated. Parameters assessed include total dissolved solids, pH, Calcium, Magnesium, chloride, potassium, electrical conductivity, and magnesium. Heavy metals were analyzed for copper, iron, zinc, manganese, chromium, mercury and lead using standard laboratory procedures. The pH values ranged from 7.15 – 8.05 indicating alkalinity and lies within the WHO standard of acceptable limit. The turbidity values were between 0 – 2.5 NTU. Zinc, manganese, and chromium ranged from 0.08 – 4.5 mg/l, 0.43- 0.15mg/l and 1.61-2.61mg/l respectively and all are slightly above WHO standard limit. Iron and copper ranged from 0.43 – 0.68 mg/l and 0.03– 0.05 mg/l respectively, which are within the acceptable limit of WHO drinking water quality standard. Lead and mercury were not detected in all the samples. The result showed that the groundwater water at the site I, is less polluted, but site II requires good waste management and disposal strategies as well as remediation in terms of further monitoring over a longer period. The waste disposal and management system of the Adamawa State Ministry of the environment must be strategized to prevent the discharge of solid and liquid waste to avoid contamination of the shallow aquifer of the alluvial deposit.**

Keywords—**Subsurface, Water Quality, Alluvial Deposit and Refuse Dump**

I. INTRODUCTION

A. General Drinking Water Quality –

Groundwater is the most reliable water supply source for domestic, agricultural and industrial use in most of Nigeria and other developing countries of the world, [1, 2, 3]. However, despite its reliability, this precious vital resource is under increasing threats due to anthropogenic activities related to incessant waste disposal and poor management, [4, 5, 6, 7]. The usefulness of water to humans is especially dependent on its chemical status; thus, assessment of groundwater quality is important for the socio-economic development of most developing countries of the world, [8, 9]. Groundwater is the primary source of potable water supply in most of Jimeta-Yola metropolis, which relies on low-cost domestic (private) boreholes or shallow hand-dug wells as well as tube wells in the alluvial deposit aquifer.

In Jimeta-Yola metropolis, uncontrolled urbanization has resulted in increased above ground anthropogenic activities. Heavy metals through incessant waste disposal, the proliferation of pit latrines effluent from sewage, routine agricultural activities are materials concern, [10,11,12]. Long pressure from these pollution sources can considerably influence negatively on the underlying aquifers, [13, 14,15]. These pollutants may infiltrate into the aquifer due to the unconfined nature of the alluvial deposit formation. As reported by [16], medical experts have associated some diseases with groundwater contamination, which include diarrhea, pneumonia, typhoid fever, asthma, respiratory and chest diseases. Water is no doubt one of the most essential resources on earth and remains man's prime need in his environment. It is also a fact that portable water supply is lacking in many communities despite being one of the most abundant resources on earth. It is therefore important that the relationship between water quality and health be fully appreciated by all concerned. According to [15, 17], poor water quality can pose health problems enough to threaten human life if consumed. The need for water treatment before consumption cannot be overemphasized, but irregularity or acute shortage of potable water to the populace has led to people drinking water from hand-dug wells and other sources including streams and ponds.

B. Refuse Waste Dumps–

The refuse waste dumps sites consist of solids and microbial organisms and in special situations, chemicals[18, 19, 20, 21]. Shallow wells like hand-dug wells and shallow boreholes are more dangerously polluted. This solid waste includes food garbage, polythene and paper/glass, leaves and some includes faces while the liquid waste usually composed of dissolved solids, effluent from the kitchen, bath, and even latrines.

As the population and urbanization increase, more water is required and greater demands are made on ground and surface water. More so greater amount of organic and inorganic wastes is spread back into water sources and makes it unsuitable for drinking. [22, 23, 24, 25]. The activities of agricultural production and waste disposal along the Numan-Mubi Bye-pass remain unregulated due to poor management practice and inefficient waste disposal practice that pose significant threats to the alluvial deposit of the shallow aquifer of the Upper Benue formation [3, 9, 26].

C. Water Quality Criteria and Usage –

The major cations (Ca2+, Mg2+, k+, and Na+) and anions (HCO3-, CO32-, SO42- and Cl-) have considerable effects on water usability, [3, 27, 28, 29]. The usability of water could also be considered in terms of total dissolved solids (TDS) which serves as an indication of salinity.

D. Domestic Water Quality Classification –

Water quality classification based on the results of the analysis can be a handy tool for a guide on water usage for communities. Several standards have been developed for domestic water quality classification but the most commonly used ones are the World Health Organization (WHO), and the U.S salinity laboratory. The quality required of a groundwater supply depends upon its purpose, [1, 2, 30]. Thus, the need for drinking, industrial and irrigation water very widely. In establishing quality, criteria measures of chemical, physical, and bacteriological constituents must be specified as well as standard methods for reporting results of water analysis, [26, 31, 32]. Recommended limits of water quality can then be used to serve as guides for the interpretation of results of groundwater quality in a basin.

E. Subsurface Water Pollution –

The pollution of groundwater sources may be from industries, agricultural and domestic wastes. According to [33], industrial pollution may involve seepage of used water containing chemicals such as metals and radioactive compounds, or contaminated water from damaged pipelines that infiltrate into the groundwater and can be in hand-dug wells. Also, domestic pollution may involve seepage from septic tanks, pit latrine, cesspools and privies. Besides, agricultural pollution is also from irrigation and runoff water carrying fertilizers, pesticides, herbicides and fecal matter to the water source. Environmental pollution may be caused by seawater intrusion into coastal aquifer, [16, 33-35] [14, 24, 25, 26]. However, the World Health Organization [36-38] recommended that wells should be located at least 30 m away from latrines and 17 m from septic tanks. This study therefore aimed at assessing the level of physiochemical and heavy metals concentration in groundwater as affected by refuse waste dump sites and to determine the degree of their deviation from world Health Organization (WHO) guidelines.

II. MATERIAL AND METHOD

***A.* Study Area –**

The study area is located between longitude 120 22' and 120 28' E and latitude 90 16 and 90 and 19 months; which is bounded to the North East by river Benue which flows in a westerly direction. While to the South and southeast is the limit of Jimeta town in Adamawa state. The area has two distinct seasons, dry and wet season with temperature and humidity varying with the seasons. The wet season begins in May and ends in September 70% of the total rainfall in the area falls within June to August.

The mean annual rainfall for the area is 982mm, while the temperature ranged from 270c to 400c. The vegetation is the savannah type (Sudan Savanah). The soil is fertile alluvial with poorly developed soil deposits due to the probable geological youthfulness of the soil [39].

Located along the Numan-Mubi Bye-pass within the flood plain of the Upper Benue River just before the Jimeta Bridge. According to [40,41,42], the climate of the region is characterized by a cool dry season (October-February), hot season March to May and raining season (June to September). The area is vulnerable to desertification, [43]. The study area dominantly derives its groundwater sources from the Benue alluvial aquifer in which tube wells and shallow boreholes are used for domestic and agricultural water supply.

B. Desks Study –

Desk's study of the area was conducted through the acquisition of maps, reports, and kinds of literature from the Upper Benue River Basin Development Authority (UBRBDA), Ministry of Land and Survey and Modibbo Adama University of Technology (MAUTECH). The materials were used to review the work. Verbal communications with the people were also conducted. The history of the study area was also investigated to get adequate knowledge and background information about the project area.

C. Water sampling and analysis.–

A sterilized 750mlplastic bottle container was used to collect water samples from shallow hand dag wells and boreholes. Samples totaling fifteen (15) were collected, properly labeled and transported to MAUTECH soil and Geology Laboratories laboratory for analysis. The samples were spread across the refuse dump area (Demsawo and Shinko

International Journal of Engineering Applied Sciences and Technology, 2020
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Published Online May 2020 in IJEAST (http://www.ijeast.com)

wards) The parameters analyzed were physiochemical and heavy metals and is indicated in table 2,3, & 4. The method used was that of the procedure described by [44, 45]. Total dissolved solids (TDS) were determined by the evaporation-changing method. The pH and ECw were read at 250 c on a pH meter and conductivity meter respectively. Calcium and magnesium were estimated by EDTA titration method, while K and Na by flame photometry. Sodium Carbonate and bicarbonate were obtained by volumetric titration method. The anions Cl, SO4, and NO3 were read on LED photometer while Boron was determined by the calorimetric indigo- carmine method.

The parameters examined for heavy metals concentration in the samples include copper (Cu), Zinc (Zn), Iron (Fe), manganese (Mn), Chromium (Cr) mercury (Hg) and lead (Pb). The qualitative analysis was carried out at the soil science and geology laboratories of the Adamawa State University (ADSU). The concentrations of heavy metals such as Cu, Zn, Fe, Mn, Cr and Pb in the water and waste samples were determined with flame atomic absorption spectrophotometer (model analyst 400). The results obtained (table 2,3&4) were compared with the World Health Organization [46] drinking water standards limit.

D. Waste sampling and analysis –

Five (5) waste samples were taken from two (2) dumpsites each totaling Ten (10). Physical analysis (the composition of the waste) was carried out. The weight percentage analysis of the waste was carried out for various components namely: - leaves, polythene, garbage metals, etc. The results are shown in Table 1. For heavy metals, five (5) composite waste samples were collected and taken to the laboratory for heavy metals analysis and the result indicated in table 2.

III. RESULT AND DISCUSSION

A. Composition of Solid Waste dumps –

For the classification of waste, ten waste components were considered. These were food/putrescible, vegetables, paper, plastic, glass/ceramic, fabrics, wood, metal, electronic waste, and "others". Others represent solid waste that is not identified or do not fall into the first nine categories. Sorting and weighing of collected waste were done at the dumpsite. The composition of the refuse waste dump on a trash weight basis is presented in table 1.

Table -1 Composition of Refuse dump from Two Representative Public Dumpsite in the study (on Fresh Weight Basis)

Components	Site I	Site II
Leaves (%)	**3.02**	**4.23**
Papers (%)	**8.41**	**6.64**
Rags (%)	**3.02**	**0.00**
Garbage (from waste (%))	**22.85**	**70.60**
Wood (%)	**1.08**	**0.00**
Metals (%)	**1.51**	**3.79**
Glass (%)	**0.65**	**0.95**
Grit and Dust (%)	**51.70**	**9.01**
Polythene and other plastics (%)	**7.76**	**4.98**

A. Heavy Metal Concentrations in Refuse waste dump –

The result of the analysis indicates that heavy metal concentrations of iron, zinc, copper, and magnesium as well as chromium are all slightly above the standard limit of WHO and may likely affect the groundwater quality, [8, 47, 48, 49, 50]. Lead and mercury were not detected, table 2.

Table -2 Heavy Metals Concentration of refuse waste dumps in Study Area

Sample	Fe	Zn	Pb	Cu	Mn	Cr	Hg
WHO	**0.5-5.0**	**0.01**	**3.0**	**1.0**	**0.1**	**0.05**	**-**
Dump Site I	**3.0**	**0.02**	**ND**	**0.8**	**0.2**	**0.04**	**ND**
Dump Site II	**2.1**	**0.02**	**ND**	**0.25**	**0.25**	**0.06**	**ND**

B. Physiochemical Properties of Water Sample –

The results of the examined physiochemical properties of both borehole and hand-dug well indicates that Ecw was 2.6mmohcm-1 and 2.4mmohcm-1 for borehole and hand-dug well respectively and fall within the limit WHO recommended limit for drinking water quality. TDS, Mg, Ca, and K for both samples are all within the acceptable limit of [51, 52]. The pH values for borehole and well 7.3 – 6.9 respectively that are within the standard limit. Table 2. Anions No, No3 and SO4 are all within the acceptable limit.

The water samples collected from boreholes and hand-dug wells show that there no variation in chemical characteristics. Table 2.

Parameter criteria of analyzed water samples were compared for the desired quality of portable water by the World Health Organization (WHO) Standard and there is little variation only.

Table -3 Physio-chemical properties of groundwater of the study area

Location	PH	EC (mmoh/cm^{-1})	TDS mg/l	NO mg/l	K mg/l	Mg^{2+} mg/l	Ca^{2+} mg/l	Hardness $coco_3$ (mgle)	HCO_3 mg/l	NO_{3+} mg/l	SO mg/l
WHO	**6.5-8.5**	**-**	**500-1000**	**-**	**-**	**125**	**-**	**-**	**-**	**-**	**-**
Borehole (BH)	**7.3**	**2.6**	**1654.8**	**ND**	**ND**	**55.6**	**100.5**	**120**	**150**	**ND**	**ND**
Hand Dug Well (HDW)	**6.9**	**2.4**	**1538.5**	**89.7**	**37.2**	**44.5**	**73.2**	**183**	**198**	**50**	**11.2**

C. Heavy metals concentrations of the water samples.–

The water samples were analyzed for heavy metals concentrations which include: Iron (Fe), Zinc (Zn), Manganese (Mn), Chromium (Cr), Mercury (Hg), Copper (Cu) and Lead (Pb) as indicated in Table 4 & 5 which are characterized as undesirable metals for drinking water.

Iron (Fe) levels ranged from 0.43-0.68 mg/l with an average of 0.59 mg/l, it falls within the WHO standard limit. Extreme dissolved iron concentration agreed with [53]. The concentration of Zinc (Zn) in Borehole is 0.04mg/l, which is within the WHO limit while in Hand-dug well is 0.16, which is higher than the acceptable limit of WHO. This could be due to source point pollution. The presence of Zn in water that can lead to a change in the color of groundwater also harms human health. [5] Reported that the consumption of Zinc (zn) above WHO recommended value might lead to gastrointestinal disturbances such as pain, cramping, nausea, and vomiting and pancreatic toxicity. In all the water samples, analyzed lead (Pb) and mercury (Hg) were not detectible, so, therefore, the wastewater is lead and mercury-free.

Copper (Cu) values of 0.3mg/l borehole and o.14 Hand-dug well are both within the WHO standard limit. Cu is a key mineral in many different body systems. It is central to building strong tissues, maintaining blood volume and producing energy in cells. Yet for all its critical importance, it might be harmful to the body if the value exceeds the WHO standard limit. The presence of manganese (Mn) value of 0.03mg/l for borehole and 0.05nfor Hand-dug well are both within the WHO standards limit. Manganese Mn is among the essential element for good human health and metabolism and it should be available in drinking water. However, if more of that essential element is present in water above certain limits, the water may not be suitable for drinking and might even become hazardous to health. The concentration of chromium (Cr) was not detected in both water samples. This result agreed with [54-56].

Table 4: Heavy metals concentrations of groundwater (boreholes) samples and their comparison with WHO standard (mg/l) in the study area.

Table -3 Table 4: Heavy metals concentrations of groundwater (boreholes) samples and their comparison with WHO standard (mg/l) in the study area.

Sample	Fe	Zn	Pb	Cu	Mn	Cr	Hg
WHO	0.5-5.0	0.01	3	1	0.1	0.05	-
Borehole	0.43	0.04	ND	0.03	0.03	ND	-
Wells	0.55	0.16	ND	0.14	0.05	ND	-

IV. SUMMARY OF FINDINGS

The research revealed that presently point source pollution from refuse waste dump hurts the groundwater quality of the alluvial deposit of the unconfined aquifer.

Results obtained showed that the water is alkaline with values within the WHO acceptable limit. The heavy metals concentrations in both borehole and Hand-dug well were in water samples within WHO limits iron, and copper fall within the acceptable limit, and zinc (zn), is above the acceptable limit. Heavy metal concentration in all borehole water samples falls within the acceptable limits of WHO, which does not pose a health hazard.

Based on the result obtained the refuse waste dump should be monitored strictly by relevant agencies to prevent subsurface water pollution especially the hand-dug wells in the future.

V. CONCLUSION

The research revealed that presently point source pollution from waste dump does not pose a threat for domestic use of the subsurface water. The heavy metals concentration was low in the dimension of all the samples of boreholes, hand-dug wells, especially iron, and copper which fall within the acceptable limit. However, zinc is above the acceptable limit. Based on the results obtained the refuse waste dumps currently do not constitute a problem.

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RECOMMENDATION

It is recommended that the Adamawa State Ministry of Environment should put in place good waste management and disposal systems. It is also recommended that further evaluation of the subsurface water be carried for at least two (2) years or more. For the conclusive result to be obtained for the impact of a refuse waste dump on subsurface water quality of the shallow aquifer of the alluvial deposit of the Upper Benue

ACKNOWLEDGMENT

This work was carried out with the funds approved by the TETfund as an institutional-based research grant and this is gratefully acknowledged. My profound gratitude also goes to the Management of the Adamawa State Polytechnic for facilitating the release of the fund and for the support and encouragement given throughout the research period. I will also like to acknowledge my College and the Institution Research-Based committees for their time, patience and understanding. Finally, I appreciate my team members for their cooperation. The laboratory technicians and field assistants are not also left out, thank you