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Full Length Research Paper

Heavy metal concentration of groundwater deposits in odeda region, Ogun state, Nigeria

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Groundwater constitutes one of major source of water supply especially in most rural communities in Nigeria, in addition to rainwater and surface water bodies. For this reason, there has been a consistent demand for groundwater through the construction of borehole and hand dug wells. In spite of this experience, however, there has been an increased concern as to the safety of groundwater for human consumption, following reported cases of the occurrence of heavy metals and several bacteria in groundwater which by nature are injurious to human health. This paper in response to this, examined the occurrence of heavy metals in groundwater samples taken from thirty locations in Odeda in Abeokuta region of Ogun State. A total of sixty samples were obtained from boreholes and hand dugged wells drawn from some location in the town and taken to the laboratory for analysis. Heavy metals such as nickel, copper, zinc, lead, iron and arsenic were analyzed Instruments such as water spectrophotometer, turbidity meter, incubator, pH Meter, arsenic kits, were used for the analysis and detection of heavy metals. Result showed that there were heavy occurrences of zinc, lead, nickel in all the sample taking from hand dug wells. There were also traces of arsenic in most of the hand-dugged wells whereas there were no traces in the borehole samples. The levels of heavy metals found in the well samples were outside the limits specified by World Health Organization (WHO). The implications of the result for the management and use of groundwater in the study area were identified and discussed and recommendations preferred so as to how water obtain from hand dug wells and boreholes can be better treated for human use.

Keywords: Groundwater, Water Quality, Heavy Metals, Boreholes, Hand Dugged Wells.

INTRODUCTION

One of the most critical and indeed fundamental problem facing Nigeria as a developing country in the last four decades has been inadequate supply of potable and safe water. This situation has resulted in huge water scarcity and stress that has forced inhabitants to search for water suitable for human consumption Faniran1983.This search has led to the drawing of water from unwholesome sources that have resulted in the spread of water borne diseases and other related epidemics Areola and Akintola 1979.The search inspite of this experience has continued and a ready source identified is the groundwater that Nigerian is adequately blessed with one of the places where abundant groundwater exists in the country is Odeda, a town in Ogun State, Southwest Nigeria.

The occurrence of large deposits of groundwater has resulted in the emergence of several boreholes and wells which constitute avenue for withdrawing water. The sinking of boreholes and wells came up as an alternative to the dwindling supply of public water in most towns and

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cities in Nigeria. The preponderance of boreholes and shallow wells have brought about a compelling and crucial need to determine the quality and suitability of water derived from these sources as a step towards establishing whether they are fit for human consumption or not. This is essential granted the fact that ground water exists as a source of portable water owing to its perceived high quality. (Essiet et al., 2000; Abdel-Majid, 1997; Haydal et al., 2009; Oloruntoba et al., 2000; Sridhar, 2000; Itama et al., 2006; Manning, 2007; Fetter, 2007; NERC, 2007; Cech, 2005; Ajibade et al., 2006; Olayemi, 1999; Kakulu, 1985; Okoye, 1989; and Nkono et al., 2003).

It is crucial to determine whether water samples obtained from Odeda fits into this assertion. This will go a long way in instilling more assurances as to its quality and ability to meet human requirements. The need to undertake a study into the quality of groundwater sources is further amplified by the occurrence of materials and bacteria which is considered harmful and dangerous to human health. One of such are heavy metals. This study therefore sought to determine the occurrence of heavy metals like lead, zinc, nickel, iron, copper and arsenic in groundwater samples obtained from Odeda in Ogun State, southwest Nigeria. Through this, it was possible to establish the suitability or otherwise of water obtained through boreholes and shallow wells for human consumption. This is in response to the current situation where there is a shortfall in public water supply in relation to the increasing demand for water in most Nigerian towns and cities. The study investigated and determined the occurrence of heavy metals in selected samples of groundwater in Odeda, Abeokuta region of Ogun State and assessed their suitability for human consumption.

Study area

The study area is Odeda Local Government which is located on Lat 7^0 23^1 N and Longitude 3^0 41^1E. It is bounded to the North by Oyo State, to the West by Abeokuta North and Abeokuta South Local governments, to the east by Obafemi-Owode Local Government. Odeda Local Government is largely a rural area. It occupies an area of 1,658km^2 with an estimated population of 864,322 according to the 2006 Nigerian census. The economy of the town is base on agriculture, informal services and small scale (cottage) industries.

Odeda has a tropical climate with distinct dry and wet seasons characterized by the prevalence of the moist south westerly monsoon winds that results in heavy rainfall spread between March and October. It is founded on an extensive part of the Pre-Cambrian basement complex rocks which are largely igneous rocks noted for low porosity. Increased weathering has resulted in the creation of cracks and fissures in the rock formation thereby making it easy for rainwater to seep through, thereby increasing the amount of groundwater existing beneath.

This has led to the increase in the number of boreholes and shallow wells existing in Odeda region occasioned by persistent incidents of water scarcity. In the light of this experience it becomes imperative to initiate a study aimed at determining the occurrence of heavy metals in the groundwater in view of the fact that in recent times there has been a substantial increase in the level of exploitation of available groundwater. In addition, it has been widely established that some heavy metals are by their nature and constitution, injurious to human health and they have negative effects on the quality of water consumed by human beings.

Samples and sampling procedure

Groundwater samples were randomly collected from thirty locations within the Odeda Local Government area (Figure 1). The samples were collected from fifteen hand dugged wells and fifteen boreholes spread all over the community. The samples were kept in clean plain 1 litre keg. The two samples were taken from each location making sixty in all. Prior to that, the kegs had been sterilized. They were completely filled with water before they were corked to avoid trapping of air bubbles. The samples were stored in a cool dry place before the commencement of laboratory analysis. The samples were tested for the occurrence of heavy metals such as zinc, iron, lead, arsenic, copper and nickel.

METHODS

The metals investigated included zinc, nickel, lead, iron, copper and arsenic. The laboratory analysis involved the use of instruments such as, water spectrophotometer, arsenic kits turbidity meter, pH meter e.t.c and the addition of some test reagents to the collected water samples in order to obtain desired reaction which will indicate the amount of specific constituents that are present in the sample. Specially, heavy metals were analysed by determining the trace of metal concentration in each water sample using the Atomic Absorption

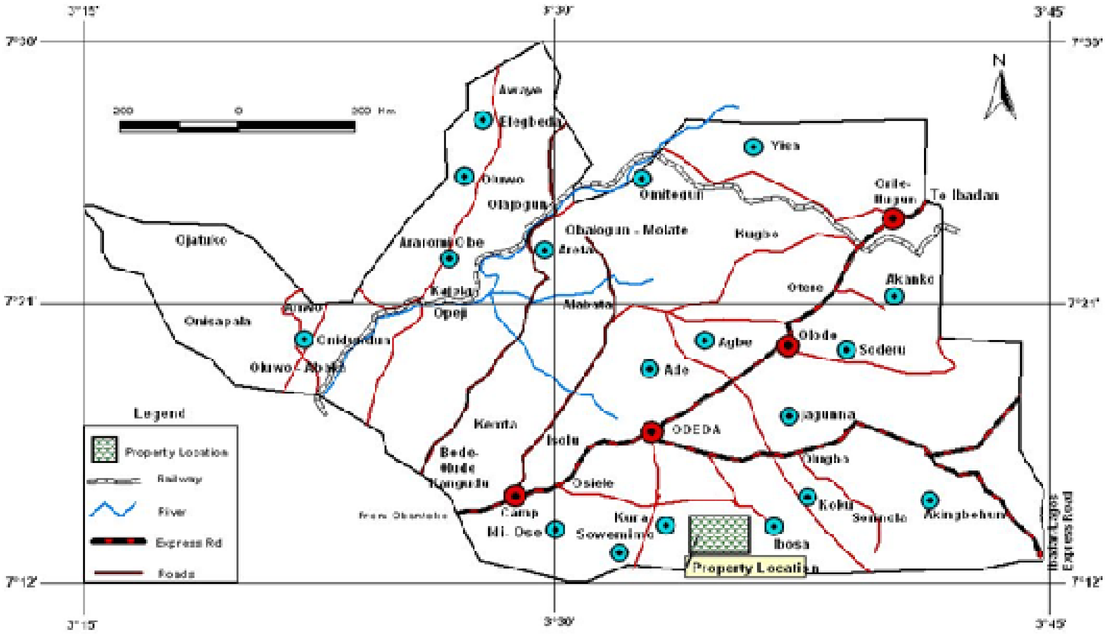

Figure 1: Map of Odeda Local Government Area of Ogun State showing Study Sites

Table 1a: Analysis of Heavy Metals in Water Samples from hand dug wells

No	Water Samples	Zn Mg/L	Pb Mg/L	Fe Mg/L	Cu Mg/L	Ni Mg/L	Ase Mg/L
1.	H*	1.51	0.04	0.91	0.21	0.59	ND*
2.	H	1.49	0.01	0.11	0.26	0.17	0.04
3.	H	1.61	0.01	0.20	0.11	0.79	0.05
4.	H	1.80	0.11	0.59	0.20	0.71	0.04
5.	H	1.79	0.11	0.55	0.16	0.17	0.05
6.	H	1.84	0.12	0.59	0.18	0.77	0.06
7.	H	1.67	0.10	0.31	0.19	0.86	0.07
8.	H	1.65	0.09	0.68	0.21	0.64	0.04
9.	H	1.89	0.14	0.54	0.23	0.54	0.22
10.	H	1.79	0.10	0.63	0.11	0.91	ND
11.	H	1.73	0.13	0.63	0.10	0.75	0.05
12.	H	1.74	0.11	0.67	0.08	0.60	0.01
13.	H	1.38	0.11	0.76	0.18	0.79	0.06
14.	H	1.97	0.14	0.98	0.23	0.99	0.02
15.	H	1.38	0.11	0.76	0.19	0.86	0.07

Key: H – Hand dugged well; B – Boreholes ; ND: Not Detected

Spectrometer.

RESULT AND DISCUSSION

The result of the analysis of the heavy metals in the water samples is presented in Table 1, wherein, six metals were investigated in the laboratory and the result for all the sampled boreholes and hand dugged wells are presented. The metals analysed include zinc, lead, iron, copper, nickel and arsenic. Viewed against the standards as prescribed by the World Health Organisation (WHO)

Table 1b: Analysis of Heavy Metals in Water Samples from Boreholes

No	Water Samples	Zn Mg/L	Pb Mg/L	Fe Mg/L	Cu Mg/L	Ni Mg/L	Ase Mg/L
1.	B	0.59	0.11	0.55	0.19	0.23	ND
2.	B*	0.79	0.14	0.24	0.01	0.25	0.03
3.	B	0.71	0.95	0.31	0.07	0.86	0.04
4.	B	0.99	0.60	0.71	0.23	0.59	0.02
5.	B	0.56	0.07	0.68	0.18	0.60	ND
6.	B	0.88	0.09	0.17	0.09	0.25	ND
7.	B	0.69	0.04	0.24	0.09	0.28	ND
8	B	0.69	0.04	0.24	0.09	0.23	ND
9.	B	1.60	0.10	0.66	0.24	0.70	0.03
10.	B	0.88	0.13	0.66	0.26	0.75	0.02
11.	B	0.81	0.14	0.54	0.26	0.30	0.01
12.	B	0.78	0.06	0.18	0.25	0.17	ND
13.	B	0.56	0.04	0.36	0.07	0.29	ND
14.	B	0.60	0.03	0.37	0.07	0.30	ND
15	B	1.73	0.13	0.63	0.26	0.75	0.05

Key: H – Hand dugged well; B – Boreholes ; ND: Not Detected

Table 2: WHO Standard for Heavy Metals

	Metal	Highest Desirable	Maximum Permissible
1.	Iron Mg/L	1.0	3.0
2.	Copper Mg/L	0.5	2.0
3.	Zinc Mg/L	1.0	3.0
4.	Lead Mg/L	0.4	0.4
5.	Nickel Mg/L	0.01	0.02
6.	Chromium Mg/L	0.05	0.05
7.	Cadmium Mg/L	0.003	0.03
8.	Arsenic Mg/L	0.01	0.01
9.	Barium Mg/L	0.05	0.05
10.	Mercury Mg/L	0.001	0.001
11.	Antimony Mg/L	0.01	0.02
12.	Tin μ/L	0.01	1.0
13.	Selenium Mg/L	0.01	0.01
14.	Manganese Mg/L	0.4	0.4

which is reflected in table 2,the results are quite revealing.

The result for zinc shows that the values obtained for the boreholes generally fall within the desirable limits set by WHO save for the last borehole that recorded a value of 1.73. This is rather a surprise given the fact that all other boreholes had values below the set standard of 1.0mg/L. A probable reason may be that the depth of the borehole may not be significant enough such that there is the risk of groundwater pollution unlike other ones. In fact, values for the boreholes ranged from 0.50mg/L to 0.88mg/L. The situation is however different as far as the hand dugged wells are concerned. The values of zinc ranged from 1.49mg/L to 1.97mg/L which is far above the desirable limit of 1.0mg/L but still within the maximum permissible limit of 3.0mg/L. The high values recorded for zinc may be attributed to the low depth of the wells, pollution due to persistent leaching along the top layers of the soil. The high occurrence of zinc in the sampled water implies that the water is not safe for human consumption particularly drinking and cooking. The water may however be suitable for other uses such as sanitation, irrigation etc.

In the case of lead the result obtained was quite satisfactory as the values obtained fell below the maximum desirable limit set by WHO.

Source: World Health Organisation (2007)

Indeed, the values ranged between 0.03 and 0.95 for the boreholes and 0.01 and 0.014 for the hand dug wells. By way of comparison, it appears some boreholes had higher values than hand-dugged wells. This is rather surprising. Specifically boreholes No 6 and No 9 respectively had higher concentration than most hand-dug wells which had lower values. A probable reason that may be attributed for this occurrence may be that the concerned boreholes might have been polluted either due to contact with heavy metals or due to low depth. Whichever way it is viewed, it should be noted that the values obtained with regards to lead were still within the desirable limit which makes the water suitable for human consumption especially drinking. The above experience is normal given the fact that lead has been established as one of the metals that is highly injurious to human health if taken in large amount. The values reported in this analysis are considered okay and appropriate, at least, within the ambit of the standards stipulated by the World Health Organisation. Furthermore, there is the confidence that water obtained from the various sources are not likely to inflict diseases on its consumers in any way.

With regard to iron, the values presented in the table shows that they are all within the highest desirable limits, that is, they all are less than 1.0mg/L. Specifically, the values range from 0.11mg/L to 0.98mg/L for hand-dugged wells while those of boreholes ranged between 0.17 and 0.71 Mg/L. Compared with each other, boreholes had less value than those of hand-dugged wells. The differences may be attributed to the nature of boreholes which are often deeper than those of hand-dugged wells and the vulnerability of hand-dugged wells to pollution as a result of its low depth.

Interestingly, the values for copper for the two water sources are all within the desirable limits set by the WHO. This is rather surprising given the fact that all previous minerals analysed so far never had this attribute. The reason of this may probably be due to the absence of metals containing copper traces and limited pollution. The implication of this is that the water may be considered suitable for human consumption.

Nickel was found to be present in most of the water samples analysed in the laboratory. Nickel was particularly prevalent in water samples obtained from hand-dugged wells as the values ranged between 0.17 and 0.99 while that of boreholes range from 0.17 to 0.86. The high occurrence of nickel in the water samples makes them unsuitable for drinking as most of values exceed the limit of 0.01 set by the WHO. A probably reason for the high occurrence may due to pollution owing to the exposure of groundwater to metal objects and materials.

Arsenic was found in some water samples obtained through hand-dugged wells, even though in low quantities. It was not detected in eight boreholes while it occurred in seven others ranging from 0.01 to 0.05. In the case of hand-dugged wells, it was not detected in two wells and existed in the remaining thirteen wells and ranged from 0.01 to 0.07.

In spite of this, however, the values are still within the maximum desirable limits set by the WHO which means that they are still suitable for human consumption. Arsenic is one of the metals known to be highly injurious to human health particularly if they exist in high proportion. However, in this case they are considered insignificant as they are within the limits set by WHO. However, there is the need for better treatment of the water obtained form these sources for them to be considered safe and portable.

DISCUSSION

The study found that there were occurrence of zinc, lead and nickel in the water samples presented of evaluation, especially those obtained from hand dugged wells. So also were traces of arsenic in some samples obtained from the wells.

The implication of this finding is indeed grave and fundamental given the fact that groundwater appears to be the major source from which water is obtained in the study area.By way of comparison, most of the wells especially 2,3,4,5,6,7,8,9,10,11,12 and 13 had higher concentration of zinc, copper, lead, nickel iron and arsenic. This can be directly attributed to either the nearness of the wells to refuse dumps, public toilet and land filled or the low depth of the wells. On the order hand all the boreholes (1-15) had low levels of heavy metals. However, there were traces of arsenic even though low in borehole 2,3,4,9,10,11 and 15 while the rest have no trace of arsenic. These founding appear similar to some other studies such as Abiola 2010, Fatoki et al 2002, Ibe et al 2005, Oluyemi et al 2010, Oyeku et al 2010 and Oyekunle et al 2012. The existence of these metals in the water samples used in the laboratory analysis portends serious danger to the health of the inhabitants in the study area.

Several studies have confirmed the great risk people are exposed to particularly where they consume the water without appropriate treatment Oyeku 2010 and Oluyemi, et al 2010. For this reason, it becomes essential that the issue of heavy metals in water consumed by the public ought to be given appropriate attention. In this regard, three other fundamental issues are associated with this and they relate to: the method used in constructing boreholes and wells, the need for proper treatment and storage methods and the issue of maintaining quality standards as a way of enhancing public health.

First is the method of constructing boreholes and wells. This might look trivial since wells and borehole have to be sunk if water is to be obtained for human consumption. However, it has been discovered that the way borehole and wells are constructed to a large extent often make the water obtained vulnerable to the infestation of micro-organisms, bacteria and heavy metals. For this reason, standards have since been established that borehole drillers and well diggers are expected to conform with if quality water is to be obtained and for them to last the test of time. Odeda being a rural area where skilled manpower and expertise is lacking, it is not surprising therefore to note the way and manner most wells and boreholes are sunk which does not only fall of established standard but make them vulnerable to infestation and contamination. Interestingly, there have been reported cases of the collapse of several wells and boreholes due to poor standards. Hence, standards must be maintained and sanctions imposed where there are proven cases of poor drilling and construction standards.

Secondly, there is a strong need to ensure that water obtained from hand dug wells are well treated in order for them to be considered safe for human consumption. Through this, the health of the consumers of water from these sources can be safeguarded and protected from certain infections. To this end, there is the need for agencies responsible for public health in rural areas to mount public enlightenment campaign on how to treat, store and preserve water obtained from boreholes and hand dugged wells.

Finally, standards must be upheld as to the rate at which boreholes and hand dugged wells are sunk in order to prevent indiscriminate withdrawal of existing groundwater and also enhance quality in the nature of wells and hand dugged well sunks. Groundwater is never an inexhaustible resource especially where there are no control as to the rate at which it is exploited which in itself constitute the danger of exhausting existing reserves. There must be control on the number of wells and boreholes that are sunked within a given locality. At the same time, mechanisms must be put in place to ensure that the existing ones are properly maintained so that they can yield potable and sufficient water for the consumers as when needed.

CONCLUSION

Over the years, groundwater has served as a potential source of water supply especially through springs, hand dug wells and boreholes. Due to their increasing popularity as a veritable source of water supply, it becomes necessary to access critically their quality and portability for human consumption.

The study investigated and assessed the quality of water samples obtained from some boreholes and hand dug wells in Odeda, Ogun State, Nigeria. The water samples were taken to the laboratory for physical-chemical analysis. Specifically, the study determined whether there were concentration of heavy metals such as lead, nickel, iron, zinc, copper and arsenic. Result showed that the quality of the properties or parameters tested for were within the acceptable and desirable limits set by the WHO and were considered fit for human consumption, although there were traces of arsenic in all the hand dug wells and some of the boreholes. However there were still within the maximum permissible limits set by the WHO

Given the fact that existing groundwater deposits in Odeda is abundant which has led to an increase in the number of boreholes and wells sunk in recent years yet, there is the need to exercise some restraint and control. This is so because it is necessary to ensure that indiscriminate withdrawal is not allowed and that the ones sunk are well maintained and few others that may be sunk later on follow laid down guidelines that will ensure their safety and suitability for human consumption.

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