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The Effect of Soak-Away on Subsurface Water Quality at Doubelli Ward, Yola North Local Government Area, Adamawa State, Nigeria

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Abstract— *The effect of soak-away on water quality of boreholes and hand dug wells in the study area at Doubeli Ward Yola North Local Government was assessed during the course of the study. The water quality of the boreholes and hand dug wells were evaluated bearing in mind the recommended water quality standard of World Health Organization (WHO) and the U.S salinity laboratory. Water samples totaling eight (8), was collected and analyzed using the standard method (U.S salinity laboratory, 1988). Results indicate that the water in the study area is contaminated. Total dissolved solids (TDS) value ranges from (120 -124mg/1) which is within the acceptable limit. Concentration of sulphates ($S0_4$) is minimal 21.39mg/l while nitrates ($N0_3$) 87.1mg/l) is very high in some of the sample water indicating that the water is highly polluted. The chlorides are moderate (N_a being 2.80mg/l and magnesium 41.7mg/l). while bicarbonate value is very high, maximum being 497mg/l. in order to minimize possible outbreak of water borne diseases, it is recommended that the people within the area should carry out local purification, existing soak-away be relocated, central soak-away be constructed by the government and awareness of the dangers of water pollution and associated diseases should be embarked upon by the local Government and Government agencies.*

Keywords— *Subsurface, Water, Quality and Soak-away.*

I. INTRODUCTION

1.1 Background of the Study

Currently it is estimated that 1.1 billion people in the world lack access to improved water supply (UNICEF. 2004). The global health burden associated with these conditions is staggering with an estimated 4000-5000 children dying each day from diseases related to lack of safe drinking water (WSSCC, 2004). The UN Millennium Development Goals (MDGS) aim to reduce by half the proportion of people without sustainable access to safe drinking water by the year 2015. Although some parts of the world are making encouraging progress in meeting these goals, serious disparities remain. In sub-sahara Africa for instance only 36% of the population has access to safe drinking water (UNICEF, 2004)

In Nigeria, population is increasing geometrically and greater demand is made on groundwater. Incidentally, the rate of urbanization is alarming with town and cities growing at rates between 10-15% per annum (Yusuf, 2007) and thus human activities such as indiscriminate refuse and waste disposal, and the use of soak-ways and pit latrines are on the increase. Ground water pollution has been attributed to the process of urbanization that was progressively developed overtime without any regard to environmental consequences which eventually result in the deterioration of the physical, chemical and biological properties of water (Isikwue et al., 2011).

Many researchers have earlier conducted research work on ground water quality in the surroundings of the study area. These literatures were reviewed for the purpose of this study. The disposal of untreated waste close to the water source has produced alarming hazardous effect on ground water quality (Malgwi, 2012). The effects of human activity on the quality of the ground water system are always not glaring. It is less recognized but its impact on the quality of ground water is enormous (Yenika et al., 2003).

The quality of ground water can be easily contaminated completely and can be assessed by studying its physiochemical properties as well as bacteriological characteristic, (Sangodoyin, 1987). For domestic water supply apart from quantity, quality is another aspect that must be considered (Malgwi, 1991 2020a, 2020b, 2020c). Common practices of locating boreholes and hand dug wells close to soak-aways in Jimeta-Yola necessitate the study. Due to the location of soak-aways being close to the water source most especially boreholes and hand dug wells in the area, ground water is likely to be contaminated. Most of the reports about the water quality of most shallow boreholes and hand dug wells in the study area points to the facts that, there might be contamination of the water source used as drinking water, (Ishaku, 2000 and Apagu 2019).

Quality of boreholes and hand dug wells in shallow aquifers has been believed to be greatly affected due to the proximity of soak-away, (Ishaku, 2000). Thus, in the study area the water quality of boreholes and hand dug wells were examined. The impairments of water quality could be due to water pollution through contaminants which affect boreholes and hand dug wells water quality especially from shallows aquifers. This has brought a lot of health problems, (Ishaku, 1995).

Water pollution could occur as results of human waste from sewage percolating in to the soil through movement of water where the formation is permeable. Health hazard will definitely arise due to the contamination of the shallow aquifer water due to bacteriological or concentration of impurities. This has been shown by research that it has adverse effects on

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the health of the consumers (Todd, 1998., Temitope, 2019., Siddha, 2020 and Rawal, 2018).

The study area falls within the category of shallow aquifer and there is likely hood of water quality problem which necessitate this research. The objective of the study among others were to evaluate the quality of ground water due pollution as a result of soak-away and to recommend possible measures, if the water is found to be contaminated as well as to give advice to Government appropriately. Doubeli Ward is situated in Yola North Local Government of Adamawa state.

1.2 Groundwater

Ground water is principally derived from the origin of the hydrologic cycle. Thus the atmospheric precipitation is the main source of fresh ground water. Specific areas of the earth crust with water bearing capacity acts as conduit for transmission of reservoir for storage of water. Virtually all ground water originates as surface water.

Ground water depending on the water table is mostly taped through boreholes and hand dug wells. The movement of ground water is usually subject to surrounding hydraulic conditions and properties of the aquifer. This is basically facilitated by the fact that most ground water bearing formation (Aquifer) is porous media. The flow of water through soil which is typified by ground water flow is usually laminar, (Ahmed, 2012 and Akindawa, 2019).

1.3. Ground Water Pollution

Previous research carried out by Malgwi (2012), Yenika (2003) and Ishaku (2000) on water quality in the basement complex revealed that, there is a degree of shallow aquifer contamination.

The relatively high concentration of pollutants indicators like $N0_3$, Cl, and SO_4 are some of the causes of poor water quality within the study area which was reported by Adekeye (2004) and could likely be caused by human waste through pit latrine and soakaway located close to hand dug wells and boreholes. These have ultimately affected quality of water and have negative consequences on the health of the populace.

The formation is permeable (alluvial deposit) to water in most of the locations and thus the movement of water through deep percolation into the aquifer becomes possible thereby contaminating the said aquifer, (Aihsatu, 2011).

1.4 Water Quality Criteria and Usage

The major cations (Ca^{2+}, Mg^{2+}, k^+ and Na^+) and anions (HCO_3^-, CO_3^{2-}, SO_4^{2-} and Cl^-) have considerable effects on water usability, Ishaku and Ezeigbo, (2000), Sangodoyin and Adelekan (1987; Godferey, 2019). The usability of water could also be considered in term of total dissolved solid (TDS) which serves as indication of salinity.

1.5 Domestic Water Quality Classification

Water quality classification based on results of analysis can be a handy tool for 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.

II. MATERIALS AND METHOD

2.1 Study Area

The study was conducted in Adamawa State, North Eastern Nigeria. It is located between latitudes 7^0 26^1 and10^0 56^1 N and longitude 11^0 30^1 and 13^0 45^1 E of the prime meridian with land area of 39.74 thousand square kilometers and a population of 3.17 million people (Adamawa State diary, 2015). The area under study is Doubeli Ward in Jimeta, Yola North Local Government Area of Adamawa State and is located along the Upper Benue river Basin trough. This area experience rainfall from the month of April to October and dry season starts from the month of October to April. August is the wettest month and April the driest month.

Temperature remains high in most part of the year. March/April has been the hottest months with a maximum temperature of 46^0c. The area is cold during the month of December and January with maximum temperature of 37^0c and 32^0c respectively. Relative humidity is high during the rainy season and low during the dry season. (Adamawa state diary, 2015)

2.2 Methodology

Preliminary survey of the study area (Reconnaissance survey) was carried out and Physical observation of the water sources (boreholes and hand dug wells) as well as their proximity to soakaways and subsequent sampling and analysis of water undertaken. Measurement of distances between soakaways, boreholes and hand dug wells was carried out by using fiber glass tape.

2.2.1 Delineation and location of boreholes and hand dug wells

In the course of the study, the first step was the reconnaissance survey of the study area, where observations of the important locations of boreholes and hand dug wells were made. In this survey the hand dugs wells and boreholes were identified and numbered accordingly for ease of work and their distances from the major contaminants suspected (soakaways) measured.

2.2.2 Water sampling

Samples of water were taken totaling up to eight (8) at the various locations for laboratory analysis. The faro water bottles plastic empty containers (75 cl) were used to sample both hand dug wells and boreholes.

In the case of boreholes, the boreholes was pumped and allowed to flow for about five (5) minutes for the borehole to be cleansed before water sample was collected. For hand dug wells the water in the well was stirred up by local water lifting mechanism (guka). The bottles were also cleansed with the well water and then filled up.

The samples were labeled and immediately transported to the laboratory of the Adamawa state water board for physiochemical and bacteriological analysis.

2.2.3 Water sampling analysis

Visual observation of the water samples were carried out in the field while taking the samples. Parameters observed

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were color, impurities and taste. The color of the water samples from boreholes and hand dug wells 1,2,3, & 4 were milky & 5,6,7 clear, table 3.1. Bacteriological analysis was also carried out using standard pour plate technique as recommended by national primary drinking water regulations (NPDWR, U.S.A, 2013), Nigeria Standard for drinking water quality (NSDWQ, 2006), and World Health Organization (WHO, 2011). To determine the presence of Escherichia coli (E-.Coli) or total coliform, the organisms are cultured for 5 days using nutrient agar, a general purpose agar for the culture of non-fastidious organisms and Mac Conkey agar which is selective medium for the isolation and differentiation of enteric organisms. The colonies were counted using plate count method as described in Amoda (1991).The samples were taken to laboratory for analysis of physiochemical properties. The analysis was carried out using the photometric method, digital titration, turbid metric and atomic absorption with the help of the laboratory technician.

Parameters such as temperature, conductivity, PH and total dissolved solid (TDS) were also determined in the Adamawa state water board laboratory. All the water samples were analyzed using the method in page, 2020 and standard methods. Parameters such as hardness, sulphate ($S0_4^{2-}$), Nitrates (No_3), chlorides (cl^-), calcium (Ca^{2+}) and magnesium (Mg^{2+}) were measured using digital titration, photometric and atomic absorption methods. Locations of boreholes and hand dug wells were well spread over the study areas. The result of the laboratory and field analysis was thus discussed fully under result discussion section.

Table 3.1 Water Sample Distribution

HW/BH NO.	LOCATION	WATER COLOR	IMPURITY	WATER TASTE	DEPTH	DISTANCE S/S (M)
HDW 1	Adjacent to Christ apostolic	Brownish color	High impurities	Salty	5m	3.7
BH 1	Opposite LCCN Cathedral	Yellowish color	Not seen	Tasteless	62m	9.7
BH 2	Adepegu	Colorless	Not seen	Tasteless	50m	6.9
HW2	Adepegu	Colorless	Not seen	Tasteless	15m	14.5
HDW 3	Bore street	Colorless	Not seen	Good taste	17m	5.8
BH 3	Hotel de-pride	Colorless	Not seen	Tasteless	60m	8.1
HDW 4	Ilorin street	Greenish color	High impurities	Salty taste	12m	7.8
BH 4	Porthacourt street	Colorless	Not seen	Salty Taste	64m	7.2

The average distance of borehole and soak-away were HDW 1, 3.7m, BH 1, 9.7m, HDW2, 14.5m, BH2, 6.9m, HDW 3, 5.8m, BH3, 8.1m HDW4, 7.8m, and BH4, 7.2m. Table 3.1 shows that most of the boreholes and hand dug wells in the study area were closely located to soak-aways. The depth of the borehole ranges from 50-64m which is reasonably deep enough for filtration of the ground water. Hand dug wells on the other hand are very shallow in depth ranging from 5-17m. There could be possibility of drinking water contaminations from the hand dug wells.

III. Result and Discussion

3.1 Physical Parameter of Sample

Based on the field observation made, the physical parameters of the water samples as outline in table 3.1 indicates that water samples from HW1, BH1, HW3 and HW4 were brownish, yellowish and greenish in color while HDW 1, 2, 3, 4 and BH 4 were all salty, indication of dissolves salts which could likely be as the result of pollution due to human waste since most of the boreholes and hands dug wells were located close to soakaways.

Some of the water samples are not good for domestic purpose base on the field observations and laboratory analysis, Tables 3.1 and 4.1. They contain impurities and have peculiar odors this could be due to contamination.

3.2 Geology and Ground Water Resources of the Area

The geology of the study area falls within the basement complex and sedimentary formation. However, due to the fact the Demsawo and Jambutu ward are located close to the River Benue. The formation of the study area could also be of an alluvial deposit which is typical of river banks and base flow after deep percolation are likely to occur, hence contamination of the groundwater particularly the hand dug wells which cannot be ruled out

Most of the boreholes are moderately deep but boreholes number one (BH 1) is an exception having yellowish color but tasteless. This could likely be as a result of base flow due to the alluvial deposit (aquifer).

3.3 Water Quality for Domestic use

The eight (8) water samples collected from hand dug well and boreholes analyzed at Adamawa State Water Board laboratory for physiochemical properties indicates that there is variation in the chemical characteristic of the water. Table 4.1

Table 4.2 is the standard water quality recommended by World Health Organization and European Standard for drinking water quality as well as the international standard of drinking water quality.

Parameter criteria of analyzed water samples were compared for desired quality of portable water by World Health Organization (WHO) Standard as indicated in table 4.2.

The bacteriological water quality for domestic water quality all falls within the NPDWR, NSDWQ and the WHO standards limits.

The extent of water pollution caused by the elements found present in the water sample under the study area was also measured by their value of Biochemical Oxygen Demand (BOD).The requirement given by the world health organization on the water quality, states that the municipal water quality for domestic uses must be colorless, odorless and tasteless. It should also be far from any form of contamination or toxic chemical compounds, (Grek S.K, (2008)

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Table 4.1: - Physiochemical Analysis of Water Samples

Sample No	Temp (T^0C)	Conductivity	PH	TDS Mg/L	K^+ Mg/L	Mg^+ Mg/L	Fe^{2+} Mg/L	CL- Mg/L	SO_1^{2-} Mg/L	Ca^{2+} Mg/L	Total Hardness	CO_3^{2-} Mg/L	$HCO3^{2-}$ Mg/L	$CACO_3$ Mg/L	M_n- Mg/L	Na^+ Mg/L	No_3^{2-} Mg/L
HDW 1	30^0	143	4.6	120	6.81	41.7	0.091	44.0	23.67	30.71	67	2.08	418	9	0.041	0.011	96.6
BH 1	28.01	162	5.8	124	6.41	28.11	0.08	40.0	21.6	26.6	51.4	4.00	409	18	0.001	0.16	71.67
HDW 2	29.21	90	4.2	111.7	5.6	29.10	0.096	39.0	17.8	32.7	69.8	2.00	487	21	0.08	2.10	41.6
BH 2	27.0	181	6.8	112.3	3.0	19.66	0.003	29.9	31.71	31.0	49.3	2.11	411	14	0.007	1.07	45.63
HDW 3	30.04	101	4.0	60.8	4.9	20.0	0.041	38.40	31.08	28.8	78.1	2.00	481	17	0.006	0.81	68.8
BH 3	28.61	1717	7.1	79.0	4.11	26.0	0.001	46.1	29.7	31.81	29.0	0.00	306	4	0.002	0.19	99.1
HDW 4	26.44	134	5.2	131.4	5.14	32.0	0.07	53.0	20.0	32.0	51.2	0.20	400	11	0.09	1.19	90.3
BH 4	29.42	212	5.7	124	7.1	30	0.04	56.0	19.1	30.4	50.3	2.01	421	8	0.001	0.21	77.6

Table 4.2:- World Health Organization drinking water quality standards.

Parameter	Unit	Values
Aluminum	Mg/l	0.2
Ammonia	Mg/l	1.5
Chloride	Mg/l	250
Chlorobenzen	-	-
Color	Tcu	15
Copper	Mg/l	1.0
Detergent	-	-
Hardness	Mg/l	500
Hydrogen Sulphite	-	-
Iron	Mg/l	0.3
Manganese	Mg/l	0.1
Oxygen – dissolved	-	-
PH	-	-
Total dissolved solid	Mg/l	1000
Sulphate	Mg/l	250
Taste	-	-
Temperature	-	-
Zinc	Mg/l	3.0
Sodium	Mg/l	200
Nitrate	$N0_3$	0.02
Magnesium	Mg	50

Source: WHO Geneva 2003/2004

These samples under discussion were found to be contaminated with high level of impurities and are almost acidic (average PH 6.5) and PH value ranging from 4.0 to 7.1, thus making some of the sources of water unfit for domestic consumption. Table 4.1.

The following anions, cations and (HCO_3^{2-}, Ca^{2+} SO_4^{2-}, Mg^+, fe^{2+}, NO_3^{2-}) present in the water samples indicates that the water quality is poor. High concentration of (NO_3^{2-}) in almost all the water sample, table 4.1 could cause gastro-entraries and typhoid fever as well as yellow fever, verbal discussion with Dr. Solomon Maurice of Adamawa State Specialist Hospital.

IV. Summary And Conclusion

4.1 Summary

The study conducted between Septembers to Decembers 2012 evaluated the subsurface water quality of some selected boreholes and hand dug wells in study areas in Yola north Local Government Area of Adamawa state in relation to water quality for domestic purposes.

Sampling and analyses using standard techniques were employed in sampling/analysis. The ground water discharge of the boreholes in the study area was found to be sufficient enough but of poor quality for consumption because of the presence of contaminants.

The physiochemical analysis carried out in Adamawa state water board laboratory, indicates that the water in selected boreholes/hand dug wells were affected by $NaHCO_3$ and Mg (HCO_3), $CaCO_3$. Also from the result it reveals that the water ranges from acidic to partially neutral in PH which makes the water naturally below the acceptable standard limit for drinking water quality. The result also indicates high level of nitrates which area above the acceptable standard limit of WHO standards.

4.2 Conclusion

The study unveils through the evaluation that the water in the selected boreholes and hand dug wells are unfit for human consumption due to contamination and pollution caused by soak-aways/ pit latrines.

The study has been able to establish that the quality of water from the aquifer underlying the study area Doubeli Ward of Yola North Local Government Area is strongly affected through:

i) Increase in population – the increase in population of the area has resulted in high demand of water.
ii) Increase in construction of pit latrine and soak-aways as well as hand dug wells.

Most of the hand dug wells are contaminated as a result of their proximity to the soak-aways and most boreholes were used by commercial water vendor as a result there could be the possibility of spread or outbreak of water borne diseases due to contamination. Hang dug wells were also not adequately spaced due to their location and proximity to soak-away and sewage disposal system (untreated sewages). Sewage disposals were any how in the drain system not considering the effects on domestic water consumption. In conclusion the poor water quality from the study area can be attributed to the proximity of soaka-ways/pit latrines as well as improper waste disposal.

4.3 Recommendations

The water quality of the shallow aquifer system could however be improved for sustainable supply of portable water to the population through the following recommendations.

i. The water from already polluted sources should be subjected to local treatment prior to use by boiling and using zero tablets as an interim measure.
ii. Setting of new boreholes should be done within a minimum of 30m from soakaways, or stagnant drain (gutter) and existing one be relocated far away from boreholes and hand dug wells.

iii. Pit latrine should be constructed far away from boreholes and hand dug wells lined up with cement.
iv. Government should assist the people by supplying adequate treated water from the water treatment plants and also create awareness as well as introducing simple water treatment methods like filtration, boiling and the use of water guard chemicals for local water purification for the people of the area.
v. Government should pay serious attention on borehole drillers and make sure they comply with borehole drilling procedures/standards as well as testing borehole water samples in line with World Health Organization (WHO) standards.
vi. Awareness campaign should be made by government in respect of the dangers associated with water borne diseases due to contaminated water.

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