



## Impact of Pit-Latrines on the Physicochemical Quality of Ground Water in Shinko and Doubeli Wards, Yola North LGA, Adamawa State, Nigeria

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### ABSTRACT

Diffusion of chemical and microbial contaminants from pit latrines to groundwater is believed to affect human health negatively. In this study, the effect of pit latrines on ground water quality and their physicochemical properties in was assessed. Non probability sampling was employed in selecting twenty households with well or borehole for water sample collection. Lateral distance between water sources and the nearest latrine in a household were determined. Ten water samples were collected from ten different sources, 5 each from wells and boreholes in the Doubeli and Shinko wards, Yola North Local Government Area, Adamawa State, Nigeria. Distance of dug-out wells to pit latrines were used to compare the physicochemical parameters of water samples from the study area. Other parameters studied include pH and Turbidity between wet and dry seasons, respectively. Results obtained shows that most water sources are closer to pit latrines. The mean pH (6.3) obtained is within the standard range of pH 7.2. While overall mean conductivity (512.1) of ground water in both locations and across seasons was far beyond the recommended (7.8) for standard conductivity, the mean Total Dissolved Solids (256.2) of ground water in both locations and across both season is still above the standard (3.6.1). These variation from the standard may be due to the relatively close distance of water sources (Wells and boreholes) to pit latrines, hence the reason for contamination observed.

**Keywords:** Pit-latrines, Physicochemical, Ground water, Turbidity, Quality, Wells, Boreholes.

### INTRODUCTION

Pit latrine is one of the most common human excreta disposal systems in low-income countries. Being the simplest, cheapest and the most efficient excreta disposal system, pit latrines are freely available and within the reach of poor people (Ayanlaja *et al.*, 2005). There is concern, however, that discharges of chemical and microbial contaminants from pit latrines to groundwater can negatively affect human health. In line with World Health Organisation (WHO), portable drinking water is fit for human consumption and can be used for various domestic purposes without any risk of acquiring water borne disease (WHO, 2011). The provision of good quality water is central to any meaningful human development. In many communities and settlements, shallow wells are commonly constructed close to pit latrines (Ahaneku and Adeoye, 2014). It is on this premise that developed nations are continually monitoring and classifying water in relation to quality. According to Mkandawire (2008), Millions of people in unplanned environments such as slums in developing countries do not have access to adequate and safe drinking water. Pit latrines is an on-plot sanitation systems that dispose off human excreta without treatment. Pollution of groundwater especially those of shallow wells sited within the plot are used as source of drinking water are a major public health challenge (Ahaneku and Adeoye, 2014). According to Hailer *et al.* (2009), increased lateral separation between the source of pollution and groundwater supply reduces risk of faecal

contamination. In this study, the effect of pit latrine on ground water quality during wet season and the dry seasons, respectively, was assessed in two wards (Shinko and Doubeli) of Yola North Local Government Area, Adamawa State. Parameters assessed include physicochemical parameters of water samples from dug wells, pH and Turbidity in relation to distances from pit latrines.

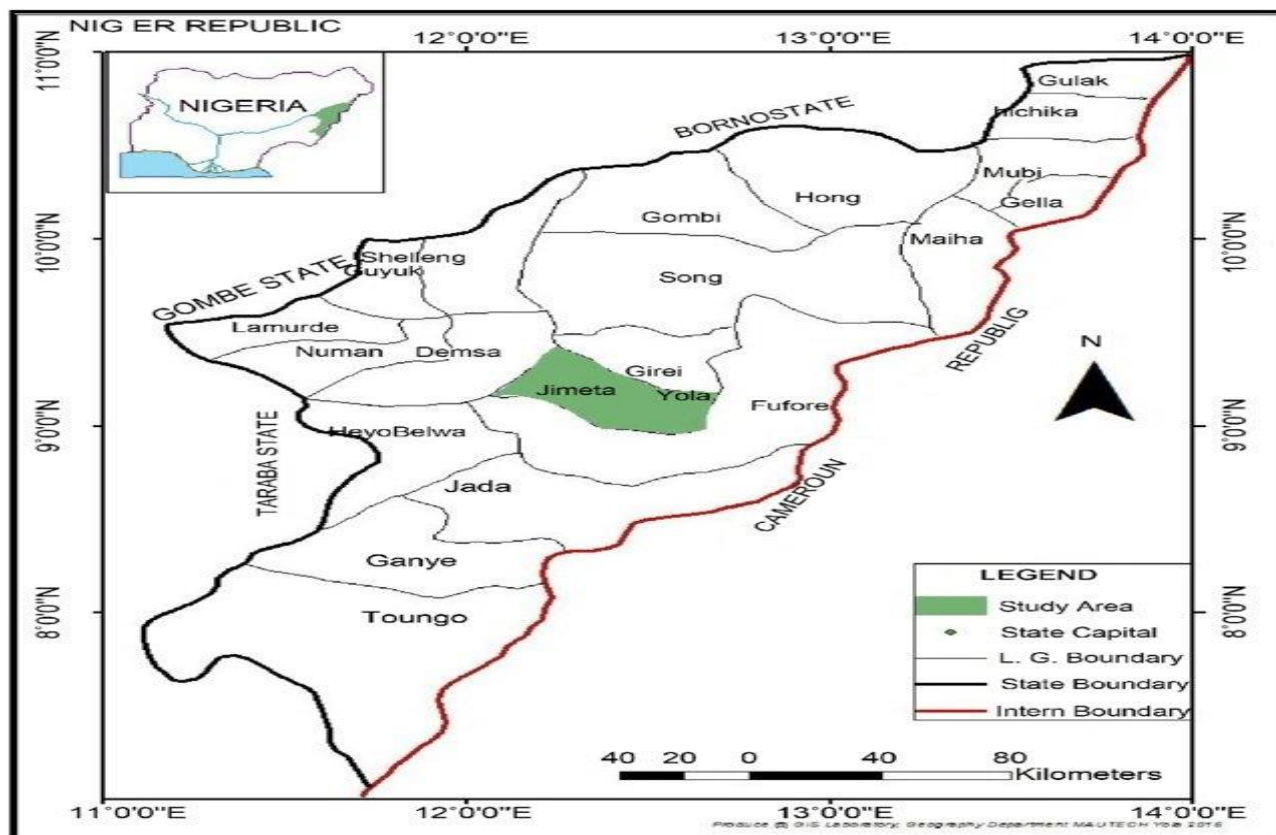
### MATERIALS AND METHODS

#### Study Area

The study was conducted in Doubeli and Shinko wards, Yola North Local Government Area, Adamawa State, Nigeria. Adamawa state is located in North-East Nigeria, and lies between 8°N and 11°N latitude and longitude 11.50°E and 13.50°E (Adebayo, 1999). As per National Population Commission (NPC), Adamawa state has a population of 3,106,585 people and total land area of 39,742.12sqkm (NPC, 2006).

#### Study Site

Jimeta is the administrative headquarters of Yola North Local Government Area (LGA) in Adamawa Central Senatorial District. Yola North LGA is the smallest LGA by landmass in Adamawa State, and has an area of 113km<sup>2</sup>. The LGA is bounded to Girei LGA in the north, east, and south and Yola South Local Government Areas (LGA) to the west Figure 1.



**Fig. 1:** Map of Adamawa State Showing Jimeta, the Headquarters of Yola North LGA

#### Sample Collection

Non probability sampling as described (Akpoveta *et al.*, 2011) was employed in selecting twenty households with well or borehole for the sample collections. The number were selected based on the approximation that it forms about fifty percent (50%) of the wells and boreholes in the study areas. Lateral distance between water sources and the nearest household latrine were determined as per WHO (1985). Ten water samples were collected using a 500ml plastic bottles, 5 each from wells and boreholes in different sources.

#### Laboratory Analysis

Samples collected were transported to the laboratory for analysis.

**Temperature:** Temperature measurement was carried out in-situ at the site of sample collection using a mobile thermometer (wet thermometer). The thermometer was dipped into the sample and stable reading was record (WHO, 2011).

**pH:** This was determined using pH meter. Briefly, the pH meter was dipped into the water samples and readings obtained was recorded as for temperature.

**Turbidity:** Turbidity of water samples were determined using 200p turbid meter. Twenty-five (25ml) each of water samples was measured and transferred into the cell in the Turbidimeter. The cell was then fixed into the Turbidimeter and covered, button pressed and allowed to stabilize,

following which, the values obtained were recorded in Nephelometric turbidity units (NTU).

**Dissolve oxygen (DO):** The amount of DO in water samples were determined using multi photometer DO analyser.

#### RESULT AND DISCUSSION

Table 1 shows that the average distances between the water sources and pit latrine are; 7.26m and 13.5m for well and borehole in Doubeli and 5.34m and 7.7m for well and borehole in Shinko respectively.

As per the recommendation of WHO (2011), the distance between water sources and pit latrines should not be less than 30 meters. Similar studies also recommended 30m as the minimum standard for the lateral distance between on-site sanitation systems and water sources. A very low travel distance between pit latrines and dug wells or boreholes obtained in this study (table 1) is far below the WHO recommended 30 m distance (WHO, 2011). This finding is in agreement with a study conducted in South Africa (Still and Nash, 2015), which also revealed a relatively short distance between water sources and pit latrines. This may not be unconnected to the high fecal coliform counts detected in their study. Verheyen *et al.* (2012) suggested that wells are likely to be contaminated if pit latrines are < 12 m away. With the exception of fissured rock, it was concluded that the safe distance between a pit latrine and water source is 10m (Banerjee, 2011).

**Table 1:** Distances of Water Sources in Relation to Pit Latrine

Water Samples	Doubeli mean Distance and Co-ordinates			Shinko mean Distance and Co-ordinates		
	Distance (M)	Longitude	Latitude	Distance (M)	Longitude	Latitude
W1	3.8	9°17'0"N	12°27'30"E	4	9°17'9"N	12°26'57"E
W2	15	9°17'1"N	12°27'30"E	5	9°17'17"N	12°26'57"E
W3	4.5	9°16'58"N	12°27'27"E	6	9°17'11"N	12°26'56"E
W4	4	9°16'58"N	12°27'38"E	6.5	9°17'8"N	12°26'51"E
W5	9	9°17'0"N	12°27'39"E	5.2	9°17'5"N	12°27'4"E
<b>Mean</b>	<b>7.26</b>			<b>5.34</b>		
<b>WHO</b>						
<b>(Standard)2011</b>	<b>30</b>			<b>30</b>		
B1	10	9°17'2"N	12°27'34"E	4	9°17'7"N	12°27'1"E
B2	9.6	9°17'4"N	12°27'35"E	8.5	9°17'7"N	12°26'56"E
B3	8.8	9°17'4"N	12°27'36"E	7.1	9°17'10"N	12°26'57"E
B4	20	9°17'3"N	12°27'37"E	10	9°17'6"N	12°26'55"E
B5	19.1	9°17'11"N	12°27'37"E	8.9	9°16'56"N	12°27'1"E
<b>Mean</b>	<b>13.5</b>			<b>7.7</b>		
<b>WHO</b>						
<b>(Standard)2011</b>	<b>30</b>			<b>30</b>		

Source: Field Survey 2019

Countries and development agencies often have siting standards for latrine construction. In Haiti, for example, latrines must be sited at least 30 m from any source of surface or drinking water, and the bottom of the pit must be at least 1.5 m above the maximum height of the water table (Reed, 2010). Environmental factors also play a role in governing groundwater pollution from latrines. Pujari *et al.* (2012) compared the impacts of on-site sanitation in two Indian megacities and concluded that hydrogeological conditions were strong predictors of the threat of nitrate contamination of well water. An area with shallow groundwater was reported to be more susceptible to pollution from latrines than areas with deeper water table. Although this value could be adjusted based on the nature of subsurface features, this means the location of the water sources are either wrong or poorly defined. The reason behind this variation might as well be traced from the obvious poor environmental management and ignorance of the basic technics for constructions and maintenance of water sources such as the well and borehole. It was also observed that, boreholes were situated in distances that doubles that of the well, which further explain the ignorance

Temperature recorded for the study areas showed variations between the dry and wet seasons. The mean increase or difference in temperature between the water sample and the standard (control) temperature might be due to the depth of the ground water, season and time of collection. Increase in the Global temperature might also be one of the possible reason for the increase. The impurities or contaminants might also alter the water temperature. Another possible reason for this high temperature of ground water in the study area is that; Adamawa has a hot environment which might in turn affect the temperature of the ground water in either way. The difference recorded between the control and the samples (dug wells and boreholes) may be associated with the depth

of the basic technics for constructions, since boreholes unlike wells were constructed by companies who are expected to exercise some bits of professionalism (From field observation).

Overall mean temperature, pH, conductivity, Total Dissolved Solid (TDS), Dissolved oxygen (DO) and Turbidity of the ground water in both locations and across seasons are presented in Table 2. While the mean temperature from the respective water sources ranges from 30°C to 33.6°C, it is clearly evident that this finding is quite above the recommended 28°C for the control (Faro water), except water samples obtained from wells in Shinko ward (27.2°C) which is below the recommended temperature. The mean pH (6.3) obtained falls within the standard range of pH 7.2. The overall mean conductivity (512.1) of ground water in both locations and across seasons was far beyond the recommended 7.8 for standard conductivity. Similarly, the mean TDS (256.2) of ground water in both locations and across both season is still above the standard (3.6.1). The result of other parameters studied are as presented in Table 2.

of the wells, exposure to the sun, as well as the climate. This corroborate with the finding of Parmar (2012), who revealed that various chemical and biological processes depend on temperature and this may likely to affect water quality. Temperature however does not have immediate health effect to humans.

The study revealed that levels of pH were below the control limits. The mean values obtained by Fasunwon *et al.* (2008) and Nkansah *et al.* (2010) in similar studies are comparable to 6.3 obtained. No much difference was observed in the pH values among the various wells. The observed pH values however contradict the results obtained in a similar studies of water samples from some boreholes near a landfill in

Akure, Nigeria (Akinbile *et al.*, 2011). This is probably because of the relative concentration of various contaminant that might decrease total number of hydrogen ion in the ground water. Some of these contaminants were presented in table 3.. The slight increase in the acidity of the well water during the dry season may probably be linked to the average increase in temperature beyond the recommend standard for ground water. Furthermore, the pH obtained in this study is below the WHO recommended limits of 6.5-8.5 for wells

and boreholes. This low pH of water below recommended levels was shown to be capable of causing corrosion and scaling, Hence resulting in significant health problems (WHO, 2004). Our finding contradicts those of Agbaire and Oyibo (2009) who reported in a study of seasonal borehole water quality in Abraka, Nigeria, that borehole water are alkaline in the wet season (pH 6.2 to 8.00) and acidic in the dry season (pH 6.3 to 7.1).

**Table 2:** Physico-Chemical Properties of Water Samples in the Study Area

Physicochemical properties	Doubeli WS		Doubeli DS		Shinko WS		Shinko DS		Mean	Control
	W	B	W	B	W	B	W	B		
Temperature	30.16	32.18	30	32.6	31.18	32.64	27.2	33.6	<b>31.1</b>	<b>28</b>
pH	6.372	5.536	7.0	6.4	6.296	5.504	7.1	6.464	<b>6.3</b>	<b>7.2</b>
Conductivity	764.2	668.4	323.4	172.42	1108.6	650.8	219.0	190.76	<b>512.2</b>	<b>7.8</b>
TDS mg/l	382.2	334.2	161.9	86.21	554.3	325.4	109.9	95.38	<b>256.2</b>	<b>3.6</b>
D.O mg/l	69.2	81.6	10.8	11.97	40.6	108.4	10.3	11.378	<b>43.0</b>	<b>16.6</b>
Turbidity NTU	0.838	0.2	0.65	0.134	0.89	0.558	0.8	0.606	<b>0.58</b>	<b>0</b>

Field Survey 2019

WS – Wet season; DS – Dry season; W – Well; B – Borehole

There were differences in terms of turbidity levels in the study area. This result is in consonance with a study (Meena *et al.*, 2012) where mean values recorded for turbidity differed with seasons with the monsoon period recording the highest. The difference observed may be attributed to the raining season and the washing of solutes into wells. In a related study, Hassan (2003), observed that associated lower values of turbidity obtained in some dug wells during April-May period (dry season) to the lack of side erosion within the wells possibly as a result of greater cohesion and vice versa especially in August during the raining season. Water become turbid when substances like silt, clay, colloids and organic matter are present (Bodoczi, 2010). The general mean for the turbidity of all the water samples collected from both locations and across all the seasons and sources is 0.58mg/l which was against the recommended 0mg/l, with exception of the samples collected from borehole in Doubeli ward during the wet season, which is 0.2mg/l. Another possible reason for the slight increase in turbidity is location of the water sources to pit latrine and other water bodies (river line as in the case of Doubeli) which may add up to the total turbidity of the water sources around.

The higher values recorded (256.2) for total dissolved solids was as a result of the higher turbidity with the exception of borehole 5 in the dry season and this is confirmed by the results of Anhwange *et al.* (2012). Similar results were attained in a study of boreholes by Agbaire and Oyibo (2009) who showed that TDS concentrations varied from Ugep area (44.47mg/L) and Anantigha area (157.59 mg/L) in Nigeria. They also studied variations in Abraka Ethiopia, which showed that TDS values were higher in the wet season (0.39 to 7.11mg/L) compared to the dry season (0.00 to 2.11mg/L), and attributed this to different forms of leachate during the rainy season. According to Edet and Worden (2009), the high concentrations in TDS can be attributed to seawater influence, changing seasons and tidal periods. WHO guideline (2011) values for TDS is 300 mg/l and all

values obtained in this study (256.2) were below this permissible level hence clean for human consumption. The differences in the levels of contamination were because of their distance to the nearest latrine and rainfall amount (Kiptum *et al.*, 2012). The concentration and composition of TDS in natural water is determined by geology, drainage, atmospheric precipitation and the water balance (Sakya and Asare, 2012). Values recorded for total dissolved solids were different between the various seasons. This was also observed between the samples (boreholes and wells) and the controls. Values recorded during the raining season were higher than those of dry season which may be due to some form of leachate from the ground (Agbaire and Oyibo, 2009). In contrast to this study, results of borehole water quality in Kotputli town, India showed that during dry season, concentrations of solids were higher in dry than rainy season (Rajana, 2010). According to Chapman (1996), a higher TDS concentration during the dry season only happens in shallow groundwater affected by evapotranspiration which increases the proportions of the TDS.

The conductivity values (512.2) in all the locations on both seasons exceeds the maximum level of the control and the permissible limit of 1000  $\mu\text{s}/\text{cm}$  recommended by World Health Organization (WHO, 2011). The groundwater in the area might be contaminated due to the infiltration of leachate from the nearby latrine and soak ways. It is undoubtedly clear that the high conductivity was brought about by the large presence of ions such as zinc, copper and so on, in the sampled ground water, which is beyond the recommended amount for a clean ground water. The possible reason for this high concentration of ions might be presence of various contaminants that changes the physical and the chemical properties of water. The higher turbidity and relatively large proportion of contaminant plus the failure of the relevant authorities to address some environmental challenges which in either way affect the properties of the ground water might

be the underpinning forces behind the high amount of the TDS.

A significant difference (0.0004) in pH and Turbidity was observed between the dry and the wet seasons in the study area (Table 3).

**Table 3:** Comparison of pH and Turbidity between the wet and dry season

Parameters	Source of Variation	SS	Df	MS	F	P-value
Ph	Between Season	6.642	1	6.6422	21.565	4.01E-05
	Within Season	11.704	38	0.308		
	Total	18.346	39			
	Between Season	0.052	1	0.051	0.429	0.517
	Within Season	4.592	38	0.121		
	Turbidity	Total	4.644	39		

Field Survey 2019

The slight variation of pH across seasons may not be unconnected to the total number of hydrogen ion in rain water. However, the level of contaminants in both sources may be attributed to hydrogen ions which will in turn alter (increase or decrease) the pH. Turbidity varies greatly across seasons and the water sources. These was due to the presences of some particles like the contaminant which differs with locations, seasons and sources. For example, during the raining season the turbidity in Doubeli was 0.838mg/l and 0.202mg/l for well and borehole sample respectively, while in the dry season it was 0.134mg/l and 0.89m/l for well and borehole sample respectively, and in Shinko wet season 0.558mg/l and 0.558mg/l for well and borehole sample respectively, while the dry season recorded 0.81mg/l and 0.606mg/l for well and borehole sample.

### CONCLUSION

In conclusion, shallow wells were polluted by pit latrine. Though some of the physiochemical properties analyzed fell within the control (faro) and WHO permissible limit for potable water standards.

### RECOMMENDATION

Based on the findings of this study, the following recommendations are drawn

- i. There is the need of awareness campaigns in the area to get residents abreast with the dangers of human activities on water quality as well as effects of poor water quality on their health.
- ii. Residents and authorities concerned are encouraged to do regular water testing to be up to date with the quality of their wells.
- iii. Environmental health workers are encouraged to assist in carrying out efficient surveillance on the various water sources on regular basis to enhance the detection of any lapses on wells and immediately give suggestions on how to solve the problem to avoid an outbreak of waterborne disease.
- iv. Wells should be constructed mechanically and adequately lined with concrete to prevent seeping of various chemicals into the wells, which could alter the microbial composition of the wells.

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