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Research Article

Impact of Pit Latrine on groundwater quality in some communities of Nguru town, Nguru Local Government area, Yobe State, Nigeria

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Abstract: Water is one of the basic necessities for sustenance of life, and its impact nearly in all areas of life. Diseases related to contamination of drinking water constitute a major burden on human health. In resource-poor and low-population-density areas, on-site sanitation is preferred to off-site sanitation and groundwater is the main source of water for domestic uses. Given the widespread use of groundwater for domestic purposes in rural areas, maintaining groundwater quality is a critical livelihood intervention. This study assessed impacts of pit latrines on groundwater quality in Nguru town, Local Government Area of Yobe State. Water Samples from boreholes, hand pumps and wells were collected from Hausari, Bulabulin, Tsohon Nguru, Sabon gari, and Garbi communities of Nguru town of Yobe State. Parameters analysed were total and faecal coliforms. The number of Total faecal coliforms as well as *E. coli* of all the samples exceeded the recommended value of 0 CFU/100 ml by WHO guidelines for a good quality for drinking water. Results indicated that significant association existed between distances from water source to the nearest pit latrine and the bacteriological loads in the water samples.

Keywords: Pit Latrine, Groundwater.

INTRODUCTION

Water is one of the basic necessities for sustenance of life, and its impact nearly in all areas of life. In many parts of the world particularly Nigeria, Groundwater is a preferred source for water supply, irrigation and industrial purposes (Wadie & Abduljalil, 2010). Due to its proximity to the surface, groundwater obtained from springs and wells continues to be attractive as a source of water supply to most rural dwellers (Wadie & Abduljalil, 2010). With increasing population, there is an increasing demand for more water (Majuru *et al.*, 2011). This in turn results in increased abstraction and hence, a strain on groundwater resources. Rapid urbanization, especially in developing countries like Nigeria, has affected the availability and quality of groundwater most of which are due to cultural waste disposal practice, such as domestic and industrial waste especially in urban areas (Earnest, 2013).

Groundwater pollution has been the focus of attention by many researchers in recent times (Howard *et al.*, 2002; Priis-Ustun *et al.*, 2004; Ayanlaja *et al.*, 2005; Pritchard*et al.*, 2007). It is partly responsible for low access to potable water and sanitation problem especially in many developing countries (Earnest, 2013). Therefore, there is urgent need to provide an improved water supply and a safe means of excreta disposal (WHO, 2008).

Pit latrine is a common method of excreta disposal in the developing world. It is popular and widely used in urban slums as well as rural areas probably because it is the simplest, cheapest and the most efficient excreta disposal method that is within the reach of poor people (Graham & Polizzotto, 2013). Pit latrine is one of the major contributing factors of groundwater pollution mostly located near water sources such as shallow wells and boreholes (Earnest, 2013). In fact, pit latrines have been identified as the major source of contamination of wells with faecal matter (Howard *et al.*, 2010). Liquids leach from the pit and pass the loss compacted soil zone which is not completely filled with water. Subsequently, these liquids from the pit enter the groundwater where they may lead to groundwater pollution (Howard *et al.*, 2010). This may cause a problem if the nearby well/borehole is use to supply groundwater for drinking purposes (Sakyi & Asare, 2012). During water passage in the soil, pathogens can die off or be absorbed significantly, mostly depending on the travel time between the pit and the well (Nick *et al.*, 2012).

Impact of pit latrine on ground water quality have been a major factor responsible for many diseases such as cholera, diarrheal disease and other forms of enteric fever that eventually results to death especially in urban areas (Adekunle *et al.*, 2013). These reasons make it necessary to carry out a study and understand whether pit latrine has effects on quality of ground water in our environment.

Pipe-borne water supply is less available and residents of Nguru town depend totally on groundwater (Hand Pumps and wells) as their main source of domestic water supply. Hand pumps are mostly constructed in the various communities and are usually accessed by the general public (Musa *et al.*, 2015). Related study of water contamination in the area (Nguru) (Akaahan *et al*., 2012) indicated that, there are few in depth studies on impact of pit latrine on ground water quality (Adelekan, 2010) despite the dangerous effect of ground water contamination in many areas that are still using the water as their drinking water source. Unpredicted changes in ground water quality in most areas where pit latrine are constructed within a short distance from water source has tremendously causes a greater impact on the population of many area (Earnest, 2013; Musa, *et al.*,2015; Makokha,2017).

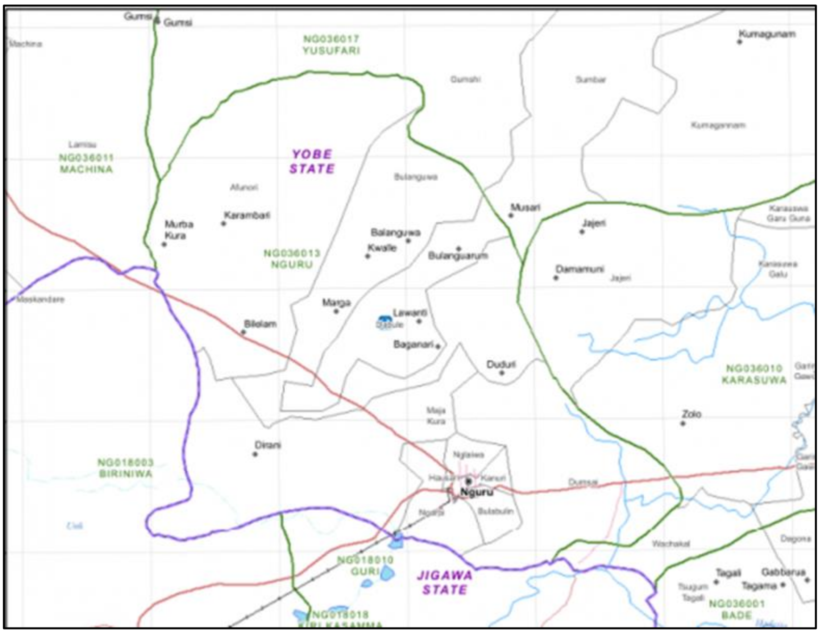
The degree of pathogen removal varies with soil type, aquifer type, distance and other environmental factors such as temperature and humidity (Graham & Polizzotto, 2013). For this reason, it is difficult to estimate the safe distance between a pit and water source. Detailed guidelines have been developed to estimate safe distances to protect groundwater sources from pollution from on-site sanitation (Moore *et al*., 2010). However, these are mostly ignored by those building pit latrines. In addition to that, household plots are of a limited size and therefore pit latrines are often built much closer to groundwater wells than what can be regarded as safe. This results in groundwater pollution and household members falling sick when using such water for drinking (Moore *et al.*, 2010).

WHO recommended that the bottom of the pit should be at least 2m above groundwater level, and a minimum horizontal distance of 30 m between a pit and water source. This is normally recommended to limit exposure to microbial contamination (Moore *et al.*, 2010). However, no general statement should be made regarding the minimum lateral separation distances required to prevent contamination of a well from a pit latrine (Wolf *et al.*, 2015).

MATERIALS AND METHODS

Study Area

Nguru is a local Government headquarter of Nguru L.G.A in Yobe State of Nigeria, the town is located in the North Eastern geo-political zone in the extreme western part of Yobe State on Latitude 12˚53North and about longitude 12˚58East. It has an average area of 916 km² with a population of 150,632 (2006 census). The town is among the old settlements in the state which dates back to 15th century (Klimatafel 2016).



A Map showing the geographical location of Nguru Local Government Area of Yobe State Distance between Pit latrines and Water Source (Well, Hand pump and Borehole)

The distances between the water source and the nearest pit latrines were measured using a steel tape. A Global Positioning System (GPS) device was used to determine the geographic positions of the water source.

Water Sample Collection Sites

Water Sample collection was carried out at; Hausari, Bulabulin, Tsohon Nguru, Sabon gari, and Garbi of Nguru town. Three water sources located near pit latrines was randomly selected from each community. A bottle water (Faro) was used as control.

Consent and collaboration with the communities was obtained before sample collection was conducted. Water samples from the water source of each community were collected in pre-washed and sterilised 500 ml bottles. The bottles were properly labelled. The collected samples were taken to Yobe State University Research Lab for analysis, in accordance with the protocols described by Ernest, (2013).

BACTERIOLOGICAL ANALYSES

Serial Dilution

The bacteriological analyses of the water samples was carried out as described by Kanika (2009). A ten-fold serial dilution technique was conducted for the 15 samples.

In each sample, five test-tubes were arranged in the test-tube holder. In each test-tube, 9ml of distilled water was poured and 1ml of sample was added to the first test-tube making 10ml (10^{-1}). 1ml was pipetted out from the first test-tube and added to the second test-tube containing 9ml to make it 10ml (10^{-2}). Similarly, 1ml from the second test-tube was pipetted and added to the third test-tube making 10ml (10^{-3}). Similar procedure was repeated up to the fifth test-tube containing 9ml making it 10ml (10^{-5}). Different pipettes were used in the serial dilution.

Media Preparation for Coliform Bacteria

Pour Plate count method was used for the total and faecal coliforms as well as *E. coli.* 31.7g of powdered nutrient agar was dissolved in 675ml of distilled water in a conical flask. The conical flask was covered with aluminium foil containing cotton to avoid contamination and spillage in the autoclaving machine. It was then autoclaved at 121^{o}c for 15minutes (Cheesbrough, 2012).

0.5ml was pipetted out from each sample into sterilized disposable petri dish. 15ml of the liquid nutrient agar was poured into the petri dish containing the sample. The petri dishes were gently mixed after covering and were allowed to stay for a period of 10 minutes sufficient for solidification before incubating the sample in an incubator machine for culturing at 37^{o}c for 24hours. After 24hours, all the 45 media were removed from the incubator for colony counting accordingly with colony counter. A pink or reddish appearance on the media indicates the presence of coliform bacteria (Kanika, 2009).

E. coli was estimated using this formula;

$$E.coli\ (CFU) = \frac{\text{Number of colonies}}{\text{Vol. of sample}}$$

Media Preparation for Confirmation of Coliform Bacteria

180g of Macconkey broth was dissolved in 2250 ml of distilled water. This was sterilised in an autoclave machine at 121^{o}c for 15 minutes. The broth medium was allowed to cool to 45^{o}c.

225 McCartney bottles were rinsed and sterilised in hot air oven at 160^{o}c for 3hours. They were removed and allowed to cool (Cheesbrough, 2012).

Each water sample from five communities of Nguru town was divided into three samples (A, B and C). The bottles were properly labelled and each bottle contains equal volume of the medium broth (10ml). Bottles labelled A (5 bottles) contains 10ml of water sample, B (5 bottles) contains 5ml and C (5 bottles) contains 1ml of the water sample. Durham tubes were then inserted into the McCartney bottles. In this aspect, the mouth of the bottles were aseptically sealed with cotton wool and incubated at 37^{o}c for 72 hours. The number of positive tubes were observed which is indicated by color change of the medium and the presence of gas bubbles in the inverted durham tube (Cheesbrough, 2012).

RESULTS

Table 1: Total coliforms and *Escherichia coli* in the water samples.

SAMPLING POINT		WATER SOURCE	TOTAL COLIFORM	E. *coli* (CFU)
GARBI	A	HP	325	650
	B	W	282	564
	C	B	232	464
MEAN			280	559
HAUSARI	A	HP	42	84
	B	B	43	86
	C	HP	19	38
MEAN			35	69
BULABURIN	A	HP	508	1016
	B	B	487	974
	C	B	380	760
MEAN			458	917
TSOHON NGURU	A	B	339	678
	B	W	351	702
	C	HP	468	936
MEAN			386	772
SABON GARI	A	HP	386	772
	B	W	397	794
	C	HP	218	436
MEAN			334	667
CONTROL			0	0
WHO			0	0

Field survey 2019

Key: HP = Hand Pump, B= Borehole, W= Well

Total coliform and *Escherichia coli* count exceeded the zero coliform count WHO standard for a good quality drinking water. High total coliform and *E. coli* count indicates that water from the water source is polluted/contaminated with fecal matter. The water samples from Bulabulin and Tsohon Nguru had the highest total coliform count (458 and 386 respectively).

Table 2: Distance of pit latrines to water sources at five communities in Nguru town.

SAMPLING POINT	SOURCE	DISTANCE TO PIT LATRINE (METERS)	CORDINATE OF WATER SOURCE
GARBI A		8.60	
B	HP	27.00	N:12.85911^{0}, E:010.42970^{0}
C	W	7.20	N:12.85751^{0}, E:010.42967^{0}
MEAN	B	14.27	N:12.85725^{0}, E:010.43051^{0}
HAUSARI A		5.70	
B	HP	24.80	N:12.87624^{0}, E:010.45105^{0}
C	B	9.50	N:12.87591^{0}, E:010.45157^{0}
MEAN	HP	13.30	N:12.8780^{0}, E:010.45129^{0}
BULABURIN A		17.00	
B	HP	14.70	N:12.87857^{0}, E:010.45745^{0}
C	B	16.00	N:12.87169^{0}, E:010.45706^{0}
MEAN	B	15.90	N:12.86988^{0}, E:010.45727^{0}
TSOHON NGURU			
A		10.00	
B	B	11.00	N:12.87780^{0}, E:010.45131^{0}
C	W	12.00	N:12.88483^{0}, E:010.45887^{0}
MEAN	HP	11.00	N:12.88335^{0}, E:010.45876^{0}
SABON GARI			
A		10.40	
B		5.00	
C	HP	10.65	N:12.88021^{0}, E:010.45605^{0}
MEAN	W	8.68	N:12.88032^{0}, E:010.45820^{0}
	HP		N:12.87861^{0}, E:010.45751^{0}
WHO		30	

Field survey 2019

Key: HP = Hand Pump, B= Borehole, W= Well

Distances of the water samples from nearest pit latrines were presented in table 4. The water sources were sited between 7.2 m to 27.0 m from nearby pit latrines in Garbi community, 5.7m to 24.8m in Hausari community, 14.7m to 17m in Bulabulin, 10m to 12m in Tsohon Nguru and 5.0m to 10.6m in Sabon Gari.

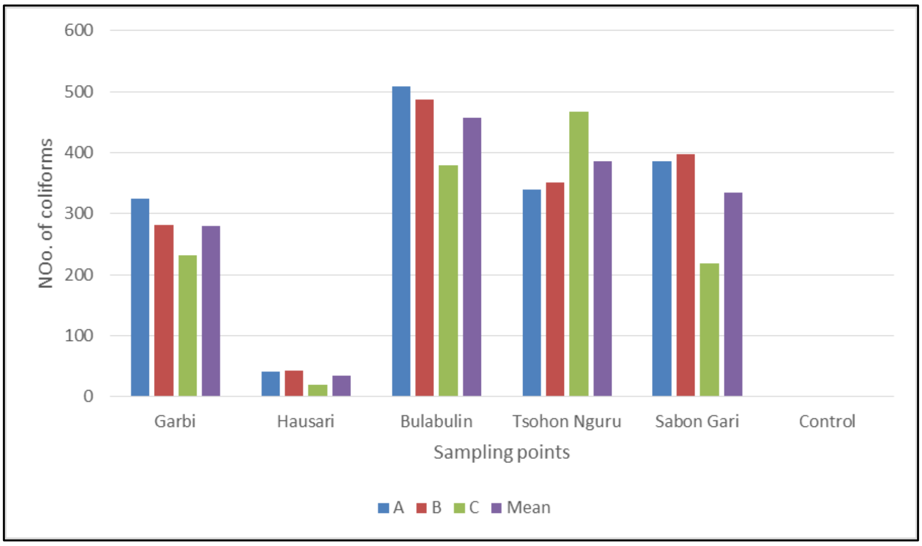


Fig 1: Samples from Different water sources showing number of Total coliforms.

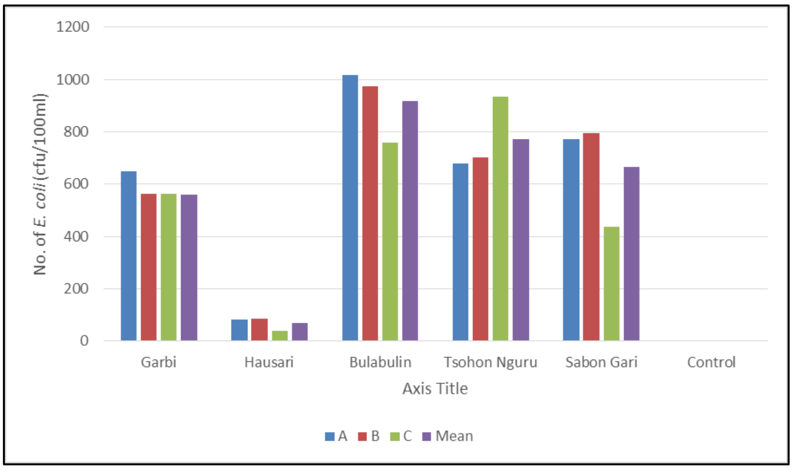


Fig 2: Samples from Different water sources showing number *Escherichia coli.*

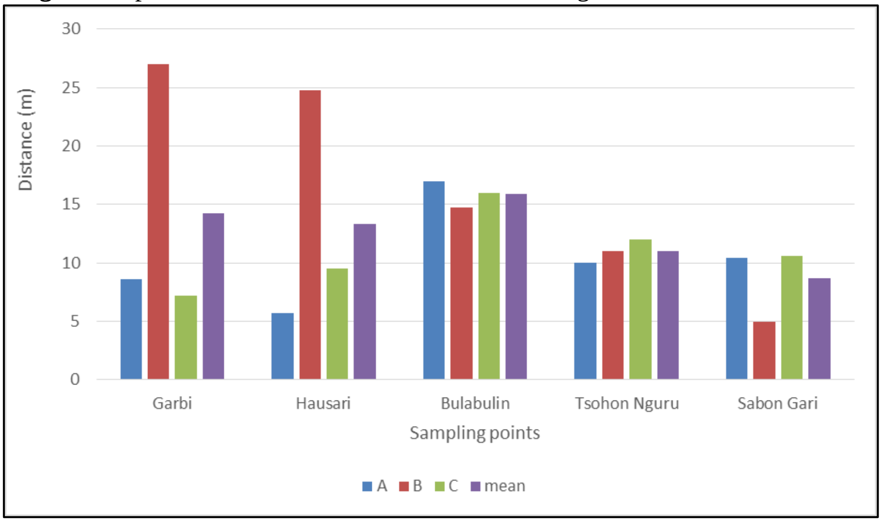


Fig 3: Samples from Different water sources showing distance to pit latrine.

DISCUSSION

The failure of the average distances of water sources to meet the recommended 30m agreed with a study conducted by Selendy and Janine (2011) which revealed that a relatively high number of bacterial load were detected from water source near pit latrine. This means the location of the water sources are either wrongly or poorly located. This gives one of the strong reasons for contamination of the water sources with high total coliform and *E coli* as seen in Sabon Gari B in table 3 with relative distance of 5 m of the pit latrine to the water source and having total coliforms of 397 and number of *E. coli* as 794. However when compared with Hausari A, the relative distance of the pit latrine and water source is 5.7 m but with few total coliform and *E. coli* of 42 and 84 respectively. 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, borehole and hand pump. It was observed that, in Hausari A the hand pumps were constructed at a distance of 5.7 metres, which explain the ignorance of the basic technics for constructions, since hand pumps unlike wells are constructed by companies who are expected to exercise some bits of professionalism. It also agreed with Rogbesan *et al.*, (2002) who conducted a research on pit latrines and their locations and suggested that pit latrines should be located no less than 30 m from groundwater abstraction.

Bacteriological parameters

Total coliform and *E. coli* count as seen in table 3 was recorded in all the samples and exceeded the zero coliform count WHO standard for a good quality drinking water. High total coliform and *E. coli* count indicates that water from the water source is polluted/contaminated with fecal matter. The water samples from Bulabulin and Tsohon Nguru had the highest total coliform count (458 and 386 respectively). This finding is not surprising, considering the close proximity of the water source to pit latrines been 15meters and 11meters respectively. This indicates that sewage can slowly seep into underground water, there by polluting it. The vulnerability of underground water to contamination could be due to improper construction, animal waste, and proximity to toilet facilities, sewage, refuse dump sites and various human activities surrounding it (Agbaire et al., 2009).

However, *E. coli* were detected in all samples tested and they exceeded the limit set by WHO and

NSDWQ of zero cfu/100ml. This indicates that water from these sources are fecally contaminated. Hence, the ability to detect fecal contamination in drinking water is of public health importance. Likewise, the presence of *E. coli* in these samples show that people that use these water sources are prone to urinary tract infections, bacteraemia, meningitis, diarrhoea, and acute renal failure (NSDWQ, 2007).

The effect of distance from pollution sources was much more defined for faecal and total coliform counts. A study by Potgieter *et al*., (2005) in Limpopo province, South Africa showed that coliform counts in borehole water were increased due fecal contamination of ground water. Study by Jayalakshmi *et al.* (2011) who found that borehole water with the highest total coliform count also have the highest faecal coliform count (Rogbesan *et al.*, 2002). A study of coliform contaminants in Ibadan city Nigeria by Oyedum (2010) and supported by Boman (2012), showed the pollution of boreholes was due to indiscriminate drilling of boreholes near pit latrines toilet and poor drainage systems. According to Potgieter *et al.*, (2005), the contamination depends on seasonal variations and resistance of particular bacteria to environmental conditions such as temperature and relative humidity.

CONCLUSION

The study was carried out to investigate the impact of pit latrine on groundwater quality in Garbi, Hausari, Bulabulin, Tsohon Nguru and Sabon Gari communities of Nguru town. The analysis revealed that samples obtained from the different water sources contained one form of contaminant or the other. In particular, the water samples contained bacterial contaminants in excess of the recommended limits set by NSDWQ and WHO. The presence of total coliform and *E. coli* suggest that there is faecal contamination of the water source from the pit latrines due to close proximity. It was also observed that a significant association existed between distances from water source to the nearest pit latrine and the bacteriological loads in the water samples. From the results, it is clear that drinking water samples collected from all the underground water sources are not safe for human consumption.

Recommendation

Based on the results of this study, the following are recommended

- The Water and Sanitation Board in the community should ensure that the distance of pit latrines to water source meet the recommended distance of 30 meters by WHO (2004).
- Government should ensure adequate and cleaner public water supply through the provision of pipe-borne water.
- There should creation of awareness and education to residents on borehole, hand pumps and wells construction, citing and maintenance.
- Water from the water sources should be boiled before use.

Detail survey and evaluation on the area surrounding the ground water sources should be carried out to determine the possible sources of all the pollutants. The general sanitary condition of the area should be improved to eliminate possible sources of contamination.

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