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AN ASSESSMENT OF TRADITIONAL METHODS OF WATER PURIFICATION IN A RURAL AREA IN NORTHERN NIGERIA: A CASE STUDY OF KUDAN LOCAL GOVERNMENT AREA OF KADUNA STATE

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Abstract

The quest for potable water has been in existence for as long as man could distinguish odour, taste, cloudiness and colours in available water. This study investigates the efficacy of some traditional water treatment methods used in a rural community in Northern Nigeria. Water samples were obtained from the various water sources in the study area and also from the households after the different types of traditional treatments have been carried out on the water. Biophysiochemical parameters of water samples before and after the traditional treatment were analyzed. The results obtained showed that the Three pots (TP), filtration through clay vessels (FTCV) and long storage (LS) methods had 95.02%, 93.68% and 91.86% turbidity removals respectively and performed better than the other methods. Total dissolved solids had average removals of 52.9% and 53.6% by FTCV and LS methods while other methods were below average. Total suspended solids recorded 81.4% removal by FTCV while filtration through cloth FTC and solar disinfection SODIS had 72.3% removals each. In terms of bacterial count, FTC, boiling (BL) and SODIS were most effective with 66.3%, 63.7% and 63.8 % removals respectively while the LS method was least effective. The study concluded that no particular method was best in removing all the parameters studied and therefore proposed the use of a combination of two or more of these traditional methods for higher water purification efficiency in the study area.

Key words: Rural area, water purification, filtration, sedimentation, solar disinfection,

INTRODUCTION

Water supply is one of the key natural resource bases that are inevitable for sustainability of human and environmental health. Studies have shown strong and direct link between people's health and development of communities (Gleick, 2002). Inadequate water supply together with poor sanitation among the rural populace is among the most serious challenges facing the developing world. Every year, approximately 3.4 million people die due to water-borne diseases, with the greatest

health burden falling on children (WHO, 2003).

In the rural areas where there are no accesses to potable water, the quantity of water that needs to be treated is the quantity required for drinking and preparing uncooked foods. Usually around 5 litres per person per day is needed but this may vary depending on climate and population (Olayemi and Alabi, 1994).

There exist numerous high technology systems for purifying water. But for a huge population in the developing world that live in the rural areas, such systems would be inaccessible or too expensive. This rural population usually adopts techniques with low level of sophistication to suit their own situation. The special features involved in such traditional treatment methods are worth considering before general technological solutions based on wider experiences can be proposed for these communities. Traditional methods of water purification include cloth filtration, filtration through clay vessels, sedimentation and boiling (Sofowora, 1997).

According to (Idika *et al*., 2002), there are various traditional purification methods, which include: long storage (LS), three pots (TP)methods, filtration through cloth (FTC), filtration through clay vessels (FTCV), solar disinfection (SODIS), and boiling (BL). Storage of water in silver containers has been shown to disinfect natural waters (Kotigadde *et al*., 2012). Studies have also shown significant correlations between radiation intensities and elimination of microorganisms such as bacteria in water (Deller *et al*., 2006). The minimum dosage of solar intensity recommended to inactive vegetative bacteria is 0.44KWh/m^2, and in Nigeria the average solar intensity in the semi-arid areas of the country is 5.25KWh/m^2 per day (Nwokocha *et al*., 2013).

Filtration is a physical process that removes larger particles that could be harmful in water prior to consuming. Studies have shown that commercially available cotton cloths can be used as simple filters in developing countries.(Tammisetti, 2010). Suspended particles become trapped within the pore spaces of the filter media, which also remove harmful protozoa and natural colour.

The study area is a rural area with limited access to potable water supply, the dwellers however engage in some form of traditional water treatment to purify their water before use. This study therefore aims at determining the adequacy and effectiveness of these traditional treatment methods employed by the dwellers of the study area to provide them with safe water. This research was assessed based on the three primary purification techniques adopted by each method which are; Sedimentation, Filtration and Disinfection.

Background information on study area

Kudan Local Government Area (LGA) is one of the local governments in Kaduna State. It was carved out of Markafi LGA in 1996. The LGA is situated along the old Kano road, though part of it lie along the Zaria–Kano express way. The LGA is surrounded by Giwa and Danja local governments (both in Katsina State), Rogo

local government (in Kano state), Markafi and Sabon Gari local governments (both in Kaduna State). Its headquarters is in the town of Hunkuyi, with a population of 138,992 people according to the 2006 census and has an area of 400km². A total of 51% of the inhabitants are men and 49% are women with an average of five persons per household. Most men in this area are peasant farmers, teachers, traders and health workers, while the women are mostly housewives and a few teachers and health workers (Abubakar, 2010). The study area is shown in the geographical map in Figure. 1.

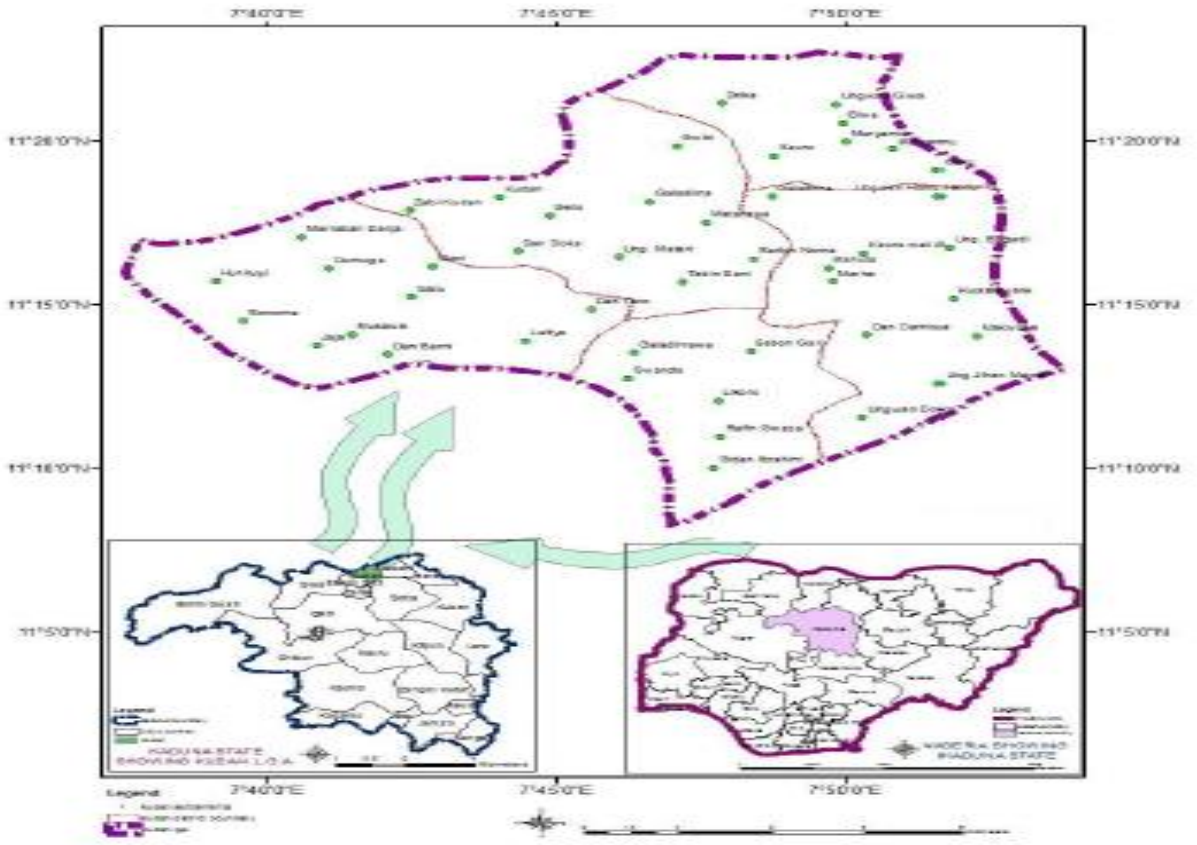

Figure 1: Map of Kaduna State Showing the Study Area (Abubakar, 2010)

MATERIALS AND METHODS

Survey of Water sources in the study area

A physical survey of the major water sources was carried out and through the application of participatory interview strategies on members (men and women) in randomly selected households in the wards, it was indicated that five major sources i.e. well, tap, borehole, dam reservoir and a stream are the most reliable sources of water available to villagers even though some of these sources are seasonal. The traditional processes of water purification practiced in the study area were identified as sedimentation, filtration and disinfection.

Water sampling

Samples (raw water) used in this study were collected by the researcher from the various sampling points, using labeled plastic containers (small buckets) and plastic bottles from the major sources of water in the study area , i.e well, tap, borehole, dam reservoir and stream and each of the samples were purified in selected households using each of the traditional methods of purification (long storage, three pots method, filtration through cloth, filtration through clay vessels, boiling and solar disinfection). The raw samples collected from the sources before purification are labeled S1 and samples collected after purification as S2 with the initials B,D,T,S, and W for borehole, dam, reservoir, tap, stream and well respectively. Also, treated samples were collected from the different households, using plastic bottles labeled according to the traditional techniques used for treatment of a particular sample,

i. Three pots method (TP)

The three pot method involves the use of three pots (1, 2, and 3) and the process is as follows:

a. Water collected from the source is poured into pot 1.

b. Slowly water stored in pot 1 is poured into pot 2 and pot 1 is washed out.

c. Slowly water stored in pot 2 is poured into pot 3 and pot 2 is washed out.

d. Water is allowed to settle for a day and then the process is repeated.

e. Water from pot 3 is used for drinking or other domestic purposes.

obtained from each of the sample points mentioned.

Sample analysis

Materials used in the sample analysis include beakers, test tubes, conical flasks, petri dishes, pipette, glass rods, filter papers, burette, measuring cylinder, Incubator, measuring cone, weighing scale. The biophysicochemical analyses carried out on the water samples were turbidity, pH, BOD, TDS, TSS and Bacterial count. The analysis of the water samples were determined before and after the traditional treatment techniques according to the standard procedures recommended by American Public Health Association (APHA, 1998) on the analysis of public water. The results of the analysis were compared with the WHO standards for drinking water and the Nigerian Standard for drinking water quality (NSDWQ) given in Table 1.

Traditional Water Treatment Methods.

Only water from pot 3 is used for drinking. This water is stored for at least 2 days to improve the quality. Periodically these pots are washed out and sterilized by baking or scalding with boiling water.

ii. Long storage (LS)

This is a form of sedimentation stage which is cheap and very easy toadopt. Water was stored in sterile clay pots or air tight containers for 3 days under room temperature, until all settable solids were settled. Sample was then taken for analysis in plastic sampling bottles.

iii. Filtration through cloth (FTC)

A thin white cotton cloth or discarded garment was used as the filter medium. This filter can filter raw water containing impurities such as insects, plant debris, dust particles or coarse mud particles. This method is most suitable for well water.

iv. Filtration through clay vessel (FTCV)

This method involves the use of two clay pots with one pot beneath the other. The Water sample collected was heated to a boiling point (bubbling boil) to ensure maximum disinfection of water. The boiled

vi. Solar disinfection (SODIS)

The water sample collected was poured into a clear plasticbucket which helped to increase the temperature of the water and the bucket was exposed directly under sunlight for 6 hrs. The bucket was placed on a roof top for maximum penetration of sunlight and greater effectiveness.

RESULTS AND DISCUSSION

Survey of Water Sources in Kudan L.G.A

The results of the physical survey of the major water sources in the study area are as given in Table 2. The information gathered from randomly selected households in the wards revealed that the stream, dam, borehole and well are the most reliable sources of water available to villagers. The physical observation of the water from each of these sources showed that the stream and dam are objectionable for general use before purification, while water samples from the borehole, tap and well need not be purified for some domestic uses like washing,

filter pot was perforated to a suitable pore size at the bottom before being placed over the filtrate pot. The sample water collected was poured into the filter pot and allowed to settle, the water trickled through the porous bottom of the pot. The trickled water was collected by the filtrate pot underneath the porous pot.

v. Boiling (BL)

water was left covered and allowed to cool before being taken
for analysis.
bathing and dish washing. The water from the stream also has a bad odor which could be as a result of pollution of the stream by human activities. However, all the water sources had high bacterial counts (Table 3) which suggests that all the water sources are not suitable for drinking without prior purification.

Impact of Traditional Sedimentation, Filtration and Disinfection Techniques on Water Quality in the Study Area

Sedimentation

The sedimentation methods adopted in the study area were three pots and long storage methods. The application of these methods in purification of the water sources gave the results as shown in Table 4. The pH values showed improvements on the various sources of water after sedimentation, notably the stream water which had a pH of 4.45 and 6.56-6.65 before and after sedimentation respectively. There were also some improvements in Turbidity, TDS, TSS and BOD of the water samples with the sedimentation methods, however, the

bacterial count were still very high in all the sources of water after purification, this suggests that sedimentation is not sufficient for bacteria removal from water.

Filtration

The filtration methods increased the pH of the water samples and Turbidity values also dropped significantly after the filtration processes as shown in Table 5. However, there was increase in the TDS for all the water samples analyzed; this is an indication that probably the cloth and clay vessels used for filtration are not properly cleaned before subsequent use. There was improvement in the TSS, BOD and bacterial count in all the samples from the various sources.

Disinfection

The effect of disinfection in the form of boiling and SODIS increased the pH of the water, the increase was significant in the stream water with pH 4.45 and 7.21 before and after disinfection respectively.

Turbidity and TDS was also reduced in all the various sources of water except for the stream water where the TDS increased from 0.44 to 2.08mg/l. the BOD values were within acceptable standards both before and after treatment while bacterial count reduced significantly.

Comparative Assessment of the Efficiency of the Traditional Purification Technique in the Study Area

The Tables below show comparison in results of the parameters analyzed in the water samples according to the purification techniques adopted in the study area for treatment of water. The pH

standard for drinking water is 6-8.5, and the pH of all the samples treated using the various traditional methods of purification fell within this standard range.

The various percentage reductions in turbidity with respect to the three techniques (sedimentation, filtration, disinfection) and six methods (three pots method, long storage, filtration through cloth, filtration through clay vessel, boiling, solar disinfection) adopted are given in Table 7. The results show that turbidity was best

The overall highest Total suspended solids removal of 97.44% was obtained for samples from well water treated by the three pots method, filtration through cloth, removed by the Three pots (95.02%), Filtration through clay vessel (93.68%) and Long storage methods (91.86%) in that order. In terms of the response of the various water sources to treatment, the reservoir water gave the best response (95.01%) in terms of turbidity removal.

From Table 8, all samples showed increase in TDS which could be as a result of retention time of samples which allow growth of micro-organisms during the period or unknown introduction of substances into the water by the purification process. The stream water sample had the highest percentage increase in TDS after purification by long storage of 99.27 % and sample tested for tap with the least percentage increase in TDS after solar disinfection of 6.06%.

filtration through clay vessels and Solar disinfection, while stream water sample treated by boiling had then lowest removal of 10.00% for TSS as shown in Table 9.

From Table 10, Samples with negative reduction are samples that had increase in the number of colonies in the water sample. The borehole water sample treated by long storage has a percentage increase of -3.08% and dam water samples treated by long storage have a percentage reduction of -4.55%. This could be as a result of long retention time of the water during purification, which gives time for bacteria to multiply. Stream water sample treated by boiling and solar disinfection have the highest percentage reduction of 96.80% which is similar to the results obtained by Idika et al, (2002) where it was found that boiling best removed microbes in raw water although it alters taste and is more expensive . The borehole water sample treated by filtration through clay vessel has the lowest percentage reduction of 30.77%.

CONCLUSION

At the end of the study, it was found that of all the water sources, the water obtained from the dam had the highest turbidity, which makes it unsuitable for consumption without purification. More so, the traditional purification methods (long storage, three pots method, filtration through cloth, filtration through clay vessels, solar disinfection) adopted by the inhabitants of the study area were assessed as fairly effective because there was significant improvement in the quality of water. However, in terms of bacterial counts, the boiling method was found to be the most effective while the long storage method was least effective of all the methods used in water purification in the study area. Therefore, it was concluded that all the local purification methods adopted are useful in the purification of water for domestic use in the study area.

A combination of two or more techniques such as, filtration and boiling (filtration through cloth, followed by filtration through clay vessels and disinfection by boiling) is highly recommended for water treatment in the study area and other similar rural areas.

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Table 1: Nigerian Standard for Drinking Water Quality (NSDWQ) and WHO International Standard for Drinking Water

S/NO	PARAMETER	NSDWQ	WHO
1.	Taste	Unobjectionable	Unobjectionable
2.	Odour	Unobjectionable	Unobjectionable
3.	pH (ph unit)	6.5 – 8.5	6.5 – 8.5
4.	Total alkalinity concentration(mg/l)	250	
5.	Residual chlorine(mg/l)	0.2 – 0.5	0.2 – 0.5
6.	Chloride ion(mg/l)	250	250
7.	Total hardness	150	
8.	Iron(mg/l)	0.3	0.3
9.	Turbidity (NTU)	5	5
10.	Colour (pt co)	15	15
11.	Methyl orange alkalinity (mg/l)	250	
12.	Phosphate (mg/l)		6.5
13.	Dissolved oxygen (mg/l)	5	
14.	Nitrate (mg/l)	50	50 as NO_3
15.	Sulphate (mg/l)	250	250
16	Bacteriological count	0	
17	E. Coli	Nil	
18	Viable plate count	0 cfu/ml	

Table 2: Physical Survey of Major water Sources in the study Area

Water sources	**Sample Label**	**Water source location**	**Field survey/ Source condition**	**Water quality**
Well	S1-W	Kudan police station	Unprotected hand dug well.	Clear with suspended solids
Borehole	S1-B	L.E.A primary school, Kauran Wali North	Rising main worn out, water point destroyed	Clear with little settable particles
Garu Dam Reservoir	S1-D	Garu ward, Kudan	Small size dam, silt accumulation, and poorly designed.	Extremely Turbid, muddy and contains suspended and settable solids
Tap	S1-T	Primary health care centre, Kudan	Well designed and maintained	Fairly clean
Stream	S1-S	Taba ward, Kudan	Natural stream, dries up in dry season, densely populated by aquatic life, e.g. frogs and leeches	Dirty, smelly with suspended and settable solids

Table 3: Biophysicochemicalcharacteristics of water samples collected from each source before purification

Water Samples sources/ labels		**Water quality parameters assessed**					
		pH	**Turbidity (NTU)**	**TDS (mg/l)**	**TSS (mg/l)**	**Bacterial Count(ml)**	**BOD (mg/l)**
Borehole	S1	6.29	2.82	0.34	0.09	130000	0.10
Reservoir	S1	6.33	510	0.56	0.27	110000	0.20
Stream	S1	4.45	90.5	0.44	0.20	2500000	0.70
Tap	S1	6.30	7.80	0.33	0.06	200000	0.50
Well	S1	7.51	13.8	0.38	0.39	150000	2.28

Table 4: Biophysicochemical characteristics of water after purification by sedimentation methods

Water samples	**Sedimentation method**	**pH**	**Turbidity (FTU)**	**TDS (mg/l)**	**TSS (mg/l)**	**Bacterial count(cfu)**	**BOD (mg/l)**
Borehole	Three pots	6.29	0.148	0.67	0.05	100000	0.40
	Long storage	6.65	0.184	0.86	0.04	134000	0.50
Reservoir	Three pots	6.13	6.20	0.59	0.02	60000	0.10
	Long storage	6.53	6.02	0.67	0.01	115000	0.13
Stream	Three pots	6.65	3.20	0.59	0.12	130000	0.10
	Long storage	6.56	3.32	0.60	0.11	262000	0.83
Tap	Three pots	5.92	0.51	0.46	0.03	10000	0.40
	Long storage	6.30	2.15	0.59	0.02	12000	0.30
Well	Three pots	6.90	1.16	0.46	0.01	50000	0.90
	Long storage	6.96	6.11	0.95	0.24	123000	0.70

Table 5: Biophysicochemical characteristics of water after purification by sedimentation methods

Water samples	Filtration Media	pH	Turbidity (FTU)	TDS (mg/l)	TSS (mg/l)	Bacterial count(cfu)	BOD (mg/l)
Borehole	Cloth	6.42	0.53	0.49	0.03	80000	0.20
	Clay vessel	6.93	0.34	0.76	0.01	90000	0.20
Reservoir	Cloth	6.02	95.29	0.98	0.08	27000	0.01
	Clay vessel	6.43	6.20	0.80	0.02	70000	0.13
Stream	Cloth	6.83	33.89	2.82	0.20	140000	0.69
	Clay vessel	6.52	7.40	18.83	0.11	100000	0.18
Tap	Cloth	7.20	4.20	0.31	0.03	10000	0.20
	Clay vessel	6.48	0.31	0.64	0.01	6000	0.47
Well	Cloth	6.80	8.60	0.23	0.01	40000	0.80
	Clay vessel	6.53	0.85	0.57	0.01	95000	0.73

Table 6**:** Biophysicochemical characteristics of water after purification by disinfection methods

Water samples	Disinfection method	pH	Turbidity (FTU)	TDS (mg/l)	TSS (mg/l)	Bacterial count(cfu)	BOD (mg/l)
Borehole	Boiling	6.93	0.43	0.43	0.02	80000	0.11
	SODIS	6.34	0.53	0.49	0.03	80000	0.30
Reservoir	Boiling	6.43	6.02	0.62	0.13	40000	0.14
	SODIS	6.39	5.29	0.98	0.08	27000	0.01
Stream	Boiling	6.52	4.70	0.51	0.18	80000	0.01
	SODIS	7.21	3.89	2.08	0.20	140000	0.69
Tap	Boiling	6.52	6.13	0.41	0.01	13000	0.42
	SODIS	6.84	4.20	0.31	0.03	15000	0.20
Well	Boiling	6.58	8.25	0.48	0.09	23000	0.63
	SODIS	6.85	8.60	0.53	0.01	40000	0.80

Table 7: Percentage Reduction in Turbidity (FTU)

	Sedimentation		**Filtration**		**Disinfection**		
Water sample/ sources labels	**Three pots method**	**Long storage**	**Filtration through cloth**	**Filtration through Clay vessel**	**Boiling**	**Solar disinfection**	**Average % reduction**
Borehole	94.75	93.48	81.21	87.94	84.45	81.21	87.17
Reservoir	98.82	98.78	81.32	98.78	98.82	98.96	95.91
Stream	96.46	96.33	62.55	91.82	94.81	95.70	84.61
Tap	93.46	72.43	46.15	96.03	21.41	46.15	62.61
Well	91.59	55.72	55.72	93.84	40.20	37.68	62.46
Average	95.02	91.86	65.39	93.68	68.54	71.94	

Table 8: Percentage increase in Total Dissolved Solids (mg/l)

	Sedimentation		Filtration		Disinfection		
Water sample/ sources labels	**Three pots method**	**Long storage**	**Filtration through cloth**	**Filtration through Clay vessel**	**Boiling**	**Solar disinfection**	**Average % reduction**
Borehole	49.25	48.43	30.61	55.26	20.93	30.61	39.18
Reservoir	5.08	16.42	42.86	30.00	9.67	42.86	24.48
Stream	99.26	99.27	84.40	97.66	13.73	97.89	82.04
Tap	28.26	44.06	6.06	48.44	19.51	6.06	25.40
Well	17.39	60.00	39.47	33.33	20.83	28.30	33.22
Average	39.84	53.64	40.68	52.94	16.93	41.14	

Table 10: Percentage reduction in Bacterial Count (cfu)

	Sedimentation		Filtration		Disinfection		
Water sample/ sources labels	**Three pots method**	**Long storage**	**Filtration through cloth**	**Filtration through Clay vessel**	**Boiling**	**Solar disinfection**	**Average % reduction**
Borehole	23.08	-3.08	38.46	30.77	38.46	38.46	27.69
Reservoir	45.45	-4.55	75.45	36.36	63.64	75.45	48.63
Stream	94.80	89.52	94.40	96.00	96.80	96.80	78.72
Tap	50.00	40.00	50.00	70.00	35.00	35.00	46.67
Well	66.67	20.65	73.33	36.67	84.67	73.33	59.22
	56.00	28.51	66.33	53.96	63.71	63.81	