APPRAISAL OF RURAL WATER SUPPLY FOR FOOD SECURITY: CASE STUDY OF KWARA STATE, NORTH CENTRAL NIGERIA

ADEOYE, PETER ADEREMI, AND MUSA, JOHN JIYA

ABSTRACT

Provision of clean domestic water for both rural and urban dwellers should be seen as a necessity by policy makers. However, this is not so for developing nations where rural dwellers are neglected or forgotten whenever water supply schemes are been contemplated. This paper assessed rural water supply system in Kwara State, North Central Nigeria. Questionnaires were administered to respondents in the area under investigation for quantitative evaluation while samples were taken from their prevailing water sources for physico-chemical analysis. The result of the study showed that these rural dwellers are still not benefiting from rural water supply schemes whether from Government or Non-Governmental Organisations. More than 90% of them still depend on contaminated streams, rivers and unlined, unprotected shallow wells for their water needs. Only about 31.1% subject the water to some forms of treatment before use. From qualitative analysis, more than 70% of the samples analysed has physico-chemical and bacteriological parameter values higher than WHO and Nigerian Standard for Drinking Water Quality Standards. This is also evident from the report of about 63 cases of water related diseases in a week from their health centres. There is an urgent need for provision of potable water within the reach of these people to prevent outbreak of more water related problems.

Keywords: Physico-chemical properties, potable water, rural homes and water borne diseases

INTRODUCTION

Within few decades ago, there have been efforts to increase provision of domestic water for both rural and urban homes. However, water is still unavailable to many mainly those located in sub-Saharan Africa, South Asia and East Asia (Ellen & Kellog, 2005). Furthermore, the availability of water varies greatly, while some people pay so dearly for domestic water, others have an easy access to adequate clean water and sanitation due to their location and social status in the society (Hunter *et al.*, 2009a). United Nations as part of its Millennium Development Goals (MDG) stipulates that by 2015 the population of people without sustainable access to safe water will be reduced by half (Linda, 2005). As a result of this, efforts are being made by the developed nations to increase provision of domestic water and sanitation, but no serious efforts are made by the developing nations to meet this target. Rural communities in many developing nations have to obtain their drinking water from untreated surface sources, often situated far away from their residence. For instance, in many Nigeria rural communities, water supply infrastructures are still at developmental stage or are completely absent (Rossiter *et al.*, 2010).

Worldwide, waterborne diseases cause death and suffering of millions of people, especially children in developing countries. This makes the World Health Organization (WHO) to suggest that improving sanitation and hygiene could drastically reduce child mortality. Recent survey by Majuru et al., (2011) estimated that 65 million Nigerians had no access to safe water. The situation was worse in the rural areas where only 24% of the population were said to have access to safe water. Provision of clean, reliable and potable water in rural areas remains therefore a challenge considering the fact that larger percentage of population live in rural areas. When provision of clean water is inadequate, people are compelled to use contaminated water that later resulting into water related diseases and in the outbreak of these diseases. Thus, governments need to spend money on what would have been prevented by provision of clean water (Mwendera, 2006).

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north, Kogi State in the east, Benin Republic in the west and Osun, Oyo in the south (Ellen & Kellog, 2005). There are sixteen (16) local government areas in Kwara state as in Figure 1.

The state is divided into three zones with each zone comprises of six local governments. Two local governments each were selected in each zone and two villages were selected in the local governments selected. All prevalent water supply sources in the villages were visited for assessment. Sixty structured questionnaires were administered to the users of those water sources in each of the villages and twelve were administered in ten health centres located in the villages. A total of three hundred and seventy two questionnaires were therefore administered. The questionnaires consist of twenty questions which focus on quantitative assessment of the major water supply sources in the communities. The nature of the sources, whether surface water and groundwater sources were assesses, containers used in fetching, methods of storage, treatment method, mode of use and distance of the sources to the residence were also assessed. The questionnaire also assessed the outbreaks of waterborne diseases in the area within the last five years.

Table 1: Statistics of Villages visited and their Water Sources

Local Government	Village	Population	Water Source	Mode of Treatment
Edu	Kokodo	2,340	River/shallow well	Coagulation
	Kusoninguba	3,440	Shallow Well	None
Ilorin East	Oke ose	2,330	Borehole	Disinfection
	Idigba Sabo	2,288	River/Tap	Coagulation
Ilorin South	Isokun	2,230	Shallow Well	Coagulation
	Alaya	3,220	Borehole	None
Ifelodun	Igberi Owode	3,200	Borehole/shallow well	None
	Owu Obalayan	4,322	Borehole	None
Irepodun	Falokun Araromi	1,900	Shallow Well	Coagulation
	Amgberi	1,540	Tap	Disinfection
Patigi	Esanti	1,980	Shallow Well	None
	Rani Ramat	1,988	River	boiliing

For water analysis, water samples were collected from these water supply sources in sterile 500mL container which was washed three times with the sample water prior collection. 30mL of the collected sample was filtered through a 0.45μm syringe filter and stored in a 20ml polypropylene container. It was stored under 4^{0}C and taken for laboratory analysis within 6 hours of collection. The pH and conductivity of the water samples were measured in-situ (Multiline p4 Multimeter) and turbidity measured with Turbidimeter (TN-100 Eutech) instruments. The water samples were analyzed for chemical and bacteriological parameters using APHA (2005) methods. Faecal and total coliforms were analyzed using Membrane Filtration technique. For chemical analysis, the water samples were divided into two and their temperature were maintained at 4^{0}C. The first portion was acidified to pH less than 2 with concentrated HNO_3 and left for 4 days to equilibrate before taking it for ICP analysis. The second portion (untreated) was used for IC (Ion Chromatography) analysis. Milliq water was used to prepare the laboratory blanks and was treated in the same way with the samples. Cations of low concentrations (≤ 0.01μg/L were analyzed with coupled plasma- mass spectrography (ICP-MS-Japan 7500). Major cations (≥ 0.1mg/L) were determined by coupled Plasma Optical Emission spectrography (ICP-OES-5300,DV, USA). Anions were analyzed using IC Diomex CA,USA. Total Dissolved Solids and Suspended solids were analysed using gravimetric method. The results of the analysis were then compared with World Health Organization (WHO, 2006) and Nigerian Standard for Drinking Water Quality (NSDWQ, 2007).

RESULTS AND DISCUSSIONS

Table 1 shows the statistics of villages visited and their population range. It also shows their prevalent water sources and the methods of treatment adopted before use.

Water Sources Used in Rural Areas of Kwara State

Result of major water supply sources in the villages and reasons for their choices are presented in Figures 2 and 3 respectively. It shows that stream and shallow wells take the larger percentage due to their proximity and affordability. Majority of the respondents would have preferred tap and boreholes but the location is far from their place. Therefore they depend majorly on nearby streams although the quality was below WHO and Nigerian standards. The quantity of the source is the prime consideration before they make their choice instead of quality. The shallow wells are not lined; therefore all physical parameters are at elevated levels in their water sources. All the preliminary tests that are supposed to be carried out on the streams are not performed, hence, it is very clear from personal observation that all these streams should be replaced with good water sources like boreholes or lined wells which should be provided with headwalls that will prevent runoff during rainy season and should be disinfected regularly.

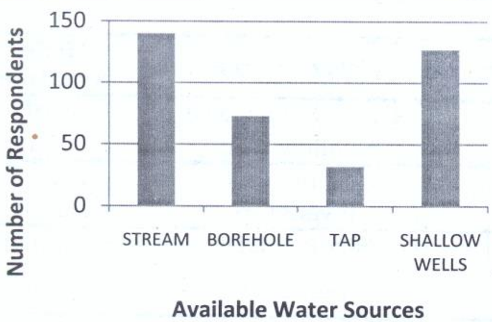

Fig.2: Water Supply Sources

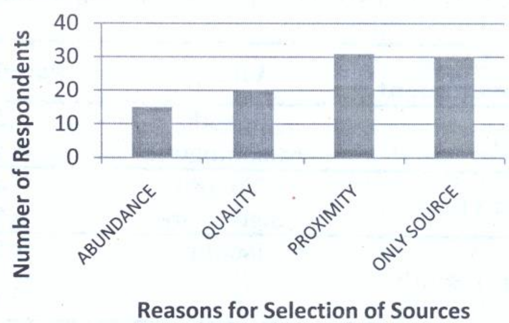

Fig 3: Reasons for water sources selection

The only water quality parameters they considered before making choice are colour, taste and odour and proximity to the residence. Other water quality parameters that are more important are not considered because other water sources of better quality are too far from their homes.

Figures 4 and 5 show the categories of people involved in fetching the water and the containers they use respectively. It can be seen from figure 4 that children (40) and young females (20) are saddled with this responsibility. Children are seen in some cases climbing the headwalls of the shallow wells before they can fetch and as such dirty water spills from their leg into the wells. The spilled water may be another source of contamination.

Young females use open plastic buckets that may likely subject the water to a lot of contamination before reaching point of use while some tribes still use gourds and clay containers. Clay containers are clean but too heavy while gourds are not hygienically good to fetch water that is meant for cooking and drinking. Adult males that fetch use covered jerry cans which they tie on their motorcycles. This to some extent is good but frequency of washing the containers will have to be considered too. Previous analysis showed that most of the water sources are having high iron content and this will make the plastic containers to be washed frequently because of deposit of slimy substances on the inner walls (Rietveld *et al.*, 2009). The respondents prefer to fetch with open containers like plastic buckets, clay buckets and steel bucket because they are easy to use especially while fetching in well and streams. What can be done to protect their water against contamination from sources to the point of use is to make the water sources close to their homes.

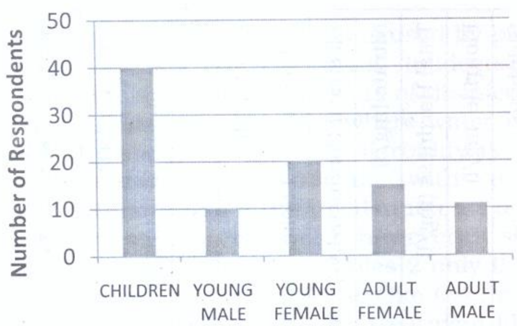

Fig 4: Category of People Fetching water

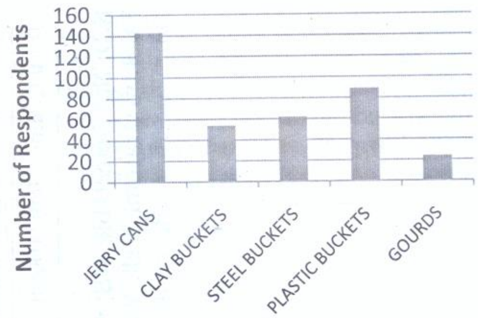

Fig 5: Containers Used to Fetch Water

Mode of Water Treatment

Methods of treatment adopted by the rural dwellers are presented in Figure 6. About 37.6% of the respondent does not treat their water before use. Coagulation is done by 18.5% of the respondents and they only perform it during rainy season when the water sources are not clean enough as a result of pollution by runoff. Addition of alum will only make the water clearer by coagulating suspended and colloidal particles but will not kill the pathogens. Boiling, chlorination and filtration are affordable water treatment techniques that should be encouraged among the rural dwellers. People depending on shallow wells and streams as drinking water should be advised to always boil the water before use because all the samples taken from these sources for laboratory analysis did not meet WHO (2006) and Nigerian Standards for Drinking Water Quality.

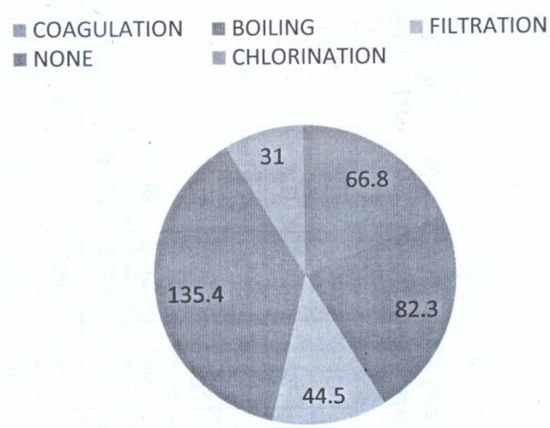

Fig. 6: Water Purification Methods Used by the Rural Dwellers

Physico-chemical Results of the Water Samples

The results of physic-chemical analysis of the water samples are presented in Tables 2.

Table 2: Physico-chemical Results of the Water Samples

Samples Parameters	**W_1**	**W_2**	**W_3**	**W_4**	**W_5**	**W_6**	**W_7**	**W_8**	**W_9**	**W_{10}**	**W_{11}**	**W_{12}**	**NSDWQ (2007)**	**WHO (2006)**
Turbidity (NTU)	7.00	0.06	6.9	9.00	7.53	3.00	0.68	2.65	0.09	0.08	6.71	5.46	0.1	0.1
Suspended Solids (mg/l)	462	31.00	238	246	287	339	341	448	38.00	19.00	456	338	NS	NS
pH	7.4	6.9	8.3	6.7	8.2	8.4	6.5	6.8	7.00	8.3	8.5	6.6	6.5-8.5	6.5-8.5
Iron (mg/l)	0.56	0.13	0.89	0.76	0.67	0.42	2.52	0.07	0.10	0.02	3.39	0.19	0.3	0.3
Total Dissolved Solids (mg/l)	689	376	648	545	544	677	453	785	231	90	876	730	500	1000
Electrical Conductivity (µs/cm)	1403	1103	1209	1564	1243	1310	1543	1643	130	1190	1260	1160	1000	1200
Nitrate (mg/l)	2.21	4.86	35.36	79.56	10.02	95.03	20.07	0.88	35.36	3.98	3.09	37.51	10	50
Total Hardness (mg/l)	421	27	44	56	46	330	22	179	41	40	68	293	150	200
Flouride (mg/l)	22.0	3.65	16.61	13.21	11.26	4.62	23.61	9.40	3.36	3.22	4.00	13.31	2.0	1.5
Sulphate	482.51	544.51	478.66	56.32	344.52	414.64	353.5	564.6	342.5	233.8	127.5	236.1	450	500
Faecal Coliform (cfu/100ml)	20.11	N.D	1.22	6.9	1.53	N.D	20.11	1.22	ND	ND	1.53	6.91	0	0
Total Coliform (cfu/100ml	3.43	N.D	2.69	1.32	6.76	N.D	13.8	3.45	ND	ND	0.45	1.67	0	0

N.D: Not Detectable, **NS**: not stated, **NSDWQ:** Nigerian Standard for Drinking Water Quality, **W_1**: Idigba Sabo River, **W_2**: Oke Ose Borehole, **W_3**: Falokun Araromi Well, **W_4:** Kusoninguba Well, **W_5,** Isokun Well, **W_6**: Obaloyan Well, **W_7**: Esanti Well, **W_8**: Rani Ramat River, **W_9**: Amgberi Tap, **W_{10}**: Alaya Borehole, **W_{11}**:Igberi Owode stream, **W_{12}**: Kokodo River

Turbidity and pH

Turbidity in drinking-water is caused by particulate matter that may be present from water source as a consequence of inadequate filtration. These particulates can protect microorganisms from the effects of disinfection and can stimulate bacterial growth (Hunter *et al.*, 2009b). In all cases where water is disinfected, the turbidity must be low so that disinfection can be effective. Turbidity is also an important parameter in process control and can indicate problems with treatment processes, particularly coagulation, sedimentation and filtration (Hunter *et al.*, 2009a). No health-based guideline value for turbidity has been proposed; however, it should be below 0.1 NTU for effective disinfection (Katsi, *et al.*, 2007). From Tables 2 only three samples have their turbidity value below the acceptable value, bore hole at Oke Ose, a shallow well at Esante and another borehole at Alaya. Some forms of primary treatment like flocculation and coagulation therefore need to be carried out on this water sources before any disinfection treatment can be done, otherwise, high turbidity values will shield the pathogenic organisms from chemicals and render the treatment ineffective.

There is no health based guideline for pH, although a range of 6.5–8.5 is often suggested because aquatic life is negatively affected below pH 6.0 (Machingambi & Manzungu, 2003). Additionally at low pH, the water is corrosive and can cause wear to equipment. All the water samples have their pH within the allowable limit and therefore, no pH correction is needed.

Total Dissolved Solid (TDS) and Suspended Solid (SS).

There is no evidence of any epidemiological reaction at high level of TDS, but water becomes unpalatable and may lead to corrosion of containers (Kruawal *et al.*, 2005). Consequently, WHO, (2006) set the highest permissible values of 1000mg/L. The palatability of water with a TDS level of less than 600 mg/L is generally considered to be good. From Tables 2, the samples that have very low TDS are samples collected from Tap at Angberi, borehole from Alaya and another borehole at Oke Ose. Other samples have their values though lower than WHO, (2006) recommended value, the values are higher than what NSWDQ, (2007) recommended as permissible level for domestic water supply. Although, no particular values are stipulated for SS by both WHO and NSWDQ, its values in water samples should be checked whenever any treatment method is being contemplated (Birol *et al.*, 2006),

Total Hardness and Electrical Conductivity (EC)

Total hardness is determined by amount of calcium, magnesium and potassium in a particular water sample. Their high concentrations are generally not a health concern but a guideline value of 200mg/l is set by WHO, (2006). This may be due to an inverse relationship that exists between cardiovascular disease and water hardness, with increased risk occurring with Calcium concentrations less than 60 mg/L (Rietveld *et al.*, 2009). In large concentrations, they may also affect the taste of the water which also leads to soap wastage if the water is used for washing (Graciana, 2010). All the water samples except Idigba Sabo river, a shallow well at Obaloyan and a river at Kokodo have their total hardness values greater than the recommended limit.

Electrical conductivity is the ease to which a substance allows free flow of electricity through the ions in electrolytes example of water sample, (Mwendera, 2006). The Nigerian Standard for Drinking Water Quality has set a maximum permissible level of the conductivity to be 1000 μS/cm. Any level above this can pose health risk of defective endocrine functions and also total brain damage with prolonged exposure (Hunter *et al.*, 2009b). The water samples have their EC very close to recommended values except for Idigba Sabo river, Kusoninguba well, Esanti well and Rani Ramat river. The high value of EC may lead to defective endocrine functions if used for drinking purpose.

Iron Content

The maximum contaminant levels of the iron content based on WHO, (2006) and Nigerian Standard for Drinking Water Quality (NSDWQ, 2007) is 0.3 mg/l. Despite not being a health concern, high concentrations of iron affect the quality of water, leading to bad taste and colouration of cooking utensils and food (Schafer *et al.*, 2009). This has caused hundreds of shallow wells to be abandoned. The alternative water sources for the rural dwellers are surface water sources which probably may not be better in terms of microbiological quality. There is no noticeable taste at iron concentration below 0.3mg/l, although turbidity and colour may develop (Kruawal *et al.*, 2005). Only five of the water samples have their iron content lower than recommended value. However, Eshanti Shallow well and Igberi Owode stream have their iron contents much higher than the recommended limit. This high iron content may probably be attributed to their location that is very close slaughter slab of the community and as such waste blood may be carried by runoff and deposited into the stream and shallow well.

Sulphate and Fluoride

Sulphate does not have a health-based guideline value; however the WHO recommends that a concentration higher than 500 mg/l is unhygienic due to problems to the gastro intestinal tract (Katsi *et al.*, 2007). All the water samples except two, Oke Ose bore hole and Rani Ramat river have their Sulphate (SO_4^{2-}) values higher than recommended limit.

Fluoride (F^-) offers protection against dental decay at low concentrations but at higher levels above 4 mg/l causes serious problems such as dental and skeletal fluorosis (Kruawal *et al.*, 2005). All the samples have their fluorine content higher than values recommended by both WHO and NSDWQ. Esanti well, Falokun Araromi well and Kusoninguba well however have their fluorine values at an elevated value. The high level of fluoride in shallow well can be corrected by introducing a concrete lining. Head wall can also be constructed on these wells to minimize surface runoff in to them.

Nitrate

Nitrate is a nitrogenous compound that when it is in excess in our drinking water can cause reduction of oxygen capacity of blood, shortness of breath and blueness of skin. The Nigerian Standard of Drinking Water Quality has set 10mg/L for Nitrate. It has a WHO guideline value of 50 mg/l and if exceeded it is regarded as one of the causes of methaemoglobinaemia (Blue Baby Syndrome) in infants (Rossiter *et al.*, 2010) as well as a potential risk of stomach cancer in adults (Mwendera, 2006). High concentration of nitrate in both surface and shallow groundwater can probably due to poor sanitation and latrine construction, fertilizer and other agrochemical use. From table 2, only two of the water samples, Falokun Araromi well and Obaloyan well have their nitrate values higher than WHO value but five samples have their values higher than NSDWQ, (2007) standards. High nitrates concentrations in drinking waters point often towards contamination (Riemann *et al.*, 2003). Therefore, water sources with high nitrate values need to be checked for bacteria contamination

Bacteriological Parameters

The presence of E-coli provides evidence of recent faecal contamination and the detection should lead to further action (Sworobuk *et al.*, 1987). It is present in high number in human and animal faeces and rarely found in the absence of faecal pollution. Total coliform should be absent immediately after water disinfection and the presence of this organism indicate inadequate treatment (Esther, 2007). Their presence can also reveal regrowth and possible biofilm function or contamination. They occur in both sewage and natural wastes and can also be excreted with human and animal faeces (Linda Stalker, 2005). Both WHO, (2006) and NSDWQ, (2007) recommend zero values for total coliform and E-coli. However, only four of the water samples taken are free from these bacteria. That may be linked to high level of dysentery and diarrhea in the area under investigation (Clasen & Bastable, 2003). The medical officers in charge of the health centers in the villages confirmed frequent occurrence of water-borne diseases especially dysentery and diarrhea. They treat an average of sixty three cases of these diseases every week and the children are majorly affected. It was also reported that within the last five years, only eighteen cases of Blue baby syndrome were recorded in the six villages covered. Research has shown that these bacteria cannot withstand high temperature (Montgomery & Elimelech, 2007, Schmidt & Caircross, 2008). It is therefore necessary to encourage the water user to always boil their water before using it for domestic purposes.

CONCLUSIONS AND RECOMMENDATIONS

It is very clear from this study that rural dwellers in Kwara State, North Central Nigeria are neglected in water supply schemes. The water quality in these areas fall short of the water quality standard of WHO and Nigerian Standard for drinking Water Quality, (NSDWQ). The rural areas have a good capacity of surface and groundwater potential that can be exploited to cater adequately for their water need. It is observed that the hand dug well people constructed for themselves is not enough to cater for their need because it dries up during the dry season. Therefore, the Government with collaboration with Civil Society group and non-Governmental organizations should come to the aid of these people. There is a need to create awareness of the hazards of drinking bacteriologically contaminated water and the rural dwellers should be trained on how contamination of water sources can be prevented. Any form of improved water supply requires community participation and commitment by the locals to ensure that long-term needs are met. More detailed sampling should be carried out in other areas of North Central region of Nigeria to have a complete account of their rural water supply system.

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