Elsevier Editorial System(tm) for Physics and Chemistry of the Earth
Manuscript Draft

Manuscript Number:

Title: SOURCE TO POINT OF USE DRINKING WATER CHANGES AND KNOWLEDGE, ATTITUDE AND PRACTICES IN KATSINA STATE, NORTHERN NIGERIA

Article Type: Special Issue: 11th WaterNet

Keywords: Key Words: drinking water quality; monitoring; Knowledge, Attitudes Practices; source to point of use

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Abstract: Abstract
In many sub-Saharan countries such as Nigeria, inadequate access to safe drinking water is a serious problem with 37% in the region and 58% of rural Nigeria using unimproved sources. The global challenge to measuring household water quality as a determinant of safety is further compounded in Nigeria by the possibility of deterioration from source to point of use. This is associated with the use of decentralized water supply systems in rural areas which are not fully reticulated to the household taps, creating a need for an integrated water quality monitoring system. As an initial step towards establishing the system in the north west and north central zones of Nigeria, The Katsina State Rural Water and Sanitation Agency, responsible for ensuring access to safe water and adequate sanitation to about six million people carried out a three pronged study with the support of UNICEF Nigeria. Part one was an assessment of the legislative and policy framework, institutional arrangements and capacity for drinking water quality monitoring through desk top reviews and Key Informant Interviews (KII) to ascertain the institutional capacity requirements for developing the water quality monitoring system. The second part was a water quality study in 700 households of twenty three communities in four local government areas. The objectives were to assess the safety of drinking water, compare the safety at source and household level and assess the possible contributory role of end users' knowledge attitudes and practices. These were achieved through water analysis, household water quality tracking, KII and questionnaires. The third part was the production of a visual documentary as an advocacy tool to increase awareness of the policy makers of the linkages between source management, treatment and end user water quality. The results indicate that except for pH, conductivity and manganese, the improved water sources were safe at source. However there was a deterioration in water quality between source and point of use in 18%, 12.5%,27% and 50% of hand pump fitted boreholes, motorised boreholes, hand dug wells and streams respectively. Although no statistical correlation could be drawn between water management practices and water quality deterioration, the survey of the study households gave an indication of the possible contributory role of their knowledge, attitudes and practices to water contamination after provision. Some of the potential water related sources of contamination were poor source protection and location, use of

unimproved water source and poor knowledge and practice of household water treatment methods, poor hand washing practices in terms of percentage that wash hands and use soap. Consequently 34 WASH departments have been created at the local government level towards establishment of a community based monitoring system and piloting has begun in Kaita local government area.

Highlights

- High pH, conductivity and manganese levels in source waters
- Deterioration in microbial quality more prevalent in unimproved than in improved sources
- No significant correlation between water quality and water handling practices
- Indications of potential contributory WASH KAP obtained from survey
- Visual documentary a powerful evidence based tool for policy makers

SOURCE TO POINT OF USE DRINKING WATER CHANGES AND KNOWLEDGE, ATTITUDE AND PRACTICES IN KATSINA STATE, NORTHERN NIGERIA

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Abstract

In many sub-Saharan countries such as Nigeria, inadequate access to safe drinking water is a serious problem with 37% in the region and 58% of rural Nigeria using unimproved sources. The global challenge to measuring household water quality as a determinant of safety is further compounded in Nigeria by the possibility of deterioration from source to point of use. This is associated with the use of decentralized water supply systems in rural areas which are not fully reticulated to the household taps, creating a need for an integrated water quality monitoring system. As an initial step towards establishing the system in the north west and north central zones of Nigeria, The Katsina State Rural Water and Sanitation Agency, responsible for ensuring access to safe water and adequate sanitation to about six million people carried out a three pronged study with the support of UNICEF Nigeria. Part one was an assessment of the legislative and policy framework, institutional arrangements and capacity for drinking water quality monitoring through desk top reviews and Key Informant Interviews (KII) to ascertain the institutional capacity requirements for developing the water quality monitoring system. The second part was a water quality study in 700 households of twenty three communities in four local government areas. The objectives were to assess the safety of drinking water, compare the safety at source and household level and assess the possible contributory role of end users' knowledge attitudes and practices. These were achieved through water analysis, household water quality tracking, KII and questionnaires. The third part was the production of a visual documentary as an advocacy tool to increase awareness of the policy makers of the linkages between source management, treatment and end user water quality. The results indicate that except for pH, conductivity and manganese, the improved water sources were safe at source. However there was a deterioration in water quality between source and point of use in 18%, 12.5%,27% and 50% of hand pump fitted boreholes, motorised boreholes, hand dug wells and streams respectively. Although no statistical correlation could be drawn between water management practices and water quality deterioration, the survey of the study households gave an indication of the possible contributory role of their knowledge, attitudes and practices to water contamination after provision. Some of the potential water related sources of contamination were poor source protection and location, use of unimproved water source and poor knowledge and practice of household water treatment methods, poor hand washing practices in terms of percentage that wash hands and use soap. Consequently 34 WASH departments have been created at the local government level towards establishment of a community based monitoring system and piloting has begun in Kaita local government area.

Key Words:* *drinking water quality, monitoring, Knowledge, Attitudes Practices, source to point of use

Introduction

The Millennium Development Goal (MDG) 7 aims to halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation. According to The WHO/UNICEF (2010), Sub-Saharan Africa faces the greatest challenge in increasing the use of improved drinking-water facilities with 37% of the 884 million people that still use unimproved sources living in this region. In Nigeria for example only about half (58%) of its very large population (1.5milion) have access to improved drinking water sources.

The challenges in increasing access to improved drinking water is further complicated by disparities in provision, which may be geographical (between urban and rural); socio economic (between the poor and more economically disadvantaged) or related to the disproportionate focus on water in comparison with sanitation. For example in comparison to the 72% of Nigerians in the urban areas only 47% of the rural populace have access to improved water sources; whilst the ratio of water access to sanitation is only 2:1 (58% water:26% adequate sanitation)(WHO/UNICEF 2010). The north central (NC), north eastern(NE) and north western(NW) zones of Nigeria are affected by these disparities with improved drinking water access of 52.2%, 27.3%, 42.5% respectively in comparison to 72.7% and 54.1% in the south western (SW) and south eastern(SE) zones respectively. Furthermore, only 29%, 34.4%, 34.1% in NC, NE and NW respectively use improved sanitation in comparison to 55.5% and 55.0% in SE and SW zones respectively (NBS, 2007).

The implications of these are grave with diarrheal diseases causing 1.8 million deaths and approximately 4 billion cases of illness annually (WHO, 2007). The great majority of those affected are children in developing countries. In Nigeria, between 5.4% and 12.5 % of the children surveyed had diarrhoea in the two weeks preceding the Multiple Indicator Cluster study (MICS) in the south west and north east respectively (NBS, 2007).

For decades, universal access to safe water and sanitation has been promoted as an essential step in reducing this preventable disease burden, using decentralised water supply interventions as a major strategy to address the disparity in access, with the World Bank investing US$5.5 billion in rural water and sanitation from 1978 to 2003 in mainly (95%) community level interventions; which are not fully reticulated to the households thus predisposing rural supplies to recontamination along the collection, transportation and storage water chain (Clark and Gundry 2004; Iyer *et al.,* 2006 ; Meierhofer and Landolt, 2009; WHO/UNICEF, 2010).

Enabor (1998) in a Nigerian field trial of solar water disinfection found that household water storage containers (before exposure to the sun) had a percentage increase in coliform count of between 543% and 6000% when compared to their original well water sources. This observed inability to guarantee water that is consistently safe at the point of use in decentralized systems provides justification for the school of thought which believes that there is a need to expand access to household water treatment systems, water storage and water quality monitoring at the point of use (Mintz *et al.,* 2001; Wright, 2004). In spite of the globally available evidence that indicates that   simple acceptable low cost interventions at the household and community level are capable of reducing the attendant risks of diarrheal disease and death (WHO, 2007), there is no context specific information on efficacy of household water treatment in the northern parts of Nigeria to influence strategic planning. The study was implemented as the first step towards promoting a comprehensive community based drinking water quality system in northern Nigeria.

It aimed to assess institutional capacity for household level drinking water quality monitoring in Katsina state; ascertain the safety and possible deterioration of drinking water provided to communities from source to point of use and examine the contributory role of the study households' water and sanitation related Knowledge Attitudes and Practices (KAP) to the observed deterioration in quality.

Methodology

To facilitate understanding, the method for each of the three parts of the study is described after the description of the study area.

The study area

Katsina state is situated in the northern western zone of Nigeria with a current projected population of 5,792,578 million out of which 60% is rural (NBS, 2006). It is made up of 34 local government areas and is bordered to the north by the Republic of Niger, and by the Nigerian states of Jigawa and Kano to the east, Kaduna to the south and Zamfara to its west. Rainy season is from May to September, with an annual average of 750 mm (Adefolalu, 1986). The main vegetation type is shrub vegetation with some wooded savannah in the south. It is mainly inhabited by Muslim Hausa (the Katsena [Katsenawa], Kano [Kanawa], and Bugaje branches) and Fulani peoples and by a few Maguzawas (animistic Hausas), who farm as the main occupation.

Methods for part 1

A consultant was hired by the Katsina state government with the support of UNICEF Nigeria, to collect and document information from the relevant stakeholders in Katsina state using Key Informant Interviews (KII) on water quality related legislation and policies, institutional arrangements and capacity for water quality monitoring, financing mechanisms, availability of water quality monitoring tools and challenges to water quality surveillance/monitoring. Data collection methods included desk top review of relevant documents, KII with relevant stakeholders and site inspections of infrastructure such as laboratories. The stakeholders included the state ministries of Water Resources, Health, Environmental Protection Agency and Local Government and Chieftaincy Affairs, Water Board, the Rural Water and Sanitation Agency and the Primary Health Care department. At the local government level, the local government councils, the water and sanitation units as well as the community level water and sanitation committees. The results obtained were then presented at a zonal workshop for the states in the north western and north central zones.

Methods for part 2

The study was conducted in twenty three (23) communities in four (4) Local Government Areas (LGAs) of Katsina state they are low income and characterised by poor infrastructure. The descriptive cross-sectional study employed a three stage sampling procedure. Firstly, randomly selecting 40% of the International Year of Sanitation (IYS) LGAs based on the national population census, 2006. Secondly, randomly selecting 40% of the IYS communities in each of the selected LGAs and proportionally allocating sample sizes to the selected communities based on the proportion of each LGA's population to the total state population. The last stage was the random selection of households for questionnaire administration.

Using this method, 711 respondents were selected for questionnaire administration and 56 water sources from the 23 communities. In addition, 56 samples were taken from households before the water was poured into their storage containers (Household Fresh - HHF), 56 samples from household storage (HHS), 8 samples from the sediments in the storage container and one (1) sachet of vended water, a total of 121 samples from source and households were analysed to assess their bacteriological and physico chemical properties (Table 1).

Qualitative and quantitative information was collected by a team of trained interviewers using Focus Group Discussions (FGD), Key Informant Interviews (KII), semi structured questionnaire, observational check list, laboratory analysis as well as Geographic Information Systems. The most senior person in the household was interviewed. The qualitative information obtained included the ascertainment of the type and functionality of water sources, potential sources of pollution (poorly constructed or located latrines, open rubbish dumps and open drains). At the household level, the presence, type and conditions of water and sanitation facilities, water handling, treatment and storage practices, sanitation and hygiene practices and common water supply , sanitation and hygiene (WASH) related ailments in the selected communities. The information obtained from observations was used to examine the veracity of the results from the survey.

The quantitative information obtained through a validated semi-structured questionnaire included demographic and socio-economic characteristics; WASH knowledge, attitude and practices (KAP) of members of the households.

Information was obtained about the physico chemical and bacteriological characteristics of 56 water sources: 8 solar powered (motorised) boreholes, 11 hand pump boreholes, 33 hand dug wells, 3 streams and 1 pond used by the community for drinking. Water from these sources was traced to 56 of the 711 KAP households to link the water collected from a household to its source. Samples were thus collected from (i) the sources, (ii) the households before pouring into the household storage container (HHF) and (iii) from the household storage (HHS) after it had been stored for at least 24 hours.

The samples from ‘Source’, HHF and HHS were analyzed for physico-chemical and bacteriological characteristics according to recommended standard methods described by the American Public Health Association (APHA, 1995). Parameters determined for physico-chemical analysis include: pH, colour, turbidity, electrical conductivity, total dissolved and suspended solids, chloride, hardness, alkalinity/acidity, and nitrate, specific toxic chemicals (lead, fluoride, arsenic and iron, zinc, copper, chromium, nickel, cadmium, manganese). House hold samples for heavy metals were acidified with concentrated nitric (tri-oxo-nitrate (IV) acid to keep the metals in solution and to minimize their adsorption to the walls of the sample bottle. The physico-chemical analysis was carried out using titrimetric, gravimetric and spectrophotometric methods. Heavy metals were determined using Atomic Absorption Spectrophotometer (AAS). Total coliforms and *E. coli* were determined using the Most Probable Number (MPN) and faecal coliform was determined using Plate Count using EMB Agar as described in APHA (1995).

Methods for part 3

A film production company was hired to produce a documentary. A technical script was provided as a basis for its development. The script covered the following areas: (i) The importance of water to all aspects of life, (ii) the potential for water to become a vehicle for chemical and microbial diseases, (iii) urban and rural drinking water quality problems, (iv) the drinking water management system, (v) drinking water problems being experienced by technocrats and (vi) community and government roles in drinking water management from source to point of use. The documentary was produced by filming real life situations in relation to the script and interviewing government and urban and rural consumers.

Results

Part 1

The draft National Water Resources Bill 2009, aims to support initiatives to reduce and prevent water resources pollution. The interviewed stakeholders were more familiar with the WHO drinking water guidelines than The Nigerian Standard for Drinking Water Quality 2007. The Federal Ministries of Health, Water Resources, Environment, Standard Organisation of Nigeria, and the River Basin Authorities are the key agencies statutorily responsible for various aspects of drinking water quality management. The same organisations as well as the State Drinking Water Quality Surveillance (not yet established) organisation are statutorily responsible at the state level. Local government health departments, communities and consumers also have their designated responsibilities. The interviews showed that stakeholders in many cases are not familiar with their roles. At the time of the interview, though water quality monitoring was being carried out by local government and the state Water Board, gaps were reported in terms of staff qualification, retraining, field site transportation, quality control, record keeping , and standardisation of equipment and reagents and laboratory infrastructure.

Part 2

Socio demographic characteristics

Male respondents account for 506 (71.2%) of total respondents sampled and the married respondents 631 (88.7%). 607 (85.4%) of the respondents have a form of education, the highest education level in the sampled communities is Qu'ranic school attended by 383 (53.4%). Farming is the major occupation of 448 (63.0%) respondents , majority of who are Hausa/Fulani 681 (95.8%) who are predominantly 661 (93.0%) Muslim.

Safety of drinking water provided to communities

Physico chemical characteristics were examined at the source and at the household level. Each parameter was compared with the Nigerian Standards for Drinking Water Quality (2007). The results were aggregated for the 23 communities in the 4 LGAs and sub analysis also carried out within the LGAs.

Physical quality of drinking water

The mean pH values for hand pump (HP) (6.3) and hand dug well (HDW) (6.2) from the 23 communities sampled in the 4 LGAs are outside the allowable limit. When disaggregated to LGA level all HP except Kaita LGA had acceptable levels, all HDW remained outside acceptable limits except in Matazu LGA and the pH of motorised boreholes (MBH) in all

LGAs except Matazu and Kaita fell outside the allowable limits. The mean colour of samples from sources and HHS did not exceed the allowable levels of 15 Hazen units, except for the source and storage samples from stream and pond (SP) with values of 200.1 and 23.7 Hazen units respectively. The mean conductivity values of 2 793.0, 2 204.6, 2 625.1 at source for MBH, HP, HDW respectively were above accepted standards of 1000 µs/cm and close to the limit for SP (994.8 µs/cm), the pattern was repeated at the HHS with 2642.1, 1863.5, 2499.3, 1005.8 for MBH, HP, HDW and SP respectively. The chloride, total dissolved solids, fluoride, nitrate, sulphate and total hardness levels were within the allowable limits. There were however variations within the LGAs for example in Kaita LGA, the mean total hardness levels of the HHS from motorised boreholes (MBH) and the mean nitrate levels of HDW sources in Bakori LGA are outside the recommended levels (Table 2).

The results of the heavy metals analysis of source waters and sediments from household drinking water storage containers indicated that of the samples analysed (Cu, Zn, Pb, Cd, Ni, Cr , Al, Mn, As) the manganese levels of most samples were above the standards recommended for safety in the 4LGAs , for example 83% in Ingawa LGA were above the safely limits of 0.2mg/L with a range of 0.201 to 0.474mg/L (Table 3 gives an indication of HHS sediment samples from Ingawa LGA) .

The microbial quality of all the water samples except MBH as indicated by the Total Coliform maximum values, were above the acceptable WHO limits at source and household level with the hand dug wells and stream being highest at source (27/100mL and 359/100mL respectively) and also at HHS 280/100mL and 280/100mL respectively).

Tracking of water quality changes from source to household

The bacteriological quality of water samples are tracked from source to households. This was done by tracking 56 households from source to samples taken before it had been poured into storage container (HHF) and to samples in storage container (HHS). In summary, the findings indicate that the nitrate and chloride values did not change significantly from source to HHF and HHS, there were however variations in the total and faecal coliform counts from source to household.

Of the four (4) households that obtained their water from streams, two (2) showed a reduction in total coliforms from source to the HHS from 350/100ml to 34/100m/l and from 280/100ml to 17/100ml. The water handling practices of one households was not reported, whilst the other reportedly treated its water by sedimentation and cloth filtration, reportedly washed hands though no evidence of soap seen, covered their water, had a toilet facility and reportedly cleaned it every day. The remaining two (2) households showed an increase in total coliforms from source to HHS. The water handling practices of the households were similar except that the household with the largest increase reported cleaning their toilet twice a week in comparison to the other three households that reportedly cleaned daily.

27% (9) of the samples taken from thirty three (33) hand dug wells and tracked to household storage in the 4 LGAs, increased in total coliform counts from the source to the household HHS , with a percentage increase range of 16.67% to 28 000% . Even though all but two of the households,(including the household with the highest increase in total coliforms) reportedly treated their drinking water with either sedimentation only or filtration only. All except one household (700% increase) had toilets, evidence of covered storage containers and reportedly washed their hands with soap. 33% (11) showed a decrease in total coliforms (range 90.3% to 97.4%). No clear relationship with the water management practices was identified. The household with the highest decrease indicated that it did not treat water but wash hands with water only. The remaining 39% (13) households maintained their microbial quality from source to household level, of these, only one reportedly treated its water by boiling but all had toilets.

Of the 8 motorised boreholes tracked to 8 households in the 4 LGAs one (1) showed a percentage increase in total coliform count from source to household HHF of 200% though it reportedly treated its water. 2 households had percentage decreases (100%), the only common practices between them were possession of toilets and covers. The remaining 5 households had unchanged total coliform levels. The only common water management practice among this group was their possession of toilets (Table 4).

Of the 11 hand pump fitted boreholes tracked, 18% (2) had a percentage increase in total coliform count of 900% and 1700%. The common water practices noted among them was that they covered their water, had toilet facilities which they reportedly cleaned every day. The total coliform counts of 27.2% (3) households decreased (range58.8% -100%), none of the two households with available information treated their water, though there was evidence of hand washing with soap, storage covers and possession of toilet facilities which they indicated that they cleaned every day. The remaining 54.5% (6) households which had unchanged total coliform counts all possessed toilets, storage container covers, all but one cleaned the toilet daily and all but one reportedly treated their water

Potential sources of water related contamination

About half (54.8%) the respondents reportedly used improved sources of water with 118 (16%) using protected hand dug wells. However it was observed that none of these wells had the full complement of sanitary features and so should have been reported as unimproved. Though it took 551 (77.5%) of the sources less than 30 minutes to fetch water and return home, 116 (16.3%) indicated that they use less than 50 litres / day/household. 288 (40.5%) respondents indicated that in the last 2 weeks before the study their major water source had been unavailable for at least one whole day. 413 (58.1%) of the respondents said they resorted to unimproved sources at such times. With regard to water handling and storage it was observed that 606 (85.2%) of the storage containers had covers and 565 (79.5%) indicated that they used a cup with handle to take water from the storage container and a separate container for taking water from the storage container was observed in 582 (81.9%) households. Only about half of the respondents 369 (51.9%) indicated that they practiced any form of household water treatment with filtration through cloth being the most commonly practiced 77 (10.8%); closely followed by boiling 61 (8.6%), addition of chlorine 33 (4.6%) and other combined forms of treatment.

Potential sources of contamination from sanitation related Knowledge Attitudes and Practices

The study findings indicated that 686 (89.7%) reported using unimproved means of excretal disposal with 591(83.1%) using traditional pit latrines and 37 (5.2%) practiced open defecation. The interviewers' observations confirmed these reports with 596 (83.8%) being observed to have an excretal disposal facility. With regard to under 5 child faeces management, most respondents 531 (74.7%) knew that children faeces were harmful and 541 (76.1%) reported throwing their under 5 children's feaces into the toilet. Almost half, 353 (49.6%) reported that they washed hands with water and soap, the interviewers found evidence of water for washing outside the toilets in 342 (48.1%) households but only 245 (34.5%) of the households had water and soap outside the toilets. Other reported hand washing practices included washing with water and ashes 13 (1.8%), and with sand and water 42 (5.9%). 216 (30%) respondents said the minimum distance between a water facility and toilet should be greater than 30m.

On maintenance of household toilet facilities, 284(39.9%) reported that they cleaned their toilets on a daily basis and 144 (20.3%) every other day. This tallied with the interviewers' observations that 520 (73.2%) households had toilets kept in a fair or good condition. With regard to solid waste management, 258 (36.3%) of the respondents reported disposal of their wastes in dump sites, 261 (36.7%) open dumping, 50 (7.0%) in pit and 66 (9.3%) burned their wastes.

Discussion

The assessment of the institutional and legislative framework for community based water quality monitoring indicates that the enforcement and compliance with the national drinking water quality guidelines is poor for reasons related to the non existence of the organisation statutorily responsible for surveillance at the state level, paucity of manpower, logistics, laboratory infrastructure, equipment and reagents. There is a need for the national, state and local government to address the gaps highlighted in the study by building institutional capacity with regard to human, financial and physical resources needed to implement state wide community based water quality monitoring and surveillance.

The high pH levels of all samples from hand dug wells, motorised boreholes and some hand pumps and the high conductivity of all samples from source and HHS is of concern due to the possible reduction of disinfection and resultant unacceptable taste and odour, which might lead consumers to seek less safe alternative sources and predispose them to water borne diseases (WHO, 2008). Though generally, the chemical characteristics were within acceptable limits, the occurrence of high total hardness in some of the samples is of concern due to the economic costs incurred from the need to use more soap in laundry and objectionable tastes of very hard water which might lead consumers to seek less safe alternative sources (WHO, 2008). The high level of manganese observed in most of the samples is of importance as it leads to an objectionable taste in drinking water and some studies have indicated a risk of neurological disorder when inhaled (WHO, 2008). The poor microbial quality of all the sources (except motorised boreholes) exposes consumers to water borne diseases. A surprising finding is the observed low faecal coliform counts at source and HHS which is validated by the low chloride and nitrate levels at source and household level as this parameters also indicate faecal and urea contamination. This might be due to the high number of toilets as observed (83.8%) and self reported (83.1%) in the study.

There was no change in the physico chemical characteristics when tracked from source to household level e.g. the nitrate and chloride levels remained the same. There were however changes observed in microbial quality between source and household this was however not in a constant direction. In some instances, there was deterioration whilst in others there was an improvement and in many others it remained unchanged. The deterioration may be attributed to poor water, sanitation and hygiene practices, whilst the improvement may be attributed to the natural die off patterns of bacteria. No clear pattern was observed between water treatments, hand washing with soap, cover on water storage containers with the observed microbial quality. This may be due to the fact that hand washing and water treatment were self reported and water treatment not validated by the investigators. The validation of the hand washing showed a discrepancy between what was self reported as a practice by almost half 353 (49.6%) of the respondents and observation of soap outside the toilets 245 (34.5%). The high total coliform count of the hand dug wells might be due to the absence of sanitary features observed in all the wells, there is a need for community training in proper well construction as well as maintenance of the boreholes, 413 (58.1%) respondents indicated that they resorted to using other sources when their main water source was non functional. The self reported use of cups with long handles by 565 (79.5%) and observation of separate containers for taking water in 582 (81.9%) is a good practice which should be encouraged and a possible explanation for the low faecal coliform count observed at source and household level. Household level water treatment is not as high as would be expected with only about half self reporting the use of any form of treatment. The high number of traditional latrines 591(83.1%) self reported and 596 (83.8%) observed as well as the limited open defecation 37 (5.2%) may be another reason for the low levels of faecal coliforms in source and household waters sampled.

Conclusion

The results indicate that the institutional framework for the establishment of the monitoring system in Katsina state needs to be improved. The waters provided at source are safe for consumption with regard to most physico chemical parameters, except for pH, conductivity, hardness and manganese with potential health and economic consequences. The constancy of the physico chemical characteristics between source and household indicates that chemical quality control can be maintained from source to point of use if the source development is correctly carried out. However the change in microbial quality suggests the importance of proper source development, protection, treatment and safe storage at household level. The findings suggest that though traditional latrines are considered unimproved, they were adequate for excretal management perhaps due to their cleanliness as observed in 520 (73.2%) of households. It is recommended that rather than discouraging the customary use of traditional latrines, users should be made aware of the importance of maintaining them hygienically. The validation of aspects of the survey with interviewer observation and the closeness of the results obtained from both sources indicates that the survey findings are a true reflection of the investigated areas. It is recommended that such studies validate water treatment claims through chlorine residual testing, observation of treatment apparatus to improve the ability to link water treatment and other water management practices with household water quality. Even whilst the sector seeks to improve the technical aspects of water quality management, it is important to ensure that policy makers are sensitized by providing them with visual and technical evidence to influence informed decision making and the release of the required funds.

Acknowledgement
The contributions of UNICEF Nigeria and Katsina State Rural Water and Sanitation Agency, who sponsored this study is acknowledged and appreciated.

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Table

Table 1: Population Sample Size and Water Sampling Size in Katsina State

S/N	LGA	Community	Respondent	Source water sample	Household Fresh	Household Storage	Sachet water	Storage container sediment heavy metal sampling
		Kurami	23	3	3	3	0	
		Rafin Kanya	23	2	2	2	0	
		Kabomo	23	3	3	3	0	
		Ungwarn Abdulrashid	21	2	2	2	0	
		Karofin Doka	23	3	3	3	0	1
		Ungwarn Lamido	23	3	3	3	0	
		Babban Kufai	23	3	3	3	0	
		Adako	23	3	3	3	0	1
		Yar Rumfa	23	2	2	2	0	
1	**Bakori**	**Total**	**205**	**24**	**24**	**24**	**0**	**2**
		Tabobi	35	2	2	2	0	1
		Rinjin Gora	35	2	2	2	0	
		Mallamawa	35	1	1	1	0	
		Kagara	35	3	3	3	0	1
		Faras	35	1	1	1	0	
2	**Matazu**	**Total**	**175**	**9**	**9**	**9**	**0**	**2**
		Yandoma	43	3	3	3	1	
		Ganjuma	42	3	3	3	0	1
		Karkarku	42	3	3	3	0	1
3	**Ingawa**	**Total**	**127**	**9**	**9**	**9**	**1**	**2**
		Gafiya	34	3	3	3	0	1
		Kokaya	34	=	=	=	=	
		Yanhoho	34	3	3	3	0	
		Modibawa	34	3	3	3	0	1
		Dutsin Safe	34	3	3	3	0	
		Waila	34	2	2	2	0	
4	**Kaita**	**Total**	**204**	**14**	**14**	**14**	**0**	**2**

Table 2: Some Chemical Characteristics of Water of Samples from Sources and Storage Containers in the 4 LGAs

		MAL	Total			Bakori			Matazu			Ingawa			Kaita		
Facility	Parameter		min	max	Mean	Min	max	mean	min	max	mean	min	max	mean	min	max	mean
source-	Chloride	250															
MBH	(mg/l)		2.4	197.1	35.7	-	-	-	2.4	18.2	7.5	6.4	6.4	6.4	5	197	72.8
HP			2.1	46.1	8.7	2.1	5	3.4	2.1	2.1	2.1	5	9.9	7.4	2.1	46.1	20.6
HDW			3.5	70.2	33.6	3.5	205.6	49.1	3.5	3.5	3.5	7.8	31.9	17.6	3.5	70.2	16.4
SP			3.5	7.1	5	3.5	3.5	3.5	4.4	7.1	5.5	-	-	-	-	-	-
storage-HHS																	
MBH			2.6	208.4	40.8	-	-	-	2.6	15.6	7.9	4.3	4.3	4.3	5.7	208	85.1
HP			1.4	11.3	4.6	1.4	5	3.4	4.3	4.3	4.3	5	7.8	6.4	2.1	11.3	5.6
HDW			0.7	70.9	41.9	0.7	378	62.5	7.8	7.8	7.8	7.8	29.8	20.2	1.4	70.9	18.9
SP			4.4	14.9	8	4.4	4.4	4.4	5	14.9	9.2	-	-	-	-	-	-
(avg)			0.7	378	31.2	0.7	378	47.1	2.6	15.6	7.9	4.3	29.8	15.4	1.4	208	18.9
sachet			2.8	4.3	3.6	4.3	4.3	4.3	-	-	-	2.8	2.8	2.8	-	-	-
source-	Total hardness	150															
MBH	(as $CaCO_3$)		25	298	95.4	-	-	-	38	126	78.8	25	25	25	30	298	134
HP			21	190	74.5	35	134	77.6	77	77	77	21	22	21.5	60	190	103.7
HDW			25	234	93.7	38	308	117.6	118	118	118	30	96	58.7	25	234	66
SP			40	65	51.3	52	52	52	40	65	51	-	-	-	-	-	-
storage-HHS																	
MBH			19	343	103.1	-	-	-	36	124	75.8	19	19	19	57	343	154
HP			19	121	60.9	42	90	63.2	121	121	121	19	37	28	51	66	59
HDW			23	207	87	34	253	107.5	112	112	112	26	102	60.7	23	207	60
SP			38	56	47.3	46	46	46	38	56	47.7	-	-	-	-	-	-
(avg)			19	343	80.5	34	253	95.2	36	124	75.4	19	102	48.8	23	343	60
sachet			19	20	19.5	20	20	20	-	-	-	19	19	19	-	-	-

Table 3: Heavy Metal Characteristics of Household Container Sediments - Ingawa LGA

Sample NO	PPM Mn	PPM Fe	PPM Cu	PPM Zn	PPM Pb	PPM Cd	PPM Cr	PPM Ni	PPM As	PPM Al
MAL (mg/l)	0.2	0.3	1	3	0.01	0.003	0.02	0.05	0.01	0.2
03GAN01	0.173	0.089	0.026	0.058	0.003	0.001	0.006	0.005	0.002	0.001
03GAN01	0.186	0.102	0.022	0.049	0.003	0.001	0.005	0.003	0.001	0
03GAN02	0.291	0.075	0.031	0.066	0.005	0.003	0.003	0.004	0.001	0
03GAN02	0.293	0.095	0.024	0.046	0.004	0.002	0.003	0.004	0.002	0.001
03GAN03	0.106	0.092	0.028	0.053	0.002	0.001	0.005	0.003	0.001	0
03GAN03	0.478	0.113	0.022	0.055	0.002	0.001	0.003	0.005	0.002	0
03KAD01	0.311	0.113	0.017	0.071	0.004	0.002	0.004	0.006	0.002	0.001
03KAR01	0.281	0.079	0.017	0.063	0.004	0.002	0.005	0.004	0.001	0.001
03KAR02	0.201	0.103	0.023	0.063	0.003	0.002	0.005	0.007	0.003	0.001
03KAR02	0.288	0.105	0.019	0.047	0.003	0.002	0.005	0.004	0.001	0
03KAR03	0.369	0.113	0.018	0.056	0.002	0.001	0.004	0.005	0.002	0.001
03YAN01	0.398	0.114	0.031	0.067	0.003	0.002	0.003	0.004	0.001	0
03YAN01	0.232	0.091	0.015	0.059	0.003	0.001	0.003	0.004	0.001	0
03YAN02	0.288	0.105	0.031	0.048	0.001	0.001	0.004	0.004	0.002	0.001
03YAN02	0.391	0.094	0.018	0.059	0.002	0.001	0.003	0.006	0.002	0.001
03YAN03	0.309	0.086	0.019	0.059	0.004	0.002	0.002	0.003	0.001	0
03YAN03	0.209	0.097	0.019	0.072	0.002	0.001	0.004	0.003	0.001	0

MAL=maximum allowable limit,

Sample code (04YAN03, 02KAG01): the first two letters, 03denotes the LGA, Ingawa,

the next three characters denote community as follows: YAN=Yandoma, GAN=Ganjuma, KAR=Karkarku;

The last two characters denotes the sample number in the respective community

Table 4 : Water quality of samples tracked from motorised Borehole sources to the households and water management practices

Tracking	Community	sample	Bacteriological total coliform	faecal coliform	% change in TC from source to HHS	chloride (mg/l)	Nitrate (mg/l)	Water Treatment	Type of Treatment	Reported Hand washing	Evidence of soap	Evidence of Cover	Reported frequency of Cleaning	Toilet facility
			total coliform	faecal coliform		chloride	Nitrate							
Increase	Waila	Source 1 (MBH)	0	0		197.1	13.3							
		HHF	0	0										
		HHS	2	0	200	208.4	8.9	Yes	Sedimentation	With soap	No	No response	Daily	No
Decrease	Rinjin Gora	Source 1 (MBH)	2	0		5	8.9							
		HHF	2	0										
		HHS	0	0	200	3.5	8.9	no response	no response	no response	no response	no response	no response	no response
	Kagara	Source 2 (MBH)	7	0		2.4	17.7							
		HHF	0	0										
		HHS	0	0	700	2.6	17.7	No	N/A	Sand and water	No	Yes	Daily	Yes
Unchanged	Mallama	Source 1 (MBH)	0	0		4.4	26.6							
		HHF	17	0										
		HHS	0	0	0	9.9	17.7	No	N/A	Sand and water	No	No	When dirty	Yes
	Faras	Source 1 (MBH)	0	0		18.2	35.4							
		HHF	0	0										
		HHS	0	0	0	15.6	35.4	No	N/A	Water with soap and ashes	Yes	Yes	Daily	Yes
	Karkarku	Source 1 (MBH)	0	0		6.4	8.9							
		HHF	0	0										
		HHS	0	0	0	4.3	13.3	No	N/A	With soap	No	Yes	Daily	Yes
	Yanhoho	Source 2 (MBH)	0	0		5	13.3							
		HHF	0	0										
		HHS	0	0	0	5.7	13.3	Yes	Boiling	With soap	No	No	When dirty	Yes
	Dutsin Safe	Source 3 (MBH)	2	0		16.3	44.3							
		HHF	0	0										
		HHS	2	0	0	41.3	66.5	No	N/A	With soap	Yes	Yes	Daily	Yes

N/A: Not Applicable