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Water Supply in Selected Villages in Katsina State-Nigeria

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ABSTRACT: This paper presents a report on water resources and water supply of four villages in Katsina state, Nigeria. The four villages (Kurechidutsi, Dogoruwa, Unguwar Mangoro and Kwari) were visited. Data were collected on the magnitude of water supply problems, the existence and bio-engineering assessment of water quality in the area was conducted. The quality of raw and treated water from sources of water were measured at the site and in the laboratory using standard methods and procedures. The study revealed that the predominant species of the fungi was Aspergillus sp having 33.3% occurrence and 12.5% each of Penicillium sp, Rhizopus sp, Mucor sp, Neurospora sp, Fusarium sp and Botrytis sp. The fungi were tentatively identified based on their cultural and morphological characteristics. Eighteen different bacterial species belonging to six different genera were isolated from the water samples. The most frequently encountered bacteria were the Enterobacter sp. with 33.2% occurrence followed by Klebsiella sp.(17.5%), Pseudomonas sp. (17.1%), and Escherichia sp. with 16.5% occurrence each. Shigella sp. has 10.1% occurrence while the Proteus sp. has the least with 5.6% occurrence. It was concluded in the study that there is a water supply problem due to poor water quality.

Keywords: water supply, water quality, gender, religion, villages

Nijerya'nın Katsine Eyaletinde Bulunan Seçilmiş Köylerin Su Rezervi

ÖZET: Bu makale, Nijerya'nın Katsina eyaletinde bulunan dört köyün su kaynakları ve rezervi konusunda bir rapor sunmaktadır. Dört köy (Kurechidutsi, Dogoruwa, Unguwar Mangoro ve Kwari) ziyaret edilmiştir. Su temini ile ile problemlere ilişkin veri toplandı ve incelenen alanda su kalitesinin varlığı ve biyo-mühendisliğine ilişkin değerlendirmeler yapıldı. Bu bölgede, su kaynaklarından temin edilen saf ve arıtılmış suyun kalitesi, laboratuvarda standart metod ve prosedürler kullanılarak ölçüldü. Çalışmada, en etkili mantar türlerinin; Aspergillus sp (%33.3), ve Penicillium sp, Rhizopus sp, Mucor sp, Neurospora sp, Fusarium sp ve Botrytis sp.nin her birinin (%12.5) eşit oranda tespit edildiği gözlenmiştir. Bu mantarlar, geçici olarak kültürel ve morfolojik özelliklerine göre tanımlanmıştır. Alınan su örneklerinden, altı farklı cinse ait olan 18 farklı bakteri türü izole edilmiştir. En çok sıklıkla karşılaşılan bakteri, %33.2 ile Enterobacter sp. olmuştur. Bu bakteriyi, karşılaşma oranı bakımından Klebsiella sp.(%17.5), Pseudomonas sp. (%17.1), ve Escherichia sp. (16.5%) bakterileri izlemiştir. Shigella sp. için bu oran 10.1% olmakla birlikte en düşük oran Proteus sp. (5.6%) aittir. Bu çalışmada, kötü su kalitesi nedeniyle bir su rezerv probleminin olduğu saptanmıştır.

Anahtar kelimeler: Bölge, Cinsiyet, Köy, Su temini, Su kalitesi,

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INTRODUCTION

Water is the most basic of human needs, used for hydration, hygiene and sanitation. Waterborne or water-related diseases (including diarrhea, cholera, typhoid, malaria, hepatitis and more) are linked to an estimated 80% of illnesses in developing countries. Tragically, diarrhea is the leading cause of childhood death in parts of the world where sanitation and access to safe water is not widespread. Non-health consequences of inadequate access to safe and reliable water include loss of economic productivity (due to financial, physical and time related costs to individuals and households) and intangible factors such as convenience and well-being. Diseases related to contamination of drinking-water constitute a major burden on human health. Interventions to improve the quality of drinking-water provide significant benefits to health. It is well known that water supply is one of the key natural resource bases that are inevitable for sustainability of human and environmental health. There is a strong and direct link between people's health and the development of communities. Gleick (2002) ; the World Health Organisation (WHO, 2003) summarised these links as: poor health reduces life expectancy and educational achievement; it reduces investment and returns from investment (as production, productivity and employment decrease); it reduces parental investment in children (and increases the fertility rate); it increases health inequity and poverty; and it reduces social and political stability. Inadequate water services together with sanitation to the rural poor are 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 and Diarrhoea accounts for 1.87 million (19%) childhood deaths each year (Boschi-Pinto et al. 2008, Preston et al., 2010). An estimated 1.1 billion people do not have access to improved water supplies (Preston et al., 2010). Rural water supply and sanitation projects that are now implemented in several rural areas (villages) in Nigeria with credit financing from the World Bank, European Union (EU) and United Nations Children's Fund (UNICEF) are facing common types of drawbacks of which poor governance and financial constraints are prominent. The outcome of this is that the few installed water facilities apart from being unable to suffice the needs of the populations, are also partially functioning, frequently impaired or completely broken down due to poor operation and maintenance (Marobhe et al., 2007).

Nigeria is located in West Africa, between latitudes 4^o 1'' and 13^o 9'' North, and longitudes 2^o 2'' and 14^o 30'' East. It is bordered by four countries: the Republic of Niger to the North, the Republic of Chad and Cameroun, both to the East, and the Republic of Benin to the West. To the South, it is bounded by the Atlantic Ocean, with a coastline of about 800 km. The country has a total surface area of 923 770 km^2 with a land area of 910 770 km^2 and a water area of 13 000 km^2. The country is endowed with about 267 billion cubic metres of surface water and about 52 billion cubic metres of groundwater, annually. In the southern part of the country, rainfall is high, surface water and springs are often the most appropriate source of water, particularly where groundwater aquifers are deep. In the North, rainfall is scarce and aquifers are shallow, groundwater is usually the only practical source. The geology is such that well yields are unpredictable; often the water can only be accessed using a hand pump. Generally, the quality of groundwater in Nigeria is better than that of surface water in terms of health criteria, but much of the groundwater is corrosive, and some areas have iron, nitrate or fluoride concentrations above WHO guideline values. Despite the generous endowment of surface and groundwater, which are capable of meeting demands, according to national sector data the average national water supply coverage was only about 57% (about 60% for urban areas, 50% for semi-urban areas, and 55% for rural areas).

In urban areas, both surface water and groundwater are used as water sources. Urban systems require treatment plants, distribution systems, elevated tanks, piped systems, house connections, yard taps and public standpipes. In semi-urban areas, water supplies are mainly based on mechanized boreholes and overhead tanks, as well as piping with yard taps and public standpipes. In rural areas of Nigeria, water are traditionally managed for two major purposes namely agriculture and domestic consumption, although this distinction is blurred sometimes. Sources of such waters vary from direct rainfall to waters from runoffs, rivers, streams, creek flows and seepage. The purpose of this study was to investigate the water supply problems in four villages located in Katsina State, Nigeria.

MATERIALS AND METHOD

As a preliminary study on water treatment techniques in villages in Nigeria, four villages (Kurechidutsi, Dogoruwa, Unguwar Mangoro and Kwari, from three Local Government Areas namely Dutsin ma, Dan Musa and Safana) were selected for this study. The state and these villages were selected for the study because they are among several villages in the country that are facing severe water supply problems. Focus group discussions were done with people. Interviews were conducted using households in each village using systematic random sampling. The respondents in households included men and women depending on their availability at home at the time of conducting interviews. Water qualities were monitored in both rainy and dry seasons. The quality of raw and treated water from sources of water were measured at the site and in the laboratory using standard methods and procedure as stated in literature (APHA, 1998). Selected parameters (pH, turbidity, alkalinity, acidity, solids, dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), organic matters, Chemical Oxygen Demand (COD), sulphate, Nitrate, bacteriological examination etc.) were monitored. In the determination of bacteriological examination multiple tubes test techniques and confirmation test were used. The procedures stated in the standard methods for water and wastewater analysis (APHA, 1998) were followed. Plankton determinations were conducted using procedures stated in the standard methods for water and wastewater analysis (APHA, 1998).

RESULTS AND DISCUSSION

Results from this study was presented and discussed as follows:

The Study Area: The studied villages namely, Kurechidutsi, Dogoruwa, Unguwar Mangoro and Kwari are located in the Katsina State in central semi arid zone of Nigeria. 41% of inhabitants are male and 59% are female. The average number of people per household is 8. In the area, rainfall pattern is typical of the central semi arid zone that is characterised by unimodal rainfall from June to October with a total annual precipitation between 500-800 mm. The rainfall is frequently erratic and much of the area is prone to drought and degraded by anthropogenic activities.

Occupational and Religion Activities: Subsistence farming, which is entirely dependent on rain fed, is the most important occupation of the inhabitants in the study area (Table 1). The main products of their labour are food and cash crops as well as livestock. The main crops that are grown in the study area are mostly millet, guinea corn, corns, groundnut, tomato and pepper. Cash and food crops are sold to earn the people some money for other family needs. The results show that an average of 99.5% of the inhabitants (both males and females) in the four villages is occupied in farming activities. Also, livestock keeping which is a male dominated task is practised by 22.5 % of households, while 3.5% of households in addition to farming have formal employment in primary schools, local government, etc. Other households have multiple occupations such as owning retail shops, transport business and so on. Table 1 shows percentage distribution of households by occupation. Religion wise it was observed that the villagers are main muslims (100%) with neither Christian nor traditional religion in the four villages.

Location of the sources of water: The main sources of water supply in the study area are surface and groundwater; the surface sources are rivers namely (river karaduwa on which a dam is nearer to Kurechidutsi, river kwari for kwari; river ungwar mangoro for ungwar mangoro and dogon ruwa has rivers dogonruwan and yasanya), shallow wells and hand dug and shallow well in the river bed (Figure 1) and traditional wells. In addition, seasonal streams and ponds are used to supplement the existing sources during the rainy seasons. The water supply situation in the surveyed villages is very unsatisfactory. Despite the joint efforts of the government, donor agencies, and local communities in installing a few water schemes, most of them are malfunctioning. It is evident from the result of this survey that a large proportion of the villages do not have access to sustainable water supply sources. It was noted during the discussions that less than 20% of the inhabitants in the study area do have access to reliable water supply. Moreover, Kwari village does not have any kind of water supply source despite its high population. The consequence is that the majority of inhabitants have to travel long distances in search of water. In most cases traditional water holes and hand dug well in the river bed are preferred sources. Water from these sources is of poor quality and in most cases highly turbid that obliges women to clarify domestic water using locally available materials (sedimentation in a local pot only). Among the main issues raised from discussion and interviews pertaining to unsustainable water supply schemes are poor local governance, poor economic situation of inhabitants to contribute to and maintain the village water funds for the operation and maintenance of the water schemes. In addition, the “free water attitude”, which is still in the mind of the inhabitants, hinders them from taking full responsibility of the schemes. It was evident from the respondents and dispensary data that water borne diseases are among the most devastating health problems in the area. It was also observed during the physical survey that 90% of the households in the area do not have any kind of excreta disposal facility. This condition most possibly aggravates the problem of water borne diseases due to the pollution of water sources and inadequate hygienic practices of the villagers. The impact of poor water supply services and poor human excreta disposal on prevalence of water borne diseases in Katsina State, Nigeria (Figure 2) and other developing countries has been reported by the Federal Ministry of Health and WHO (2002). Issues pertaining to insufficient water supply and sanitation facilities do not only affect the quality of life of the people but also have an impact on the government that fail to invest in water supply and sanitation facilities for the poor because it may eventually end up spending much more on health and lost economic activities in the case of epidemic outbreaks. Figure 2 presents reported cases of water borne diseases in the Local government areas of the selected villages.

Distribution of Preferable Domestic Water Supply Sources for Different Villages: The main sources of water available in the environment for the local government areas are reservoir, a borehole and wells in Dustin ma, river karaduwa, river kwari, river yasanya and dogonwura. About 95% to 97.6 % of the respondents obtain water from rivers; 1.2% to 2.2% from the borehole located in located in Dustin Ma; 28 % to 35% from wells elsewhere; 100 % fetch water from traditional water holes in the river beds; and 20 % to 30% fetch water from traditional wells, shallow wells, shallow wells in river beds or water holes. The results also show that women are the main domestic water carriers and have preference for water sources (this is influenced by the availability of water from the various sources during different times of the year, the distance to the water source). Women in the villages stated that it is better to fetch water from rivers, traditional wells in the river beds and traditional wells, which are the traditional sources. Water from these sources can be easily clarified at home. Also, it was stated that they prefer these traditional sources of water because other sources of water require travelling to a longer distance and for a longer time. Although, traditional sources of water supply wells, rivers, and hand dug wells in the river beds are not safe scientifically, they are the preferred sources.

The respondents also pointed out that every woman has a budget of 2 to 7 hours in her daily schedule of domestic chores, especially for water fetching and purification. This situation is analogous to that reported by USAID (1984) in the Bolgataga district in Ghana in which 96% of women walk an average of 6.1 km and spent 30 minutes to 6 hours in search of water. The impacts of tight household chores for women on socio-economic and health development of rural communities are reported by Eliufoo and Marobhe (1998). Data from the survey and discussions conveyed yet another dimension of fetching water on the basis of sex. It was pointed out that both women and men participate in fetching water. However, it was observed during the discussions that, men use donkeys and animal driven carts to carry water from the various sources for watering calves, occasionally for building activities and in very rare cases to supplement domestic water carried by women. It was further noted from the discussions that men actually spend less energy than women in this activity because they neither carry water on their heads nor walk on foot during the transporting of water. It was noted that on the average only 1 to 2 households in the village possess these facilities. This situation has health and social repercussions on women in the study area. According to Howard and Bartram (2003) women who happen to be the main water collectors and have to retrieve water from distance sources on regular basis, suffer from severe back problems.

Quality of the water: It has been reported in literature Sawyer and McCarty (2004) ; Tebbutt (1991); Steel and McGhee (1991); Metcalf and Eddy (1991);

Encyclopaedia (2001); Ogunfowokan et al., (2005); Oladipo et al., (2005) that inorganic compounds in water and wastewater are in form of heavy metals (cadmium, copper, lead, nickel, mercury, iron, chromium arsenic, manganese and zinc), nitrate ion, nitrite ion, sulphate radical, alkalinity, pH, chloride ion, fluoride ion, cyanide ion, dissolved oxygen, hydrogen sulphide, phosphate and carbon (IV) oxide. John De Zuane (1996) classifies inorganic chemicals in water and wastewaters into four categories, namely:

Type A: inorganic chemicals: These are chemicals found in water and wastewaters, which are known to be toxic to man. They are arsenic, chromium, mercury asbestos, copper, nitrate, nitrite, barium, fluoride, selenium, lead and cadmium.

a) Type B: inorganic chemicals: These are parameters that have been examined by the health authorities, which are rare in drinking waters and their toxicity is of limited concern. They are aluminium, nickel, sodium, silver, zinc, sulphate, molybdenum and cyanide.
b) Type C: They are parameters that may have a high level of occurrence in wastewaters and waters, but are safe at these concentrations. They are expected or their occurrence is rare and extremely limited. They are calcium, silicon (as silica), magnesium, carbon dioxide, manganese, bromine, chlorides, dissolved oxygen, bromide, iron, chlorine, lithium, phosphate, iodine, iodide, Ozone and potassium.
c) Type D: These are inorganic parameters that are likely to be found in very low concentrations in wastewaters and waters with no toxicity at the low concentrations.

pH: This parameter is recommended for inclusion in water quality surveys as it may influence disinfection efficiency and microbial survival and may also lead to consumer rejection of water. The pH of the Zobe (artificial lake/reservoir for irrigation and water supply project) water, water samples collected from the upper reaches of Karaduwa River near the reservoir, River Kwari, Rivers Ungwar Mangoro, DogonRuwan and Yasanya are in the acidic range (between 5.9 and 6.7). Acidic nature of the water samples can be attributed to farming activities with inorganic fertilizer around the catchment of the rivers. However, samples collected from the middle and lower reach of River Karaduwa as well as the borehole samples had a pH in the alkaline range which varied between 7.1 and 8.1. WHO (2000) recommends 6.8 -7.2 for potable water, while FEPA (1991) recommends 6-9 for wastewaters. These show that the samples can be classified as wastewaters. The alkaline nature of the borehole water can be attributed to soil composition and acidic nature of the runoff which decementing the soil and dissolve some of the basic oxide in the soil. The need to neutralise pH of the borehole must be considered.

Turbidity: Turbidity is widely accepted as one of the critical water quality parameters describing microbiological quality of drinking water. This parameter along with pH and chlorine residuals are recommended for inclusion in water quality surveys as they either directly influence microbiological quality (in the case of chlorine) or may influence disinfection efficiency and microbial survival (in the case of pH and turbidity). Very high turbidity, even in the absence of faecal indicator bacteria, may give cause for concern as it indicates that sanitary integrity has been compromised. Turbidity is the critical parameter that forms the basis of a minimum approach to water quality monitoring. Turbidity of all the water samples were above 50NTU. For borehole sample the turbidity was 60 ± 11.34 NTU, with 650 ± 22.56 NTU, 700± 36.81 NTU; 850± 52.57 NTU and 750 ± 66.56 NTU for river karaduwa, river ungwar mangoro; river dogonruwa and yasanya respectively. These water samples can be classified as polluted water. Subjecting the water samples to sedimentation process only reduced the turbidity by 10.3 %, which agrees with literature such as Humenick (1977). This indicates that there is aneed for adequate treatment such as coagulation and flocculation before sedimentation.

Alkalinity: By alkalinity of water is understood the total content in water of substances that cause an increased concentration of ions, OH -, upon dissociation or as a result of hydrolysis. The alkalinity of natural waters is usually due to the presence of ions, HCO_3^-, SiO_3^{2-}, $HSiO_3^-$ and sometimes of CO_3^{2-} (and also to the presence of salts of some weak organic acids, known as humates) that bind H^+ ions as a result of hydrolysis, thereby increasing the concentration of OH - ions. In addition to the above enumerated substances, the alkalinity of surface water is also conditioned by the presence of PO_4^{3-} and OH^- ions. Depending on the anion that is present in water (HCO_3^-; CO_3^{2-}; or OH^-), alkalinity is classified as bicarbonate alkalinity (A_b), carbonate alkalinity (A_c) or hydrate alkalinity (A_h). The total alkalinity A_{tl} of water is determined by the amount of acid spent together with a methyl orange indicator for water titration, and consequently it is due to the presence of not only ions, HCO_3^-; CO_3^{2-}; or OH^-, but also to other ions that react with acid, including humates as follows:.

$$A_{tl} = A_b + A_c + A_h \quad (1)$$

The results obtaining from the phenolphthalein and total alkalinity determinations offer a mean for stoichiometric classification of the three principal forms of alkalinity present in many waters. The classification ascribes the entire alkalinity to bicarbonate, carbonate and hydroxide, and assumes the absence of other inorganic and organic (weak) acids such as phosphoric and boric acids. It further pre supposes the incompatibility of hydroxide and bicarbonate alkalinity. Because calculations are made on a stoichiometric basis, ion concentrations in the strictest sense are not represented in the results which may not differ significantly from actual concentration especially at pH > 10. According to this scheme (Belan, 1981) :

- Carbonate (CO_3^{2-}) alkalinity is present when phenolphthalein alkalinity is not equal to zero but is less than total alkalinity;
- Hydroxide (OH^-) alkalinity is present if phenolphthalein alkalinity is more than half of the total alkalinity; and
- Bicarbonate (HCO_3^-) alkalinity is present if phenolphthalein alkalinity is less than half of the total alkalinity.

The carbonate alkalinity of the middle and upper reach of River Karaduwa was relatively high ranging between 103.4 ± 8.45 mg $L^{-1}$of $CaCO_3$ and 188.81± 12.09 mg L^{-1} of $CaCO_3$. Higher alkalinity value was also recorded for water samples collected from River Ungwar Mangoro (107.42 ± 22.96 mg $L^{-1}$of $CaCO_3$). Conversely, relatively low carbonate alkalinity was recorded in samples collected from the lower reaches of River Karaduwa (between 58.09 ± 9.22 mg $L^{-1}$of $CaCO_3$ and 56.67 ± 8.56 mg $L^{-1}$of $CaCO_3$) and in the reservoir (34.26 ± 5.26 mg L^{-1} of $CaCO_3$). Samples collected from River Dogon-Ruwan had a moderately high carbonate alkalinity value of 316.89 ± 32.76 mg $L^{-1}$of $CaCO_3$. These results show that in the treatment process of these water samples for potable purposes alkalinity of the water need not to be supported or raised for proper treatment.

Acidity: Samples from Rivers Ungwar Mangoro and DogonRuwan had relatively high water acidity (60.45 ± 6.36 mg $L^{-1}$of $CaCO_3$ and 66.86 ± 8.89 mg $L^{-1}$of $CaCO_3$ respectively). Water samples from the upper reach of River Karaduwa close to the reservoir also had a relatively high acidity levels (67.65 ± 7.16 mg $L^{-1}$of $CaCO_3$). The borehole water sample comparatively however had the highest acidity (122.44 ± 13.43 mg $L^{-1}$of $CaCO_3$). Samples collected from other locations had acidity values ranging between 34.24 ± 2.99 mg $L^{-1}$of $CaCO_3$ and 44.64 ± 4.54 mg $L^{-1}$of $CaCO_3$.

Solids: The dissolved solids (DS) content of the water samples were very high irrespective of the sample location varying between 52.65 mg $L^{-1}$and 281.28 mg L^{-1}. The high dissolved solid content of the water sample is a reflection of the very high electrical conductance of water samples collected within the area. Reservoir water has the least dissolved solid content (48.68 ± 9.16 mg L^{-1}). River Karaduwa had DS contents varying between 101.29 mg $L^{-1}$and 212.43 mg L^{-1}. Analysis of the water samples showed that the middle and the lower reaches of the river had lower DS contents (102.06 mg L^{-1}– 134.67 mg L^{-1}) compared to the upper reaches of the river (DS – 184.24 mg L^{-1}– 213.43 mg L^{-1}). High dissolved solid contents recorded in other riparian rivers were: River Kwari – 106.7 ± 8.26 mg L^{-1}; River Ungwar Mangoro – 192.4 ± 7.76 mg L^{-1}; River DogonRuwan – 134.5 ± 12.24 mg L^{-1} and River Yasanya – 118.70 ± 11.44 mg L^{-1}. The very high DS contents could be attributed to high usage of agrochemicals particularly fertilizers within the project area. The very high DS content of the borehole water (280.26 ± 32.13 mg L^{-1}) is an indication that the underground aquifer has been polluted by the soil composition, farming activities through runoff, percolation and infiltration from agrochemicals through rainfall and runoff as well. Analysis of the suspended solid (SS) load of the water sample collected from area show that reservoir (34.23 ± 2.66 mg L^{-1}) and a location on the upper reach of River Karaduwa with close proximity to the reservoir had high SS load (68.89 ± 8.15 mg L^{-1}). Samples collected from Rivers DogonRuwan (56.58 ± 8.97 mg L^{-1}) and lower reach of Yasanya (56.98 ± 12.51 mg L^{-1}) also had very high suspended load probably because they served as animal watering holes. The total solid content (TS) is a reflection of the total dissolved and suspended solid contents. The lowest total solid content (86.87 ± 9.56 mg L^{-1}) was recorded in water samples collected from reservoir, while the highest TS content (324.65 ± 25.56 mg L^{-1}) was recorded in the upper reach of River Karaduwa. The very high dissolved solid content in the borehole water sample collected accounted for the very high (296.29 ± 19.91 mg L^{-1}) total solid content during the period of sample collection.

Chemical parameters: There are numerous chemical substances that can be found in water, which may be of concern for public health, acceptability of water (aesthetics) and operational performance. Physical and chemical parameters may have natural and anthropogenic sources and show both temporal and spatial variation in their occurrence and concentration, which temporal variation being greater in surface waters and shallow groundwater than deep groundwater. The microbiological quality of shallow groundwater and surface waters is often poor and is the principal issue of concern. The chemical quality of shallow groundwater and surface water tends to be primarily related to human activity and whilst chemical quality may be poor, prevention measures are usually possible and contamination may be relatively short-lived given rapid through-flow. In deeper groundwater, microbiological quality is often very good and therefore chemical quality is often a higher priority. Furthermore, chemical contaminations are more likely to be natural and therefore removal rather than prevention may be required. Slow through flow may lead to long-term contamination problems. However, the quality of such groundwater is generally stable so the required frequency of monitoring is lower than that for shallow groundwater and surface water sources, which are both prone to both natural (e.g. erosion, run-off) and anthropogenic pollution/contamination. Many chemicals contribute to the palatability and thus acceptability (e.g. salinity, turbidity and iron) of water sources. However, some chemicals constitute a health hazard because of their toxicity (e.g. fluoride, arsenic and nitrate) and others may lead to indirect adverse health impact because they render the water objectionable and may result in consumers rejecting the water in favour of an alternative, possibly more microbiologically contaminated, source of water. Naturally occurring chemicals in water are commonly chronically rather than acutely dangerous to health, which expose to (low) concentrations over a several years being required for long-term impacts on health.

Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD_5): Samples collected from the reservoir, which is located on Rivers Karaduwa and Yasanya had very high dissolved oxygen contents during the period of sampling. The DO values recorded for samples from reservoir was 10.44 ± 2.12 mg L^{-1}while DO values for River Karaduwa ranged between 5.22 mg $L^{-1}$and 13.83 mg L^{-1}. In the Yasanya River however, DO value ranging between 8.61 mg $L^{-1}$and 11.52 mg $L^{-1}$was recorded. Extensive mixing of atmospheric oxygen at the air-water interphase, coupled with the shallowness of the water-bodies during the dry period was probably responsible for DO values recorded in the reservoir as well as in the two rivers. However, Rivers Kwari, Ungwar Mangoro and DogonRuwan, moderately levels of DO (6.16 ± 2.26 mg L^{-1}; 3.32± 1.11 mg $L^{-1}$and 1.22± 0.98 mg L^{-1}respectively) were recorded. The biochemical oxygen demand (BOD) is the concentration of oxygen needed by the biota over a 5-day period. Samples collected from the lower reaches of River Karaduwa near Kurechi village had an appreciable level of BOD (8.48 ± 4.66 mg $L^{-1}$and 7.06 ± 3.77 mg L^{-1} respectively) during the sampling period. Moderately high BOD_5 values were also recorded in the samples collected from reservoir (3.04 mg/L) and the lower reach of River Yasanya. All these can be attributed to acidic nature of the water which oxidized the oxygen demand substances.

Organic Matter (OM) and Chemical Oxygen Demand (COD): The organic matter content as well as the chemical oxygen demand of water collected from the upper reaches of Rivers Karaduwa and Yasanya were very high during the period of study. OM level in the upper reaches of River Karaduwa was 2.35 ± 0.66 mg L^{-1} while a value of 1.77 ± 0.86 mg L^{-1} was recorded in River Yasanya. The corresponding COD values for Rivers Karaduwa and Yasanya were 140.20 ± 4.36 mg $L^{-1}$and 64.60 ± 5.63 mg L^{-1} respectively. Relatively moderate levels of OM and COD were recorded in samples collected from the lower reach of River Ungwar Mangoro (0.27 ± 0.06 mg L^{-1} OM; 16.09 ± 2.34 mg L^{-1} COD) and upper reach of River Karaduwa (0.20 ± 0.05 mg L^{-1} OM; 16.90 ± 7.88 mg L^{-1} COD). Lower organic matter and COD concentrations can be attributed to acidic nature of the water, which oxidized some of the organic matters or /and reacted with some oxygen demand substances.

Ionic Content: Cations: The concentration of Na^+ in the surface water samples ranged between 3.22± 1.46 mg L^{-1} (Zobe Reservoir) and 20.20 ± 5.57 mg L^{-1} (River Ungwar Mangoro). However, in the borehole sample, the Na^+ concentration recorded was 16.5 ± 3.96 mg L^{-1}. Conversely, the K^+ ion concentration in the surface water samples was found to vary between 0.15 ± 0.08 mg L^{-1} (upper reach of Karaduwa River) and 15.25 ± 4.23 mg L^{-1} (River Ungwar Mangoro) In the borehole water sample collected from the Dustin Ma, the K^+ level recorded was 6.75 ± 2.27 mg L^{-1}. The middle and the lower reach of River Karaduwa and Rivers Yasanya and DogonRuwan also recorded relatively high concentrations of K^+. Effects of these two cations on man and animals are well documented. Higher concentration of sodium and potassium can be attributed to many these factors such as farming activities, direct contact with animal excreta. Analyses also showed that the level of Na^+ was high in samples collected from middle reach of River Karaduwa, Rivers Kwari, and Yasanya.

Anions: It is well known that excessive phosphorus loading from manmade sources is commonly linked to eutrophication of lakes and streams. Phosphorus is contributed by agricultural runoff and erosion from agricultural land, urban runoff The phosphate concentration in the surface and borehole water samples varied between 0.82 mg L^{-1} (middle reach of River Karaduwa) and 1.49 mg L^{-1} (Reservoir, River Karaduwa near Kurechi village and borehole). Effects of phosphate on human and animal are unknown with exception that phosphate in stagnant water bodies lead to eutrophication, which in-turn encourage odour and other bacterial activities. Although farming activities are common in the area, lower phosphate concentration can be attributed to higher uptake of phosphate by the plants (such as maize, millets etc). These results show that eutrophication may not be a common phenomenon in the area if the water from the reservoir is stagnant. Analyses showed no significant differences in the level of phosphate ion within the samples collected in the area. A significant variation was observed in the level of chloride ion in the water samples collected from various water-bodies within the area. In the surface water-bodies, the level of Cl^- varied between 3.01 mg L^{-1} (upper reach of River Karaduwa) and 30.34 mg L^{-1} (River Ungwar Mangoro). In River Karaduwa, the level of Cl^- varied between 3.08 mg L^{-1} and 10.04 mg L^{-1}. In River DogonRuwan, the Cl^- concentration was 13.16 ± 4.68 mg L^{-1} while the level was 19.26 ± 3.78 mg L^{-1} in River Kwari. In the borehole water sample, the recorded Cl^- concentration was 9.26 ± 1.23 mg L^{-1}. WHO (2002) recommends 250 mg $L^{-1}$of Cl^- for potable water and FEPA (1991) recommends 500 mg L^{-1} for wastewater. These results indicate that the water samples can be classified as potable water rather than wastewaters. Lower in chloride concentrations can be attributed to many factors among which are low population in the area, lack of contact with human excreta and high evaporation.

Sulphate: Analyses showed that the sulphate ion concentration in water samples collected from reservoir was 5.59 mg L^{-1}. However, high SO_4^{2-} concentration was recorded in water samples collected from River Karaduwa near Kurechi village. In other sampling locations along River Karaduwa, the SO_4^{2-} concentration ranged between 2.08 mg L^{-1} and 3.46 mg L^{-1}. In the sample collected from Rivers Kwari and Ungwar Mangoro, the SO_4^{2-} concentrations were 4.84 ± 1.43 mg L^{-1} and 6.27 ± 3.41 mg L^{-1} respectively. In River Yasanya however, a lower concentration (3.46 ± 1.77 mg L^{-1}) of SO_4^{2-} was recorded. WHO (2002) recommends 250 mg L^{-1} for potable water above, which may resulted in stooling for man and animals. FEPA (1991) recommends 500 mg L^{-1} for wastewaters to be discharged into the environment. These lower sulphate concentration than 250 mg L^{-1} can be attributed to filtration activities in the alluvial channel. These results indicate that the water samples are potable based on sulphate concentration only.

Nitrate: Nitrate is one of the most ubiquitous chemical contaminants of water bodies worldwide as it is derived from human activities and in particular from the disposal of human wastes and the use of inorganic fertilisers in agriculture. Nitrate is of concern because of its link to methaemoglobinaemia of 'blue-baby' syndrome. Although the actual health burden from nitrate is often considered relatively insignificant (because of breast-feeding practices), it is likely that the health burden is under-reported. Nitrate is also of particular concern because of its conservative nature in water. Once nitrate has entered a water body that is oxidising, only the processes of dilution and hydrodynamic dispersion are likely to cause significant reductions in concentrations until the input load is reduced. Thus, if nitrate is allowed to increase in source waters, then long-term resource problems may result leading to costly investments later. As nitrate is extremely expensive and difficult to remove during treatment, blending nitrate-rich waters with low nitrate waters may be the only viable option. It should be noted that in reducing or non-oxidising waters, nitrate may not be formed as organic nitrogen would be converted to ammonia by denitrifying bacteria. Irrespective of the type of water sample and location of collection the NO_3^- level was very high. In the reservoir, analysis showed that the NO_3^- concentration was 19.19 ± 4.86 mg L^{-1} of nitrogen while a concentration of 10.88 ± 5.88 mg L^{-1} of nitrogen was recorded in the borehole sample. In River Karaduwa system, the NO_3^- concentration ranged between 11.59 mg L^{-1} of nitrogen and 19.89 mg L^{-1} of nitrogen. In the samples from River Kwari, the recorded NO_3^- concentration was 15.03± 3.66 mg L^{-1} of nitrogen while the concentration was 15.73 ± 2.96 mg L^{-1} of nitrogen in River Ungwar Mangoro. For Rivers DogonRuwan and Yasanya, the analysed NO_3^- concentrations were 17.84 ± 5.68 mg L^{-1} of nitrogen, 13.65± 6.77 mg L^{-1} of nitrogen and 16.42 ± 6.11 mg L^{-1} of nitrogen respectively. WHO (2002) recommends 10 mg L^{-1} of nitrate as nitrogen or 45 mg L^{-1} of nitrate as nitrate for potable water. The high NO_3^- level in the water samples could be attributable to very high usage of nitrate fertilizers in the project area. The river systems and the reservoir probably act as the receiving repository of the runoffs laden with very high NO_3^- content from riparian agricultural lands.

Bacteriological parameters: There is a wide variety of micro-organisms that may be found in water. They include those that are pathogenic and those that are not pathogenic. Some of the non-pathogenic micro-organisms may lead to other problems in water supplies such as taste and odour, which may be of particular importance to users of the supply as an indicator of safety and may influence their selection of water for consumption. The principle concern for microbiological quality is the potential contamination by pathogens. Most water-borne pathogens are derived from faeces. It is usual practice to use indicator organisms, usually bacteria, for the analysis of microbiological quality of drinking water. There are a number of indicator micro-organisms that may be used in drinking water quality monitoring programmes. The most commonly used is *Escherichia coli* (*E. coli*) or as a surrogate thermotolerant coliforms. Table 2 presents results of bacteriological examination. From the table it can be concluded that these sources of water are polluted. Confirmatory tests revealed that among the contaminants is *E. coli*. It is known that *E. coli* derives almost exclusively from human and animal faeces and contains some strains that are pathogenic (Figure 2). It was also revealed that eighteen different bacterial species belonging to six different genera were isolated from the water samples. The most frequently encountered bacteria were the *Enterobacter* sp. with 33.3% occurrence followed by *Klebsiella* sp., Pseudomonas sp., and Escherichia sp. with 16.7% occurrence each. Shigella sp. has 11.1% occurrence while the Proteus sp. has the least with 5.6% occurrence (Figure 2).

The Plankton: Quantitatively and qualitatively, the planktonic composition is very poor. An overview of the planktonic composition showed that the flora and fauna consists of 14 phytoplanktonic and 5 zooplanktonic species. The phytoplanktonic floristic assemblages consist of 4 chlorophytes, 3 blue green algal species and 7 diatomic species. The zooplanktonic species consist of 5 rotiferic species. Reservoir had the highest species richness (15 species) followed by River Karaduwa (middle and lower reach) (11 species respectively) 10 planktonic species were recorded in the upper reach of River Karaduwa close to where the river empties into the reservoir. The diatoms (Bacillariophyta) with 5 species qualitatively and quantitatively dominated the planktonic flora of reservoir. Closterium ehrenbergii was the dominant green algae in the reservoir while *Synedra* sp., *Fragillaria crotonensis*, *Melosira granulate*, *Bacillaria* sp. and *Navicula pelliculosa* were the dominant diatoms. The small rotiferic fauna found in the reservoir were *Lecane luna*, *Brachionus* sp., *Keratella* sp. and *Notholca* sp. Anacystis cyanea was the cyanophyte (blue green alga) that was cosmopolitan in the river systems while Synedra sp. and Fragillaria crotonensis were diatoms found in almost all the surface water-bodies within the project catchment area. The factors which influence the algae flora is multivarious, seasonal, irregular and correlated. The flora in the area is existing under very varied conditions with irregular periodicity. The hydrology of the river system varied between flowing and dried regime interspaced with stagnant pools. The algal flora of pools is known to be dependent not only on the general climatic conditions such as rainfall and insolation but also on the irregular microclimatic factors such as abnormal temperature and sunshine which occurs perennially in the project area. An unusual concentration of salt in water during the drought period will also counteract the influence of sunshine. Drought and absence of rainfall appear to be the dominant factors, which modified the planktonic composition and abundance. In summary, nine strains of fungi were isolated and identified from the soil and water samples which were classified into seven genera. The predominant species of the fungi was Aspergillus sp having 33.3% occurrence and 12.5% each of *Penicillium* sp, *Rhizopus* sp, *Mucor* sp, *Neurospora* sp, *Fusarium* sp and *Botrytis* sp. The fungi were tentatively identified based on their cultural and morphological characteristics.

CONCLUSIONS

The study focuses on water supply and water quality in selected villages in Katsina state, Nigeria. The study revealed water supply as well as water quality in these villages were below recommended limit, which indicates that there is a need to improve on current level. It was concluded based on the study that the:

- sources of water supply are non-hygienic
- sedimentation only cannot purify the water
- water supply in the area is inadequate and there is a need to address the issue now

Figure 1 (a) Traditional well in the river bed of karaduwa

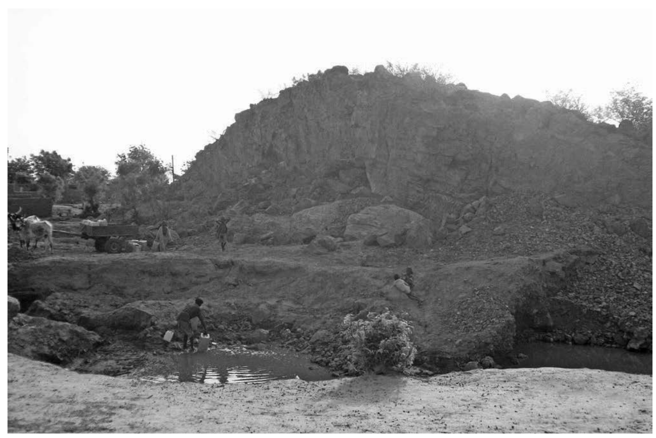

Figure 1 (b) A pond Kurechidutsi

Figure 1 (c) Traditional well in the river bed of dogonruwa

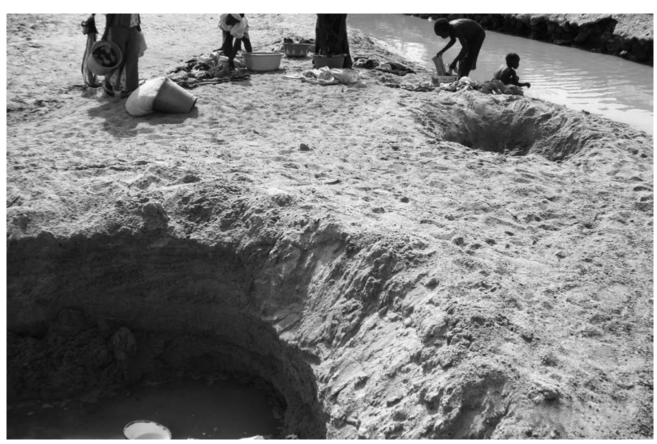

Figure 1 (d) A pond o Yasanya

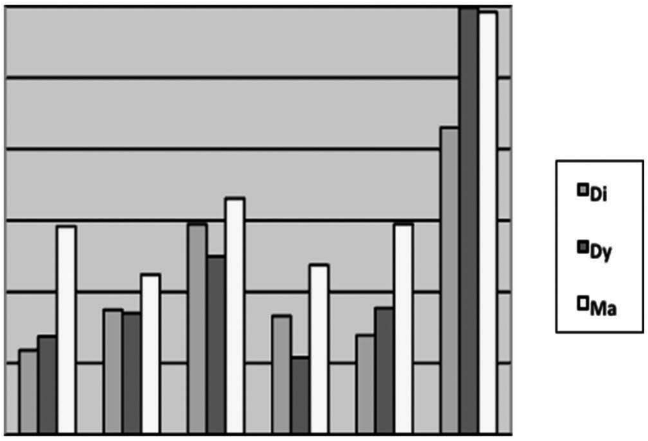

Figure 2 (a) Health data for Safana Local Government

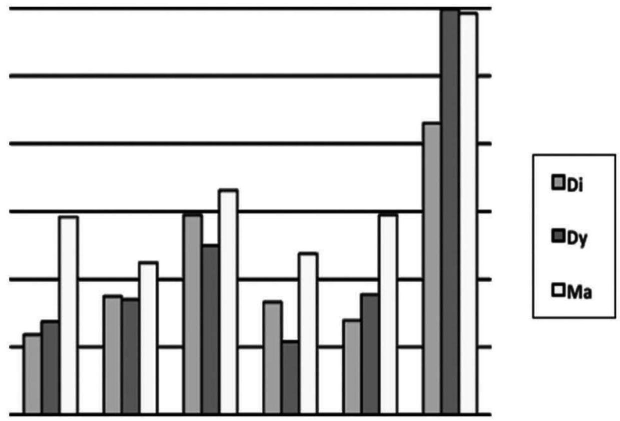

Figure 2 (b) Health data for Dustin ma Local Goverment

Table 1: Occupational activities of the inhabitants

Village	Farming (%)	Livestock (%)	Formal employment (%)	Others (%)
Kwari	99.4	32.8	2.1	1.6
Unguwar Mangoro	99.6	28.4	1.1	0.5
Dogoruwa	99.7	27.4	1.5	1.4
Kurechidutsi	99.3	30.1	2.8	2.1
Average	99.50	29.68	1.88	1.40
Standard deviation	0.18	2.36	0.74	0.67

Table 2: result of bacteriological examination

Location	Minimum (MPN/100 ml)	Maximum (MPN/100 ml)	Average (MPN/100 ml)	Standard deviation
Karaduwa	12×10^3	50×10^3	35.5×10^3	14603
Dogon ruwa	26×10^3	40×10^3	27.75×10^3	7293
Kurechidutsi	50×10^3	80×10^3	61.25×10^3	16724
Yasanya	30×10^3	60×10^3	37.50×10^3	14794
Well A	8×10^2	12×10^2	10.0×10^2	158
Borehole	20	50	35	13
Well B	5×10^2	9×10^2	6.75×10^2	148

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SYMBOLS

$A_{t\ or}\ A_{tl}$ total alkalinity (mg L^{-1} of $CaCO_3$)

A_b bicarbonate alkalinity (mg L^{-1} of $CaCO_3$)

A_c carbonate alkalinity (mg L^{-1} of $CaCO_3$)

A_h hydrate or hydroxide alkalinity (mg L^{-1} of $CaCO_3$)