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BIOLOGIA Ambiente e Diversidade

ORIGINAL PAPER

An investigation of water quality in shallow ground water sources in the Odaube area of Benue State, Nigeria

Investigação da qualidade da água em águas subterrâneas na área de Osaube, Estado Benue, Nigeria

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Abstract
This study examined shallow ground water quality in Odaube, Benue State, Nigeria. Physico-chemical parameters (taste, odour, pH, conductivity, dissolved solids, hardness, alkalinity, acidity, Nitrate and chloride) and coliform communities were investigated. Generally, results obtained did not meet the acceptable standard of the World Health Organization for potable water. 80% of sampled water sources had odour and taste problems, 10% had pH problems while 20% had elevated nitrate concentrations. Also all the sampled sites showed evidence of serious microbial pollution. This stems from the poor hygienic conditions around water sources and proximity to pit latrines and waste dump sites. Over 90% of the people in the study area depend on these contaminated shallow wells for domestic water as such cheap water treatment options like boiling and the use of chemical additives like water Guard® is highly recommended.

Keywords: *Ground Water; Coliforms; Nitrates; Shallow Wells; Odaube; Benue; Nigeria*

Resumo
O presente estudo avaliou a baixa qualidade da agua subterrânea em Odaube, Benue State, Nigeria. Foram investigados os parâmetros fisico-químicos (sabor, odor, pH, condutividade, dureza, alcalinidade, acidez, presença de nitrato e cloro), bem como as comunidades de coliformes. No geral, os resultados obtidos não representam os parâmetros aceitáveis para potabilidade da agua pela Organização Mundial da Saúde. Das fontes de agua analisadas, 80% apresentaram problemas com odor e sabor, sendo que 10% apresentavam problemas com Ph e 20% com concentrações elevadas de nitratos. Todos os locais amostrados evidenciaram contaminação microbiana séria. Isso se deve ás más condições higiénicas devido à proximidade entre as fontes de agua e as vertentes de dejetos domésticos. Mais de 90% da população da área de estudo, depende desses poços contaminados para consumo doméstico, como opções para o tratamento da agua, usam o fervimento e aditivos químicos como WaterGuard, é muito recomentado.

Palabras-chave: *aguas subterránea. Coliformes. Nitratos. Odaub. Poços*

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Introduction

A study carried out in the United states of America in 2006 concluded that the task of making safe water available, accessible and affordable for all especially in the rural areas of the world must be reduced to the household level taking into consideration the inextricable linkages between drinking water, human behaviour and daily living. The study further concluded that small water supplies in rural communities are most vulnerable to contamination, have poor source waters, treatment facilities and managerial skills and therefore have the greatest potential to transmit waterborne diseases. It was therefore recommended in line with WHO Drinking Water Guidelines (World Health Organization – WHO, 2006), that research to identify and characterize key waterborne pathogens as health-based targets including an assessment of their risks and water safety plans is exigent (Sobsey, 2006). Sobsey (2006), further stated that focus of water quality research must be on microbes because they, rather than chemicals, represent the greatest risk to public health apart from the exception of a few chemicals (such as arsenic, lead and fluoride) the risk of illness and death from chemicals are low, mostly speculative and unproven, since there is little epidemiological data to support health risks from chemicals. Pathogenic microbes on the other hand are documented causes of disease and death globally, and despite some success with some pathogens, many remain poorly understood or not even recognized (Water, 2006).

Groundwater is the largest potential fresh water source in the hydrological cycle, larger than all surface lakes and streams combined. Between earth's land surface and a depth of 4km worldwide, some 8,340,00km^3 of water resides, a volume comparable to 70 times all the fresh water lakes in the world. Despite this volume and its obvious importance, it becomes useless when it gets contaminated with unwanted substance or materials (Christopherson, 2001).

In the world today, man's existence depends on water. His needs for water resources cannot be over emphasized because water is very important for human activities e.g. agriculture, irrigation, industrial waste disposal, domestic purpose etc. The human body is made up of 70% of water, and water is not always naturally available where and when we want it. We rearrange surface water resources to suit our needs; we drill wells, build cisterns and reservoirs, and dam and divert streams to redirect water either spatially or temporally. All of this activity constitutes water- resources management (De Villiers, 2000).

The inadequate supply of good water to homes and industries has been of great concern to hydrologists, geomorphologists and planners as well. In recent decades, the growth of population in the developed countries and the rise in the standards of living have necessitated the rapid expansion of water supplies while in developing countries, the living conditions of the people are generally poor (bad), with general poor water supply. As a result, every year, unsafe water, coupled with a lack of basic sanitation, kills at least 1.6 million children under the age of five years and over 1.1billion of the world's less than 7 billion people do not use drinking water from improved sources; while 84% of world population without access to an improved source of drinking water live in rural areas (WHO/UNICEF, 2006).

Unlike in the developed world, many homes in Nigeria (52%) do not have access to safe drinking water and in the absence of good water from government utilities, communities are forced to depend on untreated groundwater sources (shallow wells, mostly) for domestic water uses. Most of these wells also suffer contamination due to proximity to septic tanks and soak away pits (Adetunji & Odetokun, 2011; Ezekwe *et al.*, 2013), unhygienic ambience of the wells (e.g. some wells have no cover/lids; are dirty and unkempt thus, exposing the well to biological contaminants). Groundwater pollution may also be caused by the improper disposal of solid or liquid wastes in pits, abandoned boreholes or even stream channels and landfills (Adetunji & Odetokun, 2011).

Kimani-Murage and Ngindu (2007) also discovered among slum dwellers in Kenya, East Africa that the urban poor often use inexpensive pit latrines and at the same time 91% of these slum dwellers draw domestic water from nearby wells. Overcrowding in slums limits the adequate distance between wells and pit latrines so that micro-organisms migrate from latrines to water sources. These domestic water sources were found to be highly contaminated with fecal matter. Total coliforms were found in all water samples from shallow wells, while 97% of these samples from shallow wells were positive for thermotolerant coliforms; and about 75% of deep wells were positive for total coliforms and 50% positive for thermotolerant coliforms.

Biological contaminants in groundwater sources are therefore a major source of public health concern among the urban poor and rural dwellers in Africa. The WHO (2004) has stated that one to three million people die from water-borne disease yearly due to unsafe drinking water, while declining water quality poses a particular threat to the poor who often lack ready access to potable water and are subject to the disease associated with contaminated water.

Groundwater quality is of strategic importance to the people of Benue State, Nigeria since it offers a safe haven from guinea-worm infestation often associated with surface water sources. However, available records reveal that water related diseases represent about 80 percent of all reported illness in Benue state, Nigeria (Aper & Agbehi, 2001; Omadachi, 2010).

Therefore this research seeks to examine shallow groundwater quality in Odaube Benue state, with a view to examine possible sources of contamination and assess potential public health risks. This study is an attempt at investigating the quality of shallow ground water in Odaube Oturkpo Local Government area of Benue state.

Materials and methods

Study area

Oduabe is located in the middle belt areas of Nigeria in Benue state in Oturkpo Local Government Area. It lies within latitude 7°N and 13°N and longitude 8°E and 9°E (Figure 1).

The study area has a total population of 30,116 people as of 2011 population census. It is an agriculture area with a level and gently undulating plains stretching eastward with an average elevation of 90m (300 ft) above sea level. The climate is humid tropical and is characterized by two different seasons, the dry and wet (rainy) seasons. The dry season which lasts for five months (November – March) typified by strong dusty and dry harmattan winds. The wet (rainy) season last for seven months from (April- October) and the relative humidity is high (70%) with an average temperature of 27°C while, the mean annual rainfall is 1510mm (Okoli & Anteh, 2010). The vegetation zones are the guinea savannah with grasses ideal for animal grazing during their early growth. The grasses however grow very tall and coarse on maturity. The landscape has been replaced by man- made savannah woodland intermingled with farmland that reflects changes induced by human activities.

Odaube is a large rural community, therefore questionnaires (200), field observation and laboratory methods were applied to this study. 20 clans with 10 respondents each was selected for the study. A total of 20 water samples were also collected from each clan including information on soil type, well depth, and well age. Samples were taken from one well in each of the following clans: Oluna, Ohaba, Odihi, Agbo, Okopoi, Clement, Audu, Omaleh, Bamina, Ikwubela, Odeh, Angelima, Jelius, Olouche, Adikwu, Ujayah, Ibalikwunu, Onyemowo, Orbangeli, and Ujah.

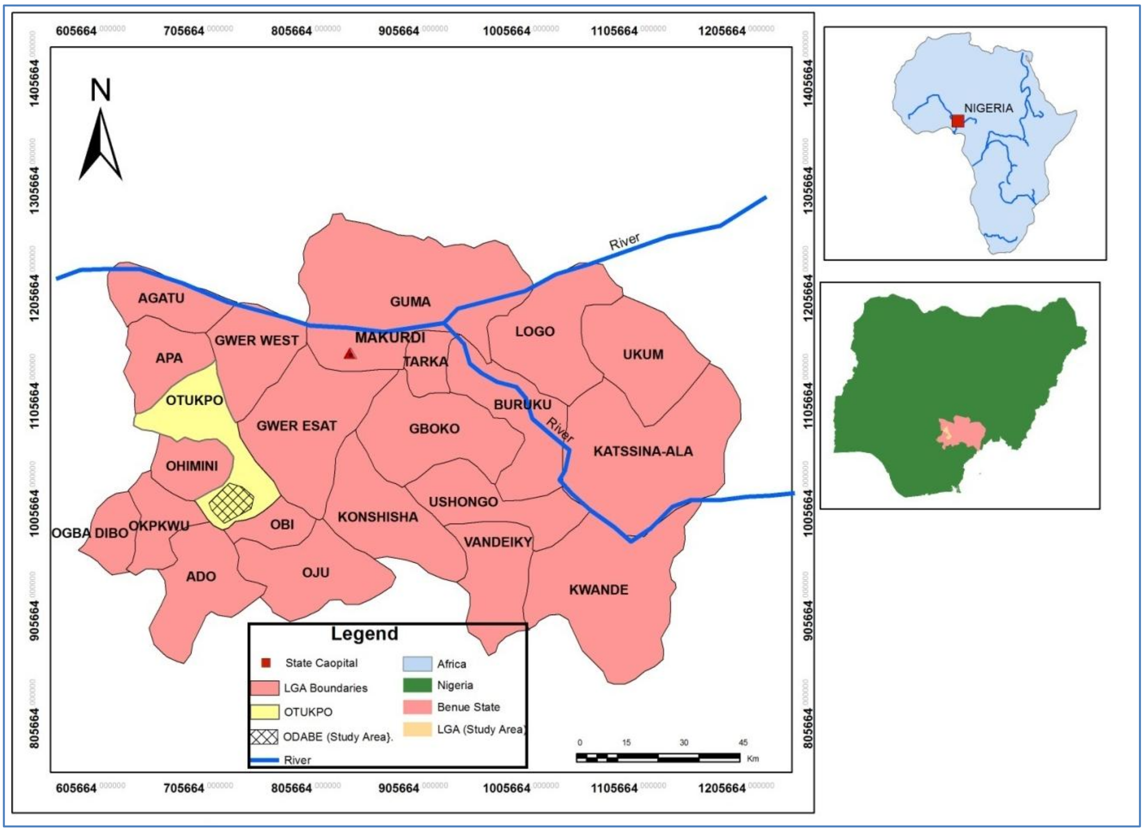

Figure1. Study area.

Water sampling and analysis

The water samples analyzed for this study were collected during the rainy season in October, 2012. Sampling and analysis followed standard methods (American Public Health Association – APHA, 1995), unless otherwise stated. Sampling materials used include one litre plastic bottles, two plastic funnel, distilled water, rope and fetcher. For the bacteriological analysis samples were taken in replicates and the following precautionary measures were taken; sample bottles were oven dried for 30min and later rinsed with ethanol for (sterilization) after which the sample was added, bacteriological analysis was also carried out the day the samples were collected.

For the physiochemical analysis, the sample bottles were rinsed with distilled water and later with a little quantity of the sample. Parameters such as odour and taste were taken in the field. However, total acidity, total alkalinity, total hardness, nitrate and chloride were examined within 24 hours in the laboratory.

The sample were tightly sealed to prevent contamination and gas dissolution, the water samples collected for the study were analyzed at the laboratories of Benue State Rural Water Supply and Sanitation Agency (BERWASSA), Makurdi, Benue state.

Water analysis

pH of water samples was determined with the “LORNIN PH” model 7. The electrode of the pH meter was rinsed with deionized water and dried with a clean filer paper. The pH meter was calibrated with buffer pH 4 and 11 solutions before usage. Total dissolved solids and conductivity were measured using the Lovibond conductivity (US) Tester, while, Chloride, Alkalinity and hardness was by (Titrimetric method). Total nitrate of water sampled were measured with nitrate sensor H- 405 (Nitrate analyzer). The instrument was rinse and test tube filled to 2.5ml line with water from the sample bottle. The subsample was diluted with mixed acid reagent, and after 2 minutes, the test tube was inserted into the nitrate comparator. Record was taken in mg/l.

Bacteriological analysis

Microbiological analyses of water samples were performed using standard methods (APHA, AWWA, WEF, 1998). The analysis of water sample was carried out within twenty four hours of collection using the pour plate technique. Cystine Lactose Electrolyte Deficient CLED (agar) medium was used to obtain plate count of living bacteria (viable cell count). The procedure involves inoculating 10ml of liquefied agar at 37°c with 1ml of water sample in Petri-dishes that have been sterilized in the autoclave at 110°C for 15 minutes. The agar sets to a jelly, thus fixing the bacteria cell in position and preventing swarming of colonies. The plates were inverted and incubated for 24 hours at 37°C for bacteria organism from animal or man. At the end of the incubation, the individual bacteria produced colonies visible to the naked eyes and the number of colonies was determined by using Stuart ®scientific colony counter. The colonies were identified by colouration and size analysis. A magnifying glass was used in counting the colonies

Results

The measured value of this parameter range from 7.1 to 8.9. Extreme high pH value in the water samples may affect the health of consumers of the water. Also, conductivity (the ability of water to conduct electrical current, which is a derivative of the amount of dissolved minerals-TDS). High conductivity in ground water could be due to the dissolution of some earth materials by infiltrating water. The value of the conductivity and TDS in the water sample collected ranges from 560 to 1160 µs/cm and 258 to 480 mg/L and are within recommended standard (2500 µs/cm) and (258 to 510 mg/L) (WHO, 2000).

Nitrate and chloride

The value of chloride (22.5-59 mg/L) was found to be below the WHO standards in all the wells, however, nitrate levels ranged from 22.8 to 58.3 mg/l and was above the permissible limit of 50 mg/l set by the WHO in over 40% of cases. Tables 1 below is the result of analyses of water sampled in the study area. From the table, the following summaries can be drawn.

Bacteriological quality, taste and odour

Total Coliforms (including fecal coliform and *E. Coli*) is used as an indicator that other potentially harmful bacteria may be present in water. While coliforms are naturally present in the environment, faecal coliforms and *E.coli* result from human and animal faecal waste contamination. All sampled wells had very high concentrations of both faecal coliform and E.Coli which are beyond the USEPA (2000) and WHO (1996) standard of zero concentration in drinking waters.

Table 1. Results of Water Analysis Compared to WHO - Cond (Us/cmm (us/uctivity(Us/cm);Total dissolved solids (TDS - mg/L); Hardnessss (Hard - mg/L); Alkalinity (Alk - mg/L); Acidity (Aci. - mg/L; Nitrate (mg/L); Chloride (Chl. - mg/L); Tasteandodour (Tast.); Faecal coliform/100ml (FC); Total coliform colonies/100mL (TCC)

Parameters	pH	Cond	TDS	Hard.	Alk.	Aci.	Nit.	Chl.	Tast	FC	TCC
WHO Guideline (2000)	6.5-8.5	2500	500	300	200	250	50	250	Notoffensive		
Oluna	8.6	720	360	440	112	260	22.8	29.5	Offensive	81	186
Ujah	8.9	910	450	278	6jl	150	58.1	59.0	Sour	112	152
Orbangeli	7.5	630	340	225	48	260	58.3	30.8	Sour	58	148
Onyemowo	7.3	650	280	190	98	100	43.1	30.3	Offensive	47	168
Ibalikwnnn	7.7	700	450	225	69	300	43.1	29.5	Sour	39	151
Ujayah	7.7	560	310	190	78	200	35.3	29.8	Offensive	21	199
Adikwn	7.	1160	350	160	72	252	28.3	22.5	Sour	62	216
Olonche	8.9	790	450	270	104	200	49.5	34.0	Offensive	31	173
Jelins	8.1	620	350	214	98	250	37.5	25.5	Offensive	23	159
Agelima	7.9	840	510	360	115	300	56.2	59.0	Sour	40	83
Odeh	7.2	890	420	240	78	200	49.5	38.3	sour	121	218
Ikwnbela	8.3	620	310	197	92	150	41.1	20.0	offensive	116	172
Bamina	7.5	810	258	270	102	200	50.3	50.9l	Sour	43	89
Omaleh	7.1	*620*	360	218	92	200	43.1	24.1	Offensive	49	61
Andn	8.0	490	280	226	64jl	100	54.0	49.1	Sour	53	155
Clement	7.9	*650*	410	260	64jl	200	50.2	24.5	Sour	18	83
Okopi	7.3	650	420	240	78	150	38.0	29.6	NotOffensive	58	230
Agbo	7.1	470	320	202	74	180	35.1	29.5	NotOffensive	16	43
Odihi	7.9	1020us/cm	480	330	120	200	39.3	33.5	Offensive	21	68
Ohaba	7.1	690	310	206	74	200	35.3	26.0	Offensive	26	53

Discussion

Side effects of consuming high pH water may include headaches, fatigue, muscle aches, a runny nose, and other flu-like symptoms. Also, it may lead to darker stools, diarrhoea and flatulence; although certain health practitioners believe this to be a sign of detoxification which may have some health benefits (Aqua Health Products, 2013). However, the optimum range of 6.5 to 8.5 is recommended by the WHO. The shallow wells in Odaube community were found respectively to have average pH values greater than this recommended standard.

Hardness in water results from the presence of divalent metallic cations, of which calcium and magnesium are the most abundant in groundwater. These ions react with soap to form precipitates and with certain anions present in the water to form a scale. Because of these adverse actions with soap, it is unsatisfactory for household cleansing purposes. The values of the hardness which range from 190 to 440 mg/l is above the WHO standards of 300mg/L in some of the water samples collected.

While alkalinity which indicates the acid- neutralizing ability of water is within standards (200 mg/L), acidity ranges between 100 to 260 mg/L. This high acidity content in some of the water samples collected could be either as a result of acidic soil leaches into this shallow wells or the presence of organic acids in decaying substances. It may also be indicative of the presence of organic shales in the geology of the wells (Ezekwe *et al.*, 2012).

High nitrate levels in water can cause methemoglobinemia or blue baby syndrome, a condition found especially in infants less than six months. Nitrite is absorbed in the blood and is converted to methemoglobin and high methemoglobin concentrations can lead to red blood cells and tissue hypoxia. These results in reduced oxygen supply to vital tissues such as the brain and can result in brain damage and death. Pregnant women also and adults with reduced stomach acidity, and people deficient in (diaphorase i), the enzyme that changes methemoglobin back to normal haemoglobin are all susceptible to nitrite-induced methemoglobinemia (Self & Waskom, 2008). WHO (1996) standards states that Total coliform bacteria must not be found in drinking water in any 100ml sample. In the case of large supplies, where sufficient samples are examined, must not be present in 95% of samples taken throughout any 12-month period (MIT, 2008). The second case does not apply to the study area.

All the 20 wells studied had very high concentrations of coliform bacteria thereby making them unfit from human consumption. Unfortunately, these contaminated wells are the only source of domestic water available to the rural dwellers; more so, these water sources are used without treatment. It is also important to note that only 10% of the sampled wells are wholesome for consumption in terms of odour or taste (Table 1). These odour and taste may be a strong indication of faecal contamination or indication of high metabolic microbial activities in the wells.

Perception of water source problems

It is pertinent to note that the residents are also aware of the dangers of drinking unsafe water and some of the health effects associated with it. Also most of the wells are located close to pit latrines and the ambiences of the wells are not in very hygienic conditions from physical observation as some of them do not readily drain waste water, creating murky conditions and some of the wells are located close to waste dump sites. Compounding these problems is that fetchers used in collecting water from wells are not properly kept in dry hygienic conditions but are littered by the side of wells which are mainly unlined and unprotected. Improvement in the quality of the ground water would considerably enhance the productivity and economic well being of the residents.

Conclusions

The aim of this study was to examine the quality of shallow ground sources in Odaube Benue State, Nigeria. In order to achieve this aim, water sampling and analysis and field observation including questionnaire study was carried out. The study revealed an alkali water groundwater contaminated by nitrates and heavily polluted by coliform bacteria which is an indicator of the presence of other pathogenic species. Some of the physiochemical properties analyzed fell within the WHO permissible limit for potable water while all the samples tested positive to coliform count which shows that the water from the shallow wells could lead to outbreak of disease including cholera, dysentery, diarrhoea, hepatitis among others and the prevalence of these diseases in the community was confirmed by the response to the distributed questionnaires. Based on the major findings of this study, the following recommendations are made:

Wells water which constitutes more than 90% of water supply in the study area should be properly treated by boiling or use of cheap chemical additives like the waterguard®.

The casing of these shallow wells from 15m depth is recommended to reduce surface contamination. The public health workers should ensure that indiscriminate dumping of waste is discouraged, while standard distances for safety of groundwater water from contaminant sources like soak-away pits or pit latrines are maintained. Government should ensure adequate and efficient public water supply through the provision of pipe borne water, while Community effort in managing and maintaining water sources is essential as the government alone cannot provide all that is needed for adequate and sustainable safe water in these rural communities. Local people must take their health and environment seriously and seek ways and partnerships that will assist them in the efficient management and maintenance of their different sources of water. Finally, Public enlightenment campaigns on the state of these water sources and their health effect must be carried out while a policy on minimum standards for domestic water well construction must be enacted.

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