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Quality of Potable Water Available to the Residents of Anambra State, Nigeria

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Abstract

Public pipe-borne water system had collapsed in Anambra state of Nigeria, for over fifteen years, challenging the residents of the state to resort to alternative sources of potable water, notably, boreholes. It is imperative to continuously assess the quality of the water. In this work, two boreholes each in nineteen communities, one from Aguluzigbo, in three local government areas (Anaocha, Awka-North, Awka-South) in the state were sampled, and tested for pH, Conductivity, Hardness, Total Suspended Solids, Lead, Arsenic, Cadmium, Bacteria and Yeast loads. The water samples were all soft and mostly acidic. While there were not much threats of yeast, the aerobic bacteria counts were above the acceptable limits. The Lead, Arsenic and Cadmium concentrations were above the tolerable limits in most communities in Anaocha and Awka-South. Arsenic, Lead, Cadmium were absent in all the samples in Awka-North except in four communities where Cadmium was present. Suspended solid contents were also high in all the Local Government Areas. Overall, the quality of the water consumed by the people in the selected population calls to question of the water and sanitation component of the public health system.

Keywords

Potable Water, Cadmium, Lead, Arsenic, pH, Bacteria Load, Total Suspended Solids, Conductivity, Hardness

1. Introduction

Water is a renewable resource and exists in a continuous state flux, the balance is governed by conservation of mass, and all land areas in a river basin are interlinked through water [1]. Water, the source of life and human civilization, has become one of the major issues in recent years. It is probably the most valuable natural resource available to man, and no doubt the most essential element to human without which no life can survive. Not only is water essential to every single cell and organ in the body, it makes up two-thirds of the weight of the human body and plays a very vital role in existence as well as maintenance of life of organisms [2] [3] [4]. Even though water covers 78% of the earth's surface, yet water available for human use is limited [5]. Without doubts, the much desired dream of all human beings having easy access to safe and affordable potable (drinking) water is generally considered by many as one of the most basics of all human rights, and should nonetheless assume the status of one of the critical drivers of any effectively planned and properly implemented human health protection and development policy framework—be it local, state, regional, national or global [6] [7] [8] [9]. Global water use has been growing at more than twice the rate of population increase in the last century due to population growth and the demands of irrigated agriculture, and although there is no global water scarcity as such, an increasing number of regions are chronically short of water [10] [11]. It is also a fact that water availability will continue to be a contributing factor to migration, particularly in those regions where compounding factors of poverty and vulnerability to natural hazards are present [12]. It was estimated that every year, millions of people die from a lack of clean, fresh drinking water. Beyond a few scientific journals and United Nations' ("UN") summit publications, major media outlets choose to ignore these staggering figures, focusing their scientific reporting instead on the impending obsolescence of fossil fuels. Water is an essential, life-giving force; its scarcity demands our attention [13].

In the last century, the world population has tripled. It is expected to rise from the present 6.5 billion to 8.9 billion by 2050, before leveling off. Currently half of the world's population lives in cities, and by 2030, this figure will grow to 60%, most notably in Africa and Asia where urban populations are predicted to double between the years 2000 and 2030. Today, urban dwellers in certain developing cities in Africa pay 5 to 7 times more for water than the average price paid in the United States or Europe [14]. At the beginning of 19th century drinking water in urban areas was available with little or no purification needed, but growing industrialization and urbanization led to increased pollution and occurrence of faecal-borne diseases [15]. The World Health Organization (WHO) estimates that almost 10% of the population in the world do not have access to improved drinking water sources, and one of the United Nations (UN) Sustainable Development Goals is to ensure universal access to water and sanitation by 2030 [16]. In recent years, water sector professionals have made considerable progress improving access to drinking water worldwide. The Millennium Development Goal (MDG) for drinking water was met in 2015, with 2.6 billion people gaining access to an improved drinking water source since 1990 [17]. Although progress has been made in supplying drinking water to more people year on year, 663 million people still lack "improved" drinking water sources in 2015 and for many people, this "improved" water is not always safe, reliable, affordable or accessible with equity [18]. According to the World Health Organization/United Nations International Children's Emergency Fund (WHO/UNICEF) 2017 and 2019, billions of people around the world are continuing to suffer from poor access to safely managed drinking water services, sanitation and hygiene and 1 in 3 people globally do not have access to safe drinking water [19] [20]. Providing safe drinking water is paramount for public health to prevent water-related diseases. Though, the "*Water for Life*" *International Decade for Action* 2005-2015 which was said to have helped around 1.3 billion people in developing countries gain access to safe drinking water, monitoring and maintaining water safety in piped systems and point sources around the world is still challenging [21] [22] [23] [24]. It has also been reported that nearly 2 million people suffer devastating waterborne diseases on an annual basis, and these even result in high mortality for certain cases [25].

Africa is the second-driest continent in the world, after Australia, and suffers from acute water scarcity problems that involve water stress, water deficit/shortage and water crisis [26]. In Africa, Water quality testing is not performed as often as is necessary, and lack of education among the people utilizing the water source leads them to believe that as long as they are getting water from a well, it is safe. Once a source of water has been provided, quantity of water is often given more attention than quality of water [27]. According to WHO, less than 50% of people in rural Africa have access to both improved drinking water and sanitation and more than 50% of the 663 million people Worldwide who lack access to safe water reside in Sub-Saharan Africa, where over 40% of all people are still without improved drinking water [28] [29]. [30]. Also According to Mukuhlani and Nyamupingidza 2014, at least 25% of countries in Africa are already experiencing water pressure; another 11 countries are expected to join them by 2025 at which time nearly 50 per cent of Africa's predicted population of 1.45 billion people will face water stress or scarcity. Nearly half of the population (300 million people) in sub-Saharan countries lack access to a supply of safe water and 41 per cent lack adequate sanitation [31]. Africa is certainly not on track to meet the Millennium Development Goal for drinking water and sanitation. Rather, it is headed to a continuous, endemic water and sanitation crisis that debilitates and kills huge numbers of people, threatens the health of the workforce, stands in the way of economic growth and limits access to education and, therefore, life opportunities. Every year, it is estimated that more than half of Africans have water-related diseases and one million Africans die from diseases related to unsafe drinking water, poor sanitation and poor hygiene, and between 1% to 2.5% of GDP of African countries and $5.5 billion are lost annually due to inadequate sanitation [32] [33].

Nigeria is blessed with abundant water resources but largely untapped. In spite of the abundant water resources, government at all levels (federal, state and local) have not been able to successfully harness these resources to ensure a sustainable and equitable access to safe, adequate, improved and affordable water supply and sanitation to its population [34]. As one of the fastest urbanizing country in the continent, the rate of urbanization in Nigeria is characterized by high population concentration, increase in industrial, agricultural activities and indiscriminate disposal of all kinds of wastes, which are perceived to pose serious pollution threats with all its concomitant health hazards on groundwater quality especially in urban areas [35] [36] [37].

The quality of any body of surface or ground water is a function of either or both natural influences and human activities [38]. Drinking water based on groundwater resources contains geogenic elements which may be important long-term exposures to humans and may result in both harmful (e.g., arsenic) or beneficial (e.g., magnesium and calcium) health effects [39]. Also Climate Change is not just an energy problem because the incursion of storms and the loss of coast may cause drinking water supplies to be contaminated with salt water. Paradoxically, climate change prevention through carbon sequestration may also risk contaminating drinking water, and risk of waterborne diseases such as diarrhea, cholera, skin and eye diseases. Also increasing changes in precipitation patterns resulting from Climate change are likely to compromise the supply and quality of water through floods and water logging [40] [41].

Various researchers have studied the quality of many samples of water, example Babič *et al.*, 2017 monitored microbiological drinking water safety by bacterial parameters and discovered faecal contamination and the parameters correlate with gastro-intestinal illness [42]. In 2015 Babic *et al.*, also studied Yeasts and yeast-like fungi in tap water and groundwater, and their transmission to household appliances and discovered that all 116 water samples sampled showed presence of selected culturable fungi with emphasis on human opportunistic pathogenic species [43]. Ayanbimpe *et al.*, 2012 analyzed 150 water samples in Jos, Nigeria and the result showed that 53.3% of the samples were contaminated with fungi [44]. Also many other researchers have reported the outbreak of diseases resulting from the use of unsafe water example, according to Chaminuka and Nyatsanza 2013, in many African countries, people still die of water related illnesses example Zimbabwe experienced a cholera outbreak in 2009 and the principal cause of the outbreak was the lack of access to safe water in urban areas and communities [45]. According to Kandji, (2006), 80% of Kenyans continue to have inadequate access to water, drink unsafe water (the water is from unreliable sources), and spend much time and money trying to acquire it. As a result, most people suffer and die due to water related issues such as waterborne diseases (diarrhoea, dysentery or cholera) mostly from consumption of untreated water, which account for 60% of all diseases in Kenya [46]. Jidauna *et al.*, 2017 assessed some domestic water sources in Dutsinma town, Kastina State. The result indicated that water from tap water was acidic and the concentration of lead was above WHO standard [47]. In Nigeria, 2010, a cholera epidemic was reported which claimed the lives of about 431 persons in 11 states [48]. Ohwo and Abotutu, 2014 assessed potable water supply in Yenagoa Metropolis, in Nigeria and discovered that the level of turbidity, lead, iron were above WHO thresholds, and the samples were found to be acidic [49].

Some Heavy metals such as lead, cadmium and arsenic are among the hazardous toxins around us [50]. The three metals, lead, mercury and cadmium, and the metalloid arsenic have all caused major human health problems in various parts of the world [51]. Chronic exposure to high levels of arsenic, cadmium, and other toxic metals has also been associated with higher risk of cancers of the bladder, kidney, liver, lung, and skin. Emerging evidence suggests that these toxic metals may have adverse effects on these outcomes even at lower concentrations [52]. Water is life, determination of quality of potable water is very important because this determines the health of man.

2. Methods

2.1. Sample Location

Anambra State Located in the South East Geopolitical zone of Nigeria is traversed by many rivers of national and regional importance which include: the river Niger, Anambra, Mamu, Idemili etc, With a population of 4,182,032 million people, spread over a land mass of 44,116 km^2; Anambra State in the Federal Republic of Nigeria is the most densely populated state in the southeastern part of the country. The state lies between latitude 5˚42'N and 6˚47'N and longitude 6˚37'E and 7˚23'E, being made up of 127 communities divided into 22 Local Government Areas. Anambra State lies within the humid tropical rainforest belt of Nigeria with an annual rainfall of about 2000 - 3000 mm, annual mean minimum temperature is about 23˚C while the annual mean maximum temperature is about 32˚C, and mean annual sunshine hours of about 1750 hours. Relative humidity varies with season with an average value of about 75% - 95% and a mean annual atmospheric pressure of about 1101 ± 1.2 m bars [53] [54] [55]. Awka South is located between latitudes 6˚10'N and 6˚15'N and longitudes 7˚2'30'E and 7˚7'30'E on the South eastern part of Nigeria. The study area covers 144.5 ha with a 2006 contested population of 116, 208 persons [56]. Anaocha local government area is one of the twenty one Local Government Areas that make up the present Anambra State, Nigeria. It is a rural Local Government Area with its headquarter at Neni. Anaocha spans over 171.62 kilometres with a population of 284,215 based on the 2006 Census. The major occupation of the people of Anaocha is farming, followed by trading and civil service [57]. Awka North Local Government Area of Anambra State, Nigeria. It is located at latitude 60 151 N and 70 101 E and longitude 6.2500 N and 7.167 0 E. It occupies a total land area of 340 square kilometers, with a population of 112,608 people [58].

2.2. Sample Collection and Analyses

Thirty nine borehole water samples were collected, two boreholes each in nineteen communities: AM1-Eke Amawbia, AM2-St Matthew Amawbia, UM1- Enugu Umuawulu, UM2-St Joseph Umuawulu, NB1-Eke Nibo, NB2-GMG Nibo, NS1-Ngodo Nise, NS2-St John Nise, MB1-St Dominic Mbaukwu, MB2-Akabor

Mbaukwu, OK1-Y junction Okpuno, OK2-Boulevard Okpuno, EZ1-Ndikpa Ezinato, EZ2-Ndiora Ezinato (Figure 1), AD1-Alor Road Adazi Ani, AD2-Eke Adazi Ani, AN1-Bubendof Adazi Nnukwu, AN2-Nkwoagu Adazi Nnukwu, AG1-Nkitaku Agulu, AG2-Okpu Agulu, AZ1-Ifite Aguluzigbo, NN1-Umueri Neni, NN2-Umueze Neni, NR1-Agbadani Nri, NR2-Iruoforo Nri, OB1-Iruowelle Obeledu, OB2-Obeledu Ani Obeledu (Figure 2), AS1-Igbagu Amansea, AS2-Umuokpara Amansea, AK1-Amaeze Amanuke, AK2-Eziama Amanuke, EB1-Amagu Ebenebe, EB2-Umuji Ebenebe, UR1-Umuife Urum, UR2-Ativ Urum, IS1-Ifite-isu Isuaniocha, IS2-Ofiakuz Isuaniocha, MG1-Amaezike Mgbakwu, MG2-Uruonage in three local government areas (Awka-South, Anaocha and Awka-North,) in Anambra State (Figure 3). One sample was collected from Aguluzigbo AZ1, because it was the only functional borehole from the community at the time of collection.

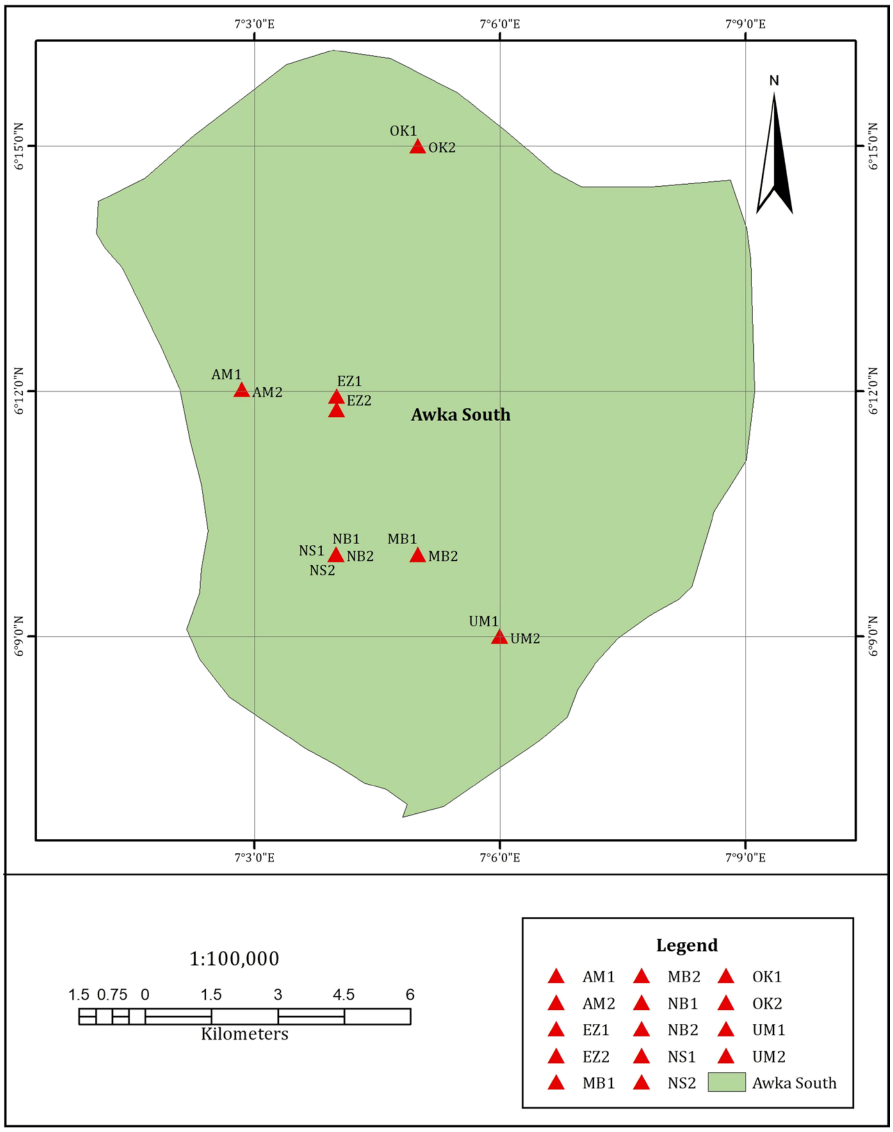

Figure 1. Map of Awka south showing sample locations.

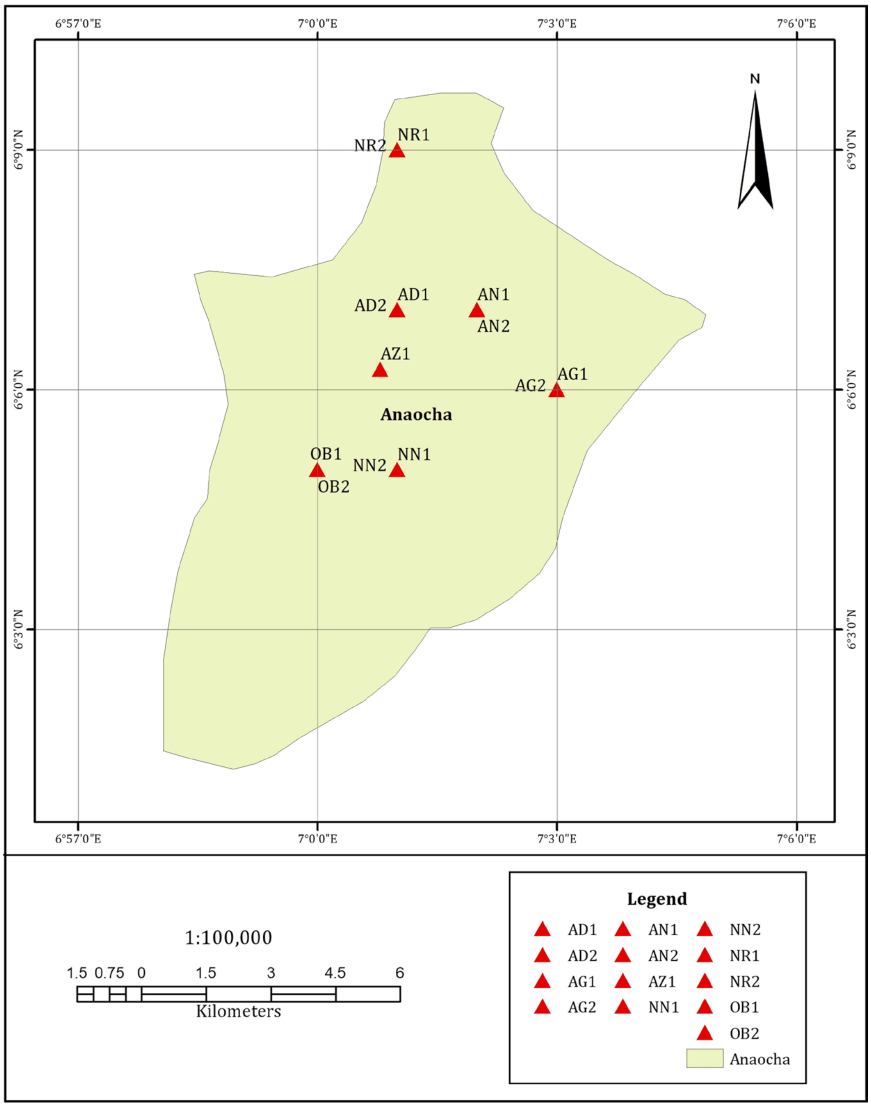

Figure 2. Map of Anaocha showing sample locations.

The samples were tested for pH, Conductivity, Total Hardness, Total Suspended Solids TSS, Lead, Arsenic, Cadmium, Bacteria and Yeast load. All of the drinking water samples were taken from the tap water of residential areas. The samples were collected in a 1-liter polyethylene bottle, which were washed with deionized water. The samples were sealed and placed in a dark environment at temperature of about 15˚C to avoid effects of temperature and light. For pH, conductivity and Total Suspended Solids TSS, a representative water sampling was carried out from each location and methods of American Public Health Association APHA. The samples were measured using a pH meter (model HI 96107). The pH meter was calibrated and standardized with buffer solution for accuracy. The value of each the sample was taking after submerging the probe of the pH meter in sufficient volume of the water sample to cover the tip of the probe. The pH reading on the meter was recorded when the reading stabilized. The probe was rinsed with deionized water after each measurement to avoid

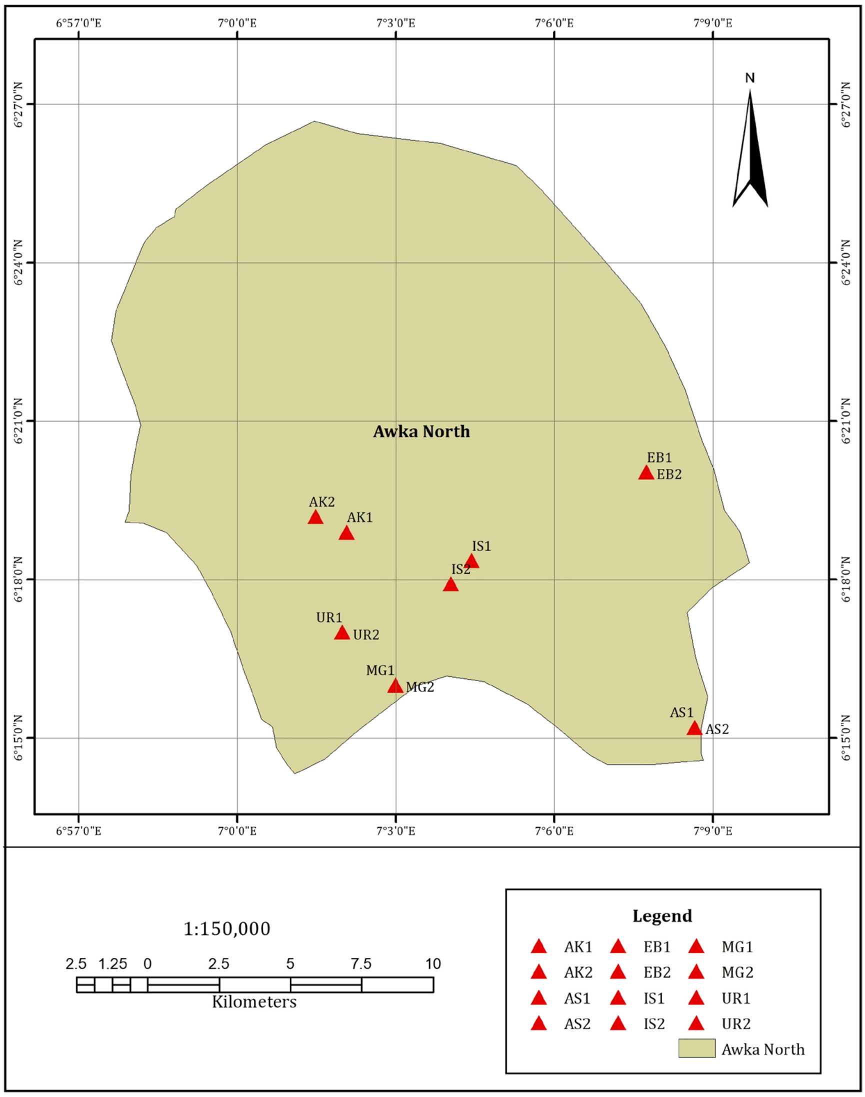

Figure 3. Map of Awka north showing sample locations.

cross contamination of the different samples [59]. The conductivity of the samples was measured using conductivity meter (model DDS 22C) by calibrating the probe of the conductivity meter and standardized. The temperature of the sample was adjusted to 20˚C ± 0.1˚C. The probe was submerged in sufficient volume of the sample. The reading was taken after the disappearance of stability indicator. The probe was rinsed after each measurement to avoid cross contamination [60]. The Total suspended solids TSS of the samples was measured according to standard methods of APHA by filtration process. The Whatman filter paper was dried in an oven to remove the moisture. The filter paper was weighed to obtain the initial weight. 50 cm^3 of each of the samples was filtered with the preweighed filter paper. The filter paper was dried and weighed to get the final weight. The total suspended solids in mg/L was calculated from the difference in the weights (amount of the suspended solids). Total hardness of the samples was conducted by introducing 50 cm^3 of each of the samples into a beaker and adding 1 cm^3 of buffer solution of ammonia. Three drops of Solochrome Black-T indicator were added and the mixture titrated with 0.01EDTA. The concentrations of two heavy metals: lead, cadmium and a metalloid-arsenic in the water samples were determined using Atomic Absorption Spectrophotometer Varian AA240. The samples were filtered through Whatman 0.45 µm membrane filter paper. One hundred milliliters of the filtered water was mixed with 5 mL concentrated nitric acid (HNO_3) and 5 mL concentrated sulphuric acid (H_2SO_4). To allow the acids to become concentrated, the mixture was heated until the volume was reduced to about 15 to 20 mL. The digested sample was allowed to cool to room temperature. It was then filtered through Whatman's 0.45 µm filter paper. The final volume was adjusted to 100 mL with double distilled water and stored for analysis [61]. The microbiological tests of the samples were carried out by serially diluting the water samples using sterile water up to 10^{-2} dilution. 0.1 ml of the diluted water was used to inoculate Nutrient Agar plates all in duplicates, using spread plate method. Nutrient Agar plates were incubated at 37˚C for 48 hours, while Sabouraud Dextrose Agar plates were incubated at 25˚C for 5 days. After incubation, the number of colonies in each petri dish was counted, and the number of colony forming unit (cfu/ml) of the water samples estimated.

3. Results and Discussions

The result of the physicochemical analyses (**Tables 1-3**) showed all the water samples were soft because the values of total hardness were all below WHO Permissible limit of 100 mg/l [62]. The results of pH analyses of samples from

Table 1. Physicochemical concentration of water samples from communities in Awka South.

Communities	pH	Conductivity (µS/cm)	TSS (mg/L)	TH (mg/L)	CaH (mg/L)	MgH (mg/L)
AM1	5.3#	539.0	0.36#	64	36	28
AM2	5.4#	204.0	0.50#	54	34	20
UM1	4.5#	45.1	0.44#	34	20	14
UM2	4.4#	16.9	0.56#	54	30	24
NB1	5.2#	41.6	0.68#	40	18	22
NB2	5.3#	40.4	0.60#	58	42	16
NS1	5.6#	74.7	0.60#	62	50	12
NS2	5.8#	75.0	0.54#	62	50	12
MB1	4.9#	157.7	0.48#	36	24	12
MB2	5.4#	100.7	0.44#	54	42	12
OK1	5.6#	203.0	0.46#	58	40	18
OK2	5.6#	211.0	0.64#	64	48	16
EZ1	5.3#	158.3	0.38#	60	40	20
EZ2	5.2#	156.8	0.34#	64	56	8

Table 2. Physicochemical concentration of water samples from communities in Anaocha.

Communities	pH	Conductivity (μS/cm)	TSS (mg/L)	TH (mg/L)	CaH (mg/L)	MgH (mg/L)
AD1	5.0$^{\#}$	15.3	0.66$^{\#}$	26	18	8
AD2	5.4$^{\#}$	44.7	0.52$^{\#}$	26	20	6
AN1	6.9	61.7	0.68$^{\#}$	54	30	24
AN2	5.6$^{\#}$	36.9	0.62$^{\#}$	28	18	10
AG1	4.6$^{\#}$	22.4	0.40$^{\#}$	34	20	14
AG2	5.5$^{\#}$	37.8	0.48$^{\#}$	28	16	12
AZ1	5.4$^{\#}$	15.6	0.58$^{\#}$	34	22	12
NN1	5.5$^{\#}$	15.5	0.46$^{\#}$	26	22	4
NN2	6.0$^{\#}$	17.5	0.60$^{\#}$	14	10	0.4
NR1	5.0$^{\#}$	85.2	0.54$^{\#}$	64	60	0.4
NR2	5.3$^{\#}$	63.3	0.50$^{\#}$	30	24	6
OB1	5.4$^{\#}$	15.4	0.42$^{\#}$	30	26	4
OB2	5.6$^{\#}$	27.5	0.36$^{\#}$	30	26	4

Table 3. Physicochemical concentration of water samples from communities in Awka North.

Communities	pH	Conductivity (μS/cm)	TSS (mg/L)	TH (mg/L)	CaH (mg/L)	MgH (mg/L)
AS1	6.3$^{\#}$	32.5	0.32$^{\#}$	46	38	8
AS2	5.4$^{\#}$	32.3	0.22$^{\#}$	32	16	10
AK1	5.0$^{\#}$	70.5	0.24$^{\#}$	34	18	16
AK2	6.0$^{\#}$	34.5	0.84$^{\#}$	44	36	8
EB1	5.0$^{\#}$	14.6	0.14$^{\#}$	46	32	14
EB2	6.2$^{\#}$	145.5	0.34$^{\#}$	36	24	12
UR1	5.7$^{\#}$	69.8	2.04$^{\#}$	48	30	18
UR2	5.0$^{\#}$	100.6	1.60$^{\#}$	40	20	18
IS1	5.3$^{\#}$	113.5	0.48$^{\#}$	36	22	16
IS2	6.7	101.2	1.48$^{\#}$	38	22	16
MG1	6.4$^{\#}$	33.8	0.44$^{\#}$	40	28	12
MG2	5.8$^{\#}$	118.5	0.52$^{\#}$	36	26	20

$^{\#}$- Not within the permissible limits for pH; $^{\#}$- Above the permissible limits for TSS.

communities in Awka South indicated the pH of all the water samples were all below WHO permissible limit of 6.5 - 8.5 [63]. The pH range and average of samples from the Local Government Area were 4.4 - 5.8 and 5.25 respectively. The results of pH of samples from communities in Anaocha Local Government Area and Awka North showed that the pH of all the samples except samples from Bubendof Adazi Nnukwu and Ofiakuz Isuaniocha respectively were below the WHO permissible limit [63] and pH range/average of samples from the two local government areas were 4.6 - 6.9/5.48 and 5.0 - 6.7/5.73 respectively. Generally the water samples from most of the communities in the three Local Government Areas were all acidic, this could be due to corrosion of the water pipes. Also The results of conductivities of the samples from communities from all the three Local Government Areas showed that all the water sample were below the WHO 1993 standard (250 µS/cm) [64] except a sample from Amawbia (539 µS/cm). The conductivities from the Local Government Areas ranged from 16.90 - 539.00 µS/cm, 15.3 - 85.2 µS/cm and 14.6 - 145.5 µS/cm respectively. The conductivity averages of the three local areas were 144.586 µS/cm, 35.292 µS/cm, 72.275 µS/cm respectively. The low conductivity values could be due to poor and rather insoluble geologic rock and mineral types [65]. Total suspended solids TSS of the water samples from all communities in the three Local Areas were all above NSDWQ standard of 0.01 mg/L [66] and showed TSS range/average of 0.34 - 0.68 mg/L (0.50 mg/L), 0.36 - 0.68 mg/L (0.52 mg/L) and 0.14 - 2.04 mg/L (0.72 mg/L) for Awka South, Anaocha and Awka North respectively.

The result of the elemental analyses (**Tables 4-6**) showed that the concentrations of lead and arsenic in water samples from communities in Awka South were all above the WHO standard of 0.01 mg/L [62] [63], except samples from St Joseph Umuawulu, GMG Nibo, Ngodo Nise and St John Nise where lead and arsenic were absent. The range and average concentrations of the lead and arsenic in the samples from the local government area were 0.000 - 0.103 mg/L (0.040 mg/L) and 0.000 - 2.637 (0.850 mg/L) respectively. Lead and arsenic concentrations from communities in Anaocha Local Government Areas were above the WHO standard except sample from Iruowelle Obeledu community where

Table 4. Concentration of As^{3+}, Cd^{2+}, Pb^{2+} in borehole water samples in Awka South (mg/L).

Communities	As^{3+}	Cd^{2+}	Pb^{2+}
AM1	2.637#	0.152#	0.056#
AM2	0.310#	0.137#	0.037#
UM1	1.032#	0.136#	0.068#
UM2	0.000	0.113#	0.007
NB1	0.503#	0.135#	0.036#
NB2	0.000	0.112#	0.000
NS1	0.000	0.115#	0.000
NS2	0.000	0.169#	0.000
MB1	2.059#	0.136#	0.044#
MB2	0.033#	0.125#	0.033#
OK1	1.800#	0.145#	0.084#
OK2	0.011#	0.135#	0.022#
EZ1	1.645#	0.172#	0.068#
EZ2	1.869#	0.139#	0.103#

Table 5. Concentration of As^{3+}, Cd^{2+}, Pb^{2+} borehole water samples in Anaocha (mg/L).

Communities	As^{3+}	Cd^{2+}	Pb^{2+}
AD1	1.446#	0.163#	0.046#
AD2	0.277#	0.171#	0.044#
AN1	2.562#	0.163#	0.061#
AN2	0.652#	0.147#	0.069#
AG1	0.555#	0.142#	0.043#
AG2	2.112#	0.152#	0.043#
AZ1	0.933#	0.165#	0.047#
NN1	1.907#	0.156#	0.064#
NN2	0.00	0.146#	0.077#
NR1	1.661#	0.154#	0.083#
NR2	1.506#	0.156#	0.059#
OB1	0.515#	0.172#	0.100#
OB2	0.986#	0.146#	0.051#

Table 6. Concentration of As^{3+}, Cd^{2+}, Pb^{2+} borehole water samples in Awka North (mg/L).

Communities	As^{3+}	Cd^{2+}	Pb^{2+}
AS1	0.000	0.170#	0.000
AS2	0.000	0.000	0.000
AK1	0.000	0.434#	0.000
AK2	0.000	0.000	0.000
EB1	0.000	0.053#	0.000
EB2	0.000	0.000	0.000
UR1	0.000	0.000	0.000
UR2	0.000	0.030#	0.000
IS1	0.000	0.000	0.000
IS2	0.000	0.000	0.000
MG1	0.000	0.000	0.000
MG2	0.000	0.004#	0.000

#- above permissible limits.

the concentration of lead was found to be 0.01 mg/L and Umueze Neni where arsenic was absent. The concentrations of lead from samples in communities in the two local government areas ranged from 0.100 - 0.100 mg/L and the average concentration was found to be 0.061 mg/L. Also the arsenic range and average from samples in communities Anaocha local government area were 0.000 - 2.562 mg/L and 1.163 mg/l. The concentration of Arsenic was high in both LGAs could be attributed to the fact that Arsenic is a natural component of the earth's crust and so could contaminate the underground water from sources of arsenopyrite, base metal sulfides, realgar and orpiment, arsenic-rich pyrite, and iron oxyhydroxide [67]. The concentrations of cadmium from samples from communities in Awka South and Anaocha were all above the WHO permissible limit of 0.003 mg/L [62] [63] and ranged from 0.112 - 0.172 mg/L and 0.142 - 0.172 mg/L respectively. The average concentrations of Cadmium in samples from the two LGAs were 0.137 mg/L and 0.156 mg/L respectively. Generally, high values of these metals in Awka South and Anaocha could be as a result of some communities in the LGAs being ravaged by erosion menace, indiscriminate siting of industries, blacksmith workshops (major occupation for indigenes of some communities in Awka South), automobile repair workshops etc. Cadmium was absent in many communities in samples from communities in Awka North except samples from Amaeze Amanuke, Igbagu Amansea, Ativ Urum, Uruonaga Mgbakwu, Amagu Ebenebe where the concentrations ranged from 0.004 - 0.434 mg/L. Lead and arsenic were totally absent in samples from Awka North, absence of arsenic could be as a result of presence of Sedimentary rocks tend not to bear high arsenic loads, and common matrices such as sands and sandstones contain lower concentrations owing to the dominance of quartz and feldspars [67]. The absence of lead and very little concentration of cadmium in water samples from Awka North was not surprising because Awka North is the least developed of the three local government areas with least number of industries, batteries from automobile repair workshops, coating, plating, alloys, automobiles, tanks, and broadcasting stations which all use rechargeable storage batteries as the energy source for light [68] [69].

The result of microbiological analyses (**Tables 7-9**) indicated that the total

Table 7. Microbiology parameters of borehole water samples in Awka South.

Communities	Aerobic Bacteria Count (cfu/ml)	Total Yeast/Mould Count (cfu/ml)
AM1	$2.48 \times 10^{4\#}$	Nil
AM2	$1.22 \times 10^{4\#}$	Nil
UM1	$3.4 \times 10^{3\#}$	Nil
UM2	$2.7 \times 10^{3\#}$	Nil
NB1	$6.5 \times 10^{3\#}$	Nil
NB2	$3.1 \times 10^{3\#}$	Nil
NS1	$1.01 \times 10^{4\#}$	Nil
NS2	$6.3 \times 10^{3\#}$	Nil
MB1	$9.7 \times 10^{4\#}$	Nil
MB2	$1.08 \times 10^{4\#}$	10
OK1	$2.03 \times 10^{4\#}$	10
OK2	$4.2 \times 10^{3\#}$	Nil
EZ1	$2.22 \times 10^{4\#}$	$20^{\#}$
EZ2	$8.7 \times 10^{3\#}$	Nil

Table 8. Microbiology parameters of borehole water samples in Anaocha.

Communities	Aerobic Bacteria Count (cfu/ml)	Total Yeast/Mould Count (cfu/ml)
AD1	$3.8 \times 10^{3\#}$	Nil
AD2	$7.6 \times 10^{3\#}$	Nil
AN1	$3.4 \times 10^{3\#}$	Nil
AN2	$4.9 \times 10^{3\#}$	Nil
AG1	$3.3 \times 10^{3\#}$	Nil
AG2	$1.5 \times 10^{3\#}$	Nil
AZ1	$1.05 \times 10^{4\#}$	Nil
NN1	5.0×10^{2}	Nil
NN2	$1.1 \times 10^{3\#}$	Nil
NR1	$6.4 \times 10^{3\#}$	Nil
NR2	$1.2 \times 10^{3\#}$	Nil
OB1	$2.24 \times 10^{4\#}$	Nil
OB2	$1.36 \times 10^{4\#}$	Nil

Table 9. Microbiology parameters of borehole water samples in Awka North.

Communities	Aerobic Bacteria Count (cfu/ml)	Total Yeast/Mould Count (cfu/ml)
AS1	$7.8 \times 10^{3\#}$	$90^{\#}$
AS2	$1.24 \times 10^{4\#}$	$60^{\#}$
AK1	$8.3 \times 10^{3\#}$	$40^{\#}$
AK2	$2.35 \times 10^{4\#}$	Nil
EB1	$8.9 \times 10^{3\#}$	10
EB2	$1.6 \times 10^{4\#}$	$120^{\#}$
UR1	$2.48 \times 10^{4\#}$	Nil
UR2	$2.74 \times 10^{5\#}$	$30^{\#}$
IS1	$2.44 \times 10^{4\#}$	$209^{\#}$
IS2	$2.21 \times 10^{4\#}$	Nil
MG1	$2.51 \times 10^{4\#}$	10
MG2	$2.84 \times 10^{4\#}$	Nil

$^{\#}$- Above permissible limits.

aerobic bacteria count of samples from communities in Awka South were all above permissible limits of WHO [64] of 1.0×10^3 cfu/ml. The values ranged 2.7×10^3 - 9.7×10^4 cfu/ml. Total aerobic bacterial count of sample from communities in Anaocha were above the permissible limit except sample from Umueri Neni which was 5.0×10^2 cfu/ml. The values from the LGAs ranged from 5.0×10^2 - 2.24×10^4 cfu/ml. Results of the microbial load of samples from Awka North also showed that they were all above the permissible standard and ranged from 7.8×10^3 - 2.74×10^5 cfu/ml. Yeast load did not pose any threat in samples from communities in Anaocha where yeasts were found to be absent. They did not pose much threats in samples from communities from Awka South where they were only present in little amounts in three locations: Akabor Mbaukwu, Y junction Okpuno, Ndikpa Ezinato with values 10 cfu/ml, 10 cfu/ml, 20 cfu/ml respectively. The yeast load of samples from Awka North also posed some threats where the total yeast counts were present except in Eziama Amanuke, Umuife Urum, Ofiakuz Isuaniocha, Uruonage Mgbakwu they were absent. The total yeast load ranged from 10 cfu/ml - 209 cfu/ml. According to Desrosier and Singh 2018, the pH range for *yeast* growth is 3.5 - 4.5 and for molds is 3.5 - 8.0. Yeasts are unable to grow at a water activity of less than 0.9, and molds are unable to grow at a water activity below 0.8. The low pH of fruits is generally unfavourable for the growth of bacteria [70]. It was expected that considering the acidity of the water samples in all the LGAs, the yeast load would be high and the bacterial load low, but reverse was the case. The high value of aerobic bacterial count in all the samples was expected because in most communities in Anambra State, pit latrines and open defecation are still being practiced. Generally, the total aerobic bacteria count and yeast load counts of samples from Awka North were highest and could be attributed to highest rate of open defecation and use of pit latrines practices in many communities in the Local Government Area.

4. Conclusion

Availability of quality potable water is key to achieving sustainable public health which is an important goal of the United Nations. Dwindling municipal water supply leads to water and sanitation crisis. For their domestic needs, people fall back on dubious water sources, many of which contain dangerous contaminants. Since they cannot afford the high expense of water treatment, people helplessly take the contaminated water [71]. The results showed "potable" water samples that were acidic, highly polluted with metals and microbial loads. Since all aspects of social, economic and health development of any people or place depend on water, absence of quality potable municipal water supply in Anambra State calls to question of the social, economic, health development and the life of the residents of the State.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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