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Quality of FADAMA and EBSCA Boreholes in Abakaliki, Southeastern, Nigeria

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Abstract: FADAMA and Ebonyi State Social and Community Agency (EBSCA) are World Bank-Federal Government-State Government-Community Development initiatives in Nigeria. Their programmes were based on bottom-top approach of current World Bank Millennium Projects/Programmes in developing countries. FADAMA I, II, III and IV have gone extra miles in all-inclusive agricultural and rural development projects; just like EBSCA. Part of them is the provision of safe and potable water to the people who cannot afford the cost of sachet-packed or canned water that sell between N100 – N350 (US$0.50 – US$1.78) (equivalent of daily wage of an average worker). At Ebonyi State University, Abakaliki, we have been curious on all sustainable development projects and programmes from International, Nigerian, States, Local Governments, Community levels. In this study, the Department of Soil Science and Environmental Management started to monitor the quality of FADAMA and EBSCA boreholes since 2013. The three years (2013 – 2015) findings showed no significant variations.

Key words: Water Quality · Potable Water · Millennium Development · Community Projects · FADAMA and EBSCA

INTRODUCTION

Nigeria became tired of top-bottom development approaches to agricultural and rural development in what we call the "Second Republic" of President Chief Olusegun Obasanjo in 1999 after several decades of Military Dictatorship. Nigeria became independent on 1st October, 1960 and a Republic on 1st October, 1963. The First Republic is used in Nigerian context to mark the era of civilian or democratic governance. The country's First Republic is referred to 1983, the administration of President Shehu shagari, which was subsequently marred by Military coups and dictatorships. The country may have blacklisted the Parliamentary democracy of President Nnamdi Azikiwe and Prime Minister Abubakar Tafawa Balewa as they felt it was a colonial-master blueprint. The country chose President Shagari American-democratically-styled elected government as First Republic of the country. Here, we are. Nigeria is 55 and has tested only five Republics under President Muhammadu Buhari [1-5].

The journey of 55 years as a nation has been that of heaven and hell fire. Heaven on the part that Nigeria is still one in a country of over 170 million people and over 350 ethnic groups and languages and 36 states structure, with Federal Capital Territory as a non state. Hell on the part that the country and citizens are still highly impoverished in the midst of plenty, with no social, economic, cultural, religious and political roadmaps. Sometimes, when Nigerians remember they are Nigerians, whether at home or in diaspora, they feel so bad and disappointed. Not on the part of their ability, but on the part of a failed state grappling with governance. No wonder the citizens defied rain and sunshine to elect President Buhari in 2016, not minding the lapses of card readers and Independent National Electoral Commission under gallant and hero Prof. Attah Jega [1-5].

Between 1960 to date, Nigeria has experimented many agricultural and rural development programmes: Operation Feed The Nation; Green Revolution; River Basin Development Authorities; National Agricultural Land Development Authority, Agricultural Transformation Agenda; FADAMA I, II, III, IV; Millennium Development

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Goals; Better Life For Rural Women; Family Support Programme; Community Development Agency, NEWMAP (Nigeria Erosion and Watershed Management Project); SURE-P (Oil Subsidy Reinvestment Programme); Women in Agriculture Programme; Petroleum Trust Fund (PTF); TETFUND (Technical and Vocational Education Fund) and many at Local, State and Federal levels [1-5].

Most of them were based on top-bottom approach of development. That is doctored at the top of government and imposed on the masses; whether they need them or not. Some modifications have been made on down-top approach; still with crisis of the more than 90% illiterate Nigerians who may find it difficult to decide the order of their needs and wants and management for sustainability criteria and requirements. The various projects covered in Nigeria development include: access roads, bridges, culverts, electricity, potable water, hospitals/clinics, schools, colleges, universities, railways, airports, seaports, market, shops, public toilets, telecommunication, irrigation, agriculture, export promotion and many more [1-5].

At Ebonyi State University, Abakaliki we have made attempts to assess and document the successes and failures of these development projects and programmes one of which is the assessment of FADAMA and Community Development Agency boreholes made available to indigenes of Abakaliki, Southeastern Nigeria through World Bank-Federal Government-State-Community Supported Programmes as part of thousands of such in all the states of Nigeria and Federal Capital Territory.

MATERIALS AND METHODS

Geographical and Climatic Information: Abakaliki lies within Longitude 08° 06¹ E and Latitude 06° 19¹ N at an altitude of 128 meters above sea level. It lies within the derived savannah belt of South eastern Nigeria. The mean annual rainfall for 25 years (1977 – 2012) was 154.75 mm spread across April – November; while the mean annual minimum and maximum temperatures for same period were 23.58 and 32.40°C, respectively; with higher and lower temperatures during the dry and rainy seasons, respectively. On the other hand, the average annual sunshine hours for same period was 5.13, while the mean annual relative humidity@09/15 hrs were 80.2 and 59.93%, respectively; with higher and lower relative humidity during rainy and dry season respectively. The rainfall, temperature and relative humidity of the area are presented in Figs 1, 2 and 3 [6]. The soil belongs to the order (Ultisol) classified as Typic Haplustult [7].

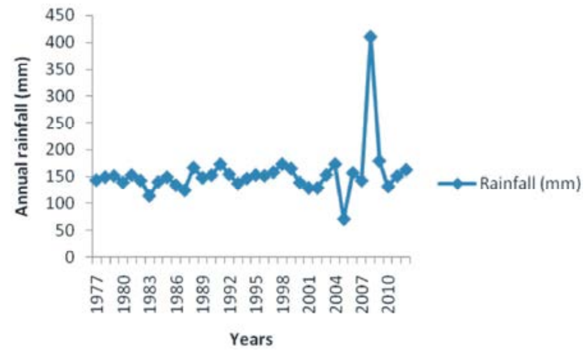

Fig. 1: Annual rainfall for Abakaliki (1977-2012)-mm

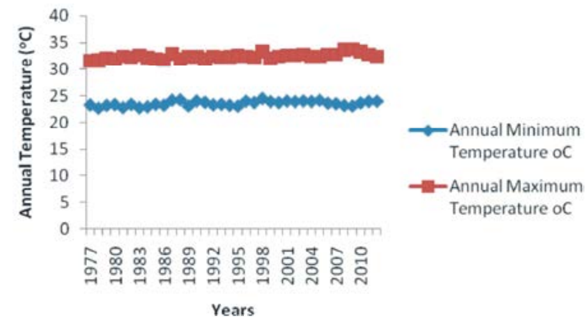

Fig. 2: Annual minimum and maximum temperature for Abakaliki (1977-2012) - °C

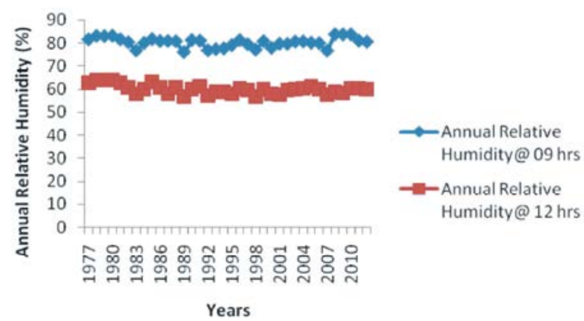

Fig. 3: Annual relative humidity@09/12 hrs at Abakaliki (1977-2012) -%

Identification of Boreholes: The Abakaliki and Ebonyi FADAMA and EBSCA intervention communities/villages for borehole projects were identified. Abakaliki Local Government Area has a population of 148,683 with 14 Federal Wards namely: Abakpa, Amachi (Ndegu I), Amachi (Ndegu II), Amagu (Enyigba); Amagu-Unuhu; Azuiyiokwu/Azugwu Layout; Azuiyiokwu Layout, Azuiyiudene Layout; Edda, Izzi-Unuhu, Ndiegu, Okpuitumo/Ndebor; Okpuitumo/Ndiegu and Timber. In these wards, Amachi I and II and Okpuitumo FADAMA boreholes were chosen [8].

On the other hand, Ebonyi Local Government Area has a population of 126,239 with 13 Federal Wards namely: Agalegu, Egwudinagu, Kpirikpiri, Mbeke, Ndiebo, Ndiegu, Echiaba I, Enyibichiri I, Enyibichiri II, Abofia, Onuenyim, Abakpa and Urban (New Layout). Abofia I, II and III boreholes for EBSCA was chosen for the study (NPC, 2006). The total number of FADAMA and EBSCA boreholes in these communities were over 30. Then six (three from each intervener) were chosen and studied for quality statistics from 2013 – 2015.

Borehole Water Sampling Procedure and In-situ Measurements: With the aid of hand pump mounted to the various boreholes, 1 – 2 litres of water were drawn into plastic buckets, once in the morning (07 – 10 am, afternoon (12 – 1pm) and evening (07 – 10 pm) once every month for 3 months (January, July and December) for three years (2013 – 2015). The water was first allowed to settle for 30 minutes in the plastic buckets, the top scooped into sterilized plastic bottles, sealed, packaged in coolers under ice-bags and returned to laboratory for analysis. In-situ temperature was taken with mercury in glass thermometer by dipping the thermometer into the water in the bucket and taking readings after stabilisation. The in-situ colour was determined in terms of percentage transmittance of light using photo electronic colorimeter (Model AE-IIM) after initial calibration with distilled water. The odour was determined using nose to perceive and record as it seems.

Laboratory Procedure/Protocols: The conductivity of the samples was determined using "SANXIN 5X723" conductivity meter. The probe was dipped into each sample in a beaker, mixed well and allowed to stabilize. The result was digitally read and recorded. For total solids (TS), 50 ml of water sample was measured into an already cleaned, dried and weighed beaker (W_1). The sample was evaporated to dryness at 103 - 105°C and the beaker cooled and dried in a desiccators and weighed (W_2) – [9]. The total suspended solids were calculated thus:

$$TS\ (mg\ L^{-1}) = W_2 - W_1/ml\ of\ sample \times 100$$

where

W_1 = Weight of sample + beaker before evaporation to dryness

W_2 = Weight of sample + beaker after evaporation to dryness

For total dissolved solids (TDS), the sample was well mixed and filtered. Then 100 ml was transferred into a weighed evaporating dish, evaporated to dryness on a steam bath. The evaporated sample was dried for 1 hour, repeated until constant weight [9]. The calculation was thus:

$$TDS\ (at\ 180°C) - mg\ L^{-1} = A - B/ml\ of\ filterable\ used \times 100$$

where

A = Weight of dried residue

B = Weight of dish.

For total hardness (TH), 50 ml of sample was measured into a conical flask, thoroughly mixed, followed by addition of 2 ml buffer solution and 2 – 3 drops of Erichrome Black T indicator. Then titrated with standard 0.01M EDTA till purple colour change to pink. The volume of EDTA required was recorded as A. A reagent blank was ran and volume recorded as B. The volume of EDTA required by sample was recorded [9]. The TH was calculated as follows:

$$TH\ (mg\ L^{-1}) = (A - B) \times D \times 100/volume\ of\ sample$$

where

A = Volume of titrant used for the sample

B = Volume of titrant used for the blank

D = $MgCaCO_3$ equivalent to 1.0 ml

The samples for heavy metals were first digested by adding 50 ml of sample that was acid-preserved in a beaker, followed by 5 ml concentrated HNO_3 and few boiling clips. The mixture was boiled slowly in a hot plate to about 20 ml. Heating was continued, with continuous addition of concentrated HNO_3 until a light coloured clear solution was obtained to indicate complete digestion. The beaker was washed with deionised water, filtered when necessary. The filtrate was transferred to a 10 ml volumetric flask with two 5 ml portions of water. The mixture was cooled and diluted to mark and mixed thoroughly. Heavy metals were analysed in the digested sample using Flame Atomic Absorption Spectrophotometer (Model 10 VGP, Buck Scientific).

Statistical and Data Analysis: The data were subjected to t-test for comparing two statistical parameters as described by Steel and Torrie [10]; followed by comparison of values with World Health Organisation (WHO) standards for water parameters [11-16].

Table 1: Physical properties of FADAMA and EBSCA Boreholes

Property	TS		TDS		C	
Location	FADAMA	EBSCA	FADAMA	EBSCA	FADAMA	EBSCA
BI	420	720	280	60	651	454
B2	720	1060	400	300	646	677
B3	220	500	140	400	113	417
Mean	460	760	273	187	470	517
tcal	0.002ns		1ns		0.779ns	
ttab(0.05)	4.303		4.303		4.303	
WHO	500		250 - 500		100	

B_1 = Amachi Borehole I for FADAMA and Abofia Borehole I for EBSCA; B_2 = Amachi Borehole II for FADAMA and Abofia Borehole II for EBSCA. B_3 = Okpuitumo Borehole for FADAMA and Abofia Borehole III for EBSCA. TS = Total Solid (mg L^{-1}); TDS = Total Dissolved Solids (mg L^{-1}). C = Conductivity (μS cm^{-1}).Values represent mean of 3 times x 3 months x 3 y

RESULTS

Total Solids Concentrations of Boreholes: There was no statistical significant difference between FADAMA and EBSCA boreholes for TS as subjected to t-test (P = 0.05). The Amachi borehole II for FADAMA gave the highest total solids concentrations of 720 mg L^{-1}; while the Abofia borehole II for EBSCA gave highest value of 1060 mg L^{-1}. The least values were 220 mg L^{-1} for Okpuitumo borehole for FADAMA and 500 mg L^{-1} Abofia borehole III for EBSCA. The Amachi borehole I and Okpuitumo borehole for FADAMA; Abofia borehole III for EBSCA passed the permissible total solids of 500 mg L^{-1} recommended by World Health Organisation. Others failed this standard (Table 1).

Total Dissolved Solids Concentrations of Boreholes: No statistical significant variation was recorded between FADAMA and EBSCA boreholes as subjected to t-test (P = 0.05) for total dissolved solids. The highest record of 400 mg L^{-1} was for Amachi borehole II for FADAMA and Abofia borehole III for EBSCA. The least total dissolved solids of 140 and 60 mg L^{-1} were recorded for Okpuitumo borehole for FADAMA and Abofia borehole I for EBSCA. All the boreholes passed the permissible TDS limits of 250 – 500 mg L^{-1} set by WHO (Table 1).

Conductivity of Boreholes: There was no recorded statistical significant difference between FADAMA and EBSCA boreholes as subjected to t-test (P = 0.05). The Amachi borehole I for FADAMA and Abofia borehole II for EBSCA gave highest conductivities of 646 and 677 μS cm^{-1},respectively. The least values of 113 and 417 μS cm^{-1} were recorded for Okpuitumo borehole for FADAMA and Abofia borehole III for EBSCA. All the boreholes failed the conductivity limit of 100 μS cm^{-1} set by WHO (Table 1).

pH of Boreholes: There was no statistical variation between FADAMA and EBSCA boreholes as tested by t-test (P = 0.05). The highest pH of 8.0 and 7.86 were recorded for Amachi borehole I for FADAMA and Abofia borehole I for EBSCA. The least pH of 6.25 and 6.96 were for Okpuitumo borehole for FADAMA and Abofia borehole III for EBSCA.

Chloride Concentrations of Boreholes: No statistical significant variation was detected between FADAMA and EBSCA boreholes as subjected to t-test (P = 0.05). The highest chloride level of 0.15 and 0.08 mg L^{-1} were recorded for Okpuitumo borehole for FADAMA and Abofia borehole I and III for EBSCA. The least chloride concentration of 0.08 and 0.06 mg L^{-1} were at Amachi borehole II for FADAMA and Abofia borehole II for EBSCA. All the boreholes passed the permissible chloride concentrations of 500 mg L^{-1} set by WHO (Table 2).

Alkalinity of Boreholes: There was statistical (P = 0.05) variation between FADAMA and EBSCA boreholes alkalinity levels as subjected to t-test. The highest alkalinity of 1000 and 750 mg L^{-1} were recorded for Amachi borehole II for FADAMA and Abofia borehole II for EBSCA. The least alkalinity of 250 and 500 mg L^{-1} were observed for Okpuitumo borehole for FADAMA and Abofia borehole I and III for EBSCA (Table 2).

Total Hardness of Boreholes: There was no statistical difference between FADAMA and EBSCA boreholes with reference to total hardness as subjected to t-test (P = 0.05). The highest total solids of 52 and 28 mg L^{-1} were recorded for Amachi borehole II for FADAMA and Abofia borehole II for EBSCA. The least values of 19.2 and 22.4 mg L^{-1} were recorded for Okpuitumo borehole III for EBSCA. All the boreholes passed the total hardness permissible limit of 500 mg L^{-1} set by WHO (Table 2).

Table 2: Chemical properties of FADAMA and EBSCA Boreholes

Property	pH		Cl^{-1}		Alkalinity		TH	
Location	FADAMA	EBSCA	FADAMA	EBSCA	FADAMA	EBSCA	FADAMA	EBSCA
B1	8.0	7.86	0.11	0.08	500	500	21	27.5
B2	7.68	7.45	0.08	0.06	750	750	52	28
B3	6.25	6.96	0.15	0.08	500	500	19.2	22.40
Mean	7.31	7.42	0.11	0.08	583	583	30.73	25.97
tcal	0.741ns		0.242ns		14.303*		0.671ns	
ttab	4.303		4.303		4.303		4.303	
WHO	Na				Na			

B_1 = Amachi Borehole I for FADAMA and Abofia Borehole I for EBSCA; B_2 = Amachi Borehole II for FADAMA and Abofia Borehole II for EBSCA. B_3 = Okpuitumo Borehole for FADAMA and Abofia Borehole III for EBSCA. Cl^{-1} = Chloride (mg L^{-1}); TH = Total Hardness (mg L^{-1}).Values represent mean of 3 times x 3 months x 3 y

Table 3: Heavy Metal Concentrations of FADAMA and EBSCA Boreholes

Property	Al		Cu		Fe		Zn	
Location	FADAMA	EBSCA	FADAMA	EBSCA	FADAMA	EBSCA	FADAMA	EBSCA
B1	0.7	0	0.4	0.4	0	0.1	0	0.03
B2	0	0	0.6	0.6	0.04	0.2	0.44	0.23
B3	0	0.9	0.5	0.5	0.1	0.8	0.3	0.1
Mean	0.233	0.3	0.5	0.367	0.047	0.245	0.247	0.12
tcal	0.899ns		0.604ns		0.226ns		0.457ns	
ttab	4.303		4.303				4.303	
WHO	Na		1.0 - 2.0				3.0 - 5.0	

B_1 = Amachi Borehole I for FADAMA and Abofia Borehole I for EBSCA; B_2 = Amachi Borehole II for FADAMA and Abofia Borehole II for EBSCA. B_3 = Okpuitumo Borehole for FADAMA and Abofia Borehole III for EBSCA. Al = Aluminium (mg L^{-1}); Cu = Copper (mg L^{-1}); Fe = Iron (mg L^{-1}); Zn = Zinc (mg L^{-1}).Values represent mean of 3 times x 3 months x 3 y

Heavy Metal Concentrations of Boreholes: There was no aluminium traces in Amachi borehole II and Okpuitumo borehole for FADAMA and Abofia borehole I and II for EBSCA. There were 0.7 and 0.9 mg L^{-1} Al in Amachi borehole I for FADAMA and Abofia borehole III for EBSCA (Table 3). On the other hand, the highest Cu concentration of 0.6 mg L^{-1} were recorded at Amachi borehole II for FADAMA and Abofia borehole II for EBSCA. The least Cu concentration of 0.4 mg L^{-1} were at Amachi borehole I for FADAMA and Abofia borehole I for EBSCA. All the boreholes passed the Cu permissible limit of 1.0 – 2.0 mg L^{-1} set by WHO (Table 3).

In terms of Fe concentrations, the highest value were 0.1 and 0.8 mg L^{-1} at Okpuitumo borehole for FADAMA and Abofia borehole III for EBSCA (Table 3). The zinc concentration was highest, 0.44 and 0.23 mg L^{-1} at Amachi borehole II for FADAMA and Abofia borehole II for EBSCA. There was no zinc in Amachi borehole I for FADAMA and least, 0.03 mg L^{-1} in Abofia borehole I for EBSCA. All the boreholes passed the permissible Zn concentration of 3.0 – 5.0 mg L^{-1} set by WHO (Table 3).

DISCUSSION

Physicochemical Properties of the Boreholes: The total solids speak of all the salt and organic load of the aquifer from where the boreholes were drawn. While they are worrisome at Amachi borehole II for FADAMA and Abofia borehole II for EBSCA, it also becomes consoling that the total dissolved solids drastically reduced in both places. Hence, others can be separated by filtration and centrifugation under some noble technology (though were not installed or available to the boreholes or users presented in this work). The passing of the boreholes test for TDS is also encouraging. Whilst, the excesses of total solids for Amachi borehole II for FADAMA and Abofia borehole I and II for EBSCA needs further investigation of the geology and other activities in the nearby water catchment areas like nearness to domestic wastes dumpsites, agricultural residues/litter, sewage and sources of solids.

The level of total and dissolved solids is also significant in the conductivity of the boreholes. Those with higher levels of ions showed remarkable higher conductivities as shown in the results at Abofia borehole II for EBSCA. All the boreholes failed conductivity test showing the total solids were high. The pH ranges are not alarming for water. They fell within 6.25 – 8.0 showing no direct contamination with acidic radicals like hydrogen, hydroxonium and aluminium ions. The chloride levels were also considerably low for the boreholes since the indigenes use them for drinking and domestic purposes.

The alkalinity of boreholes was worrisome. There were significantly different. Alkalinity is a function of bases such as NaOH, $NaHCO_3$, $NaCO_3$, $CaCO_3$, CaOH, CaO. They were higher for Amachi borehole II for FADAMA and Abofia borehole II for EBSCA. The parent material of the sites where the boreholes were located will give more clues in subsequent investigations and studies. Likewise, other parent materials that formed the river sediments that come from other rivers such as Cross River, Anambra River, Imo River, Benue River, Niger River that are connected to Ebonyi River, whose tributaries traverse the study areas.

The total hardness (Ca^{2+} + Mg^{2+}) were quite low, compared to standard. Hence, the water can flow properly and fit for domestic purposes. The cost of treating hardness from those boreholes may never arise, or be low within the limits of the natives. But for them, water is water, so far it does not kill. The boreholes were also safe for heavy metal concentrations namely: aluminium, copper, iron and zinc. Some levels of these metals in some of the boreholes may be based on the parent materials of the soils in borehole areas.

Drinking Water Sources and Quality: Drinking water is derived from three basic sources: reservoirs, groundwater and surface water namely: ponds, streams, lakes, rivers. All these sources of potable water contain high level of natural and anthropogenic organic and inorganic matter. They receive the highest level of treatment to remove micro-organisms, particulate matter and chemical contaminants. There are also occasional microbiological contamination from farm animals and wildlife [17]. According to these workers, groundwater is usually low in organic matter and is less vulnerable to both microbiological and chemical contamination. They also frequently contain high levels of rocks through which the water percolates.

Groundwater is already used extensively in Nigeria through wells and boreholes. Unfortunately, borehole water like water from other sources is never entirely pure. It varies in purity depending on the geological conditions of the soil through which the groundwater flows and some anthropogenic activities. Miller [18] reported the notion held initially of groundwater, as being a standard of purity itself, which the author asserts may be true to certain extent. It is also believed that treatment processes lead to presence of some minerals like Ca, Zn, Mn, PO_4^{2-} and Na again, scientists have reported of trace elements that are virtually present in all potable water, some of which are correlated with palatable and unpalatable mineralisation that affects the quality of drinking water [15].

Calcium and potassium has been reported as the most important minerals affecting the taste of water; while high concentrations of Na make the taste salty [15]. The recommended dietary amounts for Mg^{2+}, according to these scientists is 6 mg kg^{-1} d^{-1}, as excess Mg^{2+} makes water taste bitter. On the other hand, sulphate ions make water taste unpalatable by decreasing the concentration of Ca^{2+}, which is essential for good taste [15]. The workers also reports cobalt, chromium, iron, manganese, molybdenum, nickel, selenium, tin, vanadium and zinc to be essential for growth. Nevertheless, they caution of their toxicity to human body at high concentrations. For example, high Mn levels affecting intellectual functions.

Quality of Borehole Water: Physically, groundwater is generally clear, colourless, with little or no suspended matter and a relatively constant temperature. It is also generally free from the very minute organisms that cause disease. According to scientists, these stems from the slow filtering action provided as the water flows through the ground. Also the lack of oxygen and nutrients in the ground water that makes it unfavourable environment for disease producing organisms [15, 19, 20].

Scientists also records chemical quality of groundwater that is influenced by its relative slow rate of travel through the ground as earlier reported. Nevertheless, while they believe its purity more than surface water, they also report chemical contamination of groundwater by pesticides and fertilizers. They mention herbicide which falls under pesticide. They also note the effects of leachates and pollutants on groundwater. Once the leachates reach the groundwater, they affect flow of groundwater, permeability, impermeability and hydraulic head gradient of aquifer.

The depth of penetration in the aquifer, according to Eja [19] is also dependent on the distance from the nearest ground water divide and from the nearest drainage channel. Similarly, according to these scientists, pollutants can be introduced in a natural way via rainwater, seawater, earth crust and biological activities. Pollutants introduced by human activities come from point and non-point sources namely: farming practices – application of agrochemicals and use of sewage sludge as fertilizer supplements. Point sources of pollution are also differentiated primarily from the non-point sources by the precision with which the source of contamination can be identified, e.g the discharge of wastes to landfill sites, surface injection of wastes via deep boreholes and disposal of effluents by irrigation to land [19].

The Significance and Limits of Contaminants in Potable Waters: The total dissolved solids (TDS) are the substances remaining after evaporation and drying of a water sample, often called "residue". The residue is equivalent to the total dissolved and suspended matter in the water sample. The non-filterable residue represents total suspended solids and filterable residue represents total dissolved solids [17, 16, 21]. According to these workers, total dissolved solids comprise inorganic salts (mainly sodium chloride, calcium, magnesium and potassium) and small amounts of organic matter that are dissolved in water. They note of certain areas of the world (Abakaliki exclusive) that have naturally high amounts of total dissolved solids in their drinking water. Hence, according to the scientists, even though there may be no direct health concerns, the TDS concentrations greater than 1200 mg L^{-1} e.g brackish or saline water cause a bitter or salty taste. They also warned that some people can taste salt in drinking water at levels of 500 mg L^{-1} and may force them not to use it and choose another, possibly contaminated water instead.

The WHO does not have a suggested guideline for total dissolved solids in drinking water, since it does not have any adverse health effects, apart from people hate taste of drinking water that has 500 mg L^{-1} TDS. They may have willingly given a permissible limit of 500 mg L^{-1} referred in current studies to concerned people and regulators. Nevertheless, it is good to know that high levels of TDS stain water pipes and clothes, heater devices that come off as white flakes [16].

The total suspended solid is an indication of the amount of erosion that took place nearby or upstream. The parameter, according to scientists includes series of sediment-induced changes that occur in the water body. They can change composition of aquatic community. A large volume of suspended sediment, according to most scientists, reduces light penetration, thereby suppressing photosynthetic activity of phytoplankton, algae and macrophytes. This leads to fewer photosynthetic organisms available as food sources for many invertebrates. Overall, invertebrates decline is also decrease fish populations. Similarly, according to most workers [17] sediments interfere with essential functions of organisms. Most of these are not applicable to water drawn from aquifers like boreholes; but to surface waters. Nevertheless, they can affect biological oxygen demand (BOD) which is relevant not only to aquatic lives, but also humans. Water with high total suspended solids will ultimately have higher BOD and make oxygen concentrations of borehole water too low for huam comfort that drink it or for aquatic species like fishes when borehole water is used for fish ponds or when are they are used as irrigation water (for aerobes organisms).

Conductivity on the other hand depicts the presence of ions within the water arising from leaching, salinity and industrial discharges. These are contributed by TDS and TSS and upstream intrusion of salinity orchestrate conductivity [17]. Chloride is the ionic form of chlorine. It is a major inorganic ions in water. In potable water, the salty taste is produced by chloride concentration [17]. Chloride anions, according to the worker are present in natural waters. A high concentration occurs in waters that have been in contact with chloride-containing geological formations. Otherwise, according to the author, it may indicate pollution by sewage or industrial wastes or intrusion of seawater or saline water into freshwater body or aquifer. For example, a salty taste in water, according to the worker, depends on the ions which the chlorides are associated. With sodium ions, the taste is detectable at 250 mg L^{-1} Cl^-, but with calcium or magnesium taste may be detectable at 1000 mg L^{-1} (Abakaliki boreholes gave only 0.06 – 0.11 mg L^{-1} Cl^-). A high chloride content has a corrosive effect on metal pipes and structures.

The hardness of water is associated with the number of polyvalent ions, but is dominated by calcium and magnesium. Hardness in drinking water, according to WHO [15] ranges from 10 – 500 mg $CaCO_3^{e-}$ and water with concentrations of less than 60 mg L^{-1} are considered to be soft water (Abakaliki borehole water gave 19.2 – 52 mg L^{-1}) total hardness. According to these scientists, even though hardness caused by cations, anions also play an important role in assessing temporal (non-carbonate) hardness. While, the former is removable, the later consisting primarily of sulphates is not. Hence, calcium and magnesium are essential elements as found in variety of foods. The importance of calcium and magnesium in drinking water, as dietary intake is very controversial [17, 21]. However, in individuals who are marginal in Ca and Mg, it is supposed that hard drinking water can provide a significant source of these minerals [11-16]. For these experts, there is continuing interest in water hardness and health and evidence exist that hard water may exacerbate eczema in children.

CONCLUSIONS

An adequate supply of safe and potable drinking water is one of the major prerequisite for a healthy life and lifestyle. Water is one of the most abundant and essential resources of man and occupies about 70% of earth's surface. About 97% of this volume of earth's surface water is contained in the oceans; 21% in polar ice and glaciers; 0 – 0.8% underground; 0.009% in inland freshwaters such as lakes, while 0.00009% is contained in rivers. Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential things to life. The great majority of the available freshwater on earth lies underground. Half of it at depths exceeding one kilometre (1000 meters). Fortunately, Abakaliki water table falls within 25 – 46 meters, hence shallow and deep wells abound and boreholes easy to access with available technology. This saturated zone of groundwater is known as aquifer (given to freshwater in saturated zone and makes about 0.6% of world total water supply). The ultimate source of groundwater is precipitation that falls into the surface, a small fraction of which eventually filter down to saturated zone.

The boreholes compared for quality in this work is that of FADAMA (Nigeria Hausa name for flooded plain) that defies wet and dry season and major sustenance of irrigated agriculture in Northern Nigeria. The World Bank derived this worldwide name from this "FADAMA". Secondly, Ebonyi State Social and Community Agency (EBSCA) boreholes. All funded by World Bank-Federal Government-State-Community Initiatives. The stakeholders are hereby declared super champions in rescuing the citizens of developing world like Nigeria. Their water projects (boreholes) are hereby declared safe and potable for the areas assessed.

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