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Empirical Comparative Analyses of Drinking Water Sources in Usen Community, Ovia South-West, Edo State, Nigeria

P. T. Alufar
Lecturer, Department of Food Science Technology, Edo State Polytechnic, Usen, Nigeria

Abstract:
Empirical comparative analyses of the qualities of drinking water from some sources have been carried out for Usen community in Ovia South- West of Edo State, Nigeria. We employed physiochemical and microbiological analytical techniques. Water samples from 2 (two) boreholes, 1 (one) hand dug well, 1(one) river and potable sachet water were collected for Laboratory analysis. The parameters obtained were compared with the Nigerian Standard for Drinking Water Quality (NSDWQ) and the World Health Organization - European (WHO) standards for compliance evaluation. To examine the differences in impurities concentrations in the various samples, we used the AAS Model-Solaar 969AA Unicam Series, and the Spectronic 200+ Spectrophotometer; Conductivity, pH and TDS meters appropriate for these analyses. Laboratory analysed parameters are in the following ranges herein include pH (6.0 – 6.7), DO (5.8 – 6.7mg/l), BOD5 (0.9 – 5.8mg/l) , salinity (0.029 – 0.148g/l), Nitrates (0.17 – 1.32mg/l), (TDS(32.4 – 165.5mg/l), TSS (0.0 – 3.8mg/l), colour in Pt.Co. (colourless – brownish), turbidity (0NTU) , odour (odourless), HCO3 (6.1 – 48.8mg/l), Na (0.87 – 4.34mg/l), K (0.10 – 0.51mg/l), Ca (1.92 – 6.74mg/l), Mg (0.43 – 3.07mg/l), Chloride (17.7 – 53.1mg/l), Phosphorous (0.84 – 1.06mg/l), SO4(0.00 – 0.03mg/l), Fe (0.19 – 1.42mg/l), Mn (0.03 – 0.07mg/l), Cu (0.002 – 0.626mg/l) ,Zn (0.000 – 0.180mg/l), while Cr,Cd, Ni, Pb, V, and THC (oil and grease) where not detected and Total coliform count MPN/100ml is (1 -12). Results show that Chloride and Total coliform concentrations in all samples do not conform to national and international standards, while Fe ions does not conform in all samples except PBH sample. PBH is the only sample having colour nonconforming characteristic. Research outcomes are in conformity with earlier findings in recent work in parts of Edo State. We therefore suggest a further investigation to be done to enable appropriate action be taken by relevant authorities towards provision safe drinking water.

Keywords: *physiochemical, microbiological, impurities, concentrations, standards*

1. Introduction

Water is widely acclaimed to be a "free gift" of nature and it is assumed to be present everywhere in the surface and subsurface. Unfortunately, good quality drinking water is not found everywhere and may not be free after all. Many areas of Africa are affected by water pollutants including water bound pathogenic micro-organisms, pesticides, and heavy metals which normally accompany water runoff in the course of migration. Increase in population in an area common in Africa leads the supply of water that is unsafe for human consumption. This is the case with Usen, a small community in Ovia South-West Area of Edo State, Nigeria where the major sources of water are rivers, hand dug wells, streams, portable sachet water and borehole water. The increase in population of this community is not unconnected with the establishment of the only State owned Polytechnic by the Government . Majority of the people depend on the scarcely available borehole water which was neither analysed nor treated after drilling and installation. While the original indigenes depend on river water which they know from time immemorial to be good enough for drinking without any scientific investigation. Wheras, the presence of most harmful contaminants is not always obvious and may not cause health related symptoms for many years. As a result the only way you can ensure that your water is safe is to have a periodic laboratory water analysis done on your water supply. Ultimately, these sources have consequential health implications as ignorance cannot be an excuse. According to a 2007 World Health Organization report, 1.1 billion people lack access to an improved drinking water supply, 1.8 die of diarrheal disease each year and that diarrheal cases are preventable through access to safe drinking water. Reducing deaths from waterborne diseases is a major public health goal in developing countrie.

In the study by Iyasele and Idiata (2012), the physiochemical and microbial analysis of water samples from parts of Edo State show that the pH, iron, magnesium, and microbial levels of samples constitutes pollution above local and international standards. Consequently, suggested minimal purification before the water can be fit for human consumption. According to Wegelin – Schuringa (1999), provisions of quality drinking water is vested in Federal, State and Local Government Authourities. In spite of their efforts a

large number of people still suffer lack of adequate quality drinking water, and it is particularly worst in the area of present investigation since no effort has been made by past and present government to tackle this menance.
This report is based on the investigation carried out in Usen, Ovia South-West Area of Edo State, Nigeria and covers water samples from various sources consumed by the people.

2. Location of the Study Area

Usen is a small community in Ovia South-West Area of Edo State, Nigeria, made popular during the civil war was the place Nigeria soldiers and Biafra soldiers first met and fierce battle ensued. Today, her total population is about 10,000 people made up of original indigenes, settler farmers mainly Yorubas, staff and students of the State Polytechnic, business men and women mainly timber dealers and petty traders. The population is on the increase thereby attracting water vendors from all corners. Ovia South – West is situated on around geographical co-ordinates of latitude 60 231 45.611 (6.3960) North and longitude 50 161 19.211 (5.2720) East with average elevation of 67m/220ft (figure 1). Their main source of drinking water are boreholes (not investigated and/ treated), rivers, well water, rain water, sachet water and streams. Non of these sources has been analysed.

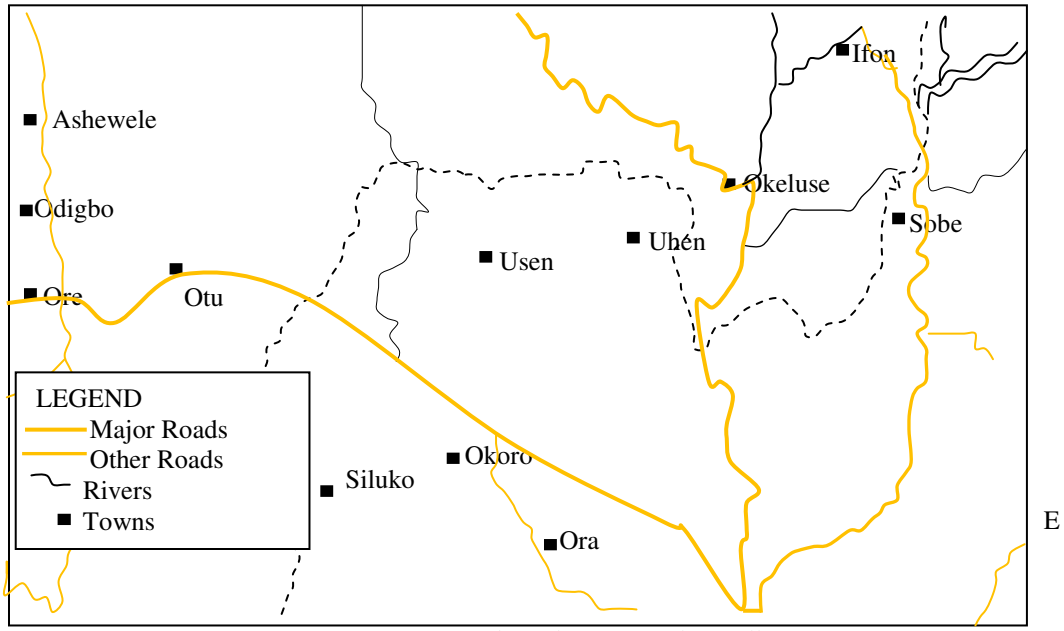

Figure 1: Map of Usen (Adapted from google satellites city maps)

3. Aim and Objectives

The aim of this research work is to provide empirical data and information about the physiochemical and microbiological constituents of drinking water samples obtainable in the area under investigation. Consequently, the objectives include:

i. To determine the physical, chemical and microbiological components of randomly selected samples from various sources of drinking water using laboratory analytical techniques;
ii. To ascertain the comparative quality of the water samples with respect to national and international standards of safe drinking water; and
iii. To suggest possible purification methods appropriate for treating water.

4. Methodology

A total of five samples were randomly selected including two borehole samples, one hand dug well sample, one sample from a popular river, and a sample of potable sachet water. These samples form main drinking water sources in the area under study.
The AAS model – Solaar 969 Unicam Series using air – acetylene flame was used to obtain the physical and chemical properties. At a wavelength of between 213.9 nm – 766.2nm , voltage 543 – 1080Volts and current 5 – 15mA acetylene flame is suitable for analysing most heavy metals. and total dissolved solids (TDS) were determined using TDS meters. The hydroxide, carbonates, bicarbonates , DO, BOD, and Chloride ions were determined using appropriate titration analysis, the Spectronic 200+ Spectrophotometer was used to determined the concentration of sulphate ions, TSS, ammonium nitrogen, colour, turbidity, nitrite, nitrate, THC, and phosphorous ions. Procedures for various analysis are described briefly below.

4.1. Laboratory Analytical Methods and Procedures

The standard reference materials utilized for all analyses without modifications are:

- Standard Methods for the Examination of Water and Wastewater (APHA);
- ASTM Standards for Water and Environmental Technology; and

The specific analytical methods and procedures used are described in Table 1.

S/N	Parameter Measured	Method
1	pH@ Recorded Temp.	APHA 4500-H^+
2	Measured Temp. of pH (^{o}c)	USEPA 170.1
3	Turbidity NTU	APHA 2130-B
4	Total suspended Solid mg/l	APHA 2540-D
5	Total Dissolved Solid mg/l	APHA 2540-C
6	Oil & Grease (THC) mg/l	ASTM D3921
7	BOD_5 mg/l	APHA 5210-B
8	Salinity (as chloride) mg/l	APHA 4500-B/4110-B
9	Cadmium mg/l	APHA 3111 B/APHA 3120 B
10	Chromium mg/l	APHA 3111 B/APHA 3120 B
11	Copper mg/l	APHA 3111 B/APHA 3120 B
12	Zinc mg/l	APHA 3111 B/APHA 3120 B
13	Iron (Total) mg/l	APHA 3111 B/APHA 3120 B
14	Lead mg/l	APHA 3111 B/APHA 3120 B
15	Nickel mg/l	APHA 3111 B/APHA 3120 B
16	Vanadium mg/l	APHA 3111 B/APHA 3120 B
17	Dissolved Oxygen mg/l	APHA 4500 – O /4500-) G/ Chemetrics
18	Total Coliform (MPN/100ml)	APHA 9216 – B
19	Sulphates mg/l	APHA 4500-SO4

Table 1: Specific Methods Adopted for the monitoring of aqueous wastes
Source: standard methods for the examination of water and waste water (20th edition)

Specific parametric analytical procedures include:

(I) pH and Temperature

pH was measured using a digital HANNA micro computer pH meter (model H19025). Temperature was measured using a thermometer.

- The pH meter was standardized with buffer solutions (4 & 7).
- The tip of the probe was rinsed with deionised water and cleaned with tissue paper.
- The probe was then immersed in the sample and the corresponding steady reading was taken.

(II) Salinity as Chloride:

This was measured by the Mohr Argentometric method (ASTMD512) using silver nitrate as titrant. 50ml of the sample was measured into a conical flask while 0.01M silver nitrate solution was placed in a burette. The sample was then titrated with the $AgNO_3$ solution using potassium chromate (K_2CrO_4) solution as indicator. The value at the end point marked by a brick red end point was noted. The blank titre was obtained by titrating 50ml of deionised water with $AgNO_3$ solution. Salinity as chloride was then calculated from the result obtained.

(iii) OIL And Grease:

The THC content of the sample was extracted from 200ml of the sample with 20ml of dichloromethane using a separating funnel and quantified using Infra Red (IR) Spectrophotometer – (ASTM D3921). The value of THC in the sample was determined by means of a standard curve prepared using the equipment standard ran under the same experimental conditions.

(iv) DISSOLVED Oxygen (DO):

DO was determined photometrically using the modified Azide – Winkler method (ASTM as adopted by HACH M 8332). The dissolved oxygen reacts with a Manganous Salt to produce a Manganic Salt, which, in an acid medium, displaces the iodine from potassium iodide, after which the iodine is treated with sodium azide. The quantity of iodine freed, which is proportional to the concentration of oxygen dissolved in the water sample, will determine the colour intensity.

(V) Biochemical Oxygen Demand (BOD_5):

BOD_5 was determined in accordance with APHA 5210B (APHA – 5210 –B Winkler's Trimetry/Dilution Method). Samples were incubated at 20^{o}C for 5 days. Dissolved oxygen was measured initially and after incubation using the above method. The BOD was computed from the difference between the initial and final DO.

(VI) Total Dissolved Solids (TDS):

The ASTMD1888 was adopted and the TDS was determined by filtering 100ml of the sample through a microfibre filter paper (grade 42c) into a 100ml beaker gently heating the filtrate to dryness and then to constant weight on a hot plate. TDS was then calculated taking into consideration the volume of sample used.

(VII) Total Suspended Solids (TSS):

According to ASTM1888, the sample was well mixed and filtered through a filtration unit fitted with a pre-weighed 0.45µmm Millipore filter paper using a vacuum pump. The used filter paper was dried at 105^{o}C to constant weight. TSS was then calculated using the appropriate formula.

(VIII) Turbidity:

The radiation attenuation method 180 (or method 7027) was adopted. Turbidity in waters which is due to light scattering and absorption by particulate matter like suspended and timely divided organic and inorganic matter is measured by allowing the water to settle and then poured into a 25ml sample cell. Turbidity developed is measured at 860nm. Blank is deionized water.

(IX) Ammonium

(HACH Method 8038 as adapted from APHA 4500 – NH_3 B & C). Three drops each of mineral stabilizer and polyvinyl alcohol dispersing agent were added to two 25ml cylinders filled with the sample and deionized water respectively. 1ml of Nessler reagent was then added to each of the cylinders and mixed thoroughly. The blank (deionized water) was used to zero the equipment and the prepared sample was introduced into the cell and the concentration read. Note that our standards record for ammonia whereas what we actually measured is ammonium nitrogen, in which the former is 10% of the latter. Ammonia in drinking-water is not of immediate health relevance, and therefore no health-based guideline value is proposed. However, ammonia can compromise dis- infection efficiency, result in nitrite formation in distribution systems, cause the failure
of filters for the removal of manganese and cause taste and odour problems (WHO, 2006).

(X) Heavy Metals:

Heavy metal analysis was carried out using Atomic absorption spectrophotometer (Unicam model 969AA) and HACH DR 4000U spectrophotometer (model 48000-82) . This involved direct aspiration of the sample into an air/acetylene or nitrous oxide/acetylene flame generated by a hollow cathode lamp at a specific wavelength peculiar only to the metal programmed for analysis. For every metal investigated, (Arsenic ASTM D2972, Chromium ASTM as adopted by HACH method 8023, Copper ASTM as adopted by HACH method 8026 and the method of Nwaichi et al. (2010), Iron ASTM as adopted by HACH method 8008, Lead ASTM D3559, Nickel ASTM D 1886, Vanadium ASTM D3373 and Zinc ASTM as adopted by HACH method 8009) standards and blanks were prepared and used for calibration before samples were aspirated and concentrations at specific absorbance displayed on the data system monitor. For the heavy metals in gaseous emissions, particulates on the membrane in the volume sampler were collected, weighed and acid –digested. The solution was aspirated into the AAS for the determination of the applicable heavy metals

(XI) Feacal Coliform Count:

The coliform bacteria were estimated using the Most Probable Number Technique (MPN). Measured amounts of single and double strength Modified MacConkey Broth was sterilized in bottles containing Durham tubes for indicating gas production. With sterile graduated pipettes the amounts of water sample were added.

One 50ml quantity of water was added to 50ml double strength medium. Five 10ml quantities of each water sample were added to 10ml double strength medium. Five 1ml quantities each water sample was added to 5ml single strength medium. The bottles were incubated at 44^{o}C and examined after 24hr. Those that showed acid and sufficient gas to fill the concavity at the top of the Durham tube were considered to be 'Presumptive Positive' as a result of the growth of coliform bacilli.

In reporting the result of the Presumptive test reference was made to MacCrady's Probability Tables. According to the various combinations of positive and negative results obtained, the probable number of coliform bacilli in 100ml of water was read.

5. Results

The laboratory analytical results of biophysicochemical constituents of water samples collected are shown along with Nigerian standards for drinking water quality (NSDWQ) and World Health Organization - European (WHO) drinking water standards in table 2.

Parameter/ Unit	Sample Code					NSDWQ Permissible Limit	WHO Permissible Limit
	Sachet Water	WAR	BHAR	PBH	ERW		
pH	6.2	6.7	6.0	6.1	6.2	6.5 – 8.5	6.5 – 9.2
Salinity(g/l)	0.148	0.074	0.086	0.057	0.029	0.20	-
Colour (Pt.Co)	colourless	colourless	colourless	brownish	colourless	colourless	colourless
Odour	odourless	odourless	odourless	odourless	odourless	odourless	odourless
Turbidity (NTU)	ND	ND	ND	ND	ND	1.0	-
TSS (mg/l)	ND	ND	ND	ND	3.8	>10	500
TDS (mg/l)	165.5	83.2	96.8	62.9	32.4	500	1000-1200
DO (mg/l)	6.7	6.3	5.9	6.1	5.8	7.5	-
BOD_5(mg/l) @ 20-25° C	2.3	5.8	2.7	0.9	2.5	0	6
HCO_3(mg/l)	18.3	48.8	6.1	12.2	24.4	-	-
Sodium(mg/l)	4.34	1.08	1.98	1.20	0.87	200	200
Potassium (mg/l)	0.33	0.26	0.51	0.38	0.10	-	-
Calcium (mg/l)	6.74	3.85	4.04	1.92	2.89	-	75
Magnesium (mg/l)	3.07	0.81	1.02	0.76	0.43	-	50
Chloride (mg/l)	53.1	53.1	35.4	35.4	17.7	250	250
Phosphate (mg/l)	0.84	0.93	1.06	1.03	1.02	>5	-
NH_3-N(Ammonium Nitrogen) mg/l	ND	ND	ND	ND	0.03	< 1	-
NO_3 (mg/l)	0.17	0.23	1.32	0.39	0.17	10.0	50.0
SO_4(mg/l)	0.81	0.45	0.28	0.19	0.11	500	500
Fe(mg/l)	0.65	1.12	0.19	1.07	1.42	1.0	2.0
Magnese(mg/l)	0.03	0.04	0.06	0.04	0.07	0.05	0.40
Zinc(mg/l)	0.045	0.180	0.021	0.027	ND	5.0	<3.0
Copper(mg/l)	0.002	0.008	0.009	0.014	0.626	0.1	2.0
Cr(mg/l)	ND	ND	ND	ND	ND	0.05	0.05
Ni(mg/l)	ND	ND	ND	ND	ND	0.05	0.07
Pb(mg/l)	ND	ND	ND	ND	ND	0.05	0.01
Cd(mg/l)	ND	ND	ND	ND	ND	0.01	0.003
V(mg/l)	ND	ND	ND	ND	ND	0.01	-
Oil and Grease	ND	ND	ND	ND	ND	0.05	-
Total Coliform count (MPN/100ml)	1	2	12	7	5	0	<1.0

Table 2: Concentration of physical, chemical and microbiological parameters of water samples
Source: Laboratory analysis of samples (Isolated bacteria : Enterobacter aerogenes)
Key: WAR = akure road well, BHAR = Akure road borehole, PBH = Polytechnic borehole, ERW = Ede river water

6. Discussion of Results

From the above table 2, we draw a comparison between laboratory derived parametric values with Nigerian standards for drinking water quality (NSDWQ) on one hand and World Health Organization - European (WHO) Standards on the other hand. We deduced the presence of Total coliform that include *E.Coli, Streptococcus faecalis, and Clostridium perfringens* which closely related to encroachment of faeces in large numbers posed by man and animals; an indication of faecal contamination of water supply. Each sample shown Most Probable Number of coliform organisms per 100ml (MPN/100ml) of at least 1. For public health safety concern, this value is set at zero count in order to exclude pathogenic organisms. Results also shows that parameters such as colour, salinity, pH and odour of all samples are within tolerance except PBH (Polytechnic bore hole) sample. The DO t is fairly good for all samples. Chloride content of the samples are higher than stipulated standards, the levels are capable of forming chlorinated phenols that may be carcinogenic or tetratogenic and imparts objectionable taste to drinking water in the presence of algae(Udoma, 2005). The presence of chloride in this range is the cause of the disease chloramin in children if not treated before drinking. Substances such as Cu, Cr, Ca, Zn, Pb, P, Cd, V, and THC are however, present/absent in acceptable amounts an indication of absence of radioactive elements and oil/gas exploration and production activities in the area under study. All samples possessed iron (Fe) values above standards in exception to BHAR sample but did not adversely affect sample colours other than PBH sample which was brownish and capable of imparting metallic taste to water. A synopsis of these claims are shown in table 3.

Parameter/ Unit	Sample Code				
	Sachet Water	WAR	BHAR	PBH	ERW
pH	within	within	within	within	within
EC(µs/cm)	short	short	short	short	within
Salinity(g/L)	within	within	within	within	within
Colour (Pt.Co)	within	within	within	short	within
Odour	within	within	within	within	within
Turbidity (NTU)	within	within	within	within	within
TSS (mg/L)	within	within	within	within	within
TDS (mg/L)	within	within	within	within	within
DO (mg/L)	NS	NS	NS	NS	NS
BOD_5(mg/L)	within	within	within	within	within
COD (mg/L)	within	short	short	within	within
HCO_3(mg/L)	NS	NS	NS	NS	NS
Sodium(mg/L)	within	within	within	within	within
Potassium (mg/L)	NS	NS	NS	NS	NS
Calcium (mg/L)	within	within	within	within	within
Magnesium (mg/L)	within	within	within	within	within
Chlorine (mg/L)	short	short	short	short	short
Phosphorous (mg/L)	NS	NS	NS	NS	NS
NH_4N (mg/L)	ND	ND	ND	ND	NS
NO_3 (mg/L)	within	within	within	within	within
SO_4(mg/L)	within	within	within	within	within
Fe(mg/L)	short	short	short	within	short
Magnese(mg/L)	within	within	within	within	within
Zinc(mg/L)	within	within	within	within	within
Copper(mg/L)	within	within	within	within	within
Cr(mg/L)	ND	ND	ND	ND	ND
Ni(mg/L)	ND	ND	ND	ND	ND
Pb(mg/L)	ND	ND	ND	ND	ND
Cd(mg/L)	ND	ND	ND	ND	ND
V(mg/L)	ND	ND	ND	ND	ND
THC	ND	ND	ND	ND	ND
Total Coliform(MPN/100ml)	short	short	short	short	short

Table 3: Inferences on concentrations levels of biophysicochemical parameters of water samples
Source: Laboratory analysed results from samples

Where:
Within: Compliant to standards
Short: Not compliant to standards
NS: No available standard for comparism
ND: parameter not detected equivalent to absence = within/compliant
From **table 3** above, we can easily pick parameters having issues see **table 4.**

Source	Parameters
Sachet water	Chlorine, total coliform, Fe,
WAR	Chlorine, total coliform, Fe
BHAR	Chlorine, total coliform, Fe
PBH	Chlorine, total coliform, colour
ERW	Chlorine, total coliform, Fe

Table 4: Parameters which do not meet standards
Source: Laboratory analysed results from

7. Conclusion
We were able to obtained data on the physiochemical and microbiological constituents of water samples using approved laboratory standards procedures for water and wastewater analysis. Results of laboratory analysis were compared with national and international standards. Conclusively, the overall samples needs to be processed before drinking. The Physical, chemical and microbiological

parameters that do not meet approved standards are Chloride and Total coliform in all samples. In addition to these common deficiencies observed Fe in WAR and BHAR samples were also not conforming to approved standards. While sample PBH is additionaly deficient in colour. Finally, ERW is also deficient in Fe. Apart from these deficiencies other parameters meet approved national and international standards. The water samples therefore needs complete treatment to become fit for drinking. Common available treatment processes are osmotic filtering and UV- filtration.

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