Examination Of The Physicochemical Characteristics Of Domestic Water Sources In Ebonyi Local Government Area Of Ebonyi State, Nigeria.

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Abstract: Lack of good drinking water due to contamination by chemicals has been a global menace. It is one of the most serious environmental problems that have greatly impacted human health. Basic quality parameters of domestic water sources in Ebonyi Local Government Area were studied in the months of September, 2014 and October, 2014. Samples were randomly collected from common water sources (well, stream, borehole, and pond) across four communities in the Local Government Area. The physicochemical characteristics of the collected water samples were investigated using standard procedures. The results showed mean pH values of 7.3, 7.8, 6.8 and 7.0 for well, stream, borehole and pond water samples respectively. The colour examination showed: 13 HU, 11 HU, 13 HU, and 16 HU for well, stream, borehole and pond water samples respectively. The turbidity were recorded as 103 NTU (well), 90 NTU (stream), 0.8 NTU (borehole) and 92 NTU (pond). Total dissolved solids (TDS) showed a record of 595 mg/L, 386mg/L, 76 mg/L, and 563 mg/L for well, stream, borehole and pond respectively. Well water recorded 78 mg/L, stream (112 mg/L), borehole (42 mg/L), and pond (795 mg/L) for Total Suspended Solids respectively. Also, the total hardness showed 525 mg/L, 779 mg/L, 44 mg/L, and 837 mg/L for well, stream, borehole and pond water samples respectively. The results show that most of the common sources of water in the studied areas are not good for drinking since the physicochemical variables evaluated mostly exceeded WHO permissible limits. We therefore recommend that water treatment should be paramount as alternative sources of drinking water in the communities should be considered.

Index Terms: Physicochemicals, Water, Pond, Well, Stream, Borehole, Contamination

1 INTRODUCTION

Throughout history, water has been pivotal in the modeling and sustenance of the socio-economic life of people and nations [1]. The importance of natural water bodies does not need elaborate emphasis as whatever affects water bodies directly or indirectly affects human health. Naturally, water is second only to air among the most important resources for human existence; however, it is the most threatened [2]. The use of various water bodies in sewage disposal and as dumping sites for industrial effluents greatly affect water qualities and its availability for domestic consumption [1].

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Well water, streams and ponds collect precipitation from the surrounding landscapes. The collected precipitations are being channeled through their interconnected networks and wetlands that recharge them [3]. This makes it easier for such water bodies to receive contaminants from point source within the environment and as well, distribute same from feeder to all the linking water bodies. The human race is under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. Due to increased human population, industrialization, use of fertilizers and man-made activities, water is highly polluted with different harmful contaminants [2]. The most common source of contaminant to water is agriculture originating from the preferred use of agrochemicals to boost harvest. This is further facilitated by increasing soil degradation and erosion menace, thanks to modern agricultural practices. The impact of industrial toxic and hazardous wastes on aquatic life including microorganisms has recently received alarming concern globally [4]. According to UNEP report, over half of the world's hospitals beds are occupied with people suffering from illnesses linked with contaminated water and more people die as a result of polluted water than are killed by all other forms of violence including wars [5]. The addition of waste water, industrial and municipal wastes into the water bodies greatly affect the physicochemical and biological quality thereby rendering them unfit for use [6]. Water contamination by effluents has raised a question of considerable public health concern because of its evidence of extreme danger to human life as well as biological ecosystems [2],[7]. The aim of this study was to evaluate the physicochemical characteristics of domestic water sources in Ebonyi Local Government Area, Ebonyi State, Nigeria and provide advice on the health implications of the use of the water sources as common water supply for domestic consumption in the communities and other likely places.

2 MATERIALS AND METHODS

2.1 Study Area
The study was carried out in Ebonyi Local Government Area, one of the 13 L.G.As in Ebonyi State, Nigeria. Ebonyi Local Government Area is predominantly occupied by farmers. It is located between longitude $7^0 59^1$E and $8^0 20^1$E and latitude $6^0 22^1$N and $6^0 43^1$N. During the study, four communities across the Local Government Area were randomly selected namely: Ndiabor, Mbeke, Ndiagu and Nkaleke, and then sampled between September, 2014 and October, 2014. The area falls within the climatic region of South Eastern Nigeria where the rainy season spans from April to October and dry season from October to April [8]. The average annual rainfall of the study area is about 1500mm with actual surface temperature (seasonal temperature) of between 24-36^{0}C during dry season and about 18^0 Cduring the rainy season [8].

2.2 Sample Source and Size
Samples were collected from 320 sample points (10 points for each water body in all communities) in two containers in each point. Well, stream, borehole and pond water bodies were used for the study. Samples were collected separately in clean sterilized plastic bottles in the months of September, 2014 and October, 2014. Samples were collected from Ndiabor, Mbeke, Ndiagu and Nkaleke communities of Ebonyi Local Government Area of Ebonyi State, Nigeria.

2.3 Sample Collection
Collection of the water samples was done using wrapped bijour bottles pre-sterilized at 121^{o}C for 15 minutes [9]. While sampling in the streams, the collection bottle was lowered in water at a depth of about 15cm to 30cm. The bottle was held at the base and placed against the direction of the water flow. As soon as each sample was collected, it was carefully labeled, after which all samples were transported to the Department of Biological Science Laboratory, Ebonyi State University, Abakaliki, for analysis..

2.4 Physicochemical Analysis of Water Samples
The physicochemical parameters of the samples were analyzed using the method described by Roohul-Amin *et al*. [9] with few changes. This entailed determination of values for the parameters by the use of their respective indicators/methods with respect to manufacturer's instructions.

2.2.1 Determination of some physical parameters
Colour determination was done virtually using a Levibond comparator (Neissler) [9] and the water samples were inhaled to note odour. The pH was determined using Jenway model pH meter. The instrument was calibrated with standard buffers of pH 4.0, 7.0 and 9.0 [10]. Water turbidometer was used to determine turbidity.

2.4.2 Determination of Chemical Parameters

Total dissolved solid (TDS) determination: A total dissolved solid meter was used. A beaker that was to be used was rinsed with the sample; it was then filled with the sample. The total dissolved solid meter was lowered into the water sample. The TDS was displayed on the TDS meter screen and was allowed to stabilize for some seconds before taking the actual reading of the TDS of each sample.

Total suspended solids (TSS) determination: Before sampling, a glass fiber filters was prepared by first soaking them in distilled water, drying them at 103^{0}C, and weighing and recording their weights. The dried, weighed glass fiber filter was placed onto a filtering flask-wrinkled side up. The water sample was shaken and poured after which the pump was turned on. The filter was dried at 103 to 105^{0}C, allowed to cool to room temperature, and then weighed. This drying, cooling and weighing was done repeatedly until the fiber reached a constant weight. The increase in weight represented by TSS was calculated, using the equation below:
TSS (mg/L) = ([A-B]*1000)/C
Where A = End weight of the filter
B= Initial weight of the filter
C = Volume of water filtered

Total hardness determination: To determine the total hardness of the water a 50ml of each water sample was placed in a conical flask after which 1 ml of buffer solution (Aluminum Hydroxide in Ammonium Chloride of hardness) was added. Three (3) drops of ferrochrome black tea was added to the flask and shaken well. The flask was placed below a burette EDTA (Ethylene diamine tetra-acetic acid) solution of 0.02 normality, after which the initial reading of the burette was noted. The tap of the burette was opened to allow the solution to flow in the flask and the final reading was taken when the colour of the water in the flask turned bluish. The total harness (temporary+ permanent hardness) was calculated using the following formula.
Hardness, epm = 20 C/S
Where:
epm = equivalent parts per million; mill equivalents per liter,
C = standard Na_2 H_2EDTA solution added in titrating hardness, ml, and
S = Sample taken, ml.

2.5 Statistical Analysis
The variations in the water quality parameters were determined by one way analysis of variance (ANOVA).

3 RESULTS
The physicochemical analysis of well water samples from four (4) communities including: Ndiabor, Mbeke, Ndiagu, and Nkaleke communities showed an overall mean pH of 7.3 for. The community with the highest pH value was Nkaleke having pH of 7.9, followed by Ndiagu community with pH of 7.31, the third community had pH of 7.11, while the community with the least pH was Ndiabor with pH of 6.9. Also, the community with the highest colour was Nkaleke community, whose value was 18, followed by Mbeke with figure of 14. Ndiagu community folowed with value of 13 while the least was Ndiabor with value of 7. The overall colour was 13. Then for the Total dissolved solid in the sample , Mbeke community was the highest with TDS of 710 mg/L, followed by Ndiabor with 680 mg/L and then Ndiagu with 532 mg/L and Nkaleke became the least with value of 458 mg/L. Also the overall value was 595 mg/L. Table 1 shows well water samples mean result of 7.3, 13HU, 103NTU, 595 mg/l, 77.6mg/l and 835mg/l for pH, colour, turbidity, total dissolved solids, total suspended solids and total hardness respectively for the whole communities. Odour was unobjectionable throughout the study. The physicochemical parameters of stream water samples from the four communities showed that the community with the highest

pH was Mbeke community which had a pH of 8.6 followed by Nkaleke (7.7), Ndiabor (7.4), while the community with the least pH was Ndiagu (7.3). The overall mean pH was 7.8. However, the community with the highest total suspended solid was Mbeke with TSS of 152 mg/L, followed by Ndiabor community with TSS of 140 mg/L, then Ndiagu community with 80 mg/L while Nkaleke with 75.2 mg/L. the overall 112 mg/L. In terms of turbidity, Ndiagu was shown to have the highest turbidity of 95, followed by Nkaleke with 88, while Ndiagu had 85. Table 2 shows stream water samples mean results of 7.8, 11HU, 90NTU, 386mg/l, 112 mg/l and 779 mg/l for pH, colour, turbidity, total dissolved solids, total suspended solids and total hardness respectively for the four communities. Odour was unobjectionable across communities during the analysis.

Table 1. *Physicochemical Parameters of Well Water in Ebonyi Local Government Area.*

	NDIABOR COMM.		MBEKE COMM.		NDIAGU COMM.		NKALEKE COMM.		OVERALL	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
pH	4.1-9.9	6.9	4.8-9.8	7.11	6.6-8.0	7.31	5.5-11.0	7.9	4.1-11.0	7.3
Colour (HU)	10-15	7	10-15	14	6-11	13	7-16	18	6-18	13
Odour	U	U	U	U	U	U	U	U	U	U
Turbidity (NTU)	88-90	98	90-95	93	100-120	120	80-95	101	80-12.0	103
TDS (mg/l)	580-900	680.0	400-900	710	120-900	532	380-600	458	120-900	595
TSS (mg/l)	66.9	78.8	60-91	77.1	60-100	80.3	65-86	73.03	60-100	77.6
Total hardness (mg/l)	500-1116	581	300-800	800	406-1010	1010	400-601	950	300-1116	835

U= Unobjectionable, TDS= Total dissolved solids, TSS= Total suspended solids
HU=Hazen unit, NTU=Nephelometric turbidity unit, mg/l = Milligram per liter
COMM=Community

Table 2. *Physicochemical Parameters of Stream Water Samples in Ebonyi Local Government Area.*

	NDIABOR COMM.		MBEKE COMM.		NDIAGU COMM.		NKALEKE COMM.		OVERALL	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
pH	7.0-8.1	7.4	6.3-12.4	8.6	5.0-9.0	7.3	6.6-9.1	7.7	5.0-12.4	7.8
Colour (HU)	6-11	6.5	1.0-15	14	6-12	9	14-15	13	6-15	11
Odour	U	U	U	U	U	U	U	U	U	U
Turbidity (NTU)	90-95	90	80-100	95	85-90	85	70-100	88	70-100	90
TDS (mg/L)	100-406	264	203-304	258	200-700	401	200-1000	620	100-1000	386
TSS (mg/L)	90-180	140	100-190	152	68- 90	80	38-9	75.2	38-190	112
Total hardness (mg/l)	800-1000	900	700-800	780	980-1000	985	500-560	450	500-1000	779

U= Unobjectionable, TDS= Total dissolved solids, TSS= Total suspended solids
HU=Hazen unit, NTU=Nephelometric turbidity unit, mg/l = Milligram per liter
COMM=Community

The result of physicochemical analysis using borehole water sample showed that Mgbeke and Nkaleke both had the highest ph with ph of 7.0, while Ndiabor and Ndiagu followed with ph of 6.8 respectively. In terms of hardness, Ndiabor community had the highest hardness with value of 50 mg/L, while Ndiagu being the next had a value of 40 mg/L followed by Mbeke and Nkaleke both recorded with 40mg/L. The odour was unobjectionable in all the communities. Table 3 showing borehole water samples mean result of 6.8, 7.0HU, 0.8NTU, 76mg/l. 42 mg/l and 44 mg/l for pH, colour, turbidity, total dissolved solids, total suspended solids and total hardness respectively throughout the communities. The pond samples from four communities in which where physicochemical analysis was carried out showed that Nkaleke community had the highest pH of 7.42, followed by Ndiagu with pH of 7.41, and then Mbeke with 6.73, the lowest pH was 6.55 from Ndiabor community. While the overall ph was 7.0.in terms of turbidity, Nkaleke had the highest turbidity to be 105, followed by Ndiabor with 98 as its value, Mbeke community had 86 the least was 78 from Ndiagu community. Overall turbidity value was 92. Table 4 shows the pond water samples mean result of 7.0, 16HU, 92NTU, 563mg/l, 128mg/l and 837 mg/l for pH, colour, turbidity, total dissolved solids, total suspended solids and total hardness respectively. Throughout the analysis, odour was unobjectionable. Table 5 compared the results as contained in tables 2-5 with the world Health Organization permissible limits for portable water.

Table 3. *Physicochemical Parameters of Borehole Water Samples in Ebonyi Local Government Area.*

	NDIABOR COMM.		MBEKE COMM.		NDIAGU COMM.		NKALEKE COMM.		OVERALL	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
pH	5.0-8.1	6.8	5.6-7.0	7.0	6.2-8.1	6.8	6.2-8.1	7.0	5.0-8.1	6.8
Colour (HU)	4.0-11.0	8.8	6.0 -11.2	8.6	3.0-8.0	5.12	4.6-8.0	5.6	3.0-11.2	7.0
Odour	U	U	U	U	U	U	U	U	U	U
Turbidity (NTU)	0.6-1.3	0.9	0.1-1.2	0.5	0.2-1.0	0.8	0.1-1.8	1.0	0.1-1.8	0.8
TDS (mg/l)	51-100	84	69-100	82	40-92	63	45-95	76	40-100	76
TSS (mg/l)	21-60	36	21-91	54	25-48	38	20-60	41	20-91	42
Total hardness (mg/l)	25-100	50	21- 66	40	30-71	45	30-50	40	21-100	44

U= Unobjectionable, TDS= Total dissolved solids, TSS= Total suspended solids
HU=Hazen unit, NTU=Nephelometric turbidity unit, mg/l = Milligram per liter
COMM=Community

Table 4: *Physicochemical Parameters of Pond Water Samples in Ebonyi Local Government Area.*

	NDIABOR COMM.		MBEKE COMM.		NDIAGU COMM.		NKALEKE COMM.		OVERALL	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
pH	6.1-7.0	6.55	6.1-8.1	6.73	6.3-9.8	7.41	6.1-8.4	7.42	6.1-9.8	7.0
Colour (HU)	15-16	15	17-18	16	14-15	14	17-19	18	14-19	16
Odour	U	U	U	U	U	U	U	U	U	U
Turbidity (NTU)	60-100	98	80-95	86	70-80	78	100-120	105	60-120	92
TDS (mg/l)	450-1000	687	380-1220	641	200-800	480	300-600	443	200-1220	563
TSS (mg/l)	40-1000	170	69-98	78	60-108	91	100-203	175	40-1000	128
Total hardness (mg/l)	600-700	670	300-1000	880	500-1200	1058	400-860	740	300-1200	837

U= Unobjectionable, TDS= Total dissolved solids, TSS= Total suspended solids
HU=Hazen unit, NTU=Nephelometric turbidity unit, mg/l = Milligram per liter
COMM=Community

Table 5: *Physicochemical Parameters of Ebonyi L.G. A. Domestic Water Compared with WHO Standard*

	Well		Stream		Borehole		Pond		WHO
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	
pH	4.1-11.0	7.3	5.0-12.4	7.8	5.0-8.1	6.8	6.1-98	7.0	6.5
Colour (HU)	16-18	13	6-15	11	3.0-11.2	13	14-19	16	6
Odour	U	U	U	U	U	U	U	U	U
Turbidity (NTU)	80-120	103	70-100	90	0.1-1.8	0.8	60-120	92	6.0
TDS (mg/l)	120-900	595	100-1000	386	40-100	76	200-1220	563	500
TSS (mg/l)	60-100	78	38-190	112	20-91	42	300-1000	795	NS
Total hardness (mg/l)	300-1116	525	500-1000	779	21-100	44	300-1200	837	500

U= Unobjectionable, TDS= Total dissolved solids, TSS= Total suspended solids
HU=Hazen unit, NTU=Nephelometric turbidity unit, mg/l = Milligram per liter
U= Unobjectionable, NS= No standard

4 DISCUSSION

The physiochemical characteristics of water bodies are greatly affected by climatic factors, vegetative factors and the general make-up of the water. The pH regime has no significant variation ($p < 0.05$) within the water bodies during the study period. Generally, the pH values obtained for the four water bodies (well, stream, borehole and pond) examined, were above the WHO guideline (6.5) for water meant for drinking and water used for recreational activities [11]-[13]. The European Union also set pH permissible limits of 6.0-9.0 for fishes and aquatic life [14]. High pH values could be due to high temperature that represses the solubility of carbon dioxide and/or due to anthropogenic activities in the water bodies. The colour of the examined well (13 HU), stream (11HU), borehole (13 HU) and pond (16 HU) were above the permissible limit set by World Health Organization. This finding is in disagreement with the earlier report of Shittu *et al*. [15], whereby all the four samples of water examined, agreed with WHO limit for drinking water. However, the result is in agreement with the works of Iyasele and Idiata [16] and Pavendan *et al*. [17]. High colour, aside possessing the tendencies to cause diseases, makes the water less attractive. The odour of the water samples were unobjectionable, this is because there is no serious indicator to verify the respective water samples odour. The turbidity profile of the examined water samples did not vary significantly ($p < 0.05$) amongst the water bodies throughout the study period. The result shows that, well water samples (103 NTU) had the highest turbidity value while borehole samples had the lowest value of 0.8 NTU. All other water bodies under study apart from borehole samples were above WHO limit of 6.0 NTU. High turbidity is regularly associated with high levels of disease causing microorganisms such as bacteria and other parasites [15]. The high turbidity recorded in well samples may be because of flooded water that is often allowed access into open wells. The finding agrees with the work of Shittu *et al*. [15] who reported high turbidity in surface waters and similar with the work of Roohul-Amin *et al*. [9]. The report differs from the works of Ajala *et al*. [18], Iyasele and Idiata [16], Shtittu *et al*. [15]. The disagreement may not be unconnected with difference in the sample areas or methods of analysis adopted. The total dissolved solids is lowest in borehole (76 mg/L) and stream (386 mg/L) water samples and highest in well (595 mg/L) and pond (563 mg/L) water samples. Only borehole and stream water complied with WHO standard of 500 mg/L. Total dissolved solids in fresh water have been associated with sewage, natural sources, industrial waste water, urban run-offs and chemical used in the treatment of water, not minding the fact that they are of aesthetics rather than health hazards [19],[20]. However, the hike in the total dissolved solids could be as a result of flooded water that is allowed access into the water bodies under study. Among the water bodies sampled, pond water samples recorded the highest total suspended solids value of 795 mg/L. Comparison with the WHO standard could not be done because of unavailable standard value from World Health Organization. Total suspended solids are one of the water contamination parameters. It plays major roles in pathogens transmissions. Though, total suspended solids are smaller in size but have greater surface area per unit mass of particles. This therefore, provides a medium for pathogens attachment as well as carriage of pollutant load on the surface of particles. There is a big relationship between the disease causing microbes and parasites and high level of total suspended solids [21]. The reported total suspended solids are in agreement with the previous works of Ajala *et al*. [18] and Pavendan *et al*. [17]. The total hardness recorded in this study is highest (837 mg/L) in pond and lowest (44 mg/l) in borehole samples. Apart from borehole samples, the sampled water bodies grossly deviated from the WHO set standards of 500 mg/L. The record of highest (837 mg/L) value of total hardness in well water may not be unconnected with the location and depth of the well as well as unwholesome activities around it. The lowest total hardness recorded in borehole water samples is in agreement with the report of

Shittu *et al*. [15] who recorded low values from four water bodies examined.

5 CONCLUSION

This study has presented the physicochemical characteristics of major sources of domestic water in Ebonyi Local Government, Ebonyi State. Results showed that most of the examined physicochemical parameters from the different water bodies exceeded the WHO permissible limits set standard. This is a sign that such water is not good for domestic consumption without thorough treatment. It is obvious that people will easily resort to the only available water for drinking and other domestic use and consequently, being exposed to various degrees of water relates diseases. However, constituted authorities should rise up to the challenges of shortage of good drinking water by providing measures for water treatment and as well, give access to portable drinking water to the populace to avoid dependence on less safe sources of water.

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