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Research Article

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Evaluation of the Water Quality Status of Raw and Conventionally Treated Water from Three Sources in Plateau State Nigeria

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Abstract Climate change coupled with growing world population has made the demand for water increase tremendously. This has made the pressure on water resources steeply worsen. Good and clean water is no longer considered a luxury, hence water quality control has in recent times gain the attention of researchers. For this cause, this paper attempts to evaluate the water quality status of water from three study areas within Plateau State, North-Central Nigeria. Physicochemical evaluation of the raw water and three conventionally treated water (CTW) was first conducted, after which, the National Sanitation Foundation Water Quality Index (NSF-WQI) method was used to determine the water quality status of the six water samples. The results of the physicochemical analysis of the raw water showed that all the parameters were within the WHO permissible limit (PL), with the exception of Electrical Conductivity (EC) and nitrate levels, which were determined to be higher than the PL. The WQI of the raw water samples fell within the range of 67-86, which is considered only fit for irrigation purposes. The physicochemical analysis of the CTW showed that all parameters except EC and dissolved oxygen were within the range of 50.77-56.16 and considered only fit for irrigation and industrial purposes. Based on the results obtained from this study, it is recommended that the raw water should not be consumed domestically, while the CTW should be used for irrigation and industrial purposes only. Further purification processes should be adopted for the CTW before being used for domestic purposes.

Keywords water quality index (WQI), physicochemical, conventional water treatment, contaminants, irrigation

Introduction

Water is key and an essential commodity for every living organism on earth. It is a fact that life on earth would be impossible without water. All living organisms contain water and humans contain approximately between 50-75% of water [1]. As the world's population grows, the demand for water mounts and pressure on finite water resources intensifies. Climate change, which is also closely tied to population growth, will also lead to greater pressure on available water resources. Clean drinking water is now recognized as a fundamental right of human beings. Around 780 million people do not have access to clean and safe water and around 2.5 billion people do not have proper sanitation. As a result, around 6–8 million people die each year due to water related diseases and disasters [2]. In the today world, the water use in household supplies is commonly defined as domestic water. This water is processed to be safely consumed as drinking water and other purposes. Contaminants in the water can affect the water quality and consequently the human health.

Water intended for human consumption must not contain pathogen germs or harmful chemicals. Good drinking water is not a luxury but one of the most essential requirements of life itself [3]. Therefore, water quality control is a top-priority policy agenda in many parts of the world [4]. Hence, it becomes paramount that the water quality status of water consumed for domestic, agricultural or industrial uses, be evaluated. It is as a result of this that this research was structured to evaluate the water quality status of raw and conventionally treated water gotten from three different sources in Plateau State, Nigeria.

Experimental

Materials

All reagent used for this research are of analytical grade marketed by Sigma Aldrich, Buchs, Switzerland. Some of the chemicals include:

Eriochrome black T, EDTA, Potassium iodide, Potassium hydroxide, Potassium dihydrogen phosphate, Potassium nitrate, Maganous sulphate, Starch indicator, Sodium thiosulphate. Sodium azide, n-Hexane (90% purity, M&B), Dichloromethne (99.5% purity, JHD), Acetic acid (99.5% purity, Hopkins &Williams), Brucine-sulfate, Sulfanilic acid, Hydrazinium sulphate, Sodium molybdate, Murexide indicator.

Sampling area

Three sampling areas were considered for this research which includes Pankshin in the central Plateau, Shendam in Southern and Jos in Northern Plateau all in Plateua State, Nigeria. The dams provide raw water for various uses by the inhabitants of these communities which include drinking, domestic activities, civil construction works and irrigation.

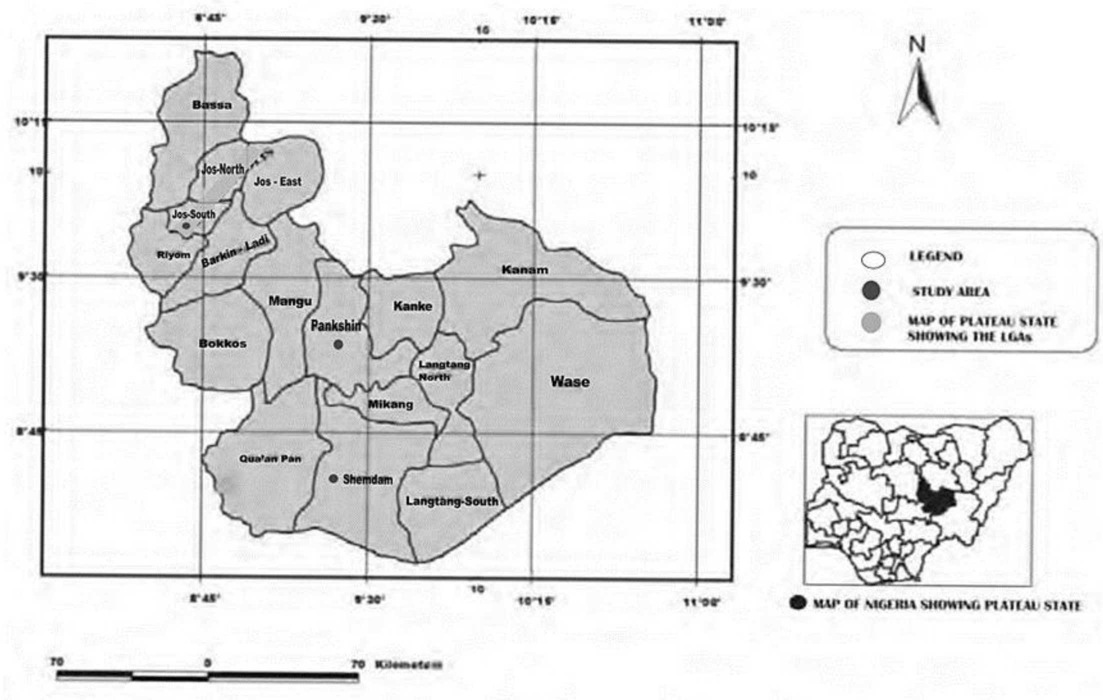

Figure 1: Map of Plateau State showing sampling areas

Sample Collection

The water samples used for this study is a three-way composite (equal parts) of the water collected from three site observation dams in dry season and the conventional treated water from the three dams within the same period. The water samples were collected in clean plastic containers and stored in an ice bag at a low temperature of about 4°C. During the sampling, the plastic containers were rinsed with the sample water three times before collection.

Physicochemical examination of the water samples

On-site analyses were carried out at the site of sample collection following the standard protocols and methods of American Public Health Organization where necessary [5].

Water Quality Index

The National Sanitation Foundation Water Quality Index (NSF WQI) developed by Brown *et al* in 1970 was used for this study.

Table 1: Physico-chemical Analysis/Water Quality Index Result for Raw Water

S/No	Parameter	RWP	RWS	RWJ	STD (Permissible Limits)
1	TEMP (°C)	22.00	23.50	22.0 0	-
2	pH	6.80	6.70	6.90	6.5 – 8.50
3	EC (μScm^{-1})	0.83	0.96	0.67	0.300
4	TA (ppm)	30.00	32.00	28.0	100.00
5	TH (ppm)	16.00	18.00	14.0	100.00
6	TS (ppm)	147.40	262.45	145.0	500
7	TDS (ppm)	135.40	147.10	134.40	500
8	TURBIDITY (NTU)	3.01	3.40	3.00	5.00
9	DO (ppm)	1.80	1.20	2.20	5.00
10	BOD (ppm)	2.20	3.20	3.00	5.00
11	PO_4^{2-} (ppm)	0.14	0.29	0.11	0.11
12	NO_3^- (ppm)	1.20	0.42	0.40	0.50
13	Cl^- (ppm)	36.00	40.00	35.45	200.00
14	WQI	75.51	86.08	67.4	0-50

RWP: Raw water Pankshin; RWJ: Raw water Jos
RWS: Raw water Shendam; WQI: Water Quality Index

Table 2: Physico-chemical/Water Quality Index Result for Conventionally Treated Water

S/No	Parameter	TWP	TWS	tWJ	STD (Permissible Limits)
1	TEMP (°C)	22.00	23.50	22.00	-
2	pH	7.10	6.90	7.20	6.5 – 8.50
3	EC (μScm^{-1})	0.45	0.52	0.31	0.300
4	TA (ppm)	18.00	22.00	16.00	100.00
5	TH (ppm)	16.00	16.00	14.00	100.00
6	TS (ppm)	120.00	135.00	118.00	500
7	TDS (ppm)	118.00	121.00	116.00	500
8	TURBIDITY (NTU)	2.10	2.20	1.00	5.00
9	DO (ppm)	4.80	4.90	5.10	5.00
10	BOD (ppm)	2.10	3.00	2.60	5.00
11	PO_4^{2-} (ppm)	0.08	0.10	0.09	0.11
12	NO_3^- (ppm)	0.19	0.13	0.12	0.50
13	Cl^- (ppm)	32.50	38.00	28.36	200.00
14	WQI	51.27	56.16	50.77	0-50

TWP: Treated Water Pankshin; WQI: Water Quality Index
TWS: Treated Water Shendam; TWJ: Treated Water Jos

Discussion

The pH values of the raw water samples were found to be in the range between 6.70 and 6.90, while that of the Conventionally Treated Water (CTW) samples were within the range of 6.9 (Tables 1 and 2), where the lowest and highest values are from samples RWS and TWJ respectively. The normal drinking water pH range mentioned in WHO guideline is between 6.5 and 8.5 (Table 1). Drinking water with a pH between 6.5 to 8.5 is generally considered satisfactory. Acid water tend to be corrosive to plumbing and faucets, particularly, if the pH is below 6. Alkaline waters are less corrosive; water with a pH above 8.5 may tend to have a biter or soda-like taste.[6]

The water temperature of samples collected ranged between 22.00 ºC to 23.50 ºC for both raw and treated water samples. The relative low temperatures in samples collected from Jos and Pankshin were due to the period of collection marked by the cold temperatures associated with the dry season in the study areas. Temperature is basically important for its effect on other properties of waste water. Temperature values for various samples are presented in Table 1, ranging from 22.00°C to 23.50°C. The highest value was found in RWS and TWS1, while water samples collected from Pankshin and Jos had the lowest temperatures (Table 1). Release of high-temperature waste water into water bodies may speed up some reactions in the water body. It will also reduce solubility of oxygen and amplified odor due to anaerobic reaction (less oxygen).[7]

The results show that the measured conductivity of the raw water samples ranges from 0.61 μS/cm to 0.96 μS/cm (Table 1), while that of the treated water ranges from 0.31 μS/cm to 0.52 μS/cm (Table 2). According to [8], the wide differences among the values of the electrical conductivity of consumed water are not yet known. Scatena [9] explained the differences based on various factors such as agricultural and industrial activities and land use, which affect the mineral contents and thus the electric conductivity of the water though conductivity does not have direct impact on human health. The CTW samples had lower EC compared to the raw water samples. However, all were higher than the permissible limits of 0.3 μS/cm. The acceptable limit of alkalinity is 100 ppm. In the present study alkalinity with phenolphthalein indicator and alkalinity with bromcresol indicator (total alkalinity) were determined and the results showed that the total alkalinity of the raw water samples ranged from 28.00 ppm to 32.00 ppm, while those of the CTW samples range between 16-22 ppm. Though all were lower than the permissible limit.

The acceptable limit of total hardness is 100 ppm. The hardness of the analyzed raw water samples varied from 14 to 18 ppm as $CaCO_3$, while that of the CTW samples were between 14-16 ppm. The highest value of total hardness was observed at Shendam sampling site, as shown in Tables 1 and 2. Durfor *et al.* [10] have classified water as soft, moderate, hard and very hard. As per this classification most of the samples comes under soft category.

Regarding the values of TS, all the water samples showed less to moderate presence of contaminants, as the values ranged from 118 ppm to 262.45 ppm. And all these measured values were within the permissible limits of WHO (≤ 500 ppm). The TS values of all the drinking water samples studied are shown in Tables 1 and 2. The highest value of 262.45 ppm was found in water samples from the Shendam area. However, it is still below the maximum standard limit of 500 ppm. It was also found that the samples collected from two other areas, Pankshin and Jos, showed very little TS contents. The TSS values of samples TWP, TWS and TWJ are also within the range of 118 to 135 ppm, as expected from these treated waters.

The standard or allowable value of the TDS set by WHO is 500 ppm.[4] The values found from the drinking water samples are all within 29.4% of the maximum limit of 500ppm. The highest TDS values of 147.10ppm and the lowest TDS values of 116ppm correspond to samples from RWS and TWJ1, respectively (Tables 1 and 2).

The turbidity results for all 6 drinking water samples studied are shown in Tables 1 and 2. The standard recommended maximum turbidity limit, set by WHO for drinking water is 5 nephelometric turbidity units (NTU).[4] The lowest turbidity values of 1.00 NTU and highest value of 3.4 NTU were found for samples TWJ and RWS, respectively (Tables 1 and 2). The treated water, which was expected to be cleaner, thus had lowest turbidity values. The results indicate that the turbidity of all the samples studied was below the maximum standard limit of 5 NTU.

Dissolved oxygen (DO) values obtained for samples collected varied between 1.20 ppm and 2.20ppm, as observed in Tables 1 and 2. The DO level at points TWP to TWJ was above these levels. The high oxygen level was recorded during cold/dry season mainly due to lack of removal of free oxygen through respiration by bacteria and other animals as well as the low oxygen demand for decomposition of organic matter.[11]

Biochemical oxygen demand is a measure of the quantity of oxygen consumed by microorganisms during the decomposition of organic matter. BOD concentration of water obtained for samples collected ranged between 2.1 and 3.20 as seen in Tables 1 and 2. The concentrations of BOD in all the sampling points are lower than the WHO value of 6ppm. High BOD concentrations observed in waste water might be due to the use of agro-chemicals in the study area.

The concentrations of nitrate and phosphate in all the sampling points varied between 0.12 and 1.20ppm for nitrate, and 0.09 and 0.29ppm for phosphate, refer to Table 6. High concentration of nitrate and phosphate was observed at RWS, while low concentrations varied at different points for phosphates for treated water samples (TWP, TWS and TWJ). The levels of nitrate at RWP exceeded the WHO limit of 0.50ppm. In addition to naturally occurring nitrates, it is also contributed to water sources by the application of fertilizers to lands.[12]

The concentration of chloride is the indicator of sewage pollution and also imparts laxative effect. The chloride content of studied water samples were within permissible limit of 200ppm prescribed by [13]. In present study, the results of chlorides in all sampling sites ranged from 28.36 to 40ppm.

Using the NSF-WQI method developed by Brown *et al*, 1970 as cited in [14], the WQI for the six samples analyzed. The three raw water samples were all higher than 50, the threshold limit set by the NSF-WQI method. It can therefore be seen that the WQI of the raw water samples fall within the range of 'Poor' WQI useful only for irrigation purposes. The WQI of the CTW samples fall within the range of 'Fair' WQI useful for irrigation and industrial purposes only and unfit for drinking.

Conclusion

The evaluation of the water quality status of raw water and conventionally treated water from Pankshin, Jos and Shendam areas of Plateau State, Nigeria. The physicochemical analysis of the obtained samples were first evaluated, before the water quality status was analyzed. The NSF-WQI method was utilized for this study. The results obtained showed that the WQI of the raw water was evaluated as only fit for irrigation purposes, while that of the conventionally treated water was evaluated as fit for only irrigation and industrial purposes. Therefore, it is concluded that the water samples analyzed in these three sources are unfit for drinking and other domestic purposes. It is hence recommended that further and more sophisticated water purification processes be utilized to make the water in the study areas fit for domestic consumption.

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