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PHYSICO-CHEMICAL AND BACTERIOLOGICAL QUALITY OF SURFACE WATER OF RIVER BENUE, NIGERIA.

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ABSTRACT

The physico-chemical and bacteriological analysis of River Benue shows that the water is suitable for both industrial and agricultural purposes. However, the concentrations of Fe (range: 0.06-0.90 mg/l, mean: 0.50mg/l), Mn (range: 0.05-1.00mg/l, mean: 0.56mg/l), Cu (range: 0.05-0.50mg/l, mean: 0.21mg/l), NO_3^- (range: 50-83 mg/l, mean: 65mg/l) and Coliform count (30-78 per 100ml) are all above WHO standard limit for drinking water, especially downstream of industrial and populated areas. The water from River Benue requires treatment for these parameters before drinking.

KEYWORDS: River Benue, physico-chemical analysis, bacteriological analysis, standard value, Coliform count.

INTRODUCTION

Water contamination has been one of the major problems facing man today. Man has recognised that water quality is as important as its quantity. Current emphasis therefore, is not only on how abundant water is but also on whether its status is good enough to sustain its various uses (Asuquo, 1999).

In Nigeria, the rapid deterioration of water bodies due to anthropogenic influences is alarming (Edet, 1993; Asuquo, 1999; Esu and Amah, 1999). Since River Benue's flood plain is fertile, it has recently witnessed a tremendous increase in population. Some important towns such as Donga, Katsina-Ala, Abinsi and Makurdi have developed in this area. Since most of the people around this area depend on water from River Benue for various purposes (domestic, agricultural and industrial) it is necessary to continuously monitor the quality of this river.

Changes in water quality are expected depending on the human activities prevalent in the area. According to Belau (1979) the quality of river water depends on the feeding sources, which in this case, may include surface run off, swamps, rainfall, underground water, waste waters of industrial enterprises and populated areas. The flood plain of River Benue is intensively cultivated. Fertilizer, herbicides and pesticides are freely used. These could introduce such pollutants as nitrates, phosphates and trace metals as well as reduce the bacteriological quality of the river. Also, there are few cottage industries still in operation within the area. These include the Benue Bottling Company Limited (BBL), Nigerian Bottling Company (NBC) and Benue Breweries among others. These could release wastes especially sewage effluent into the river thereby altering its quality.

River Benue, which rises from the Adamawa highlands in Western Cameroon, is the largest tributary of River Niger which it meets at Lokoja. The river flows through a valley which is free from rapids and waterfalls. The river owes this uniqueness to the fact that throughout its 800km journey below Yola to Lokoja, it flows through sedimentary rocks including black and grey shales, limestones, sandstones, clayey and silt deposits as well as alluvial deposits.

This work aims at determining the physicochemical and bacteriological characteristics of River Benue and therefore, assessing its suitability for intended use (domestic and other uses).

MATERIALS AND METHODS

Water samples were collected from River Benue at seven locations (Fig.1). samples were collected on two-monthly intervals starting from January to June 2001. A total of three sampling trips were made. Within each sampling location, a cross-sectional sampling was made at three points (Fig.1).200ml plastic bottles with tight fitting plastic caps and labelled within waterproof makers were used for water sampling. The bottles were first washed with 0.1M HCl and rinsed with distilled water. At the sample collection point, the bottles were rinsed twice with the water to be collected. The bottles meant for bacteriological analysis samples were sterilized and capped.

After sampling, the bottle lid was immediately replaced to minimize contamination and the escape of gases. The samples were then stored in a cooler for analysis within 24 hours. Temperature, conductivity and pH were determined in – situ using a Mercury –filled Thermometer, a Mark Electronic Switchgear Conductivity Meter and pH meter ± 0.1 units, respectively. Turbidity was measured spectrophotometrically at 810nm. Analyses for the cations; Na^+, Cl^+, Cu^{2+}, Mg^{2+}, Ca^{2+}, total Fe and Mn were carried out by using computerized Atomic Absorption Spectrophotometer (ASS) model 210. The anions, SO_4^{2+}, NO_3^-, Cl^-, HCO_3^- and hardness were determined by titration. TDS was determined by gravimetric method. The membrane filter technique, which centred only on total coliform count, was employed for bacteriological analysis (Fawole and Oso, 1988).

RESULTS AND DISCUSSION

The results of physico-chemical and bacteriological analyses of water samples from River Benue are presented in Table 1. Table 2 compares the ranges of values of the parameters in the study area with the World Health Organisation (WHO, 1984) standards. Table 3 gives the quality classification of water for irrigation. (Wilcox, 1955).

Physico-chemical Parameters

The temperature of the Benue river ranges from 25°C to 30°C with a mean value of 27.4°C. These values agree with values obtained by other workers in Nigeria (Ajiwe et al, 1990; Esu and Amah, 1999). Although the range of values is narrow, the higher values were recorded at the Nigerian Bottling Company (NBC) and Benue Bottling Company Limited (BBL) stations, indicating that the effluents from these industries have slightly altered the thermal quality of River Benue. The narrow range of values could be attributed to the general high specific heat capacity of water which impacts on it the ability to act as "thermal bufter" (Asuquo, 1999). The range of pH was from 6.50 to 7.80 with a mean value of 7.10. Table 2 reveals that these values are within the set standard of 6.50-8.50 (WHO, 1984) and therefore do not pose any environmental problem. Turbidity

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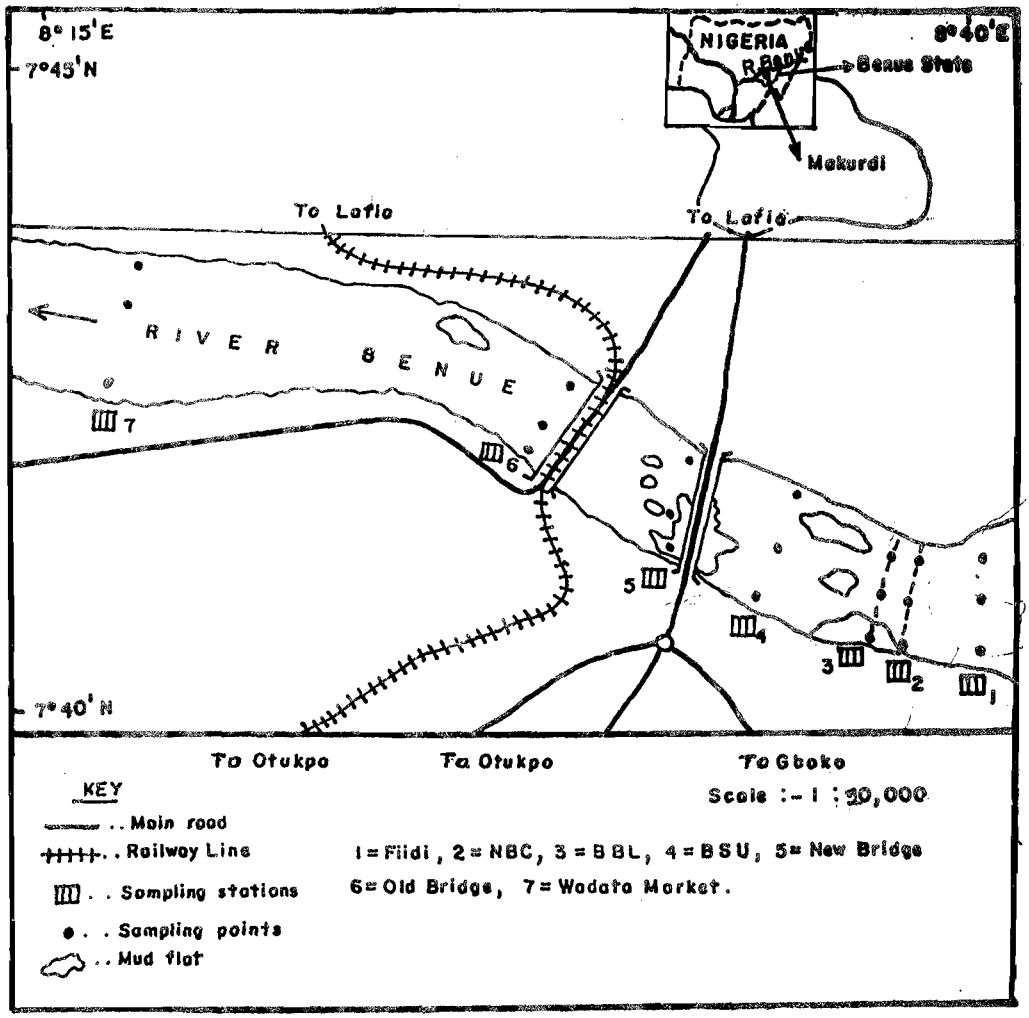

FIG. 1: Sampling location map showing sampling points. Insert: Map of Benue state showing study area.

ranged from 18 – 22 NTU with an average value of 20 NTU. These values are higher than the 5 units of turbidity stipulated by the WHO (1984) for drinking water and most industries. Turbidity in water is usually caused by particulate matter in suspension which results mainly from land erosion (Hem, 1985). In the present study, the high turbidity could be attributed to the large volume of water discharged into River Benue from tributary rivers and streams especially during the rainy season. The more than 100 rivers and streams contributing to this include Rivers Faro, Gongola, Taraba, Donga and Katsina-Ala among others. The drainage basin is underlain by sedimentary rocks which are susceptible to erosion thereby increasing the turbidity of the river.

The values of electrical conductivity ranged from 30 µs/cm to 220µs/cm. These values are well within the set standard by WHO (1984) of 1400 µs/cm (Table 2). This means that the water has low salinity. This could be explained by the large volume of fresh water that drains into River Benue as outlined above. According to Table 3 (Wilcox, 1955) water is regarded as excellent for irrigation and domestic use if electrical conductivity is less than 250µs/cm. Thus on the basis of this parameter, the water from River Benue is good for both domestic and agricultural activities. Total Hardness ranged from 30mg/l to 80mg/l with a mean value of 56.3mg/l. River Benue could be classified as being soft to moderately hard based on the UK Ministry of Health report (1949) which classes water as soft (≤60mg/l), moderately hard (61-120mg/l), hard (121-180mg/l) and very hard (>180mg/l). The contribution of hardness to the river comes mainly from Ca^{2+} and not from Mg^{2+} (Table 1). The Ca^{2+} is most probably sourced from limestone within the drainage basin. The weathering of these calcareous rocks could also be responsible for the moderately high pH values of the river.

The values of hardness obtained from this study are well within the WHO (1984) standard of 500 mg/l. In terms of hardness therefore, the water from River Benue is suitable for domestic and other purposes.

Total dissolved solids (TDS) values are between 80-350 mg/l, with a mean value of 187 mg/l (Table 1). These values are well within the WHO standard of 1000 mg/l (Table 2) and therefore do not pose any health or environmental hazard. The low TDS values are consistent with the high pH under which most salts are insoluble. Also the TDS values correlates closely with those of electrical conductivity values indicating influence of TDS on the electrical conductivity of water.

Total Fe and Mn ranged in concentration from 0.06 mg/l to 0.90 mg/l and 0.05 mg/l to 1.00 mg/l with mean values of 0.50 mg/l and 0.56 mg/l respectively in River Benue. Some values are well above WHO standard for drinking water of 0.5 mg/l for Fe and 0.1 mg/l for Mn (Table 2). Fe could probably have been leached into the river from ferruginous sands derived from the Makurdi and Keana sandstones; corrosion of railway lines, bridges and iron materials from refuse dumps. While the Mn probably originates from domestic and industrial wastes, since the value for the sample taken upstream of industrial establishment (Fiidi) has a value lower than the recommended value of 0.1 mg/l. Moreso, Fe and Mn are

Table 1: Quality Characteristics Of River Benue

S/No	Parameter	Fiidi	Nigerian Bottling Company	Benue Brewery	Benue State University	New Bridge	Old Bridge	Wadata Market	Mean (x)—
1	Temperature (°C)	27	29	30	27	26	25	28	27.4
2	PH	7.3	7.3	7.1	6.8	7.2	6.9	6.5	7.10
3	Turbidity (NTU)	18	19	18	20	20	22	21	22.0
4	Total Hardness (mg/l)	73	80	30	42	86	33	50	56.3
5	TDS (mg/l)	130	80	300	120	100	230	350	187.1
6	Conductivity (s/cm)	60	30	200	70	60	85	220	107.6
7	Fe (mg/l)	0.06	0.90	0.08	0.30	0.07	0.80	0.80	0.50
8	Na^+ (mg/l)	0.36	2.00	1.60	3.00	1.10	0.30	4.00	1.80
9	K^+ (mg/l)	3.20	0.80	1.10	0.61	1.00	3.60	0.40	1.53
10	Cu^{2+} (mg/l)	0.90	0.10	0.40	0.30	0.50	0.05	0.06	0.21
11	Mg^{2+} (mg/l)	5.12	6.30	1.20	2.40	3.72	2.20	3.00	3.42
12	Mn (mg/l)	0.05	0.20	0.30	0.70	0.80	1.00	0.90	0.56
13	Ca^{2+} (mg/l)	18.0	16.0	10.0	21.0	17.0	20.0	23.0	17.86
14	SO_4^{2-} (mg/l)	9.0	10.2	8.6	6.8	11.0	7.9	12.1	9.4
15	NO_3^- (mg/l)	65	50	60	80	70	50	83	65.6
16	Cl^- (mg/l)	5.6	8.2	6.4	3.9	10	12	2.3	7.00
17	HCO_3^- (mg/l)	0.6	6.0	0.8	16.0	10.0	8.0	4.0	6.5
18	Feacal Coliform /100ml of water	40	30	36	60	70	60	78	53.6

Table 2: Range in values of physico-chemical and bacteriological parameters in River Benue compared with WHO standards for drinking water.

Parameter	Range (in River Benue)	WHO standard Limit (1984)
Conductivity (µs/cm)	30-220	1.400
pH	6.5 – 7.8	6.5 – 8.5
Turbidity (NTU)	18 – 22	5.
Total Hardness(mg/l)	30 – 86	500
Mn (mg/l)	0.05 – 1.00	0.05
Fe(mg/l)	0.06 – 0.90	0.30
Ca^{2+} (mg/l	10 – 23	500 as $CaCo_3$
Mg^{2+} (mg/l)	1.2 – 6.30	150
Na^+ (mg/l)	0.3 – 4.0	200
Cl^- (mg/l)	2.3 – 12.0	250
NO_3^-(mg/l)	50 – 83	50
SO_4^{2-} (mg/l)	6.80 – 12.10	400
TDS (mg/l)	80 –350	1000.
Coliform Count/100 ml	30 – 78	1.0

normally found as ferrous and manganous compounds (Hem, 1985), upon aeration, the soluble ferrous and manganous compounds are oxidized to insoluble ferric and mangenese hydroxides respectively and precipitated as brownish substances. Their presence in high concentration in these areas therefore, is indicative of the closeness of the sources of the Fe and Mn. The implication for high concentration of Fe and Mn is that the water will have taste, stain laundry and cooking utensils.

Na^+ and K^+ occur relatively in low concentrations in River Benue. The concentration of Na^+ in the water lies between 0.30 and 4.00 mg/l with a mean value of 1.80 mg/l. While K^+ shows a range of 0.40 – 3.60 mg/l with a mean of 1.53 mg/l. the concentrations of Na^+ are all within the recommended limit of 200 mg/l (WHO 1984). Similarly Table 3 shows that the values of Na^+ obtained from this study are within the values considered suitable for irrigation (Wilcox, 1955). This implies that, based on this parameter, the water from River Benue is suitable for domestic, agricultural and industrial purposes. The limit for K^+ in drinking water is not stated (Table 2).

Cu^{2+} ranges from 0.06 mg/l to 0.50 mg/l with a mean of 0.21 mg/l. According to WHO (1984), Cu^{2+} is rarely found in natural waters. Invariably, its presence in River Benue is an index of anthropogenic input; most probably from fertilizers, industrial and domestic wastes. The Cu^{2+} from these sources could either have been dumped directly in the river or leached into it by rainfall. Also, the high turbidity (Table 1) implies large volume of particulate matter which according to Hem (1985) contain clays and organic matter which usually enhances the concentration of such trace elements as Cu, Zn, Cr, Ni and Bo.

Chemical factors such as SO_4^{2+} (range 6.80 –12.10 mg/l, mean 9.40 mg/l), Cl^- (range; 2.30 – 12. 00 mg/l, mean; 7.00 mg/l) and HCO_3^- (range: 0.60 – 10 mg/l, mean 6.50 mg/l) are all within the WHO standards for domestic, agricultural and industrial purposes (Tables 2 and 3). This shows that the use of River Benue is not likely to cause any harm vis-à-vis these paramenters. The low values of Cl^- correlates with

Table 3: Quality Classification of water for Irrigation (Wilcox, 1955).

Water class	%Na^+(mg/l)	Specific Conductance (µs/cm)	Cl^- (mg/l)
Excellent	⩽ 20	⩽ 250	⩽2
Good	20 – 40	250 – 750	2 – 4
Permissible	41 – 60	751 – 2000	5 – 6
Doubtful	61 – 80	2001 – 3000	7 – 8
Unsuitable	780	⩾ 3000	⩾ 8

those of Na^+ and indicates a fresh water environment. However the concentrations of NO_3^- (range 50 –83 mg/l, mean 65.60 mg/l) are in most cases above the WHO standard limit for potable water. Nwankwo (1990) contended that NO_3^- above 44 mg/l in drinking water could cause methaemoglobinemia (or "blue water baby") in children. The possible sources of the nitrates include the intensive agricultural activities going on along the banks of River Benue coupled with the intensive use of all types of fertilizers; effluent wastes from industrial establishments and domestic sewage as well as refuse dumps. Some of these wastes may undergo total hydrolysis under certain conditions thereby increasing the nitrate concentration.

Bacteriological Contamination

The bacteriological quality of water is very important from the health point of view. One of the main characteristics of good water is the absence of faceal coliform or pathogenic organisms. A raw water- source containing less than one coliform bacteria per 100ml is regarded as being acceptable. Coliform count is the simplest indication of organic contamination (Ajiwe, et al 1990). The World Health Organisation (1984) revealed that a repeated finding of 1-10 coliform organisms per 100ml of water sample suggest that undiserable material is gaining access to the water. Contrary to these standards, all the water samples for this study have high coliform counts (range 30 – 78, mean 54) per 100 ml of sample (Table 1) so the water is unfit for human use without treatment. The sanitary survey of the area sampled revealed the presence of farmlands, markets, schools and villages along the banks, and inadequate toilet facilities. Most settlers and domestic animals pass faeces and dump wastes in open bushes near their residences or directly into the river. The faeces and wastes dumped on land are also eventually washed into the river during rainfall besides those dumped directly into the river thus causing pollution. This could be the most probable cause of most water-related diseases, guineaworm, dysentery, typhoid fever and cholera, which are endemic in the area of study.

CONCLUSIONS

The physico-chemical and bacteriological composition of River Benue which drains over a hundred rivers and streams, and flows mostly through sedimentary rocks, was analysed. The results of the physicochemical parameters reveals that the river is safe for agricultural and industrial purposes when compared with acceptable limits. The water is also safe for drinking and other domestic purposes when treated for Fe, Mn, NO_3^- and Cu^{2+} especially downstream of industrial and urban areas.

Bacteriologically however, the river is heavily polluted due to high numbers of coliform organisms found in it. This calls for adequate treatment of the water from the river against bacteriological contamination before use. The health authorities in this area should continue with the campaign for cleanliness of the environment, proper application of biocides, good refuse and sewage disposal methods by the individual, institutions and industries in order to prevent water-related diseases in this area.

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