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Studies on Aesthetics Status of Water Quality of River Benue, Makurdi, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author TJA designed the study, wrote the Initial draft of the manuscript. Author SOA drafted the experimental design and reviewed the literature of the manuscript. Author SAA performed the statistical analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Continuous activities of man on the bank of river Benue has generated copious quantity of sediments and suspended particles that are washed into the river through the surface runoff. To determine the aesthetic value and quality of River Benue at Makurdi, samples of water were taken at five sampling sites on the bank of river Benue for two years (July 2011-June 2013) were analyzed for colour, turbidity and TSS as aesthetic parameters. The aesthetic parameters of the water samples examined were total suspended solids, turbidity and colour were determined in line with standard methods for the examination of water and waste waters (APHA, 1999). The results of the aesthetic parameters indicate the river water samples with the following characteristics: TSS (62.42±61.57 mg/L), Turbidity (63.08±53.01NTU) and Colour (276.50±163.42TCU). The mean values of turbidity and colour of the water samples were beyond the WHO and the Nigerian Standard for Drinking Water Quality accepted maximum limit. However the suspended solids does

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not have a control standard value. The result of Analysis of variances (ANOVA) for turbidity and colour was significant during the seasons ($P<0.05$), while for TSS it was not significant ($P>0.05$). Similarly there was significant correlation at 1% significance between the aesthetic parameters. The regression analysis between TSS and turbidity, TSS and colour and turbidity and colour indicate a relationship with the aesthetic parameters with R^2 values of 0.5306, 0.417 and 0.6201 respectively. The study conclude that the clarity of the water of River Benue during the study period was compromised due to the anthropogenic activities on the shoreline of the River that have impacted negatively on the aesthetic quality of the water during the period of the study. It was recommended that human activities on the bank of the River should be controlled, regulated and enforced by the Government regulatory authority.

Keywords: River Benue; TSS; turbidity; colour aesthetic.

1. INTRODUCTION

Aesthetics of water is the clarity, transparency or cleanness of the water. Water quality parameters such as turbidity, total suspended solids and colour determine the aesthetic of a water sample. Turbidity account for the lack of transparency or cloudiness of water due to the presence of suspended and colloidal materials such as clay, slit, finely divided organic and inorganic matter, plankton and other microscopic organisms [1]. Turbidity of the water is caused primarily by suspension of particles that are more than 1 micron in diameter in the water column, while suspended solids are particles that typically ranged from 10-100 microns in diameter. Visibility or clarity decreases as the turbidity increases in a given water body [1]. The source of turbid materials into the surface waters include natural and anthropogenic activities in the watershed. These activities include natural or excessive soil erosion from agriculture, forestry, construction, urban runoff, industrial effluents and excessive phytoplankton growth [2]. The reduction in clarity of water is due to the scattering of sunlight by the suspended particles in the water column. In addition to the turbidity water clarity is also influenced by the colour of the water. Nevertheless coloured components in the water column absorbed light energy preventing it from penetrating as deep as it is obtained in the colourless water. More so, certain wavelength of light are reflected back out of the water permitting the visibility of the colour. Other organisms usually impact a brown to black colour in the water column. Plants such as Parrot feather, *Myriophyllum aquaticum* release coloured organic compounds into the water column that impact negatively on the colour of the water [1]. The transparency and clarity of water is indispensable in determine the depth of penetration of sunlight within a given water body like River Benue. Light penetration is important to submerged aquatic plants such as hornworts algae etc. The plants depends on light interception and absorption for photosynthesis that provide energy shelter and protection for many different aquatic biota and serve to sustain the ecosystem.

Suspended solids may cloth the filtering apparatus and digestive tract of Planktonic organisms as well as irritates and or injure the gills of fish [3]. Similarly sensitive or threatened fish species may lost when turbidity of the water exceeds 100NTU [3]. Fish communities in areas subject to high quantity of suspended solids typically shift toward more sediment tolerant species [3]. The greater the amount of suspended solids in the water, the murkier it appears and the higher the measured turbidity [4]. This study is very important because the aesthetic of water is the first perception about the quality of the water by the person intending to use the water for whatever purpose. Similarly turbid water is known to hide coliform bacteria in it. These parameters are important in the sense if they are compromised the consumer may reject the supply of the water source for consumption and domestic use. The objective of this study is to examine the aesthetic parameters of the water of river Benue with respect to its turbidity, suspended solids and colour and evaluate the clarity of the water with respect to the water quality standards.

2. MATERIALS AND METHODS

2.1 Study Area

The origin of River Benue is from the mountain in Cameroun that flows west wards into Nigeria. The river Benue is the second biggest river in Nigeria after River Niger and it is about 310,000 Ha in its dimension. The length of river Benue is about 1,488 Km and have alluvia fertile flood

plains on both sides of its banks [5]. River Benue from downstream from it source from Camerroun into its lower section at Makurdi and meet River Niger in Lokoja, Kogi state, Capital Nigeria. Makurdi town is the is the state capital of Benue state and is located on Latitude 7º 41' N and Longitude 8º 28' E. The River Benue within Makurdi metropolitan area measures approximately 673 miles with its main settle patterns [6]. The period of rainfall in Makurdi results in a River pattern with highest flowing speed from August to early October and lowest flowing speed from December to April of every year. The wet months usually last from April to October with a mean yearly precipitation varying from 1200-2000 mm [7]. The atmospheric temperature in Makurdi is usually high with mean values that ranged from 28-35ºC all year round with peak temperatures values from March to April of every year. The months of December to January are usually cooled during harmantan period winds that are hazy [7]. Sampling station were selected on the bank of river Benue within Makurdi metropolitan are numbering to five. These sampling station were selected as s a result of the human activities on the bank of river as shown in the Table 1.

Table 1. The study stations, their coordinates and distance

Station	Station codes	Coordinates	Human activities
Coca-cola	I	N07^0 43.663' E008^0 35.427'	Agriculture and fishing
Benue brewery	II	N07^0 43.615' E008^0 35.300'	Industrial effluents
Mikap Nigeria Ltd	III	N07^0 43.649' E008^0 35.302'	Rice milling effluents/industrial
Wurukum abattoir	IV	N07^0 44.076' E008^0 32.840'	Abattoir effluent and sand dredging
Wadata market	V	N07^0 44.789' E008^0 30.624'	Domestic washing, refuse dump and abattoir

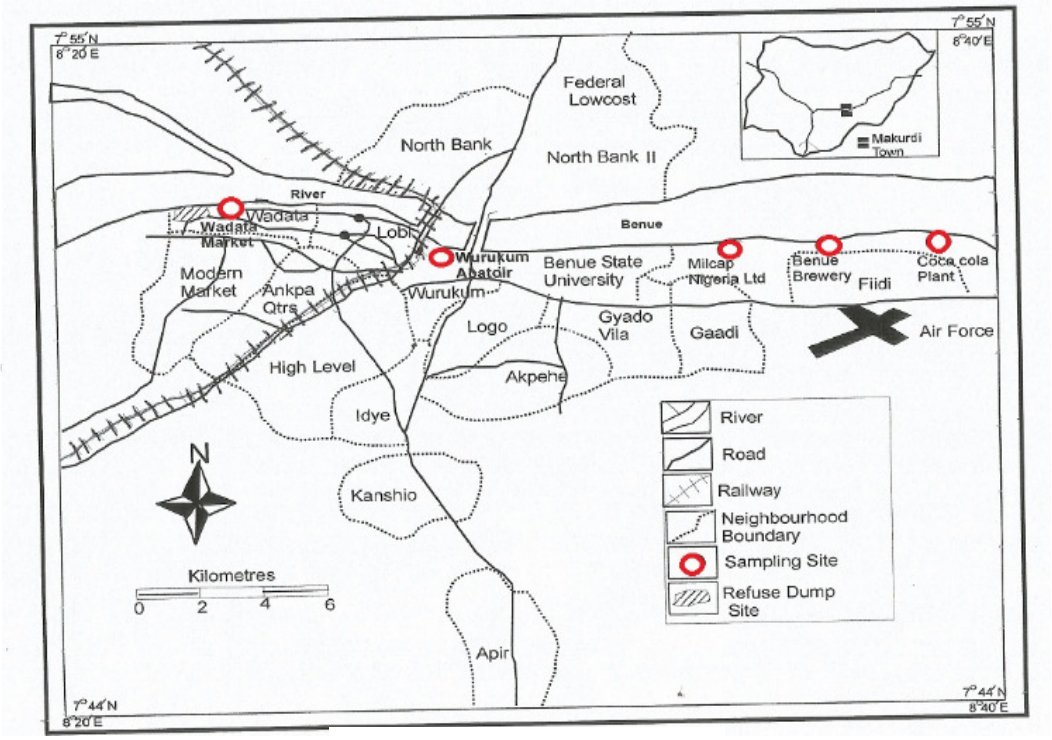

Fig. 1. Map of Makurdi town showing sampling sites
Source: Ministry of Lands and Survey Makurdi

2.2 Water Sample Collection and Analysis

Samples of water were taken at the five different sampling points on the bank of River Benue at Makurdi. On monthly basis the sampling was carried out during the early hours of the day, from 8.00 am and 12.00 noon. The water samples were collected in different sampling bottles and were labeled with respect to the parameters to be determined. After collection, the water samples were taken to the laboratory and were examined using standard methods for examination of water and waste waters [8].

2.3 Data Analysis

The graphs in the result section were plotted with the aid Microsoft excel 2013 version. SPSS version 20 statistical package was used in calculating descriptive statistics, correlation and analysis of variance. Statistical significant difference were considered at 5% level of significance.

3. RESULTS

The results of the aesthetic parameters at the stations in Table 2 indicates that TSS varied from 41.00±25.40 mg/L-87.60±57.40 mg/L, colour ranged from 193.00±143.80TCU-393.00±175.70TCU and turbidity ranged from 44.50±44.30NTU – 91.40±56.50NTU, during the 24 months study period in River Benue at Makurd. Similarly Table 3 is the correlation analysis between total suspended solids, turbidity and colour of the water samples. There significant correlation between all the aesthetic parameters of the water samples indicate that the three parameters affect each other and contribute in making the water to be turbid and coloured.

The results in Fig. 2 is the average monthly difference in the total suspended solids values in River Benue. A perusal at the results revealed that the highest concentration of 410.00 mg/L was determined in January 2013 at Station III, while the lowest concentration 5.00 mg/L was at Station I in April 2013. The result in Fig. 3, shows the difference in average values of the total suspended solids in River Benue across seasons. The result showed an increase in suspended solids load from season 1 to 5 during the study period. ANOVA between and within stations for the 24 months show that there was a significant difference ($P< 0.05$). All the same, there was no significant difference between and across seasons ($P> 0.05$). Similarly, the multivariate analysis of variance (MANOVA) between stations and seasons showed that there was no significant difference between stations and season ($P> 0.05$). Least significant difference results obtained at the locations revealed that the mean values of TSS differs significantly between locations: I and II, I and III, II and IV, II and V, III and IV, III and V only ($p<0.05$).

The result in Fig. 4 depicts the average monthly difference of the turbidity values of the water samples for two years at five locations in River Benue at Makurdi. The highest value of turbidity (258.00 NTU) was recorded in April 2012 at Station III, while the lowest turbidity (3.00 NTU) was in April 2013 at Station I. The results of the seasonal variation of turbidity of the River Benue reported in Fig. 5 showed increase in turbidity from season1-3 and then decrease from season 4 and increase again slightly at season 5. The result of analysis of variance (ANOVA) showed a significant difference in turbidity within and between locations and across seasons for 24 months ($P < 0.05$). However, the multivariate analysis (MANOVA) between stations and seasons for turbidity was not significant ($P > 0.05$). The LSD analyses of mean turbidity values obtained at the locations were significant between locations: I and II, I and III, II and IV, II and V, III and IV III and V only ($p<0.05$).

The colour of the water samples obtained varied from 23.00 - 580.00 TCU during the study period. The highest value of colour 580.00 TCU was reported in April 2012 at Station III while the lowest value of 23.00 was in April 2013 at Station I (Fig. 6). A perusal of the result showed

Table 2. Mean concentration of aesthetic parameters of River Benue at Makurdi

Parameter	Unit	Sample I	Station II	Codes III	IV	V
TSS	mg/L	41.00±25.40	87.60±57.40	87.00±91.80	52.80±51.60	44.30±49.80
Colour	TCU	244.50±128.50	393.00±175.70	344.30±157.90	208.10±113.60	193.00±143.80
Turbidity	NTU	46.90±26.70	91.40±56.50	83.50±65.80	49.10±47.20	44.50±44.30

Table 3. Correlational analysis between total suspended solids, turbidity and colour in River Benue at Makurdi

Parameter	TSS	Turbidity	Colour	Mean	Std. deviation	Sample size
TSS	1	0.728**	0.646**	62.42	61.57	120
Turbidity	0.728**	1	0.787**	63.08	53.01	120
Colour	0.646**	0.787**	1	276.50	163.42	120

***Correlation significant at 0.01 significance (2 tailed)*

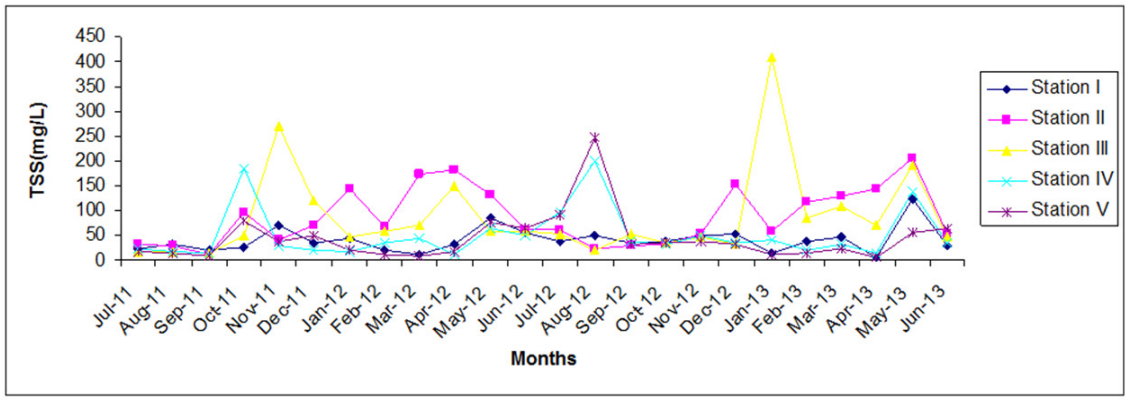

Fig. 2. The average monthly difference of TSS values in River Benue at Makurdi

that the colour of the water samples at Station II and III were recorded with higher values during the time of the study (Fig. 6). The seasonal variation of the colour of water samples during five seasons of the study revealed that the colour of the water samples increase progressively from season 1to 3 and then decrease slightly at season 4 and increase again at season 5 like it is obtained in the turbidity of the water samples as it is presented in Fig. 7. Generally turbidity increase during the wet months in comparison with the dry months in the course of the study. The ANOVA for the period of 24 months showed a significance difference at the locations and across the seasons ($P<0.05$). Nevertheless, the multivariate analysis of variance (MANOVA) between stations and seasons did not show any significant difference during the study ($P> 0.05$). The LSD of the mean values of colour of the water samples obtained depicted that the mean values at the locations significantly differs between locations: I and II, I and III, II and IV, II and V, III and IV III and V ($p<0.05$).

The results presented in Fig. 8 is the regression analysis between total suspended solids and turbidity in River Benue at Makurdi for a period of 24 months. The result showed a moderate relationship between total suspended solids and turbidity with R^2 value of 0.5306. Similarly the result in Fig. 9 is the Regression between total suspended solids and colour of water in River Benue for a period of 24 months. Within the period of the study total suspended solids and colour of the water samples showed a linear relationship with R^2 value of 0.417. Fig. 10 depicts the regression analysis between turbidity and colour with relationship strength that has a R^2 value of 0.6201. The result of the regression showed clearly that these three parameters and impacting on the aesthetic of the water.

4. DISCUSSION

Total Suspended Solids (TSS) is as a result of surface runoff that occur upstream. During this study the mean TSS value of 62.42 $\pm$ 5.62 mg/L was recorded. All the same this result is at variance with mean TSS of 18.3 $\pm$ 14.00 mg/L obtained in river Benue at Makurdi during an earlier study [7]. The amount of TSS during the presnt investigation is a result of washing of the sediments and other suspended materials from the land into the River Benue based on the activities of man on the bank of the River. [9] presented a report that TSS that exceed 8.00 mg/L. result in increasing the movement of bottom dwelling animals in surface water. With reference to the above findings and the result of TSS of the present investigation may affect the benthic fauna migration in river Benue at Makurdi. The findings of this study is at variance with the report of a study was carried out before

in River Illo, Ota Nigeria that recoded more higher concentration of suspended solids of 620.79±288.45 mg/L [10]. In a similar instance [11] report the TSS of 333.33±173.20 mg/L in a stream in south west Nigeria which differs significantly with the TSS result obtained in the present study. [12] reported that TSS that ranged from 80 mg/L to 100 mg/L may injured the gills of the fish. The result of TSS of the water samples of this study at some sampling sites may cause injury to gills of the fish and affect fish community in River Benue at Makurdi. In the course of this study the linear relationship between TSS and turbidity had a R^2 value of 0.5306 which differs significantly from R^2 value of 0.80 between TSS and turbidity reported in Singapore Rivers [13]. The variation in the results could be in the difference in the catchments of the river, the time span of the study and the human activities on the shores of the rivers. Similarly [14] reported that TSS and turbidity has revealed strong interrelationships across and within study sites in New Zealand Rivers. This result is at variance with the findings of this study that reported a moderate relationship between TSS and turbidity in River Benue during the study time. The result of the correlation between and TSS and turbidity of this study was a strong positive correlation of 0.728 at 0.01 level significance. This report is similar to an earlier study in rivers in New Zealand that reported a strong positive correlation of 0.871 at 0.01 level of significance [14].

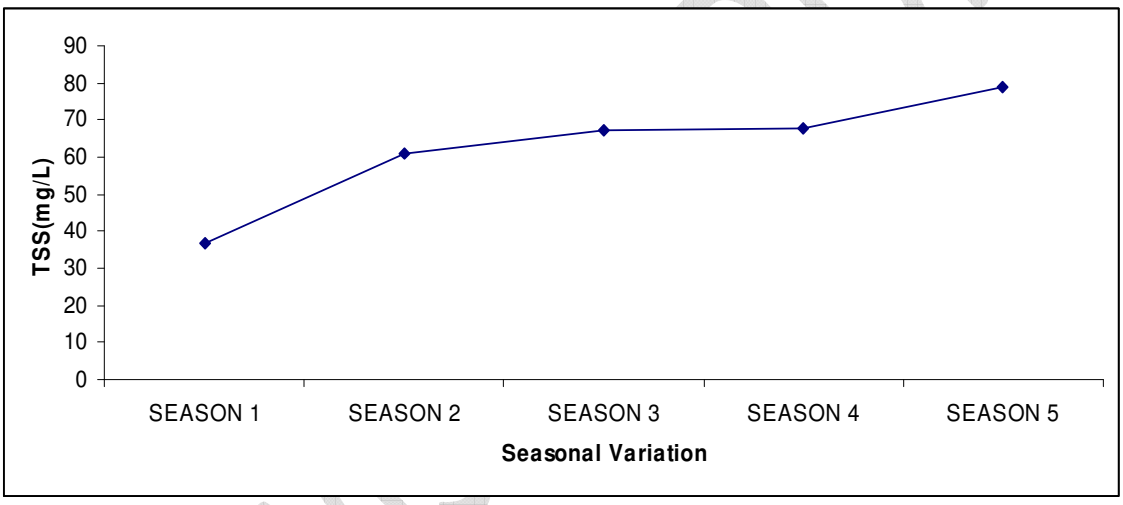

Fig. 3. The difference in average values of TSS in River Benue at Makurdi across the seasons

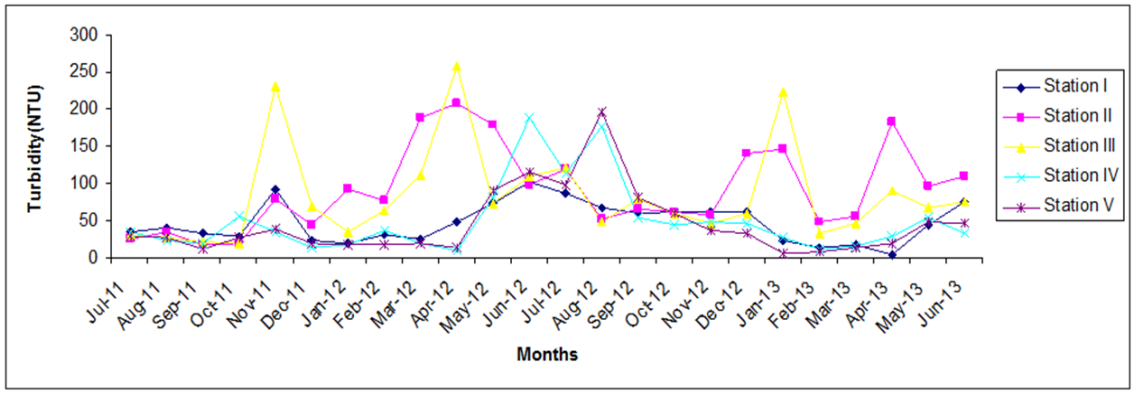

Fig. 4. The average monthly difference of turbidity values in River Benue at Makurdi

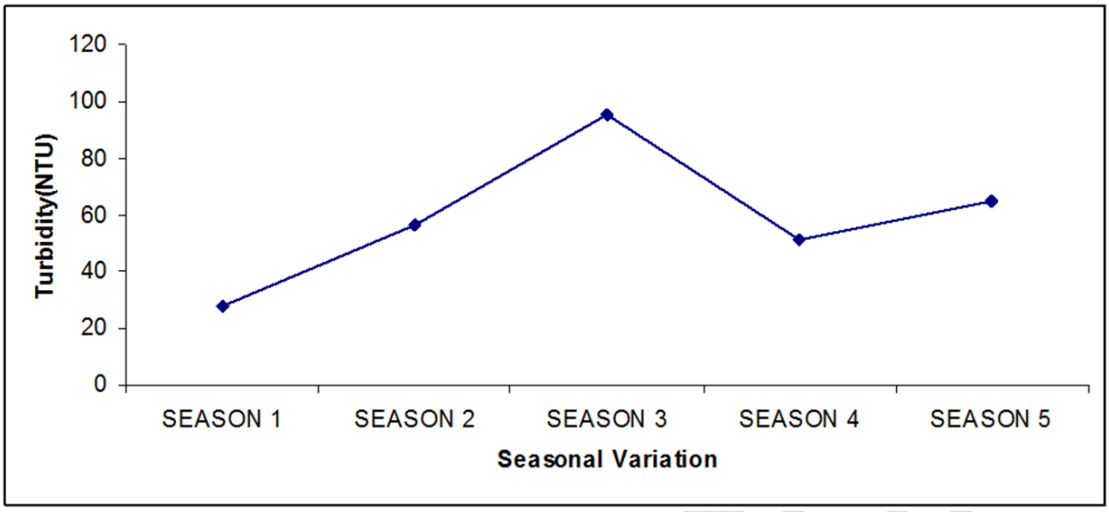

Fig. 5. The difference in average values of turbidity in River Benue at Makurdi across seasons

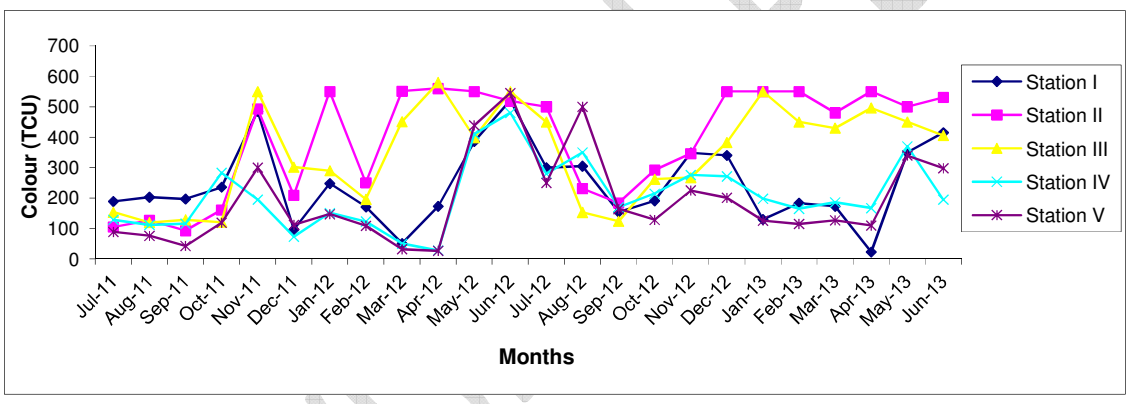

Fig. 6. The average monthly difference of colour values in River Benue at Makurdi

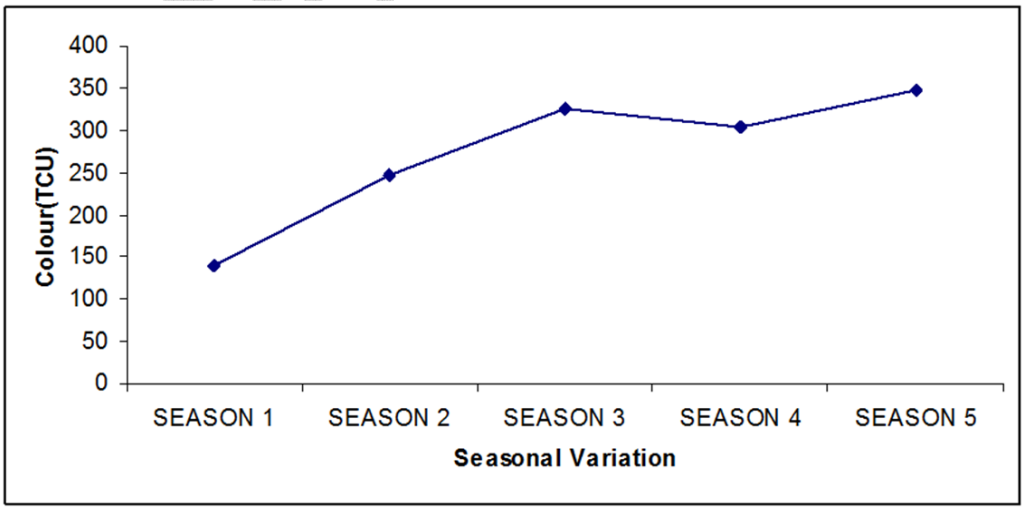

Fig. 7. The difference in average values of colour in River Benue at Makurdi across seasons

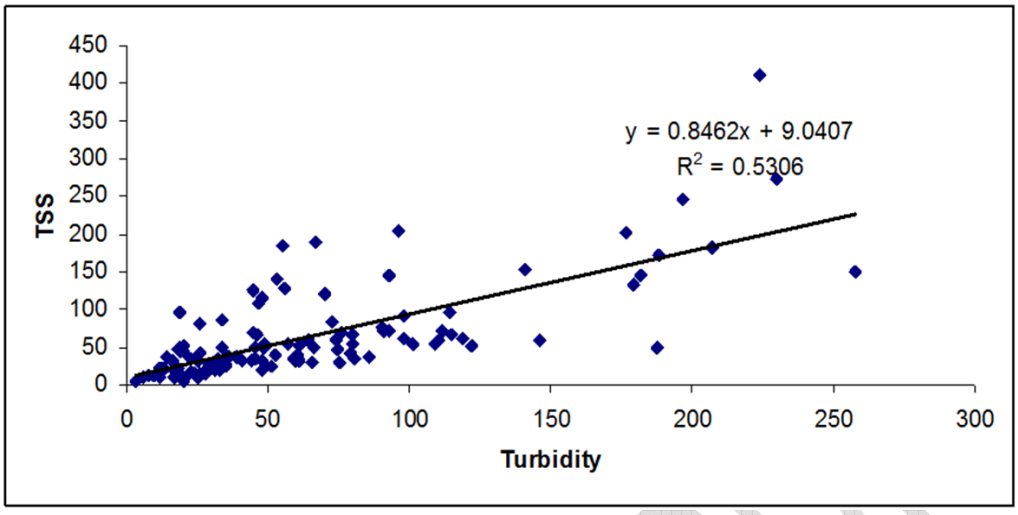

Fig. 8. Regression analysis between TSS and turbidity in River Benue at Makurdi

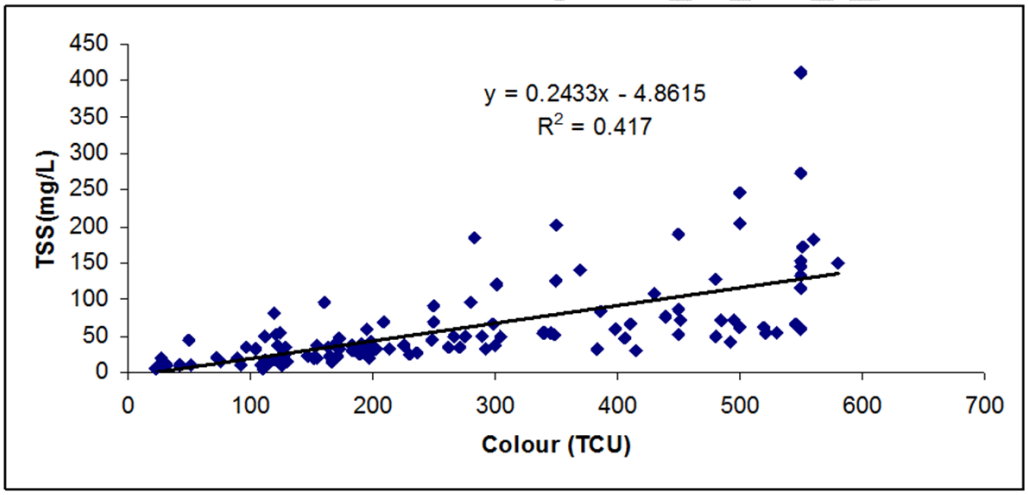

Fig. 9. Regression analysis between TSS and colour in River Benue at Makurdi

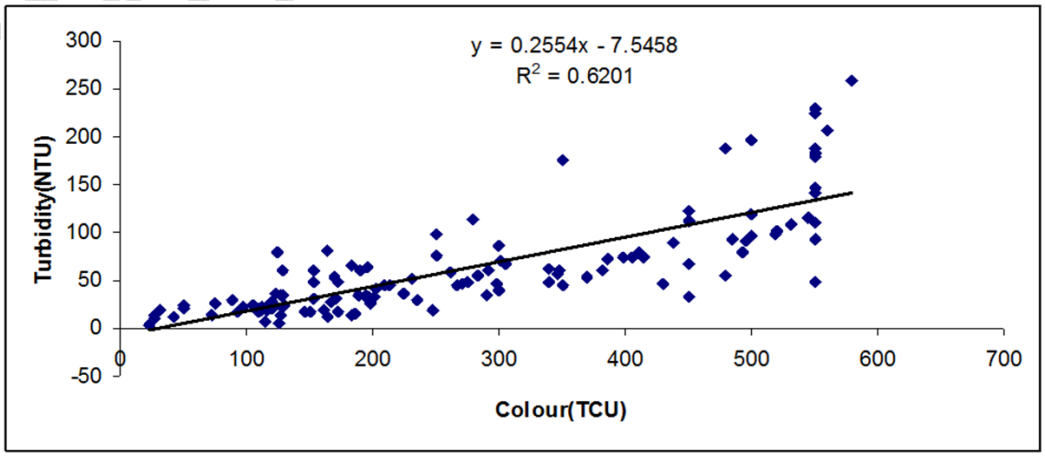

Fig. 10. Regression analysis between Turbidity and colour in River Benue at Makurdi

Turbidity of water is as a result of both organic and inorganic materials in the water column. The turbidity of water is mostly measured as a proxy indicator of suspended solids [9]. In the present investigation the mean value of turbidity of 63.08 ± 4.84 NTU was recorded. The obtained mean turbidity value of this study exceed the maximum accepted value of turbidity for drinking water quality of 5.00NTU for turbidity [15,16]. This findings differs significantly the result of the study carried out in River Benue before that recorded a mean turbidity value of 4.88 ± 0.06 NTU [7]. The result of turbidity of this study may be as a result of washout of suspended materials into the River may be due to the series of anthropogenic activities of brick making and farming that takes place on the bank of the river Benue. Turbidity may cause changes in the body of surface water which may cause changes in the aquatic biota. Similar changes may be prevalent in River Benue based the obtained results of turbidity during the study period. [17] recorded higher mean value of 550.00 NTU turbidity in Challawa River, Kano state Nigeria in the course of his study which differs significantly with the result of this investigation that recorded lower values of turbidity as compared to his study. [18] find out that warm water fishes respond to any behavioral changes except the turbidity rises to 20,000 mg/L. The values of turbidity of this present study may affect the fish hence it is far less than 20, 000 mgl.

The colour of water is indispensable because most the uses of water at home and in the industries depends on the colour of the water. The mean value of colour reported during the present study was 276.50 ± 14.92TCU. This result beyond the acceptable standard of 15.00TCU prescribed by WHO and National standard for drinking water quality in Nigeria (WHO 2004, NSDWQ, 2005). This findings is similar with the result of an earlier investigation in River Benue that recorded colour concentration close to the one obtained in this present study [19]. The colour of water has no health significance nevertheless, it is a sign that contaminants are in the water and the cleanness of the water is compromised and the water may not be accepted for drinking with other home uses. The Colour of surface water do not directly affect the fish community but it rather restrict the passage of light down the water column and may affect photosynthesis with phytoplankton population which may results to poor primary productivity and affect the fish as a result of lack of food [20]. Thus the primary productivity in the aquatic ecosystem will be affected as result of the inability of the light to penetrate deep below for photosynthesis to occur. This will affect the ecology of the River as was observed in River Benue during the course of this study. The significant relationship between turbidity and TSS indicate clearly that these parameters have a pronounced impact of the colour of the water samples during the period of the study.

5. CONCLUSION

The aesthetic parameters: total suspended solids, turbidity and colour during the course of the study indicate that the clarity of the water of river Benue was compromised and not suitable for human consumption without adequate treatment. These parameters were beyond the limited permitted by drinking water quality standards set up by WHO and Nigeria drinking water quality standards. There was a significant correlation with the parameters indicating their impacts on the clarity of the water. The study recommends that the watershed should be protected from numerous human activities that are contributing to the washing of sediments into the river.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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