

Original Research Article

STUDIES ON AESTHETICS STATUS OF WATER QUALITY OF RIVER BENUE,
MAKURDI NIGERIA.

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 status and integrity of River Benue at Makurdi, water samples collected monthly from five different locations on the shoreline of River Benue at Makurdi for a period of two years (July 2011-June 2013). The aesthetic parameters of the water samples examined were total suspended solids, turbidity and colour using standard methods (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 ± 53.01 NTU) and Colour (276.50 ± 163.42 TCU). 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 not have a control standard value. The result of 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.

Key words: River Benue, TSS, Turbidity, Colour Aesthetic

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 (Wilson 2013). 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 (Wilson 2013). 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 (U.S. EPA, 1997). 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 (Wilson 2013). 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 (Schueler, 1997). Similarly sensitive or threatened fish species may lost when turbidity of the water exceeds 100NTU (Schuler, 1997). Fish communities in areas subject to high quantity of suspended solids typically shift toward more sediment tolerant species (Schueler, 1997). The greater the amount of suspended solids in the water, the murkier it appears and the higher the measured turbidity (UNEP, 2006). 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.

MATERIALS AND METHOD

Study Area

66 The River Benue with its source from the Cameroonian mountains flows westwards into Nigeria.
 67 It is the second largest River in Nigeria and measures approximately 310,000 Ha. It is about
 68 1.488Km in length with alluvia fertile flood plains on either banks (Welcomme, 1986). The
 69 Benue River flows through Makurdi and confluence with River Niger at Lokoja the capital of
 70 Kogi state, Nigeria. Makurdi the capital city of Benue state is located on Latitude 7⁰41' N and
 71 Longitude 8⁰ 28' E. The size of the River Benue within Makurdi and major settlement runs
 72 through is approximately 671 meters (Udo, 1981). The rainfall seasons at Makurdi produces a
 73 River regime of peak flows from August to early October and low flow from December to April.
 74 The rainy season which last for seven months (April to October) has a mean annual rainfall
 75 ranging from 1200-2000mm (Enejiet *al.*, 2012). High temperature values averaging 28-35⁰C are
 76 recorded in Makurdi throughout the year, most notable from March to April. Harmattan winds
 77 are accompanied with cooling effects mostly during the nights of December and January (Enejiet
 78 *al.*, 2012). Five different stations were selected along the River course at Makurdi, due the land
 79 based activities for this study as presented in Table 1.

80 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'	Farming and fishing
Benue brewery	II	N07 ⁰ 43.615' E008 ⁰ 35.300'	Brewery 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

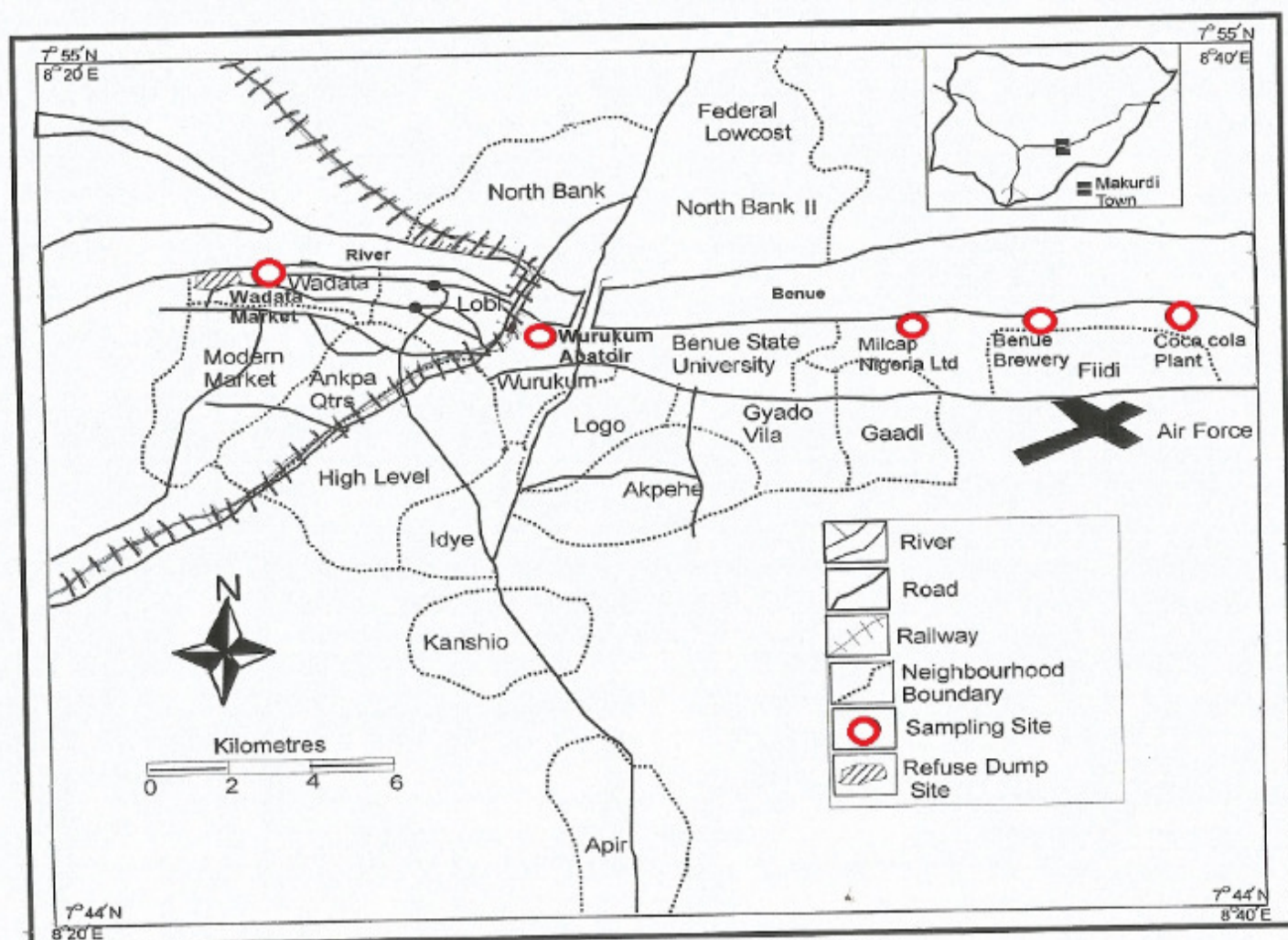


Figure 1: Map of Makurdi Town Showing Sampling Sites

Source: Ministry of Lands and Survey Makurdi

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82 Water Sample Collection and Analysis

83 Water samples for aesthetic parameter analysis were collected at five different points from each
 84 of the five sampling locations. Monthly routine sampling was conducted between 8:00am and
 85 12:00 noon on each sampling day. Each sample container was treated according to the analysis to
 86 be carried out on it on the field before they were transported to the laboratory. Turbidity, total
 87 suspended solids and colour of the water samples were taken to the laboratory and were
 88 examined using standard methods(APHA, 1999).

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Data Analysis

Microsoft excel 2013 was used for graphical illustrations. Descriptive statistics, ANOVA and correlation analysis were determined using SPSS version 20. Statistical analysis was determined to test the significant difference among means of aesthetic parameters of water quality across stations and between seasons.

RESULTS

The results of the aesthetic parameters at the stations in Table 2 indicates that TSS varied from 41.00±25.42mg/L-87.56±57.39mg/L, colour ranged from 192.60±143.79TCU-393.01±175.73TCU and turbidity ranged from 44.53±44.28NTU – 91.38±56.54NTU, during the 24 months study period in River Benue at Makurdi. Similarly Table 3 is the correlation analysis between total suspended solids, turbidity and colour. There significant correlation between all the aesthetic parameters of the water samples indicating that the affect each other and contribute to making water look turbid and coloured.

Table 2: Mean Concentration of Aesthetic Parameters of River Benue at Makurdi

Parameter	Unit	Sample	Station	Codes		
		I	II	III	IV	V
TSS	mg/L	41.00±25.42	87.56±57.39	87.09±91.17	52.17±51.58	44.25±49.75
Colour	TCU	244.54±128.53	393.01±175.73	344.28±157.89	208.07±113.63	192.60±143.79
Turbidity	NTU	46.89±26.66	91.38±56.54	83.47±65.83	49.12±47.22	44.53±44.28

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)

109 The results in Fig 2 is the monthly variation in the total suspended solids in River Benue. A
 110 perusal at the results revealed that the highest concentration of 410.00 mg/L was determined in
 111 January 2013 at Station III, while the lowest concentration 5.00 mg/L was at Station I in April
 112 2013. The result in Figure 3, shows the season variation in the total suspended solids
 113 concentration in River Benue. The result showed an increase in suspended solids load from
 114 season 1 to 5 during the study period. ANOVA between and within stations for the 24 months
 115 show that there was a significant difference ($P < 0.05$). All the same, there was no significant
 116 difference between and across seasons ($P > 0.05$). Similarly, the multivariate analysis of variance
 117 (MANOVA) between stations and seasons showed that there was no significant difference
 118 between stations and season ($P > 0.05$). Least significant difference results obtained at the
 119 locations revealed that the mean values of TSS differs significantly between locations: I and II, I
 120 and III, II and IV, II and V, III and IV, III and V only ($p < 0.05$).

121 The result in Figure 4 depicts the mean monthly variation of the turbidity of the water samples
 122 for two years at five locations in River Benue at Makurdi. The highest value of turbidity (258.00
 123 NTU) was recorded in April 2012 at Station III, while the lowest turbidity (3.00 NTU) was in
 124 April 2013 at Station I. The results of the seasonal variation of turbidity of the River Benue
 125 reported in Figure 5 showed increase in turbidity from season 1-3 and then decrease from season
 126 4 and increase again slightly at season 5. The result of analysis of variance (ANOVA) showed a
 127 significant difference in turbidity within and between locations and across seasons for 24 months
 128 ($P < 0.05$). However, the multivariate analysis (MANOVA) between stations and seasons for
 129 turbidity was not significant ($P > 0.05$). The LSD analyses of mean turbidity values obtained at
 130 the locations were significant between locations: I and II, I and III, II and IV, II and V, III and IV
 131 III and V only ($p < 0.05$).

132 The colour of the water samples obtained varied from 23.00 - 580.00 TCU during the study
 133 period. The highest value of colour 580.00 TCU was reported in April 2012 at Station III while
 134 the lowest value of 23.00 was in April 2013 at Station I (Fig 6). A perusal of the result showed
 135 that the colour of the water samples at Station II and III were recorded with higher values during
 136 the time of the study. (Figure 6). The seasonal variation of the colour of water samples during
 137 five seasons of the study revealed that the colour of the water samples increase progressively
 138 from season 1 to 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 Figure 7. Generally turbidity increase during the rainy season as compared to the dry seasons 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 Figure 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 Figure 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. Figure 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.

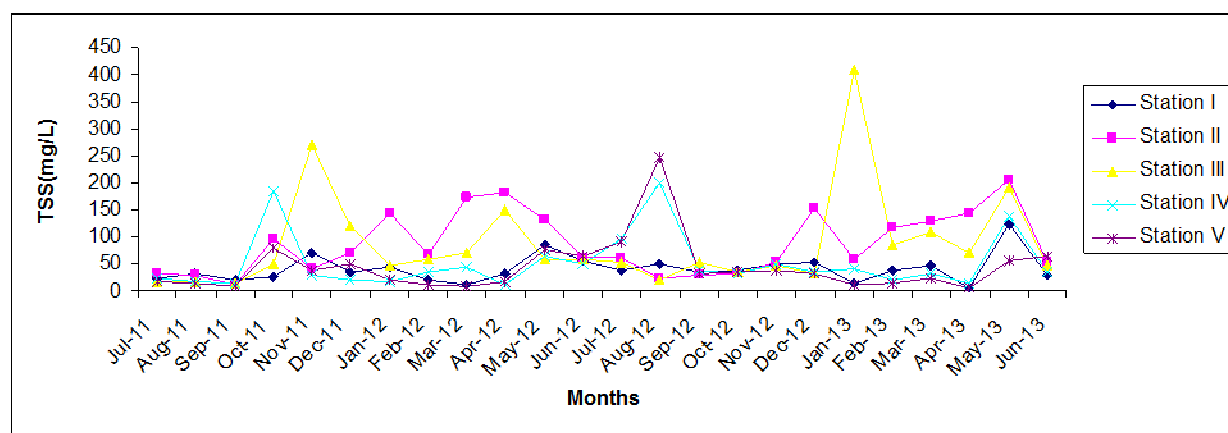


Fig 2: Mean monthly variation of TSS in River Benue at Makurdi.

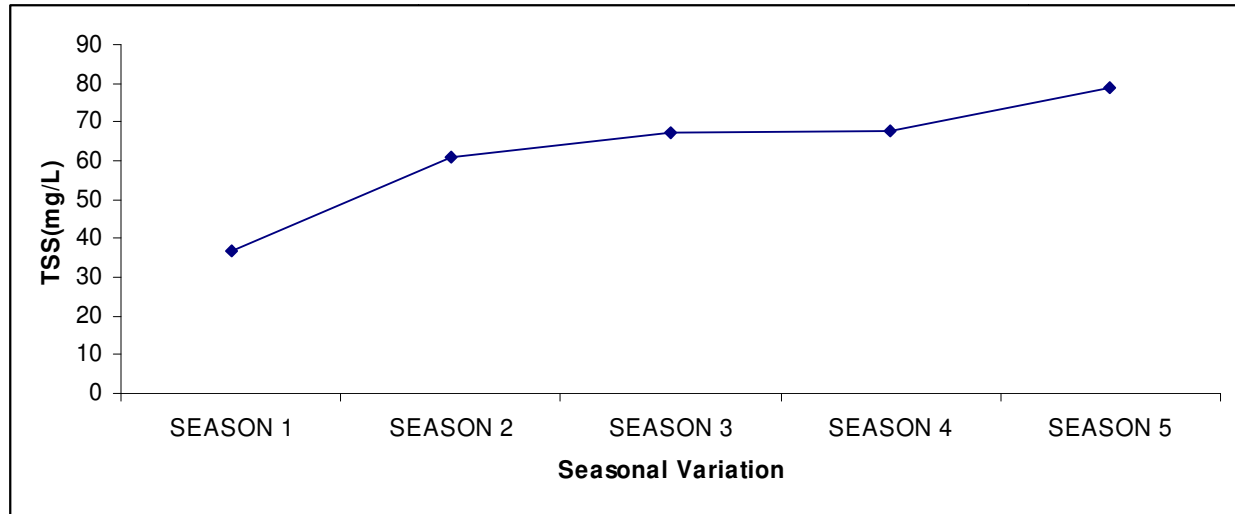


Fig 3: Seasonal variation of TSS in River Benue at Makurdi

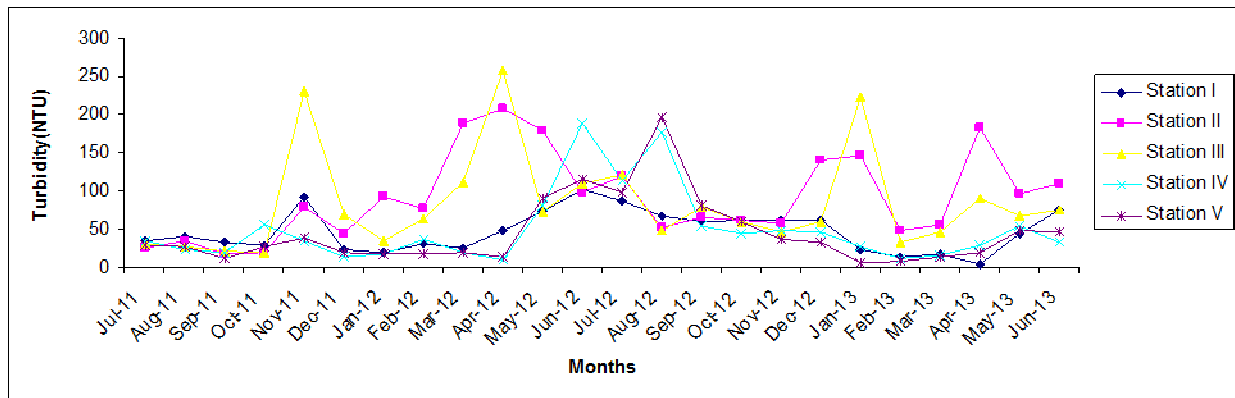


Fig 4: Mean monthly variation of Turbidity in River Benue at Makurdi.

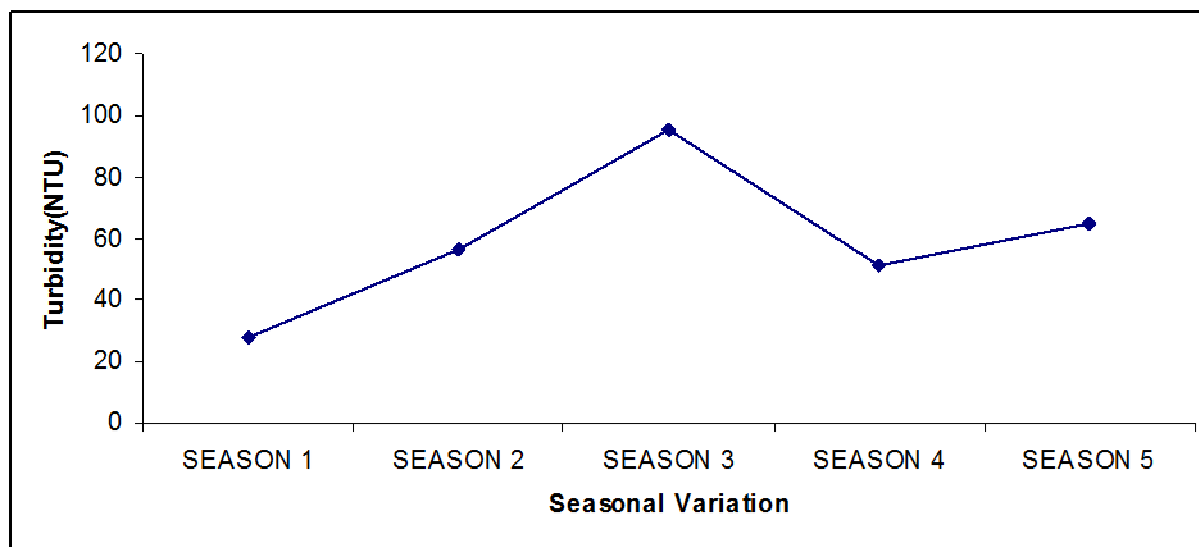


Fig 5: Seasonal variation of Turbidity solids in River Benue at Makurdi

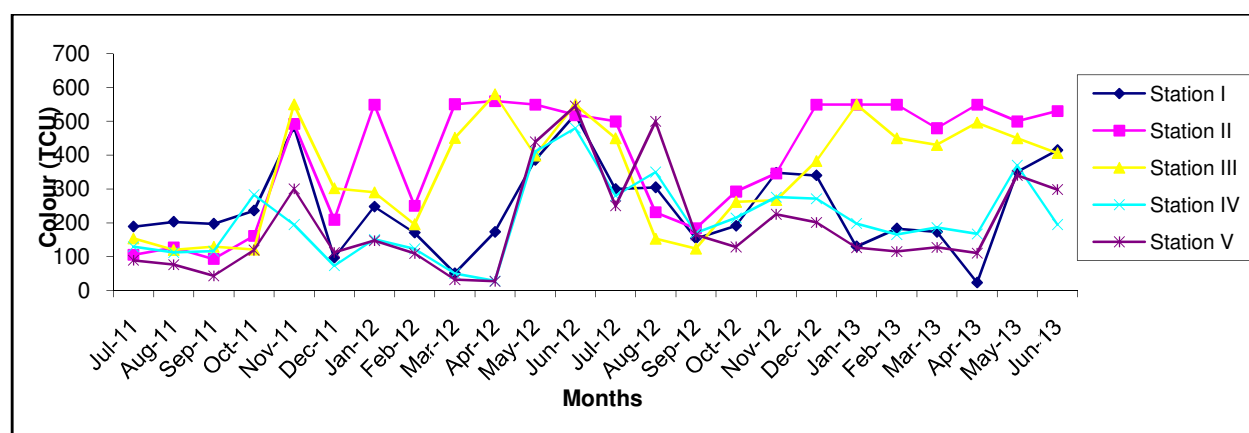
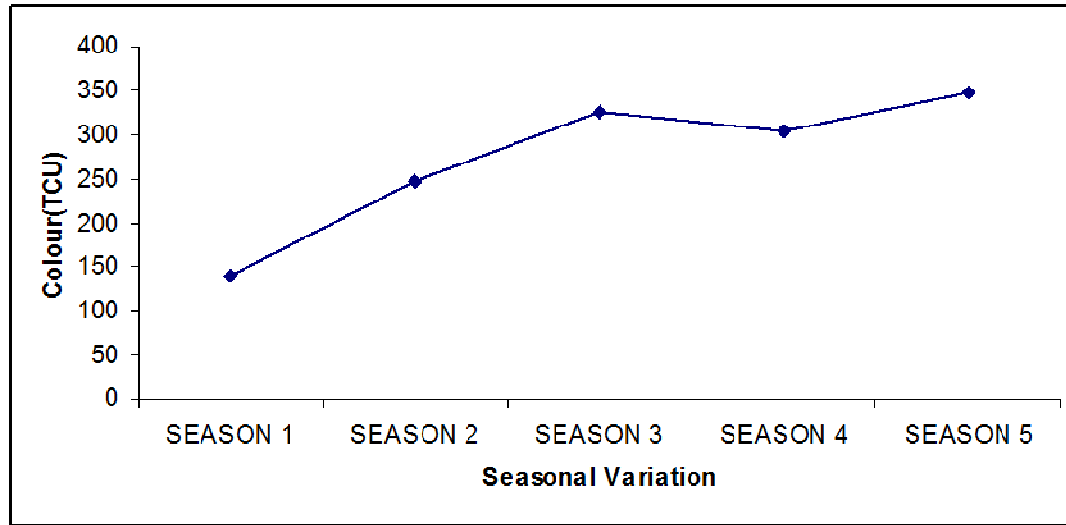
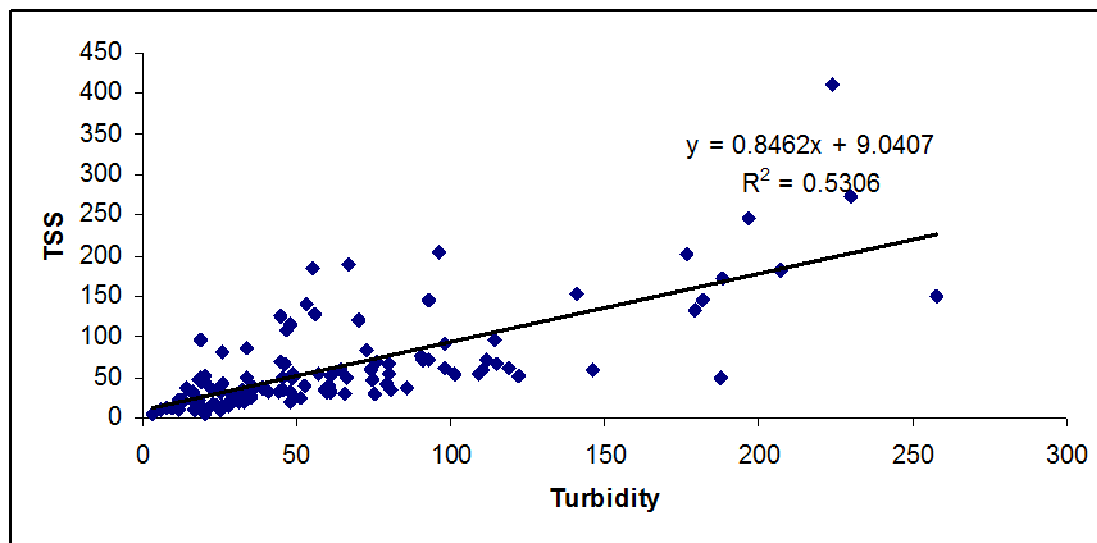


Fig 6: Mean monthly variation of Colour in River Benue at Makurdi.



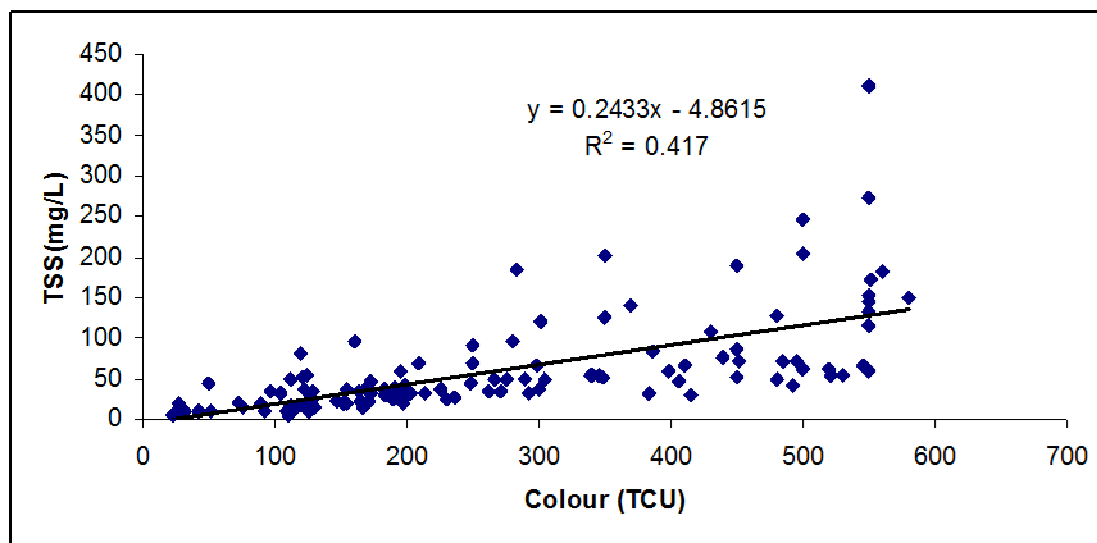
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168 Fig 7:Seasonal variation of Colourin River Benue at Makurdi



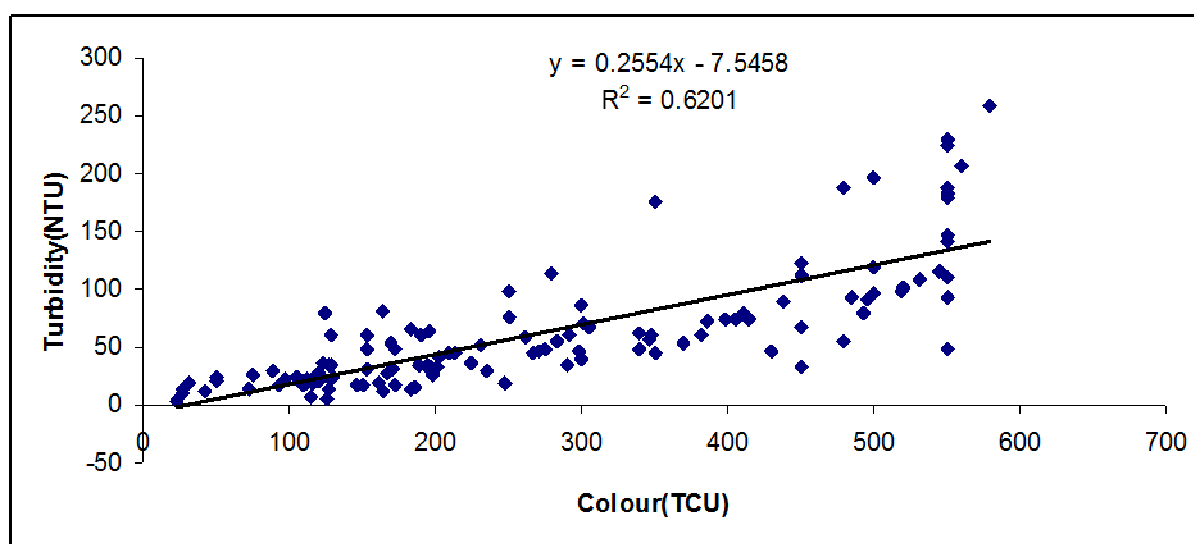
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170 Fig 8:Regression Analysisbetween TSS and Turbidity inRiver Benue at Makurdi



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172 Fig 9:Regression Analysis between TSS and Colourin River Benue at Makurdi.



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174 Fig 10:Regression Analysis between Turbidity and Colourin River Benue at Makurdi

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176 DISCUSSION

177 Total Suspended Solids (TSS) is an indication of the amount of erosion that took place nearby or
 178 upstream. In this study the mean TSS value of 62.42 ± 5.62 mg/L was recorded. However, this
 179 result differs significantly with that of an earlier study in River Benue that reported mean TSS of
 180 18.3 ± 14.00 mg/L (Enejiet *al.*, 2012). The concentration of TSS in this study is due to the level

of surface runoff in the River. Bilotta and Brazier (2008) reported that TSS in excess 8.00mg/L increased the rate of drift of benthic fauna in surface water. Based on the above findings the TSS concentration in River Benue during the course of this study may contribute to the drift of the benthic fauna in the River. The result of this study however differs significantly with the result of an earlier study in River Illo, Ota Nigeria that reported higher values of total suspended solids 620.79 ± 288.45 mg/L (Longe and Omole, 2008). Similarly Ogunfowokanet *al.* (2005) reported TSS concentration of 333.33 ± 173.20 mg/L in a stream in south west Nigeria which is at variance with the findings of this present investigation. The TSS concentration of between 80-100mg/L will cause injury to the gills of the fish (Fadaeiferdet *al.*, 2012). The TSS concentration of the water samples at some instances may cause injury to the gills of the fish of the River Benue and as such affect aquatic biota of the River Benue ecosystem. 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 (Daphneet *al.*, 2011). 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 Ballantine *et al.*(2014) 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 TSS and turbidity of this study was a strong positive correlation of 0.728 at 0.001 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 (Ballatineet *al.*, 2014).

Turbidity in the water may be due to organic and or inorganic constituents. And turbidity is often determined and used as surrogate measure of total suspended solids (Bilotta and Brazier, 2008). During the course of this study the mean turbidity of 63.08 ± 4.84 NTU was obtained. This result is beyond the recommended standard value for turbidity of 5.00NTU (WHO 2004, NSDWQ 2005). However, this result differs greatly with the findings of an earlier study in River Benue that reported a mean turbidity value of 4.88 ± 0.06 NTU (Enejiet *al.*, 2012). The turbidity result of this present investigation may be due to surface runoff into the River as a result of the numerous human activities like agriculture and bricks production on the bank on the River Benue. Turbidity induced changes in the water body which may change the composition of an

aquatic community as was observed in River Benue during the course of this investigation. Indabawa (2010) reported higher mean value of 550.00 NTU turbidity in Challawa River, Kano state Nigeria during his study which differs significantly with the finding of this study that reported lower values of turbidity. Gupta and Gupta (2006) reported that warm water fishes did not show any behavioural reaction until the turbidity get to 20,000mg/L. The values of turbidity obtained in this study may not affect the fish community in River Benue because the turbidity values obtained were far below.

The colour of water is vital as most water users be it domestic or industrial usually prefer colourless water. The mean value of colour obtained in this study was 276.50 ± 14.92 TCU. This result exceeds the recommended standard of 15.00 TCU set by WHO and National standard for drinking water quality in Nigeria (WHO 2004, NSDWQ, 2005). This result agrees with an earlier study in River Benue that reported similar colour level (Azua, 2008). This parameter has no health effect but is an indication that the water contains pollutants that are contributing to the colour of the water and affects the aesthetics of the water that leads to consumer rejection of the supply. Colour does not affect fish directly but it restricts light penetration and restricts aquatic plants growth (Olopadeo, 2013). 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.

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.

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