

LONG-TERM CHANGES IN THE WATER QUALITY OF JAMIESON RIVER, DELTA STATE, NIGERIA

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Abstract

Jamieson River was sampled in 1994/1995 and re-sampled in 2012/2013 (18 yrs) to determine water quality changes. With the indiscriminate usage of fertilizers, herbicides, pesticides, insecticides, among others and recently the increased activities of herdsmen in the catchment area, it became necessary to re-assess the state of the water quality with a view to ascertain if the water quality has significantly altered over the last twenty years, as well as its suitability for consumption and other related uses. Three sampling points were located along the river and water samples were analyzed for water temperature, pH, alkalinity, Transparency, Conductivity and dissolved oxygen at both times. Colour, turbidity, chloride, suspended solids, total dissolved solids, total solids, hardness, BOD, nitrate, sulphate and phosphate were measured only in 2012/2013. Trends in the data shows there was no significant spatio-temporal variation for most of the parameters examined except for transparency that was significantly lower at sampling station 3 as well as in 2012/2013 compared to 1994/1995. Nitrogen and phosphorus, the two key plant nutrients added in fertilizers remained very low, less than 1.2mg/l and 0.4 mg/l respectively. The overall picture emerging from this study is that water quality of Jameison River, is generally good for drinking and other domestic uses by international standards.

Key words: Trend, Physical, Chemical, Parameters

Introduction

Jamieson River is an important natural source of drinking water and income generation from fisheries resources to fishermen. The communities living along the river banks are agrarian and relatively untouched by urbanization and industrialization, hence the lack of proper attention to water quality assessments. Some previous hydrobiological investigations carried out in the river include those of Imoobe and Ogbeibu (1996), Imoobe (1997), Imoobe and Egborge (1997), Ikomi and Sikoki (2003), Imoobe and Oboh (2003), Oboh *et al.*, (2003, 2013, 2014) and Rim-Rukeh and Agbozu (2013).

The report of Imoobe (1997), Imoobe and Oboh (2003) had established some baseline conditions of the physical and chemical attributes of the river. However, water quality conditions of rivers change constantly as a result of increase in human population, agriculture, among other anthropogenic causes and natural aging processes. These communities have an agricultural economy and an extensive area under cultivation. In order to increase productivity, indiscriminate usage of fertilizers, herbicides, pesticides and insecticides, etc. have been employed in the past several years. Recently there have also been increased activities of herdsmen in the area, which all have the potential to cause the deterioration of the aquatic environment from non point pollution sources.

For the sustainable management of water resources the impacts of agrochemicals on the water

bodies need to be evaluated periodically. With the growing demand for suitable water by humans as well as aquatic organisms it is the objective of this paper, to assess the current status of the physical and chemical conditions of the river. This is with a view to ascertain if the water quality has significantly altered over the last two decades as well as its suitability for consumption and other related uses.

Study Area

Jamieson River as originally described (Imoobe, 1997) takes its origin at Ugboko-Niro from where it meanders and flow in a south-westerly direction through the rain forest vegetation to Sapele, a distance of about 70km (Fig. 1). In Sapele it empties at the same point with Ethiope River into the Benin River which is one of the four major rivers that discharges into the Atlantic Bight of Benin between Latitude 05°N and 06°N in Nigeria.

Jamieson River stretches from Latitude 05°54' N to 06° 08'N and Longitude 005° 41' E to 005° 58' E in Edo and Delta states of Nigeria. This area falls within the well known rainforest belt of Nigeria with rainy season from March to October and dry season period from November to February.

In this study, three sampling stations were established upstream, midstream and downstream. Station 1 which is located at 05°55'17"N, 005°41'49"E and 150m downstream of a bridge across the Benin – Sapele road was partially shaded from direct rays of the sun by dense trees and shrubs

canopy. Trees like *Elaeis guinensis* and coconut trees were clearly visible. There were few aquatic macrophytes like *Salvinia* sp. and *Lemna* sp. Station 2 which is the midstream station is located at 05° 55' 22.6" N and 005° 41' 59.1" E and 30m upstream of the bridge. This station had few *Eichhornia crassipes* but these were swept aside by the water current at the peak of the rainy season. The upstream section of the river is station 3 located at 05° 55' 28.7" N and 005° 41' 58.3" E and is approximately 180m upstream of the bridge. It had abundant water hyacinth.

Materials and Methods

Previous Water quality data was obtained from studies carried out between 1994 and 1995 (Imoobe and Oboh, 2003). After a period of about 19 years, eighteen water quality variables were measured monthly between May, 2012 and February, 2013 a period of ten months. Previous data are however, only available for Air and surface Water Temperatures, Transparency, Conductivity, pH, Alkalinity and Dissolve Oxygen. Air and surface water temperatures were measured in the field with Mercury-in-glass thermometer. The pH was measured *in situ* using the Griffin battery operated

pH meter (EIL, 7020), while transparency was measured with an all white Secchi disc.

Water samples for other physical and chemical analysis were collected in 250mls sampling bottles and transported in ice to the laboratory for subsequent analysis. All Laboratory analyses of Alkalinity, Dissolved oxygen, BOD, Chloride, Colour, Conductivity, Hardness, Nitrate, Phosphate, Sulphate, Suspended solids, Total dissolved solids, Total solids and Turbidity were conducted according to procedures outlined in the Standard Methods for the Examination of Water and Wastewater (APHA, 1998).

Statistical analyse

Statistical analyses carried out include means, standard deviation, range and analyses of variance to test the significance of spatial differences in parameters. Parametric multiple comparisons were performed using one way ANOVA. Where significant values ($P < 0.05$) were obtained, a least significant difference (LSD) test was subsequently applied to detect the location of difference (Zar, 1984).

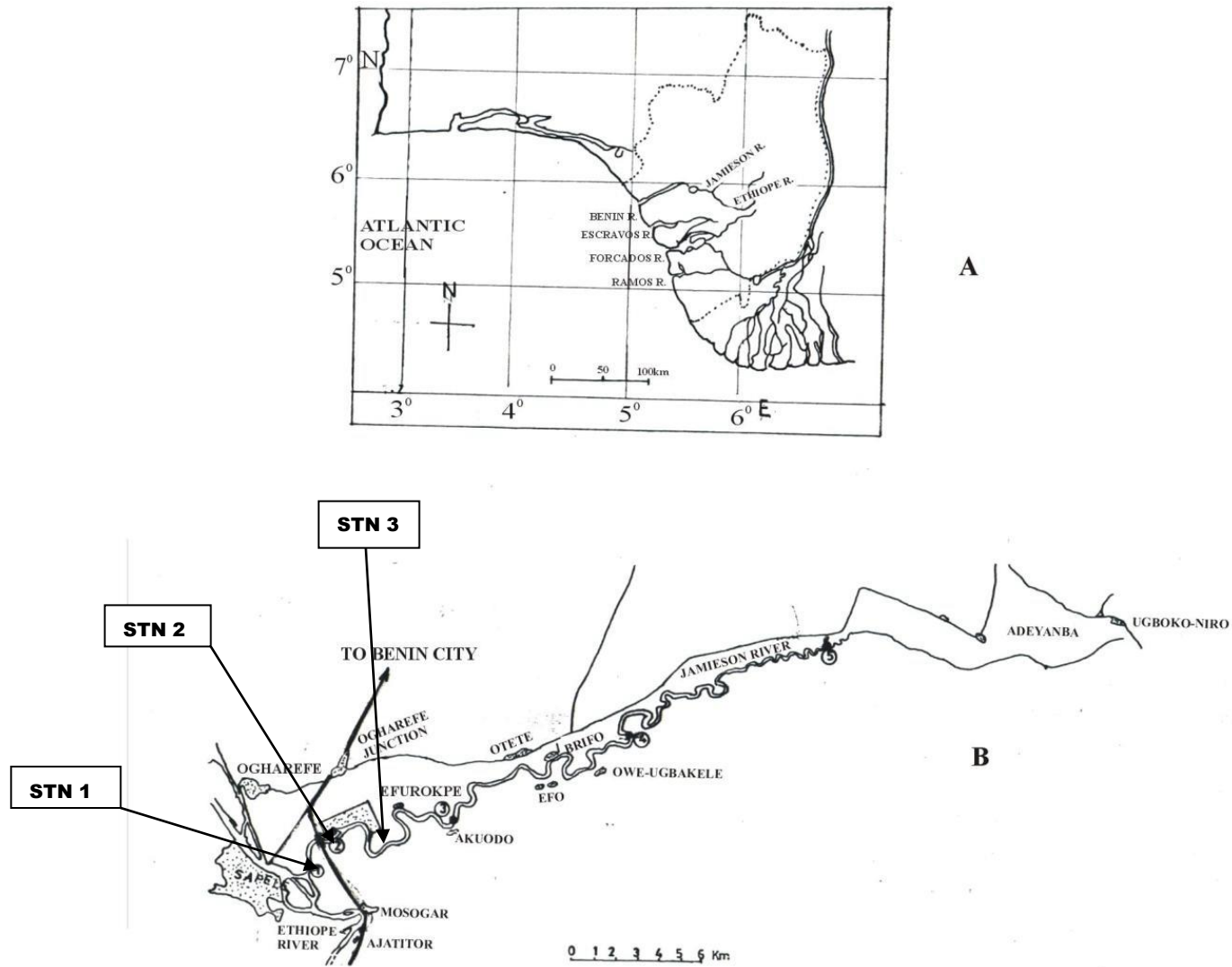


Fig. 1: Map of Study Area Showing Sampling Stations (B) with Western Delta inset (A).

Results

Water quality characteristics and trend

A summary of the results of the physical and chemical parameters of Jamieson River is presented in Table 1.

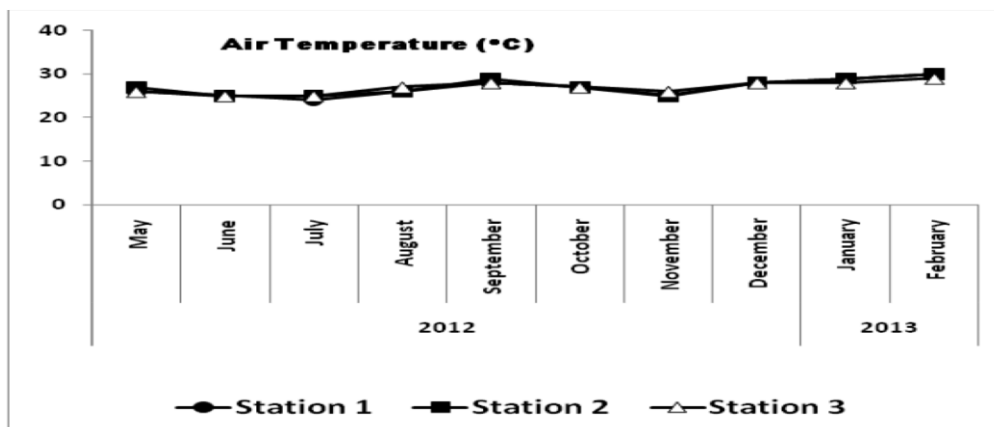
Air temperature fluctuated between 24^oC and 30^oC throughout the period of the current study and during 1994 to 1995. In the 2012/2013 study, the highest temperature of 30^oC was recorded in stations 1 and 2 in the dry season month of February. Similar pattern of variation was observed at all the stations (Fig 2) with no significant spatial differences (p>0.05) in the values recorded. There was a steady decrease from May to July 2012 before slightly increasing in the months of August and September and decreased again. It however steadily increased again from the month of December 2012 before reaching its peak in the month of February 2013. The water temperature followed closely the same pattern (Fig 2) as the variation in the air temperature, and there was no significant difference (p>0.05) among the values at the three stations sampled. The values recorded in the current study were not particularly significantly different from the 1994/1995 findings, where the range was also between 24^oC and 29^oC in all cases.

The water was generally clear with no observable colours. The month of September, 2012 recorded the highest values at all the sampling stations (Fig 3), with no significant differences (p>0.05) at the three stations. The turbidity was low with the highest value of 11 NTU recorded in station 3 in the month of June, 2012. Following the reverse trend of turbidity, the transparency was consequently high at all sampling stations. There was however, a significant difference in the values of the transparency of water (p<0.05) with station three having significantly lower value in all the months (Table 1, Fig. 3). There was however, a generally marked improvement in the transparency of the water since the last 19 years of the earlier study in 1994/1995.

Conductivity values were low at the three sampling stations during the 1994/1995 and the 2012/2013 studies. The low conductivity is an

indication of the low concentration of dissolved ions in the water. The highest value of 21.4 μS/cm was recorded in station 1 in the month of July, 2012 and then slightly decreased steadily and peaked again in the month of December, 2012 (Fig 4). This pattern was closely repeated at all the sampling stations with no significant differences (p>0.05) in their values. There was however slight increase in values over the years varying slightly from a mean of 11.73 μS/cm in the 1994/1995 study to 17.428 μS/cm during the recent study. Chlorinity was generally higher in the months of May and June, 2012 and subsequently decreased to its lowest level in January, 2013 at all the sampling stations (Fig 4). There was however, no significant difference (p>0.05) in the values of the three stations.

Suspended solid was low in the water with an overall mean value of 1.48mgL⁻¹. Relatively higher values were however, recorded at all stations in the months of July and October, 2012 (Fig 5). There was no significant differences in the mean values (p>0.05) across the three stations. The dissolved solids ranged from 5mgL⁻¹ to 17.1mgL⁻¹ in the water. The highest value of 17.1mgL⁻¹ was recorded in station1 in the month of July, 2012 while the least value of 5mgL⁻¹ was recorded in station 2 in the months of December, 2012 and February, 2013 (Fig 5). There was however, no significant difference in the mean values of the dissolve solids in the three stations. The pattern of variation was closely similar at all the stations. Values for total solids range from 5mgL⁻¹ to 22mgL⁻¹ with an overall mean of 12.2 mg/l. The highest value of 22mgL⁻¹ was recorded in the month of July, 2012 and thereafter declined during the succeeding months till January and February, 2013 when the least values were recorded at all the stations (Fig 5). At all the three sampling points similar trend was observed, and there was no significant difference (p>0.05) in their mean values.



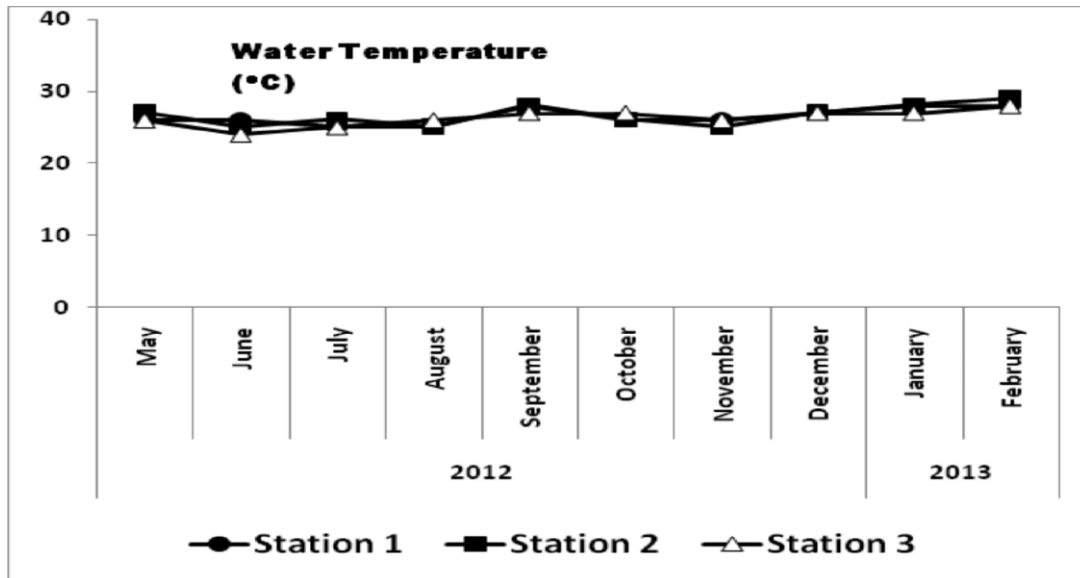
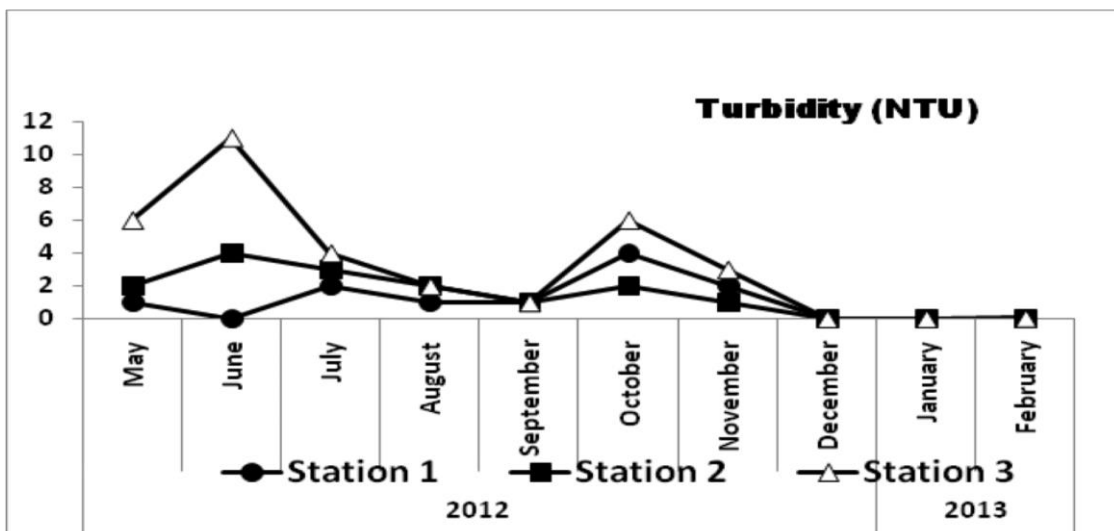
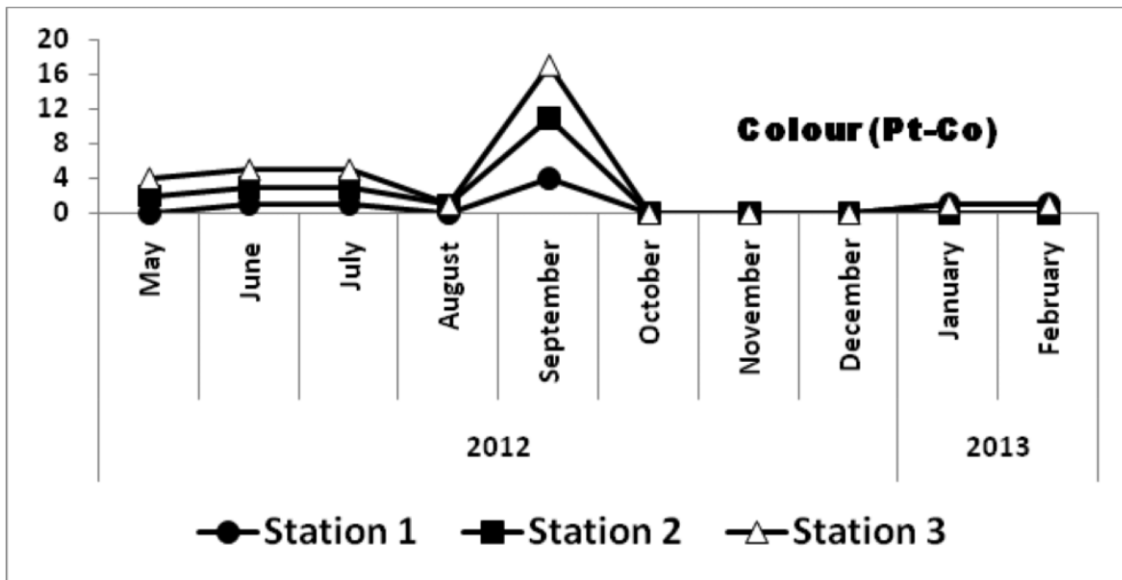


Fig.2: Spatial and Temporal variation in Air and Water Temperature from May 2012 to February, 2013 in Jameison River.



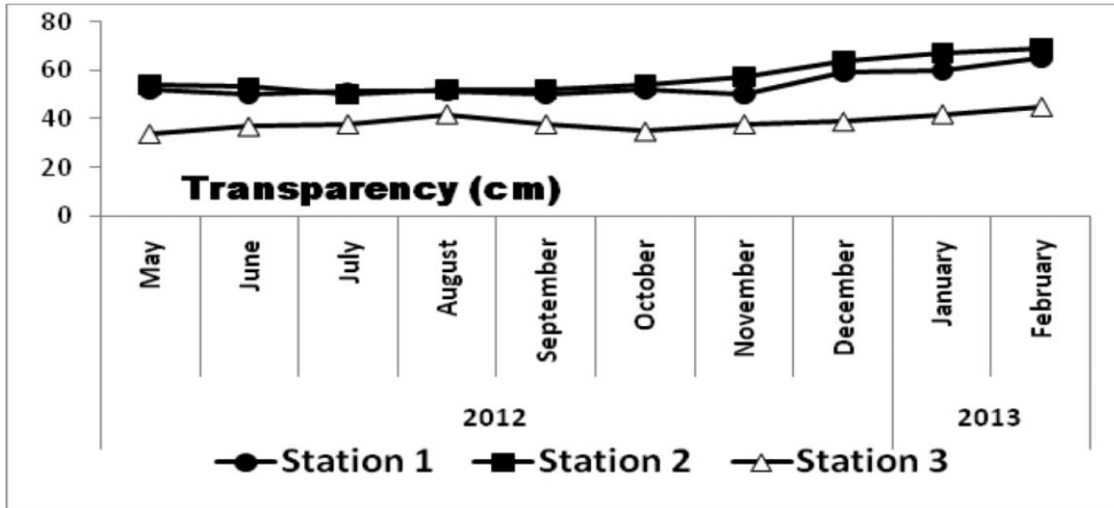


Fig. 3: Spatial and Temporal variation in Colour, Turbidity and Transparency from May 2012 to February, 2013 in Jameison River.

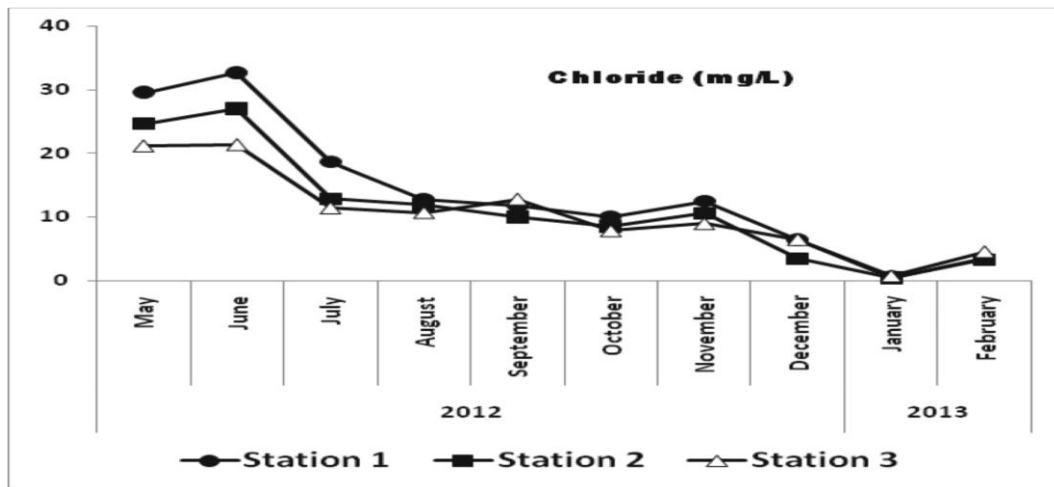
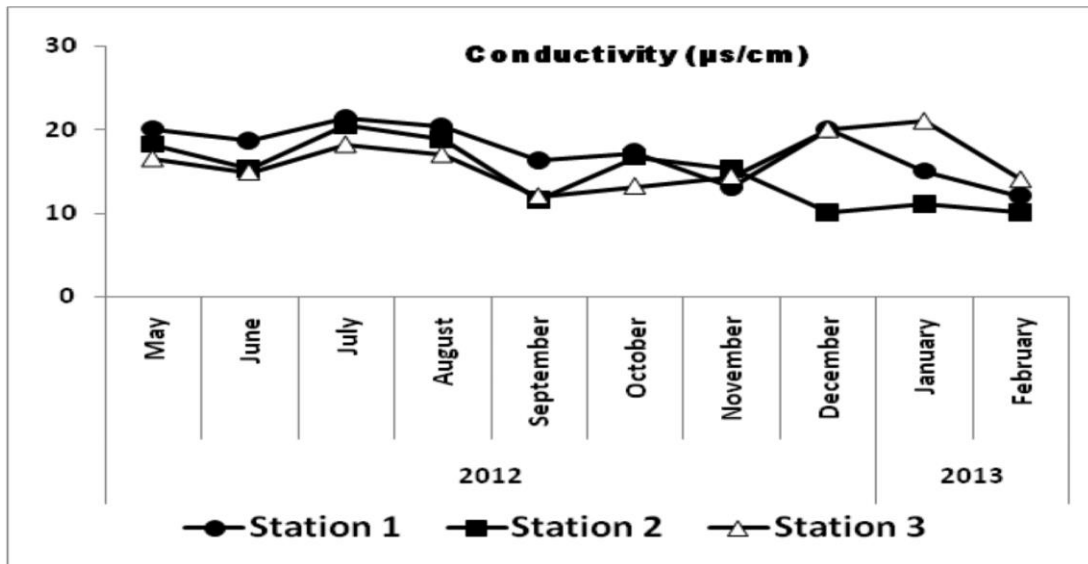


Fig.4: Spatial and Temporal variation in Conductivity and Chlorinity across the sampled stations from May 2012 to February, 2013 in Jameison River

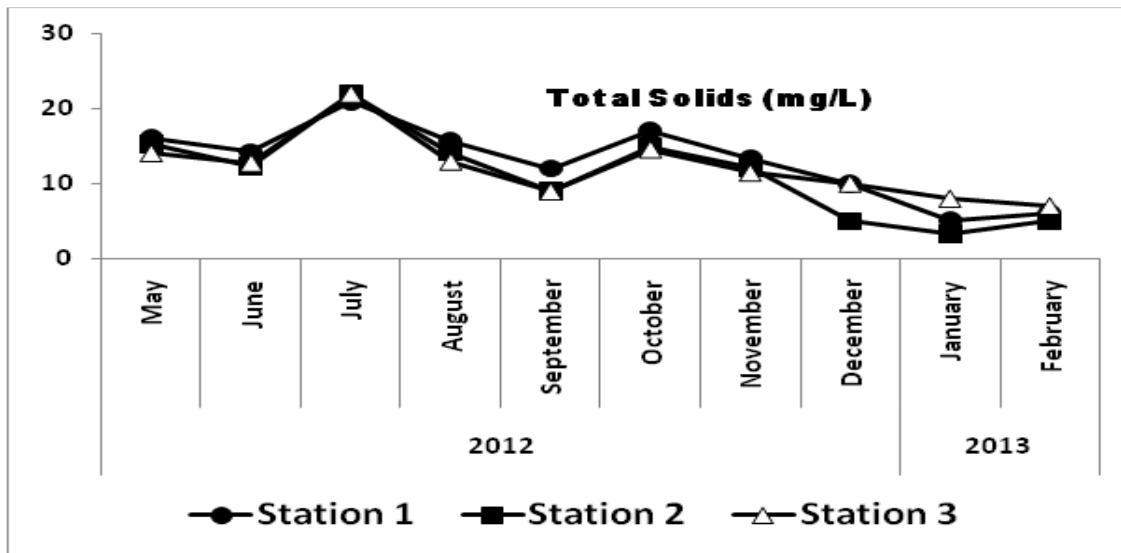
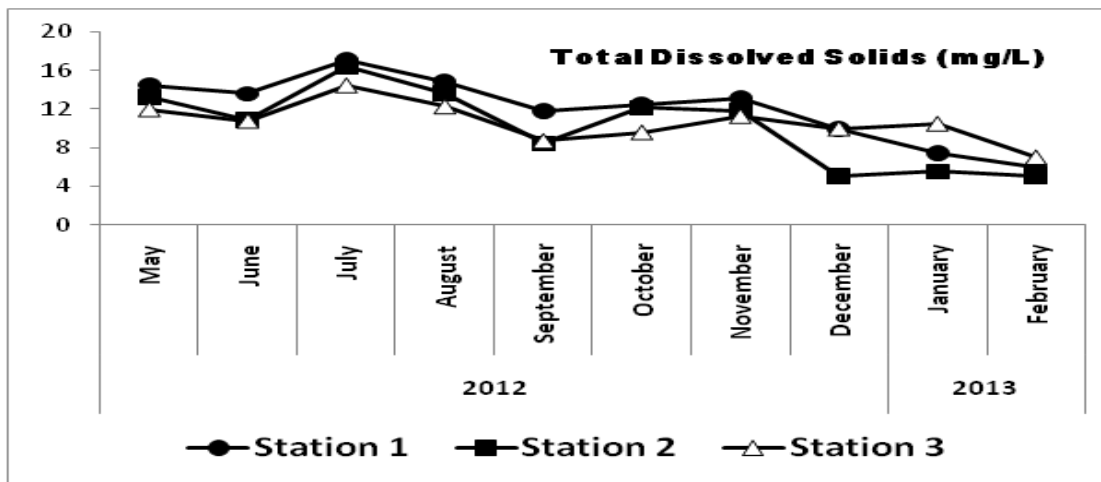
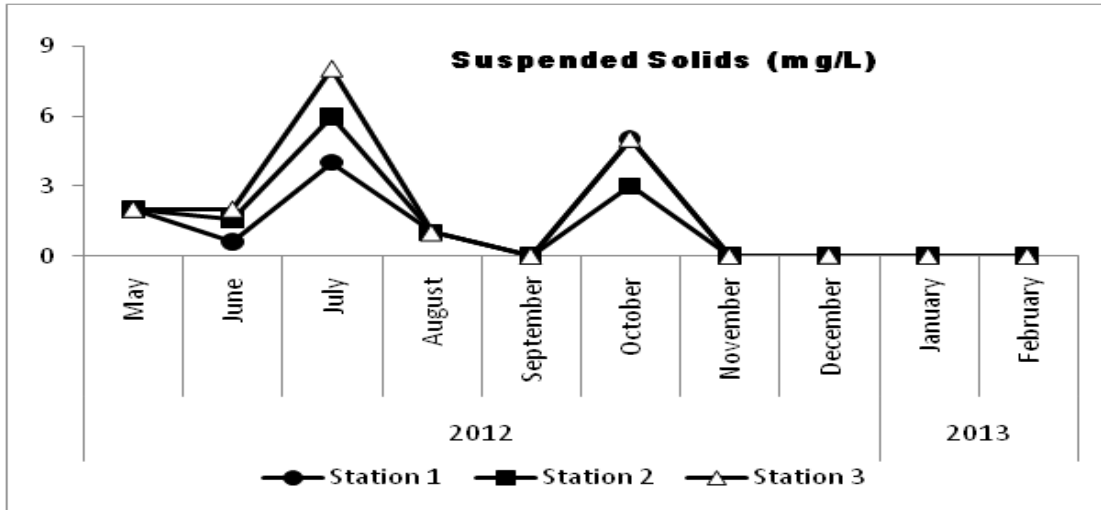


Fig. 5: Spatial and Temporal variation in Suspended solids, Total Dissolved Solids and Total Solid from May 2012 to February, 2013 in Jameison River.

The pH values recorded throughout the study indicate that the water was slightly acidic all the year round with a range of 4.4 to 6.5 and a mean of 6.0. The period of lowest pH was December, 2012 and January, 2013 with values of between 4.4 and 5.5. There was no significant difference ($P>0.05$) in the mean values of pH at the three stations as they all had similar pattern of values and variation (Fig. 6). Water pH was similarly acidic to neutral during the 1994/1995 report, but slightly became more acidified over the years.

Alkalinity ranged between $1.0 \text{ mgCaCO}_3\text{L}^{-1}$ in station 1 and $22.88 \text{ mgCaCO}_3\text{L}^{-1}$ in station 3. The highest values were recorded in December, 2012 and February, 2013 at all the stations, while the rest months recorded very low values of between 1 to $7 \text{ mgCaCO}_3\text{L}^{-1}$. There was no significant difference ($P>0.05$) in the values of alkalinity at the three stations, with all the stations showing the same pattern of monthly values (Fig. 6). The water can be described as soft as the calcium carbonate measured in mgL^{-1} range from 4 to $23.1 \text{ mgCaCO}_3\text{L}^{-1}$ with a mean of $10.1 \text{ mgCaCO}_3\text{L}^{-1}$. Relatively higher values were recorded across the three sampling stations in February, 2013. There was no significant difference ($P>0.05$) in the mean values of hardness of the three stations with all the stations showing the same pattern of monthly values (Fig. 6).

The amount of dissolved oxygen in the water was on the average high at all the sampling stations during most of the period of sampling. The highest values were reported during the period May to November, 2012 for all the sampling stations and up to December, 2012 for sampling station 2. The mean values recorded were 4.38 mgL^{-1} (station 1), 5.90 mgL^{-1} (station 2) and 5.29 mgL^{-1} (station 3). There was no significant difference ($P>0.05$) in the mean value of the dissolved oxygen in the three

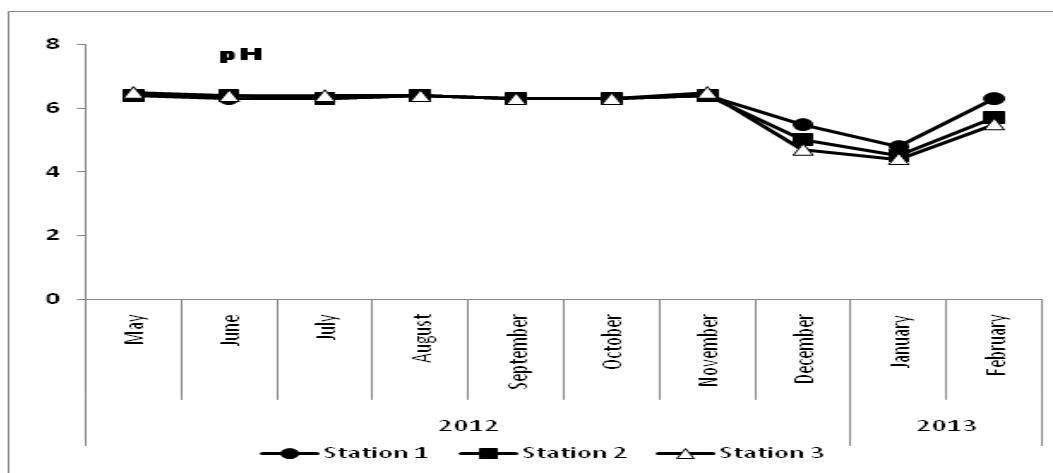
stations with all the stations showing the same pattern of monthly values (Fig. 7). The record for dissolved oxygen (DO) in Jameison River over the last 19 years has been relatively stable, if anything there was tendency towards an increase in the overall oxygen available in the water.

The biological oxygen demand ranged from 0 to 10.3 mgL^{-1} in the water, an indication that the water was in a continuum of unpolluted water to moderately polluted rivers during May to December, 2012 where values between 2 and 8 mg/L were mostly reported. The months of January and February, 2013 recorded zero values at all the sampling stations except station 2 that had 3 mg/L in January, 2013. There was no significant difference ($P>0.05$) in the mean value of the Biological Oxygen Demand of the three stations with all the stations showing the same pattern of monthly values (Fig. 7).

The level of nutrient in the water was generally low. Nitrate value ranged from 0.03 mgL^{-1} to 1.15 mgL^{-1} . The values fluctuated minimally at all the sampling stations throughout the period of the study except in November, 2012 when the level elevated at sampling station three (Fig. 8). There was however, no significant difference ($P>0.05$) in the three stations.

Sulphate values were comparatively higher in the water than nitrate at least from May to November, 2013. The range of values was from 0.01 mgL^{-1} to 3.16 mgL^{-1} . Lower values were recorded between December, 2012 and February, 2013 (Fig. 8). All three sampling points exhibited similar pattern and there was no significant difference ($P>0.05$) in their mean values.

Phosphate values ranged from 0.01 mgL^{-1} to 0.35 mgL^{-1} . Variation in the levels of phosphate was similar across the three sampling stations (Fig. 8) with no significant difference ($P>0.05$) in the mean.



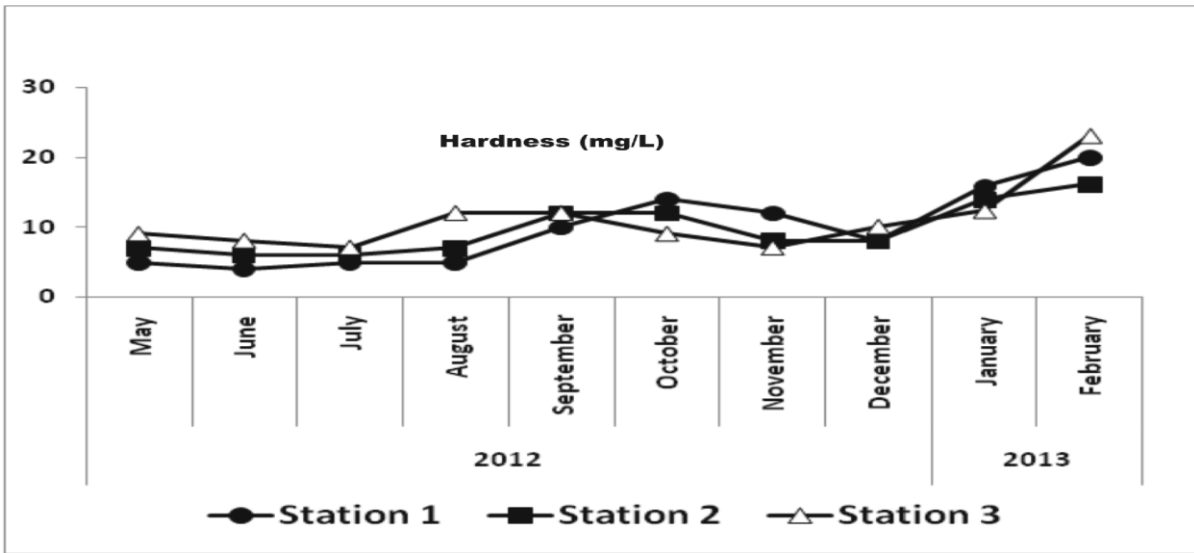
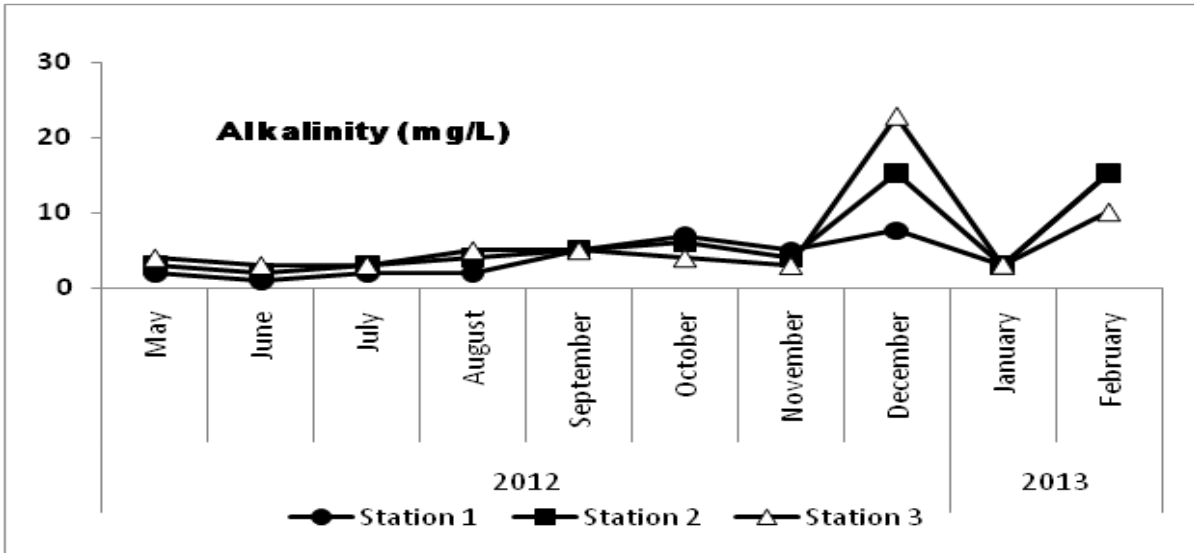
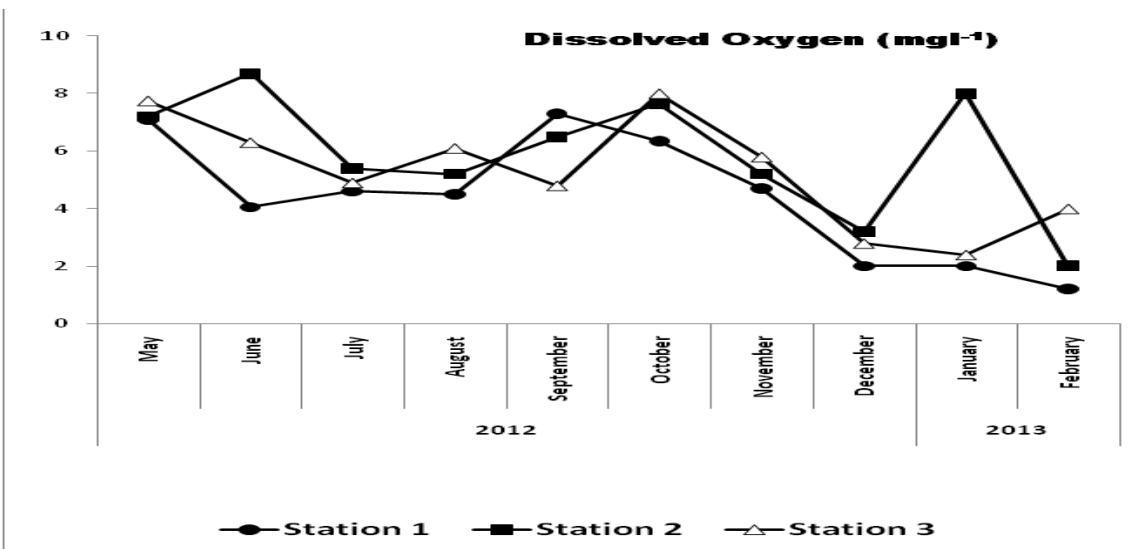


Fig. 6: Spatial and Temporal variation in pH, Alkalinity and Hardness from May 2012 to February, 2013 in Jameison River



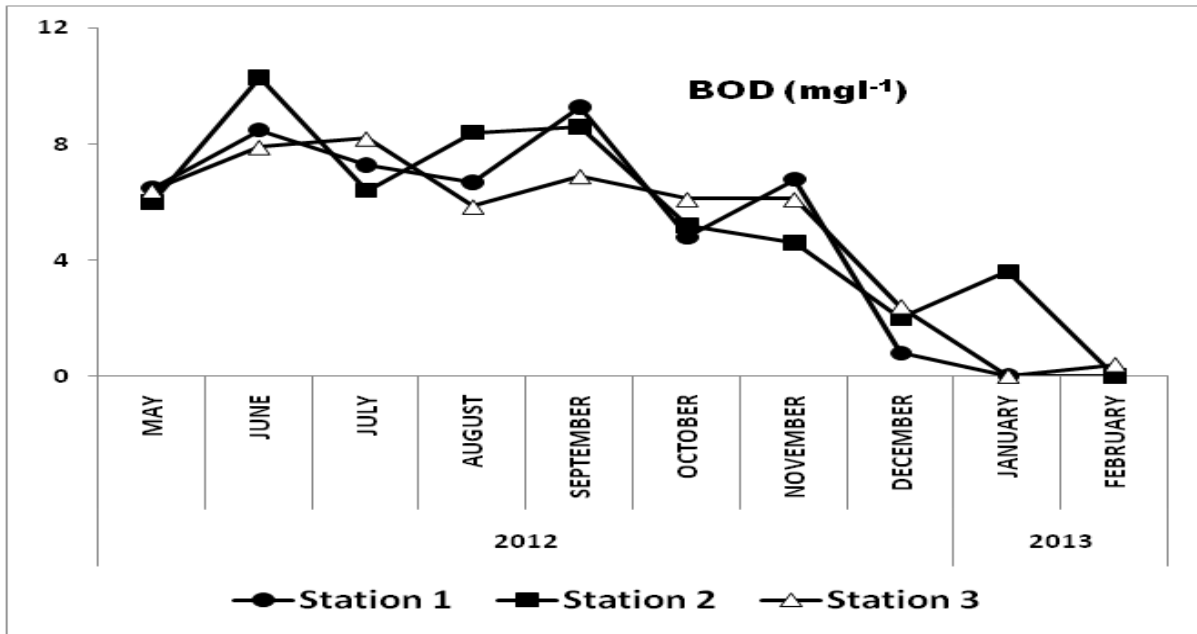
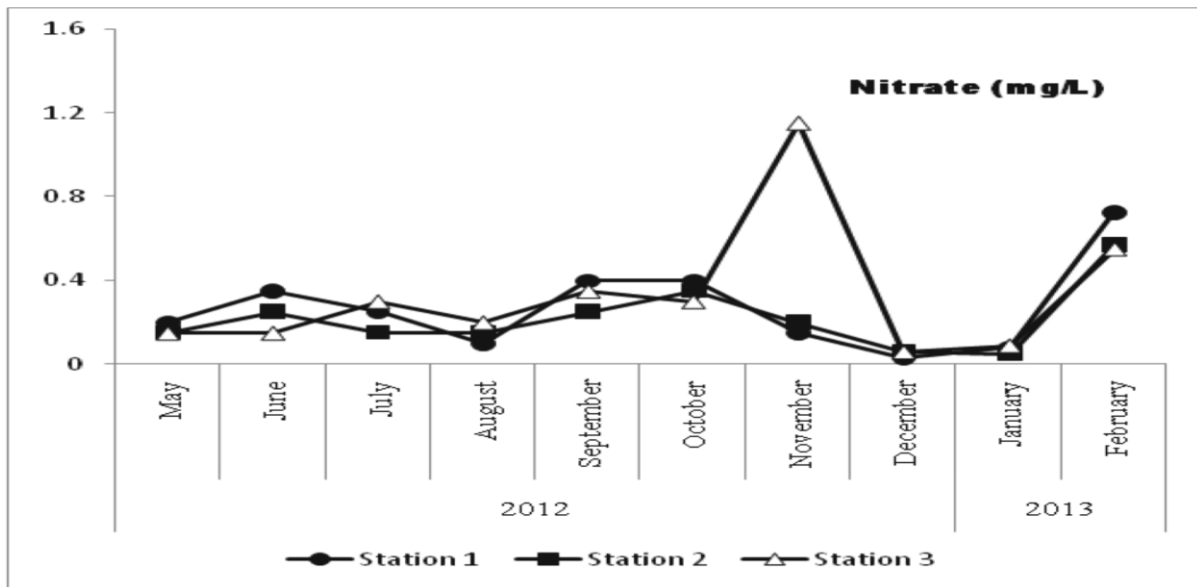


Fig. 7: Spatial and Temporal variation in the Dissolved Oxygen and Biochemical Oxygen Demand from May 2012 to February, 2013 in Jameison River



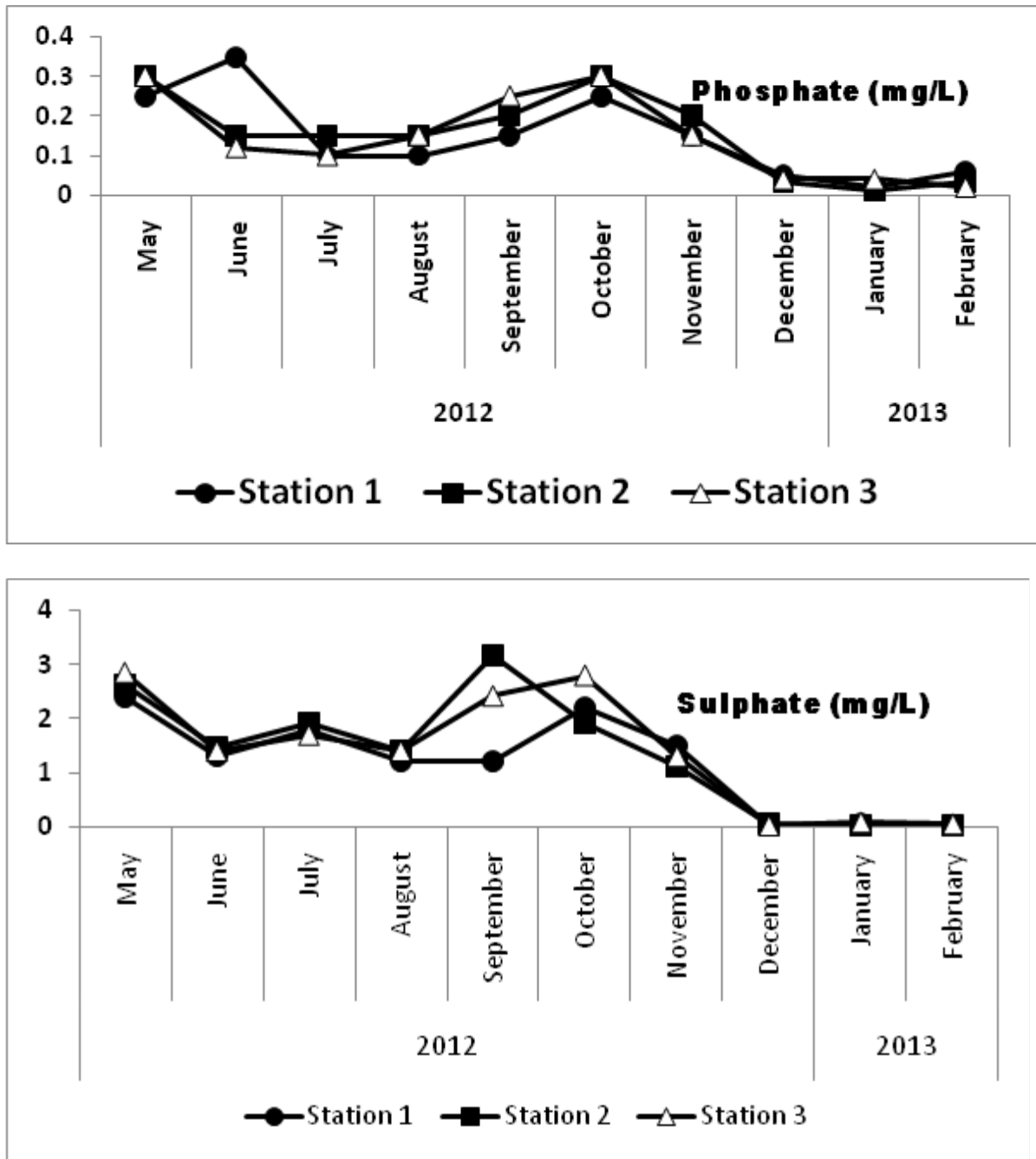


Fig. 8: Spatial and Temporal variation in Nitrate, Sulphate and Phosphate from May 2012 to February, 2013 in Jameison River.

Discussion

The physical and chemical parameters investigated during the 2012/2013 fluctuated within narrow ranges, with only transparency showing significant spatial variation. The narrow range of surface water temperatures within the three sampling points is expected partly because they all lie within very close distance of less than 500m. This is in agreement with studies on Nigerian Rivers which reveals homiothermy along the length of rivers for a distance up to

25km (Egborge, 1972, Adebisi, 1978) except when there is thermal pollution (Egborge et al., 1986; Fufeyin, 1987). Similar pattern of temperature range of between 25.0°C and 29.0°C was noticed during the 1994/1995 study (Imoobe, 1997; Imoobe & Oboh, 2003), an indication that the much talked about climate change and other factors that could elevate the water temperature have not had their toll on the ecosystem.

Quantitatively, transparency was lower in the rainy season than in the dry season as well as at sampling station 3 than other sampling points. Turbidity and colour on the other hand increased. This was probably due to the influx of allochthonous materials into the river with runoff waters. Comparatively, transparency was much higher during the 1994/1995 study. Part of the reason for the lower transparency almost twenty years later, can be adduced to the waste from wood processing factory located at the riverbank of sampling station 3. These changes were however, within acceptable limits.

Water pH at all sites were generally acidic to neutral during the 1994/1995, while the 2012/2013 studies were slightly more acidic. The acidic pH of the water agrees with findings of Welcome (1979) that rivers which flow through the forest like Jamieson River are weak to very acidic with pH ranging from 4 to neutrality due to the influx of humic substances into the river. The low pH according to Pidgeon and Cains (1987) could be from organic acids resulting from decaying vegetation. The range recorded in this study is very close to those recorded in other Niger Delta waters of Nigeria (Fregene 1978, Fufeyin, 1987, Onwudinjo 1990, Ogbeibu 1991). pH is influenced by runoff from surrounding rocks and water discharges, total alkalinity and acidity of the bottom sediment and biological activities. Extended periods of low pH water as observed here can be detrimental to benthic macroinvertebrates and fish (Sparling and Rowe 1996) as the solubility of metals such as aluminum generally increases as pH declines. With increased Aluminum in solution, it binds phosphorus into less available forms and interferes with the uptake, transport, and use of nutrients by aquatic plants.

Alkalinity values of 1 to 22.88 mgCaCO₃L⁻¹ reported in this study is low and in line with the range of 0-24mgCaCO₃L⁻¹ previously recorded in this river during the 1994/1995 investigation. Similarly low values have been reported in some other rivers in Nigeria Egborge (1979), Egborge and Fagade (1979), Egborge *et al.*, (1986) where low values of carbonate and bicarbonate have been reported. Alkalinity as an indirect measure of the concentration of anions such as bicarbonates, carbonates, hydroxides, phosphates, borates or silicates in water may be derived from dissolved rocks, salts, soils or bottom sediments.

Conductivity was generally low; thus indicating the low levels of ions namely, calcium, magnesium, bicarbonate, carbonate, nitrate and phosphate within the water. This compares favorably with the range of 15-32µs/cm recorded by Onwudinjo (1990) in Benin River at Ogorode,

which is another freshwater body a few kilometers away.

Total Dissolved Solids, suspended solid and Total solids are indications of the amount of erosion that took place nearby, and arguably the most significant measurement to assess the effectiveness and compliance of control measures along the waterways. These parameters were generally low in the water and the relatively higher values recorded during the wet season can be attributed to the increased influx of allochthonous materials brought into the river with flood.

Nutrient (Nitrate, phosphate and sulphate) levels in the water were considerably low as found in the 2012/2013 study. The naturally low level of phosphorus can be explained by its adsorption to organic matter and soil particles, while any unattached or "free" phosphorus is quickly removed from the aquatic system by algae and larger aquatic plants. Nitrates on the other hand, also occur naturally in soil and water. However, excess input of nitrate and phosphorus from human activity such as agricultural activities, human wastes, or industrial pollution does not appear to have taken place. Consequently, Jameison River, apart from having water of good quality for drinking it is suitable for recreation and aesthetic enjoyment as a result of its clarity and low turbidity.

Dissolved oxygen was generally stable and high between 1994 and 2013 just as BOD mean values at all the sampling points were all below 6 mgL⁻¹ as shown in the result for 2012/2013. This shows that there has not been any significant organic pollution of the surface water from human faeces, decayed plant materials and domestic and sawmill wastes that could find their ways into the river.

Conclusion

The overall picture emerging from this study is that the water quality of Jameison River, is generally good by international standards, with some level of decline in transparency due to suspended sediments from wood processing factory located at the riverbank of sampling station 3. Trends in the data show overall little or no degradation in the water quality of Jameison River. Over this period, nitrogen and phosphorus which are key plant nutrients added in fertilizers have remained very low, less than 1.2mg/l and 0.4 mg/l respectively. It is recommended that to determine the state of our freshwaters and the impacts of land use, periodic monitoring is fundamental.

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