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ANTHROPOGENIC IMPACTS ON THE WATER QUALITY OF ABA RIVER, SOUTHEAST NIGERIA

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Abstract
A stretch of Aba River, southeast Nigeria was studied in four stations from November 2014 to August 2015 to identify the major anthropogenic activities and their impact on the water quality. A number of major anthropogenic activities were identified; some were regular and persistent such as washing of clothes, rugs/carpets and cars as well as effluents and wastes from abattoir. Dredging was observed as a one-time anthropogenic activity during this study with its associated impacts. The identified anthropogenic and other salient activities in the watershed have individually and cumulatively impacted on the water quality of Aba River. Some of the water quality parameters had elevated values but the most affected were turbidity (6.8 – 321NTU/FEPA, 10NTU), phosphate (2.3 – 79.8mg/l/FEPA, 5mg/l) and nitrate (7.4 – 79.8mg/l/FEPA, 20mg/l). These observed impacts on the water quality have directly or indirectly affected the ecological, domestic and other uses of the river. Many residents cannot use the water for drinking, cooking, industrial or aquaculture purposes.

Key Words: *Physico-chemical parameters, Watershed, Cumulative impact*

Introduction

Anthropogenic activities result in significantly decrease of surface water quality of aquatic systems in watersheds (May *et al*., 2006). Rivers in a watershed play a major role in assimilating or carrying off municipal and industrial wastewater and runoff from agricultural land (Wang *et al*., 2007). Therefore, a river is a reflection of its watershed. River inflows contribute main pollutants to most lakes in a watershed, thereby tending to induce serious ecological and sanitary problems (Gilbert and Wendy, 2003; Kunwar *et al*., 2005). On the other hand, rivers constitute the main water resources for domestic, industrial, and irrigation purposes in a watershed (Yu and Shang, 2003). Pollution of surface water bodies, resulting from anthropogenic activities, is a growing concern worldwide (Zhai *et al*., 2014; Hillel *et al*., 2015). Thus it is imperative to prevent and control river pollution and to have reliable information on the quality of water for effective management (Wang *et al*., 2007). For most watersheds with greatly varying topographical conditions, the water quality of rivers is characterized by a

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high degree of heterogeneity in space and time, due to the variety of land cover around them. This often makes it difficult to identify water conditions and pollution sources, which is necessary for effective pollution control and water resource management (Kunwar *et al*., 2005). In Nigeria, many streams and rivers, particularly those in urban and semi urban cities, get polluted as a result of the discharge of untreated wastewater and other organic wastes directly into them (Jaji *et al*., 2007; Osibanjo *et al*., 2011; Anyanwu, 2012). Thus, river pollution is becoming a central issue in water management in Nigeria (Arimoro, 2009). Available reports cite gross contamination of most major rivers across Nigeria by discharge of industrial effluents, sewage and agricultural wastes among others (World Bank, 1995). The objective of the present study was to identify the anthropogenic activities and their impacts on the water quality of Aba River, Aba, Southeast Nigeria.

Methodology

Study Area and Sampling Stations

Ogbor community constitutes the study area and is situated in Aba, a commercial city of Abia state, Nigeria. The River, which lies between latitude 5°05' to 5°30' North and longitude 7°15' to 7°40' East, is a tributary of Imo River and transverse Aba town (Fig. 1). The river originates from the northern Ngwa hinterland of Aba, cutting through different local governments areas in Abia State and discharge into Ikot Abasi/Opobo, from where it empties with its creeks into the Atlantic Ocean. The vegetation appears more forest-like along river channels and due to intense farming in the area; grasses are taking over the original tropical forest characteristic of the area. The river receives wastes from a number of activities going on in the watershed.

Station 1 is upstream, located in Okpulor – Umuobu area of Aba. It is open and the substrate was muddy with minimal human activities. The major activities observed were children engaged in fishing with hook and line, swimming, washing of clothes and cars. Station 2, also located in Okpulor – Umuobu area, under the bridge, 44m downstream of station 1. It is also open with muddy substrate. Activities include washing of clothes and large scale washing of rugs, carpets and cars. Station 3 is located in Ogbor Hill area of Aba, about 4.17km downstream of station 2 with muddy substrate. Abattoir wastes and effluent are discharged here. Station 4, also located around Ogbor Hill area, about 256m downstream of station 3 with muddy substrate. It is close to built-up and residential area with no observed human activities during the study.

Samples Collection and Analyses

Water samples were collected from Aba River monthly from November 2014 to August 2015. Samples were collected with 1 litre water sampler and stored in sterilized 1litre plastic bottles. Water temperature, pH, conductivity and total dissolved solids were determined *in situ* using Hanna Portable Meter (HI9811-5), before the samples were taken to the laboratory for analysis. The physicochemical parameters were analyzed using standards methods described by American Public Health Association (APHA) (1998). All the results were statistically analysed using ANOVA and Tukey's pairwise comparisons test was performed to determine the location of significant difference (Ogbeibu, 2005).

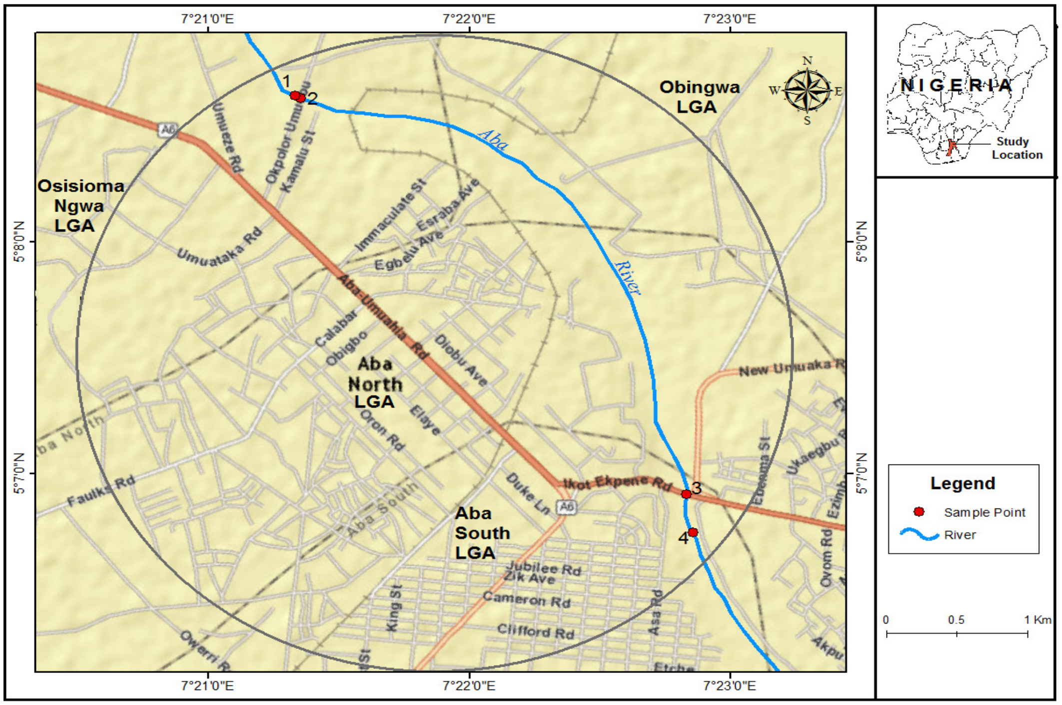

Fig. 1: Map of Aba, Southeast Nigeria showing the sampling stations of Aba River

Results

The summary of physicochemical parameters is presented in Table 1 while the spatial and temporal variations in the parameters are presented in Figs. 2 – 13. The Surface water temperatures ranged from 23.5°C to 30.1°C. The water temperature trend showed that the values were generally higher in Station 3 (Fig. 2) and significantly different (F = 10.9, $p < 0.05$) in all the stations. The temperature values recorded in this study are within the acceptable limit of 40°C set by FEPA (2003).

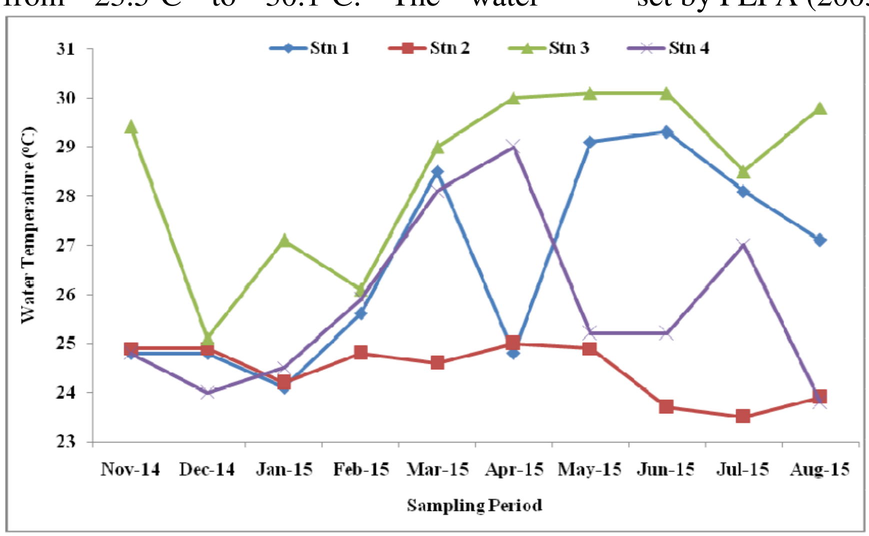

Fig. 2: Spatial and temporal variations in Water Temperature at the study stations in Aba River

Table 1: Summary of Physico-chemical Parameters of Aba River (with range in Parenthesis)

LEVEL RECORDED/DETECTED						Maximum Permissible Limits	
Parameter	Station 1 $\overline{X}$ ± SEM*	Station 2 $\overline{X}$ ± SEM*	Station 3 $\overline{X}$ ± SEM*	Station 4 $\overline{X}$ ± SEM*	*P* - Value	FEPA**	SON***
Water Temperature (°C)	26.6±0.64[a] (24.1–29.3)	24.4±0.18[b] (23.5–25.0)	28.5±0.57[c] (25.1–30.1)	25.8±0.55[d] (23.8–29.0)	$p < 0.05$	< 40	Ambient
pH	6.5±0.17 (5.3 – 6.9)	6.3±0.19 (5.0–6.9)	6.7±0.24 (5.0–7.3)	6.7±0.31 (5.3–9.1)	$p > 0.05$	6.0 – 9.0	6.5 – 8.5
Turbidity (NTU)	67.5±3.65 (50.0–84.0)	94.7±25.6 (51.2–321.0)	80.8±16.03 (6.8–197.0)	79.3±15.9 (6.8–197.0)	$p > 0.05$	10	15 (TCU)
Conductivity (µS/cm)	25.8±1.12 (20.1–29.3)	23.9±2.41 (3.5–28.4)	31.1±1.52 (24.1–41.0)	35.3±7.10 (22.8–98.0)	$p > 0.05$	-	1000
Total Dis. Solids (Mg/l)	12.7±1.44 (8.1–21.0)	12.9±1.66 (8.0–23.2)	14.9±2.20 (8.9–28.2)	12.8±1.68 (8.5–24.2)	$p > 0.05$	2000	500
Total Susp. Solids (Mg/l)	8.2±1.14 (5.4 – 15.0)	19.5±1.3 (5.4 – 110.0)	43.5±31.5 (6.0 – 324)	30.1±17.9 (5.7 – 184)		-	-
Dissolved Oxygen (Mg/l)	5.6±0.64 (2.8 –8.7)	5.8±0.69 (2.7–8.4)	6.2±0.66 (3.1–8.8)	5.6±0.63 (2.8–8.0)	$p > 0.05$	>5	-
BOD_5 (Mg/l)	4.21±0.49 (1.1–5.6)	4.25±0.34 (2.9–5.4)	5.0±0.47 (2.3–6.1)	4.5±0.44 (2.0–5.6)	$p > 0.05$	<10	-
Chem. Oxygen Demand (Mg/l)	4.8±0.42 (2.0 – 6.4)	4.9±0.40 (2.3 – 6.4)	5.5±0.42 (2.9 – 7.0)	4.8±0.42 (2.3 – 6.5)	$p > 0.05$		
Phosphate (Mg/l)	10.1±6.92 (2.3–72.3)	11.7±6.81 (2.3–72.0)	12.9±7.50 (3.2–79.8)	11.7±6.95 (2.3–73.4)	$p > 0.05$	5	-
Nitrate (Mg/l)	57.7±4.76 (35.2–77.6)	55.4±6.63 (7.4–76.9)	63.9±3.97 (46.0–79.8)	59.2±4.25 (42.5–77.5)	$p > 0.05$	20	50
Sulphate (Mg/l)	57.5±4.64 (30.1–77.0)	65.3±4.83 (45.2–85.1)	73.8±7.30 (48.9–120.0)	67.1±5.53 (46.5–95.0)	$p > 0.05$	200 – 400	100

a, b, c, d = Means with different superscripts across the rows are significantly different at $p<0.05$
*Standard Error of Mean.
**Nigerian Water Quality Standard for Inland Surface Water, Federal Environmental Protection Agency (FEPA), 2003.
***Nigerian Standard for Drinking Water Quality, Standards Organisation of Nigeria (SON), 2007

The pH values revealed that the water was moderately acidic to moderately alkaline with a range of 5.0 to 9.1 (Fig. 3). Some of the pH values are either lower or higher than the acceptable limits set by both FEPA (2003) and SON (2007).

The turbidity values ranged from 6.8 - 321.0 NTU. The mean turbidity values showed a spatial variation, Station 2 had the highest values, followed by Stations 3, 4 and 1 being the least (Fig. 4). Most of the turbidity values exceeded acceptable limits of 10NTU and 15NTU, set by FEPA (2003) and SON (2007) respectively.

The electrical conductivity values ranged from 3.5 – 98.0µS/cm; the highest value was recorded in station 4 in April 2015 (Fig. 5). All the conductivity values recorded in this study are within the acceptable limits.

The total dissolved solids values ranged from 8.0 – 28.2 mg/l. The highest value was recorded in station 3 in April 2015 (Fig. 6). All the TDS values recorded were within the acceptable limits of 2000mg/l and 500mg/l set by FEPA (2003) and SON (2007) respectively.

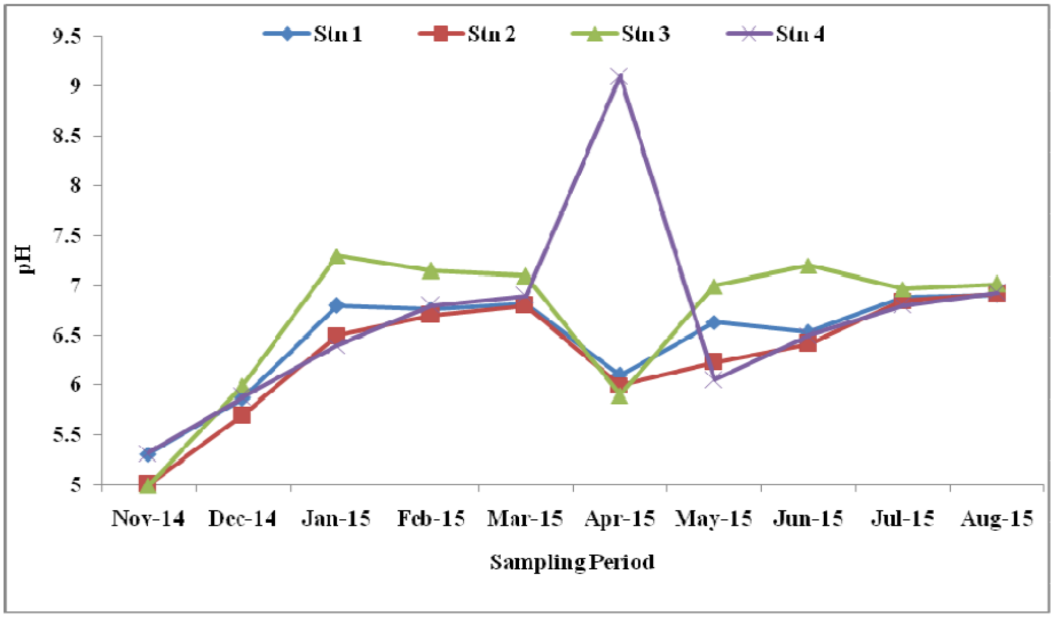

Fig. 3: Spatial and temporal variations in pH at the study stations in Aba River

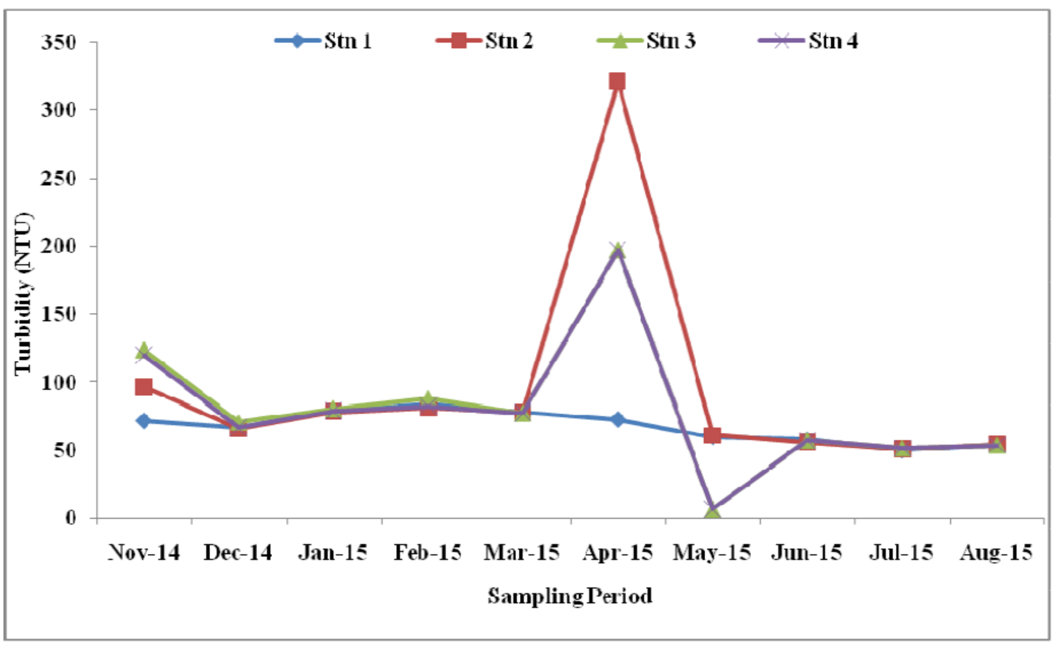

Fig. 4: Spatial and temporal variations in Turbidity at the study stations in Aba River

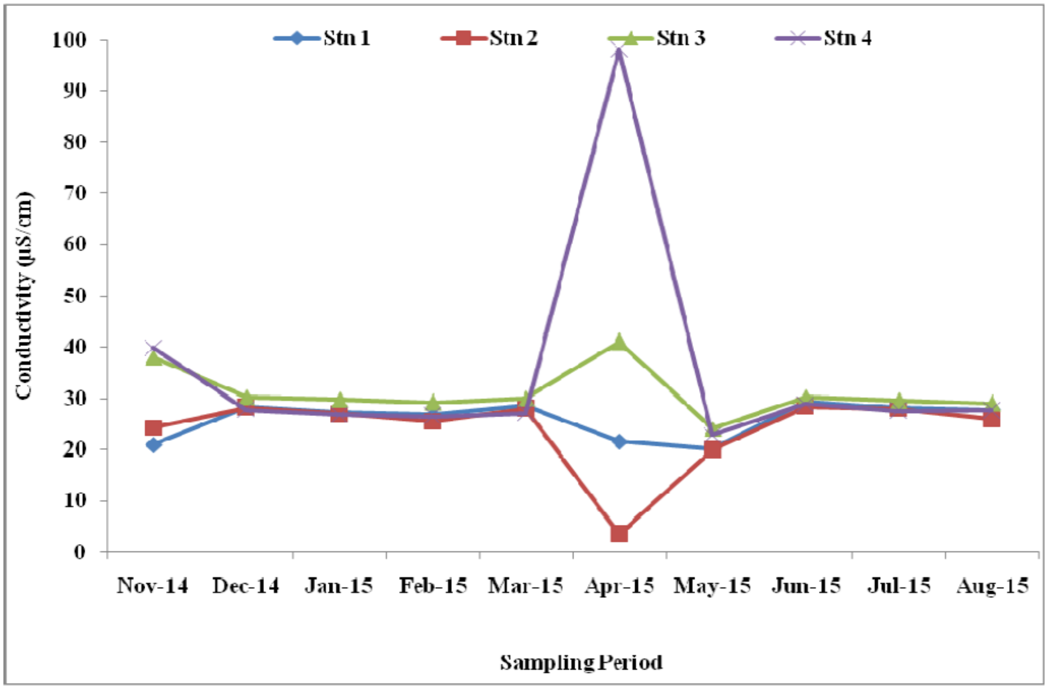

Fig. 5: Spatial and temporal variations in Conductivity at the study stations in Aba River

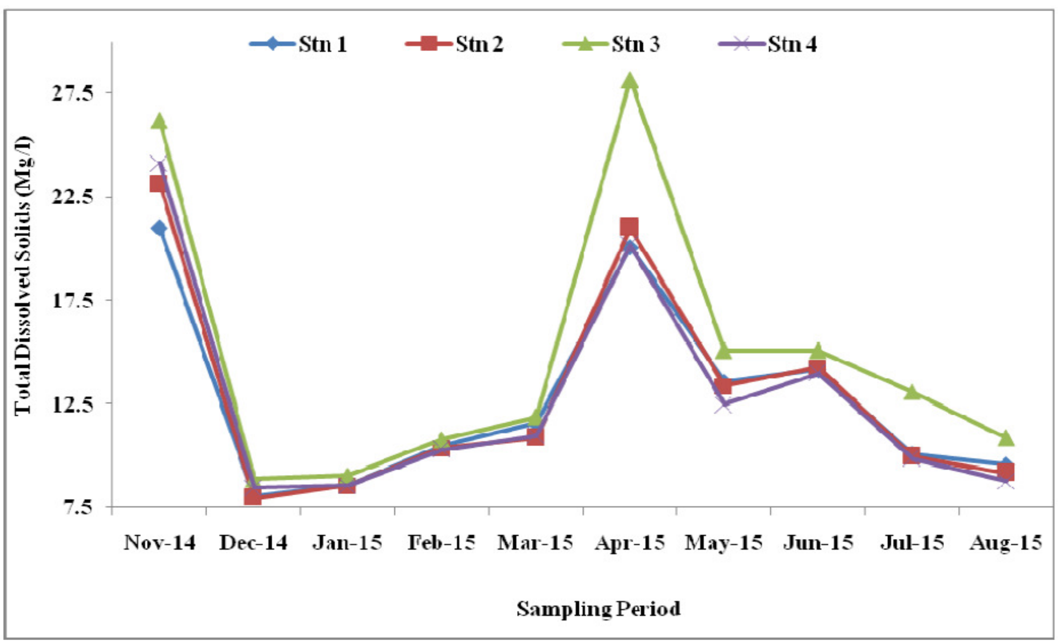

Fig. 6: Spatial and temporal variations in Total Dissolved Solids at the study stations in Aba River

The total suspended solids values ranged from 5.4 – 324.0mg/l. The highest value was recorded in station 3 in April 2015 (Fig. 7).

The dissolved oxygen values ranged from 2.7 – 8.8 mg/l. The lowest and highest values were recorded in stations 2 and 3 in December 2014 and February 2015 respectively (Fig. 8).

The Biochemical oxygen demand values ranged between 1.1 and 6.1 mg/l. The highest value was recorded at station 3 in May 2015 (Fig. 9). The lowest mean BOD value (4.21mg/l) was recorded in station 1; others were station 2 (4.25mg/l), station 4 (4.5mg/l) and station 3 (5.0).

The Chemical Oxygen Demand (COD) values recorded ranged between 2.0 and 7.0mg/l. The highest value was recorded at station 3 in March 2015 (Fig. 10). The lowest mean COD values (4.8mg/l) were recorded in stations 1 and 4; others are station 2 (4.9mg/l) and station 3 (5.5mg/l). The phosphate values ranged between 2.3 and 79.8mg/l. The highest value was recorded in December 2014 in station 3 (Fig. 11). The lowest and highest mean values of 10.1 and 12.9mg/l were recorded in stations 1 and 3 respectively. Most of the values exceeded acceptable limits set by FEPA.

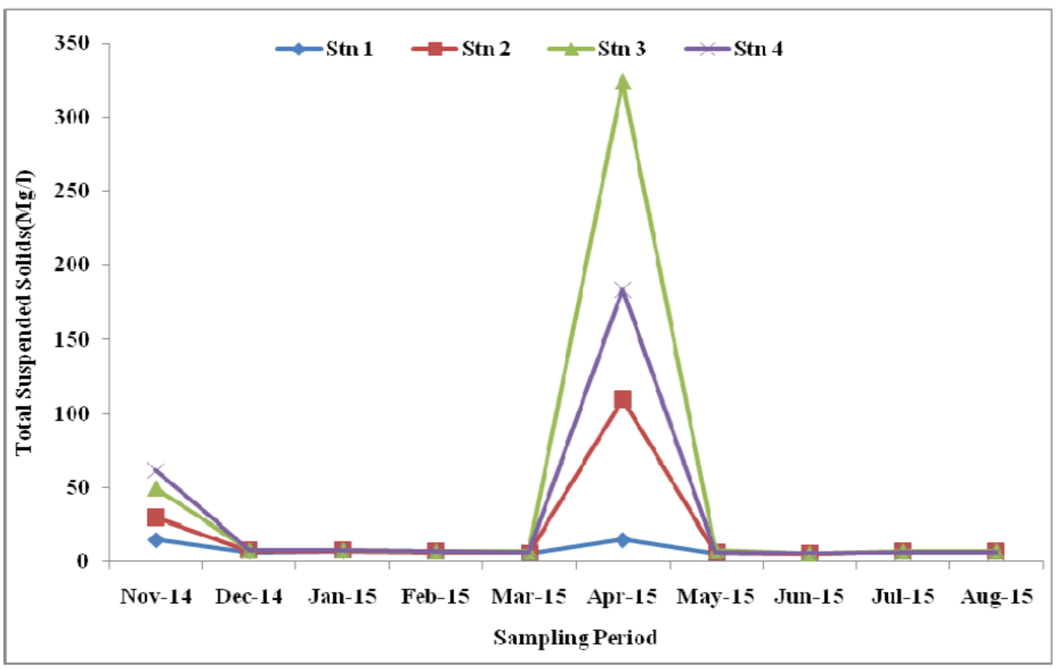

Fig. 7: Spatial and temporal variations in Total Suspended Solids at the study stations in Aba River

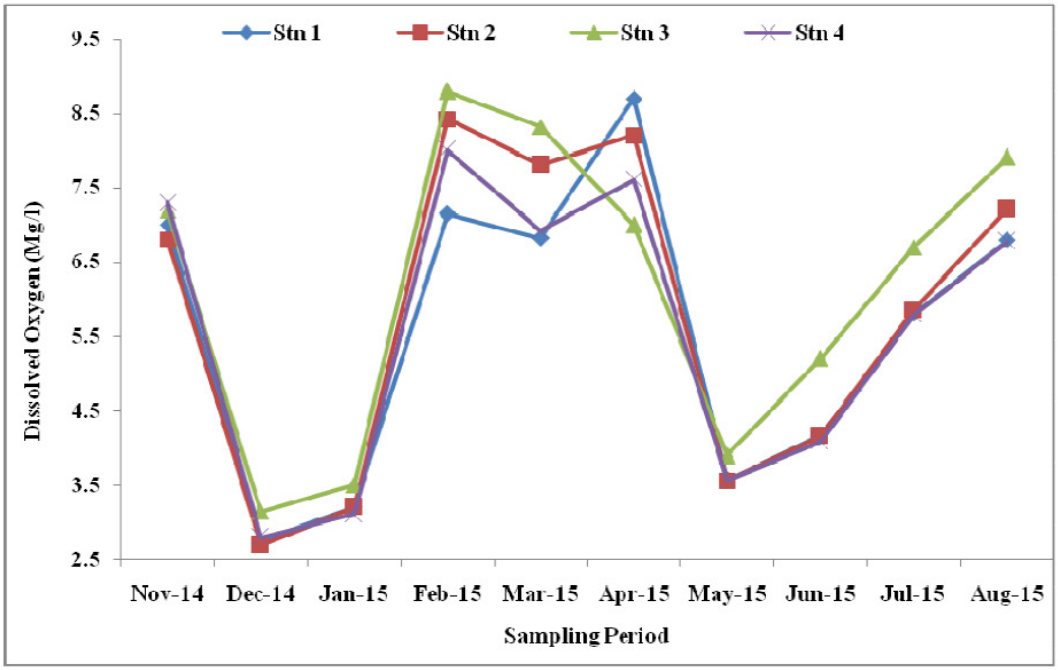

Fig. 8: Spatial and temporal variations in Dissolved Oxygen at the study stations in Aba River

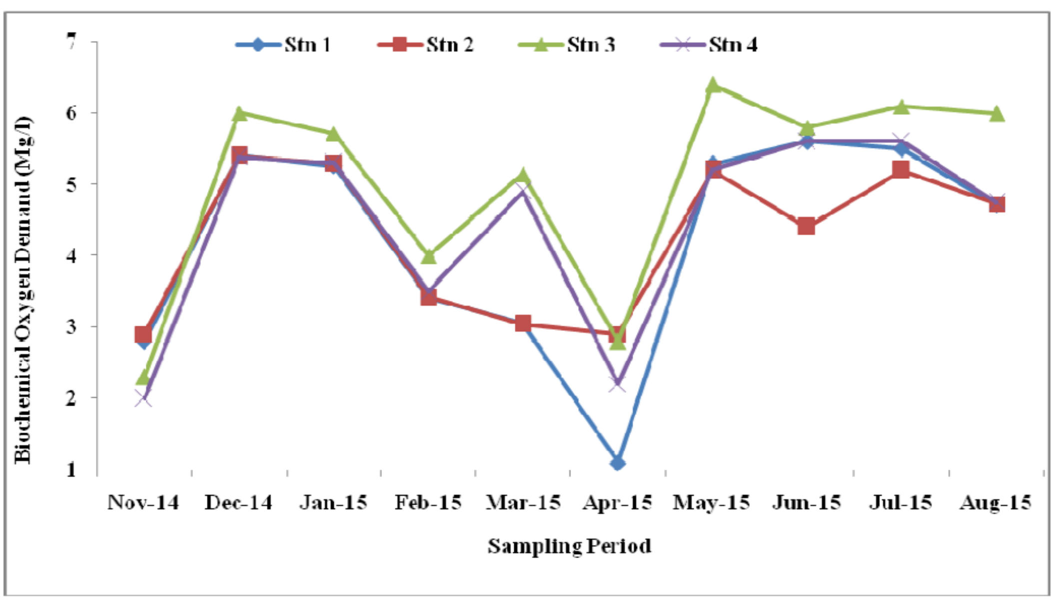

Fig. 9: Spatial and temporal variations in Biochemical Oxygen Demand at the study stations in Aba River

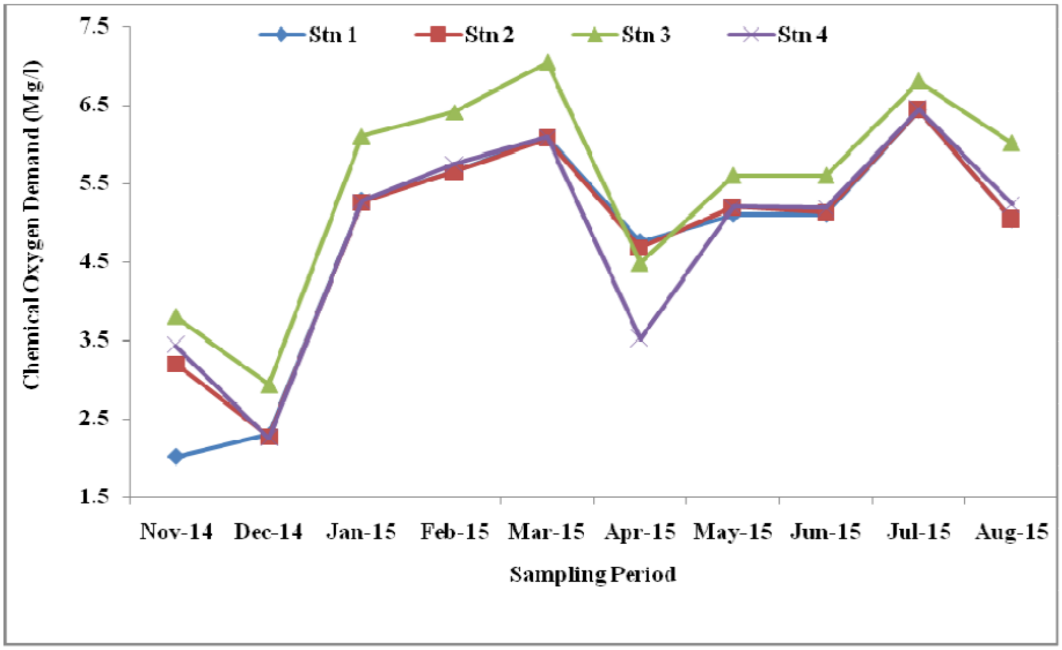

Fig. 10: Spatial and temporal variations in Chemical Oxygen Demand at the study stations in Aba River

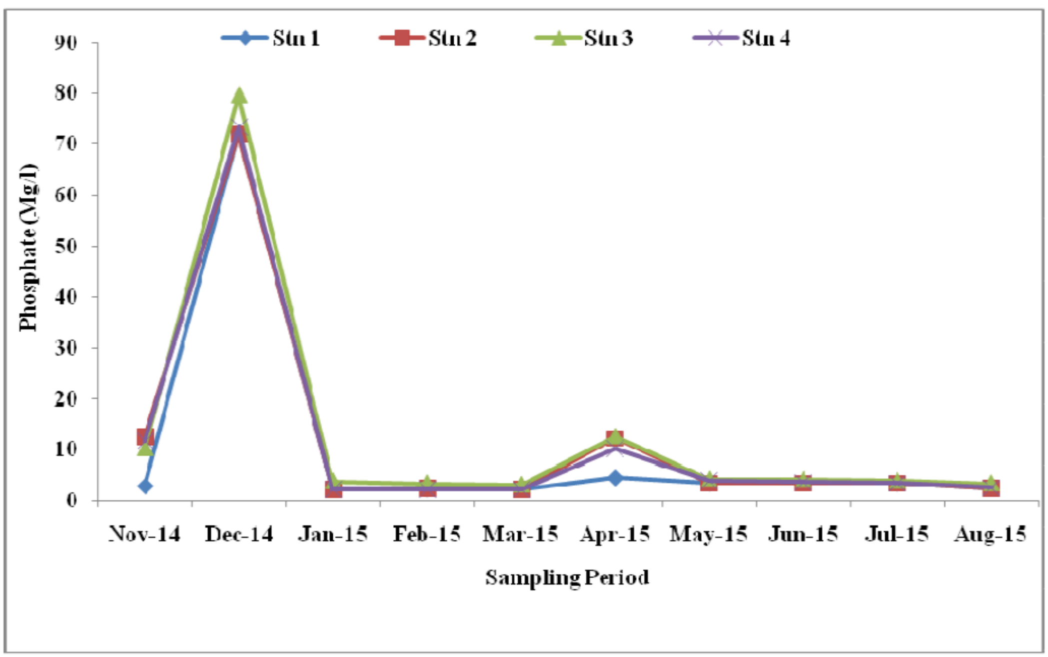

Fig. 11: Spatial and temporal variations in Phosphate at the study stations in Aba River

The nitrate values ranged from 7.4 – 79.8 mg/l. The highest value was recorded in August 2015 in station 3 (Fig. 12). The lowest and highest mean values of 55.5 and 63.9mg/l were recorded in stations 2 and 3 respectively. Most of the values exceeded acceptable limits set by FEPA and SON.

The sulphate values ranged from 30.1 – 120 mg/l. The highest value was recorded in April 2015 in station 3 (Fig. 13). The lowest and highest mean values of 57.5 and 73.8 mg/l were recorded in stations 1 and 3 respectively.

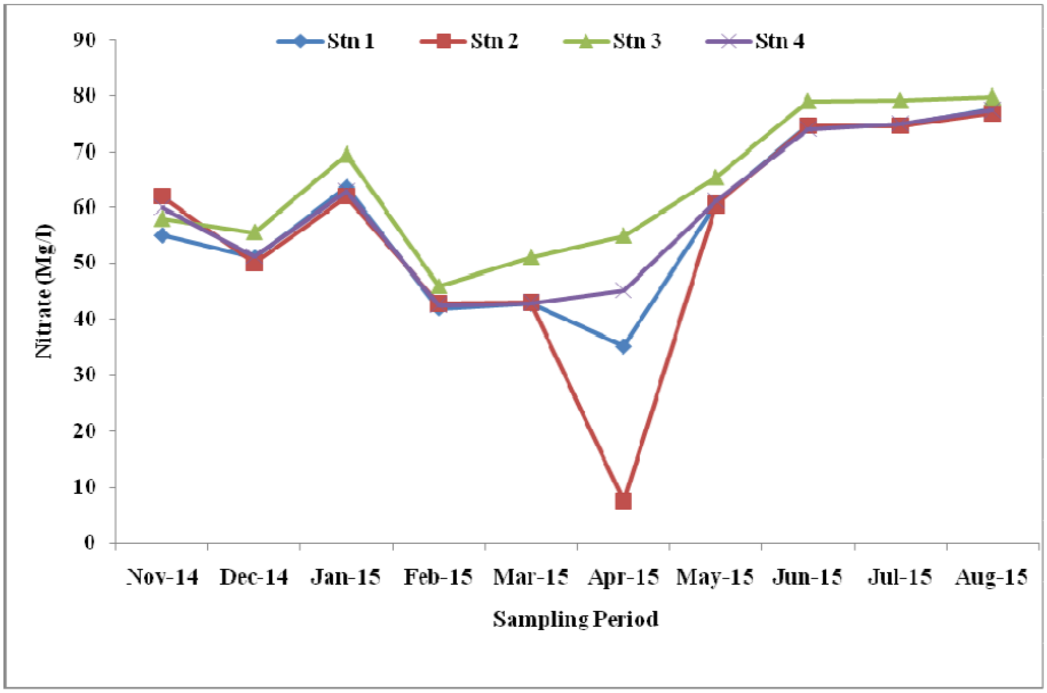

Fig. 12: Spatial and temporal variations in Nitrate at the study stations in Aba River

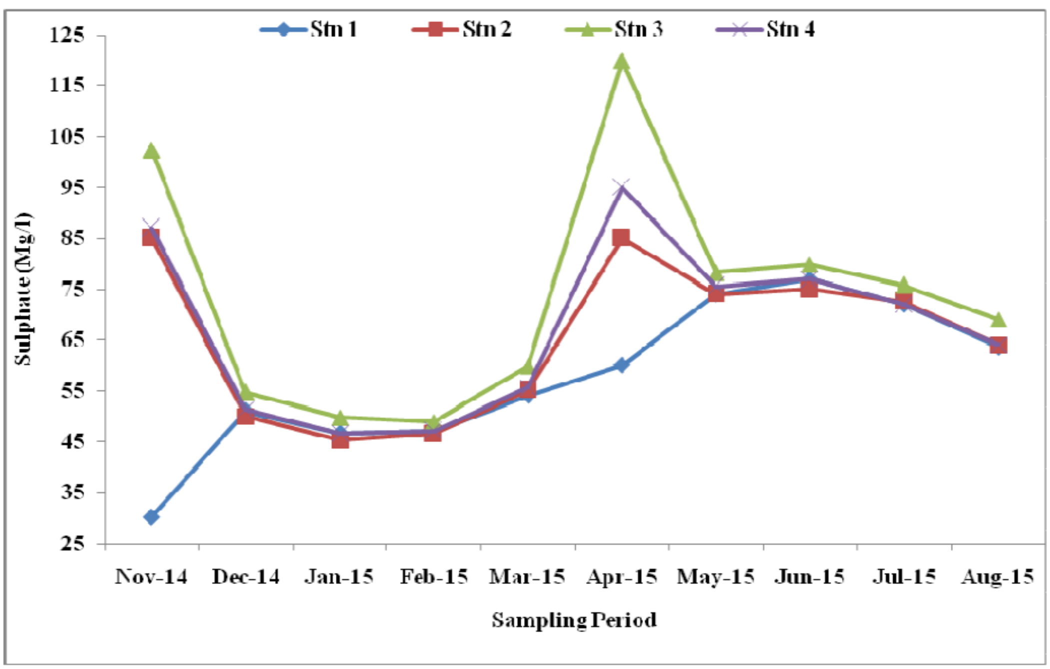

Fig. 13: Spatial and temporal variations in Sulphate at the study stations in Aba River

Discussion

This study on the anthropogenic impact on the water quality of Aba River, southeast Nigeria has considered the different activities going on around the river. The variations in the physical and chemical parameters of the Aba River showed that like most Nigerian inland waters, it is influenced by external factors as well as interactions between the various facet of its hydrology and biology. The physico-chemical parameters of Aba River did not show seasonal variations. The variations in time and space as regards water temperature were primarily influenced by the climatic factors, the time of sampling and human activities. The water temperature trend showed that the values were generally higher in Station 3 and could be attributed to the effluents of high temperature discharged from the abattoir. Related studies recorded water temperatures close to this range or slightly higher. Eni *et al.* (2014) recorded water temperature values of 25.4 to 27.2^{o}C in Obot Okoho Stream, Nassarawa village, Calabar, Nigeria while Ubwa *et al.* (2013) and Osibanjo and Adie (2007) recorded slightly higher values of 30.2 to 30.8^{o}C and 31.0 to 34.0^{o}C in a stream in Gboko, Nigeria and Oshunkaye stream in Ibadan City, Nigeria respectively. Temperature influences the amount of dissolved oxygen in water which in turn influences the survival of aquatic organisms (Ubwa *et al*., 2013).

The pH values recorded in this study could not be attributed to the effect of the abattoir effluent alone because pH exhibited the same trend throughout the study. Extremes of pH value recorded in stations 3 and 4 in April 2015 could be attributed to a combined impact of dredging activity carried out within that section of the river during the period and cumulative impact. Ohimain *et al*. (2008) and Seiyaboh *et al*. (2013) reported that dredging lowers the pH of water bodies while Radojevic and Bashkin (1999) observed that extremes of pH are associated with polluted surface waters. Clarke (1994) observed that in some cases, the most ecologically devastating environmental effects and subsequent social consequences may result not from direct effects of a particular action, project, or activity but from the combination of existing stresses and the individually minor effects of multiple actions over time.

The highest turbidity was recorded in station 2 in April 2015 while relatively high values were also recorded in stations 3 and 4 in April 2015. The turbidity value recorded in station 2 in April 2015 could be attributed to washing of cars, and rug carpets. Aikins and Boakye (2015) observed the carwash wastewater contribute to high turbidity in the receiving water body. The values recorded in stations 3 and 4 could be attributed to the impact of dredging in that section of the river. Ohimain *et al*. (2008), Seiyaboh *et al*. (2013) and IADC (2015) reported that dredging increases turbidity in a river downstream of the dredged section. Abattoir effluent also affects turbidity of the receiving water body (Ojo, 2014). The high levels of turbidity observed in the Aba River could also affect fish and other aquatic life due to obstruction of light (Izonfuo and Bariweni, 2001).

The relatively higher electrical conductivity values recorded in stations 3 and 4 in April 2015 could be attributed to the impact of the dredging carried out in that section of the river during that period (Seiyaboh *et al*., 2013; Rehman *et al*., 2016); lower values were recorded in the study outside April 2015. Abattoir effluent also impact on the downstream electrical conductivity of a receiving water body (Eni *et al*., 2014). The conductivity of most freshwaters ranges from 10 to 1,000 µS/cm but may exceed 1,000 µS/cm, especially in polluted waters, or those receiving large quantities of land run-off (Chapman, 1996).

The highest total dissolved solids (TDS) value was recorded in station 3 in April 2015. The values of TDS followed the same trend in all the stations in April 2015, which could be attributed to a cumulative impact (Clarke, 1994), rather than abattoir effluent and dredging. Studies have shown that car wash, abattoir effluents and dredging seriously impact on the TDS of the receiving water bodies (Ohimain *et al.,* 2008; Seiyaboh *et al.,* 2013; Ubwa *et al.,* 2013; Eni *et al.,* 2014; Aikins and Boakye, 2015).

The Total Suspended Solids values recorded in this study was highest in stations 3 in April 2015 and followed the same trend in all the stations as TDS. This could also be attributed to a cumulative impact rather than abattoir effluent and dredging. Studies have also shown like in TDS, that car wash, abattoir effluents and dredging seriously impact on the TSS of the receiving water bodies (Ohimain *et al.,* 2008; Seiyaboh *et al.,* 2013; Ubwa *et al.,* 2013; Danha *et al.,* 2014*;* Eni *et al.,* 2014; Aikins and Boakye, 2015).

The lowest Dissolved Oxygen (DO) values were recorded in stations 3 and 2 in February 2015 and December 2014 respectively. The low DO values (<5mg/l) recorded in December 2014, January, May and June 2015 (stations 1, 2 and 4) could be attributed to cumulative impact because DO values in this study showed the same trend in all the stations. The value recorded in station 3 could be attributed to abattoir effluent and was in line with related studies (Ubwa *et al*., 2013; Eni *et al.,* 2014). According to Chapman (1996), concentrations below 5mg/l may adversely affect the functioning and survival of biological communities and below 2mg/l may lead to the death of most fish.

The highest Biochemical Oxygen Demand (BOD) value was recorded in stations 3 in May 2015. The BOD values were generally higher throughout the study in station 3 except in November 2014 and April 2015; this could be attributed to the high organic contents of abattoir effluent released in the station. Studies have shown that abattoir effluents impact seriously on BOD values of the receiving water bodies (Omole and Longe, 2008; Ubwa *et al*., 2013). According to Chapman (1996), unpolluted waters typically have BOD values of 2 mg/l or less, whereas those receiving wastewaters may have values up to 10 mg/l or more, particularly near to the point of wastewater discharge.

The highest Chemical Oxygen Demand (COD) value was recorded at station 3 in March 2015. The trend observed in the COD values is similar to that of BOD; station 3 generally recorded higher values throughout the study except in April 2015 when the river was dredged. The values recorded in this study were quite low compared to related studies elsewhere. Omole and longe (2008) recorded values of 425.0 – 1675 mg/l in Illo River, Ota and Ubwa *et al*. (2013) recorded values of 444.0 – 1508 mg/l in a stream in Gboko all in Nigeria. The concentrations of COD observed in surface waters range from 20 mg/l or less in unpolluted waters to greater than 200 mg/ l in waters receiving effluents (Chapman, 1996).

The highest Phosphate value was recorded in December 2014 in station 3. Phosphate values followed the same trend in all the stations throughout the study and could be attributed to cumulative impact (Clarke, 1994). The phosphate values recorded in this study were generally low compared to Osibanjo and Adie (2007) that recorded higher values of 142 - 180 mg/l in Oshunkaye stream in Ibadan City, Nigeria. Phosphate is rarely found in high concentrations in freshwaters as it is actively taken up by plants. As a result there can be considerable seasonal fluctuations in concentrations in surface waters. In most natural surface waters, phosphate ranges from 0.005 to 0.020 mg/l (Chapman, 1996).

The highest nitrate value of was recorded in August 2015 (station 3) and were generally higher in station 3 throughout the study, which could be attributed the effect of abattoir effluent. Ubwa *et al*. (2013) recorded values within the same range (9.30 - 68.0 mg/l) in a stream in Gboko, Nigeria while Osibanjo and Adie (2007) recorded higher values (62 – 159 mg/l) in Oshunkaye stream in Ibadan City, Nigeria. According to Chapman (1996), when influenced by human activities, surface waters can have nitrate concentrations up to 5 mg/l, but often less than 1 mg/ l. Concentrations in excess of 5 mg/l usually indicate pollution by human or animal waste, or fertiliser run-off.

The highest sulphate value was recorded in April 2015 (station 3). This could be attributed to combined effect of the abattoir effluent and dredging activity carried out during the period (Ohimain *et al.,* 2008; Ubwa *et al*., 2013). Sulphate concentrations in natural waters are usually between 2 and 80 mg/l, although they may exceed 1,000 mg/l near industrial discharges or in arid regions where sulphate minerals, such as gypsum, are present. High concentrations (> 400 mg/l) may make water unpleasant to drink (Chapman, 1996).

Conclusion

A number of major anthropogenic activities were identified; these activities and other salient activities in the watershed have individually and cumulatively impacted on the water quality of Aba River. Some of the water quality parameters had elevated values but the most affected were turbidity (6.8 – 321NTU/FEPA, 10NTU), phosphate (2.3 – 79.8mg/l/FEPA, 5mg/l) and nitrate (7.4 – 79.8mg/l/FEPA, 20mg/l). These observed impacts on the water quality have directly or indirectly affected the ecological, domestic and other uses of the river. Residents cannot use the water for drinking, cooking, industrial or aquaculture purposes.

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