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The impact of urban environment and seasonality on the quality of Ikpoba River in Benin City, Nigeria

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Abstract
In Nigeria, most wastes (solid and liquid) are indiscriminately disposed off with partial treatment or untreated. While some wastes are dumped directly into the rivers, others are left on the earth surface and may later be moved through runoffs into the rivers and pollute them. This unwholesome and non-environment friendly practice necessitated this study which investigated the impact of urbanization and seasonal variation on the water quality in Ikpoba River, Benin City, Nigeria. Eight water samples were collected at different stations, namely pre-urban, Urban I, Urban II and post-urban. Four water samples were collected at each station during the dry season months of December 2005 and February 2006 and rainy season months of June and September 2006. Samples were analysed in laboratory for physico-chemical and microbial parameters such as PO_4^{-3}, Fe, Ca and BOD among others. A total of 500 questionnaires were administered and 492 (98.4%) well-filled questionnaires were analysed to determine the perception of the water quality by the respondents and also to what use they put the water. The data were analysed using percentages, correlation and ANOVA. The results show significant spatial and seasonal variation in the water quality, with pre-urban and dry season waters better in quality than the urban and rainy season. Urbanization was also observed to have negatively affected the water quality. The respondents used the water most for washing (30%), followed by swimming and bathing (24%) and drinking (19%). The constant and prolonged use of the polluted river water resulted in health problems like intestinal diseases, typhoid fever and skin diseases among others. It is recommended among others that the Ministry of Environment should stop both the industrialists and waste management agencies from using the river and its valley as dumping sites.

Key words: Ikpoba River, Nigeria, seasonality, urbanization, water quality, pollution, health.

Introduction
Man realized from the very beginning that water is essential for the satisfaction of his basic needs. As such, earliest human civilizations, concentrations and urbanization flourished on land made fertile by major rivers like the Tigris and Euphrates in Mesopotamia, the Nile in Egypt, the Indus in India and the Hwang–Ho in China, among others. Water makes life possible, and without it life, civilization or urbanization cannot survive and develop. Wars have been fought in the past over the availability of water and even now, relationship between nations is strained due to disputes over perceived mismanagement of shared water resources [1].

The usefulness of water as a resource is a function of its quality. The quality of water in the pre-industrial period was high because pollution was small and water plentiful [2]. Pollution at that time was low and mainly organic in nature, and watercourses were able to assimilate them and purify themselves [3]. However, with the era of industrial revolution, which began in the 16th century, and population explosion of the 20th and 21st century that concentrated more people in the urban areas, both the ground and surface waters have been found to be highly polluted mainly with inorganic pollutants such as chemical and industrial wastes [4-6].

As urban population increases, human activities also increase and more wastes are generated [7, 8]. In most developing countries, like Nigeria, wastes disposal systems are poor. While most of the wastes are indiscriminately dumped on land surface to decay, others are dumped directly into the rivers and lagoons [9, 10]. In most cities of the developing world, as in Southern Nigeria for example, land surfaces in several built-up compounds are not covered with grasses and trees, rather they are either left bare or cemented with concretes. Researches show that over 70% of built-up compounds in Benin City and Onitsha, Nigeria, are either left bare or cemented with concretes [11, 12]. The resultant increased runoffs lead to washing away of the surface wastes directly into the rivers, creeks and lagoons. Since waste collection system is very poor in Nigerian cities, most inhabitants of the cities see surface runoffs as veritable means of disposing their wastes. These wastes are carried into the rivers as overland flow [13]. Some of the dissolved pollutants infiltrate with water into the soil. The infiltrating water moves laterally in the subsurface soil and joins the streams or rivers as subsurface flow [14].

Surface water pollution has been conceptualised and linked to three components of the hydrological cycle, namely precipitation, overland flow and interflow or subsurface flow [15]. Point surface water pollution sources include effluents from industries, abattoirs and waste management plants. Other sources that are mainly non-point include sewage and solid wastes, agricultural chemicals and urban polluted atmosphere among others. All of these find their ways into surface waters through direct dumping, deliberate channelling, precipitation, overland flow and interflow. Apart from effluents from waste treatment plants, all other pollutants of surface water listed above affect the quality of Ikpoba River, Benin City, Nigeria.

Due to scarcity of portable water supply by governments at all levels, especially in developing nations, majority of the inhabitants that live along or near surface water courses heavily rely on these for their daily needs [2, 16]. It has been noted in China that approximately 700 million people, over half the population, consume water contaminated with levels of animal and human excreta with total coliform bacteria that exceed maximum permissible levels by as much as 86% in rural areas and 28% in urban areas [17]. In South Africa, over 15% of urban dwellers depend on polluted river waters for their domestic needs [4]. Over 70% of people in Sudan get their water supply from surface waters, which in most cases are polluted by agricultural chemicals and industrial effluents [3]. A research work revealed that over 40% of Nigerians depend on either polluted surface waters or wells for their domestic activities [2].

The constant use of heavily polluted water for a long time usually results in health problems. Researchers in different parts of the world have reported health problems associated with long time use of polluted river water, which range from dysentery, diarrhoea, abortion, premature birth, viral hepatitis and gastric and duodenal ulcers to hypertension among others [3, 18-21]. People have been living along the Ikpoba River and they use the water partly or wholly for their daily activities. The questions that come to mind are as follows. What are the impacts of human activities within the urban environment on the quality of the Ikpoba River? Is the volume of pollution of Ikpoba River seasonally determined? Of what uses is the river water mostly put into and what are the health implications of such uses? This study is designed to investigate these issues.

Materials and Methods

This study was carried out in a section of Ikpoba River in Benin City and environs. This stretch of the river studied lies within Utekon village (6°21'N, 5°30'E) (upstream) and Ikhueniro village (6°18'N, 5°41'E) (downstream). Ikpoba River takes its source from the Ishan Plateau, Edo State, Nigeria, at an elevation of 230 m above the sea level. It transverses Benin City and empties its waters into the Benin River. The area experiences an equatorial climate (Koppen's Af zone). Although there is hardly any month without some elements of rainfall, rains concentrate within the months of March and October (rainy season) while the dry season with little rainfall prevails between November and February. The mean annual rainfall total is constantly above 2000 mm, relative humidity is above 80% and the mean air temperature is 28^{o}C [11]. With this climatic condition, it is clear that the river lies within the tropical rainforest belt. As a result of deforestation, farming and other human activities, secondary rainforest prevails in the study area but most parts of the river valley are still protected with thick riparian vegetation.

Four sampling stations (Utekon village, Urban I, Urban II and Ikhueniro village) were selected for the study using the purposive technique. The first station is Utekon village (upstream) with a population of about 1000 inhabitants. It is 4 km away from and the nearest settlement to Benin City in the upstream of Ikpoba River. This station is referred to in this study as the pre-urban, that is, before the river enters the urban environment. The river valley is well protected in this area with dense tropical rainforest. Human activities here are scanty except for peasant farming (with little or no fertilizers being used), fishing, bathing and washing. The second station is Urban I, which is before the Ikpoba dam. The vegetation along the river valley at this point is dense and habitable buildings along the river valley are scanty. Human activities here include bathing, laundering and fishing. Two major abattoirs empty their untreated liquid and solid wastes in the river while there is a major channel that drains most parts of the moderately populated part of the city into the river. The third station is Urban II, which is toward the end of the city downstream. Here, the vegetation along the river valley is relatively sparse since parts of the river valley is built up and inhabited. Between Urban I and Urban II, there are lot of human activities taking place. These include six major abattoirs that empty their untreated liquids and solid wastes into the river. The same is applicable to a rubber factory, two poultry farms, two table water factories and two breweries in the area. Sewages are also indiscriminately and illegally dumped into the river at night since vehicles get access to the river in this area. Laundering, bathing, fishing and market gardening - using organic and/or inorganic fertilizers – are other human activities taking place between Urban I and Urban II. The fourth station is the post-urban, which means the river has passed through the urban area. The post-urban station (Ikhueniro village) is five kilometres downstream of the third station. Human activities are low with only one abattoir that empties its water into the river. Fishing, bathing and laundering are other human activities that take place along the river valley. The river valley is well forested at this stage with dense tropical forest between Urban II and post-urban station.

Data used in this study were derived from water analysis of Ikpoba River and questionnaire surveys. Samples were taken in December 2005 and February 2006 (dry season) and June and September 2006 (rainy season), this was to enable us determine the seasonal variation in water quality of the river. These months were selected because December and February are the driest months in the study area while the heaviest rainfall is recorded in June and September. Four water samples were collected each month from the four stations selected along the Ikpoba River. The first station pre-urban (Utekon village), Urban I, Urban II and post-urban are the second, third and fourth station respectively (Fig. 1).

The water samples were collected at 0.5 m depth and between 2 and 2.5 m into the river. This depth and length were chosen because bathing, washing and water for drinking is fetched within these distances and depth. Samples were sent to laboratory immediately after collection for analysis using the following notable methods. Atomic absorption spetrophotometer was used to determine copper (Cu), lead (Pb), nickel and zinc (Zn). Iron (Fe) was determined spectrophotometrically by the 1:10 phenanthroline method. Phosphate (PO_4^{-3}) and nitrate (NO_3^-) were determined using brucine colorimetric technique. Flame photometry was used for sodium (Na) determination . Calcium (Ca) was analysed with a Techicon autoanalyzer and Seiko ANA 180 was used to measure

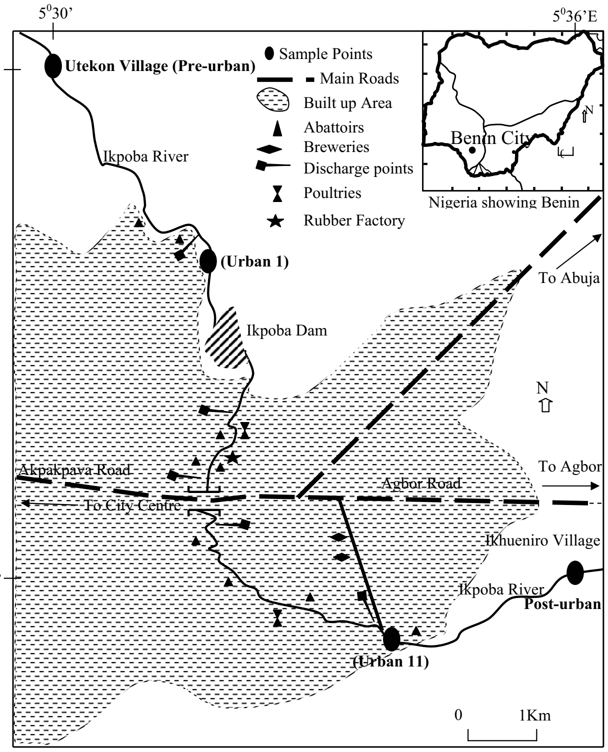

Figure 1. Ikpoba River in Nigeria showing the study area.

magnesium (Mg). Water temperature, hydrogen-ion concentration (pH), turbidity, conductivity, total dissolved solid (TDS) and biochemical oxygen demand (BOD) were measured *in-situ* using the multi-parameter water quality monitor (Orion Model 1260).

The laboratory values were compared with the World Health Organisation (WHO) 2006 and Federal Ministry of Environment (FMENV) 2006 standard guidelines for drinking water quality. The compliance level of the laboratory result with WHO/FMENV standard guidelines was computed using the equation [22] : PC = (NI x P)/N, where PC percentage compliance, NI number of times parameters complied with the stated standard, N total number of measurements and P 100% (assumed maximum compliance limit). The compliance rates were analysed using water quality classification scheme [23] as shown in Table 3.

To solicit the opinions of the respondents on their perception of the water quality, the uses to which they put the water and the health problems they have been experiencing with the constant use of the water, 500 people (sample) were selected out of the estimated 11,000 people. As a result of population differentials, 50 questionnaires were administered each to pre-and post-urban areas while Urban I and Urban II had 100 questionnaires each. In the pre- and post-urban regions, a questionnaire was administered to a randomly selected inhabitant of every other inhabited house while in the Urban I and II, every third and fifth inhabited house respectively was used. In each house, a respondent was randomly determined and a questionnaire was given to the selected respondent to answer. One hundred questionnaires were administered to workers of purposely selected rubber factory, one randomly selected brewery and two randomly selected abattoirs that discharge their effluents and part of their solid wastes directly into the river. The rubber factory was purposely selected to ensure that each group of the population is well represented. Finally, the remaining 100 questionnaires were administered to five randomly selected government registered waste management companies. Among the company workers that answered the questionnaires, half of the respondents were senior staff (grade level 08 and above) while the remaining half went to junior staff (below grade level 08). This was to ensure that both categories of staff were well represented. At the end, 492 (98.4%) well filled questionnaires were analysed.

The questionnaires were analysed using percentages. With the aid of SYSTAT statistical software [24] the relationship between the rainy and dry season water quality was analysed using the Pearson correlation, and the ANOVA was employed to show whether the differences in spatial water quality is statistically significant.

Results and Discussion

Physico-chemical analysis of water quality: As shown in Tables 1 and 2, the pre-urban region with water quality compliant rate of 96% during the dry and rainy seasons is an indication of excellent water quality (Table 3). Urban I with compliant rate of 84.6%, Urban II (46.2%) and post-urban (50%) show that the water quality ranged between good and poor during the dry season in these stations (Table 1). While Urban I (65.4%) was moderately polluted during the rainy season, water quality was poor at Urban II (46.2%) and post-urban (46.2%). Apart from the microbial factors, the pre-urban water conforms to the WHO/FMENV drinking water quality standards during the dry and rainy seasons. This is also true with the Urban I with the exception of iron and pH values that exceeded the WHO/FMENV standards during the dry season. Aesthetically, biologically and chemically Urban II and post-urban waters were poor in both seasons (Tables 1 and 2).

Aesthetically, physical parameters like colour, turbidity and total dissolved solids were above the WHO/FMENV recommended standards for drinking water in Urban II and post-urban in both seasons (Tables 1 and 2). Chemically, micro- and macro-minerals like lead (Pb), iron (Fe), manganese (Mn) and phosphate (PO_4^{-3}) were above the WHO/FMENV acceptable range for drinking water in both seasons. Also worthy of note in the Urban II and post-urban water, especially during the rainy season, is the level of water hardness and acidity. The water hardness must have resulted from the enhanced values of calcium and magnesium. The acidic nature of the water could be attributed to two basic factors. The first factor is that the river flows through dense tropical rainforest where surface runoffs of decayed organic matters derived from surrounding vegetation are washed into the river as earlier observed [25]. This fact is further supported by the elevated high levels of BOD in the urban areas and post-urban (Tables 1 and 2). The second factor is due to surface runoffs (non-point pollutants) from the urban environment and point pollutants from industries and drainage systems, which lead to relatively high level of sulphate and nitrate during the rainy season. Particles of emitted sulphate and nitrate in the air fall as acid rains and they are washed into surface waters by runoffs. Acid rains have been reported in urban and industrial areas of both developed [26] and developing countries [27, 28]. The BOD values of Urban II and post-urban were higher than the acceptable range. This pattern holds sway with the total coliform bacteria and *Escherichia coli* (*E. coli*) (Tables 1 and 2). The blood and solid wastes from the abattoirs, indiscriminately dumped sewages and

Table 1. Physico-chemical analysis of Ikpoba River during dry season.

	Parameter	Pre-urban	Urban I	Urban II	Post-urban	WHO/FMENV
1	Temperature °C	25.6	26.4	26.6	26.5	20-30
2	Colour (TCU)	3.3	12.2	16.2	15.6	15.0
3	Odour/Taste (TON)	ND	ND	1.6	1.0	3.0
4	pH	7.46	6.25	5.48	5.12	6.5-8.15
5	Conductivity (EEC) mS/cm	0.1	0.2	0.4	0.4	1.5
6	Turbidity (NTU)	2.23	4.25	8.16	7.21	5
7	Total dissolved solids mg/l	150.2	442.4	1250.5	1050.2	1000
8	Hardness mg/l	8.5	36.2	121.6	115.7	100
9	Chloride (Cl) mg/l	12.64	26.92	165.2	162.4	250
10	Nitrate (NO_3) mg/l	0.5	1.2	6.1	5.7	50
11	Sulphate (SO_4) mg/l	0.4	5.0	10.3	9.1	250
12	Phosphate (PO_4^{-3}) mg/l	0.5	1.9	6.4	6.1	5
13	Sodium (Na) mg/l	6.5	15.9	48.3	46.2	200
14	Magnesium (Mg) mg/l	3	16	52.4	52.3	200
15	Calcium (Ca) mg/l	4	20	65	60	200
16	Copper (Cu) mg/l	0.01	0.002	0.03	0.03	1.0
17	Manganese (Mn) mg/l	0.01	0.02	0.03	0.02	0.05
18	Lead (Pb) mg/l	0.003	0.008	0.02	0.02	0.01
19	Nickel (Ni) mg/l	0.003	0.005	0.01	0.009	0.02
20	Zinc (Zn) mg/l	0.04	0.04	0.08	0.08	3
21	Iron (Fe) mg/l	0.10	0.31	0.46	0.45	0.3
22	Total coliform bacteria CFU/100 ml	20.0	200.0	430.0	426.0	00
23	*E. coli* CFU/100 ml	10.0	80.0	126.0	126.0	00
24	Yeast mg/l	N.D.	10.0	250.0	220.0	100
25	BOD mg/l	1.0	1.5	10.0	8.0	<6
26	COD mg/l	1.0	4.0	22.0	21	
	Compliance rate %	96.2	84.6	46.2	50.0	

Source: Fieldwork, 200

Table 2. Physico-chemical analysis of Ikpoba River during rainy season.

	Parameter	Pre-urban	Urban I	Urban II	Post-urban	WHO/FMENV
1	Temperature °C	25.5	26.0	26.4	25.7	20-30
2	Colour (TCU)	8.8	18.6	27.7	27.1	15.0
3	Odour/Taste (TON)	ND	0.45	1.2	1.0	3.0
4	pH	7.8	5.8	4.04	4.96	6.5-8.15
5	Conductivity (EEC) mS/cm	0.54	1.4	1.8	1.2	1.5
6	Turbidity (NTU)	4.0	8.8	18.9	18.8	5
7	Total dissolved solids mg/l	480	1080.4	1843	1806	1000
8	Hardness mg/l	12.4	51.5	158.2	146.5	100
9	Chloride (Cl) mg/l	14.3	142.8	210.5	195.2	250
10	Nitrate (NO_3) mg/l	0.5	3.6	8.2	8.0	50
11	Sulphate (SO_4) mg/l	1.6	8.2	18.4	17.8	250
12	Phosphate (PO_4^{-3}) mg/l	0.6	2.8	8.6	7.8	5
13	Sodium (Na) mg/l	12.6	47.4	156.2	144.8	200
14	Magnesium (Mg) mg/l	4.8	21.2	70.7	66.4	200
15	Calcium (Ca) mg/l	8.3	27.5	75.3	70.4	200
16	Copper (Cu) mg/l	0.01	0.02	0.05	0.05	1.0
17	Manganese (Mn) mg/l	0.01	0.03	0.06	0.05	0.05
18	Lead (Pb) mg/l	0.005	0.01	0.04	0.04	0.01
19	Nickel (Ni) mg/l	0.004	0.006	0.01	0.009	0.02
20	Zinc (Zn) mg/l	0.05	0.8	1.2	1.0	3
21	Iron (Fe) mg/l	0.25	0.32	0.61	0.59	0.3
22	Total coliform bacteria CFU/100 ml	25.0	380.0	660.0	655.0	00
23	*E. coli* CFU/100 ml	10.0	110.0	250.0	240.0	00
24	Yeast mg/l	ND	40	350	320	100
25	BOD mg/l	1.0	3.5	16.0	14.5	<6
26	COD mg/l	2.0	12.0	46.0	40.6	
	Compliance rate %	96.2	65.4	46.2	46.2	

Source: Fieldwork, 2006.

effluents from the abattoirs, the breweries and the rubber factory must have enhanced the level of phosphate, coliform bacteria and BOD in Urban II and post-urban. These again must have partly accounted for the thick layers of algae observed in the stagnant and slow flowing sides of the river within Urban II and post-urban sections of the study area. While the BOD values show that the water is excellent in the pre-urban in both seasons,

Table 3. Water quality classification [23].

Quality score	Quality class
91 – 100	Excellent
71 - 90	Good
51 - 70	Moderately polluted
21 – 50	Poor
0 – 20	Very poor

it ranges between excellent during the dry season and acceptable during the rainy season in Urban I.

The pre-urban water quality was excellent because from the source of the river to the pre-urban point, there are few villages along the river that could pollute it. Another reason is that there are no industries that discharge their effluents into the river while the agricultural practice is that of peasant farming with little or no fertilizers that could be non-point sources of pollutants. This finding is in agreement with previous researches, where excellent water quality was found in the rural areas of Ethiope River in Nigeria [29].

The poor water quality experienced in Urban II and post-urban could be attributed to a number of factors. The first one is the cumulative pollutants carried from Urban I. The second factor is the concentration of human activities between Urban I and Urban II. Within this stretch, there are two breweries, two table water factories, a rubber factory, six abattoirs**,** two poultries and four laundries and car washing centres that discharge their untreated effluents directly into the river. Thirdly, there are four major drainages that link the city centre, part of the moderate and high-density residential areas and three markets to the river. The wastewaters from these sources flow into the river throughout the year. The fourth one is indirect factors. Among these are contaminants from illegal dumpsites along the river valley and organic and inorganic fertilizers from agricultural areas (market gardening). These findings agree with earlier works which showed that China's extraordinary economic growth, industrialization, urbanization, non-point sources from agricultural areas, coupled with inadequate investments in water supply and treatment infrastructure have resulted in the widespread of water pollution in China [5, 17, 30]. Studies carried out in Kangaroon Valley, Australia; the blue Danube and Black Sea; Kaoping River Basin, Taiwan; de los Funea River, San Luis, Argentina; River Bagmati, Nepal and Msumbazi River, Dar es Salaam, Tanzania, also showed that urbanization, industrial and sewage discharge into rivers, pollutants from agricultural areas, livestock wastewaters from farms and abattoirs and municipal runoffs impacted negatively on river water quality [6, 31-34].

The post-urban water quality downstream is relatively better than the heavily polluted Urban II because the river is naturally cleansing itself of contaminants and there is only one abattoir that empties its effluents into the river. There are no industries in this stretch of river and non-point pollutants are limited. If not for the natural cleansing, the cumulative pollutants from upstream pre-urban, Urban I and Urban II would have drastically increased the volume of contaminants in downstream post-urban. An earlier study also confirmed self-cleansing of the polluted Msumbazi River in Dar es Salaam, Tanzania [35].

It is obvious from the above analysis and Tables 1 and 2 that there is a spatial variation in water quality along the river course. The computed $F = 4.25$ is higher than 3.01 critical value which shows that the spatial variation in water quality of Ikpoba River is statistically significant at $p < 0.05$. From the spatial variation of the water quality, the pre-urban can be grouped as a low water pollution region. While Urban I is regarded as medium water pollution region, Urban II and post-urban is a region of heavy water pollution. The rate of progressive pollution as the river moves from pre-urban through the urban region is a clear indication of the effects of urbanization and its associated human activities. In support of the findings of this paper, a research work in Beijing, China, showed that urban and peri-urban surfaces and ground water quality deteriorated drastically due to agricultural activities and other non-point pollution sources [36].

The water quality during the dry season in all the experimental sites is better than that of the rainy season (Tables 1 and 2). A χ^2 value of 5.2 is higher than the critical value of 3.84, which shows that the seasonal variation in the water quality is statistically significant at $p < 0.05$. The poor water quality during the rainy season when compared with the dry season could be attributed to pollutants (solid and liquid) washed into the river from the metropolitan city through both surface runoffs and underground seepages. This agrees with the result of an earlier study that showed significant seasonal variation in water quality in the Gongola River, Nigeria [37].

Perception of water quality and usage: The way the respondents perceived the water quality was compared with the mean laboratory analysis of the quality of the river water in dry and rainy seasons and the result is presented in Table 4. The perceived water quality agreed with the laboratory analysis in pre-urban and Urban I but did not correspond with Urban II and post-urban regions. Majority of the pre-urban respondents (85%) perceived the water to be excellent for human consumption; the result of laboratory analysis (compliance rate), which shows a mean value of 96%, confirmed this. Exactly 62% of the respondents in Urban I rated the water to be good, the laboratory analysis (75%) shows the same. Majority of respondents in Urban II (81%) and post-urban (74%) respectively rated the water as moderately polluted whereas the laboratory analysis showed that the water (Urban II, 46%; post-urban, 48%) was poor. One thing that is obvious is that the respondents' rating is a step higher than the laboratory analyses in Urban II and post-urban. Previous studies also revealed that most respondents have poor perception of water quality in their environment [4, 15].

The respondents' perception must have necessitated the usage to which the river water is put as shown in Table 5. The pre-urban respondents used the river water more for drinking (30%) despite the fact that there is a borehole in the village (Utekon) and almost every compound has water storage tank they use in storing harvested water during the rainy season. Two basic reasons were given for their action: first, they perceived the water to be excellent (Table 4) and free of pollution. The other reason is that the water temperature is lower, making it cooler and more refreshing to drink especially during the dry season and hot days. The Urban I (29%) and II (34%) and post-urban (38%) respondents used the water more for washing, followed by swimming/bathing. The rate of waste dumping (solid and liquid) into the river and its valley by industries, individuals and environmental sanitation agencies is high and disturbing. Although, there are eight government approved dumpsites in the outskirt of Benin City, 9 and 16% respectively of respondents in Urban I and Urban II showed that their wastes were dumped either inside or along the river valley (Table 5). While the industries along the river valley channelled their waste pipes or drains directly into the river and contaminate it day and night, the waste management agencies that answered the questionnaires agreed that they occasionally do their dumping at night in order to avert tax paid at the dumping sites. On the other hand, the industries saw it cheaper to pay the tax for

Table 4. Respondents perceived water quality rating.

Urban zone	Percentage of respondents perceiving water for human consumption					Mean laboratory analysis rating (%)
	Excellent	Good	Moderately polluted	Poor	Very poor	
Pre-urban	85	7	3	3	2	92.0 {Excellent}
Urban 1	8	62	21	2	7	72.0 {Good}
Urban 11	0	10	81	4	5	22.0 {Poor}
Post-urban	3	16	74	6	1	28.0 {Poor}

Source: Fieldwork, 2006.

Table 5. River water and valley usages.

Urban zone	Percentage usage						
	Cooking	Washing	Drinking	Swimming/ Bathing	Irrigation	Dumping	Fishing
Pre-urban	13	18	33	24	8	0	4
Urban 1	18	29	16	23	4	9	2
Urban 11	6	37	10	26	6	16	1
Post-urban	13	38	18	23	4	2	2
Mean	4.5	30.0	19.3	24.0	5.5	6.5	2.3

Source: Fieldwork, 2006

environmental pollution than treating and recycling their wastewater.

Generally the water is used more for washing, followed by swimming and bathing and drinking (Table 5). This is in agreement with earlier findings, which showed that while Ethiope River is used more for drinking among the Umutu community of Delta State, Nigeria [38], in Jimeta, Adamawa State, Nigeria, the inhabitants use the Benue River water more for washing followed by drinking[39].

Health implications: The highest complaint of health problems as shown in Table 6 is associated with Urban II (36%) followed by post-urban (32%), Urban I (21%) and pre-urban (11%). This observed spatial health pattern is in line with the pattern of pollution and water quality compliant rate in Tables 1 and 2. This implies that the more the rate of pollution, the more likely the health problems if the polluted water is constantly in use. Diseases/ symptoms like vomiting, diarrhoea, abdominal pains, dysentery, jaundice and skin irritation prevailed more among the respondents in Urban II and post–urban. The high incidence of these diseases in the Urban II and post-urban areas can be attributed to the high concentration of waterborne pathogens and micro-minerals like iron, zinc and copper in the river water at that stretch (Tables 1 and 2). It has been shown that drinking water with high dose of micro-minerals for a long time has resulted in diseases like diarrhoea, dysentery, vomiting, nausea, premature birth, viral hepatitis, gastric and duodenal ulcers, hypertension and abdominal pains among others in different countries [3, 18-20,40]. High rate of cancer, spontaneous abortion and diminished intelligence quotient (IQ) were reported to be associated with long time consumption of water from the highly polluted Huai, Hai and Yellow Rivers in China [21].

Typhoid and malaria fever occurred more in the pre-urban and Urban I. While typhoid fever is associated with the drinking of the river water polluted by bacteria, malaria fever is not connected with the drinking of the river water. Rather, the stagnant and/or slowly moving sides of the river provide a favourable environment for mosquito breeding. The high incidence of malaria fever in pre-urban (40%) and low incidence in Urban II (14%) could be explained by the nature of the buildings and body exposure to mosquito bites. When administering the questionnaires at Utekon village (pre-urban), it was observed that 86% of the buildings surveyed had no ceilings while 92% of the buildings did not have mosquito nets in their doors and windows. Moreover, all the respondents interviewed showed that they have not been sleeping inside treated mosquito nets. While 16% of the respondents acknowledged the fact that they occasionally sprayed their houses with insecticides, 84% were not using insecticides. In the evenings and early parts of the night, majority of the villagers usually sit outside relaxing and telling stories especially when there is power outage (a common phenomenon in Nigeria). This situation and habit exposed them to constant mosquito bites and the occurrence of malarial fever. On the other hand, 98% of the buildings surveyed in Urban II were with ceilings, 73% have mosquito nets in their doors and windows and they had more regular power supply either from the national energy supply or personal generators. Studies have shown that the rate of mosquitoes entering buildings with roofs ceiled is lower than roofs not ceiled and that people living in buildings not ceiled are more exposed to mosquito bites and occurrence of malarial fever [40, 41]. Also significant is the 56% of the respondents who agreed that they always sleep under treated mosquito nets and 62% on daily basis spray their houses with insecticides. These situations kept them more indoors and lesser exposure to mosquito bites and hence lower malarial incidents.

Majority of the respondents in pre-urban (33%) drank the river water without treatment (Table 5). This must have accounted for the high incidence of typhoid fever (37%) recorded in the area (Table 6). The reverse is the case with Urban II where few respondents (10%) drank the river water (Table 5) with resultant lower incidence of typhoid fever (18%) (Table 6). Odjugo [19] also observed similar health problems like malarial and typhoid fever, diarrhoea and dysentery among the Ubeji community along Ubeji Creeks, Warri, Nigeria.

Conclusions

This study revealed both seasonal and spatial variation in water quality of Ikpoba River. The water quality during the dry season was significantly better than that of the rainy season, while the pre-urban water quality that outweighed the quality of the urban and the post-urban. Urbanization and its associated human activities like industrial discharges, wastes from abattoirs, municipal wastes through runoffs, and sewage and solid wastes dumped

Table 6. Health problems associated with the use of the river water.

Disease	Percentage of respondents indicating specific diseases			
	Pre-urban	Urban I	Urban II	Post-urban
Diarrhoea	2	24	42	32
Abdominal pains	2	22	42	34
Vomiting	0	13	51	36
Dysentery	6	20	36	38
Typhoid fever	37	25	18	20
Malaria fever	40	25	14	21
Skin irritation	2	24	43	31
Jaundice	0	17	46	41
Mean	11.0	21.0	36	32

Source: Fieldwork, 2006

into the river and its valley by individuals and waste management agencies, among others were found to have diminished the river water quality and constituted sanitary risks. Although the perceived water quality did not totally agree with the laboratory results, it was found to have influenced the choice to which the river water was used. Such usage over a considerable period of time may have resulted in some of the respondents suffering from some waterborne or related diseases like vomiting and diarrhoea among others.

As a remedial measure for the observed pollution, the government through the Federal and State Ministries of Environment should ensure the strict enforcement of the industrial wastewater discharge standards. Strict enforcement is important since weakly regulated industrial ethics and insufficiently coordinated management of water resources are two leading factors contributing to severe water pollution in Nigeria. This implies that the Federal and State Ministries of Environment should monitor closely the river course in order to prevent the river from being a dumping ground for industries and waste management agencies. The government should perfect its current poor domestic waste collection systems. Since the waste management agencies have failed to collect domestic wastes from individual households in Benin City, like in other cities in Nigeria, the government should establish waste collection centres within the city where individual households can dump their wastes. While this will help and ease the evacuation of the wastes by the waste management agencies to the dumpsites in the outskirts of the city, it will also prevent people from dumping their domestic wastes on unauthorized earth surfaces, drainage channels and into runoff waters, which eventually enter the river. Government should provide pipe borne water to those living along the river valley, since this will likely limit their frequent contacts and usage of the river water and consequently reduce the incidence of water-borne diseases.

Government at all levels (local, state and federal) and NGOs should provide enlightenment campaign programmes on the health implications of drinking from and bathing and washing inside the polluted river water. This is imperative and urgent because some, due to illiteracy and ignorance, still claim that the observed waterborne diseases were not as a result of the river water they drank, for according to them, their fathers and forefathers consumed the river water and they had no such diseases. However, they failed to recognise the fact that the rate of pollution then was far lower than the current rate due to increasing urbanization and its associated activities. Currently, the river water is not safe for drinking and swimming/bathing but if it must be used for these purposes, it should be fetched and given appropriate treatments.

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