

Original Research Article

Seasonal variations in Physico-chemical and Bacteriological parameters of Ulasi River, Okija, Anambra state

Abstract

The water quality conditions between December 2014 and July 2015 at the upstream and downstream of Ulasi River, Okija were evaluated for the influence of rural land use activities.

~~The upstream and downstream water quality assessment of Ulasi River, Okija, were evaluated between December 2014 and July 2015 for the influence of rural land use activities.~~ Samples were collected at 50m in triplicates from each location and the physico-chemical properties of these water samples were evaluated. Samples were stored in containers filled with ice packs and immediately taken to the laboratory to investigate some selected physico-chemical characteristics. Also, bacteriological study was carried out on the samples to check for the presence of coliforms. Results obtained were compared with World Health Organization (WHO) standard for permissible drinking water. Results obtained for turbidity are 205 ± 0.70 (downstream), 25.70 ± 0.00 (upstream) for wet season and 138 ± 0.60 (downstream), 15.8 ± 0.03 (upstream) for dry season. Turbidity values were significantly higher ($p < 0.05$) during wet season than dry season and downstream values were significantly higher ($p < 0.05$) than upstream values when compared with WHO standard. pH values were 5.90 ± 0.00 (downstream), 5.91 ± 0.31 (upstream) for wet season and 6.10 ± 0.00 (downstream), 6.12 ± 0.11 (upstream) for dry season. The results of bacteriological study showed that all the sampling locations in downstream and upstream contained significantly higher ($p < 0.05$) numbers of coliform bacteria and *E. coli* in both wet and dry seasons. The number of coliform bacteria and *E. coli* during wet season was 25.00 ± 0.00 , 2.00 ± 0.00 (downstream), 17.00 ± 0.00 , 1.00 ± 0.00 (upstream), and 18.00 ± 0.02 , 2.00 ± 0.00 (downstream), 7.00 ± 0.01 , 1.00 ± 0.00 (upstream) respectively during the dry season. Iron, ammonia and TOC content were significantly higher ($p < 0.05$) when compared with WHO standard. This makes the water unsuitable for drinking and human usage and also a threat to the lives of the rural community.

Keywords: Ulasi River, water quality, Wet season, dry season, upstream, downstream.

Introduction

Water is one of the most important of all the natural resources available on the earth. It covers 71% of the earth's surface and is vital for all known form of life. Clean and safe water is both food and health! Potable, adequate and accessible water is therefore a public asset and a vital social welfare facility to measure levels of development in space [1]. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Natural water which contains different types of impurities are introduced into aquatic system by different ways such as weathering of rocks and leaching of soil, dissolution of aerosol particles from the atmosphere and from several human activities, including mining, processing and the use of metal based materials [2].

However, access to safe water supply and sanitation is a global issue and varies significantly across the globe. The World Bank Group in their study argued that nearly half of the world

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population lack access to safe water supply and basic sanitation, and the situation is most appalling among the developing countries [3]. Chemical analysis of the water quality indices of some Nigerian Rivers reveals that water which was once an abundant natural resources is rapidly deteriorating in quality, owing to population increase and industrialization. Industrial activities, urbanization, exploration activities, refining activities in developing countries like Nigeria are some major ways through which rivers, waterbodies, creeks, swamps have been contaminated. These contaminated rivers had in one way or the other constituted public hazards and socioeconomic hazards to the flora and fauna [4]. The greatest microbial risks are associated with ingestion of water that is contaminated with human or animal faeces. Wastewater discharges in fresh waters and costal seawaters are the major source of faecal microorganisms, including pathogens. Confirmation of *E. coli* in a water system indicates recent faecal contamination, which may pose an immediate health risk to anyone who consumes the water. Access to safe and quality water is very difficult to be obtained by a number of populations throughout the world. According to the WHO [5], the mortality of water associated diseases exceeds 5 million people per year. From these, more than 50% are microbial intestinal infections, with cholera standing out in the first place. The aim of this study is to assess the upstream and downstream water quality of Ulasi River, Okija, for the influence of rural land use activities during the wet and dry seasons. The Ulasi River is the main source of water for domestic and other uses in Okija community in area of Anambra state. It is a widely spread river found in south eastern Nigeria. The Ulasi river starts from the hills in Dikenafai (latitude 050 45'N, longitude 070 10'E), in Imo State, it flows through several towns in both Imo and Anambra States (Ezinifite, Urualla, Akokwa, Okija, Ihiala, Uli, Mgbidi) gathering tributaries in its course. It forms a confluence with the Oguta Lake at Oguta, before flowing parallel to the River Niger. At some point, as the river flows southward, the name changed, due to dialectic pronunciation, to Ulashi (or Orashi). Hence it continued its flow as River Ulashi through Obiakpo, Ebocha, Kreigani, Ukodu (Bayelsa State) and Mbiama. Urashi takes another left at Okarki, flowing east to Igovia and then south-east to Egbama and Agunughan but more southerly into Orashi National Forest and Arukwa. The river overflows its banks every August and gradually recedes by subsequent months, depositing alluvial soils on its banks and floodplains, which are very fertile [6].

Methodology

Sample Collection:

Water samples were collected in triplicates at 50m interval between each sampling points from the upstream and downstream to cover both dry (December 2014) and wet (July 2015) seasons. The distance between upstream and downstream is 1.3km. A total of 36 samples were collected; 9 from the upstream and 9 from downstream in both seasons respectively. The samples were collected on the same day for each season. At the time of sample collection, each sample bottle was held at the base while a gloved hand was used to uncover the bottle. The bottle was then immersed to about 30cm below, with its mouth in upstream direction. The sample bottles were tightly capped, appropriately labelled and immediately conveyed to the laboratory and stored in refrigerator before analyses [7].

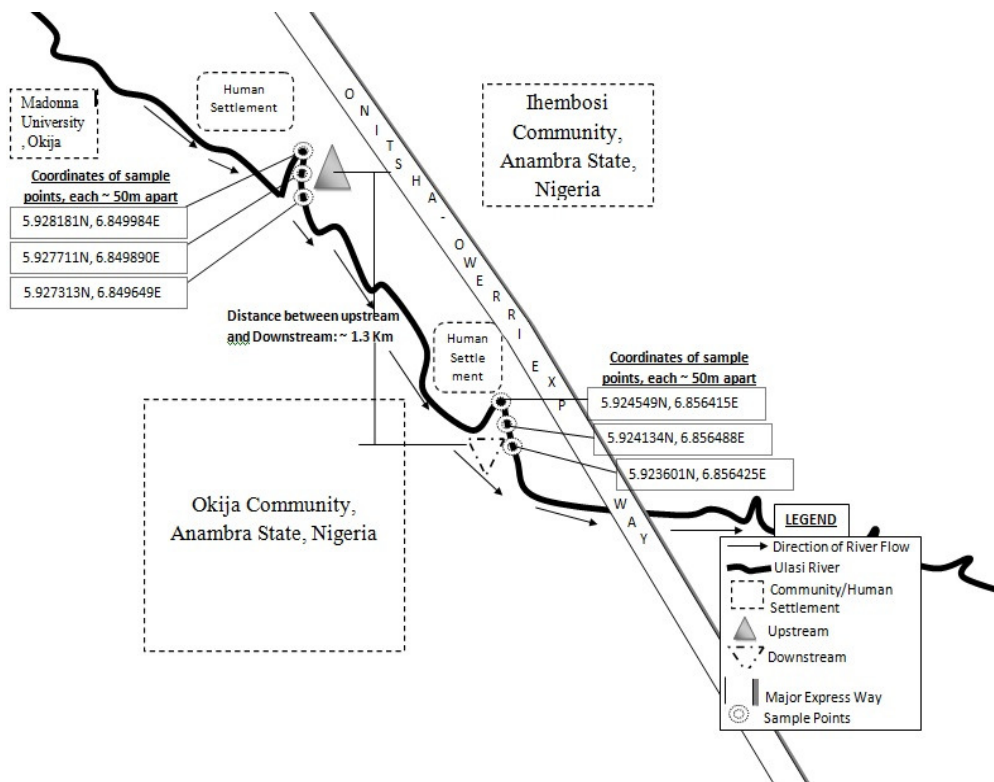


Figure 1: Map of a section of Ulsi River showing upstream and downstream sampling points.

Analysis of sample

Standard analytical procedures were used in the determination of selected physical, chemical and biological water quality parameters of the sample. The Selected physio-chemical analysis carried out include pH, temperature, turbidity, electrical conductivity (EC), total suspended solids (TSS), Nitrites, Nitrates, total hardness, Magnesium hardness, Chlorides, dissolved CO₂, etc. The pH was determined using the procedure described with Jenway 3015pH meter [8]. Calcium was determined using the flame atomic spectrophotometer. Iron and ammonium content of the sample were determined using spectrophotometer and photometer respectively. Nitrites and nitrates were measured using photometer. Bacteriological study was done using multiple tubes/ most probable number method. Turbidity was measured using turbidometer [9]. Iron, Lead and Aluminium were measured using Spectrometer [10]. Calcium and Magnesium were measured using spectrophotometer [11]. Ammonium was measured using Photometer [12]. Nitrites were measured using spectrophotometer [13]. Bacteriological study was done using most probable number method [14].

Statistical Analysis: Descriptive statistics, as well as T-test were used to statistically analyse the data generated from laboratory investigation.

Results and Discussion:

107 The mean results and standard error of the water quality parameters recorded from Ulas
 108 River Upstream and downstream during the wet and dry seasons are presented in Tables 1 to
 109 4 respectively.

110 **Table 1: Physico-chemical parameters of Ulas River water sample (downstream)**
 111 **during the wet season**

Parameters	Results	WHO Standards ^[5]
Appearance	Muddy	Clear
Colour In Hazen Unit	285 ± 0.54	5 Hazen Units
Turbidity (NTU)	205 ± 0.70	5 N.T.U
Odour	-	-
Taste	-	-
Conductivity(Us/Cm)	21.80 ± 10.96	1000 US/CM
Acidity (C.C) Of 0.5% Na ₂ CO ₃ (mg/l)	30.00 ± 0.00	
pH	5.90 ± 0.00	6.5-8.5
Chloride as Cl (mg/l)	35.50 ± 0.00	250mg/l
Chloride as NaCl (Mg/L)	58.50 ± 0.02	
Total Alkalinity as CaCO ₃ (mg/l)	15.65 ± 0.01	
Total Hardness as CaCO ₃ (mg/l)	56.00 ± 0.02	500mg/l
Calcium Hardness (mg/l)	22.00 ± 0.00	
Magnesium Hardness (mg/l)	24.00 ± 0.56	
Total Iron as Fe (mg/l)	2.70 ± 0.48	0.30mg/l
Sulphate as SO ₄ (mg/l)	12.04 ± 0.04	400mg/l
Sodium as Na (mg/l)	23.00 ± 0.00	
Bicarbonate as HCO ₃	21.50 ± 0.00	
Free Saline Ammonia (NH ₄) (mg/l)	0.185 ± 0.00	0.05mg/l
Nitrates as N (mg/l)	2.00 ± 0.01	10.00mg/l
Nitrites as N(mg/l)	0.01 ± 0.01	1.00mg/l
T.D.S (mg/l)	11.00 ± 0.00	1000mg/l
Dissolved Free Co ₂ (mg/l)	10.56 ± 0.03	
Arsenic (mg/l)	0.00 ± 0.00	0.05mg/l
Benzene (mg/l)	0.00 ± 0.00	0.007mg/l
Fat And Oil (Mg/L)	0.00 ± 0.00	0.003mg/l

Biological O ₂ Demand (mg/l)	7.50 ± 0.06	
Chemical O ₂ Demand (mg/l)	35.00 ± 0.00	
Total Organic Compound (mg/l)	10.00 ± 0.01	5.00mg/l
Coliform	25.00±0.00	Absent in 100ml
<i>E coli</i>	2.00 ±0.00	Absent in 100ml

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113 **Table 2: Physico-chemical parameters of Ulasi River water sample (Upstream) during**
114 **the wet season**

Parameters	Results	WHO Standards ^[5]
Appearance	MUDDY	CLEAR
Colour in Hazen Unit	33.00 ± 0.00	5 Hazen Units
Turbidity (NTU)	25.70 ± 0.00	5 N.T.U
Odour	-	-
Taste	-	-
Conductivity (Us/Cm)	23.90 ± 0.00	1000 US/CM
Acidity (C.C) of 0.5% Na ₂ CO ₃ (mg/l)	28.00 ± 0.00	
pH	5.91 ± 0.31	6.5-8.5
Chloride as CL (mg/l)	42.60 ± 0.00	250mg/l
Chloride as NaCL (mg/l)	70.20 ± 0.09	
Total Alkalinity as CaCO ₃ (mg/l)	20.00 ± 0.00	
Total Hardness as CaCO ₃ (mg/l)	28.00 ± 0.06	500mg/l
Calcium Hardness (mg/l)	21.00 ± 0.00	
Magnesium Hardness (mg/l)	7.00 ± 0.10	
Total Iron as Fe (mg/l)	0.70 ± 0.04	0.30mg/l
Sulphate as SO ₄ (mg/l)	13.86 ± 0.21	400mg/l
Sodium as Na (mg/l)	27.60 ± 0.05	
Bicarbonate as HCO ₃ (mg/l)	15.65 ±0.00	
Free Saline Ammonia (mg/l)	0.270± 0.00	0.05mg/l
Nitrates as N (mg/l)	0.092 ± 0.01	10.00mg/l
Nitrites as N (mg/l)	0.001 ± 0.00	1.00mg/l
T.D.S (mg/l)	11.30 ± 0.00	1000mg/l

Dissolved CO ₂ (mg/l)	17.60 ± 0.11	
Arsenic (mg/l)	0.00 ± 0.00	0.05mg/l
Benzene (mg/l)	0.00 ± 0.00	0.007mg/l
Fat And Oil (mg/l)	0.00 ± 0.00	0.003mg/l
Biological O ₂ Demand (mg/l)	4.50 ± 0.01	
Chemical O ₂ Demand (mg/l)	21.00 ± 0.00	
Total Organic Compound (mg/l)	6.00 ± 0.04	5.00mg/l
Coliform	17.00±0.00	Absent in 100ml
<i>E coli</i>	1.00±0.00	Absent in 100ml

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117 **Table 3: Physio-chemical parameters of Ulasi River water sample (Downstream) during**
118 **the dry season**

Parameters	Results	W.H.O Standards ^[5]
Appearance	Muddy	Clear
Colour In Hazen Unit	325 ± 0.54	5 Hazen Units
Turbidity (NTU)	138 ±0.60	5 N.T.U
Odour	-	-
Taste	-	-
Conductivity (Us/Cm)	29.80 ± 0.00	1000 US/CM
Acidity (C.C) OF 0.5% Na ₂ CO ₃ (mg/l)	33.50 ± 0.00	
pH	6.10 ± 0.00	6.5-8.5
Chloride as CL (mg/l)	39.00 ± 0.39	250mg/l
Chloride as NaCL (mg/l)	64.50 ± 0.00	
Total Alkalinity as CaCO ₃ (mg/l)	20.00 ± 0.06	
Total Hardness as CaCO ₃ (mg/l)	67.80 ± 0.05	500mg/l
Calcium Hardness (mg/l)	43.10 ± 0.00	
Magnesium Hardness (mg/l)	24.80 ± 0.46	
Total Iron as Fe (mg/l)	2.90 ± 0.00	0.30mg/l
Sulphate as SO ₄ (mg/l)	25.20 ± 0.00	400mg/l
Sodium as Na (mg/l)	25.00 ± 0.00	

Bicarbonate as HCO ₃ (mg/l)	27.70 ± 0.00	
Free Saline Ammonia (mg/l)	0.19 ± 0.00	0.05mg/l
Nitrates as N (mg/l)	4.20 ± 0.20	10.00mg/l
Nitrites as N (mg/l)	0.004 ± 0.00	1.00mg/l
T.D.S (mg/l)	21.00 ± 0.45	1000mg/l
Dissolved CO ₂ (mg/l)	12.70 ± 0.00	
Arsenic	0.00 ± 0.00	0.05mg/l
Benzene	0.00 ± 0.00	0.007mg/l
Fat and Oil	0.00 ± 0.00	0.003mg/l
Biological O ₂ Demand (mg/l)	8.40 ± 0.07	
Chemical O ₂ Demand (mg/l)	35.00 ± 0.00	
Total Organic Compound (mg/l)	11.00 ± 0.00	5.00mg/l
Coliform	18.00±0.02	Absent in 100ml
<i>E coli</i>	2.00±0.00	Absent in 100ml

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121 **Table 4: Physico-chemical parameters of Ulasi River water sample (Upstream) during**
122 **the dry season**

Parameters	Results	W.H.O Standards ^[5]
Appearance	Muddy	Clear
Colour In Hazen Unit	45 ± 070	5 Hazen Units
Turbidity NTU	15.8 ± 0.03	5 N.T.U
Odour	-	-
Taste	-	-
Conductivity (Us/Cm)	31.20 ± 0.00	1000 US/CM
Acidity (C.C) of 0.5% NA ₂ CO (mg/l)	30.20 ± 0.01	
pH	6.12 ± 0.11	6.5-8.5
Chloride as CL (mg/l)	48.20 ± 0.00	250mg/l
Chloride as NaCL (mg/l)	74.60 ± 0.03	
Total Alkalinity as CaCO ₃ (mg/l)	23.00 ± 0.00	
Total Hardness as CaCO ₃ (mg/l)	41.20 ± 0.00	500mg/l

Calcium Hardness (mg/l)	41.00 ± 0.32	
Magnesium Hardness (mg/l)	25.00 ± 0.00	
Total Iron as Fe (mg/l)	0.90 ± 0.00	0.30mg/l
Sulphate as SO ₄ (mg/l)	27.80 ± 0.30	400mg/l
Sodium as Na (mg/l)	28.00 ± 0.00	
Bicarbonate as HCO ₃ (mg/l)	17.30 ± 0.55	
Free Saline Ammonia (mg/l)	0.29 ± 0.78	0.05mg/l
Nitrates as N (mg/l)	1.90 ± 0.05	10.00mg/l
Nitrites as N (mg/l)	0.20 ± 0.08	1.00mg/l
T.D.S (mg/l)	21.60 ± 0.20	1000mg/l
Dissolved CO ₂ (mg/l)	15.00 ± 0.00	
Arsenic (mg/l)	0.00 ± 0.00	0.05mg/l
Benzene (mg/l)	0.00 ± 0.00	0.007mg/l
Fat And Oil (mg/l)	0.00 ± 0.00	0.003mg/l
Biological O ₂ Demand (mg/l)	5.00 ± 0.00	
Chemical O ₂ Demand (mg/l)	23.00± 0.05	
Total Organic Compound (mg/l)	8.90 ± 0.00	5.00mg/l
Coliform	7.00±0.01	Absent in 100ml
<i>E coli</i>	1.00±0.00	Absent in 100ml

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124 Discussion

125 The concentration of various quality parameters varied with seasons and areas (downstream
126 and upstream), with dry season having higher values. Results obtained from this study shows
127 a significant increase ($p<0.05$) in temperature during the dry season than wet season and this
128 could be attributed to the hot weather experienced during the dry season (hot season). Water
129 temperature regulates the metabolism of the aquatic ecosystem. High water temperature
130 makes metal more toxic to aquatic life. Toxicity of metals is affected by water temperature
131 which causes stress to aquatic life by reducing the ability of water to hold dissolved gases like
132 oxygen [15]. Also growth of micro-organism, taste, odour, colour and corrosion problem may
133 increase [16]. Low temperature has the effect of decreasing the efficiency of treatment.

134 Turbidity values were significantly higher ($p<0.05$) during wet season than dry season.
135 However, turbidity of both dry and wet season was higher than the standard limit for drinking
136 water as recommended by WHO [5]. According to Park [17], turbidity affects fish and aquatic
137 life by interfering with sunlight penetration. In drinking water, the higher the turbidity level,
138 the higher the risk that people in that area may develop gastro intestinal disease [18]. In aquatic
139 life, high turbidity level affects the ability of fish gills to absorb dissolved oxygen [19]. Thus

140 high turbidity obtained during both seasons is probably due to the indiscriminate dumping of
141 domestic waste material, agricultural waste material and soil particles transported by runoff
142 water from urban activities into the river.

143 The total organic carbon values obtained for the dry season were significantly higher
144 ($p < 0.05$) than the value for the wet season. The higher value observed during the dry season
145 could be as a result of the influence of season, dry season is characterized by low
146 precipitation, higher atmospheric temperature and evaporation but during wet season there
147 the water dissolves the organic compounds. Organic compounds causes eutrophication of the
148 river which is the sudden bloom of algae due to the presence of limiting nutrients in excess
149 [20]. Lopez-Sanchez *et al.*, [21] observed that both anthropogenic and natural processes have
150 resulted in elevated concentrations of organic carbon in sediments.

151 The general concentration of iron from this study were within 0.30mg/l, however there was
152 significant difference ($p < 0.05$) between the dry (2.70) and wet season (2.70). The presence of
153 iron in water aids iron utilizing and reducing bacteria like *thiobacillu sferrooxidans* and
154 *leptospirillum ferrooxidans* to increase causing diseases relating to the microorganism. Iron
155 bacteria in water can cause unpleasant odour and taste. Chinedu *et al.*, [22] reported the
156 presence of iron in water samples taken from different points in Canaanland and Iju River.
157 Similarly, Asaolu and Olaofe, [23], Nwajei and Gagophien, [24] also reported that iron occurs
158 in high concentration in Nigerian soils.

159 The values of pH for dry season (6.10) were significantly higher ($p < 0.05$) than wet season
160 (5.90). The values for both dry and wet season did not fall within the stipulated limits for
161 drinking water which is 6.5-8.5 according to WHO (2004), pH standard for drinking water.
162 The low pH value may probably due to built-up of organic materials. Yerel, [25] reported that
163 anaerobic conditions in Porsuk River was due to the loading of organic matter and organic
164 acids which lead to an increase in pH. Similarly, Keith [26] reported that degradation of
165 organic wastes by aerobic microbes produces carbon dioxide as a by-product, carbon dioxide
166 then dissolves in water to yield carbonic acid, hence, increasing the acidity of the water.
167 Some fish cannot tolerate low pH [27] and pH has synergistic effect on heavy metal activity.
168 Acidic pH encourage the growth of acidophiles which are organism that are able to live at pH
169 below 7, and such organisms are dangerous to human health, since freshwater is buffered at
170 pH of 7.

171 Result of Sulphate concentration of SO_4 obtained from this study was within the 400mg/l
172 limit recommended by WHO [28]. However there was significant difference ($p < 0.05$) between
173 the dry and wet season value. The value vary along the sampling point with the uphill having
174 higher value than the downhill. The source of sulphate to the water could be from effluents
175 from industries, runoffs, dumpsites and organic matters decomposition. According to WHO
176 [28] the presence of sulphate in drinking-water can also result in a noticeable taste; the lowest
177 taste threshold concentration for sulphate is approximately 250mg/litre as the sodium salt.
178 Sulphate may also contribute to the corrosion of distribution systems. In the light of these
179 considerations, no health-based guideline value for sulphate in drinking water was proposed.
180 However, there is an increasing

181 Result of Chloride concentration obtained was generally below WHO [28] permissible limit
182 (250mg/g) for both dry and wet season. Although there were inputs of pollutants from
183 municipal waste into the river, the level was not high enough to significantly increase
184 chloride level above limit. Thus the negative impact of high concentration of chloride in
185 water such as causing canned or frozen food to taste funny, killing aquatic lives and giving
186 salty taste to water will not be experienced [29].

187 Water in the study area varied in their microbial quality especially the coliform group. The
188 values were significantly higher ($p < 0.05$) in downstream but low in upstream. The variation
189 was probably due to the level of municipal waste received by the respective area. Similarly,
190 there was significant difference ($p < 0.05$) between the dry season and wet season bacterial
191 count, with the wet season having higher value due to the significant increase in organic and
192 bacterial load after rain storm [30]. Coliform count was higher than the permissible limit of
193 0.2mpn/100ml and could be considered polluted. The presence of coliform bacteria in Ulasi
194 River is an index of the presence of other pathogenic microbes in the river. This result agrees
195 with the reports of Akpan – Idot *et al.*, [31]; their study revealed that Okpauku River in Yala,
196 Cross River State contains high number of coliform bacteria. Similarly, a study by
197 Onyegeme-Okerenta *et al.*, [32] reported the presence of coliform bacteria in Otamiri-oché
198 River in Etche Ethnic Nationality of Rivers State, Nigeria. Faecal contamination of water is
199 also a significant cause for various infections caused by pathogenic bacteria, fungi, viruses,
200 protozoa, helminthes. Natural microflora of the human intestine is also found to be present in
201 water contaminated with pathogenic species [33].

202 Conclusion

203 This study demonstrates the influence of rural land use and seasonal effect on water quality in
204 Ulasi River. The data clearly shows that the downstream is more polluted than upstream. The
205 upstream though less polluted than the downstream is not still suitable for aquatic life and
206 drinking and human consumption, the downstream too is highly polluted and should not be
207 used for agricultural or human use.

208 A management plan to restrict the dumping of wastes into Ulasi River is needed in order to
209 reduce the impact on water quality and pollution related health problem. This can be achieved
210 through effective waste management strategy and provision of reliable public water supply.
211 Educating people in Okija on the health effect of Ulasi River and the effect on crops is
212 suggested to avoid diseases and mortality rate in Okija.

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