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The pollution status and effects of seasonal changes in rivers within Imo River Basin, Southeastern Nigeria

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Abstract

The pollution status and effects of seasonal changes in rivers within Imo River basin were studied between October 2015 and September 2016. Water samples and 4 species of fish samples were collected from seven rivers: Otanmiri, Nwaorie, Njaba, Blue Lake Oguta, OrashiOpuomo and AbubaUnuchi, using suitable sterile containers. The water and fish samples were analysed bacteriologically using culture technique and the method of (1) for physico-chemical parameters. The findings revealed that 11 genera of bacteria *Staphylococcus* species, *Streptococcus faecalis, Micrococcus* species, *Aeromonas* species, *Vibrio* species, *Salmonella* species, *Proteus mirabilis, Escherichia coli, Flavobacterium* species and *Klebsiella* species were present in the water and fish samples examined. The total heterotrophic bacteria count (THBC) of the rivers during the raining season ranged from 2.3 x 10^6 to 2.9 x 10^6cfu/ml and 2.02 x 10^5 to 2.6 x 10^5cfu/ml in the dry season. For the fish samples, the THBC ranged from 1.86 x 10^5 to 2.4 x 10^5cfu/ml in the raining season and increased to 2.3 x 105 to 2.8 x 10^5cfu/ml in the dry season. The physico-chemical parameters of the watersamples: cadmium, lead, mercury, nitrate, sulphate, phosphate and copper were found to be higher than WHO standard for drinking water, especially during the dry season. The prevalence of physically observed fish diseases generally increased from 35.6% percent in the raining season to 74.4% in the dry season. The study has established high pollution of rivers within Imo river basin and adverse effects of seasonal changes on aquatic organisms in the rivers due to pollution.

Keywords: Pollution; Seasonal changes; Effects in Rivers within Imo River basin; Nigeria

1. Introduction

Water is the solvent for all living systems and is used in very large quantities by all advanced cultures (2). It is undoubtedly the most precious natural resource that exists on our planet, comprising over 70% of the earth's surface (3). Water is essential for the survival of all living organisms including humans. Water possess some unique properties which make itremarkablydifferent from other compounds with closely related electronic structure, for instance, the melting point is 0^0C remarkably higher than that of methane (-184^0C), ammonia (-78^0C), and hydrofluoric acid (-92^0C). Similarly, the boiling point of water is 100^0C much higher than that of related compounds, methane (-161^0C), ammonia (-33^0C) and hydrofluoric acid (19^0C). Other physical constants of water differ markedly from those of other liquids such that if liquids other than water were to form the oceans of the earth, the seasonal temperature extremes would be far greater than those observed (4).

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All over the world, it is assumed that rivers flowing into bays and oceans presented a convenient way to flush away our domestic waste water including sewage and industrial wastes (2). Obviously, this is not so, yet, there exists an alarming lack of a sense of responsibility on the part of those wishing to get rid of waste materials. The multifarious uses of water: drinking, washing, bathing and cooking are well known (5). Rivers, seas and oceans are used for various human domestic and industrial needs. Besides many people dispose obnoxious wastes into water bodies causing varying degrees of water pollution which affect both human and aquatic lives adversely (6). In Nigeria, the input of environmental pollutants in aquatic systems is a common phenomenon (7).

Water pollution is a growing environmental and public health problem especially in developing countries of the world. In the words of Holdgate (8), pollution is the introduction into the environment of substances or energy liable to cause hazards to human health, harm to living resources and ecological systems, damage to structures or amenity or interference with legitimate uses of the environment. Thus pollutants comprise broadly of energy (heat, sound or radiation) and material substances (organic and inorganic substances), Water quality is typically determined by monitoring presenceof microbes (particularly faecal coliform) and its physico – chemical properties (9, 10). Problems of pollution cannot be over emphasized. In the United States, the Environmental Protection Agency (EPA) estimates that over half the cancer deaths in each year are caused at least partially by air pollution (2). Many lakes and rivers are becoming choked with algae and other plant growths as a result of their pollution with high levels of fertilizers from farmland runoff. These fertilizers provide nutrients that stimulate the rate of growth of algae and other aquatic plants. Other water bodies will not support any life because of pollution with industrial wastes. Some years ago, a number of people became sick and some died in Japan in two separate periods due to mercury that had been put into a river upstream from where they live. Also, 46 out of 121 people poisoned from eating fish caught in polluted water died in Minamata, while in Nigata, 7 out of 46 people died (2).

In Imo State, southeastern Nigeria, Government has embarked on a number efforts and programmes to keep the environment clean and improve on environmental health, but it appears little or no effort has been taken to fight against water pollution in various communities within the State. Seasonal changes lead to changes in activities around natural water bodies in different communities and these changes appear to impact enormous influence on aquatic environments, aquatic organisms and human lives in the various communities. The present study was undertaken to evaluate the pollution status and effects of seasonal changes in rivers wi*thin* Imo River Basin.

2. Material and methods

2.1. Study Area

This study was carried out in 7 rivers (Otanmiri, Nwaorie, Njaba, Blue Lake Oguta, OrashiOpuomo, AbubaUmuchi and Imo River) located in the three geo – political zones of Imo State. Imo State is bound on the West by Delta State, on the North by Anambra State, on the South by Rivers State and on the East by Abia State. It lies between latitudes 5^0 30′ and 6^0 15′ North, longitude 6^0 38′ and 7^0 18′ East. Imo State is densely populated with men and women of all ages engaged in different walks of life.

2.2. Sample Collection

Water and fish samples were collected asepticallyfrom the selected rivers. Water samples were collected in factory sterilized wide mouth screw capped transparent plastic containers. Each sample was opened at about 30 cm below the surface of the river and covered with the screw cap under the water before raising it. The samples were labeled and placed inside large sterile container containing sterile cotton wool to avoid friction and leakage on transit. All water samples were collected in the early hours of the day between 6. 00 – 700a.m before daily human activities resume in the rivers. The pH and temperature of each water body was measured *in situ* at the site of collection using Standard pH strips (colourpHast® indicator No 4029598) and mercury bulb laboratory thermometer after collection of each water sample.

Fish samples were collected from each water body using fishnets placed in strategic positions overnight with the aid of the local fishermen operating in the communities. The fishnets were carefully removed from the water and brought to the river shore where the field assistants (local fishermen) helped to transfer the fishes into transparent plastic pails. Clean water samples from the rivers were collected and poured into the pails containing the fish samples. They were properly labeled and covered with fine mesh gauze and loose plastic covers.

All the water and fish samples were transported to the Microbiology Laboratory, Faculty of Medicine, Imo State University, Orlu and analysed within 5 – 10 hours of collection.

2.3. Microbiological Analysis of the Samples

The water and fish samples collected were analysed microbiologically using culture technique as in Chesbrough (11), 12). Each water sample was cultured in duplicate plates of Mueller Hinton agar, MacConkey and Blood agar and incubated one set aerobically and the second set anaerobically at 37^{O}C for 24 hours. Two-fold serial doubling dilution of each water sample was prepared using sterile Peptone water and 0.1ml of each dilution was inoculated in duplicates of Mueller Hinton agar using spread – plate techniques as in (12). They were incubated at 37^{O}C for 24 hours. The bacterial colonies on each plate were counted and the mean of each duplicate plates was taken to determine the total heterotrophic bacterial count of each water sample. Similarly, 0.1ml of each dilution of the water samples was inoculated on duplicate plates of Eosin Methylene Blue agar (EMB) and incubated at 37^{O}C for 24 hours for isolation of *Enterobacteriaceae*. The total coliform bacteria for each sample were counted.

The fish samples collected from the different rivers were examined for physical injuries or disease conditions such as ulceration and necrotic leisions on skin surfaces, gills or fin rot, pop eyes and abdominal dropsy. Apparently healthy fishes and diseased ones were selected from the rivers and examined microbiologically for bacterial infections. The muscles, gills and skin of each fish were examined. The selected samples were cultured on duplicate plates of Tryptone soy agar, Chocolate agar and MacConkey agar media by streaking method as in (12). One set of the inoculated plates were incubated at 37^{O}C for 24 hours and the second set was incubated anaerobically at 37^{O}C for 24 hours. The plates were examined for bacterial growth and the colonies identified using standard methods (Gram stain, motility test, capsule and spore staining, catalase, coagulase, oxidase, citrate utilization, indole production, hydrogen sulphide production Nitrate/Nitrite reduction, Methyl red, VogesProskeur, and sugar fermentation tests) as in (12) and the results were compared with Bergy's manual of determinative bacteriology (13).

2.4. Physico – chemical Analysis

The physico – chemical parameters of the water samples and fish samples were measured using standard test strips ($QUICK_{TM}$ No. 487999, $SENSAFE_{TM}$ No. 481026, 481126, 6541269, etc), and the method of American Public Health Association (14). The following parameters: dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), Sulphate (SO_4), Nitrate/Nitrite (NO_3), Phosphate (PO_4) Total and Free chlorine, Iron (Fe^{2+}/Fe^{3+}), Copper (Cu^{+}/Cu^{2+}), Zinc (Zn), Mercury (Hg), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Lead (Pb), Total hardness (TH), Total Alkalinity (TA) and Total Dissolved solids (DS) were determined using the methods of (11, 12).

2.5. Seasonal Changes

The microbiological and physico – chemical analysis of both water and fish samples were carried out in the mid raining season (July – August 2016) and mid dry season (December 2015 – February 2016). The same age (juvenile) and species of fishes were selected in both seasons.

2.6. Data Analysis

The data obtained from this study were analysed statistically using Analysis of variance (ANOVA) as in (15).

3. Results

The findings of this study (tables 1 – 2) showed that 11 genera of bacteria were isolated from the various river water while 10 genera of bacteria were isolated from apparently healthy and diseased fishes collected from the different rivers examined in both dry and raining seasons samples. However, the bacterial load (total heterotrophic bacteria and total colifom bacterial counts) of the rivers were generally higher in the raining season than dry season. For the fish samples, the total heterotrophic bacterial count was generally higher in the dry season than the raining season while the total coliform bacterial counts were higher in the raining season than the dry season (table 3). The disease conditions observed in the fishes were more in the dry season than the raining season (table 4). Out of 90 fish samples examined in each season, 74.4% were diseased in the dry season while 35.6% were diseased in the raining season. The most prevalent disease in both seasons was abdominal dropsy (23.3%) in the dry season and (11.1%) in the raining season, followed by gills/fin rot (17.8%) and (10%) in the dry and raining seasons respectively.

The physico-chemical parameters of both the water and fish samples were higher in the dry season than the raining season (tables 5 - 6).

Table 1 Bacterial isolates from water samples in raining and dry seasons

Bacterial Isolate	Rivers Examined - Raining Season							Rivers Examined - Dry Season						
	Otamiri	Nwaorie	Njaba	Blue Lake	Imo River	OrashiOpuomo,	AbubaUmuchi	Otamiri	Nwaorie	Njaba	Blue Lake	Imo River	OrashiOpuomo,	AbubaUmuchi
Staphylococcus aureus	+	+	+	-	+	-	+	+	+	+	+	+	+	+
Streptococcus faecalis	+	-	-	-	-	+	-	+	+	+	+	+	+	+
Micrococcus sp	-	-	-	+	-	-	+	-	-	-	-	-	-	-
Pseudomonas aeruginosa	+	+	+	+	+	+	+	+	+	+	+	+	+	+
*Aeromonas*sp	+	+	-	+	+	-	+	+	+	+	+	+	+	+
Vibrio species	+	+	+	-	-	-	-	+	+	+	-	-	+	+
Salmonella sp	+	+	+	+	+	+	+	+	+	+	+	-	+	+
Proteus mirabilis	+	+	+	-	+	+	+	+	+	+	-	+	+	+
Escherichia coli	+	+	+	+	+	+	+	+	+	+	+	-	+	+
Flavobacterium sp.	-	+	-	+	+	-	+	-	-	-	-	-	-	-
*Klebsiella*sp	-	-	+	-	-	+	-	-	-	+	+	+	+	+

Key: +=Bacteria present-=Bacteriaabsent

Table 2 Bacterial isolates from Diseased and apparently healthy fishes

Bacterial Isolate	FishesExamined -(RainingSeason)				FishesExamined- (DrySeason)			
	Clariaslazera	*Tilapianiloticus*	*Latesnilotic us*	*Heterotisnil oticus*	*Clariaslazera*	*Tilapianiloticus*	*Latesnilotic us*	*Heterotisnil oticus*
Staphylococcus aureus	+(64)	+(56)	+(10)	+(15)	+(80)	+(84)	+(75)	+(65)
Streptococcus faecalis	-	+(8)	-	+(10)	-	+(24)	+(10)	+(60)
Micrococcus sp	+(12)	+(8)	-	+(20)	+(12)	+(28)	-	+(40)
Pseudomonas aeruginosa	+(48)	+(28)	+(25)	-	+(64)	+(36)	+(65)	+(35)
*Aeromonas*sp	+(24)	+(40)	+(10)	+(35)	+(60)	+(52)	+(35)	+(35)
Vibrio species	+(12)	-	-	-	+(72)	+(12)	+(15)	-
Salmonella sp	+(4)	-	+(10)	+(10)	+(56)	+(28)	+(60)	+(65)
Proteus mirabilis	+(20)	+(44)	+(35)	+(40)	+(20)	+(48)	+(60)	+(65)
Escherichia coli	+(88)	+(76)	+(60)	+(35)	+ (100)	+(88)	+(85)	+(85)
Flavobacterium sp.	-	-	+(10)	+(10)	+(68)	+(20)	+(35)	+(35)
*Klebsiella*sp	-	+(4)	+(15)	-	+(24)	+(36)	+(40)	-

Key:+= Bacteria present-=Bacteria absent(%) of Fish samples infected

Table 3 Total Heterotrophic bacterial and Coliform bacterial counts of water and fish samples

Sample	RainingSeason		DrySeason	
	Total Heterotroph bacterial count (*cfu*/ml)	**Total Coliform count(*cfu*/ml)**	**Total Heterotroph bacterial count (*cfu*/ml)**	**Total Coliform count(*cfu*/ml)**
Otanmiri	$2.8x10^6$	$2.14x10^4$	$2.52x10^5$	$1.86x10^4$
Nwaorie	$2.3x10^6$	$2.6x10^4$	$2.02x10^5$	$1.8x10^4$
Njaba	$2.6x10^6$	$2.12x10^4$	$2.33x10^5$	$1.65x10^4$
Blue Lake	$2.7x10^6$	$2.5x10^4$	$2.4x10^5$	$1.82x10^4$
Imo River	$2.53x10^6$	$2.2x10^4$	$2.6x10^5$	$1.66x10^4$
OrashiOpuomo	$2.9x10^6$	$2.16x10^4$	$2.35x10^5$	$1.84x10^4$
AbubaUmuchi	$2.72x10^6$	$2.3x10^4$	$2.2x10^5$	$1.75x10^4$
Clariaslazera	$1.92x10^5$	$2.32x10^3$	$2.3x10^5$	$1.82x10^3$
Tilapia species	$2.4x10^5$	$2.25x10^3$	$2.8x10^5$	$1.45x10^3$
Latesniloticus	$2.34x10^5$	$2.6x10^3$	$2.62x10^5$	$1.26x10^3$
Heterotisniloticus	$1.86x10^5$	$2.48x10^3$	$2.32x10^5$	$1.08x10^3$

Table 4 Disease Conditions Observed on the Fish samples

Samples	Number Examined	Number infected	Disease Condition observed in Raining Season (%)			
			Skin ulceration / necrotic leisions	**gills or fin rot**	**pop eyes**	**abdominal dropsy**
Clariaslazera	25	11	2	4	1	4
Tilapia sp.	25	10	3	2	2	3
Latesniloticus	20	6	1	2	2	1
Heterotisniloticus	20	5	2	1	0	2
Disease Condition observed in Dry Season						
Clariaslazera	25	20	3	7	4	6
Tilapia sp.	25	18	3	4	6	5
Latesniloticus	20	14	3	2	4	5
Heterotisniloticus	20	15	5	3	2	5
Total	180	99(55)	22(12.2)	25(13.9)	21(11.7)	31(17.2)

Table 5 Physico – chemical Parameters of water and fish samples in raining Season

Physico-chemical Parameter (mg/l)	Riversexamined							Fishesexamined				WHO Standard **
	Otamiri	Nwaorie	Njaba	Blue Lake	Imo River	OrashiOpuomo,	AbubaUmuchi	*Clarias*sp	Tilapiasp	Latesniloticus	Heterotisnilotic us	
pH	6.5	6.5	6.0	6.0	6.5	6.5	6.0	7.0	8.0	8.0	7.0	6.5– 8.5
Temp (^{0}C)	27	27	25	27	26	25	25	25	25	26	25	NA
Zn	0.5	1.0	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	NA
Cu^{+}/Cu^{2+}	0.5	0.5	0.5	0.7	0.5	1.0	1.5	0.6	0.4	0.4	0.5	2.0
Hg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.006
Pb	0.5	0.5	0.0	0.0	0.5	1.0	0.5	0.0	0.0	0.0	0.0	0.01
Fe^{2+}/Fe^{3+}	2.0	2.0	1.0	2.0	2.0	2.0	2.0	10	0.5	1.0	2.0	1 – 3
Cd	0.07	0.09	0.06	0.08	0.06	0.08	0.09	0.0	0.0	0.0	0.0	0.003
Co	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA
Cr	0.25	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0	NA
Cl^{2-}	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	250
SO_4	200	250	250	200	250	250	250	0.0	0.0	0.0	0.0	250
NO_3	250	500	500	250	500	500	500	250	250	250	250	50
PO_4	5.0	10.0	5.0	2.0	2.5	5.0	5.0	ND	ND	ND	ND	2.0
BOD	2.4	2.3	2.4	2.3	2.3	2.4	2.5	ND	ND	ND	ND	0 – 6
COD	5.0	6	5	7	5	6	6	ND	ND	ND	ND	NA
DO	6.5	4.6	3.7	5.6	5.4	3.8	4.7	ND	ND	ND	ND	0 – 20
Tota Hardness	550	550	600	550	600	500	600	ND	ND	ND	ND	500
Tot Alkalinity	120	110	150	140	150	120	150	ND	ND	ND	ND	NA
Tot Dis. Solid	1500	1000	1500	1250	1000	1500	1250	ND	ND	ND	ND	1000

Note:NA = Not availableND= Not determined**=WHO (1971)

Table 6 Physico – chemical Parameters of water and fish samples in dry Season

Physico-chemical Parameter (mg/l)	Riversexamined							Fishesexamined				WHO Standard**
	Otamiri	Nwaorie	Njaba	Blue Lake	Imo River	OrashiOpuomo,	AbubaUmuchi	*Clariass*p	Tilapiasp	Latesniloticus	Heterotisnilo ticus	
Ph	5.0	6.0	5.0	6.0	6.0	6.0	6.0	7.0	7.0	7.0	7.0	6.5–
Temp(^{0}C)	29	28	27	29	28	28	28	26	256	26	26	8.5
Zn	1.0	1.0	2.0	1.5	2.0	2.0	1.5	2.0	1.0	1.0	2.0	NA
Cu^{+}/Cu^{2+}	2.0	2.0	2.0	5.0	5.0	2.0	2.0	0.8	1.0	2.0	2.0	NA
Hg	0.0	0.0	0.0	0.05	0.05	1.0	0.05	0.0	0.0	0.0	0.0	2.0
Pb	1.0	1.0	0.5	0.5	0.5	1.0	1.0	0.0	0.0	0.0	0.0	0.006
Fe^{2+}/Fe^{3+}	3.0	3.0	3.0	3.0	3.0	3.0	2.0	1.0	0.5	1.0	1.0	0.01
Cd	0.09	0.09	0.08	0.09	0.08	0.09	0.09	0.0	0.0	0.0	0.0	1 – 3
Co	10.0	10.0	10.0	20.0	50.0	20.0	10.0	0.0	0.0	0.0	0.0	0.003
Cr	0.5	0.5	0.5	1.0	0.5	1.0	1.0	0.0	0.0	0.0	0.0	NA
Cl^{2-}	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA
SO_4	500	500	500	250	500	500	500	0.0	0.0	0.0	0.0	250
NO_3	500	500	500	500	500	500	500	250	250	250	250	250
PO_4	10.0	10.0	5.0	5.0	5.0	5.0	10.0	ND	ND	ND	ND	50
BOD	4.0	6.0	5.4	4.5	5.0	6.0	5.5	ND	ND	ND	ND	2.0
COD	5.5	6.5	5.5	6.5	6.0	5.0	5.0	ND	ND	ND	ND	0 – 6
DO	6.5	4.0	3.0	5.0	10	10	10	ND	ND	ND	ND	NA
Total Hardness	650	600	600	750	550	600	750	ND	ND	ND	ND	0 – 20
Total Alkalinity	80.0	100	100	100	80.0	80.0	100	ND	ND	ND	ND	500
Tot Dis. Solid	1750	1500	1750	1500	1500	1750	1500	ND	ND	ND	ND	NA 1000

Note:NA =Not availableND= Not determined**=WHO(1971)

4. Discussion

Imo State is naturally blessed with many freshwater bodies: rivers, lakes and streams. In many communities in the State, most people depended largely on these natural water bodies for livelihood. While some specialized as fishermen, others take to crop farming as their major occupation. In the recent past, urbanization and youth migration to industrialized cities have led to neglect of these major occupations of these communities leading to abandonment and lack of care for these rivers. Most of these natural water bodies are used as waste disposal points leading to gross pollution of the water bodies. In some places those who still practice crop farming around the rivers make use of organic and in organic fertilizers indiscriminately. Rain water wash away these fertilizers into the rivers and streams thereby causing alga bloom and water pollution. The fishermen on their part use different approaches and activities in fishing which pollute the water bodies and harm aquatic organisms. The present study isolated eleven genera of bacteria from the 7 selected rivers and 4 species of fished collected from these rivers. Although these species of bacteria isolated are commonly found in aquatic environments (16, 17, 18), their presence in surface water and in the muscles, gills and skin of fishes in the water is highly indicative of heavy pollution of the aquatic environment. Furthermore, the presence and isolation of enteropathogenic bacterial species such as *Vibrio* species, *Salmonella* species, faecal coliforms, etc indicates faecal contamination and makes the water unsafe for drinking. Statistical analysis of the data obtained revealed correlations between bacterial isolates and physico-chemical properties of the surface water examined. There was strong positive correlation between the bacterial isolates (total heterotrophic bacterial and total coliform) and the BOD, COD and TDS as well as strong negative correlation between the bacterial isolates and dissolved oxygen in the surface water samples. These findings are consistent with high heterotrophic and coliform counts obtained in the 7 rivers examined, where

higher values of BOD, COD and TDS were recorded. Generally the mean physico-chemical parameters measured in this study were high and above WHO standards recommended for drinking water.

Environmental pollution is a growing public health problem in Nigeria, in a study carried out by (19) on 26 rivers in North and southern Nigeria, it was observed that the concentration of most heavy metals in surface waters were generally lower than the global average level for surface water and international drinking water standard. In the present study, concentration of mercury, Lead and cadmium particularly in the dry season, were higher than WHO standard for drinking water. Also the concentration of sulphate, nitrate and phosphate were remarkably higher than the WHO standard for drinking water (20). The source of these metals and salts may be from domestic and industrial pollutants. Mercury for instance is strongly associated with its use as antiseptics, pharmaceuticals, fungicides, preservatives and reagents. Lead is associated with industrial wastes/ Sulphate, nitrate and phosphates are associated with fertilizers and agricultural materials. The indiscriminate disposal and release of these obnoxious materials into the environment must have lead to their pollution of the water bodies. Some industrial and domestic wastes reaching water bodies comprise of fats and carbohydrates. Although they are biodegradable wastes, usually broken by natural chemical processes, but this action consumes large amounts of oxygen leaving insufficient amount for aquatic organisms. Some of the trace elements were also observed in some fishes obtained from these rivers. Also the prevalence of the different fish diseases was higher in the dry season when the water pollution was higher, and the bacterial load of the fishes increased in the dry season when the water pollution was higher,

The public health implications of water pollution and microbial infections of aquatic animals used as human food cannot be over emphasized. In a related study, (21) observed that municipal waste refuse dumps in Owerri metropolis Imo State were sources of farmland pollution and contamination of farm vegetables. The natural water bodies examined in this study are sources of household water supply to many communities in the study area. Many families use the water from these rivers to cook and process food, bath, wash clothes and for recreational purposes. Also many of the communities fish in these rivers either as a hobby or for commercial purposes. Pollution of the water bodies endanger the lives of the fishes thereby reducing the quantity of fishes caught by fishermen. Fishes which are infected as a result of this pollution constitute public health risks. People who eat such fishes may be infected.

This study has established that pollution status of rivers within Imo river basin presently is high and seasonal changes affects both the pollution status of the rivers and aquatic lives. Efforts should be made by both Government and the various communities to protect natural water bodies and avoid activities which lead to pollution of these aquatic environments. The present Environmental transformation initiative of the present Government of Imo State should be extended to aquatic environments within the State to protect and preserve both the rivers and aquatic lives. Effective legislation should be put in place to monitor and control activities in and around natural water habitats within the State, waste disposal into water bodies should be avoided.

5. Conclusion

Seasonal changes and human activities affect Rivers within Imo River Basin, South Eastern Nigeria, and polluted the water with bacterial species and physico – chemical materials. Fishes and aquatic lives in the water were infected by these bacteria. Communities around the rivers should take advantage of this study to exercise caution in their use of the water and aquatic animals from them, to avoid infection and harmful effect of toxin. Government should assist by decontaminating the rivers and make laws guiding the use of the rivers to discourage abuse such as disposing wastes directly into the rivers.

Compliance with ethical standards

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Disclosure of conflict of interest

This work was carried out by Professor Ifeanyi O. C. Obiajuru of the Department of Medical Microbiology and Parasitology, Faculty of Basic Medical Science and Dr. Chinyere N. Ohalete of the Department of Microbiology Faculty of

Biological Sciences. Both Authors are of Imo State University. Both Authors read, understood and agreed to the submission declarations of the journal.

Statement of ethical approval

Ethical permit for this study was obtained from Imo River Basin Development Authority. The methods and guidelines provided in the research proposal and ethical permit was strictly followed.

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