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Impact of Seasonal Weather Variation on Three Gastrointestinal Pathogens Isolated in Catfish (*Siluriformes*) in Ebonyi State Capital City Nigeria.

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Abstract Changes in weather patterns significantly contribute in dissemination of Gastrointestinal infectious(GI) disease and have been revealed to be one of the critical drivers of the emergence, re-emergence and transmission of infectious disease. This objective of the present study was to assess the impact of seasonal weather variation on three GI bacterial pathogens isolated from catfish (*Siluriformes*) in Abakaliki, Ebonyi State, Nigeria. A total of 58 Samples were collected, 29 dry season catfish and 29 raining season catfish. (2 samples were collected from each location) and analyzed. Bacterial isolation and characterization were conducted using standard microbiological procedures. The mean bacterial load was higher in rainy season samples (7.84×10^5 cfu/g) compared to dry season samples (4.33×10^5 cfu/g). Three pathogens *Escherichia coli*, *Vibrio cholerae*, and *Salmonella* species were identified and characterized through physiological and biochemical tests. In rainy season samples, 118 isolates were recovered: *E. coli* (44.9%), *V. cholerae* (23.7%), and *Salmonella* spp. (31.4%). In contrast, 96 isolates were obtained during the dry season, comprising *E. coli* (47.9%), *V. cholerae* (20.8%), and *Salmonella* spp. (31.3%). Antibiotic susceptibility testing revealed multidrug resistance across isolates. All *E. coli* strains showed 100% resistance to more than seven antibiotics, including cefepime, cefotaxime, cefoxitin, imipenem, vancomycin, nalidixic acid, and amoxicillin/clavulanic acid, but remained highly Key words: climate change, *Siluriformes*, Gastrointestinal infectious and Antibiotic

susceptibility testing revealed multidrug resistance across isolates. All *E. coli* strains showed 100% resistance to more than seven antibiotics, including cefepime, cefotaxime, ceftazidime, imipenem, vancomycin, nalidixic acid, and amoxicillin/clavulanic acid, but remained highly susceptible to ciprofloxacin (79%), trimethoprim (67.5%), and gentamicin (64.5%). Similarly, *V. cholerae* and *Salmonella* spp. exhibited complete resistance to more than eight antibiotics but demonstrated susceptibility to ciprofloxacin (90%) and trimethoprim (55%). The findings suggest that rising temperatures, poor sanitation, and faecal contamination in aquaculture environments contribute to increased pathogen prevalence and resistance. Given the risks associated with climate change, continuous monitoring of bacterial pathogens in fish habitats is essential. Enhanced antibiotic resistance surveillance in aquatic environments is also necessary to safeguard public health and ensure food safety.

INTRODUCTION

Climate change in the 21st century is a global phenomenon and although it is a worldwide recognised issue its effects vary by geographic location making regional studies of potential impact of high importance. In general, weather conditions have become more variable with extreme weather events increasing in regularity and intensity (IPCC5, 2023). Climate change is changing precipitation patterns, causing rising sea levels, and altering seawater salinity, whilst also impacting several factors such as surface water temperature and the reproduction, survival, and sustenance of viruses and bacteria in waterbodies, which consequently affects human health (Kendrovski and Gjorgjev, 2012). The consequences of climate change have been described as an increase in temperature, unusual regional weather patterns, more severe storms, heat waves, rising sea levels, thawing permafrost, more frequent droughts, acidification of oceans, change in nutrient loads, and altered ocean circulation (Lee *et al.*, 2020). Weather parameters contribute in dissemination of Gastrointestinal infectious disease and have been revealed to be one of the critical drivers of the emergence, re-emergence and transmission of infectious disease such as Malaria, cholera, salmonellosis, typhoid, hepatitis A and E, diarrhea, leptospirosis, giardiasis, shigellosis, amoebiasis, dracunculiasis, cryptosporidiosis, *Campylobacter enteritis*, and poliomyelitis globally (Rocklöv and Dubrow, 2020) and Bidhuri *et al.*, 2018). Children are more vulnerable to Gastrointestinal infectious disease than adults because children have an impaired immune defense system and self-control (DeJarnett *et al.*, 2017). Thus, large numbers of victims have been reported owing to extremely high temperatures and cold waves globally, including in Europe, Africa and Asia (Rocklöv and Dubrow, 2020). Nearly 3.6 billion of the world population is highly vulnerable to the effect of climate change as they live in areas with high susceptibility to climate change (Mishra *et al.*, 2015). Moreover, the detrimental effects of climate change on sectors such as health, agriculture and tourism and the emergency services result in significant economic losses in addition to loss of life and property (Parliari *et al.*, 2022).

Catfish(Siluriformes) are a diverse group of ray-finned fish (Nakatani *et al.*, 2011). Catfish are of considerable commercial importance; many of the larger species are farmed or fished for food. Many catfish are nocturnal, but others (many Auchenipteridae) are crepuscular or diurnal (most Loricariidae or Callichthyidae, for example) (Sullivan *et al.*, 2006). As of 2007 there were about thirty-six extant catfish families, and about 3,093 extant species have been described (Ferraris *et al.*, 2007). However, Aquaculture is currently one of the fastest growing food production sectors in the world (FAO 2020). Its increasing global importance is directly related to the contribution it makes to reduce the gap between supply and demand for fish production. FAO (2002) asserted that fish contributes about 60% of the world supply of protein and that 60% of the developing world derives more than 30% of their animal protein from fish. Fish are generally regarded as safe nutritious foods but products from aquaculture have sometimes been associated with certain food safety issues (WHO, 2007). Yunxia *et al.*,(2001) reported that intensive production of fish increases the likelihood of and severity of parasite and diseases

outbreaks, which constitutes a major constraint to aquaculture production. Bacterial agents are among the highly encountered causes of diseases in aquaculture, stressful conditions play important role in establishing and aggravation of the bacterial diseases in fish farms (FAO, 2002). Bacterial pathogens are a great threat to fish production worldwide due to the high economic importance of diseases they cause (Bondad-Reantaso *et al.* 2005). A number of bacterial pathogens have been reported to cause fish diseases worldwide. Bacteria of particular importance in fresh water fish include *Klebsiella spp*, *Streptococcus spp.*, *Salmonella species*, *Escherichia coli*, *Pseudomonas spp.*, *Vibrio spp.*, and *Mycobacterium spp.* (Lio-Po and Lim 2014) among others. These microorganisms from feces or environmental waste contain antibiotic resistant gene that may disseminate and contaminate aquatic environment. On the other hand, aquaculture represents one means that supplement wild fish due to the growing demand of fish protein in the population (Alday *et al.*, 2006). Therefore, fish farmers normally add antibiotics into feed as growth promoters, for therapeutic and prophylactic purposes to supplement this increasing demand (FAO, 2020). Antibiotics used for animals either for therapy, prophylactic or growth promotion purposes at a sub therapeutic dose can result in transfer of resistant genes from animals to humans and thereby establishing a reservoir of resistant microbes (Angulo *et al.*, 2004). Subsequently, fish contamination with antibiotic-resistant bacteria can be a major threat to public health, as it can be transferred to other bacteria of human clinical significance (O'Brien,2002). The choices of antibiotic for the treatment of common infectious diseases in humans are becoming increasingly limited, expensive and ineffective due to the emergence of antibiotic resistant bacteria (Weese *et al.*, 2011). However, Between October – December 2009, it was speculated that more than 260 people died of cholera and gastroenteritis in four Northern states with over 96 people in Maidugari, Biu, Gwoza, Dikwa and Jere council areas of Bauchi state of Nigeria (Igomu, 2011). The source of the outbreak is still yet unknown. Suggestively it might be due to undercooked Siluriformes used for barbeque sells along the road. In 2010 there was a remarkable outbreak of cholera and gastroenteritis which started from the northern part of Nigeria, spreading to the other parts and involving approximately 3,000 cases and 781 deaths. The attendant deaths in some regions in Nigeria brought to the forefront the vulnerability of poor communities and most especially children to the infection. The regions ravaged by the scourge include Jigawa, Bauchi, Gombe, Yobe, Borno, Adamawa, Taraba, FCT, Cross River, Kaduna, Osun and Rivers (Igomu, 2011). Currently 2025, in south eastern Nigeria there is still outbreak of gastroenteritis infection ongoing which the team of epidemiologist are investigating and the source of the outbreak is still yet unknown as of the time of this study. Therefore, gastroenteritis is one the public health challenges not only in Ebonyi state but Nigeria at large. To this end, Due to rising global temperatures and extreme weather occurrence, assessing the potential impact of climate shift on infectious disease represents a key challenge for public health sectors. Additionally, one of the most important aspects of achieving sustainable development is having a clear understanding of how climate change will affect water and food borne diseases. Accordingly, this study aimed to establish the current relationship between climate change and those gastroenteritis infectious diseases, and it will generate evidence linking the burden of those infections to specific weather across Ebonyi state south eastern Nigeria. With this present study the SDGs, SDG number 3 (Good Health and Well-Being) and 13 (Climate Action), both SDG 3 and 13 aim to reduce illness and increase human well-being worldwide will be achieved.

MATERIAL AND METHOD

Study Area and Description

Ebonyi State is located in the southeastern region of Nigeria. Ebonyi State is located between latitudes 5° 40' and 6° 45'N and longitudes 7° 30' and 8° 30'E. It is predominantly inhabited by the Igbo people, with the city of Abakiliki serving as its capital and largest metropolis. Other significant cities in the state include Afikpo, Okposi, Onueke, Unwana, Ikwo, Ezzamgbo, and Nkalagu. The prevailing climatic condition in Ebonyi State is characterized by two distinct seasons: rainy and dry. The rainy season typically occurs from April to October, while the dry season spans from October to February. This region is known for its bimodal rainfall pattern, with annual rainfall ranging from 1613.8mm to 2136.27mm. Ebonyi State is primarily an agricultural region, renowned for its significant contribution to the production of rice, yam, and potatoes in Nigeria. Rice cultivation, in particular, is the primary agricultural activity in the state. The State possesses a variety of valuable mineral resources, including as lead and crude oil.

Sample Collection

A total of 58 Samples were collected, 29 dry season catfish and 29 rainy season catfish. (2 samples were collected from each location in Ebonyi state capital city). The size of the catfish used is between 1-3kg. The catfish were harvested by the help of the fish farmers who used scooping net to scoop the fish in to the sterile bucket and the catfish were selected by size using weighing balance. With gloved hands, the samples were put into a sterile bag and labeled with masking tape after which the samples were taken to the microbiology laboratory of Ebonyi State University within two (2) hours for bacteriological analysis.

Isolation and enumeration of bacterial strains

Enumeration was done using sterile distilled water to wash off the body of the fish sample, then a ten-fold serial dilution were carried out following standard microbiological procedures by measuring 1 ml of each water sample into nine (9) ml of sterile distilled water in a test tube plugged with cotton wool and

mixed properly to make a dilution of 10^{-1} . A mixture of 1 ml of the sample and sterile distilled water was introduced into another test tube containing 9 ml of sterile distilled water plugged with cotton wool. This procedure was repeated in turn until a dilution of 10^{-5} was obtained. The diluents 10^{-5} were poured into different sterile Petri dishes containing plate count agar (PCA) and the plates were incubated at 37 °C for 24 hours. The colonies were counted using a colony counting machine.

Isolation of Bacteria

Discrete colonies obtained from the plate count agar plates were further sub-cultured onto freshly prepared plates of selective and differential media such as nutrient agar, thiosulphate citrate bile salt sucrose (TCBS agar), Salmonella shigella agar (SSA) and MacConkey agar. The Petri dishes were placed in an inverted position in the incubator for 24 hours at 37 °C to obtain pure cultures.

Demobilization and dissection of the fish samples

The catfish samples were still alive and active. The fish was taken out of the sterile bag and placed dorsal upwards on a sterile dissecting white paper. A surgical blade was used to open up the intestine and a swab stick each was used to swab the intestine and the gills. Afterwards, both the swab stick used for gills and intestine were put into a test tube containing Peptone Water and was incubated for 24 hours at 37 °C for enrichment. A loop full of the mixture after incubation was streaked onto freshly prepared plates of selective and differential media such as nutrient agar, thiosulphate citrate bile salt sucrose (TCBS agar), Salmonella shigella agar (SSA) and MacConkey agar. The Petri dishes were incubated 24 hours at 37 °C to obtain pure cultures.

Identification and Characterization of Bacterial Isolates

The bacterial isolates were primarily characterized and identified by microscopic examination and standard conventional biochemical and physiological tests. The cultures were examined for colony morphology, motility and Gram stain reaction according to Bergeys Manual of Systematic Bacteriology (Onyeagba, 2004).

Statistical Analysis

The results of replicates were pooled and expressed as Mean \pm Standard error of mean. Data obtained were subjected to a one-way analysis of variance with the aid of IBM Statistical Package for Social Sciences (SPSS) version 22 and Microsoft Excel 2013 software

Results**Table 1A: Bacterial Load of rainy season catfish Samples in Ebonyi state capital city..**

S/N	No of colony	Sample code	Total aerobic plate count (cfu/g)
1	26	RC 1	2.6×10^5
2	22	RC 2	2.2×10^5
3	24	RC 3	2.4×10^5
4	37	RC 4	3.7×10^5
5	23	RC 5	2.3×10^5
6	33	RC 6	3.3×10^5
7	41	RC 7	4.1×10^5
8	25	RC 8	2.5×10^5
9	22	RC 9	2.2×10^5
10	77	RC 10	7.7×10^5
11	27	RC 11	2.7×10^5
12	28	RC 12	2.8×10^5
13	24	RC 13	2.4×10^5
14	23	RC 14	2.3×10^5
15	24	RC 15	2.4×10^5
16	26	RC 16	2.6×10^5
17	28	RC 17	2.8×10^5
18	24	RC 18	2.4×10^5
19	26	RC 19	2.6×10^5
20	37	RC 20	3.7×10^5
21	24	RC 21	2.4×10^5
22	31	RC22	3.1×10^5
23	23	RC23	2.3×10^5
24	21	RC24	2.1×10^5
25	24	RC25	2.4×10^5
25	33	RC26	3.3×10^5

27	26	RC27	2.6×10^5
28	22	RC28	2.2×10^5
29	28	RC29	2.8×10^5
Mean	433		4.33×10^5

Key: Rainy season Catfish = RC

Table 1B: Bacterial load of dry season Catfish Samples in Ebonyi state capital city..

S/N	No of colony	Sample code	Total aerobic plate count (cfu/g)
30	67	DC 21	6.7×10^5
31	19	DC 22	1.9×10^5
32	22	DC 23	2.2×10^5
33	26	DC 24	2.6×10^5
34	34	DC 25	3.4×10^5
35	18	DC 26	1.8×10^5
36	22	DC 27	2.2×10^5
37	32	DC 28	3.2×10^5
38	26	DC 29	2.6×10^5
39	29	DC 30	2.9×10^5
40	27	DC 31	2.7×10^5
41	25	DC 32	2.5×10^5
42	28	DC 33	2.8×10^5
43	32	DC 34	3.2×10^5
44	28	DC 35	2.8×10^5
45	24	DC 36	2.4×10^5
46	24	DC 37	2.4×10^5
47	27	DC 38	2.7×10^5
48	33	DC 39	3.3×10^5
49	23	DC 40	2.3×10^5
50	26	DC 50	2.6×10^5
51	21	DC 51	2.1×10^5
52	25	DC 52	2.5×10^5
53	18	DC 53	1.8×10^5
54	28	DC 54	2.8×10^5
55	22	DC 55	2.2×10^5
56	24	DC 56	2.4×10^5
57	31	DC 57	3.1×10^5
58	24	DC 58	2.4×10^5

Mean 784

 7.84×10^5

Key: DC = Dry Season Catfish.

Table 2: Morphological and Biochemical Characteristics of Bacteria species Isolated from Catfish Samples in Ebonyi state capital city.

Morphological characteristics		Microscopic characteristics		Biochemical test							Isolated organisms
SN	Shape	Colour	Gram RXN	Motility Test	OX Test	IND Test	CAT Test	M-red Test	CIT Test	VP Test	
1	Rod	Pink	-	+	-	+	+	+	-	-	<i>Escherichia Coli</i>
2	Rod	Yellow	-	+	+	+	+	+	-	-	<i>V. cholerae</i>
3	Rod	Pale white & black edges	-	+	-	-	+	+	-	-	<i>Salmonella</i> species

Key: RXN= Reaction, OX = Oxidase, IND= Indole, CAT=Catalase, M=Methyl, CIT= Citrate and VP=Voges Proskauer, += positive, - = negative.

Table 3a: Percentage Distribution of Bacteria Isolated from Rainy Season Catfish Samples in Ebonyi state capital city.

S/N	Organism isolated	NO of isolates (%)	Sample source		
			Skins	Gills	Intestine
1	<i>Escherichia coli</i>	53 (44.9)	16(30.2)	18(34)	19(35.8)
2	<i>Vibro cholerae</i>	28 (23.7)	9(32.1)	8(28.6)	11(39.3)
3	<i>Salmonella species</i>	37 (31.4)	11(29.7)	12(32.4)	14(37.9)
Total	118				

Table 3b: Percentage Distribution of Bacteria Isolated from Dry Season Catfish Samples in Ebonyi state capital city.

S/N	Organism isolated	NO of isolates (%)	Sample source		
			Skins	Gills	Intestine
1	<i>Escherichia coli</i>	46 (47.9)	12 (26.1)	15(32.6)	19(41.3)
2	<i>Vibro cholera</i>	20 (20.8)	5(25)	7(35)	8(40)
3	<i>Salmonella species</i>	30 (31.3)	8(26.7)	9 (30)	13(43.3)
Total	96				

Table 4a: Percentage Resistance and Susceptibility of Bacteria Species Isolated from Rainy Season Catfish Samples in Ebonyi state capital city.

S/N	Antibiotic	<i>Escherichia coli</i>		<i>V.cholerae</i>		<i>Salmonella</i> species	
		Resistant (%)	Susceptibility (%)	Resistant (%)	Susceptibility (%)	Resistant (%)	Susceptibility (%)
1	AMC	45(84.9)	8(15.1)	25(89.2)	3(10.9)	36(100)	00(00)
2	FEB	53(100)	00(00)	28(100)	00(00)	36(100)	00(00)
3	CTX	50(94.3)	3(5.7)	28(100)	00(00)	36(100)	00(00)
4	FOX	49(92.5)	4(7.5)	28(100)	00(00)	36(100)	00(00)
5	CIP	5(9.4)	48(90.6)	10(35.7)	18(64.3)	2(5.6)	34(94.4)
6	C	13(24.5)	40(75.5)	13(46.5)	15(53.5)	15(41.7)	21(58.3)
7	IPM	49(86.7)	6(11.3)	27(96.4)	1(3.6)	36(100)	00(00)
8	NA	43(81.1)	10(18.9)	23(82.1)	5(17.9)	30(83.3)	6(16.7)
9	WS	24(45.3)	29(54.7)	14(50)	14(50)	12(33.3)	24(66.7)
10	VA	45(84.9)	8(15.1)	24(85.7)	4(14.3)	31(86.1)	5(13.9)

Key: AMC =Amoxicillin-clavulanic acid, FEB =Cefepime, CTX =Cefotaxime FOX =Cefoxitin, CIP =Ciprofloxacin, CN =Gentamicin, IPM =Imipenem, NA =Nalidixic acid, WS =Trimethoprim and VA= Vancomycin.

Table 4b: Percentage Resistance and Susceptibility of Bacteria Species Isolated from Dry Season Catfish Samples in Abakaliki Metropolis.

S/N	Antibiotic	<i>Escherichia coli</i>		<i>V.cholerae</i>		<i>Salmonella species</i>	
		Resistant (%)	Susceptibility (%)	Resistant (%)	Susceptibility (%)	Resistant (%)	Susceptibility (%)
1	AMC	42(91.3)	4(8.7)	20(100)	00(00)	30(100)	00(00)
2	FEB	46(100)	00(00)	20(100)	00(00)	30(100)	00(00)
3	CTX	46(100)	00(00)	20(100)	00(00)	30(100)	00(00)
4	FOX	46(100)	00(00)	20(100)	00(00)	30(100)	00(00)
5	CIP	15(32.7)	31(67.3)	10(50)	10(50)	13(43.3)	17(56.7)
6	C	21(45.7)	25(54.3)	12(60)	8(40)	18(60)	12(40)
7	IPM	46(100)	00(00)	20(100)	00(00)	30(100)	00(00)
8	NA	43(93.5)	3(6.5)	20(100)	00(00)	30(100)	0(00)
9	WS	20(43.5)	26(56.5)	13(65)	7(35)	19(63.3)	11(36.7)
10	VA	40(87)	6(13)	18(90)	2(10)	23(76.7)	7(23.3)

Key: AMC =Amoxicillin-clavulanic acid, FEB =Cefepime, CTX =Cefotaxime FOX =Cefoxitin, CIP =Ciprofloxacin, CN =Gentamicin, IPM =Imipenem, NA =Nalidixic acid, WS =Trimethoprim and VA= Vancomycin.

Results and Discussion

Colony enumeration is very useful in understanding the contamination level of different microorganisms from a sample drawn from a particular habitat Nwuzo *et al.* (2024). In this study, the enumeration of bacteria isolates from rainy season and dry season catfish samples in ebonyi state capital city revealed a total average mean bacterial load of 7.84×10^5 and 4.33×10^5 cfu/g for rainy and dry season catfish samples respectively were observed (tab 1a and b).

The result revealed high microbial load from both samples. This may be attributed to increase in global warming, anthropogenic activities such as washing, bathing, indiscriminate dumping of refuse, open defecation in and around the river bank where fish habitat and also flood around Abakaliki metropolis which empty into the river Igwe *et al.* (2024). The difference in the bacteria load of the 58 selected both rainy and dry season fish samples agrees with the fact that the presence of bacteria in natural aquatic ecosystem is dependent upon the rate of contamination and the equilibrium that is established between bacteria proliferation in that environment and the rate of their elimination (Lejeune *et al.*, 2001). The total bacteria count of catfish samples were higher than that of WHO standard (1.0×10^3 cfu/100 ml). This may be because people living around Ebonyi state capital city use Ebonyi river as dumping ground, for open defecation and due to lack of proper waste management. This study agrees with Atiribom and Kolndadacha (2014) that most people in this part of the world see rivers as dumping ground for every kind of wastes. The level of bacteria load in this study is in line with the study of Amuneke *et al.*, (2020) who worked on bacteriological profile of selected fish species and water sample from Otuocha river Anambra state, their results from the bacteria enumeration of water sample shows that the total bacteria count (TBC) of plate count 10^{-2} and 10^{-1} was higher (1.42×10^5 and 1.72×10^4 cfu/ml) than the World health organisation (WHO) standard (1.0×10^3 cfu/100ml). Generally, the variation in this bacteria count load results recorded could be due to increase in temperature and the sanitary conditions of the study areas and rates of bacteria count can be attributed to differences in sample locations and varying levels of development going on at each locality as well as the enumeration techniques employed.

The result of the culture tests carried out on the bacteria organism isolated from catfish samples in Ebonyi state capital city. It gives a summary of the morphological, microscopic and biochemical characteristics of the bacteria isolated from the different study locations. According to the different tests carried out three different organisms were identified and include: *Escherichia coli*, *Vibrio cholerae* and *Salmonella* species. In Morphological characteristics all the bacteria shows rod in shape, color pink, yellow and pale white and black edges for *Escherichia coli*, *Vibrio cholerae* and *Salmonella* species respectively. Microscopically there were all gram negative organism and positive in motility test. Biochemical test shows that they were all citrate negative while *Escherichia coli* and *Vibrio cholerae* shows Indole positive and negative in *salmonella* species (tab 2). The result is in line with the work of Nwuzo *et al.* (2024) who worked on Assessment of Bacterial Contamination of Fish from Aquaculture Sources and Its Public Health Implications in Abakaliki, Ebonyi State, Nigeria.

A total of 118 isolates were obtained from rainy season catfish. Out of the 118 isolates, 53 (44.9%), 28(23.7%) and 37 (31.4%) were *E.coli*, *Vibrio cholerae* and *Salmonella* species respectively were isolated (tab 3a). While a total of 96 isolates were obtained from dry season catfish sample. Of the 96 isolates, 46(47.9%), 20(20.8%) and 30(31.3%) were *E.coli*, *Vibrio cholerae* and *Salmonella* species respectively were isolated (tab 3b). The high level of microbes in the catfish samples, from Ebonyi state capital city in both rainy and dry season probably

revealed the attitudes of people living around Ebonyi state capital city towards waste disposal and management. This agreed with the report of *Dalgaard et al.* (2006) that pollution of the aquatic habitats with faecal matter is mostly from human activities and climate change. This agreed with the opinion of *Okonko et al.* (2012) that the microbial composition of fish depends upon the microbial counts of water in which they live. *E. coli*, the predominant species of the faecal coliforms, has been found in the intestinal tract of fish (*Dang and Dalsgaard, 2012*). Presence of *E. coli* in food or water indicates the possible cause of many gastro-intestinal diseases and may constitute potential danger of antibiotic resistance transfer from aquatic bacteria to human (*Igwe et al., 2024* and *Okeh et al., 2022*). The difference in the dominating microflora between sites of colonisation has been reported by previous investigation (*kings et al., 2010*) in south Africa. In support of this study, *Allamin et al., (2015)* reported that *Escherichia coli* was the most common species isolated in their study with an overall prevalence of 98 % followed by *Aeromonas sobria* with a 67 %, *Klebsiella* species with 66%,*Salmonella* species had 44% and *Staphylococcus* species with 25% which was the lowest prevalence in pond water sources in Kaduna State Nigeria. The presence of enteric pathogens in fish may result from weather pattern, indiscriminate deposition of human and animal excreta as well as other environmental wastes into ponds and rivers that harbor fish or through washing of land surfaces into water bodies during the rainy season (*Cabral, 2010*).

Ten (10) conventional antibiotics (Cefoxitin, Amoxicillin-clavulanic acid, Imipenem, ciprofloxacin, gentamicin, cefotaxime, nalidixic acid vancomycin, trimethoprim and cefepime) were used for the susceptibility testing.

All *Escherichia coli*, isolated in this study were found to be 100% resistant to more than 7 antibacterial agents tested cefepime, cefotaxime, cefoxitin, imipenem, vancomycin, nalidixic acid and amoxicillin/clavulanic acid. It also showed high susceptibility to over 79 % ciprofloxacin, while 67.5% and 64.5% trimethoprim gentamicin respectively (tab 4a). Both *V.cholerae* and *salmonella* isolated in this study were found to be 100% resistant to more than 8 antibacterial agents tested amoxicillin/clavulanic acid, cefepime, cefotaxime, cefoxitin, imipenem, vancomycin, nalidixic acid and gentamicin. It also showed susceptibility to ciprofloxacin 75% and trimethoprim 56 (tab 4b). A finding which is supported by earlier reports of *Ogbukagu,(2020)*; *Overdevest et al. (2011)* that antibiotic resistance in Enterobacteriaceae has increased dramatically during the past decade which may be due to climate change resilience. In addition, these results provide evidence that there is an increased emergence of antibiotic resistance from bacterial isolates of fish and water, a finding which is in agreement with the reports of *Albuquerque et al. (2007)* who found increasing emergence of antibiotic resistance in bacterial isolates originating from fish. Although the use of antibiotics in human medicine has influenced the emergence of resistant bacteria, the use of antibiotic in animals has contributed to the problem of resistance and complicates the choice of treatment in human diseases (*Novotny et al., 2004*). However, the fact that transfer of resistant bacteria between aquatic animals and humans through food production line has been documented and can pose a threat to public health (*Okeh et al., 2022*).

CONCLUSION

This study demonstrated the presence of highly pathogenic agents such as *E. coil*, *V.cholerae* and *Salmonella* species. Their presence constitutes potential health risk/hazard to human beings and may cause disease to susceptible individuals, especially immune-compromised consumers. Study, may be suggestive of increase in temperature and faecal contamination due to poor hygiene and poor sanitary practices in the sample locations. These may play a significant role in the transmission of various diseases. This study has therefore proven the need for adoption of proper hygienic measures, also climate change education for fish handlers/traders and consumers. There is a need to explore more on the antibiotic susceptibility on the face of climate change and surveillance in aquatic environments where fish from pond and other fish habitat are obtained for human consumption not only in Ebonyi state but Africa at large.

Declaration of Conflict of Interest:

The authors declare no conflict of interest.

Data Availability Statement:

Data are available upon request from the corresponding author

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