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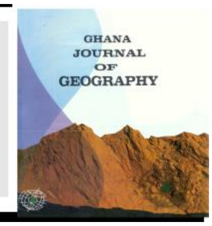

Effects of Industrial Effluents on Catfish Ecosystem In Ilorin Metropolis, Nigeria

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abstract

The ecological balance of aquatic ecosystems, particularly those supporting vital species like catfish, is increasingly threatened by industrial effluents. This study assessed the toxicological effects of industrial effluents on the catfish ecosystem in Ilorin metropolis. The objectives were to determine the physico-chemical properties of water from a natural fish pond on industrial land-use; compare the physicochemical properties of the water with the standards of WHO and FEPA; examine the growth indicator of catfish in the study area; and assess the relationship between the physico-chemical properties of the water and the growth of the catfish in the study area. Primary and secondary data were gathered and the sampling involved taking 1% of catfish from three natural ponds on industrial land, each with earthen ponds of 50 by 70 meters with a capacity of up to 5000. Water samples were collected from the river and the natural fish pond over a six-week period, divided into three phases corresponding to different developmental stages of the fish. These water and fish samples were subjected to laboratory analysis. Descriptive and inferential methods used in the study were percentages, graphs, charts, the chi-squared test, and a correlation matrix for data analysis. This study revealed that industrial effluents raised the level of parameters such as iron, copper, lead, and electrical conductivity in the water sampled beyond the recommended levels of WHO and FEPA Standard's guidelines, with mean values of 7.843, 0.23, 1.01, and 260.667 mg/l, respectively. Chemical parameters such as Fe, Mn, Cu, Co, Pb, and I in the water had no significant effect on fish growth as their p-values (0.472, 0.493, 0.180, 0.672, 0.328, and 0.511, respectively) were higher than the 0.05 level of significance. The physical parameters such as pH (0.918), temperature (0.367), nitrate level (0.292), total solids (0.495), and total soluble solids (0.502) did not show any impact on the growth of catfish. The study concluded that fish growth is affected by the availability of zinc in the fish pond, the increase in electrical conductivity, dissolved oxygen, and total dissolved solids in the water. It is recommended that water quality monitoring be conducted to ensure the good functioning of the aquatic ecosystem for increased fish productivity.

Introduction

In Nigeria, one of the main environmental problems is water contamination. The amount of pollution has increased because of both industrialization and urbanization. Since untreated water or garbage that has not been sufficiently cleaned is dumped into streams, estuaries, and oceans, water is without a doubt, facing a serious environmental challenge on a local and global scale (Novotny, 2003). In the emerging nations, one of the biggest issues is the inappropriate handling of enormous volumes of waste resulting from human activities. The hazardous release of the trash onto the surrounding environment presents greater difficulties. The most affected are bodies of water, particularly, freshwater reservoirs. This has frequently made these natural resources inappropriate for use in both primary and secondary applications (Fakayode, 2005). The contamination of natural water bodies by industrial wastewater has become a serious problem in emerging, highly populated nations like Nigeria. The primary sources of drinking water in Nigeria are inland waterways and estuaries, both of which are frequently contaminated by the activities of nearby industrial facilities and populations (Sangodoyin, 1995).). The main method of getting rid of garbage is through river systems, especially the industrial effluent from nearby enterprises. These discharges have the potential to change the physical, chemical, and biological characteristics of the water bodies into which they flow (Ajayi et al., 1991). The escalation of industrial activities has resulted in stress on surface water due to pollution originating from industrial, agricultural, and domestic sources (Ajayi et al., 1991). Waste materials introduced into these water bodies exist in both solid and liquid forms, predominantly stemming from industrial, agricultural, and domestic practices. Consequently, water bodies, which serve as primary recipients of both treated and untreated industrial waste, have become significantly contaminated. The repercussions of this contamination on public health and the environment can be substantial (Osibanjo et al., 2011).

Aquatic ecosystems encompass various bodies of water and are distinguished from terrestrial ecosystems. These ecosystems harbor communities of organisms interdependent on each other and their surroundings. The primary types of aquatic ecosystems include marine ecosystems and freshwater ecosystems (Alexander, 1999). While the focus of this study is not on marine ecosystem, freshwater ecosystems are categorized as Lentic (slow-moving water, such as pools, ponds, and lakes), Lotic (fast-moving water, including streams and rivers), and Wetland (areas periodically saturated or flooded) (Vaccari, 2005).

Catfish, a diverse group of ray-finned fish, derive their name from their prominent barbels, reminiscent of a cat's whiskers. These fish vary greatly in size and behavior, ranging from the Mekong giant catfish of Southeast Asia to detritivores and even to tiny parasitic species like the Candiru (Wong, 2001). Despite the name, not all catfish possess conspicuous barbels. Catfish, falling under the Siluriformes order, are characterized by specific features of the skull and swim bladder. They hold significant commercial importance, with larger species being farmed or caught for consumption, while smaller species, like those of the Corydoras genus, are popular in the aquarium trade. Catfish exhibit various activity patterns, with many being nocturnal, while others are crepuscular or diurnal (Wong, 2001).

In Ilorin, several industries indirectly release chemical byproducts during their routine operations, which ultimately contaminate various environmental areas, particularly water bodies, and this adversely affects non-target

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organisms. Existing literature on water pollution in Ilorin indicates that aquatic biota in contaminated water bodies often experience oxidative stress (Ajadi et al., 2016). Chemical analysis of industrial effluents provides insight into the chemical composition but fails to address the potential adverse effects on aquatic biota (Badut et al., 2000). Given the complex composition of industrial effluents, containing mixtures of chemicals with potential synergistic or antagonistic effects, suitable sentinel organisms are necessary for an accurate assessment (Carlsson et al., 2009).

Materials and Methods

Study Area

Ilorin is the capital city of Kwara State in Nigeria. Ilorin is the home to four (4) local government areas; namely Asa, Ilorin-West, Ilorin-East and Ilorin-South LGAs. It is located on latitude 8º30′ and 8º50′N and longitude 4º20′ and 4º35′E of the equator. Ilorin city occupies an area of about 468sqkm as shown in Figure 1 (Agaja and Ajetunmobi, 2022). The climate of Ilorin is tropical under the influence of the two trade winds prevailing over the country. Ilorin metropolis experiences two climatic seasons i.e. rainy and dry seasons. The rainy season is between March and November and the annual rainfall varies from 1000mm to 1500mm with the peak between September and early October. Also, the mean monthly temperature is generally high through the year. The daily average temperatures are in January with 25°C, May 27.5°C and September 22.5°C. (Tunde et al., 2013).

Ilorin is mainly drained by Asa River which flows in south-north direction. (Ajibade and Ojelola, 2004). The pattern of the drainage of Ilorin is dendritic. The Asa river has its source in Oyo state, south-west, Nigeria, while in Kwara state, it is located within the Asa and Ilorin West local governments. The river is 56km long, about 100m wide supplying water to the majority of people of Ilorin through the building of dams such as Asa, Agba, Unilorin and Sobi lake dams. (Ogunkunle et al., 2016). Asa river is a reservoir to a number of contaminants and pollution from industrial, municipal and agricultural sources (Ebikapade, 2016). These contaminants and pollutants are chemical compounds and heavy metals capable of inflicting various harmful effects on organisms at their cellular level (Opasola et al., 2019). The Asa river occupies a fairly wide valley and goes a long way to divide Ilorin into two parts; namely the eastern and the western part. The eastern part covers those areas where the GRA is located while the core indigenous area of Ilorin falls under the western part. Some other rivers in Ilorin that drain into the Asa River are river Agba, river Alubosa, river Okun, river Osere, river Aluko, river Yalu, river Odota, and river Loma. (Ajadi et al., 2016). Ilorin consists of Precambrian basement complex rock. The soil of Ilorin is made up of loamy soil with medium and low fertility. Because of the high seasonal rainfall coupled with the high temperature, there is the tendency for lateritic soil constituting the major soil due to leaching of mineral nutrients of the soil (Ajibade and Ojelola, 2004).

The inhabitants of the local government are the Yoruba, Fulani, Hausa and Nupe. Some other nationalities include the Igbo, Urhobo, Itsekiri, Ijaw etc., although it is highly heterogeneous, accommodating people from various other tribes who either engage in commercial activity or work in the public service (Ilorin West Secretariat, 2018). Although Ilorin developed as an administrative Centre, both economic and social activities have greatly influenced its growth in recent times. The major occupations of the indigenes are farming, pottery making, and weaving. There are greater percentages of the people who are also traders, while others are self-employed in different fields such as mechanics, carpentry and also, a large number of the population work as civil Servants, Bankers, Teachers, etc. (Agaja and Ajetunmobi, 2022)

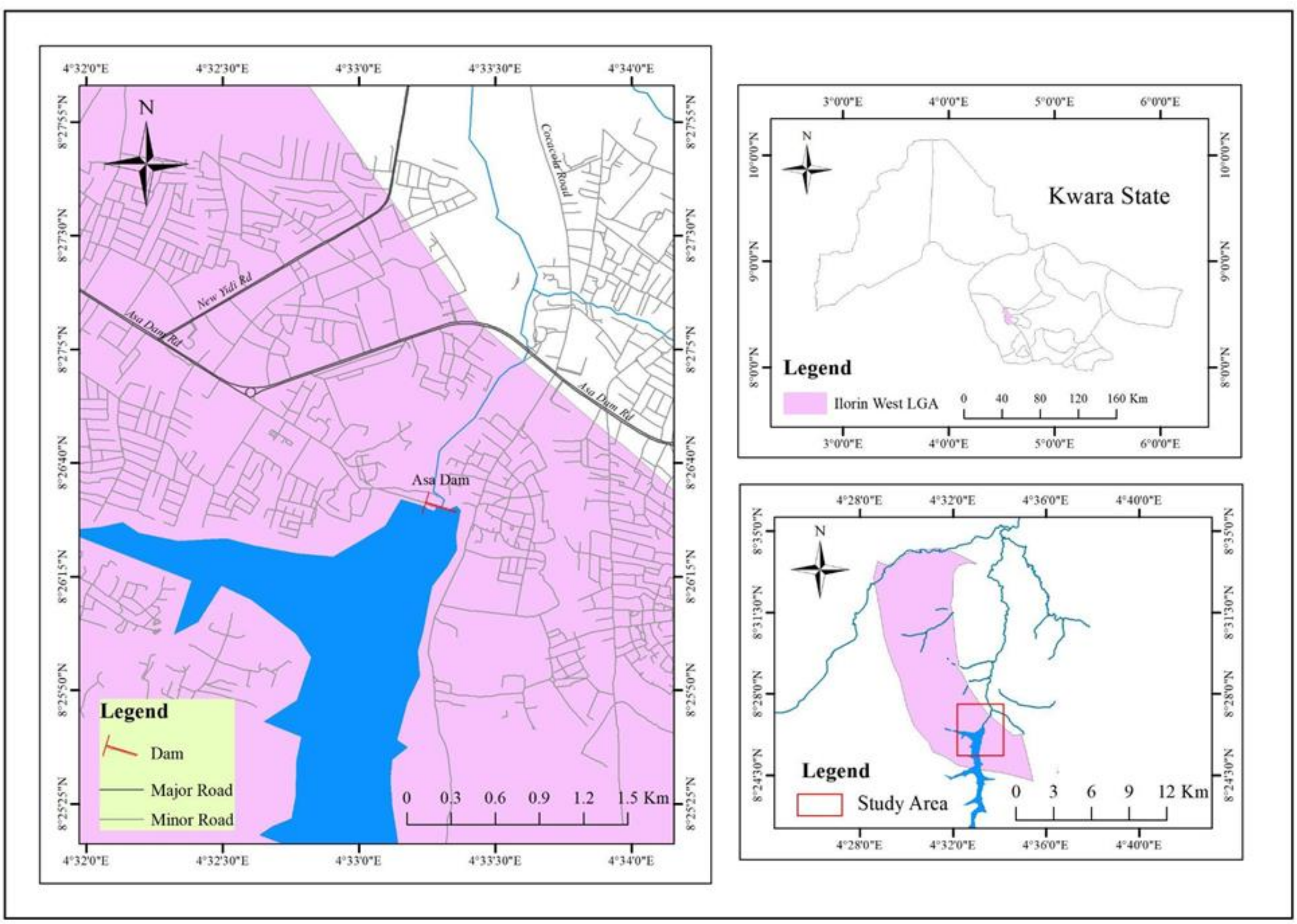

Figure 1: Asa Dam River Showing the Study Location in Ilorin, Kwara State
Source: Adapted from the Kwara State Bureau of Lands and Survey (2010)

Methods

The research utilized various types of data, including water samples from a natural pond on the Asa River, data on the physicochemical analysis of water, growth indices of catfish, fish characteristics (such as body shape, lateral line), fish mortality and survival rates, a map of the study area (showing the GPS point of the natural pond), and physical and chemical properties of catfish (such as gills, swim bladder, lipid content). Primary data were collected from water samples obtained from a natural pond on the Asa River within the industrial layout. These samples underwent evaluation for chemical, microbial, physical, and biological composition. Secondary data were compiled from existing sources, including archived research, literature reviews, published documents, and mapping.

Water samples were collected from two sources: the river and the natural fish ponds, facilitating comparison of water quality. Clean plastic bottles were used to collect samples from the river, which were rinsed with river water, submerged, and then sealed. These labelled samples were refrigerated and transported to the Biochemistry Laboratory at the University of Ilorin. Similarly, samples were collected from the natural pond and transported to the laboratory for analysis. Fish sampled from three natural ponds, allowing for composite samples, were used to obtain the growth indicators of catfish. Fish were collected using a bowl rinsed with pond water, submerged in the pond, transferred using a sieve into the bowl, and placed in a perforated nylon bag to prevent suffocation. These samples were promptly taken to the laboratory for measurement.

The study population consisted of three ponds, with 1% of catfish sampled from each pond. The catfish were sourced from earthen ponds measuring approximately 50 by 70 meters, each with a capacity of up to 5000 fish. The study spanned six weeks, divided into three phases: Phase 1 (two weeks) for fingerlings, Phase 2 (two weeks) for juveniles, and Phase 3 (two weeks) for post-juvenile fish.

Plate 1: Natural Catfish Pond at Asa Dam, Ilorin
Source: Authors' Fieldwork (2022)

Plate 2: 50 by 70 meters Natural Pond with a capacity of up to 5000 fish Catfish Farm at Asa Dam, Ilorin
Source: Authors' Fieldwork (2022)

Laboratory analyses were conducted using various methods as outlined in Table 1 and 2. Descriptive and inferential statistical methods, including percentages, graphs, charts, the chi-squared test, and correlation matrices, were employed for data analysis.

Table 1: Parameters of Water Quality of Pond

S/N	Parameters	Laboratory Method of analysis	SI.Unit
1	Total Solid (TS)	Gravimetric Method	Mg/l
2	Total Dissolved Solid (TDS)	Gravimetric Method	Mg/l
3	Total Suspended Solid (TSS)	Gravimetric Method	Mg/l
4	PH	Colorimetric	_______
5	Dissolved Oxygen (DO)	Titration Method	Mg/l
6	Temperature	Thermal Analysis	°C
7	Electrical Conductivity	Electrochemical Method	
8	Nitrate (NO3)	Electrochemical Method	

Source: EPA (1999)

Table 2: Parameter of Fish samples

S/N	Parameter	Laboratory Method of Analysis	SI.Unit
1	Length	Measuring tape	Cm
2	Weight	Weight scale	G
3	Total Solid	Gravimetric Analysis	Mg/l
4	Total Ash	Gravimetric Analysis	Mg/l
5	Water Soluble Ash	Gravimetric Analysis	Mg/l
6	Acid Insoluble Ash	Gravimetric Analysis	Mg/l
7	Protein	Gravimetric Analysis	Mg/l
8	Fat	Gravimetric Analysis	Mg/l
9	Moisture	Gravimetric Analysis	Mg/l
10	Mineral	Gravimetric Analysis	Mg/l

Source: EPA (1999)

RESULTS AND DISCUSSION

Physio-chemical Properties of Water from a Natural Fish Pond

The concentration (mg/L) of Iron, Manganese, Copper, Zinc, Cobalt, Lead, and Iodine falls within the ranges of 6.920 – 8.550, 0.09 – 0.23, 3.94 – 4.62, 1.4 – 1.7, 0.0 – 0.01, 1.0 – 1.02, and 120.01 – 121.4 respectively, with mean values of 7.843, 0.17, 4.23, 1.50, 0.007, 1.01, and 120.823. Additionally, the electrical conductivity and dissolved oxygen levels range from 259.0 – 263.0 and 7.12 – 7.98, with mean values of 260.667 and 1.7 respectively. The pH of water samples varies between 6.25 to 6.68, with a mean value of 6.48 mg/l, indicating a slightly acidic condition. Temperature (°C), an indicator of water quality, fluctuates between 26.60 and 27.90, with a mean of 27.267 (Table 3). Nitrate, TDS, TS, and TSS exhibit variations between 0.34 – 0.5, 127.0 – 131.0, 128.42 – 130.9, and 1.42 – 1.53 respectively, with mean values of 0.417, 128.667, 129.84, and 1.483.

The electrical conductivity and dissolved oxygen levels range between 259.0 – 263.0 and 7.12 – 7.98 respectively, with mean values of 260.667 and 1.7. These findings align with the recommended ranges as reported by Muamar et al. (2014), indicating that the wastewater does not contain excessive salt concentrations that would impact fish growth. This suggests the potential suitability of the water for irrigation purposes. The higher pH levels in the water samples, ranging between from 6.2 and to 6.68 with a mean of 6.48 mg/l, (Table 3) indicate a slightly acidic nature. pH values serve as indicators of water acidity or alkalinity. This implies that availability of nutrients for animals and plants may be tampered with. Some nutrients, such as iron and manganese, become more available in slightly acidic conditions, while others, like phosphorus, can become less available (Agbaire et al., 2014).

The majority of the physical, chemical, and heavy metal parameters exhibited significant differences when compared to the control water sample. Furthermore, deviations from the World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) standards were observed. Water quality that does not meet WHO and FEPA standards can harm aquatic ecosystems. Pollutants and contaminants can disrupt the balance of ecosystems, leading to the loss of biodiversity, the death of aquatic organisms, and the degradation of habitats (Bartram & Ballance, 1996; Carpenter et al., 1998). Specifically, manganese (0.170), cobalt (0.007), dissolved oxygen (7.637), pH (6.480), temperature (27.267), NO3 (0.417), total dissolved solids (128.667), total solids (129.840), and total soluble solids (1.483) were found to be within permissible limits across all categories of water. However, iron (7.843), copper (4.230), lead (1.010), and electrical conductivity (260.667) exceeded WHO and FEPA standards (Table 3). Poor water quality can harm ecosystems, leading to the loss of biodiversity and disruption of aquatic life. Excess nutrients like nitrogen and phosphorus can cause eutrophication, leading to algal blooms that deplete oxygen in water bodies, killing fish and other aquatic organisms (Smith et al., 2019).

Table 3: Physiochemical Properties of Water

Parameters	Observations	Minimum	Maximum	Mean±S.D	CV	WHO	FEPA
Iron (Fe)	3	6.920	8.550	7.843±0.683	0.087	-	<1.0
Manganese (Mn)	3	0.090	0.230	0.170±0.059	0.346	-	<1.0
Copper (Cu)	3	3.940	4.620	4.230±0.286	0.068	2.0	1.0
Zinc (Zn)	3	1.400	1.700	1.507±0.137	0.091	-	-
Cobalt (Co)	3	0.000	0.010	0.007±0.005	0.707		0.06
Lead (Pb)	3	1.000	1.020	1.010±0.008	0.008	0.01	<1.0
Iodine (I)	3	120.010	121.400	120.823±0.592	0.005	-	-
Electrical Conductivity (E.C)	3	259.000	263.000	260.667±1.700	0.007	-	200
Dissolved Oxygen (DO)	3	7.120	7.980	7.637±0.372	0.049	6.0	8 – 10
pH	3	6.250	6.680	6.480±0.177	0.027	6.5 – 8.5	6 – 9
Temperature	3	26.600	27.900	27.267±0.531	0.019	<35	27.0
Nitrate (NO_3)	3	0.340	0.500	0.417±0.065	0.157	50	20
Total Disolved Solid (TDS)	3	127.000	131.00	128.667±1.700	0.013	<500	1.0
Total Solids (TS)	3	128.420	130.900	129.840±1.044	0.008	<1000	500
Total Suspended Solid (TSS)	3	1.420	1.530	1.483±0.046	0.031	-	30

Key: CV = Coefficient of Variation

Source: Authors' Field Work (2022)

The quality of water used for fish rearing is crucial for achieving maximum production, as sub-optimal physicochemical parameters can adversely affect fish and other aquatic organisms. Water temperature, a key parameter in this study, influences the timing of fish spawning, growth of aquatic vegetation, and the biological oxygen demand in ponds. Higher water temperature results in reduced oxygen solubility, increased respiratory rates in plants and animals, and consequently, diminished oxygen availability for fish, which can limit their growth (Muamar et al., 2014).

Growth Indicators of Catfish in the Study Area

The study observed a significant growth pattern with a P-value of less than 0.05 observed in the length (p=0.004), weight (p=0.000), total ash (0.002), protein (0.005), fat (0.008), and moisture (0.000) content of the catfish (Table 4). The growth of fish in the natural ponds was notably influenced by factors such as the presence of zinc in the fish pond, as well as increases in electrical conductivity, dissolved oxygen, and total dissolved solids in the water. Fish exhibit various physiological responses to cope with fluctuations in oxygen levels, indicating the presence of sensory mechanisms for promptly detecting both hypoxic and normoxic conditions (Jobling, 2004). However, fish metabolism may be adversely affected by suffocation due to high concentrations of toxic substances, ultimately leading to an increased fish mortality. The cumulative effects of low oxygen levels also contribute to significant fish mortality and negatively impact fish growth.

The results of the regression analyses presented in Tables 5, 6, and 7 demonstrate a robust correlation between Zinc and the growth of fish in terms of both length and weight. Additionally, a positive relationship was observed between electrical conductivity and the length and weight of fish. Moreover, dissolved oxygen exhibits a positive correlation with both the length and weight of the fish (R2 = 0.996). Similarly, total dissolved solids displayed a positive association with the length and weight of the fish. Thus, the regression analysis results indicate a significant relationship ($p < 0.05$) between fish growth and the availability of zinc in the fish pond, as well as increases in electrical conductivity, dissolved oxygen, and total dissolved solids in the water. Conversely, chemical parameters such as Fe, Mn, Cu, Co, Pb, and I in the water, as well as physical parameters like pH, temperature, nitrate level, total solids, and total soluble solids, do not impact the growth of catfish in the study area.

In line with these findings, Farida et al. (2009) suggested that warm-water fish, like catfish can tolerate temperature fluctuations ranging from 20-35°C, but reproduction occurs optimally up to 32°C. However, contradicting these findings, Jobling et al. (2009) opined that fish inhabiting polluted water may suffer from pollutants in various ways, potentially affecting fish structure and physiology, resulting in their avoiding polluted water. Lloyd (2002) demonstrated through experimentation that fish possess the ability to detect even minute concentrations of chemicals in water. However, in this study, fish did not avoid polluted water as it did not impact their growth. This phenomenon could be attributed to fish habituation to elevated levels of the studied parameters in the water or the availability of food.

Table 4: Growth Indicators of Catfish

Parameters	1st sample	2nd sample	3rd sample	Chi-Square (Observed Value)	P-Value	Decision
Length	20	24	65	21.741	0.004	S
Weight	243	220	2789	124.726	0.000	S
Total Solid	62.4	102	469	7.787	0.714	NS
Total Ash	21.8	38.4	56.2	62.658	0.002	S
Water Soluble Ash	9.4	12.6	41	6.164	0.189	NS
Acid Insoluble Ash	8.2	92	32.4	391.530	0.225	NS
Protein	13.62	18.6	36.32	25.078	0.005	S
Fat	11.4	16.63	24.63	30.150	0.008	S
Moisture	40.62	49.3	52.32	141.726	0.000	S

Key: S – Significant, NS – Not Significant

Source: Authors' Field Work (2022)

Table 5: Linear Regression on Relationship between Physicochemical Properties of the Water and the Growth of Catfish

	Length				Weight				Total Solid			
Parameters	R^2	F-Value	P-Value	Decision	R^2	F-Value	P-Value	Decision	R^2	F-Value	P-Value	Decision
Fe	0.455	0.835	0.529	NS	0.543	1.189	0.472	NS	0.447	0.809	0.534	NS
Mn	0.599	1.494	0.437	NS	0.511	1.047	0.493	NS	0.607	1.543	0.431	NS
Cu	0.963	25.960	0.123	NS	0.923	11.916	0.180	NS	0.966	28.316	0.118	NS
Zn	1.000	2325.9	0.013	S	0.995	219.182	0.043	S	0.999	1206.96	0.018	S
Co	0.323	0.476	0.615	NS	0.243	0.322	0.672	NS	0.330	0.493	0.610	NS
Pb	0.677	2.100	0.385	NS	0.757	3.110	0.328	NS	0.670	2.030	0.390	NS
I	0.395	0.654	0.567	NS	0.483	0.934	0.511	NS	0.388	0.633	0.572	NS
E.C	0.994	137.356	0.003	S	0.999	115.293	0.009	S	0.976	41.428	0.098	NS
DO	0.996	121.026	0.006	S	0.999	237.720	0.002	S	0.514	1.059	0.491	NS
pH	0.002	0.002	0.975	NS	0.016	0.017	0.918	NS	0.001	0.001	0.980	NS
Temperature	0.781	3.556	0.310	NS	0.704	2.373	0.367	NS	0.787	3.698	0.305	NS
NO_3	0.868	6.601	0.236	NS	0.803	4.087	0.292	NS	0.874	6.926	0.231	NS
TDS	0.994	137.356	0.003	S	0.977	115.293	0.009	S	0.976	41.428	0.098	NS
TS	0.595	1.471	0.439	NS	0.508	1.031	0.495	NS	0.603	1.520	0.434	NS
TSS	0.585	1.410	0.446	NS	0.497	0.990	0.502	NS	0.593	1.457	0.440	NS

Key: S – Significant, NS – Not Significant

Source: Authors' Field Work (2022)

Table 6: Linear Regression on Relationship between Physicochemical Properties of the Water and the Growth of Catfish

	Total Ash				Water Soluble Ash				Acid Insoluble Ash			
Parameters	**R^2**	**F-Value**	**P-Value**	**Decision**	**R^2**	**F-Value**	**P-Value**	**Decision**	**R^2**	**F-Value**	**P-Value**	**Decision**
Fe	0.097	0.136	0.108	NS	0.444	0.797	0.536	NS	0.698	2.313	0.370	NS
Mn	0.933	13.828	0.167	NS	0.610	1.567	0.429	NS	0.253	0.339	0.665	NS
Cu	0.948	18.361	0.146	NS	0.967	29.500	0.116	NS	0.001	0.001	0.978	NS
Zn	0.816	4.424	0.283	NS	0.999	948.437	0.021	S	0.032	0.033	0.886	NS
Co	0.732	2.736	0.346	NS	0.334	0.500	0.608	NS	0.523	1.095	0.486	NS
Pb	0.268	0.365	0.654	NS	0.666	1.998	0.392	NS	0.477	0.914	0.514	NS
I	0.065	0.069	0.836	NS	0.384	0.623	0.575	NS	0.752	3.033	0.332	NS
E.C	0.933	14.029	0.166	NS	0.978	43.514	0.096	NS	0.000	0.000	0.998	NS
DO	0.879	7.232	0.227	NS	0.518	1.075	0.489	NS	0.338	0.510	0.605	NS
pH	0.140	0.163	0.756	NS	0.001	0.001	0.982	NS	0.986	69.993	0.076	NS
Temperature	0.996	239.556	0.041	NS	0.790	3.765	0.303	NS	0.104	0.116	0.791	NS
NO_3	0.997	370.490	0.033	S	0.876	7.082	0.229	NS	0.044	0.046	0.865	NS
TDS	0.933	14.029	0.166	NS	0.978	43.514	0.096	NS	0.000	0.000	0.998	NS
TS	0.931	13.423	0.170	NS	0.607	1.543	0.432	NS	0.256	0.344	0.662	NS
TSS	0.925	12.392	0.176	NS	0.597	1.479	0.438	NS	0.256	0.361	0.656	NS

Table 7: Linear Regression on Relationship between Physicochemical Properties of the Water and the Growth of Catfish

	Protein				Fat				Moisture			
Parameters	**R^2**	**F-Value**	**P-Value**	**Decision**	**R^2**	**F-Value**	**P-Value**	**Decision**	**R^2**	**F-Value**	**P-Value**	**Decision**
Fe	0.329	0.490	0.611	NS	0.164	0.197	0.734	NS	0.001	0.001	0.984	NS
Mn	0.722	2.591	0.354	NS	0.874	6.937	0.231	NS	0.999	1125.78	0.019	S
Cu	0.996	243.910	0.041	S	0.983	59.323	0.082	NS	0.752	3.025	0.332	NS
Zn	0.977	43.431	0.096	NS	0.886	7.809	0.219	NS	0.549	1.217	0.469	NS
Co	0.449	0.813	0.533	NS	0.640	1.775	0.410	NS	0.938	15.180	0.160	NS
Pb	0.551	1.229	0.467	NS	0.360	0.563	0.590	NS	0.062	0.066	0.840	NS
I	0.273	0.376	0.650	NS	0.122	0.139	0.773	NS	0.001	0.001	0.977	NS
E.C	0.999	956.779	0.021	S	0.974	38.040	0.102	NS	0.724	2.620	0.352	NS
DO	0.634	1.736	0.413	NS	0.806	4.153	0.290	NS	0.996	247.257	0.040	S
pH	0.008	0.008	0.943	NS	0.078	0.085	0.820	NS	0.391	0.643	0.570	NS
Temperature	0.877	7.156	0.228	NS	0.973	36.209	0.105	NS	0.949	18.577	0.145	NS
NO_3	0.943	16.511	0.154	NS	0.998	428.808	0.031	S	0.886	7.772	0.219	NS
TDS	0.999	956.779	0.021	S	0.974	38.040	0.102	NS	0.724	2.620	0.352	NS
TS	0.718	2.548	0.356	NS	0.872	6.782	0.233	NS	0.999	1474.32	0.017	S
TSS	0.709	2..434	0.363	NS	0.865	6.381	0.240	NS	1.000	4048.95	0.010	S

Conclusion

This study complements previous studies on the toxicological effect of the industrial effluents on catfish ecosystem and the following have been revealed. The industrial effluents raised the level of parameters such as iron, copper, lead and electrical conductivity beyond the recommended levels of WHO and FEPA Standard's guidelines. The volume of these discharges into natural ponds was already overtaxing their capacity for self-purification. In furtherance, the prevailing practice of unregulated and uncontrolled discharge of such wastes into water bodies constitutes serious abuse and portends serious danger to the resident species and beneficial use to the municipality.

Chemical parameters such as Fe, Mn, Cu, Co, Pb, and I in the water and physical parameters such as pH, temperature, nitrate level, total solid and total soluble solid did not show any impact on the growth of catfish in the study area. However, fish growth was affected by the availability of zinc in the fish pond, and the increase in electrical conductivity, dissolved oxygen and the total dissolved solids in the water. Conclusively, as cities are continually built, lands are cleared for farming such as aquaculture and this makes other man-made changes to the natural environment. Thus water quality monitoring should be done to ensure good functioning of the aquatic ecosystem increased fish productivity.

Declaration of Interest

The study had a vested interest in understanding toxicological effect of industrial effluents on the catfish ecosystem in Ilorin metropolis, however, it remained committed to conducting this research with objectivity and integrity, free from any preconceived notions or biases.

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