INTERNATIONAL JOURNAL OF RESEARCH AND TECHNOPRENEURIAL INNOVATIONS (IJRTI)

ISSN: 3043-5722
Volume 1 Issue 2 (October 2024)
Central Instrument Laboratory, University of Port Harcourt, Nigeria
E-mail: centralinstumentlaboratory@uniport.edu.ng
Website: http://cil.uniport.edu.ng/journal/

Effect of Portland Cement Powder On Liver Enzyme, Hepatosomatic and Gonadosomatic Index of African Catfish (*Clarias Gariepinus*)

Chizoba Patrick Onwuanyia[1,*], Obemeata Emmanuel Oriakpono[2]

[1]Department of Applied Biology, Nigerian British University, Asa, Nigeria

[2]Department of Animal and Environmental Biology, University of Port Harcourt, Choba, Nigeria

Email address:
[*]Corresponding author: onwuanyia.patrick@nbu.edu.ng

To cite this article:
Onwuanyia, C.P. and Oriakpono, O. E.
Effect of Portland Cement Powder on Liver Enzyme, Hepatosomatic and Gonadosomatic Index of African Catfish (*Clarias Gariepinus*). *International Journal of Research and Technopreneurial Innovations* 2024; 1(2): 24-33.

Keywords:
Cement Powder
Liver Enzyme
Hepatosomatic index
Gonadosomatic index
African Catfish

ABSTRACT
This study is designed to evaluate the effect of Portland cement powder (PCP) on liver enzyme, hepatosomatic and gonadosomatic index of African catfish (*Clarias gariepinus*). A total number of 130 juvenile African catfish of the same brood stock, both males and females (weighing 11-13g and length 11-13cm) were used for this study. The Fish were obtained from Faculty of Agriculture demonstration farm, University of Port Harcourt, Rivers state. They were transported in oxygenated plastic containers to the Department of Animal and Environmental Biology laboratory where they were placed in 100 liters capacity plastic aquarium (per group) with well aerated borehole water to acclimatize in laboratory condition for 14 days. The fish were distributed into five experimental groups of equal sexes i.e. nine males and nine females per group. The experiment lasted for the period of 3 months during which fish were fed with Blue crown at 08:00 and 16:00 hour each day and toxicant media were changed every 48 hours. At the end of each month, three males and three females' fish were taken from each group to the laboratory for analysis. The various parameter analyzed include; Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), Alkaline phosphatase (ALP), Hepatosomatic Index (HIS) and Gonadosomatic Index (GSI), the result obtained, showed that effect of PCP on AST and ALT of African catfish was significant ($P < 0.05$) while insignificant ($P > 0.05$) on ALP. No significant effect ($P > 0.05$) was observed on HIS and GSI of exposed African catfish when compared to the control groups after 3 months.

1. INTRODUCTION
Human needs have created a conflict between resource development and environmental protection, and have made various types of pollution problems increasingly prominent (Mingming *et al.,* 2019). Environmental pollution is a direct result of human, social and industrial activities which often initiates undesirable changes in the ecosystem, thereby creating some imbalances in physical, chemical and biological dynamics of the environment. Industrial activities were ranked higher among major contributors to environmental degradation (Ogedengbe and Oke, 2019). Metal mining, smelting and meat processing, oil and gas exploration, petrochemical manufacturing and other industrial activities have deleterious impact on the fragile ecosystem. These negative impacts on the environment are majorly, either direct results of production activities or by

the discharge of waste and by products which pose significant threats in their untreated states (Ogedengbe and Oke, 2019).

Man's desire to produce shelter has led to the use of basic raw materials such as cement, sand, gravels etc. Cement is a prerequisite for housing and infrastructure development and is vital to economic growth**.** All over the world, cement demand and production are directly associated with economic growth for which many developing countries depend largely for rapid infrastructural development which fuels the nations growth and economy thereby facilitating cement production (WBCSD, 2019). The production of cement is known to emit about 500 – 1700kg of particulate matter daily (ETPI, 1996). Recent study in the United States of America on air quality assessment, reported a dirt level ranging from 26-114mg/ m^3 (U.S. Census Bureau, 2022). Legator *et al*. (2023) opined that soil, ambient air and surface water qualities within the surroundings of a cement factory are highly degraded. Andrey (2021) proposed an incidence of elevated concentration of Fe, Mg, Pb, Zn, Cu, Be, Tetraoxosulphate VI and HCl among cement plant wastes. Similarly, Sivakumar and Britto (1995) and Jalkanen *et al.* (2000) also reported an elevated deposit of alkali earth metal and heavy metals such as As, Pb, Ni, Co, Zn, Cu and Phosphorous from cement dust and other particles with attendant environmental risks. These increased concentrations of heavy metals in their environs are possibly due to the use of As, Pb, Ni, Co etc. as raw materials necessary in cement production. The negative impacts of air pollution associated with cement production to human lives are of great concern. This has shown that there is a statistically significant correlation between symptoms of respiratory effects in humans with their proximity to cement kilns with CO_2, Cl, F, SO_2 and other sulphur oxides sources (Legator *et al.*, 2023; Worrell et al., 2001). Within cement factories, volatile organic compounds and micro pollutants are usually released and in high level which affects domestic lives of man and animals (Vans-Oss and Padovani, 2003). In the same vein, Ponsby *et al*. (2000), W.H.O (1999) and Wang *et al. (*1997) have denoted the negative impact of cement manufacturing activities on humans and the environment. Similar studies on the effect of cement dust on biosynthetic processes in plant also revealed reduction in chlorophyll and carotenoid content, impairing carbon IV oxide exchange and plant photosynthesis rate (Lepedus *et al*., 2003; Cesar and Lepedus, 2001). It is also reported that through fish consumption, humans are exposed to toxic contaminants; this is because extremely low concentrations of contaminants detected in the water or bottom sediments can bring about accumulation in fish tissue which can in turn pose health risks to the consumers (Rotkin-Ellman *et al*., 2012).

This study was carried out to ascertain the effect of cement powder on liver enzyme, hepatosomatic index and gonadosomatic index of African Catfish.

2. MATERIALS AND METHODS

2.1 Test material

Portland cement powder was gotten from Dangote cement depot at No. 4B East/West Road, opposite University of Port Harcourt Teaching Hospital, Alakahia, Rivers State.

2.2 Experimental Fish

A total number of 130 Juveniles of *Clarias gariepinus* of the same brood stock, both males and females (weighing 11-13g and length 11-13cm) were used for this study. The fish were obtained from Faculty of Agriculture demonstration farm, University of Port Harcourt, Choba, Rivers state. They were transported in oxygenated plastic containers to the Department of Animal and Environmental Biology laboratory where they were placed in 100 liters capacity plastic aquarium (in five different groups) with well aerated borehole water (gotten from borehole with aerator installed) to acclimatize in laboratory condition for 14 days. The experiment was conducted at water temperature of 28.6°C, pH of 7.16, Electrical conductivity of 16.1µs, Dissolved oxygen of 4.1, Salinity of 0.186 ppt and Total dissolved solute of 14.8. The experiment lasted for the period of 90 days during which fish were fed with standard feed (Blue crown) at 08:00 and 16:00 hour each day and toxicant media were changed every 48 hours.

2.3 Experimental Groups

One hundred and thirty fish were separated into five groups with sublethal concentration of PCP ranging from 4.89 m/l to 39.10 m/l (Adamu, 2010). Each group contained the total number of 18 fish (9 males and 9 females) with additional number of 8 fish (4 males and 4 females) for replacement in case of mortality.

The Experimental groups are as follows:

- Group O: 18 (9 males and 9 females) fish unexposed (control) in 100 liters capacity plastic aquarium.
- Group A: 18 (9 males and 9 females) fish exposed to sublethal concentration (4.89 mg/l) of PCP in 100 liters capacity plastic aquarium.
- Group B: 18 (9 males and 9 females) fish exposed to sublethal concentration (9.78 mg/l) of PCP in 100 liters capacity plastic aquarium.
- Group C: 18 (9 males and 9 females) fish exposed to sublethal concentration (19.55 mg/l) of PCP in 100 liters capacity plastic aquarium.
- Group D: 18 (9 males and 9 females) fish exposed to sublethal concentration (39.10 mg/l) of PCP in 100 liters capacity plastic aquarium.

During the ninety days experimental period, 6 fish (3males and 3females) were taken from each group every thirty days for sacrifice.

2.4 Bioassay Procedure

2.4.1 Liver Enzymes**:** The fish were killed by decapitation and then dissected to remove the liver. 0.5g of the samples (liver) were macerated and mixed with 5ml of physiological saline solution for enzyme assay. Another 0.5g of the homogenate sample was mixed with de-ionized water and centrifuged at 3000 rpm for ten minutes. The supernatant was transferred into plain bottles and stored frozen at -2^{O}C. Aspartate transaminase (AST) and alanine transaminase (ALT) were assayed by the method of Reitman and Frankel, (1957), while alkaline phosphatase (ALP) was assayed by the method of Babson *et al*. (1966).

2.4.2 Hepatosomatic Index: After the period of exposure fish were removed and washed with freshwater, then killed by decapitation and weighed. Blood was allowed to drain after which, the fish were dissected to take out organs. Then the total weight of the organ (liver) was used to determine the Hepatosomatic (HSI) index. The index was determined according to the formula:

$$HSI = \left(\frac{Liver\ weight\ (g)}{Fish\ weight\ (g)}\right) x\ 100\ \ \text{(Pauly, 1983)}$$

2.4.3 Gonadosomatic Index**:** After the period of exposure fish were removed and washed with freshwater, then killed by decapitation and weighed. Blood was allowed to drain after which, the fish were dissected to take out organs. Then the total weight of the gonad (both male and female) was determined for the Gonadosomatic index (GSI) indices. The index was determined according to the following formula:

$$GSI = \left(\frac{Liver\ weight\ (g)}{Fish\ weight\ (g)}\right) x\ 100\ \ \text{(Pauly, 1983)}$$

2.5 Statistical Analysis

Data obtained were presented as Mean ± Standard Deviation, and then subjected to analysis by using one-way analysis of variance (ANOVA). Randomized Block Design (Assistat version 7.6 beta, 2012) was used to ascertain the significant difference among means of different groups and means of different months. The Statistical Package for Social Sciences (SPSS) software was used for the analysis of data and the level of significance was set at $p < 0.05$. Results were depicted in a tabular form.

3. RESULTS AND DISCUSSION

3.1 Liver Enzyme Test

Table 3.1 depicts the effects of PCP on liver enzyme of African Catfish in month 1, month 2 and month 3. The mean value of AST revealed that there was a significant increase ($P < 0.05$) in the exposed groups when compared to the control groups in month 1, whereas in month 2 and 3, there was no significant difference ($P > 0.05$) between the means of the exposed groups in comparison with the control groups. The highest value of AST for month 1 was 57.67 ± 10.07 (Group A) while the lowest value was 37.67 ± 2.89 (Group D), the highest value of AST for month 2 was 22.00 ± 5.57 (Group A) while the lowest value was 15.00 ± 4.58 (Group B), and highest value of AST for month 3 was 50.67 ± 36.63 (Group B) while the lowest value was 28.00 ± 18.36 (Group D). Impact of PCP in month 1, 2 and 3 showed statistically significant difference ($P < 0.05$), that is, the impact of PCP within the groups was relatively lower in month 2 when compared to month 1 and 3.

The mean value of ALT revealed that there was a significant increase ($P < 0.05$) in the exposed groups when compared to the control groups in month 1, whereas in month 2 and 3, there was no significant difference ($P > 0.05$) between the means of the exposed groups in comparison with the control groups. The highest value of ALT for month 1 was 32.33 ± 5.77 (Group C) while the lowest value was 18.33 ± 2.31 (Group A), the highest value of ALT for month 2 was 10.67 ± 2.31 (Group A) while the lowest value was 6.67 ± 2.31 (Group B), and highest value of ALT for month 3 was 15.33 ± 2.89 (Group B and C) while the lowest value was 9.33 ± 2.31 (Group A). Impact of PCP in month 1, 2 and 3 showed statistically significant difference ($P < 0.05$), that is, the impact of PCP within the groups was relatively higher in month 1 when compared to month 2 and 3.

The mean values of ALP revealed that there were no significant differences ($P > 0.05$) between the means of exposed groups when compared to the control groups in month 1, 2 and 3. The highest value of ALP for month 1 was 96.00 ± 5.00 (Group A) while the lowest value was 72.00 ± 39.94 (Group B), the highest value of ALP for month 2 was 61.67 ± 26.58 (Group A) while the lowest value was 23.67 ± 4.04 (Group C), and highest value of ALP for month 3 was 131.33 ± 20.40 (Group C) while the lowest value was 109.00 ± 3.61 (Group A). Impact of PCP in month 1, 2 and 3 varied significantly ($P < 0.05$) with month 3 having the highest impact within the group in comparison with month 1 and 2.

Table 3.1: Impact of Portland Cement Powder on Liver Enzymes of African Catfish (*Clarias gariepinus*) for month 1, 2 and 3. (Mean ± Standard Deviation)

	Concentration (mg/l)	MONTHS		
		1	2	3
AST (U/L)	0.00 mg/l	31.33 ± 4.51[a]	20.67 ± 7.79[a]	45.00 ± 26.21[a]
	4.89 mg/l	57.67 ± 10.07[b]	22.00 ± 5.57[a]	50.67 ± 36.63[a]
	9.78 mg/l	41.33 ± 5.51[ab]	15.00 ± 4.58[a]	53.33 ± 35.01[a]
	19.55 mg/l	46.67 ± 5.51[ab]	18.67 ± 7.37[a]	35.67 ± 14.74[a]
	39.10 mg/l	37.67 ± 2.89[a]	16.67 ± 9.07[a]	28.00 ± 18.36[a]
ALT (U/L)	0.00 mg/l	29.33 ± 4.51[ab]	10.67 ± 2.31[a]	15.33 ± 2.89[a]
	4.89 mg/l	18.33 ± 2.31[a]	10.67 ± 2.31[a]	9.33 ± 2.31[a]
	9.78 mg/l	26.67 ± 2.31[ab]	6.67 ± 2.31[a]	15.33 ± 2.89[a]
	19.55 mg/l	32.33 ± 5.77[b]	9.33 ± 2.31[a]	15.33 ± 2.89[a]
	39.10 mg/l	26.67 ± 6.66[ab]	8.00 ± 4.00[a]	9.33 ± 4.62[a]
ALP (U/L)	0.00 mg/l	69.33 ± 28.22[a]	30.67 ± 10.69[a]	136.33 ± 11.85[a]
	4.89 mg/l	96.00 ± 5.00[a]	61.67 ± 26.58[a]	109.00 ± 3.61[a]
	9.78 mg/l	72.00 ± 39.94[a]	31.00 ± 16.70[a]	126.00 ± 5.57[a]
	19.55 mg/l	78.33 ± 30.66[a]	23.67 ± 4.04[a]	131.33 ± 20.40[a]
	39.10 mg/l	95.00 ± 16.82[a]	49.67 ± 15.53[a]	125.00 ± 11.36[a]

Means in columns with the same letters are not significantly different (P > 0.05)

3.2 Hepatosomatic Index Assessment

Table 3.2 depicts the impact of PCP on HSI of African Catfish in month 1, month 2 and month 3. The mean value of HSI revealed that there was a significant increase ($P < 0.05$) in the exposed groups when compared to the control groups in month 1, whereas month in month 2 and 3, there was no significant difference ($P > 0.05$) between the means of the exposed groups in comparison with the control groups. The highest value of HSI for month 1 was 0.46 ± 0.15 (Group C) while the lowest value was 0.27 ± 0.04 (Group A), the highest value of HSI for month 2 was 1.40 ± 0.67 (Group A) while the lowest value was 0.38 ± 0.27 (Group D), and highest value of HSI for month 3 was 1.29 ± 0.19(Group A) while the lowest value was 0.72 ± 0.37 (Group D). Impact of PCP in month 1, 2 and 3 showed statistically significant difference ($P < 0.05$), that is, the impact of PCP within the groups was relatively higher in month 1 when compared to month 2 and 3.

Table 3.2: Impact of Portland Cement Powder on Hepatosomatic Index of African Catfish (*Clarias gariepinus*) for month 1, 2 and 3. (Mean ± Standard Deviation).

	Concentration (mg/l)	MONTHS		
		1	2	3
HIS	0 mg/l	0.20 ± 0.06[a]	0.74 ± 0.16[a]	0.82 ± 0.37[a]
	4.89 mg/l	0.27 ± 0.04[ab]	1.40 ± 0.67[a]	1.29 ± 0.19[a]
	9.78 mg/l	0.29 ± 0.10[ab]	1.24 ± 0.77[a]	1.28 ± 0.26[a]
	19.55 mg/l	0.46 ± 0.15[b]	1.16 ± 0.49[a]	0.93 ± 0.17[a]
	39.10 mg/l	0.30 ± 0.12[ab]	0.38 ± 0.27[a]	0.72 ± 0.37[a]

Means in columns with the same letters are not significantly different (P > 0.05)

3.3 Gonadosomatic Index Assessement

Table 3.3 depicts the impact of PCP on GSI of African Catfish in month 1, month 2 and month 3.

The mean value of GSI of male in month revealed that there was no significant difference (P > 0.05) in the exposed groups when compared to the control groups while that of female revealed that there was

a significant increase (P < 0.05) in exposed groups when compared to the control groups. Then month 2 and 3 revealed that there was no significant difference (P > 0.05) between the means of the exposed groups in comparison with the control groups in month 1. The highest values of GSI of males and females in month 1 were 0.26 ± 0.26 (Group D) and 0.04 ± 0.01 (Group B and C) respectively while the lowest values were 0.04 ± 0.05 (Group A) and 0.00 ± 0.00 (Group A) respectively, the highest values of GSI of males and females in month 2 were 0.58 ± 0.29 (Group C) and 0.16 ± 0.09 (Group C) respectively while the lowest values were 0.17 ± 0.08 (Group D) and 0.03 ± 0.05 (Group B) respectively, and the highest values of GSI of males and females in month 3 were 0.24 ± 0.21 (Group A) and 0.40 ± 0.32 (Group A) respectively while the lowest values were 0.11 ± 0.03 (Group C) and 0.05 ± 0.02 (Group D) respectively. Impact of PCP in month 1, 2 and 3 showed statistically insignificant difference (P > 0.05), that is, the males and females within the groups were all affected equally

Table 3.3: Impact of Portland Cement Powder on Gonadosomatic Index of African Catfish (*Clarias gariepinus*) for month 1, 2 and 3. (Mean ± Standard Deviation)

	Concentration (mg/l)	MONTHS					
		1		2		3	
		MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
GSI	0 mg/l	0.24 ± 0.34[a]	0.00 ± 0.00[a]	0.27 ± 0.06[a]	0.13 ± 0.07[a]	0.15 ± 0.00[a]	0.06 ± 0.03[a]
	4.89 mg/l	0.04 ± 0.05[a]	0.00 ± 0.00[a]	0.53 ± 6.28[a]	0.14 ± 0.06[a]	0.24 ± 0.21[a]	0.40 ± 0.32[a]
	9.78 mg/l	0.13 ± 0.04[a]	0.04 ± 0.01[b]	0.37 ± 0.10[a]	0.03 ± 0.05[a]	0.12 ± 0.02[a]	0.27 ± 0.32[a]
	19.55 mg/l	0.22 ± 0.08[a]	0.04 ± 0.01[b]	0.58 ± 0.29[a]	0.16 ± 0.09[a]	0.11 ± 0.03[a]	0.06 ± 0.01[a]
	39.10 mg/l	0.26 ± 0.26[a]	0.01 ± 0.02[a]	0.17 ± 0.08[a]	0.05 ± 0.03[a]	0.24 ± 0.12[a]	0.05 ± 0.02[a]

Means in columns with the same letters are not significantly different (P > 0.05)

3.4 DISCUSSION

The liver enzyme test showed varying responses in AST, ALT and ALP level of exposed groups in comparison with the control groups between month 1, 2 and 3. The effect of PCP on AST and ALT of exposed groups when compared to the control groups were significant in month 1(with Group A and C mostly affected) and insignificant in month 2 and 3 while there was insignificant effect on ALP of the exposed groups in comparison with the control groups in both month 1, 2 and 3. Studies have shown that assessment of liver enzyme activities can be regarded as diagnostic tool to ascertain the physiological status of cells or tissue (Tyson and Sawhney, 2010; Manoj, 1999). Alkaline Phosphates (ALP) is a liver enzyme in which its rise in the blood above standard values shows that liver is injured in one way or the other (Dorcas and Solomon, 2014). Aspartate Aminotransferase (AST) is another enzyme of the liver and its rise always signify inflammation and liver injury. Alanine Aminotransferase (ALT) is also an enzyme that helps to process proteins and it rises in liver cells when the liver is injured or inflamed (Robert *et al*., 2011). Therefore, increased level of liver enzymes observed in the present study could be attributed to the effect of Portland cement powder. Similar results have been reported by Crestani *et al*. (2015), Gholami *et al*. (2013), Karan *et al*. (2011), Bolger and Connolly (1999) and Wedemeyer and Yasutake (1995).

Hepatosomatic Index Assessment showed varying responses in HSI of exposed groups in comparison with the control groups between month 1, 2 and 3. The exposed groups in month 1 showed high physiological response that resulted in increased HSI (where Group C were affected most) when compared to the control groups whereas in month 2 and 3, little or no impact was observed in the exposed groups in comparison with the control groups. According to findings, the HSI is a good hepatic parameter in fish which may indicate liver metabolic and feeding status (Huuskonen and Seppa, 1995). When the liver size is big, it indicates the high rate of metabolic activity while the small size of the liver could be attributed to lack of food (Sandstrom *et al*., 2005). Significant increase observed in this study is in agreement with the result reported by Johansson *et al.* (2007) and in disagreement with results reported by Dewi and Probowo (2017), Singh and Srivastava (2015) and Van der Oost *et al*. (2003). Conversely, it implies that the decrease or increase in the HSI depends on the nature of toxicant and physiological response of fish.

Gonadosomatic Index assessment of male and female revealed that there was delay in female gonad development when compared to that of male. It also revealed that among the exposed groups, females were more sensitive than males following the positive physiological response observed in month 1. Similar findings were reported by Shalaka and Pragna (2013). Studies on GSI of fish have shown that toxicants are being absorbed by epithelial membrane in the gill; these toxicants are carried by blood and conveyed to the skin, muscles, liver, kidney and kidney, following their accumulation in these organs especially in the gonad. This may likely affect the GSI of the fish leading to low reproductive capacity (Sandstrom *et al*., 2005). In this study, the insignificant difference observed in the exposed groups when comparing them with the control groups is in accordance with that of Dina *et al*. (2019) and in variance to the findings reported by Mir *et al*. (2012) and Barse *et al*. (2006).

4. CONCLUSION

It can be concluded that exposure of African Catfish to Portland cement powder for 90 days resulted in hepatotoxicity which can affect their health status and in turn poses a significant threat in their development and reproductive capacity.

Acknowledgements

We thank our host Department, Department of Animal and Environmental Biology, University of Port Harcourt headed by Prof. T. N Gbarakoro for providing the basic requirements needed for the execution of this great project. Our thanks also go to Mr. & Prof. (Mrs.) I. A. Ezeani and Prof. H. B. Fawehinmi for their financial support and encouragement.

References

[1] Adamu, K. M. (2010). Biochemical parameters of the juvenile African catfish *Clarias gariepinus* (Burchell, 1822) exposed to sublethal concentrations of Portland cement powder in solution. *Biology and Environment*, *110*, 165–172.

[2] Andrey, J. (2021). Bees and their products as indicators of environmental pollution. *Medycyna Weterynaryna,* 43(6), 352–356.

[3] Babson, A. L., Greeley S. J., Coleman C. M. and Phillips G.E. (1966). Phenolphthalein monophosphate as a substrate for serum alkaline phosphatase. *Clinical Chemistry*, 12, 482-490.

[4] Barse, A. V., Chakrabarti, T., Ghosh, K., Pal, A. K. and Jadhao, S. B. (2006). One-tenth dose of LC of 4-tertbutylphenol causes endocrine disruption and metabolic changes in *Cyprinus carpio*. *Pesticide Biochemical Physiology*, 86, 172-179.

[5] Bolger, T. and Connolly, P. L. (1999). The selection of suitable indexes for the measurement and analysis of fish condition. *Journal of Fish Biology*, 34, 171-182.

[6] Cesar, V. and Lepedus, H. (2001). Peroxidase activity, soluble proteins and chlorophyll content in Spruce (*Picea abies*) needles affected by cement dusts. *Acta Botanica Croatica,* 60, 227–235.

[7] Crestani, M., Menezes, C., Glusczak. L., Miron, D. S. and Lazzari, R. (2015). Effects of clomazone herbicide on hematological and some parameters of protein and carbohydrate metabolism of silver catfish *Rhamdia quelen*. *Ecotoxicology and Environmental Safety*, 65, 48-55.

[8] Dewi, N. K. and Probowo, R. (2017). Determination of Liver somatic index (LSI) and gonadosomatic index (GSI) value of Carp (*Cyprinus carpio*) and Nile tilapia (*Perca fluviatilis*). *International Journal of Scientific and Research Publications*, 7(6), 220-223.

[9] Dina, N. P., Priyanka, D. and Moti, L. G. (2019). Heapto-Somatic Index, Gonado-Somatic Index and Condition Factor of *Anabas testudineus* as Bio-Monitoring Tools of Nickel and Chromium Toxicity. *International Journal of Innovations in Engineering and Technology*, 12, 2319-1058.

[10] Dorcas, I. K. and Solomon, R. J. (2014). Calculation of Liver function test in *Clarias gariepinus* collected from three commercial fish ponds. *Nature and Science*, 12(1), 10-15.

[11] Enviromental Technology Program for Industry, (1996). Responding to the Environmental Challenge: A survey of Pakistans Manufacturing and Industrial Sector: Cement Industry, Karach, Pakistan. http//www.etpi.org.pk

[12] Gholami, S. S. J., Mirvaghefi, A., Farahmand, H. and Kosari, A. A. (2013). Effect of a glyphosate- based herbicide in *Cyprinus carpio*: Assessment of acetylcholinesterase activity, hematological responses and serum biochemical parameters. *Ecotoxicology and Environmental Safety*, 98, 135-141.

[13] Huuskonen, S. and Seppa, P. L. (1995). Hepatic cytochrome P4501A and other biotransformation activities in perch (*Perca fluviatilis)* – the effects of unbleached pulp-mill effluents. *Aquacultural Toxicology*, 31, 27-41.

[14] Jalkanen, L., Makinene, A., Hasanen. E. and Juhanoja, J. (2000). The effects of large anthropogenic particulate emissions on atmospheric aerosols deposition, and bioindicatiors in the Eastern Gulf of Finland Region. *The Science of the Total Environment,* 262, 123–136.

[15] Johansson, N., Larsson, A. and Lewander, K. (2007). Metabolic effects of PCB on brown trout (*Slamo trutta*). *Comparative and General Pharmacology*, 3, 310-314.

[16] Karan, V., Vitorovic, S., Tutundsie, V. and Polesksie, V. (2011). Functional enzymes activity and gill histology of carp after copper sulfate exposure and recovery. *Ecotoxicology and Environmental Safety*, 40, 49-55

[17] Legator, M. S., Singleton, C. R., Morris, D. L. and Philips, D. L. (2023). The health effects of living near cement kilns; A Sympton survey in Midlothian, Texas. *Toxicology and Industrial Health*, 14, 829–842.

[18] Lepedus, H., Cesar, V. and Suver, M. (2003). The Annual changes of chloroplast pigments contents in current and previous-year needles of Norway Spruce (*Picea abies*) exposed to cement dust pollution. *Acta Botanica Croatica*, 62, 27–35.

[19] Manoj, K. (1999). Mercury, copper and cadmium induced changes in the total protein levels in muscle tissue of an edible estauring fish *Boleopthalmus dessumuri*. *Journal Environmental Biology*, 20, 231-234.

[20] Mingming, Z., Pei, H., Guo, Q., Jiawei, W., Jintian, H. and Xiutang, Y. (2019). Distribution, sources, and risk assessment of polycyclic aromatic hydrocarbons (PAHs) in surface sediments of the Sebei Shoal, China. *Marine Pollution Bulletin,* 149, 110-640.

[21] Mir, F. A., Ghulam, M. S., Ulfat, J. and Javaid I. M. (2012). Studies on influences of sublethal concentrations of Organophosphate Pesticide; Dichlorvos (DDVP) on gonadosomatic index (GSI) of female common carp, *Cyprinus carpio* communis. *American-Eurasian Journal of Toxicological Sciences*, 4(2), 67-71.

[22] Ogedengbe, K. and Oke, A. O. (2019). Pollution impact of cement production on air,soil and water in a production location in Nigeria. *Journal of Science and Technology,* 31(2), 46-56.

[23] Pauly, D. (1983). Some simple methods for the assessment of tropical fish stocks. FAO Fisheries Technical Paper. *FAO*, Rome.

[24] Ponsby, A. L., Couper, D., Dwyer, T., Carmichael, A., Kemp, A. and Cochrane, J. (2000). The relation between infant indoor and environment and subsequent asthma. *Epidemiology,* 11, 128–135.

[25] Reitman, S. and Frankel, S. (1957). A colorimetric method for the determination of serum glutamate oxaloacetate and glutamate pyruvate transaminase. *American Journal of clinical Pathology*, 28, 56-63.

[26] Robert, K. M., Victor, W. R., David, B., Kathleen, M. B. and Anthony, P. W. and Peter, J. K. (2011). Harpers Illustrated Biochemistry (Lange Medical Book), 28th Edition, Volum 28. McGraw-Hill.

[27] Rotkin-Ellman, M., Wong, K. K. and Solomon, G. M. (2012). Seafood contamination after the BP Gulf oil spill and risks to vulnerable populations: A critique of the FDA risk assessment. *Environmental Health Perspective,* 120, 157-161.

[28] Sandstrom, O., Larsson, A., Andersson, J., Appelberg, M., Bignert, A., Ek, H., Forlin, L. and Olsson, M. (2005). Three decades Swedish experience stresses the need of integrated long-term monitoring in marine coastal areas. *Water Quality Research Journal of Canada*, 40(3), 233-250.

[29] Shalaka, S. and Pragna, P. (2013). Gonadosomatic and hepatosomatic indices of Freshwater Fish *Oreochromis mossambicus* in

response to a Plant Nutrient. *World Journal of Zoology*, 8(1), 110-118.

[30] Singh, S. K. and Srivastava, A. K. (2015). Variations in hepatosomatic index (HSI) and gonadosomatic index (GSI) in Fish *Heteropneustes fossilis* Exposed to Higher Sub-Lethal Concentration of arsenic and copper. *Journal of Ecophysiology and Occupational Health*. 15(3), 26-30.

[31] Sivakumar, S. and Britto, A. J. (1995). Effect of cement pollution on soil fertility. *Journal of Ecotoxicology and Environmental Monitoring,* 5(2), 147– 149.

[32] Tyson, C. A. and Sawhney, D. S. (2010). Organ function tests in toxicology evalution. Noyes, publication, New Jersey USA. Pp: 103-114.

[33] United States Census Bureau, (2022). Economic Census. http//www.census.gov/epcd/www/ econ97.html.

[34] Van der Oost, R., Beyer, J. and Vermeulan, N. P. E. (2003). Fish bioaccumulation and biomarkers in environmental risk assessment: a review. *Environmental Toxicology and Pharmacology*, 13(2), 57-149.

[35] Van-Oss, H. G. and Padovani, A. C. (2003). Cement manufacturing and the environment, Part II. Environmental Challenges and Opportunities, Massachusetts Institute of Technology and Yale University. 7(1), 93–126.

[36] Wang, H. D., Ryan, L. and Xu, X. (1997). Association between air pollution and low birth weight: A community based study. *Environmental Health Perspectives,*105, 514–520.

[37] Wedemeyer, G. A. and Yasutake, W. T. (1995). Clinical methods of the effect of environmental stress on fish health. *Aquacultural Sciences*, 15, 47-49.

[38] World Bank, (1998). Pollution Prevention and Abatement Hand Book – Part III: Cement Manufacturing Washington, D.C., World Bank, United States.

[39] World Health Organization, (1999). Public Health and Chemical Incidents: Guidance for National and Regional Policy Makers Cardiff U.K: University of Wales Institute, WHO Collaborating Centre for Chemical incidents.

[40] Worrell, E. L., Price, N., Martin, C. H. and Leticia, O. M. (2001). Carbon dioxide emissions from the global cement industry. *Annual Review of Energy and the Environment*, 20, 303-329.