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Study On The Impact Of Brick-Kiln Effluent On Gills, Hepatopancreas And Kidneys Of *Channa Punctata* Bloch. With Reference To Histomorphology Of The Organs

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Abstract

The study deals with the impacts of sub-lethal exposure of brick kiln effluent on the activity of lipid and protein peroxide (LPO and PPO), some xenobiotic stress marker enzymes namely Glutathione-S-transferase (GST) and Cytochrome P-450 (CYP), transaminase enzymes namely Aspartate transaminase (AST) and Alanine Aminotransferase (ALT), Alkaline Phosphatase (ALP) and concentration of nitrogenous wastes namely urea and ammonia in the serum with reference to histoarchitecture of gills, hepatopancreas and kidneys of *Channa punctata* Bloch. Healthy adult fishes of both the sexes were reared in three separated aquaria after acclimatization. After determination of LC₅₀ for 28 days which was found to be 5.5 ± 0.11 ppm, the fishes were reared in three aquaria with aquarium I comprising of normal-control fishes and aquarium II and aquarium III comprising of fishes reared at two sub-lethal concentrations of effluents i.e. 2ppm and 3ppm of effluents. Elevation in the activity of LPO and PPO depicts the oxidative stress upon the organism, and the xenobiotic stress upon the organism was clearly depicted by the increased concentration of GST and CYP. The decreased concentrations of AST, ALT and ALP in the organs with augmentations in the serum depicted the draining of these metabolic enzymes from the organs to the serum due to environmental stress. The stress upon the kidneys was clearly showed by the increased levels of urea and ammonia in the serum. All these anomalies described the stress upon the organism which was evidenced by histological changes in the organs like curving and fusion of gill lamellae, necrosis and vacuolations of hepatopancreatic and kidney tissues.

Keywords-sub-lethal, effluent, peroxide, xenobiotic, transaminase, kidney, stress.

Introduction

The use of bricks in construction is a long-standing practice, especially in developing countries like India where rapid globalization and urbanization have significantly increased the demand for bricks. As India's population grows, the need for bricks has surged, leading to the establishment of numerous brick kilns. India is the second-largest producer of bricks globally, with an annual production of approximately 240–260 billion bricks, following China. Various fuels are used in brick production, but in Eastern India, coal is the primary fuel source (Kamyotra, 2015). In Dhubri, a small district in Western Assam, about 126 brick kilns operate using coal as the main fuel (Ahmed, 2024).

Different researcher has highlighted the environmental impact of brick kilns, particularly their contribution to air pollution. While many studies focus on air and soil pollution, fewer have examined the effects on aquatic life. Elevated levels of total solids and calcium hardness in the Ksipra River, Ujjain, were linked to nearby brick kilns (Khan & Vyas, 2008). Residents of Kathmandu Valley experienced severe respiratory disorders due to emissions from brick kilns (Joshi & Dudani, 2008). Similar health issues, including respiratory diseases and eye irritation, were reported in Bhaktapur district (Pariyar et al., 2013) and Panzan, Jammu and Kashmir, where pollutants exceeded national standards (Skinder et al., 2014). The fertility of agricultural land near brick kilns decreased due to the accumulation of heavy metals like lead and chromium (Bisht & Neupane, 2015). The nutritional value of certain vegetables was reduced by brick kiln emissions in Panzan, Jammu and Kashmir (Skinder et al., 2015). The water quality and food web in Cachar district's aquatic systems were significantly deteriorated by brick kiln pollution (Dey & Dey, 2015). Emissions from brick kilns, particularly those using coal or rubber as fuel, released carcinogenic dioxins and other harmful gases (Khan et al., 2019). Similar pollutants were found in Bangladesh, affecting soil and water near brick kilns (Saha et al., 2021).

After going through the literature, the study selected **Channa punctata Bloch**, a resilient fish species, as a model to assess the impact on more vulnerable species. The study aimed to evaluate the following:

1. To Assess oxidative damage to the gills, hepatopancreas, and kidneys by studying Peroxidation Enzymes.
2. To measure the activity of detoxification enzymes like Glutathione-s-transferase and Cytochrome P-450 by studying Xenobiotic Stress Marker Enzymes.
3. To evaluate the metabolic condition of organs by studying enzymes such as Aspartate transaminase (AST), Alanine Aminotransferase (ALT), and Alkaline Phosphatase (ALP).
4. To determine stress on kidneys and hepatopancreas by analysing urea and ammonia levels in the serum.

The primary objective was to assess the effects of brick kiln effluents on these biological markers to help protect other vulnerable species.

Materials and methods-

From two selected sites at Balajan in Dhubri district, brick kiln refusals comprising of burnt and partially burnt coal ashes were collected for effluent preparation. Various concentrations of brick kiln effluents were prepared by mixing measured amount of refusals with fixed amount of deionised water of which the effluent bearing gram per ml concentration with required dilutions was selected for the study.

By netting from the water bodies adjacent to the brick-kilns, the model fish species, *Channa punctata* Bloch. with approximately 16.8 ± 3.7 cm in length and 82 ± 5 grams in weight were

collected. Minor injuries occurred during netting of the fishes was cured by treating with 1.5% of potassium permanganate solution for 4 hours (Floyd & Klinger, 2002). The fishes were further acclimatized for a week and during the total study period the fishes were fed with the fish food marketed as "Dr. Fish" containing several minerals, vegetable powder, soyabean meal, wheat germ, wheat flour, yeast, baby shells, larvae of fly, mini shellfish, Spirulina larva, vitamins.

The LC₅₀ value was found to be 5.5 ± 0.11 ppm (OECD, 2019) after acclimatization for a week and the fishes were further segregated into three separated aquaria with a capacity of 60 litres each. The fishes in the aquarium 1 were normal-control fishes but the fishes in aquarium 2 and aquarium 3 were treated with two sub-lethal concentrations of effluents i.e. 2 ppm and 3 ppm of effluents. After a period of 28 days (4 weeks), the normal-control and the experimentally treated fishes were sacrificed using diethyl ether anesthetization and the vital metabolic organs i.e. gills, hepatopancreas and kidneys were dissected out and washed in normal saline. Some amounts of the tissue samples were preserved in 10% neutral buffered formalin (NBF) but the bulk tissue was homogenised in deionised water and further centrifuged at 5000 rpm. After centrifugation, the supernatant was collected for enzymatic assays.

For estimation of AST, ALT, ALP and urea, the blood was collected from the caudal region of the fishes. The caudal region of the fishes was dipped in warm water and the caudal vein was punctured to collect the blood in centrifuge tubes. The collected blood was further centrifuged at 5000 rpm for 10 minutes. After centrifugation, the supernatant was collected as sample for estimation of AST, ALT, ALP and urea in the serum.

The collection of serum for ammonia estimation was also done from the caudal region of the fishes by puncturing the caudal vein. In heparinised glass capillaries, the blood was collected and immediately sealed using petroleum jelly in order to prevent the loss of ammonia from the blood and the assay was performed immediately after the collection of the serum.

By photometric estimation of molar extinction co-efficient of thiobarbituric acid, the lipid and protein peroxide activity were studied in the gills, hepatopancreas and kidneys of the normal-control and the treated fishes (Ohkawa et al., 1979).

The activity of GST in the cytosol of gills, hepatopancreas and kidneys of the normal-control as well as the experimentally treated fishes were estimated by GST assay kit (CS0410) working under the protocol of Habig et al., 1974.

In the normal-control and the experimentally treated fishes, the CYP activity was studied in gills, hepatopancreas and kidneys by the method of Omura and Sato, 1964.

By utilization of the reagent kit based on UV-Kinetic Assay Techniques, the Aspartate Transaminase (AST) activities were observed in the gills, hepatopancreas and kidney as well as the serum of the normal-control and treated fishes (Bergmeyer et al., 1978).

The ALT reagent kit (IFCC/Kinetic) was used to estimate the activity of Alanine Aminotransferase in the gills, hepatopancreas, kidney and the serum in the normal-control and the experimentally treated fishes (Bergmeyer et al., 1978).

In the gills, hepatopancreas, kidneys and the serum of the normal-control and the treated fishes, the alkaline phosphatase activity (ALP) was studied utilizing the ALP reagent kit (GSCC/Kinetic) (Bretandiere et al., 1977).

The estimation of ammonia in the serum of the normal control and the treated fishes was conducted by Megazyme's ammonia assay kit (Bergmeyer and Beutler, 1990).

The determination of urea in the serum of the normal control and the treated fishes was determined by Modified Berthelot method utilizing the urea kit (Fawcett and Scott, 1960).

The estimations of enzymatic as well as nitrogenous wastes were conducted by photometric analysis in a pre-programmed biochemical analyser "Benosphera C-61" which was set with necessary kit specifications and dilution factors.

Bernet's method was employed to conduct the histological studies in the gills, hepatopancreas and kidneys of the normal-control and the experimentally treated fishes. The tissues which were preserved in 10% neutral buffered formalin was dehydrated by passing different grades of alcohol and sections of tissues with 5 μ thickness were prepared using a rotary microtome. The sections were double stained using haematoxylin and eosin and after successful staining the tissue sections were examined under Almicro Trinocular Research Microscope (Bernet, 1999). The images of the tissue sections were captured using Nikon D5300 DSLR camera body utilizing Olympus Microscope Adaptor.

Results-

Table No. 1- The estimated results of Lipid peroxide (LPO), Protein peroxide (PPO), Glutathione-s-transferase (GST) and Cytochrome P-450 (CYP) activities in the gills, hepatopancreas and kidneys of the normal-control as well as the experimental fishes are tabulated bellow-

| Sl. No. | Studied Parameter | Tissue Samples | Experimental Fish groups | | |
|---------|---------------------------------------|----------------|--------------------------|--------------------------------------|--------------------------------------|
| | | | Normal-control Fishes | Fishes exposed to 2 ppm of effluents | Fishes exposed to 3 ppm of effluents |
| 1. | LPO (n mol/ml) | Gills | 204.45 \pm 0.137 | 227.48 \pm 0.227 + 11.264 % * | 249.76 \pm 0.095 + 22.162 % * |
| | | Hepatopancreas | 189.26 \pm 0.163 | 217.35 \pm 0.205 + 14.840 % * | 224.93 \pm 0.164 + 18.845 % * |
| | | Kidneys | 198.38 \pm 0.105 | 215.23 \pm 0.212 + 8.494 % * | 227.45 \pm 0.178 + 14.654 % * |
| 2. | PPO (n mol/ml) | Gills | 8.464 \pm 0.005 | 9.815 \pm 0.005 + 15.961 % * | 11.327 \pm 0.006 + 33.826 % * |
| | | Hepatopancreas | 11.425 \pm 0.006 | 13.546 \pm 0.007 + 18.565 % * | 14.943 \pm 0.007 + 30.792 % * |
| | | Kidneys | 9.321 \pm 0.007 | 9.832 \pm 0.895 + 5.482 % * | 11.644 \pm 1.100 + 24.922 % * |
| 3. | GST (μ mol ⁻¹ permin) | Gills | 0.226 \pm 0.001 | 0.251 \pm 0.001 + 11.288 % * | 0.239 \pm 0.002 + 5.667 % * |
| | | Hepatopancreas | 0.231 \pm 0.001 | 0.263 \pm 0.001 + 14.230 % * | 0.246 \pm 0.002 + 6.678 % * |
| | | Kidneys | 0.221 \pm 0.001 | 0.245 \pm 0.001 + 10.619 % * | 0.234 \pm 0.001 + 5.920 % * |
| 4. | CYP (n mol per mg of Protein) | Gills | 0.256 \pm 0.001 | 0.325 \pm 0.001 + 22.352 % * | 0.276 \pm 0.001 + 4.033 % * |
| | | Hepatopancreas | 0.275 \pm 0.001 | 0.382 \pm 0.001 + 38.780 % * | 0.282 \pm 0.0003 + 2.360 % * |
| | | Kidneys | 0.255 \pm 0.001 | 0.296 \pm 0.001 + 16.078 % * | 0.266 \pm 0.001 + 4.314 % * |

"*" indicates Significant at p<0.001, "+...%" and "-...%" indicate percent increase and percent decrease respectively.

Table No. 2–The estimations of Aspartate Transaminase (AST), Alanine Aminotransferase (ALT), Alkaline Phosphatase (ALP) activities in the gills, hepatopancreas, kidneys along with serum and concentration of nitrogenous wastes viz. urea and ammonia in the serum of the normal–control and the treated fishes are tabulated here–

| Sl. No. | Studied parameters | Tissue samples | Experimental Fish groups | | |
|--|--------------------|----------------|--------------------------|-------------------------------------|-------------------------------------|
| | | | Normal–control fishes | Fishes exposed to 2 ppm of effluent | Fishes exposed to 3 ppm of effluent |
| 5. | AST (IU/L) | Gills | 373.68 ± 0.340 | 352.78 ± 0.263 –5.593% * | 317.4 ± 0.351 –15.061% * |
| | | Hepatopancreas | 565.44 ± 0.452 | 522.14 ± 0.357 –7.658% * | 475.66 ± 0.404 –15.878% * |
| | | Kidneys | 466.72 ± 0.417 | 406.43 ± 0.698 – 12.918 %* | 368.02 ± 0.429 – 21.148 %* |
| | | Serum | 34.851 ± 0.009 | 52.550 ± 0.009 + 50.785 %* | 76.583 ± 0.010 + 119.744 %* |
| 6. | ALT (IU/L) | Gills | 187.16 ± 0.323 | 168.02 ± 0.180 –10.226% * | 132.55 ± 0.218 –29.178% * |
| | | Hepatopancreas | 276.63 ± 0.361 | 258.44 ± 0.233 –6.575% * | 219.22 ± 0.260 –20.753% * |
| | | Kidneys | 224.02 ± 0.327 | 211.49 ± 0.283 – 5.593 %* | 178.06 ± 0.181 – 20.516 %* |
| | | Serum | 29.855 ± 0.008 | 41.552 ± 0.009 + 39.179 %* | 64.585 ± 0.007 + 116.33%* |
| 7. | ALP (IU/L) | Gills | 534.56 ± 0.140 | 507.37 ± 0.137 – 5.086 % | 459.44 ± 0.208 – 14.053 % * |
| | | Hepatopancreas | 727.19 ± 0.122 | 694.18 ± 0.087 – 4.539 % * | 667.18 ± 0.260 – 8.252 % * |
| | | Kidneys | 621.09 ± 0.129 | 603.18 ± 0.204 – 2.884 %* | 563.31 ± 0.178 – 9.303 %* |
| | | Serum | 127.68 ± 0.007 | 158.78 ± 0.007 + 24.354 %* | 172.68 ± 0.009 + 35.246 %* |
| 8. | Urea (mg/dl) | Serum | 16.515 ± 0.248 | 38.530 ± 0.266 + 133.303 %* | 47.941 ± 0.610 + 190.288 %* |
| 9. | Ammonia (gm/L) | Serum | 42.104 ± 1.540 | 73.297 ± 0.768 + 74.086 %* | 97.427 ± 1.978 + 131.396 %* |
| <p>“*” indicates Significant at p<0.001, “+...%” and “–...%” indicate percent increase and percent decrease respectively.</p> | | | | | |

Histoarchitectural studies

Gills-

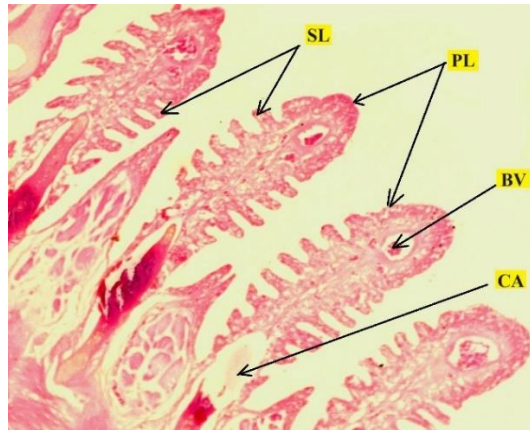


Figure 1 – Histoarchitecture of gills in normal-control fishes

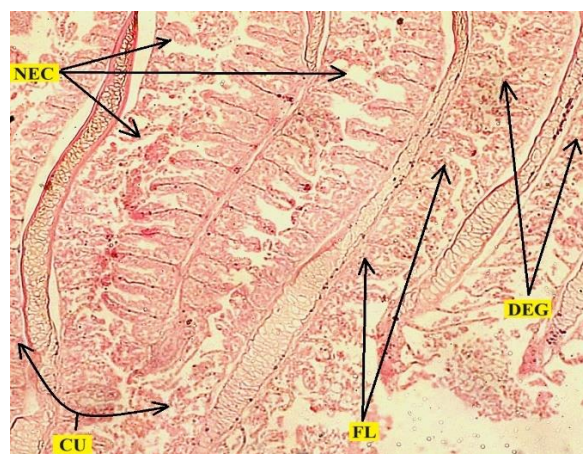


Figure 2– Histoarchitecture of gills in the fishes exposed to 2 ppm of effluent

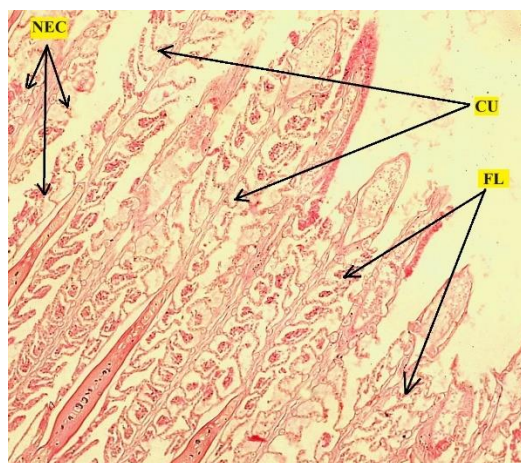


Figure 3– Histoarchitecture of gills in the fishes exposed to 3 ppm of effluent

Where, SL= Secondary lamellae, PL= Primary lamellae, BV= Blood vessels, CA= Cartilage, NEC= Necrosis, CU= Curving of gill lamellae, FL= Fusion of lamellae, DEG= Degeneration of gill lamellae.

Hepatopancreas–

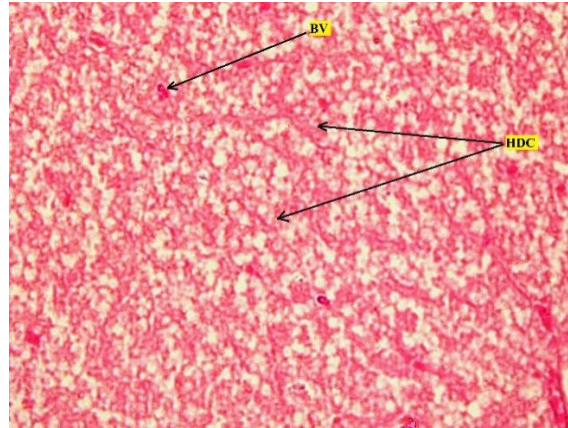


Figure 4– Histoarchitecture of hepatopancreas in normal–control fishes

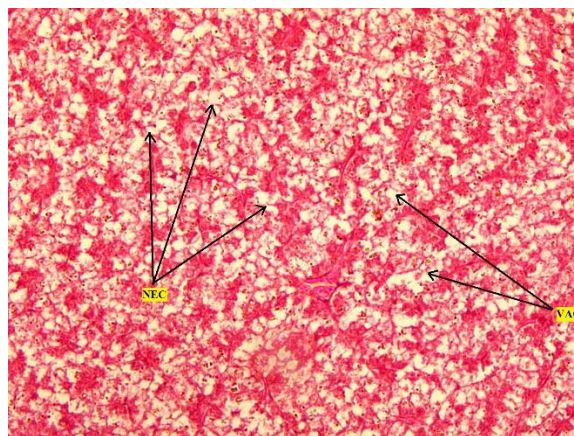


Figure 5– Histoarchitecture of hepatopancreas the fishes exposed to 2 ppm of effluent

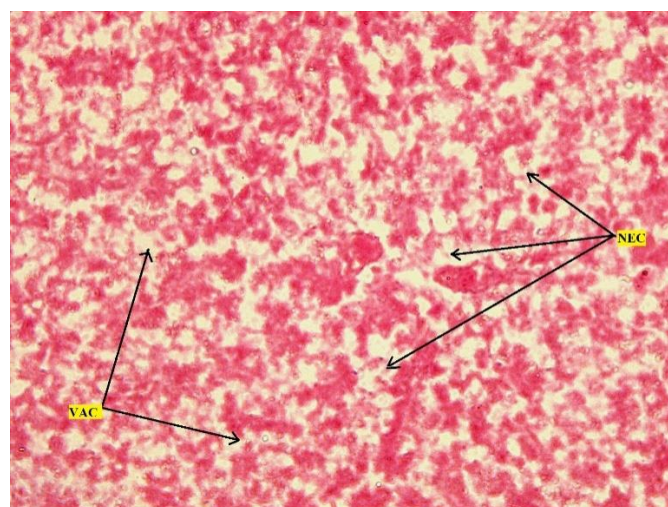


Figure 6– Histoarchitecture of hepatopancreas in the fishes exposed to 3 ppm of effluent

Where, HDC= High density of cells, BV= Blood vessels, NEC= Necrosis, VAC= Vacuolation.

Kidneys-

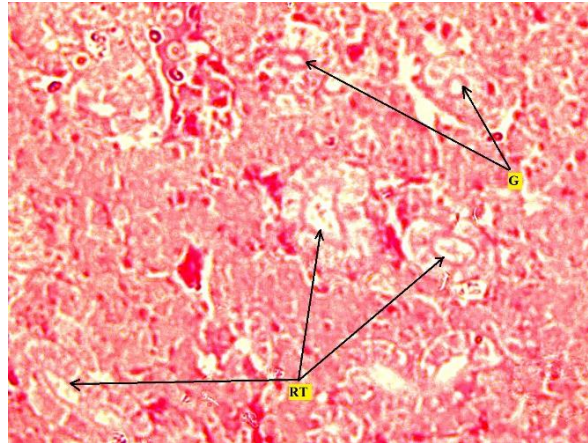


Figure 7- Histoarchitecture of kidney in normal-control fishes

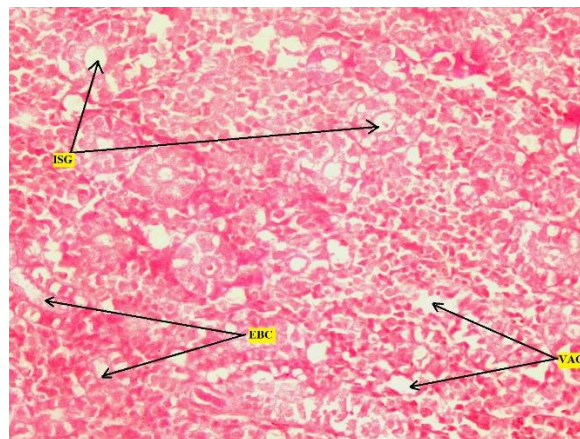


Figure 8- Histoarchitecture of kidney in the fishes exposed to 2 ppm of effluent

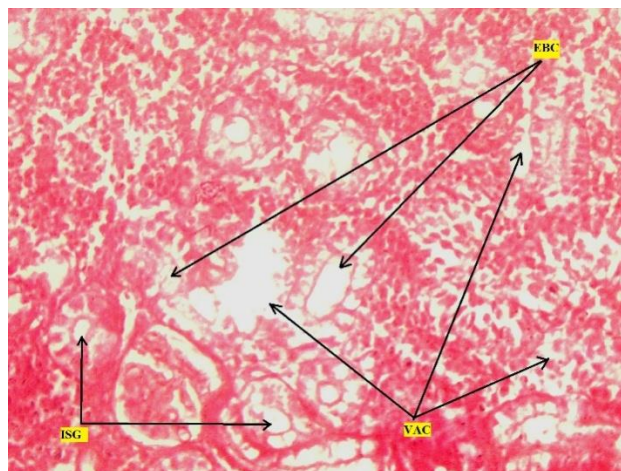


Figure 9- Histoarchitecture of kidney in the fishes exposed to 3 ppm of effluent

Where, G= Glomerulus, RT= Renel tubules, ISG= Increased space between the Glomerulus, EBC= Enlargement of Bowman's capsule, VAC= Vacuolations.

Discussion-

The LPO activity in the gills of the experimentally treated fishes was found to be increased by +11.264% and +22.162% deviations in comparison to the normal-control fishes. The LPO activity in the hepatopancreas of the fishes treated with 2 ppm and 3 ppm of effluent was found to be increased by +14.840% and +18.845% deviations with respect to the normal-control fishes respectively (Bhowmick et al., 2024). The LPO activity in the kidneys of the experimentally treated fishes was found to be increased by +8.494% and +14.654% deviations in comparison to the normal-control fishes respectively.

The PPO activity in the gills of the fishes treated with 2 ppm and 3 ppm was found to be augmented by +15.961% and +33.826% deviations in comparison to the normal-control fishes. The PPO activity in the hepatopancreas of the experimentally treated fishes with 2 ppm and 3 ppm of effluent was found to be elevated by +18.565% and +30.792% deviations in relation to the normal-control fishes respectively (Bhowmick et al., 2024). The PPO activity in the kidneys of the experimentally treated fishes was found to be augmented by +5.482% and +24.922% deviations in comparison to the normal-control fishes respectively.

The GST activity in the gills of the experimentally treated fishes was noticed to be elevated by +11.288% and +5.667% deviations in relation to the normal-control fishes. The GST activity in the hepatopancreas of the fishes treated with 2 ppm and 3 ppm of effluent was found to be increased by +14.230% and +6.678% deviations in comparison to the normal control fishes. The GST activity in the kidneys of experimental fish groups treated in 2 ppm and 3 ppm of effluent was noticed to be augmented by +10.619% and +5.920% deviations in comparison to the normal-control fishes.

The CYP activity in the gills of the experimentally treated fishes was noticed to be elevated by +22.352% and +4.033% deviations in relation to the normal-control fishes. The CYP activity in the hepatopancreas of the fishes treated with 2 ppm and 3 ppm of effluent was found to be increased by +38.780% and +2.360% deviations in comparison to the normal control fishes. The CYP activity in the kidneys of experimental fish groups treated in 2 ppm and 3 ppm of effluent was noticed to be augmented by +16.078% and +4.314% deviations in comparison to the normal-control fishes.

The AST activity in the gills of the experimentally treated with 2 ppm and 3 ppm of effluent was found to be declined by -5.593% and -15.061% deviations in comparison to the normal-control fishes respectively. The AST activity in the hepatopancreas of the fishes treated with two sub-lethal concentrations of effluents i.e. 2 ppm and 3 ppm of effluent was found to be decreased by -7.658% and -15.878% deviations in comparison to the normal-control fishes respectively (Bhowmick et al., 2024). The AST activity in the kidneys of the fishes treated with 2 ppm and 3 ppm of effluent was found to be declined by -12.918% and -21.148% deviations in comparison to the normal-control fishes respectively. But the activity of AST in the serum of the experimentally treated fishes was found to be increased by +50.785% and +119.744% deviations from the normal-control respectively (Bhowmick et al., 2024).

The ALT activity in the gills of the experimental fish groups treated with two sub-lethal concentrations of effluents i.e. 2 ppm and 3 ppm of effluent was found to be decreased by -10.226% and -29.178% deviations in comparison to the normal-control fishes respectively. The ALT activity in the hepatopancreas of the experimentally treated fishes with two sub-lethal concentrations of effluents i.e. 2 ppm and 3 ppm of effluent was found to be declined by -6.575% and -20.753% deviations in comparison to the normal-control fishes respectively (Bhowmick et al., 2024). The ALT activity in the kidneys of the fishes treated with 2 ppm and 3 ppm of effluent concentrations was found to be decreased by -5.593% and -20.561% deviations in comparison to the normal-control fishes respectively. But the activity of ALT in the serum of the experimentally

treated fishes was found to be elevated by +39.179% and +116.330% deviations from the normal-control respectively (Bhowmick et al., 2024).

The ALP activity in the gills of the fishes treated with two sub-lethal concentration of effluents i.e. 2 ppm and 3 ppm of effluent was found to be decreased by -5.086% and -14.053% deviations in comparison to the normal-control fishes respectively. The ALP activity in the hepatopancreas of the fishes treated with 2 ppm and 3 ppm of effluent was found to be decreased by -4.539% and -8.252% deviations in comparison to the normal-control fishes respectively (Bhowmick et al., 2024). The ALP activity in the kidneys of the experimental fishes treated with 2 ppm and 3 ppm of effluent concentrations was found to be declined by -2884% and -9.303% deviations in comparison to the normal-control fishes respectively. But the activity of ALP in the serum of the experimentally treated fishes was found to be augmented by +24.354% and +35.246% deviations from the normal-control respectively (Bhowmick et al., 2024).

The urea concentrations in the serum of the experimentally treated fishes with 2 ppm and 3ppm of effluent was found to be augmented by +133.303% and +190.288% deviations in comparison to the normal-control fishes.

The ammonia concentrations in the serum of the fishes treated with 2 ppm and 3ppm of effluent was found to be augmented by +74.086% and +131.396% deviations in comparison to the normal-control fishes.

Histoarchitectural studies-

Gills-

The histoarchitecture of the gills (Figure 1,2 and 3) vividly portrayed the impacts upon the organ due to the exposure of effluents. Curving of gill lamellae, fusion of the gill epithelium leading to the degradation and necrosis of gill epithelial cells was observed in the organ which depicts drastic impacts upon the organ and the degree of degradation is much higher in the fishes exposed to higher concentration of effluents.

Hepatopancreas-

The captured histoarchitectural images (Figure 4,5 and 6) clearly depicts the drastic effects of the brick-kiln refusals on the organs. The necrosis and vacuolation of the cells leading to the decrease in the density of the cells clearly displayed the damages caused to the organ. The degree of destruction was much more observed in the animals exposed to higher concentrations of the effluents.

Kidneys-

The damages caused to the excretory organ i.e. the kidneys were clearly displayed in the images (Figure 7,8 and 9). Vacuolations of the tissues, enlargement of the Bowman's capsule and increased space between the glomerulus was observed compared to the normal-control fishes which showed the stress upon the excretory system of the fishes.

Conclusion-

From the study upon a resistant fish species, the environmental stress upon the organism due to the brick kilns was clearly depicted. The oxidative stress upon the organism was noticed with the elevated concentrations of LPO and PPO activity. The increased concentration of xenobiotic stress marker enzymes i.e. GST and CYP showed the diffusion of certain harmful metabolites from the environment into the body and to detoxify those metabolites there was an increase of such

enzymes. The increased transaminase activity (AST and ALT) as well as ALP in the serum with declination of such enzymes in the organs implied the fact that there was draining of such enzymes from tissues into the serum affecting the metabolism and turnover of several amino acids. The elevated concentrations of urea and ammonia in the serum displayed the stress upon the kidneys affecting the excretion of such nitrogenous wastes from the body.

The anomalies thus observed in a resistant fish model was evidenced by the histomorphological degeneration of the tissues. And if such drastic changes were observed in a resistant fish species, then the survivability of other vulnerable species in the aquatic system was highly alarming. The people residing nearby the brick kilns depends largely on the fishes of the neighbouring water bodies for food as well as the source of income. So, the health condition and the economy of the fisherman is also greatly threatened.

From the very study it is to make aware several Non-Governmental and Governmental agencies as well as the laymen about the problem and also any steps for the management and mitigation of the problem.

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Conflict of Interest-

There is no such conflict of interest.

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