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Heavy Metals Impact on Behaviour and Morphology of *Cirrhinus mrigala*

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ABSTRACT: Today the heavy metals are kept at top priority list among the water pollutants as they are persistent, water soluble, nondegradable, vigorously oxidizing agents and strongly bind to many biochemical units and so adversely affect various physiological, histological and biochemical function of fish. The purpose of the current inquiry was to studying the effect of toxic heavy metals, arsenic, mercury, chromium and nickle alone and arsenic in combination with other three heavy metals at 0.025 and 0.05 ppm concentrations on behaviour and external body symptoms in commonly cultured freshwater fish *Cirrhinus mrigala*. Change in body colour as well as fin colour, fin erosion, descaling, haemorrhage and protruded eyes were observed in *C.mrigala* when exposed to heavy metals. Jerky and whirling movements were seen while swimming, along with frequent swimming and engulfing of air at the water surface. The changes in external body symptoms were duration dependent and were frequently evident under As+Cr and As+Hg treatment.

I. INTRODUCTION

The majority of metal ions have the ability to bioaccumulate in aquatic organisms, and at high concentrations they may cause physiological and biochemical changes that result in death. Environmental monitoring is the first step required to assess the possible toxicity of effluent being released at its intended use, to prevent the contaminants effects on water bodies. According to Aliko et al. (2018), fish are the top consumer in the aquatic food chain and are good creatures for toxicological and toxicogenomics studies. The fish have been used as a biological measurement (Biomarker) to indicate the presence of toxicant exposure and/or the impact towards the evaluation of molecular, cellular, and physiological level due to the high sensitivity of aquatic life to dissolving toxicant (Sabullah et al., 2015). Great deal of previous research has characterised heavy metals adversely affecting various physiological (Shahjahan et al 2022), biochemical and histological functions (Jain and Mittal,2004). The effects of these water contaminants on fish behaviour and morphological symptoms are however less studied. In this study, the characteristic effects of some heavy metals are reported on some behavioural and morphological symptoms which could be indicator of toxicity.

II. MATERIALS AND METHODS

These investigations used *Cirrhinus mrigala* fish that were 90±15 grams in weight and were regularly kept in good health. These fish were gathered from the nearby Hisar freshwater ponds and sterilized with a 0.1% KMNO₄ solution. Under controlled laboratory conditions, fish were acclimated for seven days in a tank of well-aerated tap water. Fish were moved into plastic containers with a 40-liter capacity for various treatments, and on alternate days, they were fed pelleted fish feed at 2% of their body weight. The fish were exposed to 0.025 and 0.05 ppm of mercury, nickel, chromium, arsenic, arsenic+mercury, arsenic+nickel, and arsenic+chromium. For each treatment, three replicates were kept, and 10 fish of the same size and weight were taken in each replicate for 45 days. Alkalinity, dissolved oxygen, conductivity, temperature, and pH of the water utilized were measured and maintained at about optimal levels on a weekly basis (Table -1). Fish waste and extra food were siphoned out on alternating days. At fortnightly interval Changes in behaviour and certain external body symptoms were recorded in fishes in all the treatments.



Table 1. Physicochemical properties of water

| Sr. No. | Parameters | |
|---------|------------------|------------------------|
| 1. | Dissolved oxygen | 5.86 – 8.1 mg/l |
| 2. | pH | 7.1 – 7.5 |
| 3. | Alkalinity | 153 – 160 mg/l |
| 4. | Conductivity | 270 – 278 μ s/cm |
| 5. | Temperature | 22 - 25 ⁰ C |

III. RESULTS AND DISCUSSION

The majority of the treatments employing metals, either alone or in combination, discovered that the behaviour of the fish had significantly changed from the active swimming and enough resting stages observed in the fish in control treatments. These fish displayed jerky, swirling movements when swimming, and occasionally these fish were seen surfacing and engorging air, indicating some sort of respiratory stress. Fish that were subjected to nickel and arsenic at concentrations of 0.05 ppm each as well as the two together became restless and displayed surfacing every 3 to 5 minutes. Fish that have been exposed to mercury, chromium, or both separately and in combination with arsenic frequently have increased surfacing. The treated fishes feeding behaviour was also noticeably subpar, and they generally refrained from feeding in the treated water. The fish that were being treated had mucus coming out of their gills and on their skin. The research on fish behaviour offers a wealth of knowledge and data because, in aquatic species, any change in behaviour can be linked to a physiological biomarker (Kristiansen et al., 2004; AmiardTriquet, 2009; Hellou, 2011). The physiological reaction of fish to an environmental influence is represented by their behaviour. Change in behaviour is thought to be a sensitive biomarker for assessing toxicant exposure (Gerhardt, 2007). According to Patil and David (2010), Ezeonyejaku et al. (2011), and Javed (2012), affected fish exhibit altered behaviour toward toxicants, particularly pesticides or heavy metals. The parameter for measuring behaviour alteration has been implemented, and examples include swimming ability, avoidance behaviour, and feed intake. According to Ballesteros et al. (2009), Cailleaud et al. (2011), and Almeida et al. (2012), swimming performance is regarded as a behavioural indicator to evaluate the physiological status of aquatic life and measure the presence and impacts of contaminants. In the past, chronic lead nitrate treatment (Shastri and Gupta, 1979) and cyanide exposure in salmonids (Neil, 1957) were linked to loss of equilibrium, jerky swimming movements. The defense mechanism for defending the fish from metallic interactions was explained as excessive mucus secretion after exposure to metals. According to Ghosh and Mukhopadhyay (2000), lead exposure caused the *Rita rita* fish for surfacing and whirling movement and to overslime on the body and gill surface. Similarly, after being exposed to Ni, *Colioasa fasciatus* grew restless and was observed rising to the surface of the water every two to three minutes, and a mucus film formed on the opercular region (Chaudhary and Nath, 1985). Gill et al. (1991) further demonstrated fish hyperexcitability and mucus secretion as a result of pesticide contamination in the water. They saw swimming movements that were gyrating as well. Lethargy, loss of equilibrium, and laboured breathing were observed in the test fish that had been exposed to pesticides and showed the most overt signs of suffering. Fish that succumbed to the pesticide's neurotoxic effects perished ostensibly from respiratory failure. Fish exposed to heavy metals were found to feed at a slower rate. Similar to this, James et al. (1992) also noted that *Heteropneustes fossilis* had slower rates of feeding, absorption, conversion, and metabolism due to the presence of sublethal amounts of mercury. In *Ictalurus punctatus* and *Carrasius auratus* exposed to 63 mg/l or more nitrofurazone, Wise et al. (1987) reported a coughing reaction accompanied with discharges of strands of mucus trailing from gill chambers and other regions of the body surface.

At fortnightly intervals during all of the treatments, observations were conducted for mortality rate and morphological alteration, including changes in body color, fin erosion, descaling, and haemorrhage. After 45 days, arsenic + chromium treatment (0.05 ppm) resulted in greatest mortality (47%), body darkening (61.90%), fin blackening (60.33%), haemorrhage (49.23%), and descaling (24%). At 0.05 ppm, arsenic + mercury treatment caused the most fin erosion. Mercury at 0.05 ppm revealed just 6.26% haemorrhage while nickel alone showed no haemorrhage (Tables 2 and 3). When used in combination, heavy metals had more drastic impacts on morphological alterations than when they were administered alone. These morphological alterations in fish exposed to metal are a sign of stress. Ghose and Mukhopadhyay (2000) discovered similar morphological variations in *Rita rita*. Chromium caused the fin margins to erode, and the body's colour changed from greyish black to yellowish. Commonly seen effects were oozing gills and fin bases, which were exacerbated by higher metal concentrations. Prior to dying, fish exposed to copper were seen to have protruding eyes. After repeated exposure to 2.8 mg/l lead nitrate, pigmentation loss in *Heteropneustes fossilis* was also documented (Shastry and Gupta, 1979). Long-term exposure of *H. fossilis* to fenvalerate led to depigmentation of the integuments; nevertheless, Kaur (1999) has noted that acute exposure can cause skin to darken before death. On prolonged exposure, it was also noted that there was an abundance of mucus secretion, regional haemorrhage, and eye bulging. According to Kanabur and Sangli (2000), paranitrophenol exposure caused haemorrhagic consequences as well as damage to the gills and skin on the ventral side of the abdomen. These

indications point to a fish under extremely asphyxic conditions. In *H. fossilis*, Bhatia and Sandhu (2004) noted haemorrhage after endosulfan exposure. When *C. punctatus* was exposed to endosulfan and mellathion, Dua (1995) noted a loss of pigmentation.

As a result, this research provides a summary of the use of fish as a biomarker of heavy metals through behavioural changes and morphological modifications, which could be very helpful in the monitoring of environmental contamination.

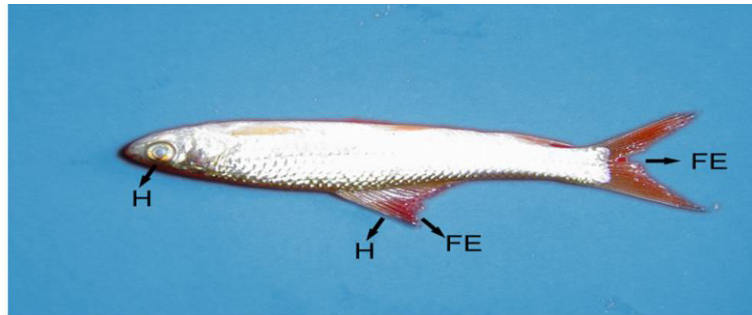


Fig.: *C. mrigala* exposed to heavy metals (FE – Fin erosion ;H- Haemorrhage)

Table 2 : Percent change in morphological symptoms in *Cirrhinus mrigala* on exposure to heavy metals

| Treat ment (ppm) | Mortality | | | Body colour change | | | Fin blackening | | | Fin erosion | | | Descaling | | | Haemorrhage | | | |
|------------------|-----------|-------|-------|--------------------|-------|-------|----------------|-------|-------|-------------|-------|-------|-----------|-------|-------|-------------|-------|-------|----|
| | Days | 15 | 30 | 45 | 15 | 30 | 45 | 15 | 30 | 45 | 15 | 30 | 45 | 15 | 30 | 45 | 15 | 30 | 45 |
| Control | - | - | 7.20 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Mercury | | | | | | | | | | | | | | | | | | | |
| 0.025 | 7.76 | 10.37 | 15.20 | - | 11.11 | 16.00 | 11.11 | 16.24 | 20.11 | 6.67 | 10.31 | 14.23 | - | 4.57 | 6.23 | - | - | - | |
| 0.05 | 9.20 | 14.21 | 21.09 | 3.70 | 11.76 | 19.57 | 11.76 | 20.23 | 27.21 | 7.72 | 12.67 | 21.90 | 3.67 | 10.00 | 12.69 | - | - | 6.26 | |
| Nickel | | | | | | | | | | | | | | | | | | | |
| 0.025 | 3.30 | 5.78 | 10.32 | - | - | 11.11 | - | - | - | - | - | 3.57 | - | - | - | - | - | - | |
| 0.05 | 4.57 | 10.20 | 15.29 | - | 4.56 | 14.20 | - | 5.26 | 9.23 | - | 6.78 | 10.23 | - | - | 6.26 | - | - | - | |
| Chromium | | | | | | | | | | | | | | | | | | | |
| 0.025 | 6.87 | 17.20 | 21.34 | 7.23 | 15.17 | 23.70 | - | 7.14 | 20.00 | 3.78 | 6.78 | 10.58 | 3.50 | 5.26 | 10.00 | - | - | 11.76 | |
| 0.05 | 12.34 | 20.62 | 27.19 | 13.00 | 20.69 | 27.80 | 5.26 | 11.76 | 25.00 | 5.32 | 10.23 | 19.23 | - | 7.14 | 13.26 | - | 13.56 | 19.26 | |
| Arsenic | | | | | | | | | | | | | | | | | | | |
| 0.025 | 10.00 | 16.21 | 23.70 | 7.40 | 14.29 | 22.00 | 3.93 | 11.76 | 20.00 | 3.78 | 6.20 | 7.49 | - | 8.20 | 15.13 | - | 12.50 | 21.20 | |
| 0.05 | 13.00 | 20.69 | 28.32 | 11.10 | 17.14 | 28.67 | 7.14 | 16.00 | 29.16 | - | 9.62 | 12.53 | - | 11.10 | 20.12 | - | 18.51 | 29.39 | |

Table 3: Percent change in morphological symptoms in *Cirrhinus mrigala* on exposure to different combinations of heavy metals

| Treat ment (ppm) | Mortality | | | Body colour change | | | Fin blackening | | | Fin erosion | | | Descaling | | | Haemorrha ge | | | |
|------------------------------|-----------|-----------|-----------|-----------------------|-----------|-----------|----------------|-----------|-----------|-------------|-----------|-----------|-----------|-----------|-----------|-----------------|-----------|-----------|----|
| | Days | 15 | 30 | 45 | 15 | 30 | 45 | 15 | 30 | 45 | 15 | 30 | 45 | 15 | 30 | 45 | 15 | 30 | 45 |
| Contro l | - | - | 7.2 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Arseni c+ mercur y | | | | | | | | | | | | | | | | | | | |
| 0.025 | 13. 00 | 20. 11 | 28. 32 | 7.6 3 | 20. 27 | 24. 67 | 11. 11 | 20. 92 | 37. 20 | 11. 11 | 17. 23 | 22. 53 | - | 8.2 0 | 12. 69 | - | - | 11. 17 | |
| 0.05 | 21. 12 | 30. 67 | 41. 57 | 14. 81 | 19. 23 | 43. 48 | 18. 51 | 28. 00 | 48. 23 | 19. 23 | 36. 36 | 43. 19 | 3. 67 | 11. 11 | 20. 12 | - | 19. 26 | 32. 18 | |
| Arseni c+ nickel | | | | | | | | | | | | | | | | | | | |
| 0.025 | 10. 00 | 17. 20 | 21. 34 | 6.9 1 | 18. 72 | 23. 00 | - | 11. 76 | 19. 29 | 3.2 3 | 10. 57 | 13. 49 | - | 7.1 9 | 12. 69 | - | 9.2 0 | 12. 26 | |
| 0.05 | 10. 00 | 20. 11 | 33. 73 | 13. 71 | 24. 21 | 36. 67 | 10. 21 | 19. 17 | 30. 11 | 9.6 2 | 13. 49 | 23. 21 | 4. 57 | 10. 10 | 17. 67 | - | 14. 22 | 26. 24 | |
| Arseni c+ Chrom ium | | | | | | | | | | | | | | | | | | | |
| 0.025 | 16. 91 | 28. 23 | 37. 11 | 11. 11 | 32. 00 | 45. 00 | 20. 32 | 28. 00 | 54. 54 | 7.4 0 | 19. 23 | 30. 43 | 3. 67 | 10. 11 | 16. 21 | - | 16. 00 | 25. 00 | |
| 0.05 | 20. 32 | 31. 53 | 47. 00 | 17. 81 | 40. 23 | 61. 90 | 26. 11 | 30. 23 | 60. 33 | 11. 53 | 28. 00 | 40. 00 | 8. 20 | 11. 11 | 24. 00 | - | 22. 26 | 49. 23 | |

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