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ORIGINAL ARTICLE

Effect of Zinc Chloride on Respiratory and Opercular Activities of Fresh Water Fish *Channa punctatus* (Bloch.)

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ABSTRACT

The water contamination by heavy metals is very much serious problem for aquatic animals in India. In this study I examine the impact of zinc chloride exposure on the respiratory physiology and opercular movement of the freshwater fish. Fish were exposed to sublethal concentrations of zinc chloride for varying durations (24, 48, 72, and 96 hours). Observations revealed significant changes in opercular beat frequency and respiratory rates, indicating respiratory distress. These findings suggest that zinc chloride negatively affects respiratory function and opercular health, potentially impairing the survival of in contaminated water ecosystems. Exposure to zinc chloride affected respiratory activities in a concentrationand time-dependent manner, with notable changes in key parameters: oxygen consumption rate (OCR) decreased, while gill ventilation rate (GVR), opercular movement rate (OMR), and respiration frequency (RF) increased. Similarly, opercular activities showed increases in opercular beat frequency (OBF), opercular beat amplitude (OBA), opercular movement rate (OMR), and oxygen consumption rate (OCR).

Keywords: *Channa punctatus, Respiratory beats, opercular activities, Zinc Chloride*

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INTRODUCTION

Environmental pollution is a world wide problem, with heavy metals being among the mostsignificant pollutants in aquatic ecosystems due to their toxicity, accumulation, and biological magnification in marine animals. Natural water systems are heavily contaminated with heavy metals due to a variety of human activities, such as household, industrial, and creative endeavors (Velez & Montro, 1998).

Freshwater bodies such as rivers, lakes, and ponds are increasingly being polluted and have becoming more dumping sites for household garbege and industrial waste. The rapid growth ofindustrialization, urbanization, agriculture, and other developmental endeavors have significantly contributed to this contamination. As a result, the discharge of heavy metals into aquatic ecosystems has led to ecotoxicological consequences. Unlike many other pollutants, metals occur naturally in the environment and are omnipresent in various forms. However, despite their natural presence, they can still pose very damaging health risks (Kakabe *et al*., 2020).

Heavy metals can accumulate in the organs of fish, especially when they enter contaminated aquatic environments, (Farkas & Solanki, 2002). The toxic effects of these metals can impact fish by reducing growth rates, disrupting biological functions, higher mortality rates, and affecting reproduction (Amundsen *et al*., 1997). Heavy metals enter fish through three primary pathways: the gills, the digestive tract, and the body surface. The gills are the most significant site for direct metal uptake from the water (Remeo *et al*., 1999). While the body surface also plays a role in metal absorption, its contribution is generally considered minor (Selda & Nursah, 2012).

Natural aquatic systems can become heavily extremely polluted with heavy metals due to domestic, industrial, and other activities by human. This contamination can disrupt the ecological balance of the affected environment, may severely to harm to a wide range of aquatic organisms (Farombi *et al*., 2007; Vosylinien & Jankaite, 2006).

Heavy metals are significant pollutants that enter fish bodies either through direct through ingestion from water or through food. These metals can adversely affected fish behavior, growth, and reproductive capacity. Some of the most toxic heavy metals include mercury, nickel, lead, zinc, arsenic, cadmium, aluminum, platinum, and copper, in both metallic and ionic forms.

According to Ferguson (1990), aquatic life is seriously at risk of poisoning from many of these metals. Zinc is an essential heavy metal that is needed in trace quantities for the normal functioning of various tissue systems (Harper *et al*., 1977). However, chemical and physiological measurements alone are not sufficient to assess its potential impact on aquatic organisms. Thus while, toxicity studies play a crucial role in evaluating water pollution (Prakash & Verma, 2018).

The paper manufacturing industry uses a lot of water-intensive, utilizing large volumes of water throughout the production process. In India alone, this industry consumes approximately 905.8 million cubic meters of water annually and discharges around 3,695.7 million cubic meters of wastewater (Srivastav *et al*., 2019). The toxic effects on fish largely depend on the concentration of pollutants and the duration of exposure, as documented by Sadguru and Ashok (2020).

The studied toxic effects of paper mill effluents on the mortality, behavior, and morphology of the snake-headed fish *Channa punctatus* (Bloch). Heavy metals can enter fish bodies through three primary pathways: the gills, digestive tract, and skin. However, the body surface is generally considered a less significant route of absorption.

MATERIAL AND METHOD

Experimental Fish:

The freshwater fish *Channa punctatus*, commonly known as the snakehead due to its resemblance to a snake's head, was selected for this study. The fish were sourced from a local market and acclimated to laboratory conditions for two to three weeks before the experiment.

Experimental Design:

Freshwater *Channa punctatus* fish, with an average weight of 38.8 ± 2.48 g and a length of 15.5 ± 3.3 cm, were selected for this experiment. The laboratory maintained a 12-hour light (L): 12- hour dark (D) photoperiod. To prevent dermal infections, the fish were initially treated with 0.04% potassium permanganate solution. They were then housed in large glass aquariums for an 18–20 day acclimatization period. During this time, the fish were fed commercial fish feed, and the tanks were regularly cleaned. Water parameters were monitored according to APHA (1998) guidelines.

Throughout the acclimatization period:

- **Water temperature:** 25–28°C
- **pH range:** 7.2–7.4
- **Dissolved oxygen:** 7.4–7.6 mg/L
- **Conductivity:** 290–300 µS/cm

The observation theory for this research experiment is based on understanding the physiological impact of zinc chloride ($ZnCl_2$) exposure on the respiratory and opercular activities of *Channa punctatus* (a species of fish).

OBSERVATION DURING EXPERIMENTAL WORK

1. Toxicity Impact on Respiration: Exposure to $ZnCl_2$ leads to increased respiratory stress, indicated by changes in operculum movement and ventilation rate. Higher $ZnCl_2$ concentrations cause an increase in gill ventilation rate (GVR), operculum movement rate (OMR), and respiratory frequency (RF), suggesting a compensatory mechanism to counteract oxygen deficiency. A decline in operculum closure rate (OCR) at higher $ZnCl_2$ concentrations may indicate respiratory distress.
2. Changes in Opercular Activity: Zinc chloride exposure leads to significant alterations in operculum beat frequency (OBF) and amplitude (OBA), with a dose-dependent increase over time. Increased operculum movement reflects heightened physiological stress, possibly due to gill irritation or hypoxia caused by $ZnCl_2$. The operculum closure rate (OCR) shows a steady increase, which suggests a defense mechanism against toxic exposure.
3. Dose-Dependent Effects: As $ZnCl_2$ concentration increases, the observed changes in respiration and operculum movement become more pronounced. The highest $ZnCl_2$ concentration (20 mg/L) results in the most significant increase in respiratory and opercular activity, indicating severe physiological stress. Over prolonged exposure (96 hours), the fish exhibit sustained stress responses, possibly leading to long-term health impacts.

RESULTS AND DISCUSSION

Exposure to zinc chloride in *Channa punctatus* resulted in dose-dependent physiological and behavioral changes, including increased melanin production, alterations in skin thickness and scale structure, heightened swimming activity, erratic movement, and reduced feeding behavior. The impact of zinc chloride on respiratory parameters varied with concentration. Observations revealed:

- **Decreased Oxygen Consumption Rate (OCR)**
- **Increased Gill Ventilation Rate (GVR)**
- **Increased Operculum Movement Rate (OMR)**
- **Increased Respiratory Frequency Rate (RFR)**

These findings, summarized in Table 1, indicate that zinc chloride exposure significantly affects respiratory physiology, potentially impairing the survival and overall health of *Channa punctatus* in contaminated aquatic environments. Further findings and summarized in Table 2, indicate that zinc chloride exposure on ppercular parameters varied with concentration.

- **Increase Operculum Beat Frequency (OBF)**
- **Increase Operculum Beat Amplitude (OBA)**
- **Increase Operculum Movement Rate (OMR)**
- **Increase Operculum Closure Rate (OCR)**

Table 1: Effect of Zinc Chloride Exposure on the Respiratory Activities of *Channa punctatus*

Controlled	Time (hrs)	Zncl2 Conc. Mg/L	OCR (mg/g/h)	GVR (Breaths/min)	OMR (movements/min)	RF (Breaths/min)
0	0	0	2.5 ± 0.5	40 ± 55	24.5±2.2	60 ± 5
T1	24 hrs	5 mg/L	2.3±0.5 (8% decrease)	68±8(45% increase)	34.6±3.4(40%increase)	72±6(20%increase)
T2	48hrs	10 mg/L	2.0 ±0.2(20% decrease)	78±10(95%increase)	50.1±4.6(108% increase)	90±9(50%increase)
T3	72 hrs	15 mg/L	1.6±0.3(36%decrese)	98±12(245%increase)	63.4±5.1(158%increase)	108±11(80%increase)
T4	96 hrs	20 mg/L	1.2±0.1(52%decrease)	118±15(295%increase)	80.1±6.4(227%increase)	132±14(120%increase)

Table 2: Effect of Zinc Chloride Exposure on the Opercular Activities of *Channa punctatus*

Controlled	Time	Zncl2 Conc. Mg/L	OBF (Beat/min)	OBA(min)	OMR (Movements/min)	OCR (closures/min)
0	Cot	0	60.2±5.1	2.5±0.2	24.52±2.1	12.09±5.2
T1	24hrs	5mg/L	79.5±4.2(32.05% increase)	3.3±0.5(32%increase)	36.5±3.5(48%increase)	14.5±2.1(19%increase)
T2	48hrs	10mg/L	99.5±5.1(65.44% increase)	4.2±0.6(68%increase)	52.1±4.8(112%increase)	19.4±3.2(60%increase)
T3	72hrs	15mg/L	118.6±8.2(96.01%increase)	5.1±0.7(104%increase)	65.5±6.1(168%increase)	24.8±4.1(105%increase)
T4	96hrs	20mg/L	138.1±10.1(129.40%increase)	5.5±1.2(136%increase)	80.1±8.4(227%increase)	30.3±5.2(150%increase)

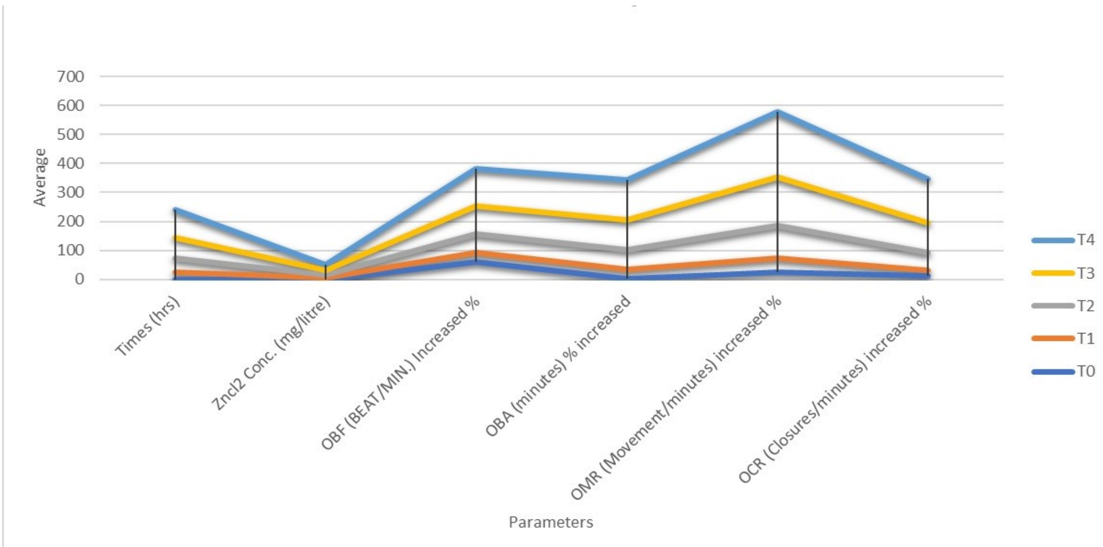

Fig. 1: Effect of Zinc Chloride Exposure on the Opercular Activities of *Channa punctatus*

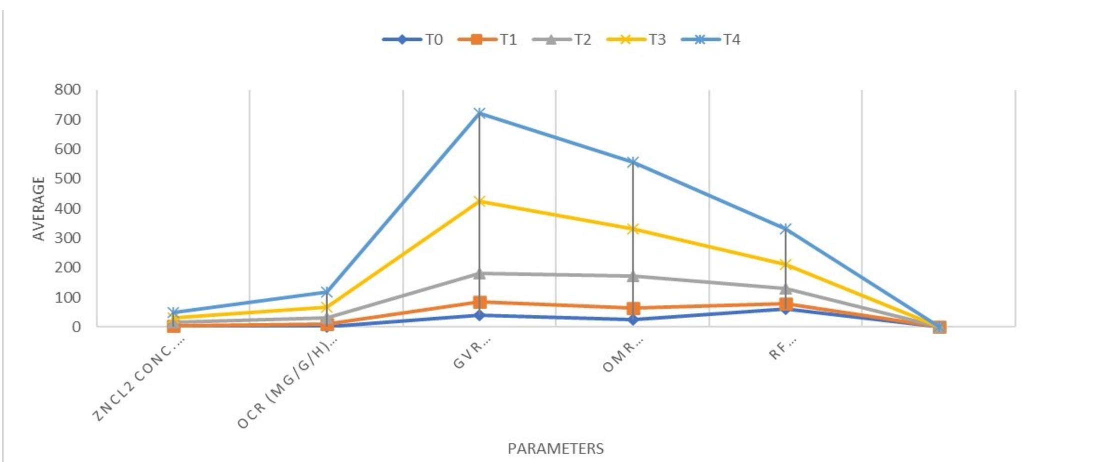

Fig. 2: Effect of Zinc Chloride Exposure on the Respiratory Activities of *Channa punctatus*

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