Histopathological Alteration in the Liver of Sardinella Longiceps as a Biomarker of Heavy Metal Pollution in Aquatic Ecosystem

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Abstract:
The discharge of heavy metals from industrial effluents into aquatic ecosystems is a major cause of serious aquatic pollution. The bioaccumulation of toxic heavy metals in aquatic species can lead to their transmission to the food chain, posing serious public health risks. Present study was done to assess heavy metal accumulation and histopathological analysis in the liver of Sardinella longiceps collected from Sassoon dock during the rainy season between 2019 to 2022. It was found that amongst studied heavy metals Cu, Cr, and Mn concentration was beyond the permissible limit of WHO and FAO guidelines. Histopathological analysis of liver tissues during the studied period showed various architectural alteration which could be due to the accumulation of heavy metals found in it.

Keywords: Heavy metal, Food chain, histopathological analysis, permissible limit

Introduction

The bioaccumulation of heavy metals is a global threat because they are persistent, non-degradable, and harmful to all living organism (Sultana, S., et al., 2022). The microscopic examination of fish tissues (histopathology) is a valuable tool for environmental monitoring, as it can be used to detect and assess the effects of pollutants on fish health (Faheem, M., et al., 2017). The liver's high metabolic capacity and role in xenobiotic detoxification make it susceptible to the toxic effects of waterborne contaminants (Camargo, M. M., et al., 2007). Fish play a vital role in aquatic ecosystems as a key trophic level and as a valuable source of protein for humans. Sardinella longiceps fish contain valuable source of protein, moisture and lipid (Singh, P., et al.,2022).

Materials and method

1.Histopathological analysis:

Sardinella longiceps were collected from Sassoon dock in Mumbai during the rainy seasons of 2019-2022. Fishes of varying size (17-20 cm, 60-100 g) were selected for histopathological analysis. Thirty samples were collected in triplicate each time. Fishes were collected with the help of local fishermen, kept in iceboxes, and brought to the laboratory. In the lab, they were cleaned with distilled water and dissected to remove liver tissue. Dissected tissues were fixed with 10% neutral buffered formalin. All chemicals used were of AR grade. Histopathological analysis was done as per Bancroft and Stevens, 1982 method. The architecture of all liver tissue samples was studied and recorded using Axio CamMRc Zeiss digital photography.

2.Heavy metal analysis:

The dissected liver tissues were processed separately for the estimation of heavy metal (Topping,G., 1973). The concentrations of heavy metals, including cadmium, lead, copper, zinc, manganese, chromium, arsenic, and mercury, were determined in the liver tissue of Sardinella longiceps collected from Sassoon dock, Mumbai using inductively coupled plasma atomic emission spectroscopy (ICP-AES).

3.Statistical analysis:

The mean and standard deviation of heavy metal concentrations in liver of the experimental fish were calculated using SPSS statistical tools.

Result and discussion:

Present work showcased that different heavy metals have found to be bioaccumulated in different amount of concentration in the liver tissue of Sardinella longiceps. The concentration of heavy metals found in the liver tissues were compared with the standard values documented by World Health Organisation (1989) and FAO (1983) limits.

Table 1. Heavy metal concentration in the liver of Sardinella longiceps collected from Sassoon dock, Mumbai.

Heavy metal	Concentration of heavy metal found in liver tissue (± SD)
Cr	6.3 ± 0.3
Cu	38.59 ± 12.3
Mn	7.73 ± 0.4
Zn	58.85±1.3
Pb	ND
Cd	ND
Hg	ND
As	ND

(Results were expressed in mg/kg wet weight mean value ± standard deviation)

Histopathological examination of the liver tissues of Sardinella longiceps during the rainy season revealed various alterations in the hepatic tissue architecture. The liver tissue showed focal necrosis, irregular shaped hepatocytes, increased sinusoidal spaces, nuclear displacement, cloudy cytoplasm, degenerated hepatic cells, cytoplasmic vacuolation, congestion, vascular dilation, peliosis hepatis with erythrophagocytosis, pyknotic nuclei, focal lymphocytic infiltration, inflammatory cluster, and disturbed distribution of hepatic cell arrangement. All the hepatic architectural changes found during the study was showcased with the help of figure F1 to F4. These histopathological changes suggest severe damage to the fish body.

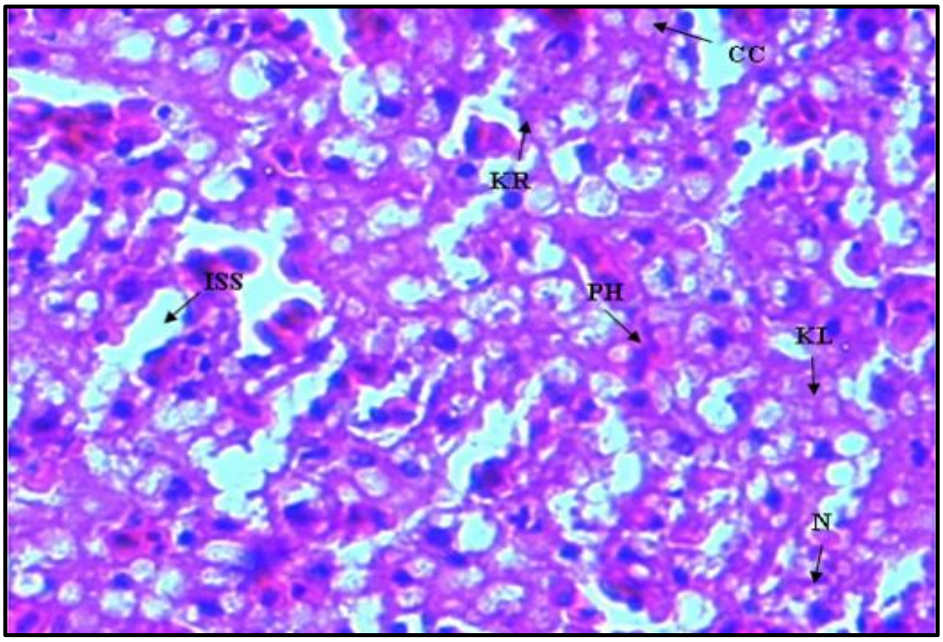

Fig.1 Liver histopathology of *Sardinella longiceps* during rainy season (Haematoxylin and eosin stained slide focused under 200X) ISS-Increased sinusoidal space, KR- karyorhexis, KL- karyolysis, N- necrosis, PH-peliosis hepatis, CC- cloudy cytoplasm

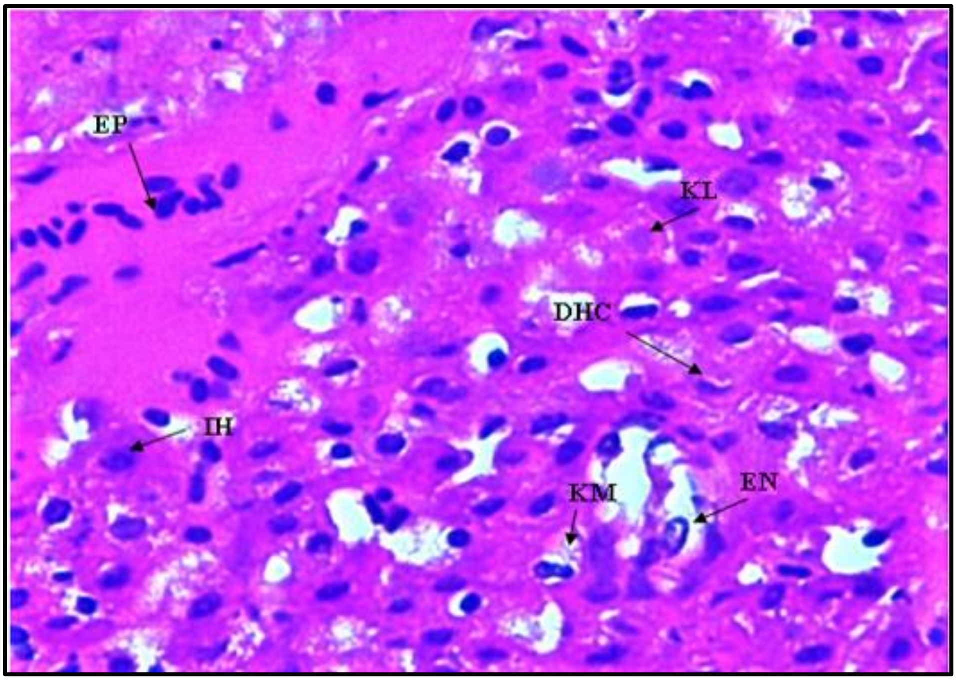

Fig. 2 Liver histopathology of *Sardinella longiceps* during rainy season (Haematoxylin and eosin stained slide focused under 400X) IR- irregular hepatic cell, KM- karyomegaly, EP- enlarged nucleus, EP- erythrophagocytosis, DHC-degenertaed hepatic cell, KL- karyolysis

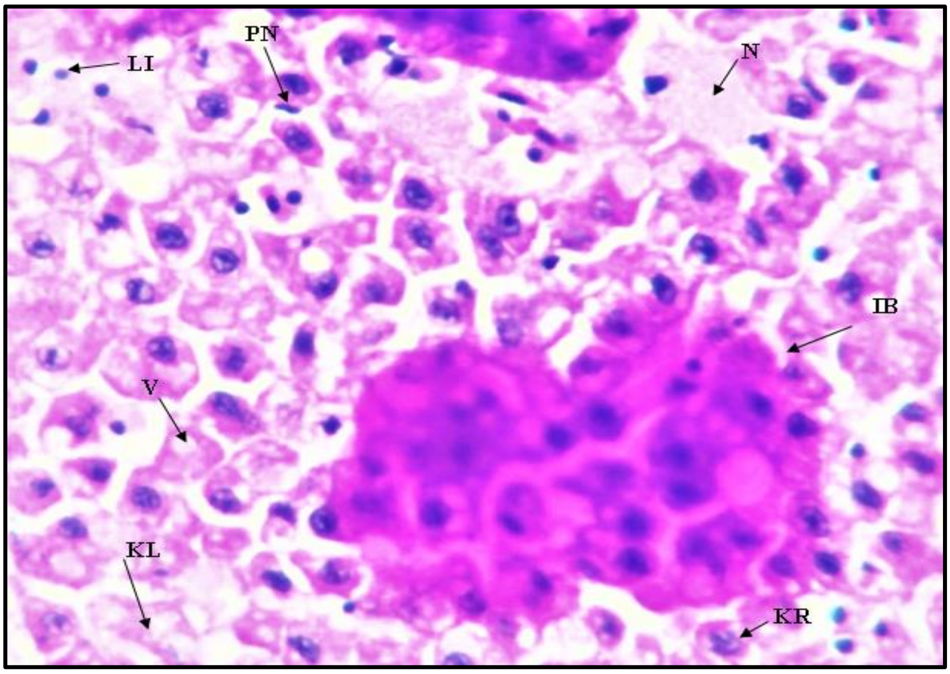

Fig. 3 Liver histopathology of *Sardinella longiceps* during rainy season (Haematoxylin and eosin stained slide focused under 400X) IB-Inflammatory cell ball, LI- lymphocyte inflammation, N- necrosis, PN- pyknotic nuclei, V- vacuolization, KR- karyorhexis, KL- karyolysis

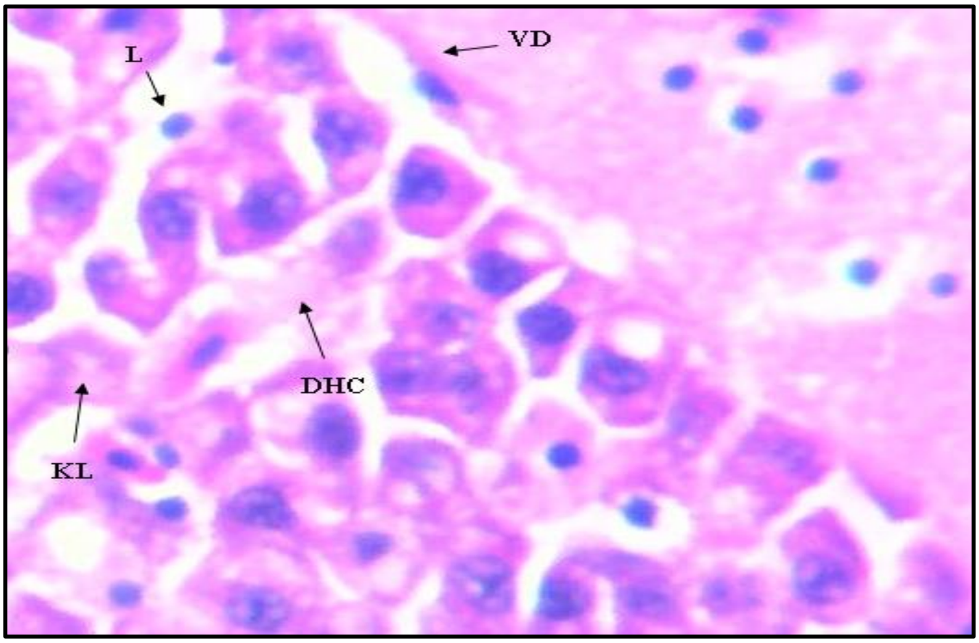

Fig. 4 Liver histopathology of *Sardinella longiceps* during rainy season (Haematoxylin and eosin stained slide focused under 400X) DHC- degenerated hepatic cell, L- lymphocyte, N- necrosis, PN- pyknotic nuclei, VD- vascular dilation, KL- karyolysis

Discussion:

Present work showed that liver tissue of Sardinella longiceps showed bioaccumulation of heavy metals with varying concentration of different metals. Chromium, copper and manganese concentration were found beyond the permissible limit of WHO and FAO guidelines. The liver tissues of Sardinella longiceps collected from Sassoon dock, Mumbai showed significant histopathological changes during the rainy season. These changes included an increase in sinusoidal space, lymphocytic infiltration, nuclear alterations, disruption of cordal arrangement of hepatocytes, vacuolization of hepatocytes, fatty degeneration, and necrosis. It has been also found that high accumulation of metals, particularly copper, zinc, manganese and chromium was present in the liver tissue of Sardinella longiceps during the rainy season of studied period. Similar observations have been reported by Khalique, N., *et al* 2023; Tlenshieva, A. M., *et al*.,2022; Mohamed, H., *et al*., 2021; Carmo, T. L. L., *et al*., 2019; Oza, A., *et al*., 2019; Faheem, M., *et al*.,2017; Bhuvaneshwari, R., *et al*., 2015; Kaoud, H., *et al*.,2010 where they showed that liver histopathology could alter due to toxicity of heavy metal. The use of histopathological biomarkers to assess pollution-induced stress in marine organisms has gained increasing attention in recent years. Although previous studies have investigated the effects of pollution on organisms, there is a paucity of literature on how bioaccumulation of heavy metal may contribute to pollution stress and associated structural alterations in the liver of fish. This study aims to address this gap by exploring the impact of heavy metal pollution stress in these organisms.

The present study on the histopathology of *Sardinella longiceps* liver indicates that they are experiencing significant pollution stress, which can adversely affect their overall health status. The documented findings provide valuable insights into the histopathological changes occurring in the examined fish species due to bioaccumulation of heavy metals.

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