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Original Article

# Bioaccumulation of heavy metals in liver tissues of three *Anas* species in Al-Hawizah marshes, southern Iraq

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**Abstract:** Bioaccumulation of Cadmium, lead, Copper, Zinc, and Iron was investigated in the liver tissues of three migratory bird species viz. *Anas platyrhynchos, A. crecca,* and *A. acuta* of both sexes in autumn and winter. Bird samples were collected from autumn 2021 to winter 2022 from Al-Hawizeh Marshes, Misan Province, Iraq. The results showed that Cd in liver tissues ranged from 0.73 to 8.174 ppm during winter and autumn, respectively in males of *A. crecca*. Pb ranged from 0.076 to 0.922 ppm in females and males of *A. platyrhynchos* during winter and autumn, respectively. Cu varied from 0.635 to 4.62 ppm in males of *A. platyrhynchos* during autumn and winter, respectively. Zn ranged between 0.402 ppm in males of *A. acuta* and 2 ppm in females *A. platyrhynchos* and *A. crecca* during autumn and winter, respectively. Fe ranged between 1.544 ppm in males of *A. acuta* and 15.85 ppm in females of *A. platyrhynchos* during autumn and winter, respectively. The concentrations of Cd, Cu, and Fe were higher than the permissible limit, whereas Zn and Pb were within permissible FAO.

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## Introduction

Al-Hawizah Marsh is one of the main and important marshes in the south of Iraq, extending from the Tigris River to Iran. It provides a suitable environment for many living organisms, such as aquatic plants, invertebrates, fishes, birds, etc. In recent years, the marsh has suffered from pollutants such as pesticides, hydrocarbon compounds, and heavy metals (Rushdi et al., 2006; Hasab et al., 2020). Aquatic ecosystems accumulate pollutants from natural and human activities, which pose adverse effects on aquatic biota.

Heavy metals are pollutants of concern attributed of their persistence, toxicity, and high ability to accumulate in the tissues of living organisms (Kanwal et al., 2020). The main sources of heavy metals in the aquatic environment are anthropogenic activities and other industrial wastes or natural sources (Behra et al., 2002; Abdullah, 2013; Bhardwaj et al., 2017). Heavy metals are toxic with chronic and acute toxicological impacts on living organisms through different trophic levels of the food chain (Merian, 1991). Some metals essential for living organisms, such as zinc, copper, manganese, and iron, have enzymatic functions in the metabolism of cells (Kadhim et al., 2018).

Birds are susceptible to bioaccumulation of heavy metals through the consumption of contaminated water and food; therefore, they can provide interesting information to monitor the quality of the ecosystems (Kim and Oh, 2013; Mansouri and Majnoni, 2014; Jazza et al., 2022). Therefore, birds are a proper indicator for assessing heavy metals in the wetland because they feed on various levels of the food chains (Burger and Gochfeld, 2016). Hence, the main objective of the present study was to investigate levels of some heavy metals of cadmium, lead, zinc, copper, and iron in the liver tissues of three migratory *Anas* species (*Anas platyrhynchos, A. crecca*, and *A. acuta*.) of both sexes in Al-

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Table 1. Seasonal variations of Cd levels (ppm) in liver tissues of studied birds.

| Name of bird | Gender | Autumn | Winter |
|---|---|---|---|
| *A. platyrhynchos* | male | 7.579 | 1.567 |
| | female | 8.139 | 1.003 |
| *A. crecca* | male | 8.174 | 0.73 |
| | female | 7.782 | 1.44 |
| *A. acuta* | male | 7.917 | 1.221 |
| | female | 8.073 | 2.276 |
| FAO (1985) | | 0.2 | |

Hawizah marsh.

## Materials and Methods

**Study area:** Al-Hawizeh Marshes are located on the eastern side of the Tigris River and extend between Al-Suwaib sub-district in the Al-Qurnah district in the north to Al-Uzayr district, Maysan Province to the villages of Al-Baydah, Al-Sawadah, and Al-Turaba, which is a common marsh between Iraq and Iran. Several subsidiary rivers run in the same direction due to the land's natural slope as a result of the topographical situation of the area. Some plants grow in saline soils, such as Tahma and Tarfa (Hashim et al., 2019; Idan and Jazza, 2022).

**Collection and prepare bird samples:** Bird samples were collected from Al-Hawizeh Marshes from autumn 2021 to winter 2022 using a fishing net (douche). The birds' samples were placed in a box containing crushed ice until they reached the laboratory. Samples were three economic migratory bird species, namely *A. crecca, A. platyrhynchos*, and *A. acuta*, from both sexes (male and female). The liver tissues were removed and then wrapped in aluminum foil and stored in the freezer for further analysis. Later, the liver samples were dried using a hot air oven at 80°C for 24 hours and then ground using an electric grinder, sieved using the metal sieve (0.3 mm), and placed in polyethylene tubes for digestion (Jayakumar et al., 2013). All utensils and glassware were rinsed with tap water, soaked in nitric acid for 24 hours, rinsed with demineralized water, and dried under a laminar flow hood before use to minimize contamination with metals.

**Digestion of liver samples:** Digestion of liver samples was done following the standard procedure suggested by Jeffrey (2003) as follows: 0.5 g of the dried samples were weighted and transferred into Teflon tubes, and then 6 ml concentrated mixture of $HClO_4$ and nitric acid $HNO_3$ in a ratio of (1:1) was added. The samples are shaken well for 12-16 hours to complete the initial digestion process in the vacuum hood. Then it was placed in a water bath at 70°C for 30 minutes and transferred to a hot plate to complete the digestion process until the mixture became clear. The solution was cooled at room temperature and transferred to a volumetric flask filled with deionized distilled water.

**Heavy metals measurement:** The concentrations of heavy metals of Pb, Cd, Cu, Fe, and Zn were measured using a flame atomic absorption spectrometer, model AI 1200 Aurora.

## Results and discussion

The results revealed that the highest Cd in the liver of *A. platyrhynchos* was 7.579 and 8.139 ppm during autumn in males and females, respectively, and the lowest were 1.003 and 1.567 ppm during winter in females and males, respectively. Accumulation of Cd in the liver of *A. crecca*, and *A. acuta* in autumn and winter is shown in Table 1. The variation in the concentrations of Cd in different species may be attributed to their different feeding habits, age, weight, size, interaction with nutrients, and gender (Peakall and Burger, 2003; Douterelo et al., 2004). Sometimes they feed on agricultural lands contaminated with chemical fertilizers and pesticides, which increase the exposure of birds to heavy metals (Degrnes, 2008; Alloway, 2012). Heavy metals in the organs of birds are affected by the level of contamination in food and water; the

Table 2. Seasonal variations of Lead levels (ppm) in liver tissues of studied birds.

| Species | Gender | Autumn | Winter |
|---|---|---|---|
| *A. platyrhynchos* | male | 0.922 | 0.077 |
| | female | 0.113 | 0.076 |
| *A. crecca* | male | 0.095 | 0.15 |
| | female | 0.195 | 0.077 |
| *A. acuta* | male | 0.35 | 0.077 |
| | female | 0.002 | 0.15 |
| FAO (1985) | | 5 | |

Table 3. Seasonal variations of Copper levels (ppm) in liver tissues of studied birds.

| | Gender | Autumn | Winter |
|---|---|---|---|
| *A. platyrhynchos* | male | 0.635 | 4.62 |
| | female | 0.84 | 3.9 |
| *A. crecca* | male | 1.366 | 2.12 |
| | female | 0.986 | 4.4 |
| *A. acuta* | male | 0.807 | 1.67 |
| | female | 1.816 | 2.03 |
| FAO (1985) | | 0.2 | |

liver tissue plays an important role in detoxification, reflecting long-term bioaccumulation (Burger and Gochfeld, 2016). Metals are absorbed into the body and then enter the circulatory system. Some interact with fats, whereas others dissolve and transfer to other tissues (Burger et al., 2003; Peakall and Burger, 2003). The migration of birds increases Cd accumulation during their flight (Durkalec et al., 2022). This study showed that the levels of Cd in the liver tissues for all studied species were higher than the permissible limit (0.2 ppm) of FAO (1985).

The results of Pb accumulation in the liver of three studied birds from the Al-Hawizah marsh are shown in Table 2. The ability of the birds to accumulate Pb varies, which may be attributed to different factors such as weight, age, gender, and their feeding habits (Idan and Jazza, 2022; Douterelo et al., 2004). Lead is absorbed by birds with food and is associated with the uptake of $Ca^{+2}$, and accumulated in bone and liver tissues (Scheuhammer, 1987). Pb is toxic, and the bones are the main depot for lead. This may explain the reason for its low concentration in liver tissues in both sexes, i.e. it may be due to the deposition of Pb in the skeleton compared to other tissues of birds (Burger et al., 1992). Birds feed on solid food materials to help grind larger food particles to make them digestible, hence pb will be consumed with such materials (Best and Stafford, 2002). Pb concentrations in this study were within the permissible limits (5 ppm) recommended by FAO (1985).

The results of Cu bioaccumulation in the liver of *A. platyrhynchos*, *A. crecca,* and *A. acuta* from the Al-Hawizah marsh are presented in Table 3. The highest levels of Cu were recorded during winter, whereas the lowest were during autumn. This seasonal variation may be due to dietary patterns impacting Cu absorption (Burger et al., 2003) or attributed to the benthic sediments spreading pollution back to the water body because of the changes that occur inside the water as a result of the difference in temperature during two seasons (Fukue et al., 2006; Lazim, 2019). Cu in the aquatic ecosystem tends to accumulate in aquatic biota through food chains (Edward et al., 2013). Cu accumulates in the liver higher than in other organs due to its high ability to accumulate, which is attributed to its distinguished location within the circulatory system, thus receiving most elements through the blood (Hamza-Chaffai et al., 1997). Cu is an important element in many physiological

Table 4. Seasonal variation of Zinc levels (ppm) in liver tissues of studied birds.

| Species | Gender | Autumn | Winter |
|---|---|---|---|
| *A. platyrhynchos* | male | 0.718 | 1.63 |
| | female | 0.892 | 2 |
| *A. crecca* | male | 1.628 | 1.31 |
| | female | 0.806 | 2 |
| *A. acuta* | male | 0.402 | 1.36 |
| | female | 1.281 | 1.58 |
| FAO (1985) | | 2 | |

Table 5. Seasonal variation of Iron levels (ppm) in liver tissues of studied birds.

| Species | Gender | Autumn | Winter |
|---|---|---|---|
| *A. platyrhynchos* | male | 7.943 | 15.38 |
| | female | 4.937 | 15.85 |
| *A. crecca* | male | 6.323 | 7.12 |
| | female | 5.679 | 14.22 |
| *A. acuta* | male | 1.544 | 11.95 |
| | female | 9.146 | 12.62 |
| FAO (1985) | | 5 | |

processes, but exposure to high concentrations of Cu can cause damage to the endocrine gland, digestive, respiratory, and reproductive systems (Abdullah et al., 2015). Levels of Cu in all studied birds were more than the permissible limit (0.2 ppm), according to FAO (1985).

The concentrations of Zn in the liver tissues of *A. platyrhynchos*, *A. crecca*, and *A. acuta* are shown in Table 4 and this low accumulation may be due to its tendency to accumulate in bones, feathers, and eggshells than liver tissues (Stout and Trust, 2002). Zinc is an essential element in the formation of feathers, so will accumulate in large quantities in feathers (Deng et al., 2007). Birds regulate Zn in their tissues which are associated with fat contents, gender, weight, and age (Burger, 2007). The soil in Al-Hawizah marshes plays an important role in the formation of complexes with heavy elements because of having a high percentage of clay and silt, reducing the chance of birds being exposed to this element (Bradl, 2004). Zinc is essential, but its high levels cause renal toxicity (Kaur and Dhanju, 2013). Our results revealed that the concentration of Zn in all samples was less than the permissible limits (2 ppm) (FAO, 1985).

Table 5 shows Fe concentrations in the liver of *A. platyrhynchos*, *A. crecca* revealing seasonal variations. The higher levels may be due to the abundance of Iron in the earth's crust, while the lower due to the tendency of Fe to accumulate in aquatic organisms and sediment (Akbar and Khazali, 2012). Increasing levels of Fe in because of its high ability to accumulate Iron (Okati and Rezaee, 2013). The results showed that the Fe in most samples was more than the permissible limit (5 ppm) (FAO, 1985).

In the current study, seasonal variations in the accumulation of Pb, Cu, Zn, and Fe in the liver tissues of three studied bird species were observed showing their ability to accumulate heavy metals. The results also revealed that the levels of Cd, Cu, and Fe in the liver tissues arere higher than the permissible limit, whereas the levels of Zn and Pb were within the permissible limits.

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