Impact of Heavy Metals Pollution on The Biochemical Parameters and The Histopathological Picture of Two Resident Wild Birds at EL-Salam Canal Area, North Sinai, Egypt

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Abstract

Heavy metals have been recognized as strong biological poisons because of their persistent nature, toxicity, tendency to get accumulated in the tissues of living organisms and their biological magnification that may cause severe health problems to human and wildlife. The aim of this study was to assess the concentrations of some heavy metals (Pb, Cd, Cu, Zn and Mn) in pectoral muscle, liver and kidney of 2 resident wild bird species (Laughing dove and Squacco heron) belonging to 2 different Families; trapped nearby El-Salam Canal from village Baloza; the northwestern part of Sinai, Egypt as a bio-indicator for the heavy metal's pollution in the study area. Also, to assess the impact of this pollution on the wild birds through biochemical parameters and histopathological examination. The current study revealed that, kidney of laughing dove showed the highest concentration of all examined metals with a significant difference ($P<0.05$) with other tissues. Regarding to Squacco heron, kidney showed the highest concentration of Cd, Cu and Mn with a significant difference ($P<0.05$) with other tissues while liver showed the highest concentration of Pb and Zn with a significant difference ($P<0.05$) with other tissues. This study showed increasing in the serum level of ALT and AST in the examined birds, however serum level of ALP was elevated only in laughing dove. Serum Creatinine was increased in Squacco heron, while exhibits no change in laughing dove. Additionally, urea was increased in all examined birds.

Histo-pathological alterations were also recorded in the current study.

Key words: Resident wild birds, heavy metals, biochemical parameters, histopathology, El-Salam Canal

Introduction

Biological monitoring is thought to be satisfactory way to quantify pollution and bio-availability. According to ***Blus et al. (1993)*** birds which are located in higher trophic levels in the ecosystem, can provide information on the range of contamination in the whole food chains; and so may reflect pollutant hazards to humans. Recently, some researchers explored the potential of monitoring metal pollution using wild species such as pigeons (e.g. *Culumba livia*), house sparrow (*Passer domesticus*), doves, herons and egrets ***(Kim et al., 2010; Salah-Eldein et al., 2012; Manjula et al., 2015; and Mustafa et al. 2015).*** These species are ideal bio-indicators because they are common and widely distributed, have fast metabolic rates, high on the food-chain so that any change in the lower trophic level is signaled by their response also they exposed to a wide range of chemicals and environmental contaminants ***(Brait and Fihlo, 2011).*** Heavy metals are essential elements for organisms, but may be toxic with high levels, affecting behavioral features and productive functions ***(Dauwe et al., 2004),*** in addition to influencing the structural and functional integrity of an ecosystem ***(Zhang et al., 2018).*** Unlike other pollutants, heavy metals are non-biodegradable environmental contaminants that may accumulate in bird and animal tissues via the food chain, and eventually, it gets bio-accumulated in the body organs; especially liver and kidneys of animals who are the final consumers ***(Bilandžić et al., 2010)*** which could result in increased mortality rate among the bird and animal population inhabiting contaminated environment ***(Muralidharan et al., 2004).*** Therefore, measuring the accumulation of the heavy metals and their concentration in the physical environment is not enough tool to estimate the potential risks for the wildlife status, but it is important to assess the effect of such pollutants on different physiological functions. Biochemical parameters have been frequently used as a useful indicator of general condition for many species of vertebrates. However, these advantages are limited by lack of reference values ***(Sánchez-Guzmán et al., 2004).***

El-Salam Canal is one of the irrigation projects in Egypt that located at the northern Sinai aimed to reclaim an estimated 620,000 feddans of desert situated along the Mediterranean coast of Sinai by diverting considerable amounts of agriculture drainage water to newly reclaimed areas after blending with Nile water in a ratio about 1:1. According to ***Donia et al. (2017)*** great efforts are needed to protect the Canal from pollution and reduce environmental risk due to the over-usage of agricultural waste water. Also, regular evaluation of pollutants in the Canal is very important.

So, the aim of this study was to determine which species of the examined birds and which tissue is better to use as indicator for heavy metal pollution. Also, to assess the impact of the heavy metal pollution on resident wild birds from El Salam Canal area through biochemical parameters and histopathological examination.

Material and Method

Study area

El-Salam Canal is a canal built as a project for the development and horizontal agricultural expansion of Sinai; aimed to providing irrigation from the Nile in addition to other sources such as; rain, subterranean waters and some of the drainage systems water of Alsro Al-Asphal and Bahr Hadous (1:1 ratio), crosses the Suez Canal eastward to the deserts of north Sinai. This study considered an investigation in area of village Baloza which lies between latitude (30° 58' and 30° 59' N) and longitude (32° 25' and 32° 28' E) (the coordinates were determined using GPS); one of 24 villages belonging to Bir Al-Abd center; the northwestern part of Sinai, Egypt; irrigated with water through El-Salam Canal.

Sampling

Total of 36 resident wild birds were trapped using nets in non-migrating season (April, May and June) and they identified into two species; Laughing dove *(Spilopelia senegalensis*) (n=32) and Squacco heron *(Ardeola ralloides)* (n= 4). Just after trapping, blood samples (c.a. 1mL) were collected through wing vein using 3ml syringes in screw capped test tubes.

Pectoral muscles, livers and kidneys were dissected and divided into two parts; the first part was stored separately in polyethylene bags at −20◦C till preparation and digestion for heavy metals analysis, the second part was stored in clean and dry screw capped bottles and fixed in buffered formalin (10%) for histo-pathological examination.

Preparation of samples and analysis

Muscle, kidney and liver samples were digested according to ***Binkowski et al. (2013)*** by using highly concentrated nitric acid and perchloric acid (4:1) respectively. The samples were analysed using inductively coupled plasma (ICAP- 6500 Due) Thermo Scientific, England in Desert Research Center. To check for contamination, blank samples were prepared and analysed using the same procedure. All heavy metals concentration (µg/g) in tissues was estimated on a dry weight basis.

Plasma samples were analysed for biochemical parameters alanine amino-transferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), total protein (TP), Urea and Creatinine were determined photo-metrically using spectrophotometer; with appropriate kits following the provided instructions.

Muscle, liver and kidney samples were prepared for histo-pathological examination stained with haematoxylin, and counterstained with eosin. The slides were observed under compound light microscope at 100X and 400X magnifications.

The statistical analysis of data was carried out using SPSS 17.0 version (Chicago, USA) program. One-way ANOVA at a significance difference ($P<0.05$) was used according to ***Snedecor and Cochran (1989)*** to compare the level of heavy metals between different tissues and birds

This study was approved by the Scientific Research Ethics Committee at the Faculty of Veterinary Medicine, Suez Canal University (Ismailia, Egypt) (code # 2016004).

Results and Discussion

Metals Concentrations in tissues

Regarding to the concentration of heavy metals in all the examined tissues of laughing dove (as terrestrial seed eater birds) it is worth to mention that, the highest bio-accumulation of all the examined heavy metals was showed in the kidney with a significant difference ($P <0.05$) (Table, 1). This finding agrees with ***Almalki et al. (2019)*** who reported higher concentrations of heavy metals in kidney of the laughing dove in Riyadh Province (Saudi Arabia) than other tissues. Meanwhile, this finding is disagreed with ***Mansouri et al. (2015)*** who stated that, the liver showed the highest accumulation of examined metals than the other tissue in feral pigeon (*Columba livia*) from Iran. The kidney is an organ of detoxification in the body and this explains its high metal content. The accumulation of toxic heavy metals in the kidney may indicate chronic exposure ***(Janaydeh et al., 2017).***

Regarding to the concentration of heavy metals in all the examined tissues of Squacco heron (as aquatic piscivorous birds) in the current study (Table, 1); Liver showed the highest accumulation of both Pb and Mn with a significant difference ($P < 0.05$) with the other examined tissue while both liver and kidney showed highest accumulation of Zn with a significant difference with Muscle ($p < 0.05$). Cd and Cu showed the highest accumulation in kidney with A significant difference with the other examined tissue ($P < 0.05$). Higher concentration of Pb and Mn but lower in Cd and Zn recorded in the pectoral muscle of Squacco heron than that recorded in pectoral muscle of Black-crowned night herons from Korea ***(Kim et al., 2010).*** Also, the same result recorded in the liver of Squacco heron in comparison with Grey heron from Poland ***(Komosa et al., 2012).*** Meanwhile, lower concentration of Cd, Zn and Mn but higher in Cu recorded in the liver of Squacco heron than that in Gulls from different habitats in East Poland ***(Kitowski et al., 2017).***

In this study, the two examined species represent different food chains. Diet and feeding habits, storage and elimination, changes in nutritional requirements during breeding and molting duration, seasonal changes in diet, age and metabolism are the most important factors of variability in metal levels among species ***(Boncompagni et al., 2003 and Sinka-Karimi et al., 2015).***

Pb is a highly toxic, non-degradable heavy metal which cannot be regulated in the body and has been widely reported as indicator of metal pollution caused by anthropogenic source; including sewage disposal, fuel combustion, and vehicles industry ***(Markowski et al., 2013).*** After ingestion through foods Pb quickly transported from blood to target organs, mainly to the liver and kidney, where they remain complexed with metallothionein ***(Bilandžić et al., 2010).*** Hepatic Pb level in waterfowl was suggested by ***Pain (1996):*** (7.5–23 mg/Kg d.w.) for subclinical poisoning, (23–57 mg/Kg d.w.) for clinical poisoning. According to ***Pain (1996)***; Laughing dove and Squacco heron in the current study recorded hepatic Pb concentration indicating clinical poisoning. Levels exceeding a threshold concentration have been related to impaired eggshell structure ***(Eeva and Lehikoinen, 1995)*** moreover, it can affect the developing of brain and nervous system also can cause; reproductive problems, stunned growth, impaired thermoregulation and locomotion and also decreased survival of nestlings ***(Burger, 2000)*** even lower Pb concentrations can induce severe histo-pathological damages and necrosis associated with reduced enzymatic functionality and reduced ability to sustain necessary metabolic function ***(Kou et al., 2020).*** In the current study, the highest mean concentration of Pb is observed in the kidney of laughing dove.

Cadmium is a non-essential element enters the environment naturally from erosion in rocks and surface deposits of minerals containing this element and from anthropogenic sources such as consistent application of pesticides used in crop field ***(Parmeggiani, 1983).*** Generally, Cd is accumulated in a bird's body through the food chain and inside the body it is first accumulated in liver tissues and delivered to several organs but generally it is the highest in kidney tissues even higher than liver tissues where it is thought that metallothionein makes the metal harmless ***(Lee, 1996);*** this is in agreement with our findings as in all the examined birds, Cd tend to concentrate in kidneys in concentration higher than livers. Cadmium is toxic at extremely low levels and considered as carcinogenic metal and also, linked to kidney damage, testicular damage, oviduct malfunctions and egg deformation ***(Burger, 2008).*** Also, higher concentrations of Cd may affect the metabolic processes through replacement of essential elements at the active sites of biologically important molecules, thus indirectly inducing nutritious deficiencies ***(Malik, and Zeb 2009).*** The highest mean concentration of Cd in the current study is observed in the kidney of laughing dove.

The high concentrations of Cu may be due to the extensive use of bactericides and fungicides in agriculture ***(Canova et al., 2020).*** Although Cu is considered as an essential element for various physiological functions and structural component of numerous metallo-enzymes, its uptake in excess quantity is related to harmful effects including ocular damage, respiratory malfunctions and certain disorders in gastrointestinal, hepatic, reproductive, hematological and endocrine systems also, growth irregularity and carcinogenesis are reported ***(Stern, 2010).*** The highest mean concentration of Cu in this study is recorded in the kidney of laughing dove.

Zn may be a secondary impact of farming activity where herbicides and fungicides with zinc are used ***(Binkowski et al., 2013).*** Increased dietary intake of Zn does not usually affect liver concentrations in birds because normally Zn is successfully regulated unless homeostatic mechanisms fail under exposure to extremely high levels ***(Sileo et al., 2003).*** Hepatic Zn concentration level of 525mg/kg d.w. can be regarded as indicative of poisoning ***(Taggart et al., 2009).*** None of the examined birds in the current study recorded that level. In this study, the highest mean concentration of Zn is recorded in the kidney of laughing dove.

Mn is involved in several biochemical reactions in living organism, and acts as an essential micronutrient; however, contamination in food chain generally occurs through anthropogenic sources such as urban waste dumps, municipal wastewater discharges, sewage sludge and also emissions from the combustion of fuel additives (MMT) as well as agriculture practices because inorganic and organo-metallic Mn compounds are used as fertilizers, and fungicides ***(Abdullah et al., 2015).*** In general, Mn are alkaline metal elements found to be accumulated higher in terrestrial birds than in aquatic ones ***(Horai et al., 2007)***. This agrees with the present results as laughing dove recorded higher concentration of Mn in all the examined tissues than that in Squacco heron. Toxicity caused by Mn can produce anemia, hemorrhage, stunted growth, limb twisting, and behavioral disorders ***(ATSDR, 2012).*** The highest mean concentration of Mn in the present study is observed in the kidney of Laughing dove.

In the present study, the most impacted bird species due to heavy metal contamination in the studied site is laughing dove (*Spilopelia senegalensis*). It is intermediate level consumer whose diet consists of seeds picked up from soil which may contribute to high Pb hepatic and renal concentrations ***(Carpene et al., 2006).*** Also, the rest of soil pollutants may easily get into the bird´s body ***(Sundaramahalingam et al., 2016).*** Birds living in terrestrial ecosystems contained more heavy metals than aquatic birds because of high metabolic rate of the small birds. This may mean that small species are more susceptible than larger one ***(Lebedeva, 1999).*** Also, the kidney considers the most tissue burdens the highest concentration of all the examined heavy metals in this study.

Biochemical parameter

According to ***Sant'Ana et al. (2005)*** and ***Butt et al. (2018),*** ALT recorded in the current study showed high activity in Laughing dove (Table 2). Comparing the results of biochemical parameters in the current study with that of feral pigeon (*Columba livia*) reported by ***Harr (2002)*** who reviewed the reference values for some biochemical parameters in selected companion avian species, the current study showed increasing in the activity of AST and in the concentration of urea while, normal concentrations of Total protein and Creatinine were recorded in laughing dove. Comparing the results in the current study with that of ***Almalki et al. (2019)*** who studied laughing dove (*Spilopelia senegalensis)* collected from a gold mining site, ALP in the current study showed increasing activity in Laughing dove.

Increasing the activity of ALT in laughing dove recorded in the current study was in the same line as that recorded in Japanese quail treated with high levels of CdCl2 indicating sever liver damage ***(Sant'Ana et al., 2005; Karimi et al., 2017; and Butt et al., 2018).*** The same finding was observed in poultry treated with Pb and in poultry reared in industrial area ***(Hamidipour et al., 2016; and Kar et al., 2018).*** Concerning the high activity of ALP in this study, the results agreed with that obtained by ***Karimi et al., (2017), Kar et al., (2018) and Almalki et al. (2019)*** but disagreed with ***Elezaj et al. (2011) and Hamidipour et al. (2016).*** In this study**,** Total protein showed normal concentrations in laughing dove. This result is agreed with ***Sant'Ana et al. (2005), Elezaj et al. (2011), Hamidipour et al. (2016), and Butt et al. (2018)*** but disagreed with ***Karimi et al., (2017*).** In this study, urea showed high level of concentration in laughing dove; similar result recorded by ***Karimi et al., (2017), Butt et al., (2018) and Almalki et al., (2019).*** The current study also recorded normal level of creatinine in laughing dove; this agreed with **Sant'Ana *et al. (2005) and disagreement with Hamidipour et al. (2016), Karimi et al. (2017), Butt et al. (2018), and Almalki et al. (2019).***

Regarding to activity of ALT enzyme in squacco heron in the current study (Table, 2), the same activity is recorded by ***Elarabany and El-Batrawy (2019)*** in cattle egret from industrial area but was higher than that recorded in northern shoveler and Eurasian teal obtained by ***Elarabany (2018).*** Meanwhile, the current study showed increase in the activity of AST in squacco heron in comparison to the results of northern shoveler and Eurasian teal stated by ***Elarabany (2018)*** and cattle egret from industrial and rural area obtained by ***Elarabany and El-Batrawy (2019).*** The results of ALP activity in squacco heron in the current study are lower than that of northern shoveler and Eurasian teal recorded by ***Elarabany (2018).*** Concerning the concentration of

Total protein, the result obtained in the current study is agreed with that of northern shoveler and Eurasian teal recorded by ***Elarabany (2018)*** but disagreed with that of cattle egret from industrial area ***(Elarabany and El-Batrawy, 2019).*** Regarding to the urea level in the squacco heron in the current study, the same level is obtained in northern shoveler and Eurasian teal ***(Elarabany, 2018)*** while lower level is recorded in cattle egret from industrial and rural area ***(Elarabany and El-Batrawy, 2019).*** Creatinine concentration in squacco heron in the current study showed slight increase than that obtained from northern shoveler and Eurasian teal ***(Elarabany, 2018)*** and that recorded for cattle egret from industrial and rural area ***(Elarabany and El-Batrawy, 2019).***

Increasing serum activity of ALT, AST and urea concentration in the examined birds may be indicative to sever liver and kidney damage with hepatic and renal function changes. The same degenerative picture is noticed as a result of long-term exposure of Japanese quail to CdCl2 (100 ppm) ***(Sant'Ana et al., 2005 and Karimi et al., 2017)*** and in poultry exposed to lead acetate ***(Hamidipour et al., 2016).*** Increased activity of transaminases and ALP (as observed in Laughing dove in the current study) is an indicator of degenerative changes in organs and tissues such as the liver ***(Kaneko, 1980).*** Reduced serum protein level may be related to increase the activity of transaminases that may lead to failure to reproduce protein ***(Hamidipour et al., 2016)***. Also, it is may be due to higher energy costs to create homeostasis, tissue repair and detoxification ***(Neff, 1985).*** Creatinine level is naturally constant in normal status and its increase in blood (as in case of squacco heron in the current study) is an indicator of kidney dysfunction that may be caused by the toxic impact of some elements such as Pb and Cd on kidney function.

Histopathology

In the current study, histo-pathological examination of the examined bird's breast muscles of laughing dove (Figure 1) revealed dilated blood vessel and hemorrhage in between the muscle bundles, this agrees with that recorded by ***Akter et al. (2019)*** when investigated the toxic effects of Cd exposure in commercial quail. Moreover, histo-pathological examination of the livers of the examined birds (Figure 2,4) showed vacuolated hepatocytes with peripheral nucleous, congestion in the hepato-portal blood vessel, central veins and blood sinusoids and focal areas of mononuclear cells infiltration, this is in agreement with that recorded in common moorhens (*Gallinula chloropus*) reported by ***Salamat et al. (2014),*** in commercial quail ***(Akter et al., 2019)*** and in the liver of laughing dove (*S. senegalensis)* from mining site reported by ***Almalki et al. (2019).*** Also, histo-pathological examination of the examined bird's kidney (Figure 3,5) revealed dilatation and congestion in the interstitial blood vessels, focal leucocytic cells infiltration and focal areas of renal tubules necrosis, this is in agreement with that recorded in kidneys of mallard and coot from Poland ***(Binkowski et al., 2013),*** in kidneys of Japanese quails caused by dietary cadmium ***(Karimi et al., 2016; Butt et al., 2018)*** and also with the results recorded in commercial quails reported by ***Akter et al. (2019).***

The results obtained from histo-pathological examination support the biochemical findings. The tissue injury in the examined birds is directly connected to the increase in the heavy metal concentrations. The liver and kidney represent the main site for Pb and Cd deposition within the body and upon entering the body, they are transported to the liver by albumin and forms complexes with metallothionine, these complexes are transferred into the circulation and then accumulate in the kidney. This could explain the observed hepatic and renal tissue injury in the examined birds.

Table 1. *Comparison of heavy metals concentration (µg/g) within different tissues of each birds.*

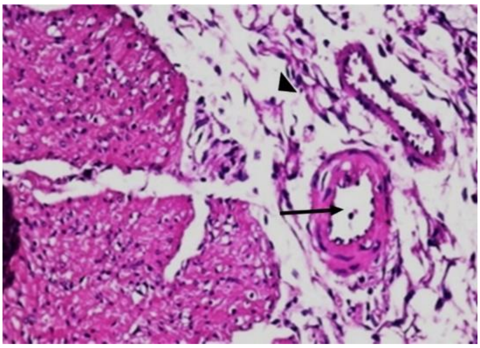
		Muscle	Liver	Kidney	P Value
Laughing dove	Pb	13.83^{a}±0.9	33.54^{b}±1.3	97.23^{c}±5.7	0.001
	Cd	3.73^{a}±0.23	4.91^{a}±0.2	13.7^{b}±0.8	0.000
	Cu	20.56^{a}±1.7	35.54^{b}±2.9	98.58^{c}±5.9	0.015
	Zn	28.4^{a}±1.5	90.59^{b}±5.5	179.17^{c}±7.7	0.001
	Mn	45.36^{a}±4.1	85.04^{b}±5.5	319.87^{c}±18.6	0.027
Squacco heron	Pb	4.96^{a}±0.02	30.32^{b}±0.2	23.94^{c}±0.02	0.000
	Cd	0.56^{a}±0.04	0.17^{a}±0.008	3.51^{b}±0.1	0.000
	Cu	18.68^{a}±1.3	19.62^{a}±0.8	32.29^{b}±1.8	0.000
	Zn	26.34^{a}±1.06	66.3^{b}±1.6	63.73^{b}±2.3	0.000
	Mn	10.97^{a}±1.08	18.47^{a}±1.2	69.52^{b}±4.9	0.003

Data are presented as (Mean±SE). Within the same row, means carrying different superscript are significant at ($P<0.05$)

Table 2: *Biochemical parameters of laughing dove and squacco heron.*

Plasma Parameters	Laughing dove	Squacco heron
ALT (U/L)	27.43±2.6	58.43±0.89
AST (U/L)	283.51±26.8	858.23±1.29
ALP (U/L)	548.17±50.04	83.54±0.33
Total Protein (mg/dl)	3.59±0.14	5.3±0.40
Urea (mg/dl)	7.55±0.55	21.03±0.038
Creatinine (mg/dl)	0.24±0.02	0.97±0.011

Data represented in means ±SE.



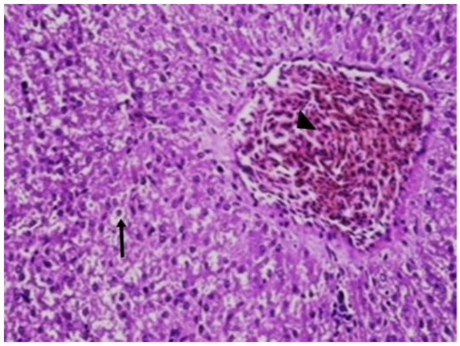
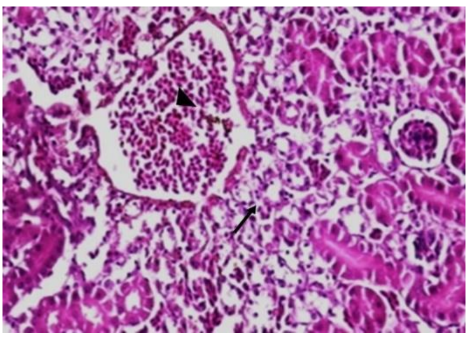


Figure 1: Dove's muscle showing edema in the interstitial tissue (arrow head) and dilatation in blood vessels (arrows) (H&E X 400).

Figure 2: Dove's liver showing moderately vacuolated hepatocytes (arrows) and congestion in the hepato-portal blood vessel (arrow head) (H&E X 400).



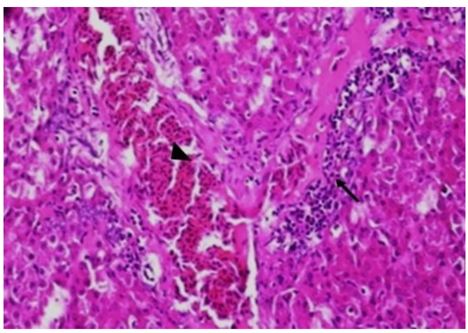


Figure 3: Dove's kidney showing dilatation and congestion in the interstitial blood vessel (arrow head), and large focal area of renal tubules necrosis (arrow) (H&E X 400).

Figure 4: Heron's liver showing congestion in the hepatoportal blood vessel (arrow head), and mononuclear cells infiltration in the portal area (arrow) (H&E X 400).

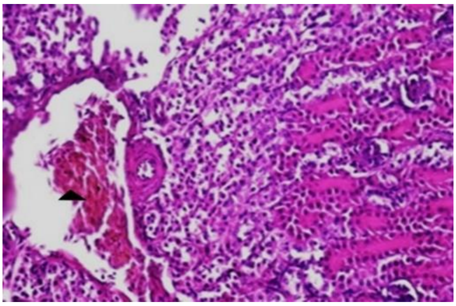


Figure 5: Heron's kidney showing dilatation and congestion in the interstitial blood vessel (arrow head) (H&E X 400).

Conclusion

The concentration of heavy metals in tissues of the examined birds in this study reflects the degree of pollution of El-Salam Canal water; this pollution may be due to continuous discharge of different pollutants as a result of mixing drainage water with the Nile water. Kidney of laughing dove can be considered the best indicator for heavy metals pollution than the other examined tissue. Kidney of Squacco heron can be used as a bio-indicator for Cd, Cu and Mn pollution while liver of Squacco heron can be used as bio-indicator for Pb and Zn pollution. Generally laughing dove is better indicator than Squacco heron for the heavy metal's pollution. The biochemical tests and histopathological examination done in the present study, revealed changes in the biochemical measurements and cellular damages; this can be used as a useful tool to assess the health condition of the birds and provides positive correlation with different environmental burdens. So, considering the high concentrations of heavy metals in tissues of the examined birds in this study, we can say that there is a danger for biota.

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تأثير التلوث بالمعادن الثقيلة على المؤشرات البيوكيميائية والصورة النسيجية المرضية لأثنين من الطيور البرية المقيمة بمنطة ترعة السلام - شمال سيناء ، مصر

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الملخص العربى

تعتبر المعادن الثقيلة سموم بيولوجية قوية و ذلك لقدرتها على البقاء في الطبيعة لفترات طويلة وقابليتها للتراكم في انسجة الكائنات الحية و تضخيمها البيولوجي الذي قد يسبب مشاكل صحية خطيرة للإنسان والحياة البرية. في هذه الدراسة، تم قياس تركيزات 5 معادن ثقيلة (الرصاص، الكادميوم، النحاس، الزنك، المنجنيز) في العضلات الصدرية والكبد والكُلى لنوعين من الطيور البرية المقيمة (اليمام البلدى و الواق الأبيض) ينتمون لعائلتان مختلفتان. وقد تم تجميع الطيورفي غير موسم الهجرة؛ من قرية بالوظة بمنطقة ترعة السلام- بشمال سيناء. وقد أظهرت النتائج أن كلى اليمام البلدي تعتبر افضل نسيج ممكن استخدامه كمؤشر حيوي للمعادن الثقيلة محل الدراسة و بفارق معنوي عن الانسجة الاخري. كذلك يعتبركلى طائر الواق الابيض مؤشر حيوي جيد لكل الكادميوم والنحاس والمنجنيز بينما يعتبر كبد الواق الابيض مؤشر جيد للرصاص والزنك وبفارق معنوي عن الانسجة الاخرى. وبشكل عام يعتبر اليمام البلدي مؤشر حيوي جيد للتلوث بالمعادت الثقيلة مل الدراسة. أظهرت نتائج الدراسة الحالية زيادة في نشاط إنزيم ALT و AST في الطيور المفحوصة و زيادة في نشاط أنزيم ALP فى اليمام البلدى، بينما تم تسجيل التركيز الطبيعي للبروتين الكلي في الطيور التي تم فحصها. كما تم تسجيل التركيز الطبيعي من الكرياتينين في اليمام البلدى ولكن تم تسجيل تركيزات عالية منه في الواق الأبيض. في حين أظهرت النتائج زيادة في تركيز اليوريا فى دم الطيور المفحوصة. كما كشف الفحص المرضي النسيجي الذى تم إجراؤه في هذه الدراسة عن أضرار خلوية.