57 *Egypt. J. Vet. Sci.* **Vol. 56, (Special issue),** pp. 649-654 (2025)

Egyptian Journal of Veterinary Sciences

https://ejvs.journals.ekb.eg/

Assessment of Some Heavy Metal Residues in Fish Muscles Collected From Kitchiner Drain and Burullus Lake in Kafrelsheikh Governorate, Egypt.

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Abstract

The current study was conducted to investigate the bioaccumulation of lead (Pb), cadmium (Cd),iron (Fe) and chromium (Cr) in the muscle tissues of Tilapia, Catfish, Sea bream and Sea bass fishes collected in Autumn (2023) from Kitchener Drain and Burullus Lake, Kafrelsheikh Governorate, Egypt. For this purpose, a total of 120 muscle samples, 60 of Tilapia and Catfish (30, each) from three different areas in Kitchener Drain in the Nile river (10, each). And 60 of Sea bream and Sea bass (30, each) from three different areas in Burullus Lake (10, each) were analyzed for the heavy metals mentioned above in order to assess the health risk. Our results revealed that Fe and Cr levels in all analyzed fish samples from different areas were less than the maximum permissible limit. While Pb and Cd residues in all analyzed fish samples from all different areas were higher than the maximum permissible limit. Results showed that the highest mean levels of all tested heavy metals were recorded in southern area of Kitchener Drain and eastern area of Burullus Lake with respect to all metals. The dangerous residues for human health were shown in the following order with referring to their heights above the maximum permissible limits: Cd>Pb> Fe> Cr. In conclusion, Kitchener Drain and Burullus Lake are considered a hazardous source for lead and cadmium in fish muscles.

Keywords: Iron, Lead, Cadmium, Chromium.

Introduction

A significant supply of drinking water is the water found in lakes, rivers and streams. Pollution of these supplies is therefore one of the most important environmental issues of our day. Both natural and synthetic inorganic compounds are constantly entering the aquatic ecosystem and pose a significant risk due to their toxicity, long-term persistence, bioaccumulation, and food chain bio magnifications [1].

Fish are a source of many toxicants, such as heavy metals, which degrade and pollute ecosystems, aquatic life. These issues with water quality are caused by industrialization, agricultural output, and urban life. Toxic element pollution of fish affects health and the ecosystem globally [2].

Because lead (Pb), cadmium (Cd), iron (Fe), and chromium (Cr) are deposited in aquatic environments and build up in fish tissue, they are toxic and disrupt cellular processes such as growth, differentiation, proliferation, DNA damage-repairing mechanisms, and apoptosis [3,4,5,6].

All bodily organs are toxically affected by lead as an environmental contaminant [7, 8]. Lead is absorbed through the skin, mostly through the digestive and respiratory systems [9]. Because lead disrupts the equilibrium of the oxidant–antioxidant systems and inflammatory responses in several organs, exposure to lead causes neurological, respiratory, urinary, and cardiovascular diseases through immunomodulation, oxidative and inflammatory pathways [10,11,12].

The International Agency for Research on Cancer (IARC) had categorized cadmium as carcinogenic agent [13,14]. Degenerative bone disease, kidney failure, and lung and gastrointestinal disorders were all discovered by cadmium exposure [15, 16].

Iron damages the liver, pancreas, kidneys, and

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(Received 11 April 2025, accepted 10 July 2025)
DOI: 10.21608/ejvs.2025.374047.2775

other important organs, leading to hemochromatosis and diabetic mellitus, which are thought to be the silent killers [17, 18, 19].

Chromium leads to liver injury and necrosis [20, 21], gastric, kidney, urogenital, bone, blood, nasal and lung cancer [22], genotoxicity, oxidative stress and death [23, 24].

This study was conducted to evaluate the levels of lead, cadmium, iron, and chromium in freshwater fish (tilapia and catfish) and marine water fish (sea bream and sea bass) in the Kafrelsheikh Governorate of Egypt.

Material and Methods

Collection of samples

In all, 120 fish samples were gathered from 6 distinct locations: 60 tilapia and catfish (30 samples each) and 60 sea bream and sea bass (30 samples each). Within the boundaries of Kafrelsheikh Governorate, freshwater fish were collected from the Kitchener Drain's south, middle, and north regions of the Nile River. The East, Middle, and West regions of Egypt's Burullus Lake were used to gather marine water fish. All samples were taken between October and November 2023, and their weights were 350±50, 800±100, 450±50, and 650±50 grams for tilapia, catfish, sea bream and sea bass, respectively (Figure 1).

Preparation of samples

The samples were made in compliance with [25]. After being thoroughly cleaned with deionized water, the containers were allowed to dry in an incubator away from any potential sources of dust or contamination.

One gram was used to represent each fish sample (musculature). After being transferred to a sterile screw-capped bottle, the tissue samples were digested using a 10 ml solution of nitric, sulfuric, and perchloric acid (8:1:1). After four hours of initial digestion at room temperature, the temperature was raised to 75 degrees Celsius until the digestion was completed, after which it was heated for an hour at 40 to 45 degrees Celsius in a water bath. The digest was allowed to cool at room temperature before being filtered through 0.45u Whitman filter paper and diluted with 20ml of deionized water. Each sample's clear filtrate was stored in a refrigerator for analysis.

Quantitative determination

An atomic absorption spectrophotometer (Model Thermo Electron Corporation, S. Series AA Spectrometer with Gravities furnace, UK) was used to determine the presence of heavy metals. In the Toxicology Unit of Central Laboratory, Kafrelsheikh University, Egypt. Concentrations were reported as ppm .The following formula was used to determine the metal residual values, which were taken straight from the AAS digital scale:

Element (ppm) = R×D/W, where R is the element concentration reading in ppm from the AAS digital scale. D = Prepared sample dilution. W stands for sample weight.

Statistical analysis

All data presented as mean ± SD were subjected to analysis of variance (ANOVA) and means were compared to significance by Student-Newman Keuls at the probability of 0.05 [26].

Results and Discussion

Lead concentrations in freshwater fish (tilapia and catfish) varied significantly throughout the three Kitchener Drain study regions (south>middle>north) as follows: 2.443±0.060, 1.766±0.044, 0.7740±0.027, and 3.584±0.072, 2.568±0.074, 1.501±0.092 ppm, respectively (Table 1).

Lead concentrations in marine water fish (sea bream and sea bass) varied significantly between the three Burullus Lake study locations (east>west>middle) as follows: 0.785±0.030, 0.550±0.018, 0.332±0.015, and 1.195±0.024, 0.786±0.018, 0.539±0.028 ppm, respectively (Table 2).

Cadmium concentrations in freshwater fish (tilapia and catfish) varied significantly between the three Kitchener Drain study regions (south>middle>north) as follows: 1.556±0.056, 0.820±0.039, 0.425±0.018, and 2.599±0.063, 1.717±0.067, 1.143±0.045 ppm, respectively (Table 1).

The concentrations of cadmium in marine water fish (sea bream and sea bass) varied significantly throughout the three locations of Burullus Lake that were studied (east>west>middle) and were 0.190±0.007, 0.145±0.011, 0.105±0.102, and 0.487±0.001, 0.197±0.007, 0.143±0.101 ppm, respectively (Table 2).

Iron concentrations in freshwater fish (tilapia and catfish) varied significantly between the three Kitchener Drain study locations (south>middle>north) as follows: 21.48±0.674, 14.22±0.599, 11.03±0.393, and 27.23±0.638, 18.48±0.748, 15.86±0.496 ppm, respectively (Table 1).

Iron concentrations in marine water fish (sea bream and sea bass) varied significantly between the three locations of Burullus Lake that were studied (east>west>middle) as follows: 20.65±0.924, 11.71±0.474, 6.902±0.336, and 23.89±0.801, 14.66±0.432, 11.53±0.244 ppm, respectively (Table 2).

Chromium concentrations in freshwater fish (tilapia and catfish) varied significantly throughout the three Kitchener Drain study regions (south>middle>north) as follows: 1.191±0.016, 0.796±0.015, 0.507±0.008 and 2.442±0.096, 1.618±0.036, 0.849±0.032 ppm, respectively (Table 1).

The concentrations of chromium in marine water fish (sea bream and sea bass) varied significantly throughout the three locations of Burullus Lake that were studied (east>west>middle) and were 0.410±0.019, 0.266±0.012, 0.146±0.004, and 0.627±0.016, 0.398±0.016, 0.206±0.012 ppm, respectively (Table 2).

Our results revealed that Iron and Chromium levels in all tested fish samples at all different areas were less than the maximum permissible limits in fish muscle (30 ppm) for iron [27]and (8 ppm) for chromium [28].

Our results revealed that Lead and Cadmium residues in all tested fish samples in all different areas where higher than the maximum permissible limits in fish muscle (0.5ppm) for lead and (0.05 ppm) for cadmium [29].

The increasing heavy metal concentrations in fish muscles within the Kitchener Drain and Burullus Lake can be attributed to multiple interconnected factors as:

Industrial Discharges

Near the Kitchener Drain in Mahalla, Egypt, factories and other industrial sites frequently release untreated or insufficiently treated effluent that contains heavy metals like lead and cadmium. The concentration of heavy metals in Kitchener Drain was declining from downstream to upstream, which was consistent with our findings [30]. These metals build up in the sediment and water before eventually making their way into the aquatic food chain.

Agricultural Runoff

Fertilizers, insecticides, and herbicides used in nearby agricultural operations frequently include trace metals. These pollutants are carried into the drain by runoff from farmlands during irrigation or rains, municipal wastewater. The heavy metal burden is influenced by urban runoff and untreated or partially treated domestic sewage. Pollutants, particularly metal-containing household chemicals, are directly released because of inadequate wastewater treatment [31].

Bioaccumulation and Bio-magnification

Heavy metals are non-biodegradable and tend to accumulate in the tissues of organisms. Fish take in these metals directly from the water or through their diet e.g., consuming contaminated algae or smaller organisms [32].

Fishing Practices

Due to using of fishing gear and materials, containing heavy metals can also contribute to contamination over time. Atmospheric Deposition, airborne pollutants from industrial emissions and vehicular traffic and fishing ships can settle into the lake, increasing heavy metal concentrations, Urban and Coastal Development [33].

Our results revealed that the concentration of heavy metal residues in the east area of Burullus Lake were higher than other tested areas, this may be due to the additional heavy metals come from Kitchener Drain in this area.

Our results showed that lead and cadmium levels exceeded the maximum permissible limit in all tested areas in all fish spp. These results come in agreement with other researches as [34] who mentioned that cadmium and lead residues in Catfish in Kitchener drain were above the international permissible limits in fish muscle (0.55 ± 0.19and14.10 ± 4.93 ppm) respectively.

Lead and cadmium residues in mullet fish collected from Burullus Lake were 0.322 and 0.093 ppm respectively, which was higher than the maximum permissible limit [35].

Cadmium and lead residues in tilapia and catfish muscles in Kitchener drain were 0.19±0.0002 and 24.98±0.031 for tilapia and 0.28±0.0001 and 19.89±0.012 ppm for catfish respectively, which were above the international permissible limits [36].

Cadmium and lead residues in Catfish in Kitchener drain were above the international permissible limits in fish muscle (1.54±0.99 and 11.16±2.4 ppm) respectively [37].

Lead residue in tilapia collected from Burullus Lake was 0.56 ppm, which was higher than the maximum permissible limit [38].

Lead and cadmium residues in tilapia and catfish collected from Burullus Lake were 0.56, 0.23 for tilapia and 0.54, 0.33 for catfish respectively, which were higher than the maximum permissible limit [39].

Conclusion and recommendation

Kitchener Drain and Burullus Lake are considered a hazardous source for lead and cadmium in fish muscles. There is no doubt that the environment, location, industrial pollution, species, have a major role in heavy metal deposition in fish so all must be monitored to control heavy metal toxicity in fish. There is a risk of fish consumption originating from Kitchener Drain and Burullus Lake on public health at Kafrelsheikh governorate. A care must be taken considering some people regularly consume large quantities of fish as heavy metals especially Pb and Cd have the ability to do toxicity even at a low concentration.

Acknowledgments

The authors would like to thank all staff members of the Faculty of Veterinary Medicine, Kafr elsheikh University, Egypt, for their collaboration during this study.

Funding statement

This study did not receive any funding support.

Declaration of Conflict of Interest

No conflict of interest

Ethical of approval

All techniques employed in this study were directed in compliance with applicable standards and regulations.

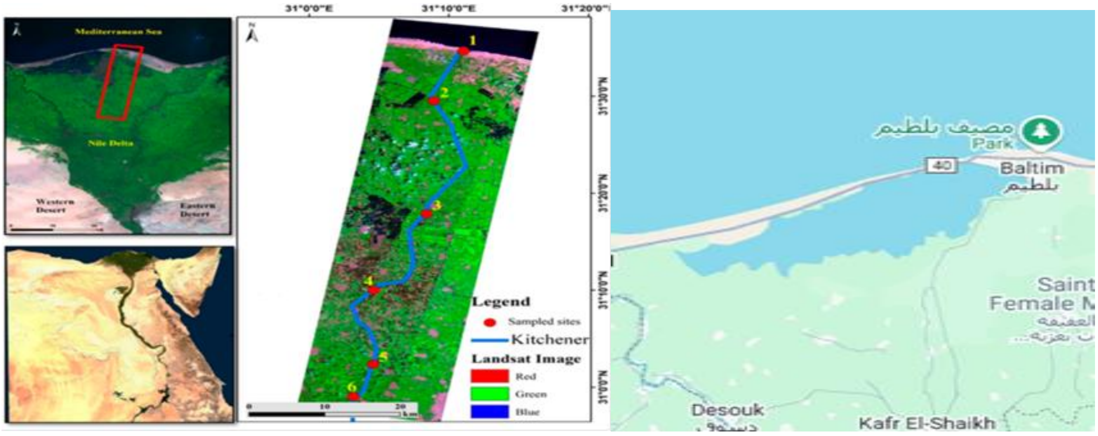

Fig. 1. Kitchener Drain and Burullus Lake of Egypt (study area).

TABLE 1. Concentrations of Pb, Cd, Fe and Cr ppm in the Muscle of Tilapia and Catfish Collected from Kitchener Drain, Egypt

Fish Sp.	Area of Kitchener Drain	Pb	Cd	Fe	Cr
Tilapia	South	2.443± 0.06011^{a}	1.556±0.05612^{a}	21.48±0.6745^{Ba}	1.191±0.01663^{Ba}
	Middle	1.766±0.04492^{b}	0.8200±0.03947^{b}	14.22±0.5996^{Bb}	0.7960±0.01536^{b}
	North	0.7740±0.02725^{c}	0.4250±0.01893^{c}	11.03±0.3934^{Bc}	0.5070±0.008825^{c}
Cat fish	South	3.584±0.07221^{a}	2.599±0.06390^{a}	27.23±0.6389^{Aa}	2.442±0.09633^{Aa}
	Middle	2.568±0.07482^{b}	1.717±0.06730^{ab}	18.48±0.7483^{Ab}	1.618±0.03608^{b}
	North	1.501±0.09283^{c}	1.143±0.04583^{bc}	15.86±0.4960Ac	0.8490±0.03202^{c}

TABLE 2. Concentrations of Pb, Cd, Fe and Cr ppm in the Muscle of Sea bream and Sea bass Collected from Burullus Lake, Egypt

Fish Sp.	Area of Burullus Lake	Pb	Cd	Fe	Cr
Sea Bream	East	0.7850±0.03023a	0.1900±0.007a	20.65±0.9249^{Ba}	0.4100±0.01994^{a}
	Middle	0.3320±0.01541^{c}	0.1050±0.102^{c}	6.902±0.3361^{Bc}	0.1460±0.004761^{c}
	West	0.5500±0.01897^{b}	0.1450±0.011^{b}	11.71±0.4740^{Bb}	0.2660±0.01204^{b}
Sea Bass	East	1.195±0.02464^{a}	0.4870±0.0015^{a}	23.89±0.8018^{Aa}	0.6270±0.01680^{a}
	Middle	0.5391±0.02811^{c}	0.1436±0.1015^{c}	11.53±0.2445^{Ac}	0.2064±0.01201^{c}
	West	0.7864±0.01894^{b}	0.1973±0.0076^{b}	14.66±0.4325^{Ab}	0.3982±0.01661^{b}

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تقييم بعض بقايا المعادن الثقيلة في عضلات الأسماك في بحيرة البرلس ومصرف كيتشنر في محافظة كفر الشيخ، مصر

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الملخص

أجريت هذه الدراسة لتقييم التراكم الحيوي لبعض العناصر الثقيلة مثل الرصاص (Pb) والكادميوم (Cd) والحديد (Fe) والكروم (Cr) في الأنسجة العضلية لأسماك البلطي والقراميط والدنيس والاروس التي تم جمعها في خريف عام (2023 م) من مصرف كيتشنر وبحيرة البرلس، محافظة كفر الشيخ، مصر. ولهذا الغرض، تم تحليل إجمالي 120 عينة عضلية، 60 من البلطي والقراميط (30 لكل منهما) من ثلاث مناطق مختلفة من مصرف كيتشنر في نهر النيل (10 لكل منهما) و60 من الدنيس والاروس (30 لكل منهما) من ثلاث مناطق مختلفة في بحيرة البرلس (10 لكل منهما) لتقييم مخاطرها على الصحة العامه. وقد كشفت نتائجنا عن أن مستويات الحديد والكروم في جميع عينات الأسماك التي تم تحليلها من المناطق المختلفة كانت أقل من الحد الأقصى المسموح به في عضلات الأسماك للحديد والكروم. في حين كانت بقايا الرصاص والكادميوم في جميع عينات الأسماك التي تم تحليلها من المناطق المختلفة أعلى من الحد الأقصى المسموح به في عضلات الأسماك للرصاص والكادميوم. أظهرت النتائج أن أعلى مستويات المتوسط لجميع المعادن الثقيلة المختبرة تم رصدها في المنطقة الشرقية من بحيرة البرلس والمنطقة الجنوبية من مصرف كيتشنر فيما يتعلق بجميع المعادن. كما أوضحت النتائج أن أخطر البقايا على صحة الإنسان بالترتيب التالي مع الإشارة إلى الحد المسموح به: Cd> Pb> Fe> Cr. وفي الختام، تعتبر بحيرة البرلس ومصرف كيتشنر مصدرًا خطيرًا للرصاص والكادميوم في عضلات الأسماك.

الكلمات الدالة: الحديد، الرصاص، الكادميوم، الكروم.