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(RESEARCH ARTICLE)

Pollution induced change of liver of *Oreochromis niloticus*: metals accumulation and histopathological response

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Abstract

The present study, pointed to assess heavy metal accumulation like Aluminum (Al), Cadmium (Cd), Chrome (Cr), Cobalt(Co), Copper(Cu), Iron(Fe), Lead (Pb), Manganese(Mn), Nickel(Ni), Selenium(Se) and Zinc(Zn) in water, sediments and liver of *Oreochromis niloticus*, which collected from sewage water in El-kharja, New Valley, Egypt using inductively coupled plasma mass spectrometry (ICP-MS). Also, the histopathological changes of liver of *Oreochromis niloticus* were reported. These histopathological changes were detected using different staining types as a pollution biomarker. Iron showed the highest accumulation level in water (9.06±0.86 ppm), sediments (175.1±20.8 ppm) and liver (158.17±38.59 ppm), followed by Al> Mn> Ni> Zn> Pb> Cr> Se> Cu> Co> Cd. However, these elements showed Fe> Al> Ni> Mn> Cr> Cu> Zn> Pb> Cd> Se> Co accumulation trend in sediments. In liver these metals showed Fe> Se>Al> Zn>Mn> Cu>Ni> Cr> Pb> Co> Cd trend. Histopathological examination of fish liver showed signs of progressive alterations such as disorganization of architecture of liver cells, hydropic degeneration and vacuolation of hepatocytes. Also, dilation and congestion in blood sinusoids, hypertrophic and increase in number of küpffer cells were chronicled. Sever deposition of hemosiderin pigments were reported while necrosis with pyknotic nucleus and focal histopathological characters were observed side by side with normal cell. Our results concluded that water, sediment and liver accumulation toxicity tests and histopathological changes of liver may be associated, and these approaches may be used together to describe the environmental state and water quality assessment.

Keywords: Metal accumulation; Liver; Histopathology; Oreochromis; Sewage water

1. Introduction

The contamination of fresh water, with a wide range of pollutants has become a matter of concern over the last few decades [1-3], and is getting extensively contaminate metals released from domestic, industrial and other anthropogenic activities [4-8]. Metals are the main culprit for these undesirable changes in water quality [9].

Heavy metals exposure for a long time in very low concentrations caused histopathological and biochemical alterations in different tissues of fish [10]. Fernandes, Fontaínhas-Fernandes [11], Mahboob, Al-Balwai [12] confirmed that, Cd, Pb and Hg are the most toxic metals, followed by Cu, Cr, Ni, Al, Mn and Zn; and the soluble forms of these metals are highly toxic to fish.

In polluted aquatic ecosystems, the histopathological alertation of organs is a tool to bioindicator of toxicant impact assessment to indicate fish health and toxicant effects. Also, these Histopathological alterations allow for speed detection of disease and detection of long-term injury in cells, tissues, or organs. Also the structural changes in many tissues in the contaminated ecosystem have also been approved [13]. Heavy metals accumulation, caused the formation of reactive oxygen species that caused changes in metabolism, further leading to cellular intoxication and

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death at a cellular level. This manifests as necrosis at the tissue level [14]. Mohamed [15], Thophon, Kruatrachue [16], Van Dyk, Pieterse [17] reported that the exposure of fish to pollutants like heavy metals resulted in several pathological alterations in different tissues of fish.

The liver of fish plays a vital role in basic metabolic functions and it is the most accumulated, biotransformated and excreted organ of toxins in fish [18]. Also, the histopathology of liver used as a bio-monitor for the environmental contamination [19]. Au [20], [21] reported that histopathological alteration of liver that exposed to heavy metals.

The present study was carried out in El-kharja city, New Valley Governorate, Egypt at El-shikh pond [22]. The quality of this ecosystem has been degrading due to industry, agriculture and human activities. Thus, the present study aimed to determine heavy metals accumulation in water, sediment and liver *Oreochromis niloticus* and histopathological alteration as a response to metallic pollution in liver as a bioindicator of the environmental quality of water, sediments and biota of the Lake.

2. Material and methods

2.1. Studied area and sample collection

It was carried out from April to July 2014 in El-shikh pond, which located between 25° 41' N to 25.43N and longitudes 30° 56' E to 30° 57' E at 4.33 Km extends. This pond receives untreated domestic sewage from numerous villages in addition to the agricultural and industrial wastes. One hundred and Fifty specimens of *Oreochromis niloticus* (23.85±10.29 cm) and (268.17± 124.11 gm) were collected in the same period. Fishes were transported to the laboratory in the containers with constant aeration. The wet weight and total body length of the fish were measured, blood sampling was done.

2.2. Heavy metals assessment

During the summer of 2014; water, sediments and fish liver samples were collected from the selected area. Water samples were collected from five localities in each of selected areas and different depth of water surface according to Boyd [23]. Five sediment samples were collected from 20 cm depth in polyvinyl chloride (PVC) corers [24]. Liver of fish were collected after fish minced and about 0.5 g was placed in a 100 ml beaker and 10 ml concentrated nitric acid was added for digestion and preparation. Heavy metals in water, sediment and fish liver were estimated using ICP-MS (Inductively Coupled Plasma Mass Spectrometry) (Thermo Fisher Scientific, Bremen, GmbH).

2.3. Histology and histopathological examination

After liver collection of fish, immediately fixed in 10% Neutral formalin, then embedded in paraffin wax, passing through ascending grades of alcohol, clear in xylene, infiltrated using paraffin wax, embedded, mounted, sectioned at 3-5 µm using microtome (rotary) and subsequently stained with haematoxylin and eosin stain [25]. For the demonstration of the collagenous fibers Milligen's Trichrome stain used [26].

Polysaccharides, periodic acid Schiff's (PAS) technique were demonstrated using Mc Manus [27] technique. Mercury-bromophenol blue method was used to demonstrate the general protein, using Mazia, Drewer [28] method. Sections that stained were tested using Optica microscope and a digital camera.

2.4. Statistical analysis

The basic statistics (mean, standard error (SE),) were estimated using SPSS package release 10 [29].

3. Results

Table 1 The presented data (Mean ±Std. Err.) of heavy metals accumulation of sewage water, liver and sediment of El-Shekh pond, undertaken during April-July 2014

* Heavy Metals	Water	EOS, 1993*	WHO, 2008#	Liver	EOS, 1993*	WHO, 2008#	Sediment
Aluminum (Al)	7.94±1.83*#	3	1	42.29±5.77#	50	30	173.9±3.8
Cadmium(Cd)	0.003±0.0004#	0.01	0.003	0.20±0.05#	0.5	0.05	2.04±0.02
Chromium(Cr)	0.20±0.01	1	0.5	1.31±0.15	20	10	4.85±0.05
Cobalt(Co)	0.01±0.002	0.2	0.2	0.25±0.04	10	1	0.25±0.01
Copper(Cu)	0.08±0.01	1	1	1.49±0.36	20	20	4.17±0.02
Iron(Fe)	9.06±0.86*#	0.3	0.3	158.17±38.59*#	30	30	175.1±20.8
Lead(Pb)	0.33±0.14*#	0.1	0.01	1.24±0.14#	2	0.05	3.43±0.05
Manganese(Mn)	0.90±0.24*#	0.1	0.1	3.67±0.75	10	10	124.4±5.2
Nickle(Ni)	0.82±0.03*#	0.1	0.1	1.41±0.19	10	2	150.2±7.3
Selenium(Se)	0.09±0.02	0.4	0.2	47.59±14.05	50	50	1.50±0.06
Zinc(Zn)	0.42±0.06	5	3	16.41±1.83	40	40	3.57±0.03

(*) More than EOS [30] permissible limits. (#) More than WHO [31] permissible limits.

Agricultural and domestic wastes are the main indicators of chemical pollution that caused increases in heavy metals level in water resources. Metals accumulation data of water, liver and sediments are presented in table 1. Aluminum, Cd, Fe, Mn, Ni and Pb concentrations were more than permissible limits of EOS [30], and WHO [31] mentioning to the negative state of the studied ecosystems. Also, Fe then Al was the highest of metals concentration in sediments, on the other hand, was the lowest one.

Different patterns of heavy metal accumulations were observed in liver (Table 1). These patterns reflect the history and variety of fish in this aquatic ecosystem. This study showed accumulation of Al, Cd, Fe, and Pb were (42.29±5.77 ppm), (0.20±0.05 ppm), (158.17±38.59 ppm) and (1.24±0.14 ppm), respectively. These metals were more than the permissible limits of EOS [30] and WHO [31].

The normal structure of liver appears forming a meshwork and they arranged in a definite cord like pattern. The hepatocytes are polygonal in shape with an eccentric or centric spherical nucleus with a prominent nucleolus. Blood sinusoids separated these cells from each other (Fig. 1A). The defused pancreatic tissue surrounds branches of the hepatic portal vein within the liver. The exocrine portion consists of a large number of conical glandular cells. Each glandular cell has an eccentric, deeply stained nucleus with a prominent nucleolus. In the nuclear portion of the cell, the cytoplasm is homogenous and basophilic. On the other hand, the nature of the remaining part of the cell is acidophilic(Fig. 1B). Histopathological examination of fish liver showed signs of progressive alterations such as disorganization of architecture of liver cells, hydropic degeneration and vacuolation of hepatocytes. Also, dilation and congestion in blood sinusoids, hypertrophic and increase in number of Küpffer cells were chronicled. Sever deposition of hemosiderin pigments were reported while necrosis with pyknotic nucleus and focal histopathological characters were observed side by side with normal cell (Fig. 2). Examination of the hepatopancreatic tissue showed histopathological alterations such as shrinkage and disarrangement of pancreatic acinus. Vacuolation in pancreatic cells and adipose tissue were noticed between pancreatic cells. Increase in edema and thickening in the wall of portal vein (Figs. 3). Milligen trichrome stain revealed a great amount of connective tissue (fibers and adipose tissue) around the portal vein and between pancreatic acini respectively, also in hepatic tissue (Fig. 4).

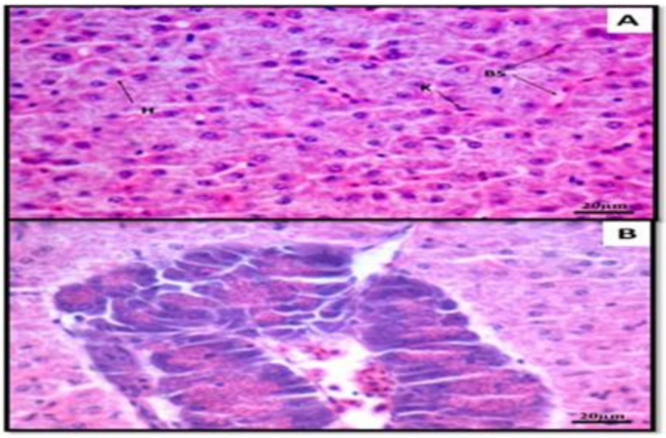

Figure 1 Photomicrograph of fish normal liver showing the general structure (A): Blood sinusoids (BS), hepatocytes (H) and Küpffer cell (K) (B): portal vein (PV) and the basophilic portion with nucleus and the acidophilic cytoplasm of the acinar cells. (H&E, X 400).

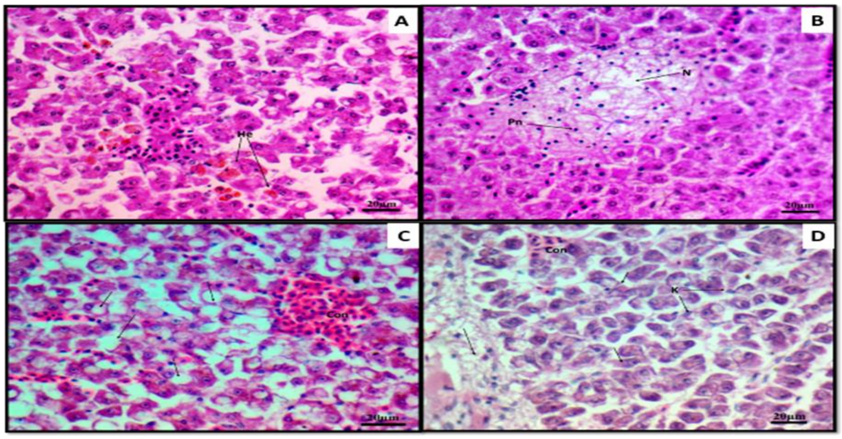

Figure 2 Photomicrograph of fish liver showing (A): hemosiderin granules (He), (B): necrotic area (N) with pyknotic nuclei (Pn), (C): fatty degeneration (arrows) blood congestion (Con) and (D): blood congestion (Con), acute massive necrosis, shrinkage and dissociation of cell (arrows) and hypertrophy of Küpffer cell (K). (H&E, X 400)

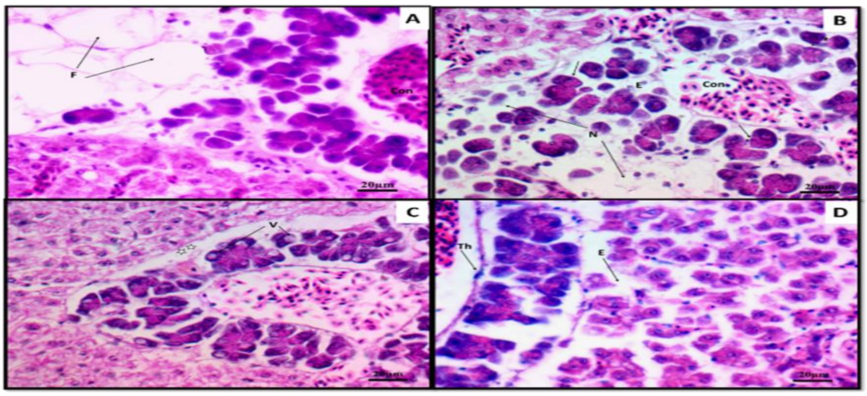

Figure 3 Photomicrograph of fish hepatopancreas showing (A): adipose tissue (F) between pancreatic cells and blood congestion (con), (B):blood congestion (Con), edema (E), necrosis (N), shrinkage and disarrangement of pancreatic acinus (arrows), (C): space between liver and pancrease (stars), vacuolation in pancreatic cells (V) and (D): thickening wall of portal vein (Th), edema between hepatocytes (E) and disarrangement of hepatocytes. (H&E, X 400).

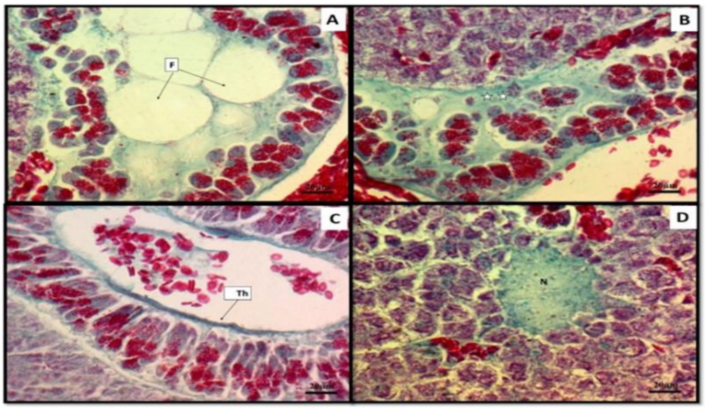

Figure 4 Photomicrograph of fish hepatopancreas showing (A): adipose tissues (F) between pancreas cells, (B): increase of fibrous connective tissues (stars), (C): thickening (Th) around portal vein and (D): necrotic area (N) between hepatocyte. (Milligen Trichrome, X 400).

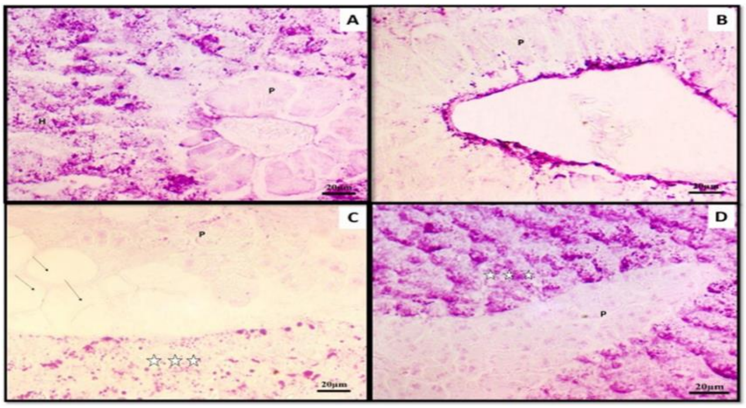

Figure 5 Photomicrograph of fish normal liver showing (A): glycogen content in hepatocytes (H), hepatopancreas (P) tissue, (B): thickening around in portal vein, (C): fatty infiltration between pancreas cells (arrows) and depletion of glycogen contents in hepatocytes (stars) and (D): negative reaction for pancreas cells (P) and increment of glycogen contents in hepatocytes (stars). (PAS-reaction, X 400)

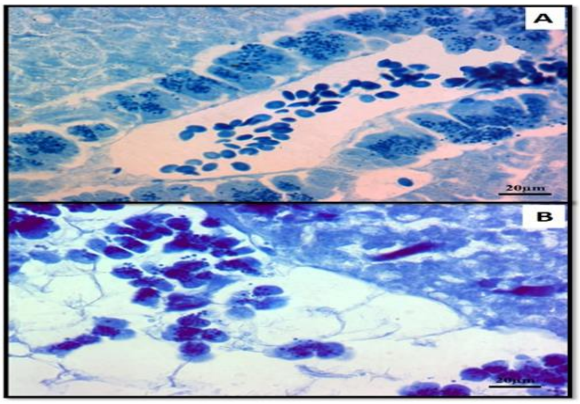

Figure 6 Photomicrograph of fish normal hepatopancreas showing (A): zymogenic granules within pancreatic portion. Equivalent to acidophilic portion of cells and (B): adipose tissue between pancreas cells and liver. (Bromophenol Blue stain, X 400).

PAS reaction revealed a high fluctuation of glycogen content in liver tissue. The negative PAS reaction was noticed in hepatopancreatic tissue, while the positive PAS reaction was detected near the portal vein (Figs. 5). Using bromophenol blue to identify general proteins, the cytoplasm of hepatocytes in normal tissue was faintly stained but the zymogen granules were strongly stained. In alter tissue both hepatocytes and hepatopancreatic acini were strongly stained (Figs. 6).

4. Discussion

The Using of fertilizers in agricultural uprising caused increases of heavy metals accumulation in fresh water due to the water run-off, which caused metallic pollution [32, 33]. In this respect, Abou Elnaga and Allam [34] reported that heavy metals bioaccumulation in different tissues of fish body not similar to its concentration in the ambient water. Also, the low concentration of heavy metals in water may cause high concentration of heavy metals in fish tissues [35]. Fish are exposed to pollutants through two pathways (direct and indirect); up taking from water, through food or both. The direct uptake depends on the total concentration and the bioavailability of the pollutant, like the physiological factors of fish [36].

Our results showed that Al, Fe, Mn, Ni and Pb concentrations were more than permissible limits of EOS [30], and WHO [31] mentioning to the negative state of the studied area. Sediment showed that Fe then Al were the highest metals in concentration. However Co than Se was the lowest one. Similar to our results, Omar, Zaghloul [37] and Ibrahim, Wassif [22] who found highly precipitation of heavy metals concentration from water column sediment samples.

The present investigation showed that Al, Cd, Fe and Pb concentrations in liver of *O. niloticus* were more than the permissible limits of EOS [30], and WHO [31]. Similarly, Authman, Abbas [38], Ibrahim [39] and Ibrahim, Wassif [22] found that these elements are more than permissible limits in liver of *O. niloticus.* Also, Kaoud and El-Dahshan [40] reported that Cd and Cu concentrations were the highest in liver. The high Zinc accumulation in liver was in agreeing with Ibrahim [39], El-Naggar and Tayel [41], Ibrahim and Omar [42]; Ibrahim, Wassif [22]. Ibrahim [39] also, found that Fe and Ni accumulation in liver as a target organ of *Oreochromis niloticus*.

Liver play as multiple oxidative reactions site that formed from metal accumulation and maximal free radical generation [22, 39, 42]. Metallic pollution caused the formation of free radicals in different tissues which caused histopathological alteration in different tissues [43]. Liver is the detoxification organ of fish; and its high tendency of liver to accumulate heavy metals more than other organs caused the formation of complexation of metal ions, which leads to DNA fragmentation [44].

The normal structure of liver appears forming a meshwork and they arranged in a definite cord like pattern. The hepatocytes are polygonal in shape with an eccentric or centric spherical nucleus with a prominent nucleolus, which separated from each other by blood sinusoids. Fayed [45] reported that hepatic vein received blood from the hepatic portal vein and hepatic artery through the sinusoids to the central veins. The defused pancreatic tissue surrounds branches of the hepatic portal vein within the liver. The exocrine portion consists of a large number of conical glandular cells. Each glandular cell has an eccentric, deeply stained nucleus with a prominent nucleolus.

The present study showed a histopathological alteration of liver like hydropic degeneration, vacuolation of hepatocytes, dilation and congestion in blood sinusoids, hypertrophic and increase in number of Küpffer cells. Also, hemosiderin pigments were reported while necrosis with pyknotic nucleus and focal histopathological characters were observed side by side with normal cell. Examination of the hepatopancreatic tissue showed histopathological alterations such as shrinkage and disarrangement of pancreatic acinus. Vacuolation in pancreatic cells and adipose tissue were noticed between pancreatic cells. Increase in edema and thickening in the wall of portal vein. Similar alterations were observed in the hepatocytes of *Clarias gariepinus, Tilapia zillii and Solea vulgaris* living in contaminated areas with endocrine disrupters and heavy metals [46-48]. *Oreochromis niloticus* exposed to heavy metals in its environment and laboratory display the same histopathology [21]. The vacuolization of hepatocytes in the liver was a more common pathology in the fish exposed to contaminants in their environments [49, 50] and is associated with the inhibition of protein synthesis, energy depletion, and desegregation of microtubules, or shifts in substrate utilization and accumulation of lipid responses to toxic substances. [51] suggesting that vacuolization might be the result of the chemical substance exposure. Oxygen deficiency as a result of gill degeneration and/or to vascular dilation and intravascular hemolysis reported in blood vessels with subsequent stasis of blood cause of the cellular degeneration in liver [52]. The increasing of Küpffer cells in size and number were as a defense mechanism against stress and foreign material in the blood circulation [53]. These alterations were also described under the effect of herbicide or heavy metals on *Oreochromis niloticus* and catfish *Chrysichys auratus* in the laboratory [54-56]. Similar results were observed by Triebskorn, Telcean [57], Van Dyk, Pieterse [58] who reported similar histopathological alterations in liver of fish that exposed to different metals.

The abnormal accumulation of hemosiderin in liver may be due to many factors like, rapid destruction of RBCs by conversion of hemoglobin it into hemosiderin and damage of Fe metabolism [46, 59]. Also, high amount of Fe accumulation in fish liver, leading to abnormal accumulation of hemosiderin [59]. Khan [60] also, reported a strong link between hemosiderin pigment formation and hepatic alteration.

The present staining with Milligen trichrome showed a great amount fibers and adipose tissue as a connective tissue, which were found around the portal vein and between pancreatic acini respectively, also in hepatic tissue. Also, the fatty degeneration alteration in liver may be due to a decrease in the rate of utilization of energy reserve or pathological enhance synthesis, and abnormal accumulation of fats was reported in experimental animal, which formed due to induced imbalance between fat production and utilization [61]. The hepatic necrosis results from pollutant within cells, causing disturbs on biochemical process as enzyme inhibition, failure on protein synthesis and carbohydrate metabolism [62, 63].

Acute massive necrosis of liver were noticed in the present investigation. Sandritter and Thomas [64] described this alteration as a disorganization of liver cell cords, that is, the individual liver cells have become unattached and appear as separated cellular elements. The cells vary in size, and some are already shrunken. The cytoplasm is homogenous and stains more blue than normal (decrease in glycogen content). The nuclei more faintly stained than normal (karolysis) (Fig. 5D).

Similar to our findings, fish inhabiting areas contaminated with different types of pollutants such as heavy metals [21], waste water treatment plant effluent [38] and laboratory experiments [55] displayed histopathology alterations on their liver tissues.

The high fluctuation of glycogen content in liver was revealed due to PAS reaction as a negative reaction in hepatopancreatic tissue, while a positive reaction was detected near the portal vein. Hepatopancreas showed an inhibition of acidity of the apical portion of pancreatic acinar cells. Wassif, Kider [56] reported similar results when exposed of *Oreochromis niloticus* to different pollutants. Cellular proliferation observed here in pancreatic tissues could possibly explain by the stimulatory effect that is originated from striking deterioration of liver cells. Enhanced fibrosis, i.e., High proliferation of CT, of the examined organs resulted in marked inhibition of the various vital activities [19].

Using bromophenol blue to identify general proteins, the cytoplasm of hepatocytes in normal tissue was faintly stained but the zymogen granules were strongly stained. In alter tissue both hepatocytes and hepatopancreatic acini were strongly stained. The present study showed a notable collection of connective tissue fiber adjacent to some blood vessels in liver. Similar results were observed by Blazer [65] who found fibrosis and suggested to be a chronic tissue response to chemical injury.

5. Conclusions

The metallic pollution in the selected area, with high metal concentrations that recorded in water, sediment samples, because of the continuous discharge to the aquatic habitats. It confirms that it is having a strong impact on fish health as these heavy metals are accumulating in liver of *Oreochromis niloticus*. Application of metal detection in liver of *Oreochromis niloticus* and histopathological alteration, provides valuable biomarkers in field surveys, in monitoring studies and in comparing different levels of metallic pollution. Severe histopathological lesions and cellular alterations were observed in fish liver, which could be attributed to the significant accumulation of several heavy metals in liver, which, used as a sensitive model to monitor the aquatic pollution. That heavy metals accumulation reached to a dangerous level that affecting the health of local human communities.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflicts of interest.

Statement of ethical approval

All experiments were carried out in accordance with the Egyptian laws and University guidelines for the care of experimental animals. All procedures of the current experiment have been approved by the Committee of the Faculty of Science, New Valley University, Egypt.

References

[1] Vutkuru S. (2005). Acute effects of Hexavalent chromium on survival, oxygen consumption, Hematological parameters and some biochemical profiles of the Indian Major Carp, *Labeo rohita*. International Journal of Environmental Research and Public Health, 2(3), 456-462.

[2] Baršienė J, Bjornstad A, Rybakovas A, Šyvokienė J, and Andreikėnaitė L. (2010). Environmental genotoxicity and cytotoxicity studies in mussels and fish inhabiting northern Atlantic zones impacted by aluminum industry EKOLOGIJA. 56, 116-123.

[3] Adeboyejo AO, Fagbenro AO, Adeparusi YE, Clarke EO, Lawal O, Amosu AO, and Bashorun OW. (2013). Eco-Histopathology of Nile Tilapia (*Oreochromis niloticus*) and African Catfish (*Clarias gariepinus*) From Industrially Contaminated Locations of Ologe Lagoon, South-Western, Nigeria. Environment and Natural Resources Research, 3(2), 28-36.

[4] Lemos CT, Rödel PM, Terra NR, Oliveira NCD, and Erdtmann B. (2007). River water genotoxicity evaluation using micronucleus assay in fish erythrocytes. Ecotoxicol. Environ, Saf. 66, 391-401.

[5] Omar WA, Zaghloul KH, Abdel-Khalek AA, and Abo-Hegab S. (2012). Genotoxic effects of metal in two fish species, *Oreochromis niloticus* and *Mugil cephalus*, from highly degraded aquatic habitats, Mutat. Res. 746, 7-14.

[6] Polard T, Jean S, Gauthier L, Laplanche C, Merlina G, Sánchez-Pérez JM, and Pinelli E. (2011). Mutagenic impact on fish runoff events in agricultural areas in south-west France Aquat. Toxicol, 101, 126-134.

[7] Rocha PS, Luvizotto GL, Kosmehl T, Böttcher M, Storch V, Braunbeck T, and Hollert H. (2009). Sediment genotoxicity in the Tietê River (São Paulo, Brazil): *in vitro* comet assay versus *in situ* micronucleus assay studies. Ecotoxicol. Environ, Saf. 72, 1842-1848.

[8] Summak S, Aydemir NC, Vatan O, Yılmaz D, Zorlu T, and Bilalog R. (2010). Evaluation of genotoxicity from Nilufer Stream (Bursa/Turkey) water using piscine micronucleus test. Food Chem. Toxicol, 48, 2443-2447.

[9] Garg S, Gupta RK, and Jain KL. (2009). Sublethal effects of heavy metals on biochemical composition and their recovery in Indian major carps. Journal of Hazardous Materials, 163, 1369-1384.

[10] Kaoud HA and El-Dahshan AR. (2010). Bioaccumulation and histopathological alterations of the heavy metals in *Oreochromis niloticus* fish. Nat. Sci, 8(4) 147-156.

[11] Fernandes C, Fontaínhas-Fernandes A, Cabral D, and Salgado M. (2008). Heavy metals in water, sediment and tissues of Liza saliens from *Esmoriz-Paramos lagoon.*Port. Environ.MonitAsses, 136, 267-275.

[12] Mahboob S, Al-Balwai HFA, Al-Misned F, and Ahmad Z. (2014). Investigation on the genotoxicity of mercuric chloride to fresh water *Clarias gariepinus* Pak.Vet.J, 34(1), 100-103.

[13] Marchand MJ, van Dyk JC, Pieterse GM, Barnhoorn IE, and Bornman MS. (2009). Histopathological alterations in the liver of the sharptooth catfish *Clarias gariepinus* from polluted aquatic systems in South Africa. Environ. Toxicol, 24(2), 133-47.

[14] Bailey GS, Williams DE, and Hendricks JD. (1996). Fish models for environmental carcinogenesis: the rainbow trout. Environ. Hlth Perspect, 104, 5-21.

[15] Mohamed FAS. (2008). Bioaccumulation of Selected Metals and Histopathological Alterations in Tissues of *Oreochromis niloticus* and *Lates niloticus* from Lake Nasser, Egypt, Glob Veterin, 2(4), 205-218.

[16] Thophon S, Kruatrachue M, Upatham E, Pokethitiyook P, Sahaphong S, and Jaritkhuan S. (2003). Histopathological alterations of white sea bass, *Lates calcarifer*, in acute and sub-chronic cadmium exposure. Environ. Pollut, 121, 307-320.

[17] Van Dyk J, Pieterse G and Vuren VJ. (2007). Histological changes in the liver of *Oreochromis mossambicus* (Cichlidae) after exposure to cadmium and zinc. Ecotoxicol. Environ, Safe. 66, 432-440.

[18] Figueiredo-Fernandes A, Fontainhas-Fernandes A, Rocha E and Reis-Henriques MA. (2006). The effect of paraquat on hepatic EROD activity, liver and gonadal histology in males and females of Nile Tilapia, *Oreochromis niloticus*, exposed at different temperatures. Archives of Environmental Contamination and Toxicology, 51(4), 626-632.

[19] El-Serafy SS, Abdel-Hameid NAH and El-Daly AA. (2009). Histological and histochemical alterations induced by phenol exposure in *Oreochromis aureus* (Steindachner, 1864) juveniles. Egyptian Journal of Aquatic Biology and Fisheries, 13(2), 151-172.

[20] Au DWT. (2004). The application of histo- cytopathological biomarkers in marine pollution monitoring: a review Marine Pollution Bulletin, 48, 817-834.

[21] Abdel-Moneim AM, Al-Kahtani MA and Elmenshawy OM. (2012). Histopathological biomarkers in gills and liver of *Oreochromis niloticus* from polluted wetland environments, Saudi Arabia. Chemosphere, 88, 1028-1035.

[22] Ibrahim ATA, Wassif E and Alfons MS. (2016). Heavy Metals Assessment in Water, Sediments and Some Organs of Oreochromis nilotius under the Impact of Sewage Water Journal of Heavy Metal Toxicity and Diseases, 1(1-4), 1-7.

[23] Boyd CE. (1990). Water quality in ponds for aquaculture, in Alabama Agriculture Experiment Station, Auburn Univ, Alabama, U. S. A.

[24] Cabrera F, Conde B and Flores V. (1992). Heavy metals in the surface sediments of the tidal river Tinto (SW Spain) Fresenius Environ Bull, 1, 400 – 5.

[25] Bancroft D and Stevens A. (1982). Theory and practice of Histological Techniques, ed. Churchill Livingstone, Edinburgh, London, Melaborne.

[26] M. M. (1946). Trichrome stain for formalin-fixed tissue. Am J Clin Pathol, 10(6), 184.

[27] Mc Manus JFA. (1946). histological demonstration of mucin after periodic acid Nature. Lon, 158, 202.

[28] Mazia D, Drewer PA and Alfert M. (1953). The cytochemical staining and measurement of protein with mercuric bromophenol blue J. Biol. Bull, 104, 57-67.

[29] SPSS. (1998). Spss for windows. in SPSS Inc.

[30] EOS. (1993). Egyptian standard, maximum levels for heavy metal concentrations in food, in *UDC*. 546-815.

[31] WHO. (2008). Guidelines for drinkingwater quality, in *3rd edition, incorporating the first and second addenda*, 515.

[32] Adefemi SO, Asaolu SS, and Olaofe O. (2008). Determination of Heavy metals in Tilapia mossambicus Fish, Associated water and Sediment fom Ureje Dam in South Western, Nigeria. Research Jour. of Environ, Sci. 2, 151-155.

[33] Prasath PMD and Arivoli S. (2008). Biochemical study of freshwater fish Catla catla with reference to mercury chloride Iranian Jour. Environ, Health Sci. Eng. 3, 109-116.

[34] Abou Elnaga WM and Allam SM. (1996). Heavy metal concentrations in the tissues of Tilapia zillii Gerv, exposed to waste water discharge of Egyptian copper factory Comparative physiology, 19(A), 21-35.

[35] Kock G and Hofer R. (1998). Origin of Cadmium and Lead in clear Soft Water Lakes of High-altitude and High-latitude, and their Bioavailability and toxicity to fish J, Exs. 87, 225-257.

[36] Sjöblom A, Meili M and Sundbom M. (2000). The influence of humic substances on the speciation and bioavailability of dissolved mercury and methylmercury, measured as uptake by Chaoborus larvae and loss by volatilization. The Science of the Total Environment, 261, 115–124.

[37] Omar WA, Zaghloul KH, Abdel-Khalek AA and Abo-Hegab S. (2012). Genotoxic effects of metal pollution in two fish species, *Oreochromis niloticus* and *Mugil cephalus* from highly degraded aquatic habitats. Mutation Research, 746, 7– 14.

[38] Authman MMN, Abbas HH and Abbas WT. (2012). Assessment of metal status in drainage canal water and their bioaccumulation in *Oreochromis niloticus* fish in relation to human health. Environ. Monit.

[39] Ibrahim ATA. (2014). Seasonal variation of heavy metals concentrations in muscles of *Oreochromis niloticus*, River Nile water and sediments at Assiut Governorate, Egypt,, in *Seventh International Conference on Environment and Development in the Arab World,*. Assiut, Egypt.

[40] Kaoud HA and El-Dahshan AR. (2010). Bioaccumulation and histopathological alterations of the heavy metals in *Oreochromis niloticus* fish, Nat. Sci. 8(4), 147–156.

[41] El-Naggar SM and Tayel S. (2009). Bioaccumulation of some heavy metals and histopathological alterations in liver of *Oreochromis niloticus* in relation to water quality at different localities along the River Nile, Egypt. World J Fish Mar Sci, 1(2), 1 05-11 4.

[42] Ibrahim ATA and Omar HM. (2013). Seasonal variation of heavy metals accumulation in muscles of the African Catfish Clarias gariepinus and in River Nile water and sediments at Assiut Governorate, Egypt. J Biol Earth Sci. 3(2), B236-B248.

[43] Rajeshkumar S, Liu Y, Ma J, Ying Duan H, and Li X. (2017). Effects of exposure to multiple heavy metals on biochemical and histopathological alterations in common carp, Cyprinus carpio L, Vol. 70.

[44] Omar WA, Zaghloul KH, Abdel-Khaleka AA, and Abo-Hegab S. (2012). Genotoxic effects of metal pollution in two fish species, *Oreochromis niloticus* and Mugil cephalus, from highly degraded aquatic habitats Mutation Research, 746, 7-14.

[45] Fayed DBMM. (2004). Aspects of manzalah Lake pollution on Mugil species, in *Fac. Girl.* . Ain Shams Univ., Egypt.

[46] EL-Naggar AM, Mahmoud SA, and Tayel SI. (2009). Bioaccumulation of some heavy metals and histopathological alterations in liver of *Oreochromis niloticus* in relation to water quality at different localities along the River Nile, Egypt. World J. Fish and Marine Sci. 1, 105-114.

[47] Marchand MJ, van Dyk JC, Pieterse GM, Barnhoorn IEJ, and Bornman MS. (2009). Histopathological Alterations in the Liver of the Sharptooth Catfish Clarias gariepinus from Polluted Aquatic Systems in South Africa Environmental Toxicology, 24, 133-147.

[48] Mohammed RH. (2009).The effects of atrazine and its interaction with supplementations of lycopene and vitamin E on some biological, biochemical and histological characteristics, of *Clarias gariepinus*, in Zoology Department. Assiut University: Faculty of Science.

[49] Kelly JM and Janz DM. (2009). Assessment of oxidative stress and histopathology in juvenile northern pike (Esox lucius) inhabiting lakes downstream of a uranium mill Aquatic Toxicology, 92, 240-249.

[50] Lukin A, Sharova J, Belicheva L and Camus L. (2011). Assessment of fish health status in the Pechora River: Effects of contamination Ecotoxicology and Environmental Safety, 74, 355-365.

[51] Van der Oost R, Beber J, and Vermeulen NPE. (2003). Fish bioaccumulation and biomarkers in environmental risk assessment: a review Environ Toxico Pharmac. 13: p. 57-149.

[52] Mohamed FA. (2001). Impacts of environmental pollution in the southern region of Lake Manzalah, Egypt, on the histological structures of the liver and intestine of *Oreochromis niloticus* and Tilapia zilli J. of Egyptian Academic Society for Environmental Devels, 2, 25-42.

[53] Mahmoud AA. (1999). Cytogenetic studies on the effect of some chemical pollution on a fresh water fish, in Faculty of science. Zagazig University (Benha branch), Egypt. .

[54] Khidr BM, Wassif ET, Hussein SY and Mekkawy IAA. (2001). Studies on the effect of the herbicide atrazine on the liver and kidney of the fresh water Catfish Chrysichys auratus J. Egypt, Ger. Soc. Zool. 34, 283-300.

[55] Mekkawy IAA, Mahmoud UM, Wassif ET and Naguib M. (2012). Protective Roles of Tomato Paste and Vitamin E on Cadmium-induced Histological and Histochemical Changes of Liver of *Oreochromis niloticus* (Linnaeus, 1758) Journal of Fisheries and Aquatic Science, 7, 240-265.

[56] Wassif ET, Kider BM, Hussein SY, Mekkawy IA and Hassan HI. (2000). Effects of the herbicide Atrazine on the structure of some organs of the Nile fish *Oreochromis niloticus*. Egypt J. Aquat. Biol. &Fish, 4, 197-234.

[57] Triebskorn R, Telcean I, Casper H, Farkas A, Sandu C, Stan G, Clarescu O, Dori T, and Kohler HIp. (2008). Monitoring pollution in River Mures, Romania, Part II: Metal accumulation and histopathology in fish Environmental Monitoring and Assessment, 141, 177-188.

[58] Van Dyk JC, Pieterse GM, and Van Vuren JHJ. (2007). Histological changes in the liver of *Oreochromis mossambicus* (Cichlidae) after exposure to cadmium and zinc Ecotoxicology Environmental Safety. 66, 432-440.

[59] Ibrahim SA and Mahmoud SA. (2005). Effect of heavy metals accumulation on enzyme activity and histology in liver of some Nile fish in Egypt J. Aquat. Biol. and Fish, 9, 203-219.

[60] Khan RA. (1999). Study of pearl dace Margaricus margarita inhabiting still water pond contaminated with diesel fuel Bull. Environ. Contam. Toxical, 62, 638-645.

[61] Kadry MS. (1997). Impact of carbamate insecticide carbofuran on the liver of the Nile catfish, *Clarias gariepinus* (Barchell, 1822), A light and electron microscopic study Egypt J. Hitol, 20, 379-394.

[62] Mela M, Randi MAF, Ventura DF, Carvalho CEV, Pelletier E and Oliveira Ribeiro CA. (2007). Effects of dietary methylmercury on liver and kidney histology in the neotropical fish *Hoplias malabaricus*. Ecotoxicol. Environ, Saf. 68, 426-435.

[63] Rabitto IS, Alves Costa JRM, Silva De Assis HC, Pelletier FM, Akaishi FM, Anjos A, Randi MAF and Oliveira Ribeiro CA. (2005). Effects of dietary Pb(II) and tributyltin on neotropical fish, *Hoplias malabaricus*: histopathological and biochemical findings Ecotoxicol. Environ, Saf. 60, 147-156.

[64] Sandritter W and Thomas C. (1979). Color Atlas and Textbook of Histopathology. Year Book Medical Publishers.

[65] Blazer VS. (2002). Histopathological assessment of gonadal fish tissue in wild fishes Fish Physiology and Biochemistry, 26, 85-101.

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