International Journal of Aquatic Science
ISSN: 2008-8019
Vol 13, Issue 01, 2022

The Effect of Chemical Pollutants on The Blood Components of Two Types of Local Fish Within The City Oof Mosul

Eman S. Y. Al-Sarraj

Pharmacy Department, Al-Noor University College, Iraq

E-mail: eman.sami@alnoor.edu.iq

Abstract: The current study included estimating the concentration of some industrial chemical pollutants (heavy metals) such as lead (Pb) and cadmium (Cd), which are thrown directly with industrial and agricultural waste and human activities into the Tigris River, within the city of Mosul, without any treatment, and, the study of some physical and chemical properties that affect the toxicity of these pollutants in the river, as well as, the effect of the bioaccumulation of the aforementioned minerals on some blood parameters in two types of local fish represented by the common carp Cyprinus Carpio and the royal thrush Condrostoma Regium. These are considered the most economically important fish and the most eaten by humans as food. Water and fish samples were collected monthly for the period from June 2018 to March 2019, from three locations on the Tigris River, represented by the beginning of the river entering the city of Mosul, the city center, and the south of the city. The results showed a variation in water temperature, electrical conductivity, pH function, total hardness, dissolved oxygen concentration, biochemical oxygen requirement, as well as the concentration of heavy metals represented by lead (Pb) and cadmium (Cd). The impact of environmental pollutants and the different seasons of the year and geographical locations resulted in a significant decrease in hemoglobin concentration (Hb), the volume of pressured blood cells (PCV), the total number of red blood cells (RBC), and an increase in the total number of white blood cells (WBC) in both types of local fish selected from the second and third locations compared to fish from the first location (controlling).

Keywords: chemical pollutants, lead, cadmium, blood components, hemoglobin

1. INTRODUCTION

Water resources have witnessed a significant deterioration in recent times, due to the lack of attention, and that water pollution is one of the major global problems that preoccupy scientific and political circles, as it endangers the health and threatens aquatic life[1], as a result of the increase in human activities. The development of agriculture and industry led to a significant increase in the levels of chemical pollutants such as heavy metals that cause severe damage to aquatic organisms within the food chain[2]. Chemical pollutants are concentrated and accumulated in aquatic organisms, especially animals such as fish[3], which can collect these pollutants at higher concentrations than in water and sediments due to their feeding on algae and small aquatic organisms[4], as well as the organic materials exist in the aquatic environment, chemical fertilizers and pesticides, in addition to the wastewater that carries a lot of human, agricultural and industrial wastes into water bodies [5]. All of them increase the chemical and biological pollution, and its transmission to humans through the food chain[6]. Fish is one of the important foods that humans have relied on since ancient times because it contains minerals, vitamins, amino acids, and fatty acids such as omega-3[7], especially common carp fish. *Cyprinus Carpio* inhabits freshwater bodies such as lakes, dams, streams, and rivers[8], and has global importance[9]. Many heavy metals that are found in the aquatic environment can accumulate in the tissues of fish through indirect absorption from water through the skin and gills or directly from food or contaminated water[10]. The rate of pollutant accumulation depends on several physical and chemical properties represented by water temperature, turbidity, salinity, pH, dissolved oxygen concentration, vital oxygen requirement, and heavy metals concentration in water, as well as the length of the food chain. As their influence is transmitted from one organism to another by feeding through the food chain[11]. Fish are at the top of the food chain in aquatic ecosystems and contain important elements that are involved in building the body, such as iron, phosphorous, calcium, and zinc[12]. Cadmium and lead are two of the most harmful chemical pollutants that pollute water and accumulate in fish:

1 - cadmium

It is a non-essential ingredient that is highly toxic. Cadmium is present with zinc and lead in sulfide and reaches the water as a result of industrial sewage. But the main source is phosphate fertilizers, and it is mainly used in electroplating metals, dyes, batteries, and alloys. Cadmium has a very damaging effect on tissue physiology, changing the biological and chemical properties, in addition to increasing oxidative stress. It releases free oxygen molecules in tissues in large quantities and also inhibits antioxidant enzymes, which results in an increase in oxidative stress in tissues and then damage. Available reports indicate that the gills, liver, and kidneys in fish are most affected by cadmium. It has also toxic effects on the skeletal system due to its effect on calcium phosphorous metabolism, where a decrease in calcium absorption occurs, and the result is osteomalacia. It has a direct impact on high blood pressure due to the effect of cadmium on the constriction of blood vessels and has carcinogenic effects, as it causes a disturbance in the functions of the kidneys. Cadmium also affects the components of the blood, as it leads to the destruction of red blood cells, a decrease in the volume of clumped blood cells, and a decrease in the concentration of hemoglobin.

2 – lead

Lead is a toxic heavy metal and it is one of the widespread pollutants in the environment and is not biodegradable. The high concentration of lead in the aquatic environment comes from the remnants of industrial and human activities, battery factories, and household waste, in addition to the wastewater that goes directly to the river[5]. Lead is absorbed directly through the mucous membranes and reaches the bloodstream and to the various organs and tissues of the body. The toxic effects caused by lead include many systems such as the nervous system, renal excretion, and the circulatory system (blood). Lead binds with hemoglobin and causes red blood cells to break down, as it is deposited on their walls, causing their decomposition and reducing their lifespan[13]. Thus, it causes changes in blood parameters such as hematocrit levels, hemoglobin levels, and the total number of red blood cells.

The importance of measuring blood parameters

Fish blood is a viscous red liquid that passes to all parts of the body through the blood arteries. The mechanism of contraction and diastole in the heart muscle works on the flow of blood inside the blood arteries and its distribution to all parts of the body. The percentage of blood volume in fish is lower than that of other vertebrates, as it is in bony fish 2-4 ml/100 g of weight, and in cartilaginous species, it is about 6-8 ml/100 g of weight. Physiological analyzes of blood are very important for identifying the effects of chemical pollutants in fish food and their effect on their health and production[14]. It also causes pathological consequences such as hemolysis, anemia, and hemodilution. Blood assays are frequently used in assessing the metabolic and health status of fish[15]. Blood parameters are influenced by environmental conditions, physiological factors such as age, sex, maturity, body length, weight, temperature, salinity, dissolved oxygen, pH, metabolism, and seasonal variations[16].

Aim of the study

The current study aims to estimate the concentration of lead and cadmium in the waters of the Tigris River, and their effect on some blood parameters represented by the concentration of hemoglobin (Hb), the volume of compacted blood cells (PCV), and the total number of red blood cells (RBC) and white blood cells (WBC), in Both types of fish studied and collected from the study areas in the waters of the Tigris River.

2. MATERIALS AND WORKING METHODS

The study was conducted on the waters of the Tigris River within the city of Mosul, three geographical locations were identified:

- The first location: the waters of the Tigris River, the entrance to the city of Mosul (control area).
- The second location: the waters of the Tigris River in the center of the city of Mosul.
- The third location: the waters of the Tigris River in the south of the city of Mosul.

Water samples were collected from the three locations starting from June 2018 until March 2019 with one sample per month from the surface layer at a depth of 30 cm from the surface of the water and away from the coast. Physical and chemical tests were performed and the concentration of lead (Pb) and cadmium (Cd) for water were measured according to the method mentioned in[17].

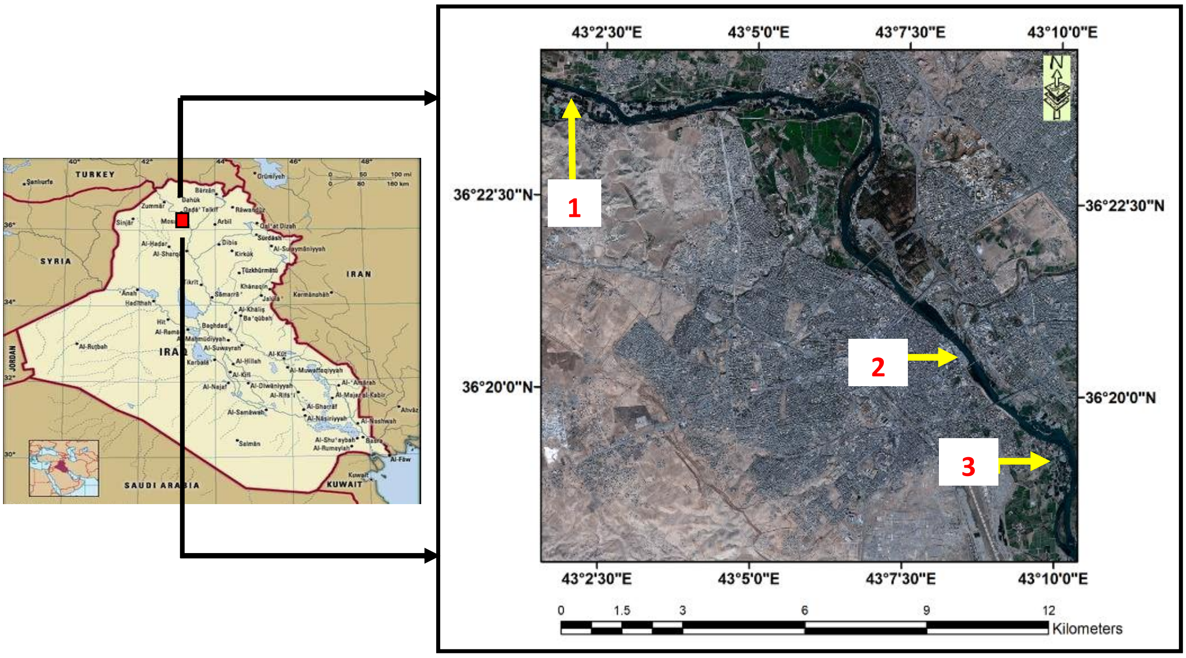

Figure (1): Shows the studied sites on the Tigris River within the Mosul City from Google Earth.

Collect local fish samples

The studied fish samples were collected from the three locations of the waters of the Tigris River, with one sample per month. Two types of local fish were selected, the common carp, *Cyprinus carpio*, and the royal oak *Condrostome regium*. The lengths of the fish ranged between (15-20) cm, with similar weights, and ages not exceeding one year. Their ages were estimated based on the scales of each fish according to what was mentioned[18]. The fish were transferred to the laboratory, and then the blood of the studied fish was obtained from the caudal vein behind the outlet fin about 1 cm from the base of the outlet fin. (EDTA to estimate the volume of compacted red blood cells (PCV, hemoglobin concentration (Hb) and the number of RBC red blood cells was calculated and plastic tubes containing EDTA were used)) in which blood samples were placed, and transferred to the laboratory, used to measure hemoglobin by the Sahli method. PCV) and total red blood cell count using a Hemocytometer.

statistical analysis

The results were statistically analyzed according to a system of randomized complete experimental design, which was selected according to Duncan's multiple range test, and the different treatments were distinguished at the probability level ($p \leq 0.05$).

3. RESULTS AND DISCUSSION

The physical and chemical properties of the water of the Tigris River affect the toxicity and accumulation of chemical pollutants, Table (1). The water temperature ranged between 10-27 ° C, it was observed that the water temperature increased in summer, and it was higher in the second and third locations as a result of the increase in the presence of pollutants and the mixing of river water with estuary water, in addition to water evaporation due to high temperatures. The temperature has a significant impact on fish life, as it affects growth, reproduction, rates of biological and chemical processes, metabolic rates of aquatic animal organisms, and sensitivity of organisms to toxic waste, parasites, and diseases[3]. It was noticed that the electrical conductivity values increased in the spring season in the second location, which was 522 micro-Siemens/cm, as a result of the increase in water turbidity, the increase in rainfall, and the high water levels that lead to the washing away of large quantities of soils of agricultural lands located on both banks of the river. Electrical conductivity (EC_{25}) is considered an important criterion in the osmotic regulation of aquatic organisms. High electrical conductivity values in polluted locations cause an increase in the toxicity of many pollutants such as lead and cadmium[19]. The pH value appeared between (6.9-8.1), as it decreased in the second location in the winter season as a result of its mixing with the effluents of the estuaries. The acidity function of the aquatic environment is one of the main factors that affect the life of fish, and the limits that are directly fatal to fish lie between less than 5 and more than 9. The severity of the acid function depends on several factors, including water hardness, the age, and size of the fish, and the presence of toxic substances such as heavy elements. The growth of fish in an acidic environment is slower than in an alkaline environment. The sudden change that occurs in the environment is negatively reflected on the living organisms, while if the change was gradual, the amount of damage caused would be less for the adaptability of the organisms. The highest value of dissolved oxygen appeared in the first location equals 8.3 mg/liter in the winter season because the concentration of dissolved oxygen is inversely proportional to the environment temperature, while the value decreased to 6.2 mg/l in the second location in the summer due to the high temperature, and the presence of liquid waste and pollutants from the downstream waters that lead to a decrease in the dissolved oxygen concentration[20]. Dissolved oxygen in the aquatic environment is one of the important factors for fish life[21]. The speed of fish growth, activity, and survival can be determined by the amount of available dissolved oxygen in the water. The values of BOD_5, was inversely proportional to the values of dissolved oxygen, as it showed the lowest value in the first location of 0.8 mg/L in the spring season and the highest value of 2.4 mg/L in the second site in the winter, due to the increase in pollutants from estuaries to the river directly in addition to torrents of rain going into the river. The highest value of the total hardness was recorded in the second location of 328 mg/L in the winter season due to the increased mixing of estuaries and torrential waters with river water.

Table (1): Physical and chemical properties and concentration of lead and cadmium for the waters of the Tigris River for the studied sites during the seasons of the year 2018-2019.

Seasons	Summer			Autumn			Winter			Spring		
Sites / Variables	1	2	3	1	2	3	1	2	3	1	2	3
Temprature (°C)	25	26	27	24	24.5	24	10	12	11.4	13	15.5	15
EC_{25} (µS/cm)	354	390	401	363	431	392	430	446	450	501	522	516
pH	7.7	7.1	7.6	7.8	7.2	7.4	7.9	6.7	7.1	8.1	6.9	7.5
DO (mg/L)	7.9	6.2	7.0	7.8	6.8	7.1	7.6	7.0	7.4	8.3	7.2	7.6
BOD_5 (mg/L)	1.3	1.8	1.2	1.2	2.0	1.3	1	2.4	2.0	0.8	2.2	1.7

TH (mg/L)	220	235	230	232	266	257	260	328	326	311	320	324
Pb (mg/L)	0.01	0.09	0.07	0.06	0.11	0.09	0.12	0.22	0.15	0.19	0.26	0.24
Cd (mg/L)	0.002	0.006	0.004	0.003	0.007	0.005	0.011	0.019	0.014	0.012	0.023	0.019

As for the concentration of chemical pollutants (lead and cadmium) in the three locations, they showed a decrease in their rates in the summer in the first site (0.01, 0.002), while their concentration increased in the second and third locations due to their mixing with sewage water and human, agricultural and industrial wastes with no treatment. [22] found that there is an inverse relationship of lead and cadmium with temperature, electrical conductivity, acidity function, and dissolved oxygen, and there is a direct relationship with total hardness and the biological demand for oxygen. While it was observed that there is a direct relationship between both elements lead and cadmium.

Hematological parameters

A significant decrease at the probability level ($P < 0.05$) in hemoglobin concentration, red blood cell volume, and the total number of red blood cells in both types of local fish, that collected from the second and third sites of the waters of the Tigris River within the city of Mosul compared with the first site (control), Table (2) and (3), because of the concentration of the volume of aggregated blood cells is affected by the total number of red blood cells and the concentration of hemoglobin in the blood of fish, and blood parameters in fish change according to the concentration of chemical pollutants, changes in the season, and the general health of the fish. Continuous exposure to chemical pollutants (Lead and Cadmium) has a clear effect on some blood components with the increase in exposure periods to these pollutants, causing damage and disruption of hemoglobin synthesis[23] and [24], and consequently, the anemia is occurred in fish[25]. The results showed that chemical pollutants have an effect on blood components, especially on hemoglobin, as the percentage of hemoglobin decreased in both types of fish collected from the second and third sites to (6.905) (6.867) (7.847) (5.740) mg/100 ml, and it was significantly decreased at the level ($P < 0.05$). This is attributed to the fact that Lead and Cadmium cause a deficiency of iron content in the serum and a deficiency of heme, which leads to anemia, accompanied by a decrease in the total number of red blood cells and the volume of pressurized red blood cells in both types of local fish mentioned above which collected from the second and third sites (2.07) (1.71) (2.10) (2. l) million blood cells / mm^3 compared to the fish of the first site (2.80) (2.82)million blood cells / mm^3.These results agree with the study of[26] and[27]. The toxicity of Cadmium and Lead accumulated in the studied fish increases when the amount of dissolved oxygen in the water decreases in the second and third sites due to the increase in the percentage of pollutants released from estuaries without treatment to the river water. These results are consistent with the study of[28] on the effect of Cadmium toxicity in the aquatic environment. Also, the accumulation of heavy metals in fish tissues disrupts the ionic balance and then changes the purity of the cell membrane, which leads to the destruction of red blood cells and shortens their lifespan and decomposition. It is accompanied by a decrease in the hemoglobin concentration and the volume of compressed blood cells, as well as a decrease in the iron ion concentration in the blood, and a differential effect on white blood cells. The study showed an increase in the total number of white blood cells in both types of local fish and both the second and third sites (8.07) (7.87), (6.86) (7.48) thousand cells/mm^3 compared with the fish of both types in the first site (6.40)). 6.52) thousand cells / mm^3. This increase is attributed as a kind of immune and defense factor to the presence of a toxic substance or tissue damage, and it is considered as an adaptive value for fish.

Blood tests are used as an indicator of the health status of fish as a result of continuous exposure to different environmental conditions, and to several types of chemical pollutants [29], which cause changes in different blood parameters[30]. The number of red blood cells in fish is less than that of mammals, ranging between 2-3 million cells/ml [3]. Red blood cells in fish are oval with a nucleus, and the proportion of immature cells is about 20%, and the percentage of hemoglobin in the blood of fish ranges between 8:12 g/100 ml, and the ability of hemoglobin to carry oxygen varies from fish to fish according to its activity. PCV is an important parameter in expressing the health status of fish, and the normal level is from 20-40%, and it can change according to food status, season changes, and general health of the fish[15]. [31] indicated that the presence of pollutants in high concentrations and for long periods is toxic, because they prevent the absorption of iron and copper in the body, and lead to a defect and change in the properties of cellular membranes, especially the membranes of red blood cells, which leads to severe anemia, kidney failure, and liver diseases. [32] indicated that the low concentration of Hb and PCV is an indicator of the occurrence of anemia, due to the resulting defect in the process of building the protein fragment. This is necessary for building the Hb molecule, accompanied by a decrease in the rate of production of the heme group in the bone marrow, which causes chronic anemia. Several studies have shown that continuous exposure for long periods and in direct contact with pollutants such as heavy metals affects the presence and metabolism of iron, by inhibiting the activity of some enzymes necessary for iron formation, which in turn negatively affects the shape and number of live blood cells. In addition to its effect on the cells in the kidneys and spleen, it increases the permeability of the membrane, which reduces the number of red blood cells and causes anemia. These changes lead to decreased oxygen consumption in the fish and eventually death. [27] reached the same result when studying the effect of the sublethal concentration of cadmium on red blood cells indicators of *C. punctatus* (Bloch) fish after exposure for 5-7-30 days, where there was a decrease in the number of total red blood cells as well as cell volume (PCV), and the level of hemoglobin concentration led to a decrease in the blood's ability to carry oxygen, and it is shortening the life of red blood cells and their decomposition[33]. At the same time, an increase in the number of white blood cells was observed. Similar findings were given by[34], who observed that the low value of PCV (Hematocrit value), Hb, RBCs in fish exposed to stress was attributed to a reduction in RBC volume caused by osmotic changes. On the other hand, similar findings were noticed also by[35] in Cyprinus carpio. They mentioned that the hematological changes in Hb, RBCs, and PCV, reveal a prominent anemic effect which is confirmed by the results of blood indices as hemoglobin converted into methemoglobin as a result of hemolysis and reduced blood oxygen-carrying capacity.

TABLE (1) Effects of Chemical pollution on some hematological *parameters* of *Cyprinus carpio*

Parameter (units) / **Locations**	**Hb 100/g** Mean ±SD	**%**	Change **%**	**PCV %** Mean ±SD	**%**	Change **%**	**Total RBC 10^6Xmm** Mean ±SD	**%**	Change **%**	**Total WBC 10^3Xmm** Mean± SD.	**%**	Change **%**
Control	9.4025	10	----	31.3200	10	------	2.8250	10		6.5250	10	----

() North of the city	a .31595	0		a 1.05840	0		b .09574	0		c .17078	0	
City center	6.9050 b .41988	73 .4	_26.6	23.0025 b 1.39672	73. 44	26.56	2.0750 c .12583	73 .4	_26. 45	7.8750 b .17078	12 0.6	+20. 6
South of the city	5.7400 C .32031	61 .0	_39	9.1275 C 1.06274	29. 14	70.86	1.715 C .09574	60 .7	- 39.3	8.0750 a 17078	12 3.7	+23. 7

Mean ± SD (n = 4)
Significance of difference (p≤0.05). within groups F-value

TABLE 2 - Effects of Cadmium and lead on some hematological parameters of *Condrostoma Regium*

Parameter (Units) / **Locations**	**Hb /g 100** Mean ±SD.	**%**	**Change %**	**PCV %** Mean ±SD.	**%**	**change %**	**Total RBC 10^6Xmm** Mean ±SD.	**%**	**change %**	**Total WBC 10^3Xmm** Mean ±SD.	**%**	**change %**
Control)) North of the city	9.3200 a .2694	100	----	31.0425 a .9022	100	------	2.8000 a .0816	100		6.4000 c .0816	100	----
City center	7.4875 b 42991 .	84.19	-15.81	24.9425 b 1.42913	80.34	_19.66	2.2500 b .1291	80.35	_19.65	7.4875 b .4299	116.8	+16.8
South of the city	6.8675 c .3641	73.68	-26.32	22.9000 b 1.58314	73.76	_26.24	2.1000 b .0816	75	_25	6.8675 c .3641	107.18	+7.18

Mean ± SD (n = 4)
Significance of difference (p≤0.05). within groups F-value

4. CONCLUSIONS

The waters of the Tigris River are exposed to industrial chemical pollutants such as Lead and Cadmium, which leads to their bioaccumulation in fish tissues and thus causes pathological changes in the blood parameters. Fish play a vital role in transporting heavy metals accumulated in their tissues to the human who consumes them, providing a public health risk and significant population harm. Fish blood components indicate the harmful effects of water quality, its act as the biological indicator of aquatic pollution.

5. REFERENCES

[1] Vinodhini, R. and Narayanan, M. Bioaccumulation of heavy metals in organs of freshwater fish *Cyprinus carpio*. Int. J. Environ. Sci. Tech., 2008; 5(2):179-182.
[2] Wahab, H.R. and Al-Zubaidi, F. Investigation of lead and chromium in phytoplankton and zooplankton at a Section of Tigris River at Baghdad City. Ist, Sci, Confer March 2012; 6-7, Baghdad Univ., Iraq.
[3] Murugan, S. S., Kanippasam, R., Poongodi, K. and Puvaneswari, S. Bioaccumulation of zinc in Freshwater fish Chana punctatus (Bloch) after chronic exposure. Turkish Journal of Fisheries and Aquatic Sciences, 2008; 8: 55 – 59.
[4] El-Sarraj, Eman S. Y. Study of pollution of the Tigris River with the various wastes within the city of Mosul and its impact on several local fish, Ph.D. thesis, College of Science, University of Mosul, 2013.
[5] Sahani, S. k. "Hazardous metals and minerals pollution in India Sources, Toxicity, and management". Apposition paper. India National Science Academy. Bahadurshah Zafar Marg. New Delhi, 2011.
[6] Olaifa, F., Olaifa, A., Adelaja, A., and Owolabi, A. Heavy metal contamination of Clarias *gariepinus* from a lake and fish farm in Ibadan, Nigeria. African Journal of Biomedical Research, 2004; 7(3).
[7] Mohanty, BP. Mahanty, A. Ganguly, S. Mitra, T. Karunakaran, D. Anandan, R. Nutritional composition of food fishes and their importance in providing food and
[8] nutritional security. Food Chem. https://doi.org/10.1016/j.foodchem.2017;11.039.
[9] Vilizzi, L. Tarkan, A.S. & Copp, G.H. Experimental evidence from causal criteria analysis for the effects of common carp Cyprinus carpio on freshwater ecosystems: A global perspective. Rev. Fish. Sci. Aquac., 2015; 13 (3):253-290.
[10] Ljubojević, D.; Radosavljević, V.; Pelić, M.; Đorđević, V.; Živkov, B.M. & Ćirković, M. Fatty acid composition, chemical composition, and processing yield of traditional hot smoked common carp (*Cyprinus carpio*, *L*). Iran. J. Fish. Sci. 2016; 15(4):1293-1306.
[11] Rajesh Kumar S, Li X,. Bioaccumulation of heavy metals in fish species from the Meiliang Bay, Taihu Lake, China. Toxically Rep, 2018; 5:288–95.
[12] Tiimub, B. M., and Afua, M. A. D. Determination of selected heavy metals and iron concentration in two common fish species in Densu River at Weija District in the Greater Accra region of Ghana. American International Journal of Biology, 2013; 1(1):45-55.
[13] Mohamad, A., Azlan, A., Shukor, A., Yunus, M., Halmi, M. I. E., and Razman, M. R. Heavy metals (mercury, arsenic, cadmium) in selected marine fish and shellfish along the Straits of Malacca. International Food Research Journal, 2012; 19(1):135-140.
[14] Buha, A.; Wallace, D.; Matovic, V.; Schweitzer, A.; Oluic, B.; Micic, D.; Djordjevic, V. Cadmium exposure is a putative risk factor for the development of pancreatic cancer. Three different lines of evidence. BioMed Res. Int., 2017; 31(16):837-981.
[15] Burgos-Aceves, M.A. Lionetti, L. Faggio, C. Multidisciplinary hematology as the prognostic device in environmental and xenobiotic stress-induced response in fish. Sci. Total Environ., 2019; 670:1170-1183.

[16] Adhikari, S. and B. Sarkar. Effects of cypermethrin and carbofuran on certain hematological parameters and prediction of their recovery in a freshwater teleost, Labeorohita(Ham). Ecotoxicol. Environ. Saf., 2004; 58: 220-226.
[17] Sancho, E., J.J. Cerón and M.D. Ferrando. Cholinesterase activity and hematological parameters as biomarkers of sublethal molinate exposure in *Anguilla anguilla*. Ecotoxicol. Environ. Saf., 2000; 46:81-86
[18] APHA (American Public Health Association). Standard Methods for the Examination of water and wastewater, 1998; 20th Edition, American Public Health Association, New York, USA.
[19] Lagler, K. F. "Fresh Water Fishery Biology". 2nd ed. W. M. Brown Co. publi., Dubqu, Iowa, 1956; 545 P.
[20] Harrison, R. M. An introduction to pollution scince. 2ed. RSC public. The UK. 345. freshwater ecology report, 2006; 25.
[21] Al-Sarraj, Eman.S.Y. A Study of Physiochemical Characteristics of Al- Khoser River Effluent and its Effect Upon Tigris River Quality within Mosul City. Rafidain Journal of Science, 2019; 28(3):77-89.
[22] Konzen, G. B., Figueiredo, J. A.S. and Quevedo, D. History of Water Quality Parameters: A Study on the Sinos River/Brazil. Braz. J. 2015; 75(2):1-10.
[23] Al-Sarraj, Eman.S.Y.; Jankeer M. H. Effect of Pollutants of the Tigris River Water on Activity of the Acetylcholinesterase Enzyme in Brain Tissues of *Cyprinus carpio* and *Condrostoma regium*. Indian Journal of Ecology . 2020; 47(4):949-954.
[24] Goel, K.A., K. Gupta and M.L. Sharma. Hematological characteristic of Heteropneustesfossilis under the stress of zinc. Ind. J. Fish, 1985; 36:186-188.
[25] Goel, K.A., and S.D. Sharma, Some hematological characteristics of Clariasbatrachus under metallic stress of *Arsenic.Comp*. Physiol. Ecol., 1987 ;12: 63-66.
[26] Praveena M., V. Sandeep, N. Kavitha, and K. Jayantha Rao.(2013)Impact of Tannery Effluent, Chromium on Hematological Parameters in a Fresh Water Fish, LabeoRohita (Hamilton). Res. J. Animal, Veterinary and Fishery Sci., 1(6):1-5.
[27] Karak, J., Alnaser, O. and Thanaa Sh., Accumulation of some heavy metals in Him (*Barbu luteus*) and common Carp (*Cyprinus carpio*) fish in Euphrates river - Syria, J. Animal, and poultry prod., Mansoura university, 2010; 1(12), 669-675.
[28] Karuppusamy R, S. Subathra and S. Puvaneswari. Hematological responses to exposure to sublethal concentration of cadmium in air-breathing fish, *C. punctatus* (Bloch.). J. Environ. Biol., 2005; 26(1):123-128.
[29] Hattink J, De Boeck G, Blust R. The toxicokinetics of cadmium in carp under normoxic and hypoxic conditions. Aquat Toxicol. 2005; 75(1):1 -15.
[30] Blaxhall P.C. The hematological assessment of the health of freshwater fish. Journal of Fish Biology, 1972; 4(4):593- 604.
[31] Heath, A.G. Water Pollution and Fish Physiology. Seconded. Lewis Publishers, Boca Raton. 1995.
[32] Palacios, A.; Hurley, K.; Ponce, S.; Alfonso, V.; Tilton, N.; Lambden, K.; Reinhart, G.; Freeland, J.; Villanueva, L. and Black, M. Zinc deficiency associated with anemia among young children in rural Guatemala. J. Nutri., 1111(10):1-10.
[33] Al-Mashhadani, Nour Abdel Halim Abdel Rahman (2013). Studying the effect of aromatic benzene on some blood components, liver enzymes ALP, ALT, AST, and blood urea level among workers at filling stations in Anbar Governorate. Tikrit Journal of Pure Sciences 18 (4):35-38. (In Arabic).

[34] Gill T.S., Epple A., (1993). Stress-related changes in the hematological profile of the American eel (*Anguilla rostrata*). Ecotoxicol. Environ Saf. 25: 227-235.
[35] Lena P. J. and Sivaprakasam M. Impact of heavy metal pollution on haematological parameters in freshwater fishes. International Journal of Environment, Ecology, Family and Urban Studies (IJEEFUS) ISSN (P): 2250-0065; ISSN (E): 2321-0109. 2018; 8(2), 1-8 © TJPRC Pvt. Ltd.
[36] Abdul Majid Tak, FA Bhat*, Ulfat Jan and G Mustafa Shah. Sub lethal, Hematological Effects of Dichlorvos on the fresh water fish, Cyprinus carpio var. Communis. International Journal of Recent Scientific Research, 2014; 5(7), pp. 1334-1337.