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# DETERMINATION OF HEAVY ELEMENTS (Pb, Cd, Cu AND Cr) CONCENTRATION IN SOME WATER SOURCES

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**Abstract.** This study focuses on identifying some of the heavy and toxic elements concentration in several sources of water in Diyala Governorate in Iraq, such as the Diyala River and the Khirisan River. The samples of tap water and bottled drinking water were taken three water wells from and two companies. The elements under study were: lead, cadmium, copper and chromium. Flame atomic absorption spectroscopy has been used to determine the concentrations. It was determined that copper concentrations are within normal limits and satisfy Iraqi and world health organization standards for drinking water, whereas the concentrations of lead, chromium, and cadmium are higher than the standard limits.

**Keywords:** metal, lead, cadmium, copper, chromium.

## 1. Introduction

Water sources in Iraq have undergone significant deterioration in recent times due to the lack of government support. The last twenty years Iraq has faced serious and dangerous pollution in the natural environment, such as air pollution, soil pollution, and water pollution due to wars and many other factors. The country is now going through a decline and deterioration related to the quality of water because the multiple sources of pollution with no strategies to develop and strengthen the foundations for the provision of clean water. The water sources in Iraq represented by drinking water, rivers, and groundwater are polluted [1]. The pollution problems of rivers water by heavy metals are considered the most prominent environmental problems.

The solutions for these problems are difficult because of the neglect from the government side and the large amounts of trash and remnants of war, factories and hospitals waste, such as chemicals, pesticides and agricultural fertilizers [2]. Heavy elements referred to in this study have a specific density of 5 g/cm$^3$ (five times more than the specific density of water 1 g/cm$^3$) and adversely affect the environment and living organisms [3]. The main important and toxic heavy elements contaminated water are lead, mercury, chromium, cadmium, copper, nickel, and zinc. Table shows the maximum concentrations for some heavy elements in drinking water, permitted by the World Health Organization (WHO) and Iraqi standards.

**Limit values for some heavy elements in drinking water (mg/l) [4, 5]**

| Heavy element | WHO | Iraqi standards |
|---|---|---|
| Cd | 0.003 | 0.003 |
| Cr | 0.050 | 0.050 |
| Cu | 2.000 | 1.000 |
| Pb | 0.010 | 0.010 |

Many studies have proven the risks of heavy metals as a significant threat in addition to associated health risks. The toxic effects of these elements, although they do not have any biological role, are still present in harmful forms in the human body. Sometimes, heavy elements act as a deceptive element in the body, and in some cases they may interfere with the human metabolic processes [6]. Lead is a cumulative toxicant that affects the body system and causes dangerous harm to kids [5]. Besides, lead has carcinogenic properties, and it impairs both the respiratory and digestive tracts and crushes the immune system of a human body; this element is harmful to children and can damage their brain and nervous systems [7-10]. Cadmium deposit goes directly in the human circulatory system, kidney (the renal cortex), respiratory tracts, and the heart. Cadmium has been classified as a group 1 carcinogen [11-13]. Chromium can exist in many oxidation states. Hexavalent chromium (VI) is highly soluble and is extremely harmful to the skin, liver, kidney, and lungs [14], and it can cause various diseases, lung cancer in particular [15]. Increasing concentration of copper can cause many diseases, such as kidney failure, blood cell damage, and central nervous system inhibition [16].

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A few research studies highlighted the serious effects of the contamination of water sources with heavy elements in Diyala Governorate (Fig. 1). This is attributable to many reasons, such as the dangerous security conditions and lack of scientific research capabilities in the governorate [17, 18]. However, Diyala Governorate is one of the most polluted regions in Iraq due to the government neglect, the lack of clean water sources, untreated sewage water, and the remnants of hospitals and military weapons in the Diyala River. Actually, the Diyala River flows from the Zagros Mountains in Iran and then enters Iraq from the province of Diyala. It pours into the Tigris River south of Baghdad. This river has a total length of 445 km. As for the Khirisan River, it is a branch of the Diyala River and it runs from the Lake Hamrin and ends in the orchards at the end of the city of Buhriz where it disappears. Other small rivers are considered the main sources of drinking water in the governorate (Figs. 2, 3).

This study focuses on the determination of concentrations of some heavy metals, such as lead, cadmium, chromium and copper in different sources of water in Diyala Governorate. It also shows the rates of pollution in these water sources with heavy elements which cause environmental and health risks.


**Fig. 1.** Map of Diyala Governorate

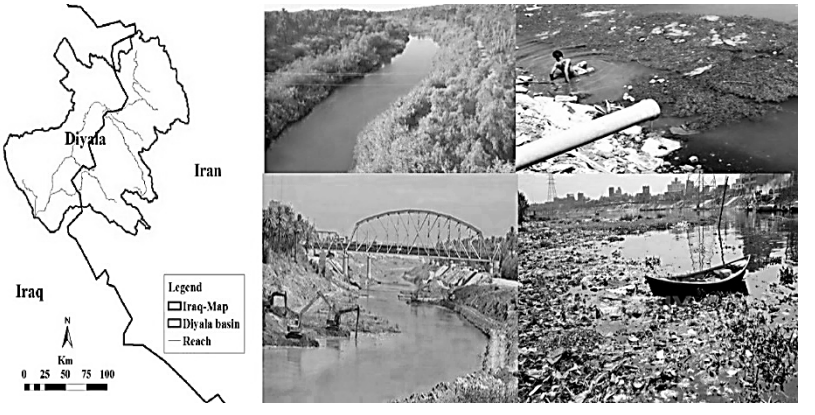



**Fig. 2**. Pictures of the Diyala River and its pollution.
The pictures were taken in 2016–2017

**Fig. 3.** Pictures of the Khirisan River and its pollution.
The pictures were taken in 2016-2017

# 2. Experimental

## 2.1. Samples Collection

Samples from the Diyala River were collected from four locations in Baquba city (Fig. 2), and samples from the Khirisan River were collected from three locations in Buhriz city and Huider town (Fig. 3). Many samples of refinery drinking water were collected in Al-Hadd Al-Akhder village, Huider town, and Baquba city. Samples of bottled drinking water sterilized by ozone were taken from different companies in Baquba city (Fig. 4) while some samples were collected from three water wells which are located in Baquba city, Al-Abara region, and Buhriz city. All samples were collected in sterile plastic tubes between August 2016 and February 2017. We re-analyzed all samples for 3 times.

## 2.2. Instrumentation

The concentration of heavy elements was determined by using flame atomic absorption spectrometer AAS (Aurora Instruments Ltd. 1200, Canada 2004). All instrumental parameters were established according to the recommendations of the manufacturer. Lead, cadmium, copper and chromium hollow cathode lamps were used as the radiation sources, operated at 5 mA with a slit width of 0.2 nm. The wavelengths for all lamps were set at 217 nm resonance line. The air-acetylene flame was used in these analyses, and fuel flow rate was 1.5 l·min$^{-1}$.

# 3. Results and Discussion

The experimental results are presented in Fig. 5. The concentrations of heavy elements (Pb, Cu, Cr, Cd) are distributed in different resources of water in Diyala Governorate.

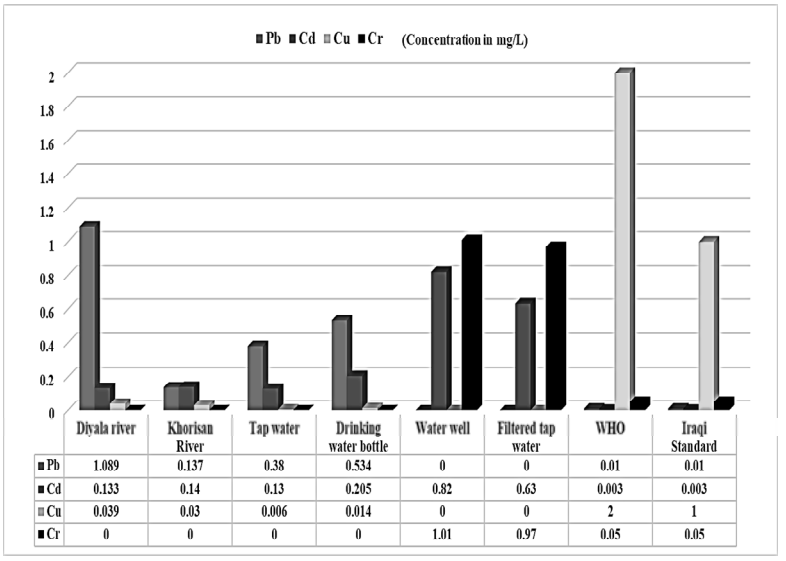
In this study, concentrations of lead (Fig. 6) in different study areas were as follows (mg/l): the Diyala River (1.089±0.006), the Khirisan River (0.137±0.008), tap water (0.380±0.011) and bottled drinking water (0.534±0.003). These results are worthy of interest and are taken into higher consideration by researchers and specialists because they significantly exceed the limit values (0.010 mg/l). It is a serious risk to the public health of water consumers in these areas in addition to dangerous environmental effects. Water pollution by lead in the Diyala River is about 109 times more than the limit values of heavy elements according to Iraqi and WHO standard. However, water pollution is about 14 times higher than the normal values in the Khirisan River while the pollution by lead concentrations in the tap water and bottled drinking water are respectively by 38 and 54 times more than international allowed limits. The highest percentage of contamination by Pb is in the Diyala River. This can be shown as follows:

the Diyala River > bottled drinking water >
> tap water > the Khirisan River

According to the WHO and Iraqi standards (Table) for drinking water, the concentration of cadmium cannot exceed 0.003 mg/l. At higher concentrations cadmium is harmful to the body; it causes several diseases, such as renal failure and increased exposure to various cancers. The results of identifying cadmium concentrations in (mg/l): the Diyala River (0.133±0.002), the Khirisan River (0.140±0.012), tap water (0.130±0.001), filtered tap water (0.630±0.013), bottled drinking water (0.205±0.009) and well water (0.820±0.010). All values were extremely high compared to the standards (Fig. 7), especially in the well water which is used for drinking and irrigation of agricultural land in many regions in the governorate (Cd concentrations found in well water are by 274 times more than limit value of Cd concentration in drinking water (0.820 mg/l *versus* 0.003 mg/l). However, the lowest percentage of contamination with cadmium is found in tap water. It is clearly seen as follows:

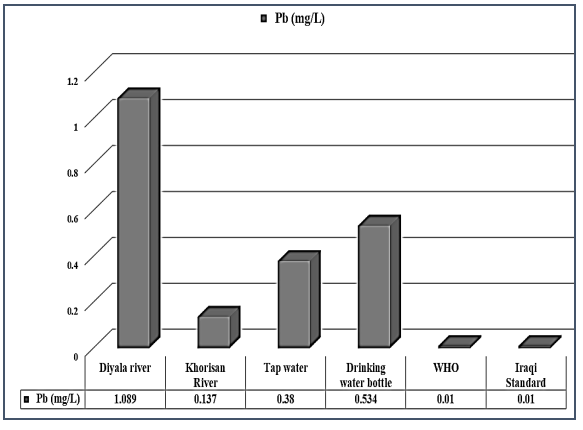
Well water > filtered tap water > bottled drinking water >
>the Khirisan River > the Diyala River > tap water.


**Fig. 4.** Pictures of well water and refinery drinking water.
The pictures were taken in 2016-2017



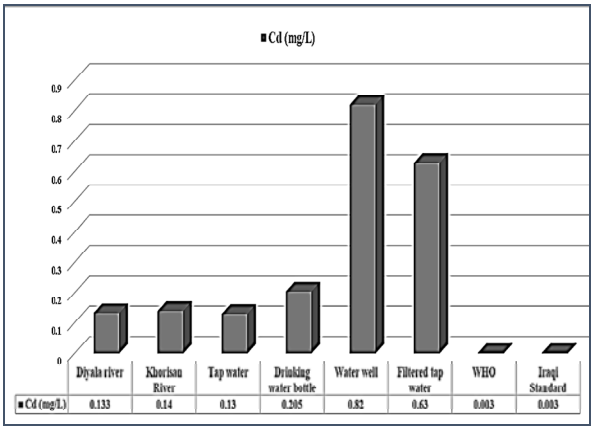

| | Diyala river | Khorisan River | Tap water | Drinking water bottle | Water well | Filtered tap water | WHO | Iraqi Standard |
|---|---|---|---|---|---|---|---|---|
| Pb | 1.089 | 0.137 | 0.38 | 0.534 | 0 | 0 | 0.01 | 0.01 |
| Cd | 0.133 | 0.14 | 0.13 | 0.205 | 0.82 | 0.63 | 0.003 | 0.003 |
| Cu | 0.039 | 0.03 | 0.006 | 0.014 | 0 | 0 | 2 | 1 |
| Cr | 0 | 0 | 0 | 0 | 1.01 | 0.97 | 0.05 | 0.05 |

**Fig. 5.** Atomic absorption analysis of the studied samples of some heavy elements



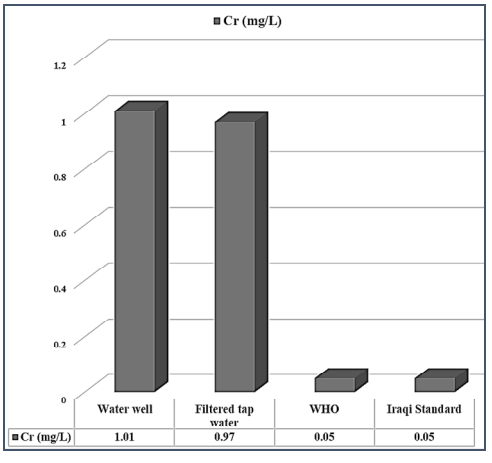

| | Diyala river | Khorisan River | Tap water | Drinking water bottle | WHO | Iraqi Standard |
|---|---|---|---|---|---|---|
| Pb (mg/L) | 1.089 | 0.137 | 0.38 | 0.534 | 0.01 | 0.01 |

**Fig. 6.** Concentrations of Pb in different investigated areas



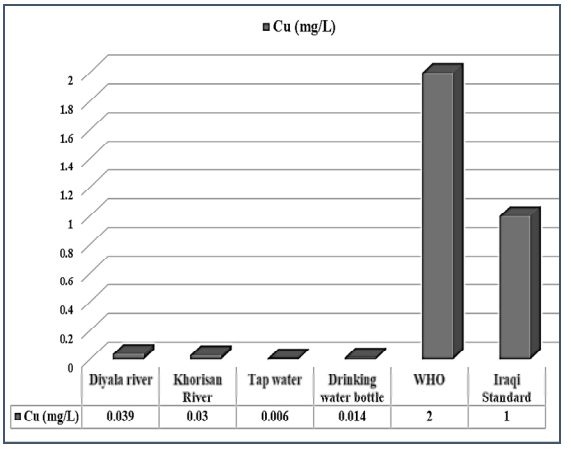

| | Diyala river | Khorisan River | Tap water | Drinking water bottle | Water well | Filtered tap water | WHO | Iraqi Standard |
|---|---|---|---|---|---|---|---|---|
| Cd (mg/L) | 0.133 | 0.14 | 0.13 | 0.205 | 0.82 | 0.63 | 0.003 | 0.003 |

**Fig. 7.** Concentrations of Cd in different investigated areas




| | Water well | Filtered tap water | WHO | Iraqi Standard |
|---|---|---|---|---|
| Cr (mg/L) | 1.01 | 0.97 | 0.05 | 0.05 |

**Fig. 8.** Concentrations of Cr in different investigated areas




| | Diyala river | Khorisan River | Tap water | Drinking water bottle | WHO | Iraqi Standard |
|---|---|---|---|---|---|---|
| Cu (mg/L) | 0.039 | 0.03 | 0.006 | 0.014 | 2 | 1 |

**Fig. 9.** Concentrations of Cu in different investigated areas

The chromium concentration (Fig. 8) in filtered tap water samples (0.970±0.004 mg/l) and well water samples (1.010±0.014 mg/l) are higher by about 20 times compared to the limit concentration according to the World Health Organization and Iraqi standards (Table). This can be explained by the fact that Cr in water in Diyala Governorate may be presented as remnants of war weapons, soil pollution, and domestic waste from various synthetic materials. Additionally, waste incineration may contribute to the pollution of the environment when protection is insufficient. Between 2008 and 2014, many cases of of drinking water and wells water contamination by chromium have been monitored by US military laboratories in many areas in southern and central Iraq, including Diyala Governorate [19-22].

The results of the study show the decrease in copper concentration (mg/l): the Diyala River (0.039±0.002), the Khirisan River (0.030±0.003), tap water (0.006±0.003), and bottled drinking water (0.014±0.008) (see Fig. 9). The reason of copper low concentrations in water is attributable to the low concentration of copper in the Iraqi territories on the whole [23].

## 4. Conclusions

The study shows that the water in all investigated resources (the Diyala River, the Khirisan River, tap water and bottled drinking water) is contaminated with heavy metals. Moreover, there are several other contaminating factors behind the increase of the pollution in water resources in Iraq in general and in Diyala Governorate in particular. Some of these factors are automobile exhaust, irresponsible industrial activities, throwing hospital waste in the rivers, lack of advanced systems to extract heavy and toxic metals and ions from water, as well as the military operations and dangerous security conditions in the governorate and the continuous neglect of the government to find solutions for these problems.

Therefore, we recommend the following to reduce the level of pollution in Iraqi water resources:

The industrial facilities built along the Diyala River, including small factories, industrial workshops, and hospitals should be upgraded to treat contaminated water before being put into rivers.

To carry out damage control of the pipes of drinking water, to build new pipes, and get rid of the old ones. The previous period of wars and conflicts led to the breakage of water pipes and caused sterile drinking water mixing with heavy ground water.

To conduct a comprehensive survey of environmental problems according to their location. To study the pollution caused by the water entering Iraq from the neighboring countries and conducting all the studies related to water. To declare a plan for the comprehensive protection of water resources and environmental components by the new government and consider this part as a national program.

Follow-up of the operations of the filter stations to ensure that the stations complete the filtration and sterilization steps despite the power cut. The operations of filtration and sterilization stop when there is power cut and this leads to the continuity of contaminated and poisonous water supply to the houses. It is highly necessary to find a solution to this problem.

The inspection of drinking water should be done periodically by the municipalities or health authorities.

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## ВИЗНАЧЕННЯ КОНЦЕНТРАЦІЇ ВАЖКИХ ЕЛЕМЕНТІВ (Pb, Cd, Cu, Cr) У ДЕЯКИХ ВОДНИХ ДЖЕРЕЛАХ

***Анотація.*** *Визначено концентрації важких і токсичних елементів у декількох водних джерелах в провінції Діяла в Іраку, таких як річка Діяла та річка Хірісан. Відібрано зразки питної води та води у пляшках з трьох водяних свердловин та двох компаній. Визначено вміст таких елементів як свинець, кадмій, мідь та хром. Для визначення концентрацій елементів застосовано атомно-абсорбційну спектроскопію. Встановлено, що концентрація міді є в межах норми і відповідає стандартам Іраку та світової організації охорони здоров'я щодо питної води, а концентрації свинцю, хрому та кадмію перевищують вказані норми.*

***Ключові слова:*** *метал, свинець, кадмій, мідь, хром.*