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Lead, Cadmium and Mercury Concentrations in the Tap, River and Well Water with Different Treatment from Regions along Tigris River

By

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Abstract

This study was conducted to investigate the concentration of heavy metals (lead, cadmium and mercury) in tap, well and river water along the Tigris River. Water samples were taken from different regions (Mosul, Salahuddin, Baghdad, Wasit and Misan) to study the concentration of these pollutants in the different regions. Chlorine and alum were used in river and well water to reduce pollution in some heavy metals.

Lead concentration in the river, tap and well water of the Mousel governorate were significantly higher ($P<0.05$) compared with other governorates. The different treatment to the river and well water with Chlorine and Alum showed that concentration of lead from the different governorates were decreased significantly ($P<0.05$) than untreated water except for river and well water of Wasit governorate. However Cadmium concentration in the river and well water of Baghdad, Mousel and Misan governorate were significantly higher ($P<0.05$) compared with it concentration in other governorates. After river and well water treated with Chlorine and Alum, results showed that cadmium concentration in Baghdad governorate lowest concentration ($P<0.05$) of the cadmium compared with its concentration in the river and well water of other governorates.

Mercury concentration were recorded only in well water of Misan governorate and when treated with chlorine and alum the results showed the concentration of mercury in decreased significantly compared with untreated water. While mercury and cadmium concentration in the tap water of different governorates shows non – significant difference between them.

Keywords: heavy metals; Tigris River; pollutants

Introduction

Water pollution is described as the alteration of water's physical, chemical, and biological qualities, which limits or prevents the use of water for a variety of purposes **(Taha et al., 2004).** Water that has been contaminated by agriculture or houses, sewage water, or industrial discharges can be harmful to the environment or human health **(Ashraf et al., 2010).** Any metallic chemical element, including lead, cadmium, mercury, and arsenic, is referred to as a "heavy metal" and is exceedingly dangerous to both humans and animals, uncontrolled human behavior, such as fast industrialization, excessive urbanization, and environmental manipulation, has drastically altered the biogeochemical processes, at the end

of the nineteenth century, pollution began to arise and grow in size as a result of human activity, especially in and around large urban areas, which received thousands of tons of gas and dust that polluted and disturbed the air **(Fadhil et al., 2013).**

When heavy metals like lead are excessive levels in drinking water can be harmful, while cadmium is exceedingly dangerous even at low quantities, it will bio-accumulate in species and ecosystems. Renal harm is also brought on by prolonged exposure to cadmium **(Zbaar & Marbut, 2009).**

Heavy metal deposition may develop in the crops that grow in the soil as a result of polluted water aggregation, which continues to damage agricultural soil **(Verma et al., 2018).** As one of the most ecotoxic metals that have extremely negative impacts on soil biological activity, plant metabolism, human health, and the animal world, there is growing environmental concern about Cd **(Okereafor et al., 2020).**

Aluminum sulfate(Alum) is used in water purification and for chemical phosphorus removal from wastewater, it causes suspended impurities to coagulate into larger particles and then settle to the bottom of the container (or be filtered out) more easily, this process is called coagulation or flocculation **(Ilje & Keshab ,2014)**

However, as high concentrations of chlorine may be harmful to public health, the WHO recommends that chlorine levels in drinking-water should not exceed 5 mg/L, World Health Organization (WHO,2011).

The aim of this study was to find out the concentrations of some heavy metals in the river, wells and tap water, as well as to remove or reduce these metals by using alum and chlorine.

Material And Method

This study lasted 3 months (February, March and April 2022). Collected one hundred and fifty water samples from each of the river, tap and well water from different areas along the Tigris River in Iraq (Mosul, Salahuddin, Baghdad, Wasit and Maysan) Samples were collected in clean and dry 1-liter plastic containers. The samples were kept in a refrigerator at 4 °C prior to analysis, after which they are sent to the laboratories of the Iraqi Ministry of Science and Technology for measurement of heavy metal concentration.

Lead concentration measurement

The procedure to estimating of lead examination was by atomic absorption spectrometry device flame (Bryson, 1996).

Cadmium concentration measurement

Estimating of cadmium was examined by using atomic absorption spectrometry device, flameless (Bryson, 1996).

Cadmium concentration measurement

Mercury estimation were done by using cold vapor atomic absorption spectroscopy

The samples by standardized procedure, stock standard (1000 µg /dl) was used to make working standard of different one (10, 20, 30 µg /dl) and a calibration curve was done (GUPTA et al., 2010). The spectrometer is operated with wavelength, (253.7 nm); equipped with deuterium are background correction and a mercury hollow cathode lamp source (stux & rothery, 1971).

Water treatment

Alum (Aluminium Sulphate) powder is a white, crystalline solid, Preparation of a 500ml water sample inside the laboratory and Alum 15mg/L for the purpose of treating the water sample,Add 15 mg /L to 500 ml of the (river &wells) water samples,Leave it for 30 minutes for the purpose of homogeneity,sent to the laboratory for the purpose of measuring the concentrations of lead, mercury and cadmium after treatment with alum (APHA .1998). treatment well & river water with Chlorination involves adding a measured amount of chlorine to water to produce enough residue to kill bacteria, viruses, cysts, and reduce heavy metals. (Landaburu et al. 2010). Preparation of a 500ml water sample inside the laboratory, Add 1.25 mg /L to 500 ml of the water sample,Leave it for 30 minutes for the purpose of homogeneity,sent to the laboratory for the purpose of measuring the concentrations of lead, mercury and cadmium after treatment with chlorine. (WHO,2011).

Statistical analysis

The program was used to detect the effect of difference locations in study parameters. Least significant difference -LSD test (Analysis of Variation - ANOVA) was used to significant comparison between Estimate of correlation coefficient between variables in this study means (SAS, 2012).

Results And Discussion

Table (1) showed that lead concentration in the river and well water of the Mousel governorate were significantly higher (P<0.05) compared with other governorates. While, lead concentration recorded lowest in the river and well water of Salah Uddin governorate (1.04±0.01, 1.04±0.005) respectively.

The different treatment to the river and well water with Chlorine and Alum showed that concentration of lead from the different governorates were significantly lower (P<0.05) than untreated water except for river and well water of Wasit governorate.

After river and well water treated with Chlorine the results showed that lead concentration in the river water lowest in Baghdad and Mousel governorate compared with other governorates (0.93±0.1, 0.93±0.01) respectively. While treatment with Alum showed the concentration of the lead in the River water lowest in Mousel governorate (0.86±0.01) compared with the concentration of lead in other governorates.

Table (1) *Lead Concentrations in the River and Well (with or without) Treatment with Chlorine or Alum from Different Regions along Tigris River (µg\dl)*

Governorate	Source	Without treat	Treated with Chlorine	Treated with Alum
Baghdad	River	A1.25±0.01bc	B0.93±0.10f	B0.91±0.01ef
	Well	A1.24±0.03bc	B1.07±0.04d e	B1.03±0.009d
Mousel	River	A1.32±0.01a	B0.93±0.01f	C0.86±0.01f
	Well	A1.35±0.02a	AB1.31±0.01a	B1.25±0.008a
Salahuddin	River	A1.04±0.01e	A1.03±0.007ef	B0.94±0.008e
	Well	A1.04±0.005e	A1.04±0.005e	B0.95±0.007e
Misan	River	A1.27±0.01b	B1.19±0.01bc	C1.07±0.01cd
	Well	A1.24±0.01bc	A1.21±0.008b	B1.11±0.01bc
Wasit	River	A1.13±0.008d	A1.13±0.009cd	A1.12±0.005b
	Well	A1.20±0.005c	A1.19±0.004bc	A1.17±0.007b
LSD		0.06		

Means with a different small letter in the same column are significantly different (P<0.05)

Means with a different capital letter in the same row are significantly different (P<0.05)

Table (2) showed that cadmium concentration in the river and well water of Baghdad, Mousel and Misan governorate were significantly higher (P<0.05) compared with it concentration in other governorates. While cadmium concentration in the river and well water of Wasit governorate recorded the lowest concentrations (0.053±0.0006, 0.054±0.0005) respectively.

After river and well water treated with Chlorine results showed that cadmium concentration in Baghdad governorate lowest concentration compared with it concentration in the other governorates (0.050±0.0006, 0.050±0.0007) respectively. While river and well water of Baghdad and Wasit governorates treated with Alum showed significant lowest concentrations (P<0.05) of the cadmium compared with its concentration in the river and well water of other governorates. Cadmium concentration were decreased significantly (P<0.05) in the river and well waters after treated with chlorine compared with non-treated water. While the concentration of cadmium were decrease (P<0.05) in all governorate in the river and well water when treated by alum compare with untreated water. On the other hand the concentration of cadmium were decreased significantly (P<0.05) in the river and well water of all governorates when treated by alum compare with treated by chlorine.

Table (2) *Cadmium Concentrations in the River and Well (with or without) Treatment with Chlorine or Alum from Different Regions along Tigris River (µg\dl)*

Governorate	Source	Without treat	Treated with Chlorine	Treated with Alum
Baghdad	River	A0.076±0.001a	B0.050±0.0006g	C0.035±0.0008h
	Well	A0.075±0.0007a	B0.050±0.0007g	C0.039±0.0007g
Mousel	River	A0.074±0.0007a	B0.063±0.0007b	C0.055±0.0008b
	Well	A0.075±0.0006a	B0.071±0.0004a	C0.064±0.0007a
Salahuddin	River	A0.055±0.0007b	A0.053±0.0004f	B0.045±0.0004de
	Well	A0.056±0.0004b	A0.056±0.0004de	B0.046±0.0006d
Misan	River	A0.076±0.0006a	B0.058±0.0006cd	C0.051±0.0006c
	Well	A0.076±0.002ba	B0.058±0.002cd	C0.052±0.002c
Wasit	River	A0.053±0.0006c	A0.054±0.001ef	B0.041±0.001fg
	Well	B0.054±0.0005bc	A0.059±0.001c	C0.043±0.0007ef
LSD		0.002		

Means with a different small letter in the same column are significantly different (P<0.05)
Means with a different capital letter in the same row are significantly different (P<0.05)

Table (3) showed the concentration of Mercury were significantly higher (P<0.05) in the well water of Misan governorate (0.00051±0.0001) compared with its concentration in the river and well water of other governorate.

After well water of Misan governorate treated with chlorine and alum the results showed the concentration of mercury in decreased significantly compared with untreated water

Table (3) *Mercury Concentrations in the River and Well (with or without) Treatment with Chlorine or Alum from Different Regions along Tigris River (µg\dl)*

Governorate	Mercury µg/L	Lead µg/L	Cadmium µg/L
Baghdad	0.00±0.00	1.15±0.02a	0.04±0.001a
Mousel	0.00±0.00	1.16±0.01a	0.05±0.0008a
Salah Uddin	0.00±0.00	0.98±0.01c	0.04±0.0008a
Misan	0.00±0.00	0.98±0.02c	0.04±0.001a
Wasit	0.00±0.00	1.04±0.01b	0.04±0.0008a
LSD	0.00	0.04	0.02

Means with a different small letter in the same column are significantly different (P<0.05)
Means with a different capital letter in the same row are significantly different (P<0.05)

Table (4) showed that lead concentration in the tap water of Baghdad and Mousel governorates were significantly higher (P<0.05) compared with the other governorates. While, lead concentration in the tap water of Misan and Salah Uddin governorates recorded the lowest (P<0.05) concentration in tap water. However, Mercury and Cadmium concentration in the tap water of different governorates shows non – significant difference between them.

Table (4) *Concentrations of Mercury, Lead and Cadmium in Tap Water from Different Regions along Tigris River (µg\dl)*

Governorate	Source	Without Treat	Treated with Chlorine	Treated with Alum
Baghdad	River	A0.00±0.00b	A0.00±0.00b	A0.00±0.00a
	Well	A0.00±0.00b	A0.00±0.00b	A0.00±0.00a
Mousel	River	A0.00±0.00b	A0.00±0.00b	A0.00±0.00a
	Well	A0.00±0.00b	A0.00±0.00b	A0.00±0.00a
Salahuddin	River	A0.00±0.00b	A0.00±0.00b	A0.00±0.00a
	Well	A0.00±0.00b	A0.00±0.00b	A0.00±0.00a
Misan	River	A0.00±0.00b	A0.00±0.00b	A0.00±0.00a
	Well	A0.00051±0.0001a	B0.00025±0.0001a	B0.0002±0.0001a
Wasit	River	A0.00±0.00b	A0.00±0.00b	A0.00±0.00a
	Well	A0.00±0.00b	A0.00±0.00b	A0.00±0.00a
LSD		0.00020		

Means with a different small letter in the same column are significantly different (P<0.05)

Table (1) showed that concentration of lead in river and well water were significantly higher (P<0.05) in Mousel governorate than its concentration in the other governorate may be due to the military operation which take place there. **Abbas et al. (2018)** revealed that the high levels of pollution in recent years are due to various factors including directly from wars, factories, and the discharge of water from houses and hospitals directly into the Tigris River, which contains many polluted materials (chemicals, pesticides, and agricultural fertilizers). Certain factors that are not explicitly due to government negligence and the lack of a systematic management strategy to tackle these pollution causes. Since 2003, as showed in table (2) due to widespread implications for irrigation of plants and as water supply for animals, aside from intense industrial pollution, multi-faceted hydrogeochemical interactions control Cd mobility **Kubier and Pichler, (2019).** However, Mercury concentration recorded significant (P<0.05) increase in the well water of Misan governorate compared with the other water sources and governorates as showed in table (3) because the confined area southeast of

Misan Governorate contains red mercury, which is the most expensive among minerals. Quantities of highly toxic heavy metals are discharged, such as mercury Silver and lead are from the sections of radiography and others **(Pruss et al., 1999)**. Until now, the sewage treatment plants are not able to get rid of it and the pollution comes Mercury from several medical sources, including dental clinics and filling processes for patients' teeth with filling material 1 mg (which contains 49% mercury and results from the breakage of some medical devices containing this Article **(Barron., 2001).** Our results were agreed with **Jernelov (1976)** who recorded the outbreak of organ mercury poisoning in Iraq, an investigation was carried out during the spring and summer of 1972 to evaluate environmental contamination by organ mercury. While **Al-imarah et al. (2003)** found that Mercury is expected to pollute water in southern Iraq due to exploded weapons, pesticides and paper and chlorine industries. Levels of mercury in water and sediments correlate quite fairly in Tigris River and Shatt Al-Arab River. However, concentrations of heavy metals in tap water from different governorates as showed in table (4). Revealed that lead concentration increased significantly in the tap water of Baghdad and Mousel governorates compared with other governorates and heavy metals, which agreed with the results of **Salman& Dawood (2021)** that may related to its dissolution from natural sources, primarily from household plumbing systems in which the pipes, solder, fittings or service connections to homes contain lead. Polyvinyl chloride (PVC) pipes contain lead compounds that can be leached from them and result in high lead concentrations in drinking water **Ruckart (2019).** The reason is that most of the water pipes are old and corroded, and they leak, all these things were caused by an increase in lead in tap water,**(Al obaidy et al .,2016).** The researcher showed that water quality levels incline due to the dissolution process of salts, leaching process, and higher level of population. **(Hasan uzzaman et al., 2017).** Most of the research work on surface water and groundwater showed that physicochemical, microbial, minerals, and heavy metals levels were higher than the prescribed limits as per the WHO, APHA, OSHA, ISI guidelines throughout the world Arup **(Giri et al., 2020). Mahdii BA and Turki AM 2020** Heavy metal pollution threatens agriculture and other human food sources.

River and well water treatment with chlorine from the different governorates recorded significant decrease in the lead and cadmium concentrations except in Salah Uddin and Wasit, Table (1& 2). These results may because of the nature of soil and the possibility of the presence of some mineral elements associated with the lead element, which prevents chlorine and alum from removing the lead element from the water when treating addition to the presence of factories and industrial waste. These results were agreed with **Clausen et al., (2015)**. **Najim and Aziz (2012)** revealed that the free chlorine in drinking water was below the standards set by the World Health Organization (WHO) in the period from July up to the end of August 2007. There are some variables which affect drinking water such as quantity of free chlorine, temperature, pH and oxidation-reduction potential of water on the sanitizing efficiency of the chlorine were studied theses were in the same trend with **Mohammed et al. (2009).** While water of the river and well treated with alum showed significant decrease in the lead and cadmium concentration except lead concentration in the water of Salah Uddin governorate because of the nature of soil and their high content of sulfur, phosphorous and other minerals that increase the interaction of alum **(Welch,1999).** Aluminium sulfate (alum) is used as a sedimentation agent in the treatment of drinking water for the control of algae in raw and public water supplies **(McGuire et al., 1984).**

In addition, when treating wells and river water with chlorine for the purpose of knowing the effect of chlorine on heavy metals in the water, the same result was observed in the absence of chlorination, because of the presence of some industrial waste, such as

pharmaceutical factories. While alum has an effective role in reducing cadmium in the water of rivers and wells **(Baker. 1979).** Mahdii BA and Turki AM 2020 Heavy metal pollution threatens agriculture And other human food sources. On the other hand, when treating well water with chlorine, it had the least effect by removing cadmium from the water. The reason is the nature of the soil in Wasit Governorate and the effect of chemical fertilizers, as well as factory and hospital waste, all of which play a role in reducing reaction rate. Soil texture affects the run-off process because it determines, the degree of permeability and then the amount of leakage losses to the interior, since the governorate represents the area between the Iran highlands ,Therefore, the governorate soils are considered to be from the transferred sedimentary torrent soils that were collected by running water to the east, the flood stream of the Tigris yoke, to the west, From the neighboring heights as a result of rains and temporary torrents in the winter season, and the following describes the types of soils in the governorate, **(AL Samareaa., 1985). In addition** may be due to the high suspended matter in the water in that province, as well as calcium, sodium and magnesium, which reduced the efficiency of alum and chlorine used for water treatment (Hamdan, 2016).

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