

Ministry of Higher Education and Scientific Research
University of Diyala
College of Science
Department of Biotechnology



Assessment of heavy metal pollution of Diyala River in Baquba, Iraq

Graduation Research Submitted to the Department of Biotechnology
as Part of Requirements for the Degree of Bachelor in
Biotechnology Sciences

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July, 2020

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

فَنَعَالَى اللَّهُ الْمَلِكُ الْحَقُّ وَلَا تَعْجَلْ بِالْقُرْآنِ مِنْ
قَبْلِ أَنْ يُقْضَىٰ إِلَيْكَ وَحْيُهُ
وَقُلْ رَبِّ زِدْنِي عِلْمًا

صدق الله العلي العظيم

(سورة طه: الآية 114)

الاهداء

ها قد وصلت الان الى حصاد ثمرة تعبى و اتمام رحلتى الجامعية بمناقشة مشروعى التخرج
لم يكن ذلك سهلا علي و لم اكن بمفردي بطريقي الى النجاح بل كان هناك من مهد لي الطريق
حيث كان طول مسيرتي شمسا تضيئ نهاري و قمرا ينيّر عتمتي ، خير سند و اكبر داعم
لنجاحي ، بدعائه قد وفقني الله و بكده وقفت اليوم (ابي) كلمة شكر او اهداء لا تقي جزأ
الجزئي لما قدمته لي شكرا لك و شكرا الى الله كونك ابي و سأسأل الله بكل سجدة ان يطيل
عمرك لي و (امي) في كل يوم في مسيرتي الحياتية و الدراسية اشكر الله لأنه وضع الجنة
تحت قدميك ، دعائك في الصباح حين خروجي هو سبب ما وصلت له الان كنت قنديلا ينيّر
عقلي قبل دربي . اهدي ثمرة تعبى الى اخوتي الذي هم من اول وثق بي واعتمدوا علي والى
اصدقائي رفاق دربي بالسراء والضراء اسأل الله ان يديمكم ذخرا لي الى الابد.

الشكر والتقدير

الشكر الاول والاخير والابدي الى من وفقني ويسر مسيرتي ومن كتب لي هذا المكان والقدر الجميل الى ذي الجلال والاکرام (الله تعالى) الحمد لله حتى يبلغ الحمد منتهاه والشكر لله حتى الرضا. تحية حب واجلال وشكرا كبير الى كل من علمني حرفا الى كل من نور عقلي بعلم شكرا للمعلم في بدايتي والى المدرس حين نضوجي والى الدكتور حين بلوغي شكر وتقدير الى كل من قام على التعليم من ادارة وعمادة كلية العلوم الأستاذ الدكتور تحسين حسن مبارك وكذلك رئيس قسم التقانة الاحيائية الدكتور عصام حامد حميد وأعضاء الكادر التدريسي في القسم وشكر خاص مع بالغ الاحترام والتقدير لمشرف بحثي الأستاذ صباح محمود حمد حيث كان في قمة التواضع وقمة الرقي حين تعامله معنا.

اقرار المشرف وترشيح رئاسة قسم التقانة الاحيائية

اشهد بان اعداد هذا البحث الموسوم بـ

(Assessment of heavy metal pollution of Diyala River in Baquba, Iraq
الذي قدمته الطالبات/الطلبة (هبة سالم محمد عيسى، نور محمد اسماعيل محمد، موج محمد
فهد أحمد، حسين احمد سعدون علي) قد جرى تحت اشرافي في كلية العلوم/قسم التقانة
الاحيائية/جامعة ديالى، وهو جزء من متطلبات نيل درجة البكالوريوس في علوم التقانة
الاحيائية.

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بناء على التوصيات المتوافرة أرشح هذا البحث للمناقشة

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رئيس قسم التقانة الاحيائية

كلية العلوم/جامعة ديالى

التاريخ: 2020/ /

اقرار لجنة المناقشة

نشهد باننا اعضاء لجنة المناقشة، اطلعنا على هذا البحث الموسوم بـ
(Assessment of heavy metal pollution of Diyala River in Baquba, Iraq)
الذي قدمه كلا من الطالبة (هبة سالم محمد عيسى، نور محمد اسماعيل محمد، موج محمد
فهد، حسين احمد سعدون علي) في محتوياته وفيما لها علاقة به، ونعتقد بانهم جديرون
بالقبول لنيل درجة البكالوريوس في علوم التقنية الاحيائية بتقدير ().

رئيس اللجنة

التوقيع:

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عضو اللجنة

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التاريخ: 2020/ /

مصادقة رئاسة قسم التقنية الاحيائية

رئيس اللجنة

التوقيع:

الاسم:

المرتبة العلمية:

التاريخ: 2020/ /

Abstract

This study focuses on identifying some of the heavy metal in several sources of water in Diyala Governorate in Iraq, such as the Diyala River. The Diyala River is the major tributary of the Tigris River within Diyala Province-Iraq water coming in the upstream of the Diyala River at Derbendikhan dam. Water quality became important due to the water scarcity in most regions. Freshwater systems monitoring is the most important issues in Iraq, while it suffers from water shortage and quality altering. At present, pollution has become a serious threat and has brought hazards to the growing population as well as the Earth/environment. The heavy population and uncontrolled discharging wastes to the river affected the river water quality. Research dealing with the Heavy Metals in Diyala River aimed to investigate the status of Diyala River water quality in Iraq concerning heavy metals. From the research, we can conclude that the Diyala River in Baquba city, severely polluted.

Keywords: Heavy metals, Pollution, Diyala River.

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1. Literature Review

1.1. Diyala River:

Diyala River is one of the important water resources and one of the main tributaries of Tigris River in Iraq. It covers a total distance of 445 km Diyala, controls the river floods and irrigates the area northeast of Baghdad. Diyala city depends mainly on the Diyala River for water supply for domestic, municipal, agriculture and other purposes (Hamza, 2012). Many towns are located on the river banks. Wastes from agricultural and industrial activities in these towns are drained straightway to the river (Al-Musawi, 2018). The river passes through Diyala province as shown in Figure 1.

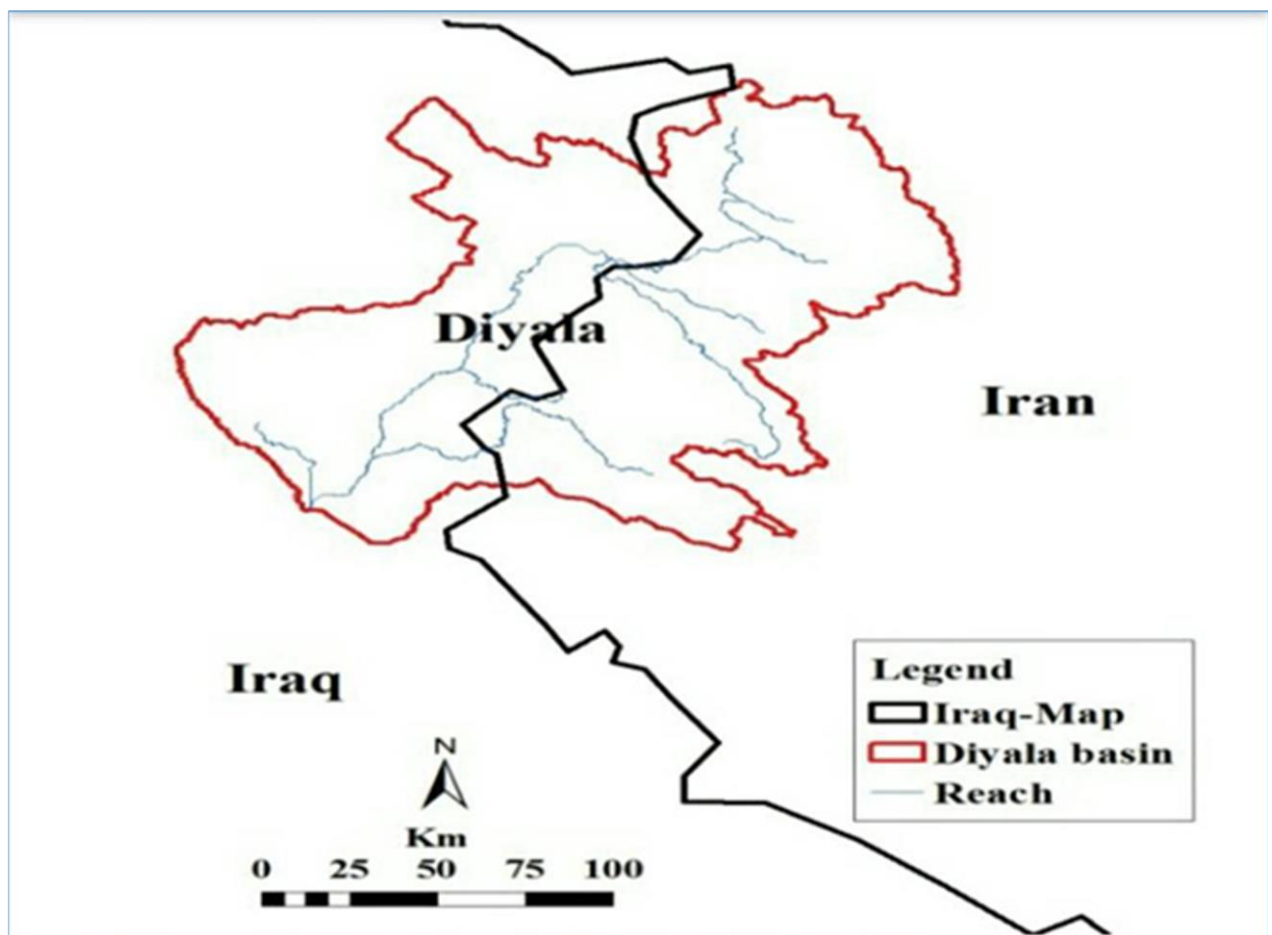


Figure 1: The Diyala River passes through Diyala province.

covers a total distance of 445 km (275 miles). The catchment of Diyala River is located between Latitude ($33^{\circ} 13' 00''$ N- $35^{\circ} 50' 00''$ N) and Longitude ($44^{\circ} 30' 00''$ E- $44^{\circ} 50' 00''$ E), many towns are situated on its banks, agricultural and industrial wastes are discharged into Diyala river. The river drains 32600 km² of the area between Iraqi-Iranian borders. North of Baghdad, the catchment is varied from semi-arid plain while the mountainous area at western Iran.

1.2 Heavy Metals:

Water resources in the world have been profoundly influenced over the last years by human activities, whereby the world is currently facing critical water supply and drinking water quality problems. In many parts of the world heavy metal (HM) concentrations in drinking water are higher than some international guideline values (Chamberlain, 2007). The main threats to human health from HM are associated with exposure to cadmium, lead, mercury and arsenic (arsenic is a metalloid, but is usually classified as a HM) Fernandez *et al.* 2013, but additionally, there are others 19 elements known as HM: antimony, bismuth, cerium, chromium, cobalt, copper, gallium, gold, iron, manganese, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium and zinc. Interestingly, small amounts of HM are common in our environment and diet, even some of them are necessary for good health, for example, living organisms require varying amounts of HM such as iron, cobalt, copper, manganese, molybdenum and zinc, which are required by humans too. However, large amounts of any of them may cause acute or chronic toxicity (poisoning) (Kabata and Mukherjee, 2007).

1.2.1 Arsenic:

Arsenic is the 20th most abundant element on earth and the 33rd on the periodictable. The inorganic forms such as arsenite and arsenate compounds are lethal to humans and other organisms in the environment. Humans get in contact with arsenic through several means which include industrial sources such as smelting and microelectronic industries. Drinking water may be contaminated with arsenic which is present in wood preservatives, herbicides, pesticides, fungicides and paints) Sauvé, 2014).

1.2.2 Mercury:

The metallic mercury is a shiny silver-white, odorless liquid metal which becomes colorless and odorless gas upon heating. Mercury is used in producing dental amalgams, thermometers and some batteries. Also, it can be found in some chemical, electrical-equipment, automotive, metal-processing, and building industries. Mercury can exist in a gaseous form thus it can be inhaled. Other forms of mercury contamination in humans may be through anthropogenic activities such as municipal wastewater discharges, agriculture, incineration, mining, and discharges of industrial wastewater (Rahimzadeh *et al.* 2017).

1.2.3 Cadmium:

This metal is mostly used in industries for the production of paints, pigments alloys, coatings, batteries as well as plastics. Majority of cadmium, about three fourths is used as electrode component in producing alkaline batteries. Cadmium is emitted through industrial processes and from cadmium smelters into sewage sludge, fertilizers, and groundwater which can remain in soils and sediments for several decades and taken up by plants. Therefore, significant human exposure to cadmium can be by the ingestion of contaminated foodstuffs especially cereals, grains, fruits and leafy vegetables as well as contaminated beverages (Unaegbu

et al. 2016). Also, humans may get exposed to cadmium by inhalation through incineration of municipal waste.

1.2.4 Chromium:

Chromium is a metal that is present in petroleum and coal, chromium steel, pigment oxidants, fertilizers, catalyst, oil well drilling and metal plating tanneries. Chromium is extensively used in industries such as wood preservation, electroplating, metallurgy, production of paints and pigments, chemical production, tanning, and pulp and paper production. These industries play a major role in chromium pollution with an adverse effect on biological and ecological species (Ghani, 2011). Following the anthropogenic activities by humans, disposal of sewage and use of fertilizers may lead to the release of chromium into the environment (Ghani, 2011). Therefore, these industrial and agricultural practices increase the environmental contamination of chromium. Environmental pollution by chromium has been mostly by the hexavalent chromium in recent years (Zayed and Terry 2003).

1.2.5. Copper:

This is a heavy metal which is used in industries to produce copper pipes, cables, wires, copper cookware, etc. It is also used to make copper intrauterine devices and birth control pills. Copper in the form of copper sulfate is added to drinking water and swimming pools (Morais, 2012). Due to man's anthropogenic and industrial activities, it can accumulate in the soil and up taken by plants. As such, copper is present in some nuts, avocado, wheat germ and bran.

1.3 Sources of Heavy Metals in the Environment:

Heavy metals are found naturally in the earth, and become concentrated as a result of human activities, or, in some cases geochemical processes, such as accumulation in peat soils that are then released when drained for agriculture (He ZL *et al.* (2005). Common sources are mining and industrial wastes; vehicle emissions; lead-acid batteries; fertilizers; paints; treated woods; aging water supply infrastructure; (Borah *et al.* (2010) and micro plastics floating in the world's oceans Butterworth (2010). Arsenic, cadmium and lead may be present in children's toys at levels that exceed regulatory standards. Lead can be used in toys as a stabilizer, color enhancer, or anti-corrosive agent. Cadmium is sometimes employed as a stabilizer, or to increase the mass and luster of toy jewelry. Arsenic is thought to be used in connection with coloring dyes (Chen, 2006). Regular imbibers of illegally distilled alcohol may be exposed to arsenic or lead poisoning the source of which is arsenic-contaminated lead used to solder the distilling apparatus. Rat poison used in grain and mash stores may be another source of the arsenic (Cheng *et al.* 2010). Heavy metals enter plant, animal and human tissues via air inhalation, diet, and manual handling. Motor vehicle emissions are a major source of airborne contaminants including arsenic, cadmium, cobalt, nickel, lead, antimony, vanadium, zinc, platinum, palladium and rhodium (Dabeka *et al.* 2002).

Water sources (groundwater, lakes, streams and rivers) can be polluted by heavy metals leaching from industrial and consumer waste; acid rain can exacerbate this process by releasing heavy metals trapped in soils (Shovon *et al.* 2017). Transport through soil can be facilitated by the presence of preferential flow paths (macropores) and dissolved organic compounds (Eisler, 2000). Plants are exposed to heavy metals through the uptake of water; animals eat these plants; ingestion of plant- and animal-based foods are the largest sources of heavy metals in humans (Soomro, 2019). Absorption through skin contact, for example from contact with soil, or metal containing toys and jewelry Arora *et al.* (2018), another

potential source of heavy metal contamination. Toxic heavy metals can bioaccumulate in organisms as they are hard to metabolize (Ali and Khan, 2019).

1.4 Historical changes in the heavy metals in water sources in Iraq:

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. Lead is a cumulative toxicant that affects the body system and causes dangerous harm to kids Russell *et al.* (2019). 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 (Sharma *et al.* 2016). 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 (Hartwig, A. 2018). Chromium can exist in many oxidation states Hexavalent chromium (VI) is highly soluble and is extremely harmful to the skin, liver, kidney, and lungs (Mishra and Bharagava 2016). Increasing concentration of copper can cause many diseases, such as kidney failure, blood cell damage, and central nervous system inhibition (Shok *et al.* 2016).

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 (Mawlood *et al.* 2018). 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. 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. According to the WHO and Iraqi standards the concentration of cadmium cannot exceed 0.003 mg/l but in the Diyala River reached 0.133 mg/l, Cd concentrations 274 times more than limit value and chromium is higher by about 20 times compared to the limit concentration (Al-Musawi, 2018). 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 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 (Zannetti *et al.* 2015 and Grandjean *et al.* 2014).

1.5 Heavy metal pollution Water sources in Iraq:

Iraqi aquatic environment is seriously contaminated with heavy metals (Al-Obaidy *et al.* 2016). Diyala River, being one of the Tigris River tributaries, was proved to be one of the most polluted rivers in Iraq (Al-Samawi and Al-Hussaini 2017), especially at its last part where the raw and treated effluents of Al-Rustimiyah wastewater treatment plants discharge into it before its confluence with Tigris River in about 15 km. Al-Rustimiyah is the oldest sewage network in Iraq, in which third of Baghdad population are served (Shakir *et al.* 2017).

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 (Hamza, 2012).

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 (Al-Musawi, 2018). Heavy elements referred to in this study have a specific density of 5 g/cm³ (five times more than the specific density of water 1 g/cm³) and adversely affect the environment and living organisms (Ewaid and Abed 2017). The main important and toxic heavy elements contaminated water are lead, mercury, chromium, cadmium, copper, nickel, and zinc.

1.6 Heavy metal pollution Water sources in the world:

Pollution is defined as the introduction of elements, compounds or energy into the environment at concentrations that impair its biological functioning or that present an unacceptable risk to humans or other targets that use or are linked to the environment, while HM are common pollutants which might be found in drinking water throughout the seven continents arising scientific and public concern on human health. The continents identified by convention rather than any strict criteria are (from largest in size to smallest): Asia, Africa, North America, South America, Antarctica, Europe and Oceania. One of the worldwide problems regarding pollution of aquatic environment is the accumulation of heavy metals, due to their toxic effect on the living being (Mac-Farlane *et al.* 2006).

The increased population and the expanded economic activities would lead to various uses of water and by that rise the stress in terms of water quality (Lugoli *et al.*, 2011). The water quality of any water body is affected by its sources and supplies in terms of their quality and quantity (Alobaidy *et al.* 2010), in which

heavy metals mostly come from anthropogenic activities (Al Haidarey *et al.* 2010).

1.7 Environmental and Health Risks by Heavy Metals:

HM toxicity can result in brain damage or the reduction of mental processes (Gaza *et al.*, 2005) and central nervous function (Bouchard *et al.*, 2011), lower energy levels (Holmstrup *et al.*, 2011), damage to DNA (Jomova *et al.*, 2011), alterations on the gene expression (Salgado-Bustamante *et al.*, 2010), skin (Burger *et al.*, 2007), muscle (Visnjic-Jeftic *et al.*, 2010), blood composition (Di Gioacchino *et al.*, 2008), lungs (Thomas *et al.*, 2009), kidneys (Johri *et al.*, 2010), liver (Burger *et al.*, 2007), heart (Otlés and Cagindi, 2010), and other vital organs for humans and other living organisms. Long-term exposure to HM may result in slowly progressing physical, muscular and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, multiple sclerosis (Jones and Miller, 2008), gangrene, diabetes mellitus, hypertension and ischemic heart disease (Otlés and Cagindi, 2010). Allergies are commons and repeated long-term contact with some HM or their compounds may even cause cancer (Dietert and Piepenbrink, 2006). For some HM, toxic levels can be just above the background concentrations naturally found in nature.

However, HM have been excessively released into the environment due to rapid industrialization, manufacture of fertilizers and to the high production of industrial waste (Katsou *et al.*, 2011) originated from metal plating, mining activities, smelting, battery manufacture, tanneries, petroleum refining, paint manufacture, pesticides, pigment manufacture, printing or photographic industries (Aguilera *et al.*, 2010). This has created a major global concern because they are non-biodegradable and can be accumulated in living tissues, causing various diseases and disorders within the food chain. It is well known that groundwater supplies most drinking water throughout the world, which the global population is 7 billion of people (UNFPA, 2011), and whereas about 1.1 billion

of them worldwide lack access to improved drinking water supplies and use unsafe surface and groundwater sources. Even people who have access to “improved” water supplies such as household connections, public standpipes, and wells may not have safe water (Sobsey *et al.*, 2008) because it is well known that drinking water could be polluted with microorganisms (Lugoli *et al.*, 2011), arsenic (Akter and Ali, 2011), polycyclic aromatic hydrocarbons (PAHs) (Bruzzoniti *et al.*, 2010), organic pollutants, nitrate and nitrite and HM (Bourdineaud, 2010). At our knowledge, there are not reviews summarizing the global risk for the human health by the HM pollution in drinking water.

2. The Aim of the Study

The objectives of this research study were to evaluate heavy metals in different sources of water in the Diyala River. It also shows the rates of pollution in these water sources with heavy metals which cause environmental and health risks.

3. Conclusions and Recommendations

3.1 Conclusions

The study shows that the heavy metals contaminate the water at the Diyala River. In addition, there are several other contaminating factors behind the rise in water resource pollution in Iraq in general, and in the governorate of Diyala 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.

3.2 Recommendations:

we recommend the following to reduce the level of pollution in Diyala River:

- 1- 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.
- 2- To conduct a comprehensive survey of environmental problems according to their location.
- 3- To study the pollution caused by the water entering Iraq from the neighboring countries and conducting all the studies related to water.
- 4- 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.

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الخلاصة:

تركز هذه الدراسة على التعرف على بعض العناصر الثقيلة والسامة في العديد من مصادر المياه في محافظة ديالى في العراق مثل نهر ديالى. نهر ديالى هو الرافد الرئيسي لنهر دجلة داخل محافظة ديالى - المياه العراقية القادمة في الجزء العلوي من نهر ديالى عند سد دربندخان. أصبحت جودة المياه مهمة بسبب ندرة المياه في معظم المناطق. تعتبر مراقبة أنظمة المياه العذبة من أهم القضايا في العراق، بينما تعاني من نقص المياه وتغيير الجودة. في الوقت الحاضر، أصبح التلوث تهديدًا خطيرًا وجلب المخاطر على السكان المتزايد وكذلك الأرض / البيئة. أثرت الكثافة السكانية والنفايات غير المنضبطة إلى النهر على جودة مياه النهر. يهدف البحث إلى التحقق من حالة جودة مياه نهر ديالى في العراق فيما يتعلق بتركيزات معادنه الثقيلة. نستنتج من البحث أن نهر ديالى في مدينة بعقوبة ملوث المياه وبشدة.



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تقييم تلوث بالمعادن الثقيلة لنهر ديالى في بعقوبة، العراق

بحث تخرج مقدم الى

مجلس قسم التقنية الاحيائية/كلية العلوم/جامعة ديالى

وهو جزء من متطلبات نيل درجة البكالوريوس في التقنية الاحيائية

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