



Chemical and Bacteriological Evaluation of Water Quality in some Water Treatment Units in Diyala Governorate

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Abstract:

The purpose of this study is to assess the water quality at a few Diyala Governorate water treatment facilities, taking into account factors like pH, electrical conductivity, heavy metals, and some dangerous bacteria. It also assessed the effectiveness of a few water treatment facilities, where samples were subjected to chemical and biological analyses both before and following water treatment. Five water treatment facilities located in Abu Saida, Dhubab, Awasheq, Zherat, and Jabinat are included in this study. In December 2022, water samples were collected from the Iraqi Diyala Governorate. Certain heavy metal concentrations were found to be higher than the limits set by the World Health Organization (WHO). All water treatment facilities had lead and cadmium concentrations above the allowable level of 0.01 and 0.003 parts per million, respectively. At each site under study, the pH and electrical conductivity levels fell within the WHO-established acceptable ranges. Nine different types of bacteria were isolated using the centrifugation method to assess the bacterial component of this study. *Streptococcus faecalis* was found in all water stations. Whereas *Salmonella Typhi* was found at Zherat and Jabinat stations and *Escherichia coli* was found at Abu Saida station.

In addition to raising public awareness about adhering to WHO water regulations to ensure public health, this study suggested that periodic monitoring and examination of water treatment plants in Diyala Governorate be carried out.

Keywords: Environmental Pollutants, Heavy metals, Water Quality.

التقييم الكيميائي والبكتريولوجي لنوعية المياه في بعض وحدات معالجة المياه في محافظة ديالى

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الخلاصة:

ان الهدف من هذه الدراسة هو تقييم جودة المياه في بعض من مرافق معالجة المياه في محافظة ديالى، اخذين بنظر الاعتبار الرقم الهيدروجيني، والتوصيل الكهربائي، والمعادن الثقيلة، وبعض البكتيريا الخطرة. كما قيمت الدراسة فعالية عدد من مرافق معالجة المياه، حيث خضعت العينات للتحليلات الكيميائية والبيولوجية قبل وبعد معالجة المياه. وقد شملت هذه الدراسة خمسة مرافق لمعالجة المياه تقع في أبو صيدا وذباب وعواشق وزهيرات وجابينات. تم جمع عينات المياه في محافظة ديالى العراقية في شهر كانون الأول عام ٢٠٢٢. وأشارت النتائج الى أن تراكيز بعض المعادن الثقيلة أعلى من المعدل المسموح بموجب لوائح منظمة الصحة العالمية (WHO). وكان تركيز الرصاص والكاديوم في جميع مرافق معالجة المياه أعلى من المستوى المسموح به وهو ٠,٠١ و ٠,٠٠٣ جزء من المليون على التوالي. وفي كل موقع من المواقع قيد الدراسة، كانت مستويات الرقم الهيدروجيني والتوصيل الكهربائي ضمن النطاقات المقبولة التي حددها منظمة الصحة العالمية. تم عزل تسعة أنواع مختلفة من البكتيريا باستخدام طريقة الطرد المركزي لتقييم المكون البكتيري لهذه الدراسة. وُجدت البكتيريا العقدية البرازية (*Streptococcus faecalis*) في جميع محطات المياه بينما وجدت المكورات العنقودية الذهبية في محطتي الزهيرات والجبانات، كما وجدت الإشريكية القولونية في محطة أبو صيدا. فضلا عن مقترح رفع الوعي الثقافي حول الالتزام بلوائح منظمة الصحة العالمية المتعلقة بالمياه لضمان الصحة العامة، اقترحت هذه الدراسة إجراء مراقبة وفحص دوري لمحطات معالجة المياه في محافظة ديالى.

الكلمات المفتاحية: المعادن الثقيلة، الملوثات البيئية، جودة المياه.

1. Introduction:

Safe drinking water supply is still a major problem, especially in developing countries. Water-related problems have gotten worse due to rapid population increase and rising daily water use. At the same time, ongoing industrial development has greatly increased water contamination, making it hazardous to human health [1]. Water is one of the most important

chemicals for life. Its ability to dissolve organic chemicals, salts, inorganic substances, and gasses involved in metabolic processes is a result of its universal solvent feature. As a result, water is essential for sustaining membrane integrity, sustaining macromolecules, ensuring homeostasis, permitting material transit, and controlling body temperature [2]. Certain metals are necessary micronutrients needed for a variety of biological processes, including copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), and zinc (Zn). Other metals, such as cobalt (Co), lead (Pb), and cadmium (Cd), may be hazardous and have no recognized physiological function [3]. Moreover, both natural processes like the weathering of rocks and soils and human activity can introduce these metals into water supplies [4]. Through bioaccumulation and bioconcentration throughout the aquatic food chain, heavy metal pollution of water puts aquatic creatures at risk, putting consumers at risk [5]. The discharge of hazardous metals, which pose enormous threats to ecosystems and human health, is largely caused by industrial and agricultural operations. Metals, especially those from human activity, are regarded as main contaminants in many aquatic habitats [6]. Additionally, drinking water pollution by microorganisms is a serious problem. To guarantee adherence to the drinking water standards established by global organizations like the World Health Organization [WHO], water samples are therefore examined in specialist laboratories.

Finding harmful bacteria in drinking water is a top priority for the Environmental Protection Agency (EPA) and other regulatory agencies. The membrane filtering method is one of the most promising and successful methods for identifying different types of bacteria [7]. Human and animal waste, as well as effluent from poorly planned, mislocated, misinstalled, or poorly maintained septic systems and residential lagoons, can all contribute to bacterial pollution in drinking water sources. Bacterial contamination is particularly common in older water supply systems, notably cisterns, spring-fed systems, and dug wells. Crucially, neither taste nor odor nor visual inspection can identify the presence of bacteria in water. Testing in a lab by qualified experts is the only trustworthy way to find out if drinking water is bacterially polluted. Although bacteria are present in all natural water, their presence alone does not always indicate a health risk. Water becomes unfit for human consumption when pathogenic, or disease-causing, microorganisms are present. Routine microbial testing typically includes screening for total coliform bacteria, fecal coliforms, *Escherichia coli* (*E. coli*), and heterotrophic bacteria [8].

Long used as markers of the microbiological quality of drinking water, coliform bacteria are members of the *Enterobacteriaceae* family and include genera like *Enterobacter*, *Klebsiella*, *Citrobacter*, and *Escherichia coli*. These bacteria are normally prevalent in fecal waste and

are naturally present in the intestinal flora of humans and other warm-blooded animals. Even though the majority of coliform strains are not thought to be harmful, their presence in water can nevertheless indicate possible contamination. Furthermore, many coliform species can survive and reproduce in the environment, which occasionally results in their detection in water sources that aren't directly contaminated by feces. The existence of waterborne pathogens or fecal contamination is not always confirmed by the presence of coliform bacteria in the water [9]. The problems associated with drinking ...drinking water quality and quantity in Iraq have worsened significantly in ...in the last few years. The ongoing water crisis has been caused by a number of factors, including pollution, population growth, climate change, poor water management, and deteriorating infrastructure [10]. Access to adequate and safe drinking water is still a major issue in many places, including Diyala Governorate, especially in rural and underserved areas [11]. Despite the urgency of the issue, comprehensive studies and reliable data about the microbiological composition and environmental circumstances of Diyala's water treatment facilities are noticeably absent. [12]. The majority of reports that are currently available either concentrate on overall water availability or offer scant microbiological evaluations without taking seasonal fluctuations or chemical profiles into account [13].

Problems with the quantity and quality of drinking water in Iraq have gotten worse. This study was conducted to investigate some of the chemical characteristics and bacterial contamination of water supply stations in Diyala governorate due to the lack of sufficient studies and information about the local water stations' microbial diversity and environmental characteristics.

2. Material and methods:

Despite the seriousness of the case, comprehensive studies and reliable information about the microbiological composition and environmental circumstances of Diyala's water treatment facilities are noticeably absent.

Symbols of Stations: 1,2 - ABU SAIDA 3,4 - DHUBAB 5,6 – AWASHEQ 7,8 – ZHERAT 9,10 – JABINAT.

The samples

In December 2022, samples were collected from five unique drinking water stations located in the Diayla governorate of Iraq (Abu saida, Dhubab, Awasheq, Zherat and Gebinat). Water samples have been collected using glass bottles that have been sterilized. A sample of

1000 milliliters of water was gathered and brought to the Department of Chemistry's laboratory at Diyala University of Science in Iraq.

Chemical analysis

Chemical analysis of water samples is done by dividing each sample into three portions and performing three chemical tests (PH, heavy metals and electrical conductivity). After calibrating the meter equipment (PH WTW, 7110) with standard solutions, every water sample was subjected to chemical testing utilizing a PH meter equipment and a flame atomic absorption spectrometry device, and electrical conductivity apparatus, as well as microbiologically by the use of Centrifugation method. The findings of the measurement of the acidic function at laboratory temperature are displayed in (**Table1**). To ascertain ion concentration ratio in these water samples, an electrical conductivity instrument (Pw-9526-Digital Conductivity meter) was utilized, and following Using standard solutions for calibration Laboratory-temperature measurements of electrical conductivity are displayed in (**Table1**). A standard was utilized to calibrate the flame atomic absorption spectrometry apparatus (AA-UN.BG.IBN-H. C.S.L.), Table 3 displays the solutions and outcomes [14].

Microbiological evaluation

The samples are randomly collected from tanks before settling and placed in special test tubes. Avoid leaving them at high temperatures or under sunlight, and ensure that the sample does not come into contact with the surrounding environmental conditions. Subsequently, work is done in the laboratory to tabulate and label the samples to differentiate between them. The samples are then sedimented by placing them in a centrifuge to obtain all solid contents, germs and microbes if present. Then we filter the samples using special filter paper to collect the sample sediment. After that, we divide the sample into two parts. The first part is placed on a previously prepared blood agar culture medium, and the second part is placed on another differential culture medium prepared in advance such as macconkey agar, while maintaining the cleanliness of the work site and tools used. The work is done inside a hood. These cultures media are placed in an incubator at a temperature of 37°C for 24-48 hours to ensure the growth of any biological cells inside the culture medium. After that, the result is read using special determinants and detectors to determine the type of parasite, fungus or bacteria that grew on this medium, if any. The results are recorded every 12 hours to determine the biological activity inside the dish.

3. Results and discussion

PH and Electrical Conductivity Measurement

The values of the acidic function were (7.3 and 7.1) at Abu Saida station before and after treatment respectively, (7.15 and 6.5) at Dhubab station, (6.87 and 6.7) at Awasheq station, (6.83 and 6.75) at Zherat station and (7.1 and 7) at Jabinat station. All of these samples fell within the acceptable pH range set by the US Environmental Protection Agency (USEPA)[15] (6.5-8.5) (Table 1). The ratio of ions in these water samples was ascertained using electrical conductivity; the electrical conductivity results were (638 and 643 $\mu\text{S}/\text{Cm}$) at Abu Saida station before and after treatment respectively, (654 and 656 $\mu\text{S}/\text{Cm}$) at Dhubab station, (618 and 620 $\mu\text{S}/\text{Cm}$) at Awasheq station, (606 and 636 $\mu\text{S}/\text{Cm}$) at Zherat station and (556 and 555 $\mu\text{S}/\text{Cm}$) at Jabinat station. According to the WHO manual, these values fell between medium and good, as shown in (Table 2).

Table 1: water samples' useful PH and conductivity.

Sample No.	Water Station	PH meter	Conductivity $\mu\text{S}/\text{Cm}$
1	Abu Saida (B)	7.3	638
2	Abu Saida (A)	7.1	643
3	Dhubab (B)	7.15	654
4	Dhubab (A)	6.5	602
5	Awasheq (B)	6.87	618
6	Awasheq (A)	6.7	620
7	Zherat (B)	6.83	606
8	Zherat (A)	6.75	636
9	Jabinat (B)	7.1	556
10	Jabinat (A)	7	555

Table 2: The WHO handbook describes the electrical conductivity of water.

No.	Conductivity $\mu\text{S}/\text{Cm}$	Water quality
1	50-400	Excellent
2	400-750	Good
3	750-1500	Medium
4	> 1500	Water with high metal

Heavy Metals Measurement

When consumed in excess, a number of heavy metals have detrimental effects on human health, making them hazardous. Human health is at risk from heavy metals because these are tenacious by nature and likely to accumulate in biological systems [16]. An apparatus that uses flame atomic absorption spectrometry was used to examine water samples in order to find the amounts of heavy components in these samples, and the outcomes for each component were as follows in (Table 3): lead was (0.017 and 0.016) at Abu Saida station before and after treatment, (0.028 and 0.026) at Dhubab station, (0.017 and 0.016) at Awasheq station, (0.014 and 0.013) at Zherat station and (0.013 and 0.012) at Jabinat station. Children are especially vulnerable to lead exposure because of their permeable blood-brain barrier and rapid gastric absorption, that causes neurotoxic consequences. Peripheral neuropathy, an indirect cardiac effect, renal tubular injury, and reproductive issues are all present even at modest exposure levels [17]. Cadmium was (0.013 and 0.012) at Abu Saida station before and after treatment, (0.016 and 0.015) at Dhubab station, (0.009 and 0.008) at Awasheq station, (0.008 and 0.007) at Zherat station and (0.006 and 0.005) at Jabinat station. Apart from water, the two main sources of Cd are diet and cigarette smoking. Cd builds up in the kidney and Long-term liver exposure to cadmium combined with deficits in calcium, iron, zinc, protein, fat, and vitamin D [18]. Mercury was (0.0002 and 0.0001) at Abu saida station before and after treatment, (0.0005 and 0.0004) at Dhubab station, (0.0002 and 0.0002) at Awasheq station, (0.0002 and 0.0001) at Zherat station and (0.0001 and 0.0001) at Jabinat station. Through oxidative stress and enzyme interference, mercury damages the neurological, renal, immunological, cardiovascular, and reproductive systems, even at low exposure levels. It is regarded as one of the most dangerous substances in the world, and its consequences can range from liver and kidney damage to developmental brain impairment [19]. Elevated concentration of cadmium and lead have been detected in some drinking water stations, exceeding the permissible limits established by the World Health Organization (WHO) [20].

Table 3: The mean amount of heavy metals present in water

Sample no.	Station	Pb (ppm)	Cd(ppm)	Hg(ppm)
1	Abu saida (B)	0.017	0.013	0.0002
2	Abu saida (A)	0.016	0.012	0.0001
3	Dhubab (B)	0.028	0.016	0.0005
4	Dhubab (A)	0.026	0.015	0.0004
5	Awasheq (B)	0.017	0.009	0.0002

6	Awashq (A)	0.016	0.008	0.0002
7	Zherat (B)	0.015	0.008	0.0002
8	Zherat (A)	0.014	0.007	0.0001
9	Jabinat (B)	0.013	0.006	0.0001
10	Jabinat (A)	0.012	0.005	0.0001

Biological Activity Measurement

The study was conducted on five water samples taken from water purification and treatment plants in Diyala Governorate as shown in the **Table 4 and 5**. The samples were taken from water stores before treatment and from treated water stores before pumping it to homes. The samples were transferred into special test tubes and protected from contamination during transport. The study showed the presence of some types of pathogenic and non-pathogenic bacteria in the water before treatment for example *Escherichia coli*, *Staphylococcus aureus* and *Streptococcus* (*S. faecalis*). The presence of non-pathogenic bacteria in the water is evidence of contamination of the main water sources with animal or human feces. After examining the water treated by the aforementioned stations, shown in the table below, it was found that some stations purify the water with biological pollutants using special technologies as in Abu Saida and Dhubab stations, while other stations do not operate with the required efficiency to purify water from biological pollutants that threaten human health as in Awashq station. While some types of bacteria were treated in some stations and others were not treated as in Zherat and Jabinat stations. Numerous studies in this field mention that bacteria are present in every water. Bacteria do not necessarily indicate that water is dangerous. to consume only pathogens, which are bacteria that cause disease. In general, total coliform bacteria are not dangerous. *Escherichia coli* bacteria and fecal coliforms suggest that the water may contain additional microorganisms linked to fecal matter as well as human or animal waste [21].

Table 4: the description of the bacterial species that were isolated in water stations before treatment.

Isolated bacterial Spp	Name's of water station				
	Abu saida	Dhubab	Awashq	Zherat	Jabinat
<i>Escherichia coli</i>	+	-	-	-	-
<i>Klebsiella sp</i>	-	-	-	-	-
<i>Aeromons sp</i>	-	-	-	-	-
<i>Pseudomonas sp</i>	-	-	-	-	-
<i>Shigilla sp</i>	-	-	-	-	-
<i>Enterobacter vulneris</i>	-	-	-	-	-
<i>Enterobacter aerogenes</i>	-	-	-	-	-
<i>Staphylococcus aureus</i>	-		-	+	+
<i>Streptococcus (S.faecalis)</i>	+	+	+	+	+

Table 5: the description of the bacterial species that were isolated in water stations after treatment.

Isolated bacterial Spp	Names of water station				
	Abu Saida	Dhubab	Awashq	Zherat	Jabinat
<i>Escherichia coli</i>	-	-	-	-	-
<i>Klebsiella sp</i>	-	-	-	-	-
<i>Aeromons sp</i>	-	-	-	-	-
<i>Pseudomonas sp</i>	-	-	-	-	-
<i>Shigilla sp</i>	-	-	-	-	-
<i>Enterobacter vulneris</i>	-	-	-	-	-
<i>Enterobacter aerogenes</i>	-	-	-	-	-
<i>Staphylococcus aureus</i>	-		-	+	+
<i>Streptococcus (S.faecalis)</i>	-	-	+	-	-

4.Conclusions

According to the study's findings, certain water stations in the Diyala Governorate provide drinking water that is unsafe for human consumption due to the presence of toxic heavy metals and harmful bacteria. toxic heavy metals can cause serious health effects even at low concentrations. Long-term exposure to cadmium may lead to kidney damage, while lead exposure is especially harmful to the nervous system, particularly in children. This could be because the water level of the Tigris and Euphrates rivers is steadily declining in Turkey as a

result of the construction of dams and reservoirs on these rivers, while Iraq's drinking water quality is lacking due to inadequate water filtration and sterilization techniques as well as deteriorating water distribution networks, can cause drinking water to become contaminated by sewage that contains a variety of harmful germs and disrupts Heavy metal concentrations in drinking water. For this reason, it is crucial to raise environmental awareness through all available channels, including educational resources and the media. Regular use of the membrane filter technology and other tests is necessary to assess the water's bacterial content and standard heavy metal levels. The network tubes that distribute the water from these stations must also be controlled.

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