**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

# Evaluation of the Drinking Water Quality Index in Dibis District – Kirkuk

**Omar Taha Mahmoud Al-Taay[1*], Rushdi Sabah Abdulqader[2]**

*[1*]Master student, Department of Biology, College of Education for Pure Sciences, University of Kirkuk, Kirkuk, Iraq.*
*[2]Professor, Department of Biology, College of Education for Pure Sciences, University of Kirkuk, Kirkuk, Iraq.*

*Email: [2] rushdisabah@uokirkuk.edu.iq*
*Corresponding Email: [1*]altaayomar24@gmail.com*

**Received:** 16 February 2024 **Accepted:** 29 April 2024 **Published:** 13 June 2024

***Abstract:** In this study, a weighted mathematical model was utilized to evaluate the water quality of the filtration station in the Al-Dibs district. The assessment was conducted at five different sites from October 2023 to April 2024. Various characteristics of the water samples were measured, encompassing physical properties like turbidity, total suspended solids, total dissolved solids, and electrical conductivity. Additionally, chemical properties such as pH, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, total nitrogen, and available phosphorus were analyzed. Bacterial properties, including total bacterial count, coliform bacteria, and fecal bacteria, were also assessed. The study monitored various sites along the Lower Zab River, including the raw water collection point, water pumping area, Oil Quarter, Diyarbakır Quarter, and Kolan Quarter. Results revealed unsatisfactory water quality at the raw water collection point, while excellent quality was observed at the other sites (2, 3, 4, 5). The water quality index rankings were as follows: 18.10, 17.61, 47.96, 30.40.These findings suggest that the water treatment station effectively produces water suitable for daily sanitary purposes.*

***Keywords:** Zab River, WQI, Water Pollution, Bacterial Properties, Chemical Properties.*

## 1. INTRODUCTION

Water plays an important role in our development, survival and commercial activities, despite its importance, water resources are often not exploited adequately and not fully protected that approximately 95-97% of surface water is salty water in the seas and oceans [1] and though Among the regulations and controls that governments and institutions apply all over the world to ensure the availability and quality of water resources, but many water sources are

**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

still vulnerable to pollution [2]. Water pollution has great risks to human health and can lead to significant economic losses and one of the challenges in this context is the preservation of water resources of appropriate quality and usable [3] Water quality is naturally affected by the properties of the river basin and artificially by human activities within this basin [4]. The concept of quality is closely related to the specific uses of water and then a distinction is made between the quality required for home use, which differs from the quality irrigation water and for the water to enjoy certain quality, it must have a set of properties and apply to it a sum of the determinants that lead to the loss of water and low quality What occurs water pollution when strange materials are inserted, often the result of human activities [5]. The physical and chemical properties of water are of great importance in determining water quality.
These properties give an idea of the organic and inorganic compounds contained in water, as well as the elements and It allows to know the level of pollution and the true chemistry of water, allowing correct decisions to be made to improve water quality [6] they contribute to the growth and prosperity of phytoplankton through temperature and light and the provision of nutrients, salts, dissolved chemicals, dissolved oxygen and others. In addition, it contributes to the diversity of aquatic communities [7]. Water is considered undrinkable when it contains pathogenic microbes that are transmitted through water. These organisms reach the water by excreting food waste, causing many diseases that can be transmitted to humans through water. Thus, a large proportion of human health problems are directly due to water pollution [8]Most studies have also shown that animals are the most important store of waterborne pathogens, especially through their excreta that is excreted into water or soil and thus increases the number of pathogenic bacteria such as E. coli and Salmonella spp in that environment, which may lead to the emergence of several disease conditions because of them [9]. Effective assessment of water quality and accurate measurement of pollution sources is essential for the sustainable use of water resources Although Water Quality Index (WQI) models have proven applicable to surface water quality assessments and pollution source divisions, these models still have the potential for further development in the rapidly evolving data-driven technological age [10] , based on the above, our study aimed to evaluate and estimate the quality of the water produced for the Dibis district and its suitability for health uses.

## 2. RELATED WORKS

[11] In their study to assess the quality of water produced from the Hawija district desalination plant - Kirkuk that the plant produces high quality water and is suitable for various human uses, including drinking, and they showed in other study [12] that this plant produces water with physical and chemical properties and within the normal acceptable range for domestic uses. In their study, [13] pointed out the effect of the physical and chemical properties of the Tigris River water on wastewater in Wadi Al-Danafi. The study [14] indicated a significant decrease in the bacterial content of liquefied water in all sites after the purification plant, and here is an indication of the quality of the water treatment process in the studied plant in Baghdad Governorate.

**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

## 3. METHODOLOGY

### Study Area

The study area is located in the district of Dibs in the province of Kirkuk, north of Baghdad, on longitude (44°-23) and latitude (35°-28) and away from the city of Baghdad about 240 km and from the city of Kirkuk 40 km and the lower Zab River is the source of water in this project, where water is withdrawn from the river through the station's pumps, which feed all areas of the Dibs district. The study sites were chosen on the feeder channel during its passage within the Dibs district, and the following is described: - The first site _ represents raw water from the feeding channel, the second site is the water payment area, the third site _ the Dur Al-Naft neighborhood area, which is 1 km away from the project, the fourth site _ the Diyarbakir neighborhood area, which is 2.7 km away from the molasses water project, and the fifth site _ the Kolan neighborhood area and is 3 km away from the liquefaction project.

### Sample Collection

Water samples were collected for the five sites selected to conduct physical, chemical and biological factors tests from the study area for a period of six months, starting from October 2023 to April 2024, where samples were collected using polyethylene bottles in the early morning hours to ensure their arrival to the laboratory within the specified period. For each test, samples were collected after letting the water run from the tap for approximately 10 minutes in order to obtain water free of scale and pipe debris. They were transported to the laboratory in a special container prepared for this purpose, cooled with pieces of ice.

### Method of Measurement of Physical, Chemical and Biological Factors

The studied variables were analyzed according to the methods of work described by [15] and for all samples taken from the study sites and in the laboratories of the Department of Biology, College of Education for Pure Sciences, University of Kirkuk, the laboratories of the Directorate of Agriculture of Kirkuk and the laboratories of the Department of Irrigation for the period from 1-9-2023 to 1-3-2024.

### Water Quality Index

The weighted mathematical model was used to estimate water quality in the Demo lasses treatment plant, which was referred to by many researchers [16,17, 18, 19, 20].

1. The first step:
   The relative weight was determined by applying the following equation:
   RWi=
2. Second Step
   Finding the average values of the Quality rating (qi) as in the following equation:
   qi= limited Valuex Factor measute values
3. Third Step
   Calculate the values of the Subindex (SLi) as in the following equation:
   SLi= Wi × qi

**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

Table 1 Classification of water quality by WQI values [11]

| Water quality | WQI |
|---|---|
| Excellent | < 50 |
| Good | 100-50 |
| Poor | 200-100 |
| Very Poor | 300-200 |
| Unsuitable | > 300 |

## 4. RESULTS AND DISCUSSIONS

The Dibis district station, which was mentioned by, had its water quality assessed using a weighted mathematical model. [11][17][18][19][20], where the model was applied to fifteen variables (MPN E.coli, MPN, TPC, TP, TN, CL). , MgH ,CaH, TH, Talk, PH, EC, TDS, TSS, Tur) as shown in table 2 to evaluate the water produced from the liquefaction station in Dibs district for drinking and domestic uses.

Table 2 shows the studied factors

| **Factors** | **The first site** | **Second site** | **Third site** | **Fourth site** | **Fifth site** |
|---|---|---|---|---|---|
| Tur N.T.U | (0- 0.77) 0.162a | (0-0.026) 0.089 a | (0.22-0) 0.074a | 0.332-0.004 0.071 a | (0.11-0) 0.62 a |
| Tss PPm | (1.02-0.5) 0.77a | (1.04-0.22 0.71a | 1.04-0.5 0.803a | (1.42-0.6) 0.83a | (1-0.3) 0.666a |
| TDS PPm | (0.24-0) 0.123a | (0.16-0) 0.096a | (0.18-0) 0.136a | (0.76-0.2) 0.233a | (1.98-0.2) 0.47a |
| EC MS/cm | (441-285) 358.666a | (472-265) 368a | (543-294) 395a | (427-264) 351.5a | (443-274) 366.333a |
| PH | (7.5-6.5) 7.183a | (7.6-6.6) 7.183a | (7.7-6.4) 7.15a | (7.5-6.2) 6.983a | (7.6-6.7) 7.233a |
| TalK PPm | (140-100) 122.333a | (136-112) 121a | (140-112) 127.22a | (140-108) 121a | (140-108) 121.667a |
| TH PPm | (190-120) 152.5a | (190-120) 154.166a | (230-135) 167.5a | (180-120) 152.5a | (180-120) 154.166a |
| CaH PPm | (125-95) 105.833a | (130-85) 110.833a | (165-98.75) 120.625a | (125-85) 108.333a | (125-85) 108.333a |
| MgH PPm | (65-25) 46.666a | (60-30) 43.333a | (65-30) 46.875a | (55-30) 44.166a | (65-30) 45.833a |
| Cl PPm | (11.36-5.68 8.756a | (11.36-5.68) 9.23a | 31.24-8.5 14.97c | (11.36-8.52 9.94b | (11.36-8.52 9.94b |
| %TN | (0.1-0.2) 0.15a | (0.1-0.2) 0.133a | (0.1-0.2) 0.15a | (0.1-0.2) 0.15a | (0.1-0.2) 0.15a |
| TP PPm | (0-0.033) 0.0081a | (0-0.022) 0.006a | (0-0.011) 0.0058a | (0.011-0) 0.004167a | (0.011-0 0.006a |
| TPC | (250-163) | (60-0) | (0-0) | (189-0) | (125-0) |

**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

| | | | | | |
|---|---|---|---|---|---|
| | 215.5b | 10a | 0a | 31.5a | 33.33a |
| MPN | (16-16)<br>16b | (0-0)<br>0a | (0-0)<br>0a | (16-0)<br>0a | (5.1-0)<br>0.85a |
| MPN<br>*E.Coli* | (16-0)<br>13.333b | (0-0)<br>0a | (0-0)<br>0a | (16-0)<br>2.666a | (5.1-0)<br>0.85a |

The study findings (table 2) revealed diverse values at the locations where samples were collected. In October 2023, values varied from imperceptible levels at the first, second, and third sites to a peak of 1.98 ppm at the fifth site in December 2023. Statistical analysis indicated that the mean total dissolved substance levels in water did not show significant differences across all sites ($P \leq 0.05$). The observed variations in total dissolved substance values could be attributed to the absence of both residential sewage systems and industrial facilities. Water attributes are predominantly reflected in water supply networks [21]. A significant correlation ($P \leq 0.05$) was observed between the total dissolved materials and magnesium hardness, with a correlation coefficient of 0.365. This correlation also extended to the variations in the percentages of total dissolved materials in water distributed through neighborhood networks, as well as the precipitation levels during the winter and spring seasons. The increase in rainfall was found to lead to higher soil erosion and salt content. Particularly, water from agricultural areas showed a higher percentage of dissolved salts under these conditions[22]. The results of our study showed similarities with a previous study [11], where the highest concentration was 310 mg/L and the lowest was 244 mg/L. However, our findings differed from another study [23] conducted in the Lower Zab River in Hawija District, Kirkuk Governorate, where the highest total suspended matter concentration was 1600 mg/L and the lowest was 823 mg/L. The study observed a range of electrical conductivity values varying from 259 to 543 ms/cm. The lowest value was observed in January 2024 at the fourth site, while the highest value was recorded in March at the third site. Statistical analysis, including an analysis of variance test and the Duncan test, revealed significant differences ($P \leq 0.05$) among the monthly averages of sample collection. However, no significant differences were found among the collection sites. This discrepancy can be attributed to the presence of floating materials, clays, and organic substances carried by the river water, which contribute unequally to the overall conductivity values. It is noted that electrical conductivity is influenced by the concentration of dissolved salts in the water [24]. The results of the study agreed with the study [25] and [26] who showed that this factor is not affected by the change in months and this is due to several reasons, including the geological composition of the region, the salt content of the soil, and the amount of materials added in the filter stations for the purpose of purifying the water and reducing its turbidity. The correlation factor also documented a positive correlation at a moral level ($p \geq 0.01$) between the values of electrical conductivity and pH ($r=0.001$) may be due to an increase in hydrooxide ion concentration in water by an increase in the pH, which is considered to be a good ion for electrical delivery as opposed to hydrogen ion, which increases the value of pH and the increase in water acidity, which is considered to be weak for electrical conductivity. Thus, its increase reduces the electrical conductivity of water. The best examples of this relationship are rainwater for which pH low. As a result, its conductivity is low and the seawater for which the pH is high, while the results are not consistent with the study [12] in

**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

which the electrical conductivity values are compared between 430-380 microcms/l. The results presented in table 2 demonstrate variations in pH values, with the highest value of 7.7 observed at the third site in November 2023, and the lowest value of 6.2 recorded at the fourth site in December 2023. Statistical analysis findings indicate that there were no significant differences ($p \leq 0.05$) among the sample collection sites. These pH values comply with Iraqi standard specifications and fall within the parameters set by the World Health Organization. A negative correlation was identified between pH and total suspended matter ($r = -0.414$) at a significant level ($p \leq 0.05$), while a positive correlation ($p \leq 0.01$) was found between pH and electrical conductivity ($r = 0.501$) at a significant level ($P \leq 0.01$). Furthermore, a positive correlation was observed between pH and total basicity ($r = 0.458$) at a significant level ($P \leq 0.05$), and a negative correlation was noted between pH and magnesium hardness ($r = -0.404$). In our study, the pH values observed were lower than those reported in a previous study [27], which documented pH levels ranging from 8.5 to 6.6 in the Tigris River located in the city of Al-Ishaqi within the Salah Al-din Governorate. The study's findings, as presented in table 2, revealed diverse values across the sample collection sites. The lowest value was observed at the initial site in January, while the highest values were noted at the first, third, fourth, and fifth sites in March 2024. Statistical analysis indicated no significant variances ($P \leq 0.05$) among the means of total basicity across the sample collection sites. However, notable differences ($P \leq 0.05$) were observed concerning the dates of sample collection. Interestingly, our research contradicted a prior study [28] which reported a basicity range of (240-145) for the Tigris River in Mosul The reason for this is due to the high concentration of organic matter consumed by microorganisms in aerobic decomposition and produces carbon dioxide gas, which changes the properties of the aqueous medium when it interacts with water, producing several compounds, including dissolved carbonic acid bicarbonate ions and carbonates, which cause an increase in total basicity.

The results of our study (table 2) showed that the total hardship values were recorded at a low of 120 mg/L at sites I, II, IV and V in November 2023 and at a high of 230 at site III in month 2024. The results of the statistical analysis documented that averages of total water hardship at all locations did not record moral differences ($p \geq 0.05$), while moral differences were recorded relative to the dates of the collection of samples.The reason for the increased difficulty in some sampling times may be that the water in the Zab River has been affected by rainfall, especially in the month of Aur, when high - Zab areas have experienced large amounts of rainfall from this month. A significant negative correlation was observed between the average values of total hardness and total alkalinity ($r = 0.527$) as well as between the hardness levels of calcium ($r = 0.579$) and magnesium ($r = 0.834$), with a significance level of ($P > 0.01$). The high levels of total hardness in water can be attributed to the abundance of calcium and magnesium ions, likely influenced by the geological composition of the river basin, characterized by calcareous soils. This geological composition contributes to the formation of water hardness [29,30]. The study revealed significant correlations at a significance level of $P \leq 0.01$ between various water quality parameters. A positive correlation was found between total hardness and chloride ($r = 0.711$), while a negative correlation was observed between total hardness and total nitrogen ($r = 0.655$). These results differed from a previous study [22], showing total hardness values ranging from 184 to 160 mg/L. Additionally, significant correlations at a significance level of $P \leq 0.01$ were noted

**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

between the averages of total basicity and electrical conductivity (r = 0.589), total hardness (r = 0.527), calcium hardness (r = 0.579), and chloride values (r = 0.565). Furthermore, a significant correlation at a significance level of $P \leq 0.05$ was documented between the averages of total basicity and turbidity (r= 0.362) and pH (r= 0.458), with a negative correlation observed between total basicity and total nitrogen (r= 0.386). The results presented in table 2 indicate a range of 0 to 250 cells/100 ml of bacteria in total. Statistical analyses, including the results analysis test and Duncan's test, revealed significant differences ($P \leq 0.05$) among the mean total bacteria counts across the various sample collection sites, but no significant differences were observed based on the collection dates. Specifically, the initial site stood out as statistically different from all other sites ($P \leq 0.05$) due to the absence of additional Chlorine treatment, whereas Chlorine was introduced into the water after the second site. At a significance level of ($P \leq 0.01$), a negative correlation was observed between the mean values of the total bacterial count and the locations where the samples were collected, as indicated by the correlation coefficient, the presence of fecal coliform bacteria (r = 0.959), coliform bacteria (r = 0.900), and water quality index (r = 0.987) were all shown to be strongly correlated. Escherichia and E. coli bacteria are clear indicators of fecal contamination in water. The method may be employed to detect recent presence of fecal matter in water, as stated by the World Health Organization in 2011. The numbers observed ranged from 0 to 16 cells per 100 ml, which serves as an indication of water pollution. The findings of our investigation revealed that the levels of Escherichia coli and coliform bacteria varied from 0 to 16 cells per 100 ml. The highest value of 16 cells per 100 ml was consistently observed at the first site throughout the study period, as well as at the fourth site in January. Conversely, the second, third, fourth, and fifth sites consistently exhibited the lowest, undetectable levels of these bacteria, except in January. The correlation coefficient demonstrated a statistically significant association ($P \leq 0.01$) between the mean values of coliform bacteria and E.coli with the total bacterial count, water quality, and coliform bacteria quality index, surpassing the findings of the previous study [11].

Table 3 shows the drinking water quality parameter values in the sample collection sites

| Locations | Water quality parameter value | Qualitative function |
|---|---|---|
| 1 | 197.784 | Poor |
| 2 | 18.109 | Excellent |
| 3 | 17.614 | Excellent |
| 4 | 47.969 | Excellent |
| 5 | 30.408 | Excellent |

**Evaluation of Drinking Water Quality and Daily Use:**
The weighted mathematical model was utilized to evaluate water quality in the Debs district station in Kirkuk governorate. The assessment was based on 15 criteria. The results, presented in table 3, revealed a decline in water quality at the initial site, which corresponds to untreated raw water. The water quality coefficient values were measured at 197.784, indicating unsuitability for drinking purposes. This classification falls within the "weak" level. The primary cause for this is the elevated bacterial levels. Regarding the locations (5, 4, 3, 2), they indicated water that had undergone treatment at the station, and the WQI values

 

**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

were classified as Excellent. This suggests that the channel functions optimally and with high efficiency in the water treatment procedure, as seen by the fourth and fifth locations having the lowest airflow. The probable cause for this is the age of the distribution networks and pipes, which are estimated to be around 60 years old. The study's findings were in line with those of [31], as the indicator demonstrated. The water quality assessment reveals that the raw water samples are unsuitable for consumption, as they have been categorized as bad. Conversely, the treated water samples have been certified as excellent quality water.

## 5. CONCLUSIONS

We conclude that the values of the drinking water quality index divided the study sites into two groups, the first group is the one that showed the water quality index that it is not suitable for drinking and is the first location of the Zab River water and the second group is the treated water and includes the second, third, fourth and fifth sites in which the water was treated and the values were included The water quality in it is the best in the third, second and fifth location.

## 6. REFERENCES

1. Sharqawy, M. H., Lienhard, J. H., & Zubair, S. M. (2010). Thermophysical properties of seawater: a review of existing correlations and data. Desalination and water treatment, 16(1-3), 354-380.
2. Ahmed. T.M., and Hasan. S.A. (2021). The microbial contamination and water quality of lezzer-ZAB rever in kirkuk province. EM international. 40 (3) : 709-712. University of Kirkuk.
3. Sierra-Porta, D. (2024). Assessing the impact of missing data on water quality index estimation: a machine learning approach. Discover Water, 4(1), 11.
4. Ferreira, C. S., Walsh, R. P., & Ferreira, A. J. (2018). Degradation in urban areas. Current Opinion in Environmental Science & Health, 5, 19-25.
5. Novotny, V. (2002). Water quality: diffuse pollution and watershed management. John Wiley & Sons.
6. Al-Douri, I. Sh. (2014). Levels of Some Polycyclic Aromatic Hydrocarbon Compounds (PAHS) in the Tigris River within Salah Al-Din Governorate, Master Thesis, Faculty of Science, University of Tikrit.
7. Al-Zubaidi, Kh. A. M. (2017). The effect of the succession of day and night times on the phytoplankton and zooplankton communities in the Diwaniya River. Ph.D. Dissertation, College of Education, University of Al-Qadisiyah.
8. Cunningham, W. P.,Cunningham, M. A., and Saigo, B. W.(2007). Environmental Science (A Global Concern).8th ed .McGraw Hill Companies, Inc. New York.
9. Dezutter, L., and Vanhoof, J.(1980). Bacteriological contamination in waste waters from slaughter houses. Zen. Bl. Bac.,17:269.
10. Zhang, H., Ren, X., Chen, S., Xie, G., Hu, Y., Gao, D., and Wang, H. (2024). Deep optimization of water quality index and positive matrix factorization models for water

 

**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

quality evaluation and pollution source apportionment using a random forest model. Environmental Pollution, 123771.
11. Deidan, M. T. A., and AbdelQader, R. S.(2022). Assessment of the quality and coefficient of water quality of Hawija district using treatment the Water Quality Index (WIQ). University of Kirkuk.
12. Ahmed, Y. H., and Mahmmoud Kamel T.(2014). Studying some physical and chemical characteristics of some drinking water stations in the city of Kirkuk and determining their suitability for use .Scientific research is our way to serve society (pages 54-65). Tikrit: Tikrit University.
13. Al-Safawi, A., and Al-Assaf, A. (2014). Environmental and biological study of the effluents of the Danafi Valley and its impact on the water quality of the Tigris River in the city of Mosul, Iraq. Journal of Education and Science, 27(1), 71-89.
14. Lafta, J. G. (2015). Analysis of Water Quality Using Chemical-Physical-Biological Parameters of the Kinds of Water Used for Drinking in the Baghdad Province Al Adhamiya City. Chem. Mater. Res, 7, 1-4.
15. APHA, AWWA and WCPE. (2017). Stand Method for Examination of water and wastewater".23th ed., Washington, DC, USA. https://doi org/10.2105/SMWW.2882.216.
16. Al-Hamdani, A. Sh. A. and Al-Safawy, A. Y. T. (2018). Evaluating the water quality of the wells of the right side of the city of Mosul for drinking purposes using the WQI water quality index. Proceedings of the First International and Third Scientific Conference of the College of Science - Tikrit University, December 17-18, 2018 (Part 3): 23-32.
17. Ibrahim, M. N. (2019). Assessing Groundwater Quality for Drinking Purpose in Jordan: Application of Water Quality Index. Journal of Ecological Engineering, 20(3).111-101. https://doi.org/10.9734/sajrm/ 2020/v6i130139.
18. Sahoo, S., and Khaoash, S. (2020). Impact assessment of coal mining on groundwater chemistry and its quality from Brajrajnagar coal mining area using indexing models. Journal of Geochemical Exploration, 215 (1):1-17. https://doi.org/10.1016/j. gexplo. 2020. 106559.
19. Boateng, T. K. ; Opoku, F.; Acquaah S. O. and Akoto, O. (2016). Ground water quality assessment using statistical approach and water quality index in Ejisu-Juaben Municipality. Ghana Environ Earth Sci. 75(489):1-14.
20. Maskooni, E. K., Naseri-Rad, M., Berndtsson, R., and Nakagawa, K. (2020). Use of Heavy Metal Content and Modified Water Quality Index to Assess Groundwater Quality in a Semiarid Area. Water, 12(4), 1-22. https://doi.org/10.3390/w12041115.
21. Jassim, M. A., and Saleh, M. A. (2021). Determining some physical and chemical features on lower Zab river and wells water in the Zab township. Tikrit Journal of Pure Science, 26(1), 24-32.
22. Al-Muslih, R. M. (1988). Microbiology. Dar Al-Hikmah, University of Baghdad, Iraq.
23. Al-Azzawi, A. M. J. (2019). An environmental and diagnostic study of algae in the Tigris River within Salah al-Din Governorate, Master’s thesis, College of Science, Tikrit University.

**Journal of Environmental Impact and Management Policy**
**ISSN: 2799-113X**
Vol: 04, No. 04, June-July 2024
http://journal.hmjournals.com/index.php/JEIMP
**DOI:** https://doi.org/10.55529/jeimp.44.14.23

24. Tebbutt. T.H.Y.(1998). Principles of water Quality Control5th ed.,Butter worth Heinemann ,1998 ,280 p.
25. Zainulabdeen, I. H. (2018). Study of the properties of drinking water for Kirkuk city and its pollution in some areas. In MATEC Web of Conferences (Vol. 162, p. 05008). EDP Sciences.
26. Mohammed, A. A., Almaliki, D. F., Qasim, R. M., and Najemalden, M. A. (2020). Multivariate statistical application for the assessment of surface water quality in lower zab river, Kirkuk. WSEAS Transactions on Environment and Development, 16, 480-492.
27. Al-Majjami, S. H. S., and Al-Jubouri, Y. H. A. (2022). Some physical, chemical and bacteriological study of water samples from the Isala Al-Ishaqi station / Salah al-Din Governorate, Master's thesis in life sciences, College of Education for Girls, Tikrit University.
28. Al-Sultan, F. M. H. (2019). Evaluating the efficiency of liquefaction of the old Al-Asr and indicating the sources of pollution in the conveyor lines. Master Thesis. College of Environmental Sciences and Technologies - University of Mosul.
29. Al-Assaf, A. Y., and Muhammad, R. M. (2009). Environmental study of Wadi al-Danfali dumps in the city of Mosul, College of Science, University of Mosul.
30. Mustafa, M. M., and Mona, H. C. (2007). Qualitative variation of two sites on the Tigris River within the city of Mosul. Al-Rafidain Science Magazine 18 (1): 125_113.
31. Al-Salihy, A. I., Sadeq, S. N., and Al-Jumaily, H. A. (2021). Hydrochemical Evaluation of Raw Water and Treated Water in the Liquefaction Plant of Kirkuk Unified Water Project Using WQI Technique, Northern Iraq. The Iraqi Geological Journal, 78-87. University of Kirkuk.