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Article

Evaluation Of the Proposed Physical Characteristics of Some Health Units in Tikrit General Teaching Hospital, Iraq

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Abstract: The physical properties of the liquid waste discharged from Tikrit Teaching Hospital were studied as one of the main problems of water pollution. One of the most harmful pollutants affecting surface water is sewage that leaks from hospitals into rivers directly without treatment. Physical examinations were conducted for a period of three months (October, November, and December) during the winter of the year (2023), and physical properties such as temperature, water turbidity, electrical conductivity, total dissolved solids, and total suspended solids were measured. The results showed that all physical properties were higher than the control treatment of tap water entering the hospital and higher than the Iraqi standard criteria for drinking water.

Keywords: Sewage, Pollution, Hospital Waste, Tap Water

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1. Introduction

Wastewater is defined as the water generated from all hospital activities, such as medical and non-medical activities, including surgical and emergency operations, laboratory work, diagnostic imaging, radiography, cooking, and washing (Khan et al., 2021). The discharged water poses a real threat to the ecosystem as large quantities of wastewater are discharged on a large scale to wastewater treatment plants for treatment, and these treatments may face difficulty in dealing with compounds and medicines (Ramírez-Coronel et al., 2023; Perrodin et al., 2013).

These wastes and pollutants resulting from this water cause an increase in various environmental and health problems by harming plants and animals, as well as affecting humans and causing them to contract a variety of waterborne diseases (Pandey and Ramontia, 2016). Water pollution in rivers and lakes has increased significantly in many regions of the world, especially in economically developed countries with high population density. Assessing physical, chemical, and biological water pollution is of great importance to reduce freshwater pollution and develop methods for treating polluted water (Burnham et al., 2006).

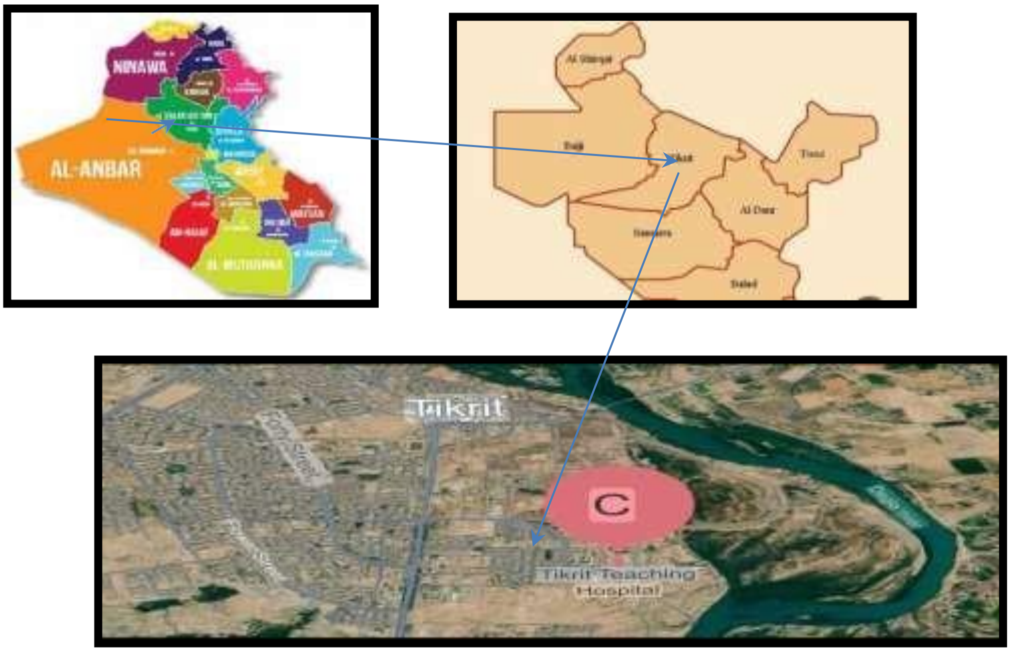
Given the urgent need for water, this thesis was chosen to target the liquid pollutants flowing from hospitals directly into the river and identify their effects and treatment options. Therefore, the current study aimed to study the physical characteristics of wastewater discharged from some health units in Tikrit Teaching Hospital through the study sites.

The study aims to evaluate the physical characteristics of wastewater discharged from some health units in Tikrit Teaching Hospital.

2. Materials and Methods

Description of the study area

The study was conducted at the University of Mosul, College of Environmental Sciences, and Tikrit University, College of Education for Girls, Iraq. Samples were taken from the wastewater discharged from Tikrit Teaching Hospital for the purpose of evaluating its quality. Four sites were selected to collect samples. The first site represents the tap water (running water) entering the hospital. The second site is the lobby basin. The third site is the consulting basin. The fourth site represents the general complex and includes all hospital departments. The study samples were collected from Tikrit Teaching Hospital, which is located in Tikrit city, the center of Salah al-Din Governorate, north of the capital Baghdad. It was established in the year 1981 with a capacity of 483 beds at coordinates N43. 7206496 - E34. 5730969. It is one of the major hospitals in the governorate, as shown in the picture (1).



Picture (1): City of Tikrit, with Tikrit General Teaching Hospital showing sampling stations.

Sample collection:

Samples were collected from the wastewater discharged from Tikrit Teaching Hospital, and the process of collecting samples from the sites began for a period of three months (October, December and November) for the year (2023), as four sites were chosen to collect samples, the first site represents the tap water (running water) entering the hospital, while the second site is the lobby basin, while the third site is the consulting basin, while the fourth site represents the general complex and includes all hospital departments, and six samples were taken for each site and for every 15 days a sample during three months, while the samples were collected between 8 am and 9 am while the pump was operating, and the samples were taken at a depth of 10 cm to 25 cm below the surface of the water, and the samples were taken using polyethylene bottles with a volume of 1 liter, noting that they were not exposed to light, in order to preserve the properties of the water samples collected from the site, then stored at a temperature of 4 ° C, provided that their storage period does not exceed 24 hours (Apha, 2005). The physical tests were conducted in the quality control laboratory at the Tikrit Unified Water Supply Station.

Laboratory tests:

Laboratory tests were performed and described as follows:

Physical tests:

Temperature concentration: Temperature was estimated using a UT3200 Mini Type K/J Dual Thermometer.

Water turbidity concentration: Turbidity was estimated using HANNA-LP2000.

Electrical conductivity concentration: estimated according to the method (APHA, 2003).

Dissolved solids concentration: estimated according to the method (APHA, 2003).

Dissolved solids concentration: estimated according to the method (APHA, 2003).\

3. Results and Discussion

Physical properties of water

a. Temperature:

The results shown in Table (4-1) showed clear changes in the temperatures of wastewater discharged from the departments of Tikrit Teaching Hospital during the study period, as the highest temperature value reached 28.2 °C in the lobby basin sample for the first sample, while the lowest value was 17.6 °C in the tap water sample entering the hospital for the sixth sample, and the average values of water temperature spatially ranged between 22.91-24.66 °C, while the average values of water temperature temporally ranged between 20.02 - 27.7 °C, and the results of the statistical analysis using Duncan's test for averages also showed that there were no significant spatial differences between the study basins, but they were significant compared to the tap water entering the hospital, and significant temporal differences were observed during the study period at the probability level of $P \leq 0.05$

Table (4-1): shows the semi-monthly and locational changes in water temperature (°C) during the study period.

Sample Date Sample Location	Sample 1)) 1/10	Sample (2) 15/10	Sample (3) 1/11	Sample 4)) 15/11	Sample (5) 1/12	Sample (6) 15/12	Average Locations
Tap water	**27.8**	**24.5**	**24.0**	**22.6**	**21.0**	**17.6**	**22.91 B**
Atrium basin	**28.2**	**25.5**	**25.5**	**24.3**	**22.1**	**21.1**	**24.45 A**
Consulting Basin	**27.4**	**25.2**	**25.8**	**24.7**	**22.0**	**19.5**	**24.10 A**

General complex basin	**27.5**	**25.5**	**25.3**	**25.5**	**22.3**	**21.9**	**24.66 A**
Average months	**27.72 a**	**25.17 b**	**25.15 b**	**24.27 b**	**21.85 c**	**20.02 d**	

Different letters mean significant differences (P<0.05) and similar letters mean no significant differences (P<0.05).

The slight decrease in the temperatures of the studied waters is attributed to the seasonal changes in temperatures during the winter, but its effect was small because the wastewater drainage network is a closed network and is slightly affected by weather conditions. The reason for the fluctuation and difference in temperatures may be due to climate changes during the study period (Weiner, 2000).

b. Turbidity

The results showed that the concentrations of water turbidity varied clearly among themselves in Table (4-2) The highest concentrations of water turbidity were 4000 NTU in the lobby basin sample at more than one time for taking the sample, while the lowest concentration was 170 NTU in the consulting basin sample for the first sample, compared to the comparison formula (tap water), as the averages of water turbidity concentrations ranged spatially between 11.9-3855.8 NTU, while the averages of water turbidity concentrations temporally ranged between 1265.4-1941 NTU, and the results of the statistical analysis using Duncan's test for averages showed that there were significant spatial differences according to the study sites compared to the control sample of tap water and no significant temporal differences during the study period at a significance level of P ≤ 0.05. The results of the current study were higher than the standard value (NTU 5) for the Iraqi standards for water resources (Dunia Frontier Consultants, 2013) As in Appendix (1).

Table (4-2): shows the semi-monthly and locational changes in water turbidity (NTU) during the study period

Sample Date Sample Location	Sample 1)) 1/10	Sample (2) 15/10	Sample (3) 1/11	Sample 4)) 15/11	Sample (5) 1/12	Sample (6) 15/12	Average Locations
Tap water	**5.86**	**9.69**	**8.81**	**8.34**	**15.2**	**23.5**	**11.9 C**
Atrium basin	**4000**	**3990**	**3870**	**4000**	**4000**	**3275**	**3855.8 A**
Consulting Basin	**170**	**277**	**1537**	**562**	**203**	**636**	**564.2 C**
General complex basin	**3588**	**1338**	**1015**	**2858**	**2226**	**1127**	**2025.3 B**
Average months	**1941 a**	**1403.7 a**	**1607.7 a**	**1857.1 a**	**1611.1 a**	**1265.4 a**	

Different letters mean significant differences (P<0.05) and similar letters mean no significant differences (P<0.05).

The results of the current study agreed with what was reached by Mohammed (2022) when evaluating some physicochemical and biological properties of liquid discharges from the Medical City Complex/Baghdad, and the results showed that they were higher than the Iraqi standard determinants for water resources. The current study also agreed with what was reached by Ali and Yasin (2016) as they were higher than the Iraqi standard determinants for water resources.

The reason for the increase in turbidity in the water may be due to the increase in the concentrations of suspended and colloidal materials such as organic and inorganic materials, clay, and other microorganisms. This is what our results in Tables (4-5) confirmed: that there is a significant increase in suspended solids (Kazim, 2008).

c. Electrical Conductivity (EC)

The results of the electrical conductivity concentrations of the study basins showed a clear increase during the study period as in Table (4-3), as the highest value of 2800 ms/cm was recorded in the third sample of the advisory basin, and the lowest value of 886 ms/cm was recorded in the sixth sample of the lobby basin, and all samples are higher than the comparison factor of tap water, as the values ranged between (433-478 ms/cm), while the averages of the electrical conductivity concentrations ranged spatially between 454-1579 ms/cm, while the averages of the electrical conductivity concentrations temporal ranged between 932.8-1455.5 ms/cm, as the results of the statistical analysis using Duncan's test for averages showed that there are no significant spatial differences between the study basins, but they are all significant compared to the comparison formula of tap water, and there are no significant temporal differences during the study period at the level of Significant $P \leq 0.05$, and the results of the current study were higher than the standard value except for the lobby basin sample for the sixth sample as well as the tap water entering the hospital (1000 ms/cm) according to the Iraqi standards for water sources (Dunia Frontier Consultants, 2013). As in Appendix (1).

Table (4-3): shows the semi-monthly and site changes in electrical conductivity (ms/cm) in water during the study period.

Sample Date Sample Location	Sample 1)) 1/10	Sample (2) 15/10	Sample (3) 1/11	Sample 4)) 15/11	Sample (5) 1/12	Sample (6) 15/12	Average Locations
Tap water	455	445	436	477	478	433	454 B
Atrium basin	1729	1245	1336	1241	1056	886	1248 A
Consulting Basin	899	1760	2800	1555	1052	1408	1579 A
General complex basin	2545	1338	1250	1481	1253	1004	1478 A
Average months	1407 a	1197 a	1455.5 a	1188.5 a	959.8 a	932.8 a	

Different letters mean significant differences ($P<0.05$) and similar letters mean no significant differences ($P<0.05$).

The results of the current study agreed with what was reached by (Muhammad, 2024) and the results in Al-Hawija Hospital showed that they were higher than the environmental determinants, and the current study also agreed with what was reached by (Abdul Majeed, 2022) and the results in the Medical City Complex/Baghdad showed that they were higher than the Iraqi standard determinants for water resources and also agreed with (Hussein, 2018) and the results in Kirkuk General Hospital, Azadi Teaching Hospital, and Children's Hospital showed that they exceeded the environmental determinants.

The reason for the rise may be due to the decomposition of dissolved molecules into positively charged and negatively charged ions (Al-Hasani et al., 2022). It was found that the wastewater discharged from hospital departments is loaded with organic and inorganic materials and that the rise resulting from the various dissolved solids present in the water is directly proportional to the electrical conductivity, which leads to an increase in the solution temperature and thus an increase in the conductivity values (Dahham and Zulkepli, 2020). This is confirmed by our results in Table (4- 4).

d. Total Dissolved Solids (T.D.S)

The results showed that the concentrations of total dissolved solids in Table(4-4) increased significantly during the study period, as the highest concentration reached 2750 mg/L in the third sample of the consulting basin and the lowest concentration reached 456 mg/L in the first sample of the consulting basin, and that all samples were higher than the comparison factor of tap water, as the values ranged between 232 and 308 mg/L. The average values of total dissolved solids spatially ranged between 251.8-1175.3 mg/L, while the average values of total dissolved solids temporally ranged between 576.3-1108.8 mg/L. The results showed that there were significant spatial differences according to the study sites compared to the control sample of tap water, and there were no significant temporal differences during the study period at a significance level of $P \leq 0.05$. The results of the current study were within the value standard except tap water and the third sample in the consulting basin sample (500–1500 mg/L) according to the Iraqi standards for water resources (Dunia Frontier Consultants, 2013). As in Appendix (1).

Table (4-4): shows the semi-monthly and site-specific changes in total dissolved solids (mg/L) in the water during the study period.

Sample Date Sample Location	Sample 1)) 1/10	Sample (2) 15/10	Sample (3) 1/11	Sample 4)) 15/11	Sample (5) 1/12	Sample (6) 15/12	Average Locations
Tap water	**242**	**237**	**232**	**256**	**308**	**236**	**251.8 B**
Atrium basin	**951**	**710**	**730**	**704**	**604**	**558**	**709.5 AB**
Consulting Basin	**456**	**1170**	**2750**	**956**	**690**	**1030**	**1175.3A**
General complex basin	**1270**	**537**	**723**	**944**	**703**	**805**	**830.3 A**
Average months	**729.8 a**	**663.5 a**	**1108.8 a**	**715 a**	**576.3 a**	**657.3 a**	

Different letters mean significant differences (P<0.05) and similar letters mean no significant differences (P<0.05).

The results of the current study agreed with both (Dawudi, 2020) and (Mahmood, 2022) and (Salem et al., 2008) and (Hussein, 2018) and (Abdullah and Mahmood, 2023) in the high values of total dissolved solids in hospital wastewater.

Dissolved solids are an important indicator in wastewater because they represent colloidal materials, ions, and salts in solution. The concentration of solids is related to the values of electrical conductivity, as the higher the value, the higher the conductivity. This is confirmed by our results in the following tables (4-3) (Bhat et al., 2018). The reason for the high dissolved solids in hospital wastewater is due to the high concentrations of salts or ions dissolved in the water (Rajamanickam and Nagan, 2016).

e. Total suspended solids (T.S.S)

The results showed the concentrations of total suspended solids for the study basins in Tables 4-5, as the highest concentration was recorded at 8320 mg/L in the sample of the lobby basin for the fourth sample, and the lowest value was recorded at 131 mg/L in the sample of the consulting basin for the first sample, as all samples are higher than the comparison factor of tap water, as the values ranged between 0 and 12 mg/L. Also, the average concentrations of total suspended solids spatially ranged between 9.8 and 3641.8 mg/L, while the average values of total suspended solids temporally ranged between 421 and 2515 mg/L. The current results showed using Duncan's test for averages that there were significant spatial differences according to the study sites compared to the control sample of tap water, and there were no significant temporal differences during the study period at a significance level. P ≤ 0.05

The results of the current study were higher than the standard value except for the tap water entering the hospital (100 mg/L) according to the Iraqi standards for water sources (Dunia Frontier Consultants, 2013). As in Appendix (1).

Table (5-4): shows the semi-monthly and site-specific changes in total suspended solids (mg/L) in water during the study period

Sample Date Sample Location	Sample 1)) 1/10	Sample (2) 15/10	Sample (3) 1/11	Sample 4)) 15/11	Sample (5) 1/12	Sample (6) 15/12	Average Locations
Tap water	**12**	**27**	**20**	**0**	**0**	**0**	**9.8 B**
Atrium basin	**866**	**805**	**7600**	**8320**	**1080**	**3180**	**3641.8 A**
Consulting Basin	**131**	**302**	**940**	**560**	**240**	**160**	**388.8 B**
General complex basin	**673**	**925**	**980**	**1180**	**1540**	**640**	**989.7 B**
Average months	**421 a**	**515 a**	**2385 a**	**2515 a**	**715 a**	**995 a**	

Different letters mean significant differences (P<0.05) and similar letters mean no significant differences (P<0.05).

The results of the study agreed with Mahmood (2022) as they were higher than the Iraqi standard determinants for water sources in the Medical City

Complex/Baghdad, and the current study also agrees with what was reached by Kumarathilaka et al. (2015) that hospital wastewater exceeds the permissible limits for wastewater discharge requirements in Sri Lanka.

The increase in suspended solids in water is due to the presence of organic and inorganic materials and is often the result of the cleaning and washing process resulting from daily water consumption and for various uses within the hospital. The presence of these suspended solids in large proportions in the water makes it unsuitable for use (2009; Zaidan et al., Mayahy, 2020).

Appendix (1): Clarifies the Iraqi standard specifications for drinking water.

Sequence	Variables	Iraqi standard
1	Turbidity	5 (NTU)
2	Electrical Conductivity (EC)	1000 (ms/cm)
3	Total Dissolved Solids (T.D.S)	1500 -500 (mg/l)
4	Total suspended solids (T.S.S)	100 (mg/l)

4. Conclusion

The concentrations of some of the studied physical properties were high and higher than the Iraqi standard criteria for drinking water.The concentrations of some of the physical properties were high and exceeded the control treatment of tap water (drainage water) entering the hospital.The samples of the hall basin witnessed high levels in most of the factors that were examined.

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