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Determination of Some Physicochemical Properties of the Wastewater System of the Al-Ramadi teaching hospital for Maternity and Children

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ABSTRACT

Hospitals pose a significant risk to human health due to the contamination of their environment with chemical elements. Exposure to these elements can have adverse health effects, such as neurological and developmental problems, cancer, and endocrine disruptors. To prevent and mitigate the risks associated with contamination, it is important to identify and control the sources of contamination. This study intends to investigate how chemical elements are contaminating hospitals, including the sources of contamination, possible health impacts of exposure, and preventative and remedial actions that may be done to lessen the dangers. To reach the aims of this study, water samples from three different spots at two different seasons (winter and summer) of the water flow through the hospitals (Hospital water on its first entry inside, Wastewater after use inside and around the hospital and Wastewater after passing through the treatment unit inside the hospital) have been collected. Suspended total solid (TS), Total dissolved solids (T.D.S), Electrical Conductivity, and Turbidity tests have been done on the collected water samples. Additionally, heavy materials have been detected in the collected samples. The results showed that the pH function increased slightly and insignificantly for the alkaline after using the water, while the water conductivity, alkalinity, hardness, and percentage of Total suspended solids (T.S.S) and total dissolved solids (TDS) reached the highest in wastewater. From the results of this study, we can conclude that the stages of treatment are slow and inefficient.

1. Introduction

Hospitals play a vital role in promoting health and treating diseases, but they can also pose a significant risk to human health through the contamination of their environment with chemical elements (Zhang et al., 2020). The sources of contamination in hospitals are varied and can include medical devices, cleaning products, building materials, and wastewater. Exposure to these chemical elements can have adverse health effects on patients, staff, and visitors, particularly those with pre-existing medical conditions or compromised immune systems (Exner et al., 2020).

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Hospitals are complex environments where many different types of chemical elements can be present. Medical devices, such as IV tubing, thermometers, and blood pressure cuffs, can contain heavy metals such as lead, cadmium, and mercury (Witkowska et al., 2021). Cleaning products and disinfectants can also contain hazardous chemicals, including quaternary ammonium compounds, hydrogen peroxide, and sodium hypochlorite. Hazardous compounds including lead, cadmium, and chromium may be found in building materials like paint, flooring, and pipes (Lineback et al., 2018). Additionally, a range of chemical pollutants, such as medications, disinfectants, and other compounds used in patient care, may be found in hospital wastewater. If wastewater isn't adequately treated, these chemicals might enter the environment and possibly endanger people's health. They can be challenging to remove from wastewater (Majumder et al., 2021).

Depending on the chemical element and the quantity of exposure, being exposed to chemical elements in hospitals may have a number of negative health impacts. For instance, exposure to lead may result in developmental and neurological issues, while exposure to mercury can harm the nervous system, kidneys, and lungs (Fernandes Azevedo et al., 2012). Exposure to cadmium may result in lung and prostate cancer, whereas exposure to chromium can result in lung cancer and skin rashes. While exposure to other elements like arsenic, copper, and zinc may also have harmful health consequences, exposure to nickel can also result in skin allergies and asthma (Balali-Mood et al., 2021). Endocrine disruptors are substances that interfere with the body's hormones' regular functioning. Several negative health impacts, such as cancer, reproductive issues, and developmental defects, may result from this (Zlatnik, 2016).

It's crucial to identify and manage the sources of contamination in order to avoid and reduce the dangers related to chemical contamination in hospitals. Using secure medical equipment and cleaning supplies, maintaining correct waste management and recycling practices, and monitoring and treating hospital wastewater are a few examples of what this might entail. Additionally, routine testing and observation of hospital surroundings may aid in identifying possible sources of contamination and enable the implementation of remedial measures (Padmanabhan et al., 2019).

Hospital chemical contamination is a serious public health issue that might have negative impacts on patients, employees, and visitors (Larson et al., 2016). Although there are many different types of pollution, the hazards associated with them may be reduced with careful detection and management. To maintain the safety and well-being of patients who rely on these vital institutions for their medical needs, further study into the health impacts of exposure to chemical components in hospitals is required (Lebelo et al., 2021).

This study intends to investigate how chemical elements are contaminating hospitals, including the sources of contamination, possible health impacts of exposure, and preventative and remedial actions that may be done to lessen the dangers.

1.1. Study Area:

The study was conducted in Anbar governorate specifically in the Women's and Children's Teaching Hospital. Figure (1) shows the study area (Anbar Governorate - Iraq)

Fig. 1 The study area Anbar Governorate – Iraq (*MUSINGS ON IRAQ: Iraq's Security Forces Collapse As The Islamic State Takes Control of Most of Anbar Province*, n.d.)**.**

2. Experimental Part

2.1. Samples collection

Three repeats of water samples were collected at a rate of one liter from different sites within the Women's and Children's Teaching Hospital, and as follows:

1- Hospital water on its first entry inside.
2- Wastewater after use inside and around the hospital.
3- Wastewater after passing through the treatment unit inside the hospital.

1- And those samples have been collected during February of 2023 and another batch of samples during the summer season of the same year. The standards of the Environmental Protection Agency 1977, EPA were carefully followed during the determination of the physical such as PH and other chemical parameters of the water quality. The temperature and the acidity function (PH) were measured directly upon collection. As for the rest of the measurements, the levels were determined by corresponding and standard methods.
2- Magnetic suspended matter (T.S.S) was measured by following the protocol mentioned by the previous study (Chan et al., 2008).
3- Total materials (T.D.S) I followed the method of (T.D.S) (Samuel, 2022).
4- An electrical conductivity meter (EC meter) by following the protocol provided by the previous study.(Nazarious et al., 2021)
5- Turbidity (turbidity) (T.U) was measured by relying on a Nephelometric Turbidity Unit (NTU) for measuring turbidity (Tomperi et al., 2022).

3. Results and Calculations

The results show in table (1) the readings obtained for the values of the parameters studied in the water stations that were included in the study, where the temperatures showed fixed values throughout the three stops. The results showed that the value of the pH function increased slightly and insignificantly for the alkaline after using the water, as it reached 7.4 in the wastewater, and this reinforces that the chemicals, alkaline and detergents that are thrown into the sewage network, and this value stayed the same after treated by the treatment unit.

The water conductivity showed higher levels in the wastewater that have been used by the hospital and left the treatment unit (2754 μs/ cm) followed by the wastewater before entry into the treatment unit (2725) and the lower level showed by the water once entered the hospital (1565 μs/ cm).

The results of Alkalinity such as CaCo3showed higher levels in the water that have been treated (663) followed by the water before entry into the treatment unit (546) and the lower value was recorded by the water once enter the hospital.
The test of hardness recorded a higher level in the water that have been used by the hospital and has not been treated (632) followed by the water after treatment (560) and followed by water once entered the hospital (558).
As for the percentage of suspended solids (T.S.S) and dissolved solids (TDS), it reached the highest in wastewater, reaching 412mg/L and 1922 mg/ml, respectively, while it reached 342 mg/L and 1936mg/ml, respectively, after passing through the internal treatment unit used in the hospital and this indicates that the stages of treatment are slow and inefficient.
The measures of physical determinants for the collected water samples during the winter seasons are shown in table (2) the measurements made for the values of the parameters examined at the study's water stations, where the temperatures were constant throughout the course of the three pauses. The results of turbidity showed a higher level in the sample of water after treatment (26) followed by Water before entry to the hospital (19.5) and the least with a sample of Wastewater after use (11.9).

Table 1 – showing the measures of pollution determinants in winter.

Parameters in mg/l	Water before entry to the hospital	Wastewater after use inside and around the hospital	Wastewater after passing through the treatment unit inside the hospital
Turbidity, NOU	0.7	119	143
Temperature	17	17	17
p H	6.9	7.4	7.4
E.c. H SOM 25	1565	2725	2754
Alkalinit (as CaC09)	140	546	663
Hardness (as CaCO,)	558	632	560
Calcium (as Ca)	125	162	122
Magnesium (as Mg)	59	55	62
Chloride (as Cl)	190	281	278
Sulphates (as Soa)	410	450	482
Sodium (as Na)	140	250	230
Potassium (as K)	7.8	41	42
TDS	1096	1922	1936
TSS	8	342	412

The temperature remained constant by the three stages at (25 C). the pH remains the same at two stages water before entry to the hospital and wastewater after passing through the treatment unit (6.7) and Wastewater after use showed a lower level (6.2). the E.C. showed higher measures at the water before entry to the hospital (3090) followed by wastewater after passing through the treatment unit inside the hospital (2830) and then the used water (1839). The alkalinity recorded the higher level in samples of treated water (138) followed by unused water (130) and then wastewater (112). Hardness was higher in the samples of Water before entry to the hospital (1056) followed by treated water (978) then untreated water that has bean used (630). Magnesium levels were the same at both stages Wastewater after passing through the treatment unit inside the hospital and Water before entry to the hospital (86) and recorded a lower level at Wastewater after use inside and around the hospital (52). Chloride showed the higher level at Water before entry to the hospital (382) followed by Wastewater after passing through the treatment unit inside the hospital (339) then Wastewater after use (230). The measurements of the amount of oxygen required to remove waste organic matter from water in the process of decomposition by aerobic bacteria Bod has showed a higher level in Water before entry to the hospital (29) followed by Wastewater after use inside and around the hospital (21), then the water after passing through the treatment unit (17).

Heavy metals are a common type of water pollutant and can have harmful effects on human health and the environment. They are often present in water sources because of industrial activities, mining, and urbanization. The results of this study obtained from the atomic absorption apparatus are shown in the table (3). The result of Cu showed pollution since it recorded 0.529ppm in the normal water, 0.4763ppm in the water before the treatment and 0.472 in the treated water. This result exceeded the exemptible limit. According to National drinking water regulations (Drinking Water Standards), the permissible limit for Copper in drinking water is 1.0 mg/L. According to WHO (World Health Organisation), the permissible limit for Copper in drinking water is 2.0mg/lit.

According to the national drinking water regulation (Drinking Water Standards), the permissible limit for Zinc in drinking water is 5.0 mg/L. According to WHO (World Health Organization), the permissible limit for Zinc in drinking water is 3.0mg/lit, and since the results of this study showed concentration in normal water is 0.211ppm, 0.038ppm in untreated water and in the treated water 0.013ppm, this means the water in the three stages is not polluted with Cu.

Table 2 – showing the measures of pollution determinants in summer.

Parameters in mg/l	Water before entry to the hospital	Wastewater after use inside and around the hospital	Wastewater after passing through the treatment unit inside the hospital
Tu,rbidity, NOU	19.5	11.9	26
Temperature	25	25	25
p H	6.7	6.2	6.7
E.c. H SOM 25	3090	1893	2830
Alkalinit (as CaC09)	130	112	138
Hardness (as CaCO,)	1056	630	978
Calcium (as Ca)	280	164	249
Magnesium (as Mg)	86	52	86
Chloride (as Cl)	382	230	339
Sodium (as Na)	242	270	230
Potassium (as K)	10	8.3	10
TDS	2060	1264	1930
TSS	62	54	78
Bod	29	21	17

The results showed pollution with Cd since the concentration of Cd showed 0.234ppm in the normal water, 0.030ppm in the untreated water and 0.0152ppm in the treated water. All the concentrations exceeded the permissible limit of Cd which is 0.003 (Monchanin et al., 2021). The Lead limit is 0.01ppm (Monchanin et al., 2021), and this limit has been exceeded in the three stages of the water system, the sample from normal water recorded 0.153ppm, the untreated sample recorded 0.143ppm and the treated water sample showed 0.1077ppm concentration of Pb.

Table 3 – heavy metals concentration in the selected water samples

heavy metal	normal water	before treatment	after treatment
Cu	0.529 ppm	0.4763 ppm	0.472 ppm
Zn	0.211 ppm	0.038 ppm	0.0134 ppm
Cd	0.234 ppm	0.0303 ppm	0.0152 ppm
Pb	0.153 ppm	0.143 ppm	0.1077 ppm

The results of figure (2) showed the recorded concentration of Cu in the water collected from the different stages of the water system.

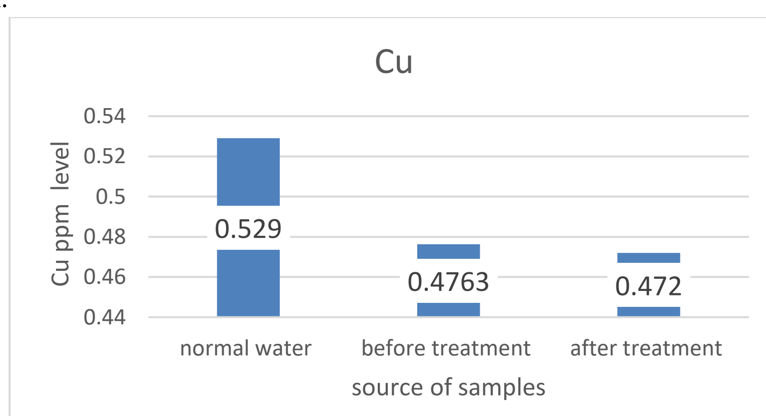

Fig. 2 concentration of Cu in the normal water sample, a sample of water before treatment and water sample after the treatment unit

Figure (3) showed the concentration of Zn within the samples of water collected from the three different stages of the water treatment unit.

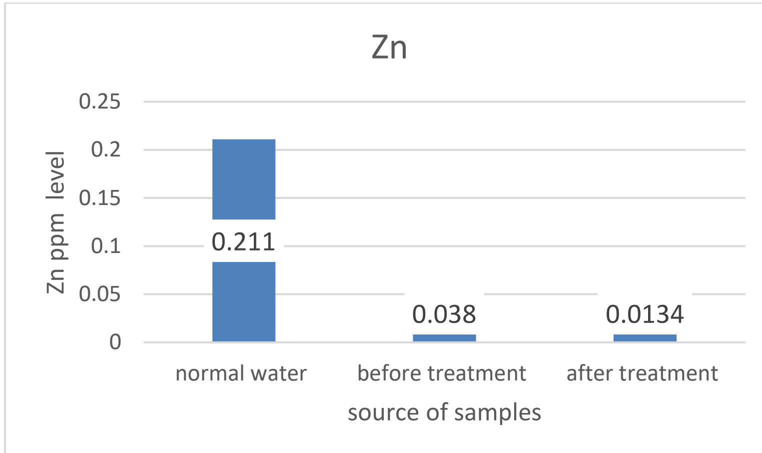

Fig. 3 concentration of Zn in the normal water sample, sample of water before treatment and water sample after the treatment unit

The results in figure (4), shown the higher polluted sample of water with Cd is the normal water before entering the hospital.

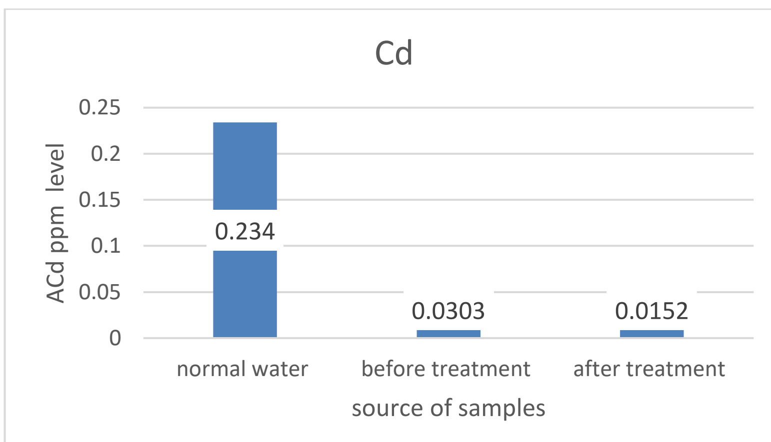

Fig. 4 concentration of Cd in the normal water sample, a sample of water before treatment and water sample after the treatment unit

The results of figure (5) show high pollution with Pb within all the samples of the water of the hospitals' system.

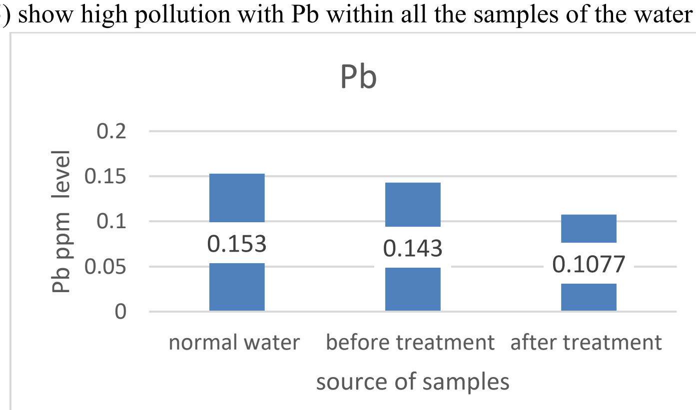

Fig. 5 concentration of Pb in the normal water sample, sample of water before treatment and water sample after the treatment unit

4. Discussion

The results showed PH values increased after the using by the hospital. The main source of alkalinity may be the salts of carbonates, bicarbonates, and hydroxide compounds, in addition to the contribution of borates, silicate, and phosphates in them. There is a relationship between alkalinity, but in the total hardness in terms of calcium carbonate, nitrate, and pH of water, it is because calcium carbonate is the main cause of hardness. As for nitrates and pH, the relationship between them and the alkaline water is due to the fact that the water contains organic substances that come from sewage water without treatment. These organic substances are decomposed into ammonia, then the ammonia is transformed into nitrite by the bacteria called Nitrosomonas as a first stage, and in the second stage the nitrite is transformed into nitrate by the action of the Nitrobacter bacteria (Daims et al., 2016). During these two processes, all A kilogram of ammonia is oxidized to nitrite, it needs 8.18 km of alkalinity and 1.78 kg of oxygen, followed by a decrease in The pH is a result of the decrease in the regulatory action of water first and the increase of acidic ions (nitrates) secondly (Moloantoa et al., 2022).

A common metric for assessing the quality of water is water conductivity. Total dissolved solids (TDS), which may be an indicator of the presence of inorganic substances such as salts, minerals, and metals, are correlated with the conductivity of water (Li et al., 2023). The number of contaminants in the water is often determined by the conductivity of the water. In this situation, the conductivity of hospital wastewater may be a crucial factor in determining how well the wastewater treatment process is working (Sinitsa et al., 2022).

Numerous research have looked at the conductivity and treatment of hospital wastewater. Ahmad et al. (Ahmad-Mansour et al., 2021) conducted research on the conductivity of sewage generated by a tertiary care hospital in India. The analysis discovered that the wastewater's conductivity was greater than the suggested values, suggesting the presence of significant TDS levels in the water. The authors hypothesized that this may be caused by the hospital's usage of chemicals and disinfectants, as well as the wastewater's disposal of medications and medical waste. Gao et al (Zhou et al., 2022) investigation on the efficacy of a hospital's wastewater treatment system in China was part of another research. According to the research, contaminants were removed throughout the treatment process since the conductivity of the wastewater before treatment was much greater than that of the treated wastewater. The conductivity of the wastewater was also discovered by the authors to have a positive correlation with total nitrogen and phosphorus concentrations, showing the presence of both organic and inorganic chemicals in the water (Banerjee et al., 2022). Hospital water conductivity has also been researched in addition to hospital wastewater. The water quality in hospitals in the United States was examined in research by (Strosnider et al., 2019). According to the research, there are more pollutants in the water owing to hospital activities since the conductivity of the water entering the hospital is lower than that of the water leaving the hospital. The authors hypothesized that this may be caused by the hospital's usage of medical equipment, cleaning supplies, and disinfectants. The findings of the alkalinity test revealed that the treated water had a greater level of alkalinity than the water that had not yet entered the treatment unit. Once the water reached the hospital, it was discovered to have less alkalinity than the other two samples.

The existence of leftover chemicals employed in the treatment process, like lime or sodium hydroxide, which may raise the alkalinity level of water, may be the cause of the treated water's greater alkalinity level after the hospital. On the other hand, the reduced alkalinity of the water after it reached the hospital may have been caused by chemical processes there consuming bicarbonate and carbonate ions (Nelson et al., 2021).

5. Conclusions

That the stages of treatment are slow and inefficient. Results of alkalinity indicated that the treated water had a higher alkalinity level than the water that had not yet reached the treatment unit. When the water arrived at the hospital, it was revealed that it had less alkalinity than the other two samples. The presence of remaining chemicals used in the treatment process, such as lime or sodium hydroxide, which may boost the alkalinity level of water, may be the source of the higher alkalinity level of the treated water after the hospital. The lower alkalinity of the water when it arrived at the hospital, on the other hand, may have been produced by chemical reactions there that consumed bicarbonate and carbonate ions.

6. Recommendations

1- Regular Testing and Monitoring: Implement a comprehensive water testing and monitoring program to ensure the quality of water throughout the hospital. Regularly test for bacteria, pathogens, chemical contaminants, and other potential hazards.
2- Use of Point-of-Use Water Filters: Install point-of-use water filters at critical areas such as patient rooms, surgical areas, and laboratories to provide an additional layer of protection against waterborne contaminants. These filters should be regularly maintained and replaced as per the manufacturer's instructions.
3- Implement Backflow Prevention Measures: Install and regularly inspect backflow prevention devices in plumbing systems to prevent the reverse flow of contaminated water back into the potable water supply. This helps to safeguard against potential cross-contamination.
4- Regular Maintenance and Cleaning: Develop and enforce a regular maintenance schedule for water treatment equipment and plumbing systems. This includes routine inspection, cleaning, and maintenance of water storage tanks, pipes, filters, and other components to prevent the buildup of sediments, biofilms, or other contaminants.
5- Staff Education and Training: Provide comprehensive education and training programs to hospital staff regarding water safety and infection control practices. This should include training on proper hand hygiene, the risks associated with waterborne pathogens, and guidelines for using and maintaining water-related equipment.

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