Evaluation of the hospital's wastewater treatment plant in Basrah province

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Abstract. This paper concentrates on evaluating the wastewater properties and performance of the hospital wastewater treatment plant (WWTP) for two hospitals in Basrh province Al-Taaleme hospital, and Al-Fayhaa hospital. Samples were collected from the WWTS influent and effluent then evaluated pollutants containing by using American Public Health Association (APHA) methods and in comparison to standard guidelines. Laboratory tests of wastewater were conducted to investigate ten parameters: chemical oxygen demand (COD), biochemical oxygen demand (BOD), pH, temperature, electric conductivity (E.C), total suspended solids (T.S.S), total dissolved solids (T.D.S), dissolved oxygen (DO) sulfate (SO₄), phosphate (PO₄), ammonia (NH₃) and nitrate (NO₃) which have been chosen to assess the quality of wastewater. The results showed that all pollutants were in compliance with the standard limit in Iraqi standard specification B₁ for the year 1998, except for the NH₃ results for Al-Fayhaa hospital (B), which were 12 mg/L while the standard was 10 mg/L, and COD effluent was exceeded the Iraqi standards for both hospitals Al-Taalemee hospital (A) and Al-Fayhaa hospital (B), which were 155 mg/L and 150 mg/L respectively while the standard was specified effluent by 100 mg/L, and for SO₄ effluent was exceeded the Iraqi standards for both hospitals Al-Taalemee hospital (A) and Al-Fayhaa hospital (B) was 760 mg/L and 650 mg/L respectively while the standards were specified by 400 mg/L.

1. Introduction

On average, hospitals produce 750 liters of wastewater per bed and day [1]. These residues contain pollutants that must be treated. Any sewage treatment plant's primary purpose is to minimize or eliminate organic matter, solids, nutrients, disease-causing microorganisms, and other contaminants from wastewater. The lack of natural water supplies and the increased demand for clean water supply are the main drivers behind sewage treatment [2].

Hospital wastewater is a swage result from hospital tasks such as medical and non-medical first-aid activities and operating emergency, radiology diagnostic, laboratory, laundry, and kitchen [3],[4]. Hazardous contaminants can be found in hospital wastewater like pharmaceutical partially metabolized, microorganisms that cause disease, toxic chemical substances, and radioactive elements [5].

Al-Dulaimi [6] explained, through the study he conducted on evaluating the efficiency of treatment plants for three hospitals in Mosul city, that the characteristics of the wastewater of these hospitals are similar to the characteristics of the municipal wastewater, this study showed a big decrease in removal efficiency for wastewater treatment plant of Al-Khansaa hospital which depends on activated sludge treatment and the reason for this decreasing because of many problems that the wastewater treatment plant suffers from it, as well as the nature of the wastewater treating in this treatment plant.
Al-Hashemi [7] conducted a study on the effect of hospital laboratories (Al-Khansa, Al-Batoul, Ibn Sina) on the biological process. The study showed that laboratory wastewater contains toxic substances and heavy metals, which leads to inhibition of biological activity as well as causes shocks to biological systems even after it has been acclimatized the sludge for one month on hospital wastewater, as the researcher used two basins for biological treatment, the first receiving hospital wastewater without mixed with laboratory wastewater and the second basin receiving hospital wastewater mixed with laboratory wastewater, and high biological efficiency was observed for the first basin, while the removal efficiency in the second basin decreased because the laboratory wastewater contains chemicals and heavy metals.

Mustafa et al [8] reported that the concentrations of organic and microbial loads in wastewater of three hospitals (General Hospital, Republic Hospital, and Maternity Hospital) exceed those found in conventional wastewater through experimental research for the hospitals' wastewater.

We take samples from influent and effluent to evaluate the efficiency of WWTP in Altaaleme hospital, and Alfayhaa hospital, the biological method is used to treat wastewater in these hospitals.

The pollutants were considered in this research are; chemical oxygen demand (COD), biochemical oxygen demand (BOD), PH, temperature, electric conductivity (E.C), total dissolved solids (T.D.S), total suspended solids (T.S.S), dissolved oxygen (DO) sulfate (SO₄), phosphate (PO₄), ammonia (NH₃) and nitrate (NO₃).

This study would contribute to the application of wastewater treatment technologies for increased efficiency based on wastewater characteristics. The objective of this research is to understand more about the characteristics of hospital's wastewater and the efficiency of some of Basrah's hospitals' wastewater treatment plants (WWTP) for example Al-Taaleme hospital denoted as (A), and Al-Fayhaa hospital denoted as (B).

2. Materials and methods

2.1 Samples collection
In this study, samples were collected at influent and effluent of WWTP in clean glass bottles according to the APHA standard methods [9]. Samples were taken once a day (11 a.m.) In March and the beginning of April. Most of the tests were done directly after the samples were taken with a field device and we stored the other duplicate samples in a refrigerator at 4C° in the laboratory of sanitary at the College of Engineering, University of Basrah.

2.2 The analytical method or experimental procedure
Dissolved oxygen (DO), E.C, temperature, and PH (before measurement the device was calibrated by using standard solutions) were measured by a digital metal. COD, BOD, T.S.S, T.D.S, SO₄, PO₄, NH₃, and NO₃ under the standard method [9]. The samples analyses are carried by using DR5000 and DR1900 Hach spectrophotometric.

Filtered wastewater samples through filter paper (pore size 0.45Mm) when the test requires that.

3. Results and discussion
Basrah city (which is located south of Iraq) has many hospitals the sewage treatment in most of these hospitals was biological treatment.

We are given a symbol to every hospital Al-Taaleme hospital (A), and Al-Fayhaa hospital (B), table 1 showed the results of this research.

The conversion or removal efficiency equation of any pollutant is calculated as follows [10]:

Removal efficiency % = \[
\frac{[A_0] - [A_t]}{[A_0]} \]

(1)
Where:
\[ [A_0] = \text{Initial concentration of pollutant at time zero, mg/L} \]
\[ [A_t] = \text{Concentration of pollutant after time } t, \text{ mg/L} \]

**Table 1.** The average pollutant concentration in the influent and effluent WWTP, removal rate %, and quality standard.

| Parameter | unit  | influent | effluent | Removal rate % | Quality standards |
|-----------|-------|----------|----------|----------------|------------------|
|           |       | A        | B        | A              | B               |
| DO        |       | 3        | 4.2      | 1.5            | 1.8             |
| COD       | mg/L  | 550      | 500      | 155            | 150             | 72               | 70               | 100             |
| BOD       | mg/L  | 280      | 250      | 35             | 30              | 87               | 88               | 40              |
| PH        |       | 7.3      | 8.1      | 7.2            | 6.7             |
| Temperature | C°    | 37       | 38       | 37.5           | 38              |
| E.C       |       | 4820     | 5000     | 4925           | 5100            |
| T.S.S     | mg/L  | 227      | 75       | 54             | 46              | 76               | 38               | 60              |
| T.D.S     | mg/L  | 2320     | 3000     | 2635           | 3500            |
| SO₄       | mg/L  | 730      | 600      | 760            | 650             |
| PO₄       | mg/L  | 5.4      | 4.3      | 3.2            | 3               | 40               | 30               | 3               |
| NH₃       | mg/L  | 30       | 30       | 6              | 12              | 80               | 60               | 10              |
| NO₃       | mg/L  | 26.5     | 30       | 17.6           | 20              | 33               | 33               | 50              |

Under temperature (25-35) C°, DO values were (0.5-2) mg/L of wastewater for two hospitals, this indicates that the oxygen requirements of the aquatic organisms will be achieved by this treated water, figure 1.

![Figure 1. Dissolved Oxygen Concentration.](image)

Figure 2 shows a moderate PH rate, while electrical conductivity and total dissolved solids of treated wastewater increase by percentages (13 percent and 14 percent for hospitals A and B, respectively) as compared to raw wastewater, as shown in figure 3 and figure 4.

As for raw sewage, it is easy to decompose, and this conclusion is supported by the BOD/COD rate of 0.6. From the above, it is evident that hospital wastewater was similar in quality and strength to domestic wastewater [11]. The removal of COD mainly occurred in the first hour because of the dilution reactor and the biological activated sludge adsorption [12]. COD removal was over 70% in figure 5, and the COD concentration of the effluent is reduced to a lower concentration.
Solids in water that can be trapped by a filter are referred to as total suspended solids (TSS) [13]. TSS in high concentrations can cause problems with stream health and aquatic life. Note the rate of total suspended solids within the specifications in all hospitals, so there is no problem with these values.

SO₄ increase my limits so that the presented value is more than the Iraqi standard, which defined it by (400 mg/L) see figure 8, but however sulfate is good sulfur for many anaerobes, sulfate will be reduced to sulfide under anaerobic conditions and that also may act as a sulfur source. For many wastewaters, the sulfur limitation is not a concern because it is present already, even in drinking water there is sufficient sulfate.
Figure 4. Total Dissolved Solids.

NO$_3$ concentration decreases from 26.5 mg/L before treatment to 17.6 mg/L for hospital A, and 30 mg/L to 21 mg/L for B. This indicates the nitrification process has occurred in figure 9.

Figure 5. COD Concentration.

Figure 6. BOD Concentration.
Therefore, it is noted that the PO$_4$ concentration is reduced by (40%, and 30%) after treatment for hospitals (A, and B) respectively, as it is used in building the oxidation process in the activated sludge tank works favorably to remove the organic load. Look figure10.

![Figure 7. TSS Concentration.](image)

However, it does not meet the required standard. As a suggestion, calcium may be added. It's normally applied in the form of lime (Ca(OH)$_2$), which reacts with the wastewater's natural alkalinity to form calcium carbonate, as the pH value increase beyond about 10, excess calcium ions will then react with the phosphate, to precipitate in hydroxylapatite.

![Figure 8. Sulfate Concentration.](image)

NH$_3$ is a nitrogenous compound that is oxidized in nitrification. The tests indicated that the ammonia value is within the limits of the standard. Except for hospital B (Al-Fayhaa hospital), the value exceeded the required by about 20%. See Figure11.
Figure 9. NO$_3$ Concentration.

![NO$_3$ Concentration Graph]

Figure 10. PO$_4$ Concentration.

![PO$_4$ Concentration Graph]

Figure 12 clear removal rate% for some parameters. In general, there is a fairly good treatment rate of most pollutants in hospitals' wastewater. For example, at least 60% for BOD, 70% for COD, 30% for NO$_3$, see table1.
Figure 11. NH₃ Concentration.

Figure 12. Removal efficiency for all pollutants in hospitals

4. Conclusions
Despite the hospital wastewater was diluted and treated in a wastewater treatment plant (WWTP), the lab tests found that some wastewater parameters still exceeded Iraqi standards, for example, NH₃ effluent for Al-Fayhaa hospital (B) which were 12 mg/L while the standard was 10 mg/L, COD effluent was exceeded the Iraqi standards for both hospitals Al-Taalemee hospital (A) and Al-Fayhaa hospital (B), which were 155 mg/L and 150 mg/L respectively while the standard was specified effluent by 100 mg/L, and for SO₄ effluent was much exceeded the Iraqi standards for both hospitals Al-Taalemee hospital (A) and Al-Fayhaa hospital (B) was 760 mg/L and 650 mg/L respectively while the standards were specified by 400 mg/L.
Influent wastewater hospitals are considered to have high concentrations, although some pollutant concentrations of effluent seem to exceed quality requirements. Hospitals in Basrah use WWTPs, which have advantages and disadvantages in terms of reducing pollutant concentrations of COD, BOD, PH, (T.S.S), (T.D.S), SO$_4$, NO$_3$, and other pollutants, but not efficient in reducing pollutant concentrations of PO$_4$ and NH$_3$. In total, the results showed good removal rates for most of the pollutants.

5. References
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