JKAU: Sci., **Vol. 34**, No. 2, pp: 89 - 97 (2024)
DOI:10.4197/Sci.34-2.7

Studying the Optimal Techniques for Removing the Organic Load from Wastewater of Hospitals Laboratories

Abdalrhman Tattan[1], Fatimeh Jaara[2] and **Nozete Nebghali[3]**

[1] PhD student, Dept of Environmental Engineering, Faculty of Civil Engineering, [2] Dept of Environmental Engineering, Faculty of Civil Engineering, and [3] Dept of Science Basic, Faculty of Civil Engineering, University of Aleppo, Aleppo, Syria

Abstract. Hospital wastewater poses a strong threat to human health security as it contains a variety of difficult-to-degrade organic compounds, active pharmaceutical compounds, multiple inorganic pollutants, etc., causing complex pollution in water resources and ecosystems. In this study, wastewater of analysis laboratories in the hospital were treated using several techniques, including biological treatment using the Rotating Biological Disk method (RBC), adsorption with Syrian natural clay, coagulation with aluminum sulphate, advanced oxidation with ultrasound, and dual treatment using natural clay with ultrasound waves. The removal of organic load was determined after each type of treatment. Results showed that the best method for treating the studied water sample was treatment using natural clay with ultrasound, where water suitable for irrigation was obtained according to the Syrian standard, when adding natural pollutants at a concentration of 1gm per liter of polluted water and applying ultrasound waves at a frequency of 40kHz for 30 minutes, chemical oxygen demand COD reached to 212 mg/l with a removal rate of 94% and the biochemical oxygen demand BOD was 82 mg/l with a removal rate of 87%. Finally, it can be concluded that it is preferable to treat hospital wastewater using multiple techniques due to the diversity of pollutants to obtain acceptable results.

Keywords: Wastewater, Coagulation, Adsorption, Ultrasound, Biological treatment, Chemical treatment.

1. Introduction

Medical and solid waste from hospitals, and the environmental pollution they cause, are among the most critical issues that must be addressed urgently due to their catastrophic impact on humans, soil, and water sources if not disposed of properly [1].

Most hospitals, if not all, lack in-house waste treatment plants. Hazardous waste often ends up in public gardens or rivers, eventually contaminating crops irrigated with this polluted water.

We studied many sewage units belonging to distinguished hospitals. The distinguished one in this field is Beryl's study, which determines the specifications of fresh water drains from the hospital laboratory in Gaziantep. The final result, which is the search for effective water for the hospital laboratory, contains some polluting elements that are above The required limits are required globally so this water is necessary [2].

It contains many polluting sources resulting from its large activities. These are excreted in the high turquoise acid of luxury cars, chemical compounds, radioactive isotopes, viruses that cause viruses, and viruses resulting from the various units in the hospital, especially the laboratory unit, which contains multiple types of laboratories, including (chemicals laboratory, hematology laboratory, Bacterial laboratory, vitamin laboratory, PCR laboratory, testing laboratory, serology laboratory, electrolytes laboratory, PT laboratory) [3,4].

Certainly, these many laboratories are conducted in which various chemical materials and compounds are used, the most important of which are (cyanide, phenol, mercury, bromine, formaldehyde, chromium, and zinc). These compounds are used through the network to the general stream to detect and affect the qualitative profits in it and are disposed of as they are with all It is carried by blood [3,4].

Next, a clear and bacteriological film of hospital wastewater demonstrates the presence of a wide range of hazardous chemical compounds and their residues, including scents, hormones, smoke, disinfectants, dyes, cytotoxins, and visible isotopes. It is characterized by hospital wastewater and the complexity of biochemical oxygen demand BOD, chemical oxygen demand COD, total dissolved solids TDS, total suspended solids TSS, total solids TS, total organic carbon TOC, total nitrogen TN, nitrite, nitrate. Drainage water also creates high concentrations of harmful bacteria and drug-resistant bacteria, therefore, it remains essential for the environment.

The percentage of sewage resulting from laboratories in the hospital represents about 7-20% of the sewage of the hospital college. [5,6]

After wastewater treatment by WWTPs, the particle removal for small and minor PC steps is 20-50%, 30-70%, and > 90%, respectively. Conventional viral treatment; Bagdad Bioactives, multi-organism-activated treatment, and filtrate, are present (<80%) in BOD, COD, and TSS but are ineffective in removing combinations of mild discrimination, psychiatric drugs, and antibiotic resistance. Advanced industry needs such as advanced refrigerator, ozone refrigerator, Fenton oxidation, nano-regeneration, and hybrid technologies for comprehensive study of complete fungi removal. The ozonation cell removes up to 93% of the various active substances present in the wastewater. Just as modern AOPs remove a significant amount of antibiotics and antibiotics from hospital wastewater, it has been shown that MBR reactors in conjunction with urbanization with advanced readiness AOPs are not successful in discharging hospital wastewater on a full scale [5,7,8].

Aims of this research is determine the best way to treat wastewater from Aleppo University Hospital laboratories using known treatment methods and focusing on the use of ultrasound as it is one of the modern methods that does not generate any harmful products and does not require chemical additives.

2. Materials and Method

2.1 Wastewater Collection

Samples of wastewater were collected from laboratories of Aleppo University Hospital, then mixed to form a composite sample and stored in tightly sealed polyethylene containers at low temperature. The specifications of wastewater were determined according to standard methods Table 1 [9].

2.2 Biological Treatment of Wastewater

To study the effectiveness of biological treatment of water sample, a rotating biological discs RBC was used. RBC was consist of a cylindrical treatment basin with a length of 1m and a diameter of 55 cm, with a capacity of 80 litres, it contains 18 disks, the diameter of each disk was 45cm, the spacing between the disks was 1cm, the thickness of the disk was 3 mm, and the length of the axis was 1m, where the horizontal distance of the first disk was approximately, the inlet was 38 cm, and horizontal distance of the last disc from the exit 38cm, as shown in Fig. 1. Number of cycles were controlled and the disc immersion rate was 35%. There is a sedimentation basin after the treatment basin.

The reactor was operated at a laboratory temperature of (25±2) ºC, samples of wastewater were added daily in order to grow bacteria on the surface of the discs.

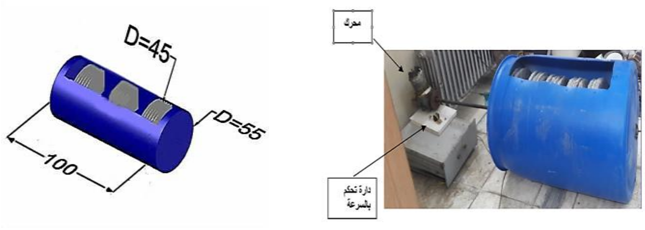

Fig. 1. RBC rotary disk biological reactor.

2.3 Treatment Wastewater by Adsorption

To study the effectiveness of chemical adsorption treatment of the studied water, natural clay was collected from Tal Ajar in Aleppo, Syria, with the following chemical composition: SiO_2 (47.44%), Al_2O_3 (19.25%), Fe_2O_3 (8.5%), MgO (1.79%), CaO (6.18%), Na_2O (0.19%), K_2O (2.35%), SO_3 (0.97%), L.O.I (13.05%)

Eight samples of the studied water, each with a volume of 1 liter, were treated with varying amounts of clay, granular sizes, and treatment times according to the following:

- Sample (A): amount of clay 0.5gr, particle size 500µm, processing time 30min
- Sample (B): The amount of clay is 1gr, the particle size is 500µm, the processing time is 30min.
- Sample (C): Amount of clay 2gr, particle size 500µm, processing time 30min
- Sample (D): Amount of clay 3gr, particle size 500µm, processing time 30min
- Sample (E): The amount of clay is 2gr, the granular size of the clay is 300µm, the processing time is 30min.
- Sample (F): The amount of clay is 2gr, the granular size of the clay is 100µm, the processing time is 30min.
- Sample (G): Amount of clay 2gr, particle size 100µm, processing time 60min
- Sample (H): amount of clay 2gr, granular size of clay 100µm, processing time 120min

2.4 Treatment Wastewater by Coagulation

To study the effectiveness of coagulation treatment hydrated aluminum sulphate was used, $Al_2(SO_4)_3.18H_2O$, with a purity of 98%, produced by Sigma-Aldrich.

Treatment was carried out by adjusting the acidity at pH=7 using a diluted solution of sodium hydroxide and a diluted solution of hydrochloric acid until the required value was reached, treatment conditions were according to Table 1.

Table 1. Conditions of treatment wastewater by Coagulation.

Sample	Aluminum sulphate gr/L	Treatment time min
A0.5	0.5	120
A1	1	120
A1.5	1.5	120
A2	2	120

2.5 Treatment Wastewater by Ultrasonic

To study the effectiveness of ultrasonic treatment, an ultrasonic wave generating device, model WUC-D 3.3, with a high frequency of 40 kHz, produced by witeg, was used

Labortechnik GmbH, frequency, and exposure time in reducing organic pollutants present in the water sample was studied, where the applied frequency was kHz (20, 30, 40), and the exposure time was min (15, 30, 45). Each test was repeated 3 times, then the COD and BOD were measured after treatment.

2.6 Treatment with Clay and Ultrasound

Treatment was carried out with clay and in the presence of ultrasound. Sample was coded with the symbol AU and stirred mechanically, the best conditions from results of this study were applied.

2.6 Bacterial Tests

The Total Count Plate **TPC** method was used, and each of the following media was used:

- General counting medium: (Oxoid) plate count agar was used to enumerate the germs in the studied sample
- MacConkey Agar: (HIMEDIA) MacConkey agar was used to detect the presence of Enterobacteriaceae bacteria.

As for bacterial analyzes, they were conducted on the final treated sample by planting 1ml of the sample by spreading it on both types of medium and incubating at a temperature of 37 degrees Celsius for 48 hours. The number of bacteria in 1ml of the sample was calculated after developing colonies and applying the counting law by multiplying the number of growing colonies by the reciprocal of the dilution.

3. Results and Discussion

3.1 Biological Treatment of Wastewater

Table 2 shows the specifications of the studied wastewater. The biological layer development took 35 days, forming a membrane layer of approximately 0.5 mm. Processing experiments were then conducted. Table 3 shows the results during the reactor start-up phase.

Table 2. Specifications of studed wastewater.

Symbole	Syrian standard for irrigation /2752/ of 2008	Sample
pH	6-9	7.1
S.S (mg/l)	-	8.1785
T.S.S (mg/l)	150	465
SO_4 (mg/l)	500	540
NH_4-N	5	30
PO_4 (mg/l)	20	122
Cr (mg/l)	1	0.5
Cu (mg/l)	5	4
BOD (mg/l)	150	635
COD (mg/l)	300	3600
T.D.S (mg/l)	1500	4300
Cl (mg/l)	350	3944
F (mg/l)	15	40.2

As noted from Table 2, as the development time increased, the efficiency of COD removal improved due to the increasing growth of biomass that was feeding on organic materials and breaking them down to obtain the energy needed for growth and construction.

After the completion of the reactor start-up process (biological membrane development), treatment was carried out by adding the water sample to be treated to the treatment basin in batches at a flow rate of 2 L/h, using a rotation speed equivalent to 6 rpm. Samples were taken from the sedimentation basin after the treatment basin, after different times (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12) h.

Table 3. Results of experiments conducted in the reactor start-up phase.

start-up (day)	COD (mg/l)
0	3600
5	1523
10	1342
15	924
20	575
25	437
30	263
32	251
33	245
35	240

Chemical analyses were conducted to determine the extent to which treatment effectiveness was affected by time, as shown in Table 4.

Table 4. Organic load after biological treatment.

Treatment Time (h)	COD (mg/l)	BOD (mg/l)
Raw water	3600	635
1	2683	530
2	2119	466
3	1709	326
4	1366	301
5	1095	278
6	894	251
7	724	231
8	528	227
9	388	206
10	294	191
11	186	135
12	147	124

It can be observed that as the treatment time increases, it decreases. The COD value reached the value of 147 mg/l at a treatment time of 12 hours and also at a time of 10 hours. The Syrian standard for irrigation of agricultural lands /2752/ of 2008 was reached, where the COD concentration decreased to 294 mg/l. The results also indicated that with increasing treatment time, it decreased. The BOD value reached 124 mg/l at a time of 12 hours, and also at a residence time of 10 hours. The Syrian standard for irrigation of agricultural lands was reached, as the BOD concentration decreased to 135 mg/l, which indicates that the ideal treatment time to obtain water suitable for irrigation is 10 hours.

3.2 Treatment Wastewater by Adsorption (clay)

Results in Table 5 showed the following points:

-The effectiveness of treatment increases with the amount of added pollutants, and the best amount was 2gr per liter of polluted water. Adding a larger amount does not give a clear increase in the effectiveness of treatment.

-The effectiveness of the treatment increases with the decrease in the granular size of the clay used as a result of the increase in the specific surface. We note that the size of 100 microns was the best and we did not study the size less than 100 because there is difficulty in grinding and a high cost to reach smaller sizes.

-The effectiveness of treatment increases with increasing treatment time, and the best time is 120 minutes. 60 minutes can be sufficient if the goal is to dispose of water into sewage.

Table 5. Organic load after adsorption treatment.

Water sample	COD (mg/l)	BOD (mg/l)
Raw water	3600	635
A	610	225
B	436	198
C	410	172
D	380	150
E	312	131
F	277	112
G	252	91
H	240	85

3.3 Treatment Wastewater by Coagulation (aluminum sulphate)

Results in Table 6 showed that the effectiveness of treatment with aluminum sulphate was less than the effectiveness of treatment with adsorption agents. The explanation for this result is due to the type of pollutant materials accompanying the studied water, where their ability to aggregate and settle is weak and their solubility is high. Therefore, adsorption is considered to be of high quality. Better effectiveness in capturing and collecting these organic pollutants.

Table 6. Organic load after Coagulation treatment.

Water sample	COD (mg/l)	BOD (mg/l)
Raw water	3600	635
A0.5	2198	379
A1	1755	341
A1.5	1689	330
A2	1630	310

3.4 Treatment Wastewater by Ultrasonic

Results in Table 7 were indicated the effectiveness of the treatment increases with the increase in the applied frequency and the frequency application time, and that the treatment is greatly affected by the increase in frequency. It is more than affected by the time of applying the frequency, so it can be concluded that treatment at a frequency of 40 kHz for 30 minutes is sufficient to obtain water with an organic content acceptable for use in irrigating crops.

Table 7. Organic load after ultrasonic treatment.

Water sample		COD (mg/l)	BOD (mg/l)
Raw water		3600	635
kHz	min		
20	15	3120	592
20	30	2833	500
20	45	2773	432
30	15	2688	401
30	30	2430	344
30	45	2332	312
40	15	2312	378
40	30	1934	284
40	45	1885	255

3.5 Treatment with Clay and Ultrasound

In order to reduce the amount of clay required for treatment and to give good results during a short treatment period, the treatment was carried out with clay and in the presence of ultrasound.

The results in Table 8 indicated the great effectiveness of the double treatment method applied using ultrasound (advanced oxidation) with with natural clay (adsorption) with applied conditions:

- The amount of clay was 0.5gr/L
- Treatment time 30min.
- Frequency 40 kHz.

As following this technique resulted in obtaining a low organic content. It was suitable for use for irrigation with a relatively short treatment time and low clay content compared to other experiments in which natural clay alone was used in this research.

Table 8. Organic load after clay and ultrasound treatment.

Water sample	COD (mg/l)	BOD (mg/l)
Raw water	3600	635
AU	212	82

Bacterial tests showed that the number of bacterial colonies in the untreated sample reached 3100 cfu/ml on plate count agar and 2200 cfu/ml on MacConkey agar. This number decreased significantly in the treated sample, as the number of bacterial colonies reached 80 cfu/ml on plate count agar.

plate count agar and 40cfu/ml on MacConkey medium as in Fig. 2, which indicates the efficiency of the double treatment process applied.

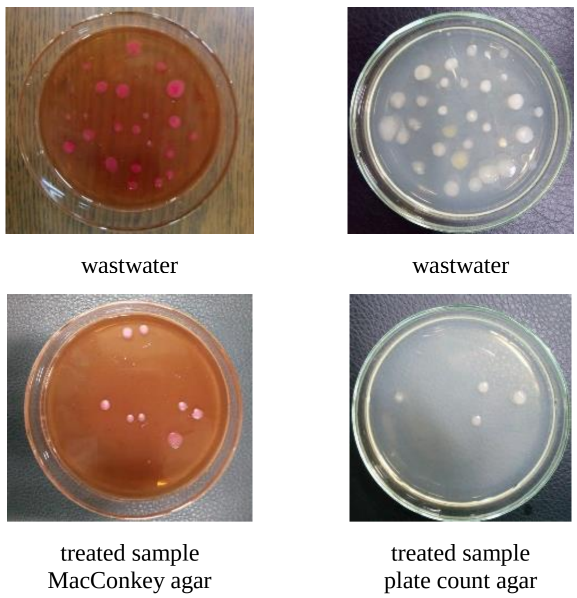

Fig. 2. Results of bacterial analysis of the raw sample treated with natural clay and ultrasound.

4. Conclusion

After a series of experiments and tests conducted in this research, the following was revealed:

When treating laboratory wastewater resulting from Aleppo University Hospital using the rotating biological disk method, it was found that treatment for 10 hours an hour was sufficient to obtain water suitable for irrigation according to Syrian Standard /2752/ of 2008, where the concentration of COD decreased to 294 mg/l, as well as the BOD to 135 mg/l.

The best conditions for treating the studied polluted water sample using the natural clay adsorption technique were 2gr of natural clay with a granular size smaller than 100 microns per liter of polluted water, for a period of 120min to use the water for irrigation, and 60min to throw the water into the public sewer.

The effectiveness of treating the studied contaminated water sample with aluminum sulphate was less than the effectiveness of treatment with adsorption agents. The explanation for this result is due to the type of contaminated materials accompanying the studied water, where their ability to collect and settle was weak. Therefore, adsorption was considered to be more effective in capturing and collecting these organic pollutants.

The best way to treat the studied water sample was by adding natural clay at a concentration of 1g per liter of polluted water and applying ultrasound waves at a frequency of 40kHz for 30 minutes, resulting in a COD value of 212 mg/L with a removal rate of 94% and a BOD value of 82 mg/L with a removal rate of 87%.

References

[1] Parida VK, Sikarwar D, Majumder A, Gupta AK. An assessment of hospital wastewater and biomedical waste generation, existing legislations, risk assessment, treatment processes, and scenario during COVID-19. Journal of Environmental Management. 2022 Apr; 308:11460

[2] Akin BS. Contaminant Properties of Hospital Clinical Laboratory Wastewater: A Physiochemical and Microbiological Assessment. Journal of Environmental Protection. 2016; 07(05):635–42.

[3] Khan MT, Shah IA, Ihsanullah I, Naushad Mu, Ali S, Shah SHA, et al. Hospital wastewater as a source of environmental contamination: An overview of management practices, environmental risks, and treatment processes. Journal of Water Process Engineering. 2021 Jun; 41:101990.

[4] Boillot C, Bazin C, Tissot-Guerraz F, Droguet J, Perraud M, Cetre JC, et al. Daily physicochemical, microbiological and ecotoxicological fluctuations of a hospital effluent according to technical and care activities. Science of The Total Environment. 2008 Sep;403(1-3):113–29

[5] Anirudhan TS, Ramachandran M. Adsorptive removal of basic dyes from aqueous solutions by surfactant modified bentonite clay (organoclay): Kinetic and competitive adsorption isotherm. Process Safety and Environmental Protection. 2015 May; 95:215–25.

[6] Bharath G, Alhseinat E, Ponpandian N, Khan MA, Siddiqui MR, Ahmed F, et al. Development of adsorption and electrosorption techniques for removal of organic and inorganic pollutants from wastewater using novel magnetite/porous graphene-based nanocomposites. Separation and Purification Technology. 2017 Nov; 188:206-18.

[7] Khan NA, Vambol V, Vambol S, Bolibrukh B, Sillanpaa M, Changani F, et al. Hospital effluent guidelines and legislation scenario around the globe: A critical review. Journal of Environmental Chemical Engineering. 2021 Oct; 9(5):105874.

[8] Verlicchi P, Al Aukidy M, Galletti A, Petrovic M, Barceló D. Hospital effluent: Investigation of the concentrations and distribution of pharmaceuticals and environmental risk assessment. Science of the Total Environment [Internet]. 2012 Jul 15 [cited 2022 Jun 23];430:109–18

[9] Standard methods for the examination of water and wastewater: 20th ed. Choice Reviews Online. 2000 Jan 1; 37(05):37–279237–2792.

دراسة التقنيات الأمثل لإزالة الحمل العضوي من مياه الصرف الناتجة عن المختبرات في المشافي

عبد الرحمن تتان[1]، و**فاطمة جعارة**[2]، و**نوزت النبغلي**[3]

[1] *قسم الهندسة البيئية، كلية الهندسة المدنية، و*[2] *قسم العلوم الأساسية، كلية الهندسة المدنية، و*[3] *طالب دراسات عليا (دكتوراه)، قسم الهندسة البيئية، كلية الهندسة المدنية،* جامعة حلب، حلب، سوريا

المستخلص. تشكل مياه الصرف الصحي في المستشفى تهديدًا قويًا على أمن الصحة البشرية حيث تتواجد مجموعة متنوعة من المركبات العضوية الصعبة التحلل، والمركبات الدوائية الفعالة والملوثات اللا عضوية المتعددة وغيرها التي تسبب حدوث تلوث معقد في موارد المياه والنظام البيئي. تهدف هذه الدراسة لمعالجة مياه الصرف الناتجة عن مختبرات التحاليل في المشفى. تم معالجة العينة الملوثة باستخدام عدة تقنيات شملت المعالجة البيولوجية بطريقة الأقراص البيولوجية الدوارة RBC، الادمصاص بالغضار الطبيعي السوري، التخثير بكبريتات الألمنيوم، الأكسدة المتقدمة بالأمواج فوق الصوتية، ومعالجة ثنائية باستخدام الغضار الطبيعي مع الأمواج فوق الصوتية، حيث تم تحديد فعالية إزالة الحمل العضوي بعد كل معالجة وبتطبيق شروط معالجة مختلفة. بينت النتائج فعالية طرائق المعالجة المتبعة في معالجة العينة المدروسة، أن أفضل طريقة لمعالجة عينة المياه المدروسة كانت المعالجة باستخدام الغضار الطبيعي مع الأمواج فوق الصوتية، حيث تم الحصول على مياه صالحة للري بحسب المواصفة القياسية السورية، وذلك عند إضافة الغضار الطبيعي بتركيز 1gr لكل لتر ماء ملوث، وتطبيق الأمواج فوق الصوتية بتردد 40kHz لمدة 30min، حيث وصلت قيمة COD لحدود 212 mg/l، بنسبة إزالة 94%، وقيمة BOD لحدود 82 mg/l، بنسبة إزالة 87%. وأخيرًا يمكن الاستنتاج أنه يفضل معالجة مياه الصرف الصحي في المستشفيات باستخدام عدة تقنيات معًا، نظرًا لتنوع الملوثات، للحصول على نتائج مقبولة.

الكلمات المفتاحية: مياه الصرف، التخثير، الادمصاص، الأمواج فوق الصوتية، معالجة البيولوجية، معالجة كيميائية.