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Treatment of wastewater from a technical poultry slaughterhouse using up flow anaerobic suspended sludge bed reactor UASB

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ABSTRACT

Due to the wide spread of technical slaughterhouses for poultry; and the severe pollution caused by the drained water of poultry slaughterhouses, the aim of this study was to treat this water in order to protect the environment on the one hand; rationalizing water consumption on the other hand; also, this study is as a contribution to get biogas as a source of energy. In this research, the startup process was carried out at a temperature of (15 ± 2) °C, and it took (111) days, where a decrease in the COD and TDS values was observed until the COD value was fixed at (1136 mg/l), whereby the removal efficiency of COD and TDS improved. with an increase in startup time. The factors affecting the efficiency of poultry technical slaughterhouse wastewater treatment were studied which were (the residence time, the temperature, initial concentration of raw water). Five residence times were studied (6 - 18 - 24 - 35 - 48) h It was noted that the concentration of COD and TDS decreased with an increase in the hydraulic residence time. Studying the effect of temperature on the treatment efficiency within the range (5-50) °C, It was noted that the removal efficiency of COD and TDS increasing with increasing temperature, and at temperature of (45-50) C° the concentration of COD in the treated water was (285.12 mg/l), which reached the specification Syrian Standard No. 2752/2008 Class C (forest trees and industrial crops). Five initial concentrations of raw water were studied, and it was noted that the increase in the COD concentration in the raw water was accompanied by an increase in the COD concentration of the treated water. It was noticed that the removed organic load decreased with the increase in the residence time, while it was noted that with the increase in temperature, the value of the removed organic load increased. The volume of biogas resulting from the treatment was also calculated according to the same conditions studied for each experiment and by (3) replications. The maximum biogas production was 0.27 liters per gram COD removed.

KEYWORDS: poultry slaughterhouses, residence time, organic load, biological treatment, processing efficiency, biogas, up-flow anaerobic suspended sludge bed reactor UASB

1 INTRODUCTION

In view of the pollution caused by the slaughterhouses wastewater as a result of the highly polluted discharged water, the large values of Total Dissolved Solids (TDS), the Chemical Oxygen Demand (COD) and the Biochemical Oxygen Demand (BOD), the treatment of this water It is very necessary in order to protect the environment on the one hand, and in order to save water consumption on the other hand, and to secure water suitable for reuse for irrigation and benefiting from the resulting biogas.

2 SEARCH METHOD

here are many methods to treat *Poultry slaughter wastewater* like chemical treatment , but this method requiring large quantities of chemicals and large amount of sludge to be wasted, so the better option to reduce the generated biosolids might be an anaerobic digestion using up-flow anaerobic sludge blanket reactors (UASB)([1] [2] [3]).In the USAB process, anaerobic bacteria convert organic material into methane,carbondioxide, (4) Some of the operational factors (residence time, temperature, and initial concentration) affecting the performance of the anaerobic reactor have been studied, where a laboratory study has been conducted to influence the residence time, temperature, and initial concentration on the efficiency of the treatment, choosing the optimal residence time and the appropriate temperature, as well as the estimated organic load removed and the volume of Biogas from Processing Using the Up flow Anaerobic Suspended Sludge Bed Reactor (UASB) [5] [6].

2.1 Theoretical study of anaerobic bioremediation

The symbiotic relationship between the different types of bacteria collected in the form of bio-sludge provides an effective anaerobic treatment system in which the organic matter in the wastewater is sequentially dismantled. Three groups of microorganisms decompose the organic matter in three stages:

The first stage (hydrolysis stage):

This stage includes the existence of hydrolyzed microorganisms that convert high molecular weight organic compounds (such as proteins and polysaccharides ..) into soluble organic compounds with low molecular weight (such as amino acids..) that can cross the cell wall of microorganisms to benefit As an energy source, using special enzymes related to the type of each pollutant [7] [8]

The second stage (the acid formation stage):

At this stage, the organic compounds resulting from the first stage are converted into volatile organic acids with short chains of carbon (such as carbonic acid, propionic acid, and butyric acid) with a small amount of Long-chain acids are converted into acetates by acetic acid-generating microorganisms, as a result of the conversion of propionic acid:

$$C_3H_5O_2 + 2H_2O \rightarrow C_2H_4O_2 + CO_2 + 4H_2 \qquad (1)$$

During the acid manufacturing stage, a slight decrease of COD occurs in the form of acid, and this decrease rarely exceeds 10% [9] [10]..

The third stage (methane formation stage):

The third group of anaerobic bacteria converts the acids containing the vinegar root formed in the previous stage into CO2 and new bacterial cells, and the bacteria responsible for that are called methane-producing bacteria[11

Methane-making bacteria can use a specific number of substances to form methane, including CO2, acetate, and methyl alcohol. Anaerobic organisms work together to transform organic matter.

Methane-producing bacteria grow at a very slow rate, so their food transformation is of a limited rate in the anaerobic treatment of organic waste [12].

The waste is fixed in the anaerobic treatment when methane gas and carbon dioxide are produced, and the methane gas is highly insoluble, and its release from the solution represents a real fixation of the waste. [13].

Typical energy from the conversion of compounds is produced as in the following reactions:

$$4H_2 + CO_2 \rightarrow CH_4 + 2H_2\text{O} \qquad (2)$$

$$4HCOOH \rightarrow CH_4 + 3CO_2 + 2H_2 0 \qquad (3)$$

$$CH_3COOH \rightarrow CH_4 + CO_2 \qquad (4)$$

$$4CH_3OH \rightarrow 3CH_4 + CO_2 + 2H_2O \qquad (5)$$

$$4(CH_3)_3N + H_2O \rightarrow 9CH_4 + 3CO_2 + 6H_2O + 4NH_3 \qquad (6)$$

The formation of methane gas in anaerobic processing includes two basic methods:

Convert hydrogen and carbon dioxide as in equation (2).

Converting acids containing vinegar root to methane gas and carbon dioxide gas as in equations (3) and (4).

Methanogenic bacteria are able to use the hydrogen produced by acid-forming bacteria because of their effectiveness in hydrogenation, and there is a state of dynamic balance between acid-making and methanogenic bacteria, and this balance is maintained by permanent monitoring of the system [14].

To maintain this condition, the contents of the reactor must be free of dissolved oxygen.

The pH of the water must also be within the limits between 6.6 – 7.6, and the alkalinity must be sufficient to ensure that the pH does not drop below 6.2 because methane-forming bacteria cannot perform their function in conditions where the pH is lower than 6.2. [15].

2.1.1 Principle of Anaerobic Bioremediation UASB Reactor

The water to be treated enters from the bottom of the UASB reactor and heads upwards through the sludge layer consisting of bio- formed granules or particles that are formed during the reactor start-up[16]

The water to be treated passes through an expanded sludge bed that contains a large concentration of biomass. This sludge is present in the reactor in the form of granules called sludge bed, which is responsible for the treatment that takes place [17].

Some of the gas bubbles formed within the sludge layer remain attached to the vital granules, and the free gas and the particles to which the gas bubbles are attached rise to the top of the reactor, and then the particles collide with the bottom of the plates designated for removing gas, which causes the release of gas bubbles. The particles that got rid of the gas bubbles fall down. After that, the gas and liquid are thrown out of the reactor, as shown in Figure (1).

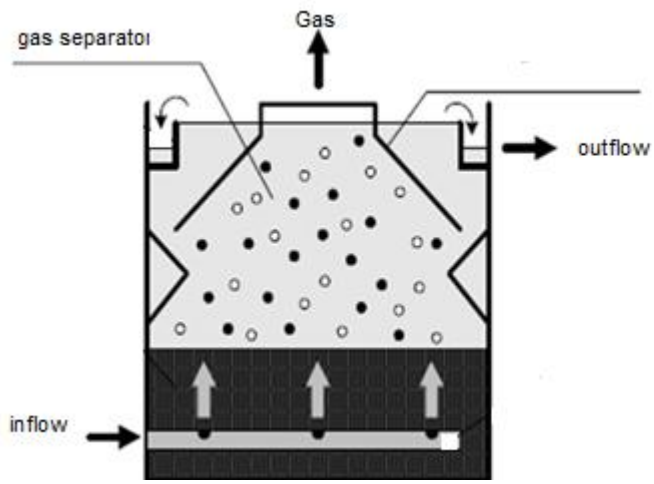

Figure 1: UASB reactor

Practical study of wastewater treatment from technical poultry slaughterhouse using UASB reactor.

2.1.2 Studying the start-up process of the UASB anaerobic reactor

Where the reactor was fed using wastewater from a technical slaughterhouse for poultry with specifications shown in Table (1) by pumping it from a collection tank with a capacity of (25 l).

Table (1) specifications of the raw water used in the start- up process COD indicator

PH	TDS mg/l	COD mg/l	pointer
7.25	1330	6510	the value

The temperature of the water inside the reactor was set to (25 ± 2)C °,and the periodic monitoring of the reactor was carried out by studying several indicators, namely: TDS, COD, and the start-up process of the reactor was carried out by circulating the raw water within the reactor in a closed cycle that lasted 110 days, during which samples of water were took periodically and the COD measured until the COD value reached a constant value of (1136 mg/l), as there was no change in the COD value, the formation of sludge from the agglomerated suspended materials within the reactor was noticed.

Figure2: shows the relationship between COD concentration, TDS and start- up time:

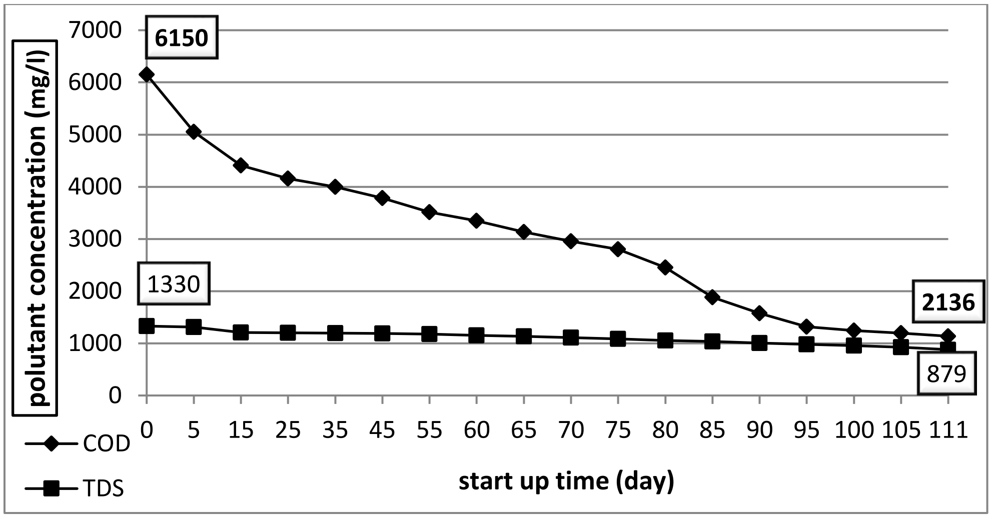

Figure 2: The relationship between COD concentration, TDS and start -up time

From Fig(2) a decrease in the COD values and TDS values was noticed with the increase in the start-up time, on the 110th day a value of COD equivalent to (1136 mg/l), as well as a value of TDS equivalent to (879 mg/l), and this is due to the fact that as the reactor start-up time progressed, the biomass grew better and the sludge layer responsible for treatment was formed until a sufficient amount of bio-granules was developed. Figure(4) shows the relationship between COD and TDS removal efficiency and the start-up time:

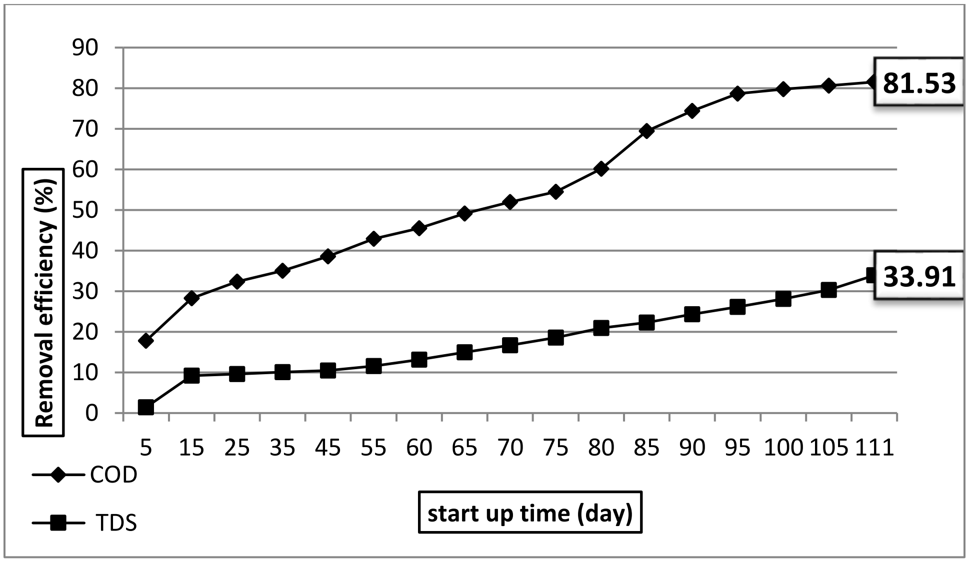

Figure 3: The relationship between COD removal efficiency, TDS and start- uptime

From Figure (3) an improvement in the COD and TDS removal efficiency was noticed with an increase in the start- up time, where a COD removal efficiency of 81.53% ,and TDS removal efficiency of 33.9%, was obtained, this can be explained by the formation of biomass that performs the treatment process and the reduction of COD and TDS of the treated water.

2.1.3 Studying the effect of hydraulic residence time on processing efficiency

The effect of the hydraulic residence time on the treatment efficiency was studied at a temperature of (25)°C, where five residence times (6 – 18 – 24 – 35 – 48) h was studied and the raw water specifications are shown in Table (2):

Table 2: Specifications of raw water used in the study of the effect of hydraulic residence time

PH	TDS mg/l	COD mg/l
7	1281	1510

Figure 4 shows the effect of hydraulic residence time on TDS and COD concentration:

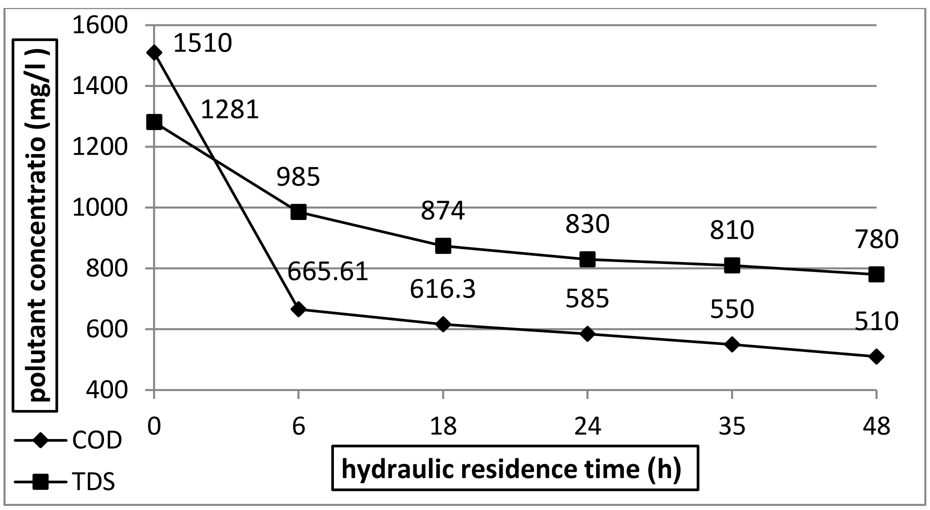

Figure 4: Effect of hydraulic residence time on COD concentration and TDS

from Figure (5) that with the increase in the hydraulic residence time, the values of TDS and COD decreased until we got a value of TDS equivalent to 780 mg/l and a value of COD equivalent to 510 mg/l was noticed for a residence time of 48 h, as Figure (6) shows the effect of time Hydraulic retention on processing efficiency.

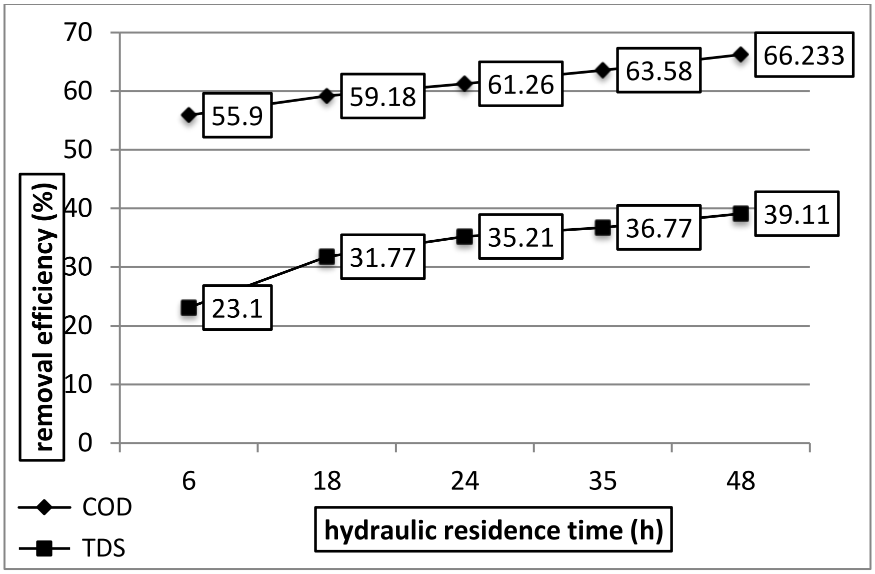

Figure 5: Effect of hydraulic residence time on processing efficiency

An improvement in the COD removal efficiency, and TDS removal efficiency with increasing the residence time was noticed, where a COD removal efficiency was 66.23%, as well as an a TDS removal efficiency of 39.11%, at the largest residence time, which is 48 h, and this can be explained by the increase in contact between the organic materials present in the water and the bacteria that break down these materials, but the improvement in the removal efficiency when increasing the residence time from 24 h to 48 h was very simple and does not necessitate this increase because this increase requires Increasing the volume of the reactor and thus increasing the cost.

2.1.4 Studying the effect of temperatures on the treatment efficiency at a residence time of 18 hours

The effect of temperature on the treatment efficiency was studied within the range (5-50)°C, at a residence time of 18h. The raw water specifications are shown in Table (3):

Table (3): Specifications of raw water used in the study of the effect of temperature

PH	TDS mg/l	COD mg/l
7.2	1320	2160

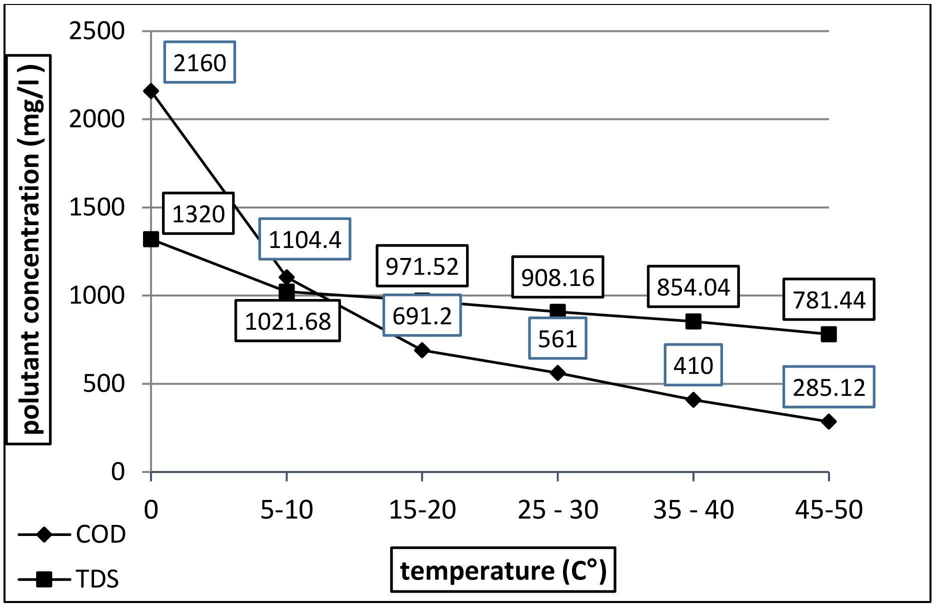

Figure 6: Effect of temperature on COD concentration and TDS

From Figure (6) was noticed with increasing temperatures, the values of TDS and COD decreased until a value of TDS equivalent to 781.44 mg/l and a value of COD equivalent to 285.21 mg/l for a temperature ranging between (45-50)°C. at a residence time of 18 h, as with the increase in temperature the activity of the bacteria that carry out the treatment process increases, as Figure (8) shows the effect of temperature on the treatment efficiency:

Figure 7: shows the effect of temperatures on TDS and COD concentration:

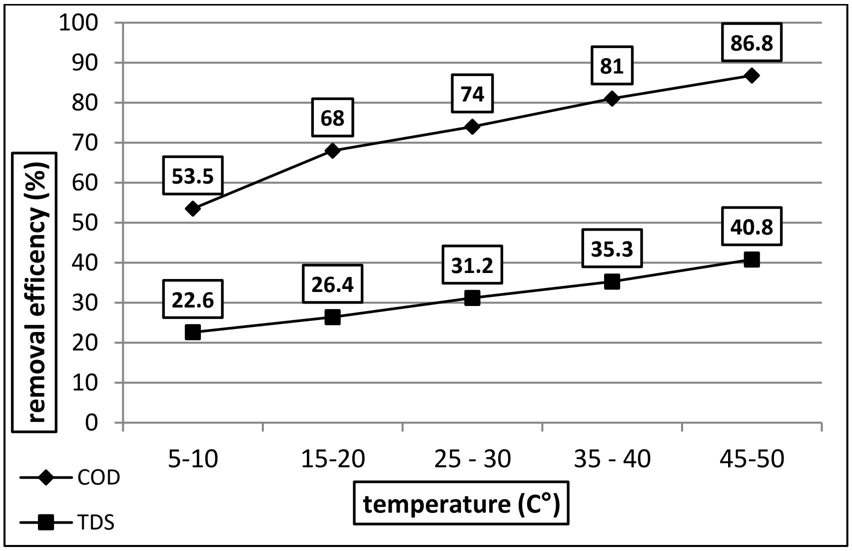

Figure 7: Effect of temperature on removal efficiency

From Figure (7) was noticed that with increasing temperatures, the removal efficiency improved, as a removal efficiency of TDS was equivalent to 40.8% and a removal efficiency of COD equivalent to 86.8% for a temperature ranging between (45-50) C°, and this can be explained Because of securing the appropriate environment for the work of thermopile bacteria, which decompose organic materials, where the concentration was reached 285.12 mg / l of COD in the treated water, and this corresponds to the Syrian Standard No. 2752/2008 Class C (forestry trees and industrial crops) at a temperature (45-50) C° which was the best treatment temperature.

2.1.5 Studying the effect of the initial concentration of raw water on the treatment efficiency at a residence time of 18 hours and a temperature within the range (40-45) degrees Celsius

The effect of the initial concentration of raw water on the treatment efficiency was studied at a residence time of 18 h and a temperature ranging between (45-50) ° C. We studied five initial concentrations shown in Table (4):

Table (4): Specifications of raw water used in the study of the effect of initial concentration

6000	4800	3500	2160	1500	COD concentration of raw water (mg/l)
1383	1365	1350	1320	1281	TDS concentration of raw water (mg/l)
7.25	7.25	6.8	7.2	7	pH

Figure 8: shows the effect of the initial concentration of raw water on the COD concentration of the treated water:

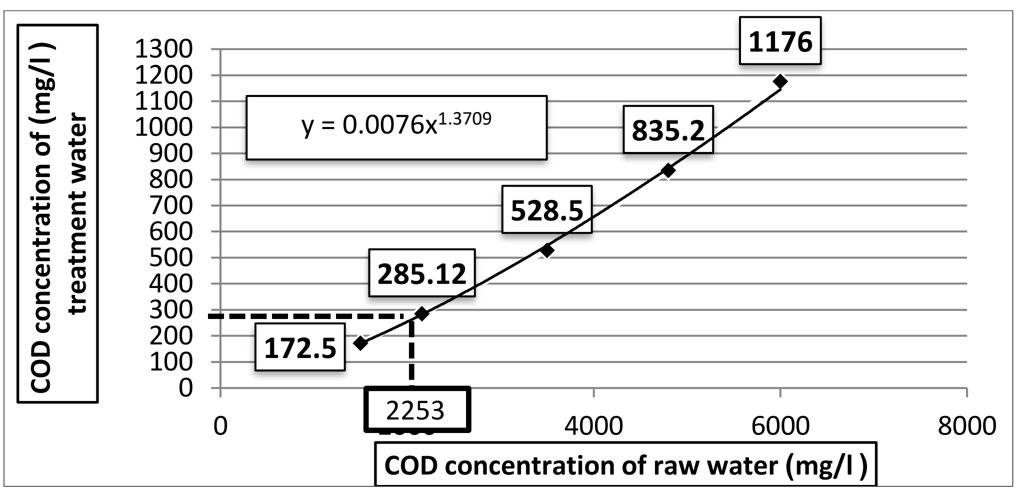

Figure 8: Effect of raw water concentration on COD concentration

From Figure (8) was noticed that the increase in the concentration of COD in the raw water was accompanied by an increase in the concentration of COD in the treated water, due to the lack of sufficient biological granules to remove the high organic load.

Figure (10) shows the effect of the initial concentration of raw water on the TDS concentration of treated water:

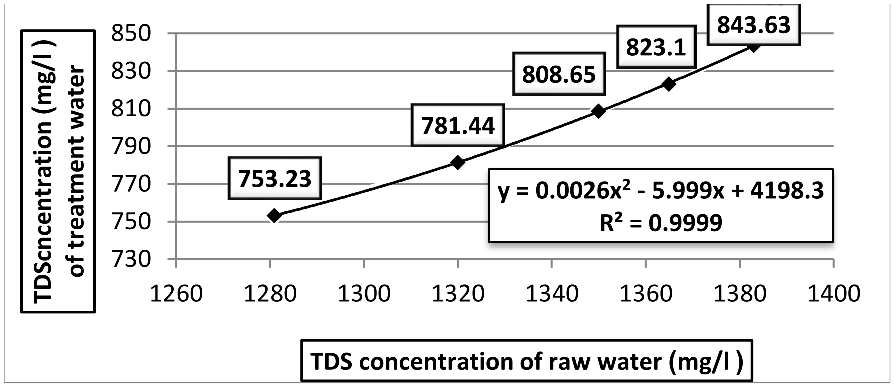

Figure 9: the effect of the initial concentration of raw water on the TDS concentration of treated water

From Figure (9) was noticed that the increase in the concentration of TDS in the raw water was accompanied by an increase in the concentration of the TDS in the treated water.

Figure (10) shows the effect of the initial concentration of raw water on the treatment efficiency:

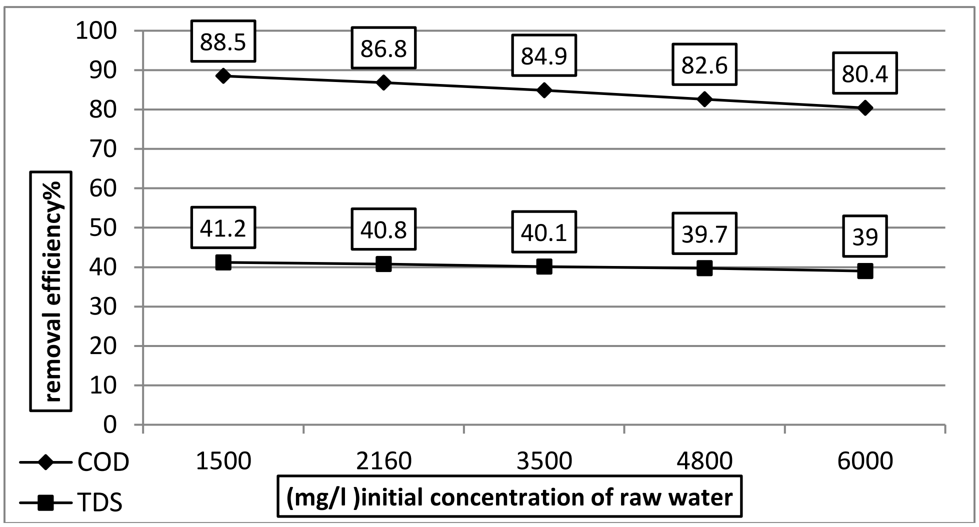

Figure 10: Effect of initial concentration of raw water on treatment efficiency

From Figure (10) was noticed that with the increase in the COD concentration of raw water, the removal efficiency decreased. This is explained by the large organic load and the lack of sufficient bacterial population to dismantle this high load of raw water.

2.1.6 Calculation of the removed organic load

The organic load removed in one volume was calculated from the relationship:
OLR=CODr/HRT

Where OLR is the volumetric load rate on the reactor (gCOD/l.d).
CODr is the COD removed (g/l).
HRT: hydraulic residence time (d).

1- Calculating the organic load removed at different residence times and a temperature of 10°C:

The organic load removed during the previously studied residence times was calculated from the previous relationship at a temperature of 10°C. The results are shown in Table (5):

Table 5: The organic load removed with the change of residence time

organic load removed gCOD/l.d	Residence time h
3.38	6
1.19	18
0.93	24
0.57	35
0.5	48

Figure 11: shows the relationship between the hydraulic residence time and the removed organic load

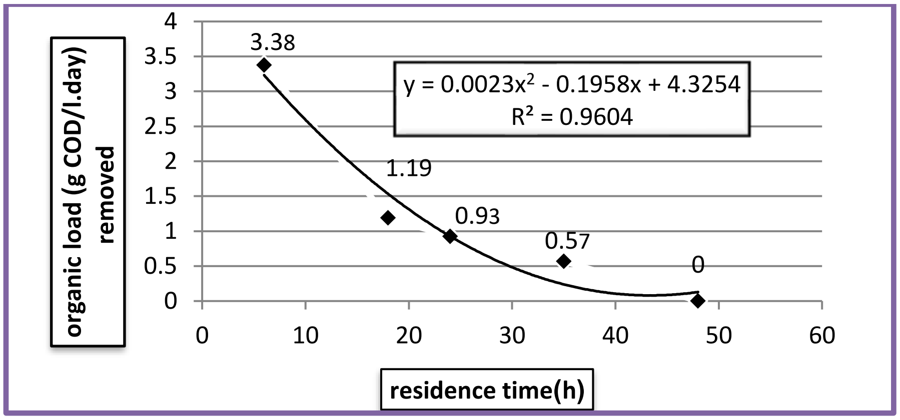

Figure 11: The relationship between the hydraulic residence time and the removed organic load

From Figure (11) was notecid that the organic load removed decreases with the increase in the residence time, because the relationship is inverse between them, as we obtained a value of the removed organic load equivalent to 3.376gCOD/l.day at a residence time of 6h, and this value decreased to 0.5gCOD/l.day at a time of Residency 48 h. The relationship between the residence time and the removed organic load was:

$$y = 0.0023x^2 - 0.1958x + 4.3254$$

2- Calculating the organic load removed at different temperatures and a residence time of 18h:

The organic load removed from the previous relationship was calculated during the previously studied temperatures within the range (5-50)°C, at a residence time of 18h. The results are shown in Table (6):

Table 6: Organic load removed during temperature change

Organic load removed g_{COD}/l.d	temperature C°
4.62	10-5
5.88	15-20
6.39	25 – 30
6.99	35 – 40
7.5	45-50

Figure (12) shows the relationship between temperature and the removed organic load

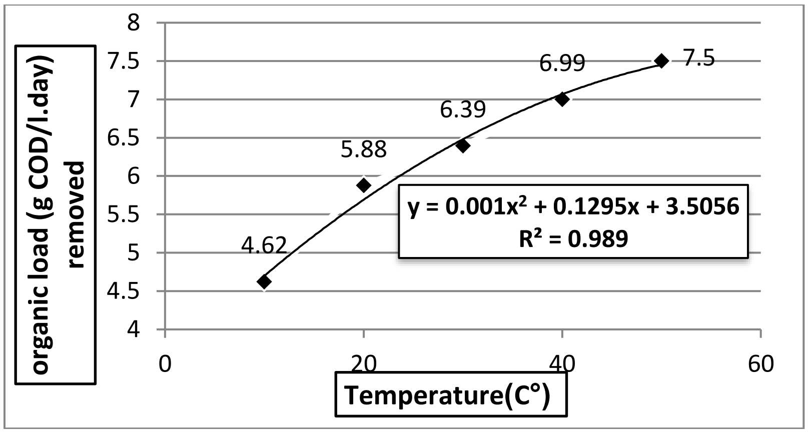

Figure 12: The relationship between temperature and the removed organic load

From Figure (13), was noticed that with the increase in temperature, the value of the removed organic load increased, as we obtained a value equivalent to 4.62 gCOD/l.day, at a temperature ranging within the range (5-10) °C, and this value increased to 7.5 gCOD/l. .day at a temperature ranging within the range (45-50) °C, and this is due to the fact that with the increase in temperature, the activity of bacteria that break down organic matter increases, and thus the rate of the removed organic load increases. The relationship between the removed organic load and the temperature was:

$$y = 0.001x^2 + 0.1295x + 3.5056$$

3- Calculating the organic load removed when the initial concentration of raw water changes:

The organic load removed from the previous relationship was calculated through the change in the concentration of the raw water at a residence time of 18 h and a temperature ranging from (45-50) °C. The results are shown in Table (7):

Table (7): The organic load removed during the change in the initial concentration of the raw water

organic load removed g_{COD}/l.d	initial concentration of COD in the raw water mg/l
5.31	1500
7.46	2160
11.89	3500
15.86	4800
19.3	6000

Figure 13: shows the relationship between the initial concentration of raw water and the removed organic load:

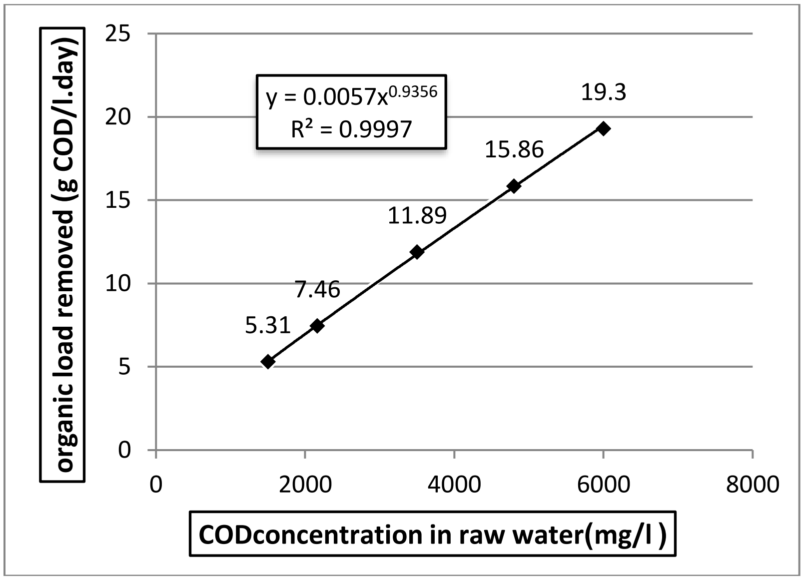

Figure 13: The relationship between the initial concentration of raw water and the organic load removed

From Figure (13) was noticed that with the increase in the initial concentration of the raw water COD, the value of the removed organic load increases, as we obtained a value of the removed organic load equivalent to 5.31 gCOD/l.day, at an initial concentration of the raw water COD of 1500 mg/l, and this value increased to 19.3 gCOD/l.day at an initial concentration of raw water COD 6000mg/l, as there is a direct proportion between the value of the removed organic load and the initial concentration of the raw water COD, and the relationship between the removed organic load and the concentration of the raw water COD is:

$$Y = 0.0057X^{0.9356}$$

2.1.7 Calculating the volume of biogas

The volume of biogas resulting from the treatment was calculated under the same conditions studied for each experiment (flow, residence time, temperature, and initial concentration of raw water).

1- Calculating the volume of biogas produced at different residence times and a temperature of 10°C:

The volume of biogas produced was calculated at different residence times at a temperature of 10°C. The results are shown in Table (8):

Table 8: Biogas produced during the change in residence time

Biogas produced/ removed organic load l.d/g_{COD}	**removed organic load g_{COD}/l.d**	**Biogas produced L_{gas}/L_{liqued}**	**residence time (h)**
0.22	3.38	0.75	6
0.22	1.19	0.26	18
0.22	0.93	0.19	24
0.22	0.57	0.125	35
0.22	0.5	0.11	48

Figure (14) shows the relationship between the hydraulic residence time and the resulting biogas

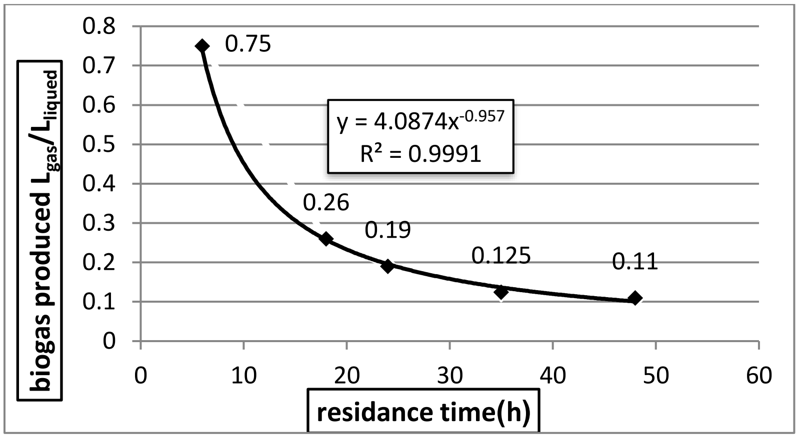

Figure 14: The relationship between residence time and volume of biogas produced

From Figure (15) was noticed that with the increase in the residence time the volume of biogas produced decreases, because with the increase in the residence time the removed organic load decreases. The average biogas production in these conditions was 0.22 liters per gram of COD removed, and the relationship between the biogas produced and the residence time was she:

$$Y = 4.0874X^{-0.957}$$

2- Calculating the volume of biogas produced at different temperatures and a time of 18 h:

The volume of biogas produced was calculated at different temperatures and h6 residence time, and the results are shown in Table (9):

Table 9: Biogas produced during temperature change

Biogas produced/ removed organic load l.d/gCOD	removed organic load gCOD/l.d	Biogas produced Lgas/Lliqued	temperature C°
0.24	4.622	1.1	5-10
0.24	5.875	1.4	15-20
0.25	6.394	1.6	25 – 30
0.25	6.998	1.75	35 – 40
0.25	7.5	1.88	45-50

Figure (15) shows the relationship between temperature and the resulting biogas:

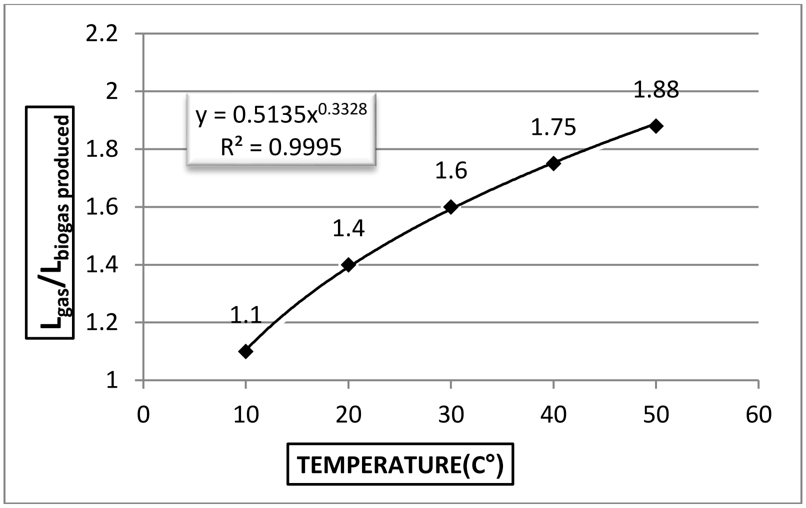

Figure 15: The relationship between temperature and volume of biogas produced

From Figure (16) was noticed that with the increase in temperature, the value of the biogas produced increases as a result of the increase in the removed organic load. Upon achieving the Syrian standard, a gas volume of 1.88 L gas/L liqued was reached at a temperature of (45-50)°C and a residence time of 6h, and the average production was Biogas in these conditions is 0.25 liters per gram of COD removed.
The relationship between biogas output and temperature was:

$$Y = 0.5135X^{0.3328} \quad -$$

3- Calculating the volume of biogas produced when the initial concentration of raw water changes:

The volume of biogas resulting from the treatment was calculated when the COD concentration of raw water changed at a residence time of 6 h and a temperature ranging from (45-50)°C. The results are shown in Table (10):

Table 10: Biogas Produced During The Change In The Initial Concentration of Raw Water

Biogas produced/ removed organic load l.d/g_{COD}	removed organic load g_{COD}/l.d	Biogas produced L_{gas}/L_{liqued}	Row water COD concentration mg/l
0.25	5.31	1.35	1500
0.25	7.46	1.88	2160
0.26	11.89	3.1	3500
0.265	15.86	4.3	4800
0.27	19.3	5.31	6000

Figure (16) shows the relationship between the initial concentration resulting from natural gas:

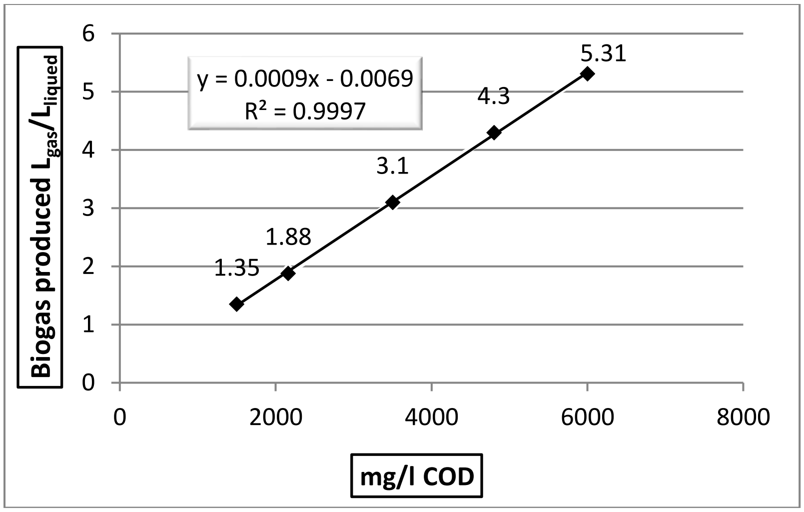

Figure 16: The relationship between the initial concentration of raw water and the volume of biogas produced

From Figure (16) was noticed that with the increase in the primitive concentration of raw water COD, the volume of biogas produced increases, and the production of biogas increased day by day until it reached a relatively stable value. The maximum biogas production was 0.27 liters per gram COD removed.
The relationship between biogas produced and COD concentration of raw water was

$$Y = 0.0009X - 0.0069$$

3 CONCLUSIONS AND RECOMMENDATIONS

1) By studying the start-up process, it was noticed that the COD and TDS values decreased until the COD value was fixed at the value (1136mg/l) after 111 days.
2) By studying the effect of the hydraulic residence time, the removal efficiency of COD and TDS improved with the increase of time until reaching a residence time of 24h. With the increase of residence time, the improvement was simple and did not require an increase in time.
3) By studying the effect of temperature, it was noticed that with increasing temperatures, the values of TDS and COD decreased, Syrian Standard No. 2752/2008 Class C (forestry trees and industrial crops) was reached at a temperature (45-50) c°
4) Biogas production increased with the increase of the COD concentration of raw water until it reached a relatively constant value, and the maximum production of biogas reached 0.27 liters per gram of COD removed.

4 RECOMMENDATIONS AND SUGGESTIONS

1. Using sludge from other reactors in order to speed up the reactor start-up process.
2. Studying the effect of temperature using several reactors, each of which operates at a constant temperature.
3. Analyzing the gas resulting from the treatment and determining the percentage of methane gas in it.

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