LEMNA MINOR INFLUENCE IN THE TREATMENT OF ORGANIC POLLUTION OF THE INDUSTRIAL EFFLUENTS

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ABSTRACT

The purpose of the research was to determine the influence of industrial wastewater treatment using the Lemna Minor aquatic plant. Certain varieties of macrophyte plants can absorb or retain various contaminants. Thanks to this, it has been determined that the variety known as Lemna Minor presents this type of property. Three treatment trials were carried out varying the amounts of Lemna Minor (100, 200, and 300g). They are keeping constant the retention time of 10 days that were analyzed at 3, 6, and 10 days after the treatment and with a constant volume of the residual effluent. The results indicate that in terms of the parameters that determine organic contamination, BOD was reduced by (61 %); COD was reduced by (68 %) and the concentration of total suspended solids by (61 %).

KEYWORDS

Lemna minor, Organic pollution, Industrial effluents, Wastewater treatment, Macrophyte plants.

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1. INTRODUCTION

The effluents from industrial processes coming from dyestuffs present organic matter expressed as chemical oxygen demand (COD), biochemical oxygen demand (BOD), and total suspended solids (TSS). The bathing ratios (BR) in these types of processes comprise 1:7 to 1:12; this leads to the use of large quantities of water. These effluents must be treated before being introduced into the industrial drainage system, to comply with national regulations related to the use of public sewage systems and to avoid contamination of the receptors.

The main benefit of treatment systems with aquatic plants is their low cost of construction and maintenance, as well as their simplicity of operation using an available resource.The presence of a large amount of organic contamination depletes the oxygen in the water, resulting in a decrease in the appropriate conditions for life, producing fermentations that lead to bad odors. The sedimented solids, many of them are toxic because they carry heavy metals such as Cu, Mn, Cd and Cr (Hoyos *et al.*, 2016).

In this research thesis: Influence of the use of Lemna minor in the treatment of organic contamination of industrial effluents in Cotexsur. The objective of the present work was to determine the influence of the treatment of industrial wastewater from the company Cotexsur, using the aquatic plant Lemna Minor. The research was of an applied type and experimental design with a quantitative approach. The sample was taken considering the convenience and criteria previously evaluated by the types of analysis performed and the treatment proposed (Sun *et al.*, 2020; Walsh *et al.*, 2020).

The theoretical bases that support the research, thus, the advantages of using the Lemna Minor, previous definitions of textile dyes, and parameters for measuring organic contamination. The research was also carried out with Lemna Minor, which has a percentage of removal expressed as COD 72.57 %, BOD5 73.36 %, total solids 75.21 % and in the first six days of treatment with different masses of 100g, 200g of Lemna Minor there is a high percentage of decrease in the concentrations of the mentioned parameters (Hoyos *et al.*, 2016; Li *et al.*, 2020).

https://doi.org/10.17993/3ctecno/2020.v9n3e35.77-97

2. METHOD AND INSTRUMENTS

The measurements obtained are analyzed (often using statistical methods).The sample was considered according to convenience. The criteria previously evaluated, the types of analysis performed, and the treatment proposed, therefore the sample was non-probabilistic.

The total volume of the sample was 70 liters from the industrial textile effluents. These 70 liters will be divided into 3 types of treatment: 100g, 200g, and 300g of Lemna Minor and each of the treatments with 7 experimental runs (Coronel, 2016).

For the collection of data, as Rodriguez *et al.* (2020), which made it possible to have better control over the data that allowed the characterization of the effluents from Cotexsur. The following equipment was used to obtain the concentrations of the parameters:

- HI 2210 potentiometer.
- COD digester DRB 200.
- Colorimeter DR 900.
- Equipment for determining BOD.
- Analytical balance NBL 124 E.
- Digital sterilization and drying oven DHG 9023 A.
- Button lid dryer, 150 mm.

The equipment and materials for the analyses were provided by the laboratory of the Universidad Autónoma del Perú, which allowed to determine: PH, Biochemical Oxygen Demand, Chemical Oxygen Demand, and Total Suspended Solids (Jojoa, Rodríguez, & Cardona, 2015).

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2.1. 1ST COLLECTION AND IDENTIFICATION OF LEMNA MINOR

From the lagoons adjacent to the villa marshes in the Chorrillos district, samples of Lemna Minor were collected to be used in the experimental runs, considering the following conditions:

- Have good pigmentation
- That they do not present an anomaly in any of their parts.

The laboratory where the analyses were carried out has adequate ventilation and sunlight. The temperature and humidity in the experimental runs were:

- Maximum temperature: 210C
- Minimum temperature: 180C
- Humidity: 89%.

2.2. 2ND COLLECTION AND ANALYSIS OF SAMPLES OF THE INDUSTRIAL EFFLUENTS OF COTEXSUR

Wastewater analysis was performed according to standardized methods (Standard Methods for the examination wáter and wastewater, APHA) and instruments, equipment, reagents, which are recommended in the methods. Table 1 details the method or technique applied for each analysis parameter.

Table 1. Health quality monitoring protocol, according to DIGESA (Dirección General de Salud Ambiental).

Parameters /Dimension of the dependent variable	Method / Technique	Bottle material
Biochemical Oxygen Demand	Dilution	Plastic or glass
Biochemical Oxygen Demand	Colorimetric	Plastic or glass
Total suspended solids	Gravimetric	Plastic or glass
PH	Electrometric	Field Determination

Source: (Dirección General de Salud Ambiental e Inocuidad Alimentaria (DIGESA), s.f.).

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4. RESULTS

4.1. DESCRIPTIVE

The results obtained in the development of the research are presented below:

Table 2. Distribution of average BOD concentrations vs. treatment time for 100 g mass of Lemna Minor.

Mass Lemna Minor (g)	Time (Days)	Media DBO (ppm)
100	0	823
100	3	518
100	6	389
100	10	319

Source: authors' own elaboration.

Table 2 and Figure 1 show the decrease in the average concentration of BOD as a function of time, for a mass in contact of 100 g of Lemna Minor, the average BOD concentration in the initial time was 823 ppm; when in contact for 3 days the average concentration of BOD decreases to 518 ppm; for 6 days of treatment the BOD concentration was 369 ppm, and for 10 days the BOD concentration was reduced to a concentration of 319 ppm. (Esenarro *et al.*, 2020).

Table 3. Distribution of average BOD concentration vs. treatment time for 200 g Mass of Lemna Minor.

Mass Lemna Minor (g)	Time (days)	Media DBO (ppm)
200	0	823
200	3	468
200	6	346
200	10	389

Source: authors' own elaboration.

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In Table 3, we can see the decrease in the average concentration of the biochemical oxygen demand as a function of time. For a mass in contact of 200 g of Lemna Minor, the average concentration for the initial contact time was 823 ppm; when in contact for 3 days, the average concentration of the biochemical oxygen demand decreased to 468 ppm; for 6 days of treatment, the BOD concentration decrease to 346 ppm for 10 days, the BOD concentration was reduced to 389 ppm.

Table 4. Distribution of average BOD concentration vs. treatment time for 300 g mass of Lemna Minor.

Mass Lemna Minor (g)	Time (days)	Media DBO (ppm)
300	0	823
300	3	429
300	6	331
300	10	533

Source: authors' own elaboration.

In Table 4, the decrease in time-averaged BOD concentrations for a contact mass of 300 g of Lemna Minor is shown. The average concentration for the initial treatment time was 823 ppm. This, when in contact for 3 days, the average concentration of BOD decreases to 429 ppm. For 6 days of contact, the BOD concentration was 331 ppm, and for 10 days, the BOD concentration was 533 ppm.

Table 5. Distribution of average BOD concentration vs. treatment time and mass of Lemna Minor.

Mass (g)	Time (days)	BOD average (ppm)	Standard deviation	N
100	0 days	833,57	26,018	7
	3 days	517,71	34,028	7
	6 days	389,43	29,205	7
	10 days	318,57	20,354	7
	Total	512,07	198,242	28

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Mass (g)	Time (days)	BOD average (ppm)	Standard deviation	N
200	0 days	822,57	26,018	7
	3 days	468,29	34,898	7
	6 days	345,57	33,125	7
	10 days	388,57	30,237	7
	Total	506,25	193,563	28
300	0 days	822,57	26,018	7
	3 days	429,43	27,367	7
	6 days	331,43	15,736	7
	10 days	532,86	17,995	7
	Total	529.07	188,367	28
Total	0 days	822,57	24,683	21
	3 days	471,81	48,041	21
	6 days	355,48	36,049	21
	10 days	413,33	94,092	21
	Total	515,8	191,336	84

Source: authors' own elaboration.

Table 5 shows the averages of BOD concentration versus treatment time at different masses of Lemna Minor. The results obtained according to ANOVA show that the greatest decrease in BOD concentration was for a mass of 100 g of Lemna Minor and 10 days of treatment with a decrease in the concentration of biochemical oxygen demand from 823 ppm to 319 ppm.

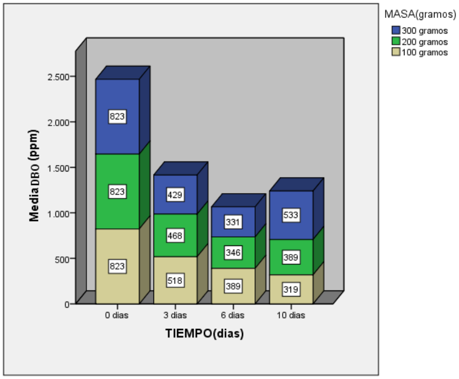

Figure 1. Average BOD concentration levels vs. treatment time and mass of Lemna Minor. **Source:** authors' own elaboration.

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Figure 1 shows the decrease in average BOD concentration for a treatment time of 10 days and mass of 100 Lemna Minor g from 823 to 319 ppm. With a treatment of 200 g of Lemna Minor, the BOD concentration decreases in 6 days from 823 ppm to 346 ppm and then increases in 10 days to 389 ppm, the same behavior is obtained for treatment with 300 g of Lemna Minor. The BOD concentration decreases in 6 days from 823 ppm to 331 ppm, concluding: a better treatment of organic contamination expressed as BOD is obtained with a mass of 100 g of Lemna Minor.

Table 6. Distribution of average COD concentrations vs. treatment time for a mass of 100 g of Lemna Minor.

Mass Lemna Minor (g)	Time (days)	DQO average (ppm)
100	0	1747
100	3	1062
100	6	749
100	10	554

Source: authors' own elaboration.

In Table 6, we can see the decrease in the average concentration of chemical oxygen demand as a function of time for a treatment with a mass of Lemna Minor of 100 g of Lemna Minor, the average concentration in the initial time was 1747 ppm; when being in contact for a period of 3 days, the average concentration of chemical oxygen demand decreases to 1062 ppm; for 6 days of contact the COD concentration was 749 ppm, and in 10 days a COD concentration of 554 ppm is obtained, obtaining a considerable reduction.

Table 7. Distribution of average COD concentrations vs. treatment time for 200 g mass of Lemna Minor.

Mass Lemna Minor (g)	Time (days)	DQO average (ppm)
200	0	1747
200	3	913
200	6	603
200	10	684

Source: authors' own elaboration.

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Table 7 show the decrease in the time-averaged concentrations of the chemical oxygen demand for a treatment with a Lemna Minor mass of 200 g Lemna Minor. The average concentration in the initial time was 1747 ppm; when in contact with Lemna Minor for 3 days the average concentration of the chemical oxygen demand decreases to 913 ppm; for 6 days of contact with Lemna Minor the COD concentration was 603 ppm, and for 10 days an increase in the COD concentration to 684 ppm is obtained.

Table 8. Distribution of average COD concentrations vs. treatment time for 300 g mass of Lemna Minor.

Mass Lemna Minor (g)	Time (days)	DQO average (ppm)
300	0	1747
300	3	1046
300	6	839
300	10	1250

Source: authors' own elaboration.

Table 8 show the decrease in the time-averaged concentrations of chemical oxygen demand for a contact mass of 300 g of Lemna Minor. The average concentration in the initial time was 1747 ppm; when in contact with Lemna Minor for a period of 3 days the average concentration of the chemical oxygen demand decreases to 1046 ppm; for 6 days of contact the COD concentration was 839 ppm, and for 10 days an increase in the COD concentration to 1250 ppm is obtained.

Table 9. Distribution of average COD concentrations vs. treatment time and mass of Lemna Minor.

MASA (gramos)	TIEMPO (días)	DQO average (ppm)	Desviación estándar	N
100 gramos	0 días	1747,14	85,968	7
	3 dias	1061,71	59,905	7
	6 dias	748,57	86,877	7
	10 dias	554,29	76,345	7
	Total	1027,93	467,129	28

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MASA (gramos)	TIEMPO (días)	DQO average (ppm)	Desviación estándar	N
200 gramos	0 días	1747,14	85,968	7
	3 dias	912,86	59,362	7
	6 dias	602,86	51,223	7
	10 dias	684,29	61,606	7
	Total	986,79	465,936	28
300 gramos	0 días	1747,14	85,968	7
	3 dias	1045,71	58,838	7
	6 dias	838,57	49,473	7
	10 dias	1250	96,609	7
	Total	1220,36	350,571	28
Total	0 días	1747,14	81,556	21
	3 dias	1006,76	88,581	21
	6 dias	730	117,004	21
	10 dias	829,52	318,535	21
	Total	1078,36	438,263	84

Source: authors' own elaboration.

In Table 9 the distribution of average COD concentrations vs. treatment time at different masses of Lemna Minor is shown. The results obtained according to ANOVA were determined that the best reduction of COD concentration was with a mass of 100 g of Lemna Minor and 10 days of treatment; the chemical oxygen demand was reduced from 1747 ppm to 554 ppm.

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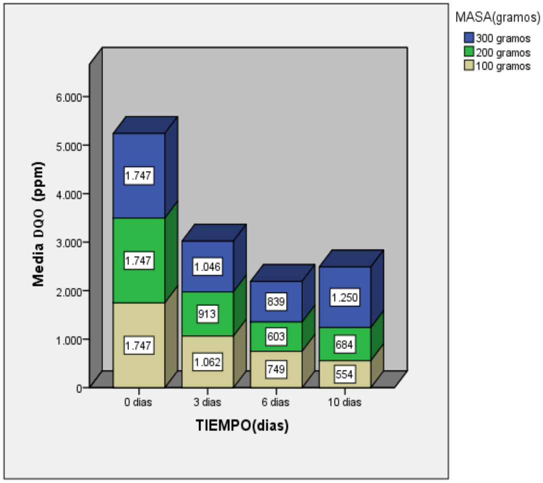

Figure 2. Average COD concentration levels vs. treatment time and mass of Lemna Minor. **Source:** authors' own elaboration.

Figure 2 shows the most significant reduction in average COD concentration for a treatment time of 10 days and a mass of 100 g from 1747 to 554 ppm. With a treatment of 200 g of Lemna Minor, the COD concentration decreases in 6 days from 1747 to 603 ppm and then increases in 10 days to 684 ppm. The same behavior is obtained for treatment with 300 g of Lemna Minor, the COD concentration decreases in 6 days from 1747 to 639 ppm, concluding that a better treatment of organic contamination expressed as COD is obtained with a mass of 100 g of Lemna Minor.

Table 10. Distribution of TSS concentration averages vs. treatment time for a mass of 100 g of Lemna Minor.

Mass Lemna Minor (g)	Time (days)	Media SST (ppm)
100	0	124
100	3	82
100	6	60
100	10	48

Source: authors' own elaboration.

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In Table 10, the decrease of the average concentrations as a function of time of the total suspended solids for a treatment with a mass of 100 g of Lemna Minor, the average concentration of TSS initially was 124 ppm; when being in contact for 3 days, the average concentration of TSS decreases to 82 ppm; for 6 days of contact, the concentration of TSS 60 ppm and in 10 days a concentration of TSS at 48 ppm is obtained, obtaining a considerable reduction.

Table 11. Distribution of TSS concentration averages vs. treatment time for 200 g mass of Lemna Minor.

Mass Lemna Minor (g)	Time (days)	Media SST (ppm)
200	0	124
200	3	86
200	6	63
200	10	78

Source: authors' own elaboration.

Table 11 show the decrease in the time-averaged concentrations of total suspended solids for treatment with 200 g Lemna Minor. The average concentration of TSS initially was 124 ppm; when in contact for 3 days, the average concentration of TSS decreases to 86 ppm. On the other hand, for 6 days of contact, the concentration of TSS is 63 ppm, and in 10 days, a concentration of TSS at 78 ppm is obtained, obtaining a considerable reduction.

Table 12. Distribution of TSS concentration averages vs. treatment time for 300 g mass of Lemna Minor.

Mass Lemna Minor (g)	Time (days)	Media SST (ppm)
300	0	124
300	3	75
300	6	51
300	10	99

Source: authors' own elaboration.

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In Table 12 the decrease of the average concentrations as a function of time of the total suspended solids for a treatment with a mass of 300 g of Lemna Minor, the average concentration of TSS initially was 124 ppm; when being in contact for 3 days the average concentration of TSS decreases to 75 ppm; for 6 days of contact the concentration of TSS to 51 ppm and in 10 days a concentration of TSS to 99 ppm is obtained, obtaining an increase.

Table 13. Distribution of TSS concentration averages vs. treatment time and mass of Lemna Minor.

MASA (gramos)	TIEMPO (días)	Media SST (ppm)	Desviación estándar	N
100 gramos	0 días	123,71	8,361	7
	3 dias	82,29	6,157	7
	6 dias	60	6,733	7
	10 dias	48,43	4,685	7
	Total	78,61	29,93	28
200 gramos	0 días	123,71	8,361	7
	3 dias	85,86	6,283	7
	6 dias	63	3,367	7
	10 dias	77,71	4,923	7
	Total	87,57	23,524	28
300 gramos	0 días	123,71	8,361	7
	3 dias	74,71	7,544	7
	6 dias	51,14	3,288	7
	10 dias	98,57	2,507	7
	Total	87,04	28,083	28
Total	0 días	123,71	7,932	21
	3 dias	80,95	7,934	21
	6 dias	58,05	6,845	21
	10 dias	74,9	21,445	21
	Total	84,4	27,295	84

Source: authors' own elaboration.

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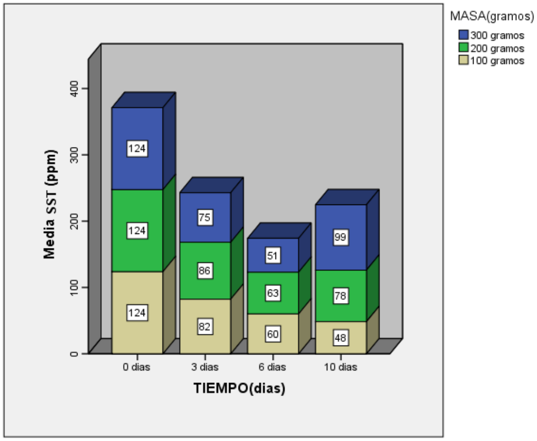

Figure 3. Average TSS concentration levels vs. treatment time and Lemna Minor mass. **Source:** authors' own elaboration.

In Figure 3, it can be seen that the most significant reduction in average TSS concentration is achieved with a treatment time of 10 days and a mass of 100 g of 124 to 48 ppm. With a treatment of Lemna Minor of 200 g, the concentration of TSS decreases in 6 days from 124 to 63 ppm. It then increases in 10 days to 78 ppm; the same behavior is obtained for treatment with 300 g of Lemna Minor, the concentration of TSS decreases in 6 days from 124 to 51 ppm and at 10 days increases to 99 ppm, concluding that a better treatment of organic contamination expressed as TSS is obtained with a mass of 100 g of Lemna Minor.

Table 14. Distribution of % Average removal of BOD concentration vs. treatment time for a mass of 100 g of Lemna Minor.

Masa Lemna Minor (g)	Media DBO	% Remotion
100	0-3 días	37
100	0-6 días	53
100	0-10 días	61

Source: authors' own elaboration.

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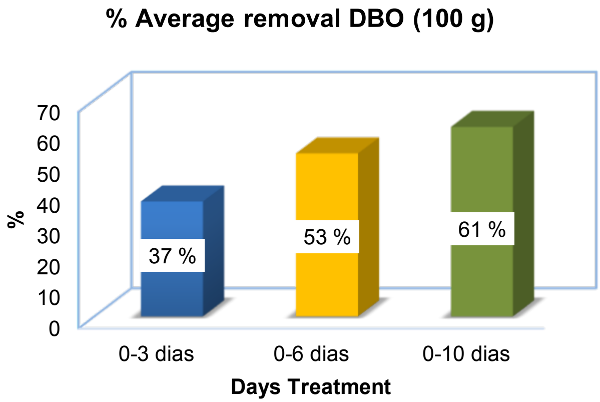

Figure 4. Average % BOD removal concentration vs. treatment time for 100 g mass of Lemna Minor. **Source:** authors' own elaboration.

Table 14 and Figure 4 show the average levels of % removal of BOD BOD concentration vs. treatment time for a treatment mass of 100 g of Lemna Minor. On the third day of treatment, 37%, on the sixth day, 53%, and the tenth day of treatment, 61% of average BOD removal was obtained. It is concluded that for the treatment with a mass of 100 g of Lemna Minor, the maximum removal of BOD is obtained at the tenth day of treatment.

Table 15. Distribution of % Average removal of BOD concentration vs. treatment time for a mass of 200 g of Lemna Minor.

Mass Lemna Minor (g)	Media DBO	% Remotion
200	0-3 días	43
200	0-6 días	58
200	0-10 días	53

Source: authors' own elaboration.

Table 15 show the average levels of % removal of BOD concentration vs. treatment time for a treatment mass of 200 g of Lemna Minor. On the third day of treatment, 43%, on the sixth day of 58%, and the tenth day of treatment, 53% of average BOD removal was obtained. It is concluded that for the

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treatment with a mass of 200 g of Lemna Minor, the maximum removal of BOD is obtained on the sixth day of treatment.

Table 16. Distribution of average removal of BOD concentration vs. treatment time for a 300 g mass of Lemna Minor.

Mass Lemna Minor (g)	Media DBO	% Remotion
300	0-3 días	48
300	0-6 días	60
300	0-10 días	35

Source: authors' own elaboration.

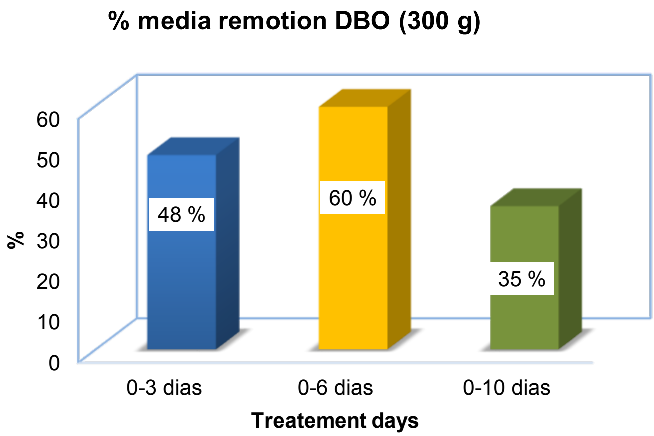

Figure 5. Average % removal of BOD concentration vs. treatment time for 300 g mass of Lemna Minor. **Source:** authors' own elaboration.

In Table 16 and Figure 5, the average levels of % removal of concentration of the biochemical demand of oxygen BOD versus the time of treatment for a treatment mass of 300 g of Lemna Minor is observed, obtaining 48% on the third day of treatment, 60% on the sixth day and 35% on the tenth day of treatment of average removal of BOD. It is concluded that for the treatment with a mass of 300 g of Lemna Minor, the maximum removal of BOD is obtained on the sixth day of treatment.

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5. DISCUSSION

Sarango, Sánchez and Landívar (2016), in their experimental design and applied type, designed 2 biofilters of 68 L capacity each. In contrast to the present research, both investigations were carried out with Lemna Minor applied to industrial effluents, in which there is a percentage of removal expressed as COD 72.57 %, BOD5 73.36 %, total solids 75.21 % and in the first six days of treatment with different masses of 100g, 200g of Lemna Minor there is a high percentage of decrease in the concentrations of the parameters mentioned expressed as organic matter. In the treatment with 300 g of Lemna Minor, there is a decrease but not in the same proportion. From the sixth day of treatment, there is a minimum reduction or increase depending on the masses of Lemna Minor due to a stage of withering, which decreases its capacity of assimilation.

But in both, it is concluded that there is a decrease of COD, BOD5, and TSS in the treatment of industrial effluents with Lemna Minor.

6. CONCLUSION

Of the three treatments of 100g, 200g, and 300g of Lemna Minor, it is observed that the parameter of BOD obtains a greater removal at 10 days of treatment with a mass of 100g Lemna Minor and 6 days with 300g of Lemna Minor.

For the DQO in the treatments with 100g, 200g, and 300g of Lemna Minor, a greater removal is obtained to the 10 days of treatment with a mass of 100g of Lemna Minor and the 6 days with 200g of Lemna Minor.

For TSS in the treatments of 100g, 200g, and 300g of Lemna Minor, there is a greater removal at 10 days of treatment with a mass of 100g of Lemna Minor and at 6 days with 300g of Lemna Minor.

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From the analysis of the parameters that measure organic contamination such as BOD, COD, and TSS versus contact time we found that there is an inverse relationship, as contact time increases these parameters decrease, but in the tests carried out with 200 and 300g it increases from the 6th day, this occurs due to the increase of Lemna Minor that dies during the treatment.

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