Article.

Operational monitoring and mass balance in the biodegradation of oil for two scenarios: Experimental Plant of Active Sludge and Aerobic Digestor

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Abstract: Fats and oils are the most common contaminants in wastewater and are usually discarded through physical processes. This paper studies its elimination through an environmentally friendly biological treatment, yielding good results on both laboratory scale and in the field. In this study a comparative evaluation of the biodegradation of fats and oils in two scenarios were developed in an activated sludge plant at laboratory scale, and a wastewater treatment plant. The full-scale values for some key parameters are compared, such as the oil concentration in the influent and effluent, mass loading and removal efficiency and biodegradation systems. Activated sludge plant at laboratory scale working on a mass load range from 0.2 to 0.8 (kg COD / day / kg MLSS) initially reaches levels of 75% biodegradation thereafter influent concentration is increased and thereby the mass load is increased in a range of working system under high load and biodegradation rates ranging from 71 to 64% are achieved. The actual system consists of a treatment plant wastewater with an aerobic digester for sludge treatment. Fats and oils are retained in a previous degreaser to biological treatment and subsequently sent to the aerobic sludge digester, constituting of thus on a single substrate, resembling an activated sludge plant with extended aeration mode, and levels of biodegradation in the range of 69 to 92%. From this work, we can say that the choice of biological treatment for fats and oils is feasible and adequate. Furthermore, the biomass presents great adaptability to the oil substrate, favored in this case for being the only source of carbon, therefore fats and oils should be removed using biological treatment, instead of the flotation procedure or at most using it as an intermediate process.

Keywords: Biodegradation; fats and oils; activated sludge.

1. Introduction

The following work will study the elimination and behavior of fats and oils using a biological treatment with active sludge in two structurally and different magnitude scenarios: on a laboratory scale and a real scale.. We make a comparative analysis between the field scale, where fats and oils are eliminated in the sludge digester, very similar to an extended aeration regime, and on the laboratory-scale experience, where sunflower oil is the only source of carbon. In both cases, a triacylglyceride is eliminated through the biological route which is a better environmentally alternative to the commonly recurrent option of flotation.

Table 1. Conditions of design and systems operation

Parameter	Real situation sludge digester [1].	Laboratory scale aeration tank active sludge
Single substrate	Fats and oils	Sunflowers oil
Mass loading	0.08-0.42	0.15-1.0
Structure	SBR	Conventional-continuous
Concentration range of affluent Fats and Oil	1000-2500	333-460
SSLM	8.8-14	302-4.8
% Fats and oils biodegradation	69-95	64-71
Volume (m^3)	5128	0.01
Affluent flow (m^3/day)	1000	0.024

Generally, residual water treatment plants eliminate fats and oils by flotation. In this case the biological pathway to eliminate fats and oils is an environmentally appropriate option with excellent field results.

Fats and oils are a very important component in domestic and industrial wastewater. The amount of lipids in municipal wastewater is in the order of 30\% to 40\% of the organic matter measured as chemical oxygen demand [2]. The displacement of oils and fats has been based on its lower density with respect to water, between 920-964 g / l, which allows its flotation [3]. That is the reason why the Residual Water Treatment Plants eliminates fats and oils through flotation. Until now the fats and oils have always been separated from the influent that contain them, through physical processes, in order to prevent them from reaching the stage of biological treatment. Flotation is used in the separation of immiscible or solid fluids and the use of flotation is an increasing methodology in wastewater treatment. Flotation may be done by air at atmospheric pressure, by air dissolved under pressure or by induced air. The difference lies in the way of introducing air into the sewage [4].

Therefore, biological treatment must be considered for water mixed with oils and fats contents in order to reduce the fatty residues that will potentially be disposed. Such methodology has considerable advantages from an environmental point of view. Fats and oils are classified as slowly biodegradable substances. Cells initially store these substances in their cytoplasm and then they use hydrolytic enzymes to convert fats and oils into an assimilable and biodegradable substrate [5].

The biological pathway to treat wastewater mixed with fats and oils, on a real scale and on a laboratory scale is compared. At the laboratory-scale experiment, the removal of sunflower oil in wastewater is studied through an active sludge treatment system. The assay experimented with sunflower oil which is of easy access and a standardized product in Chile and for that reason is commonly used for domestic consumption. The chemical composition of sunflower oil is shown in table 2.

Table 2. Fatty acids of the sunflower oil and analysis specific stereo [6]. Results are given in % moles.

Fats	Position	16:0	18	18:1 (9)	18:2 (9.12)	18:3 (9.12.15)
Sunflower oil	1	10.6	3.3	16.6	69.5	
	2	1.3	1.1	21.5	76	
	3	9.7	9.2	27.6	53.5	

The wastewater treatment plant utilized in this work is located in Los Angeles city, Chile. This treatment plant treats the oils and fats in an aerobic digester along with the sludge obtained from the biological treatment, then the fats and oils are retained by a degreaser and sent to the aerobic digester.

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The biodegradation of organic matter in an active sludge system is enhanced by the cultivation and development of a dispersed bacterial biomass in form of flocs. Those are called active sludge dispersed in an aerated and agitated pond which is continuously fed by sewage with organic matter or sludge. The stirring of the tank aims to homogenize the mixture constituted by the bacterial biomass and the residual water avoiding sediments and zones of short distance circuit. Aeration is carried out to supply oxygen to the purifying bacteria, since its metabolism requires to carry out biological degradation of organic matter or sludge [7].

Parameters Design and operation of an active sludge treatment system:
- Mass loading (ML): It is called the aeration tank mass loading (ML) in relationship between the daily feed mass of biodegradable organic matter entering the aeration tank and the degrading biomass contained therein [8].

The behaviors of lipids elimination in biological treatment systems have been exhaustively evaluated. The literature shows that lipids eliminated by biological treatment, also inhibit microbial growth, and are the cause of foaming, filamentous bacteria and floc flocculation [9].

In an active sludge biological treatment system, the efficient contact of the microorganisms present in the aqueous phase and oil is fundamental. It requires a considerable interfacial area, this can be extended by delivering energy to the system, either by mechanical agitation or by electric fields. The increase of the interfacial surface between the aqueous phase and the oily or greasy phase is often implemented by mechanical agitation [10].

There are two important factors that determine an extension of the level of emulsivity in the full-mix stirred aeration tank and the corresponding dispersion level. The influencing factors are the bubble size distribution and the dispersed phase fraction. The average bubble size is between 150 µm and 250 µm [11], this is achieved with a suitable impeller and fine bubble diffusers.

A suitable enzymatic concentration and optimum interfacial area, must be obtained between the aqueous phase and the oily phase, in order to solve the mass transfer and the hydrolysis step. [12].

For the estimation of biodegradability the oil entering the aeration tank in the laboratory experience and the fats and oils entering to the aerobic digester of the treatment plant are considered as the basis of the calculation, both cases corresponding to a treatment process Active sludge. In this work, a comparative analysis is performed on the levels of biodegradation of oils and greases achieved both in the treatment plant on a real scale and on a laboratory scale.

The estimation of the biodegradable material is obtained from a mass balance and in addition a monitoring of the operational parameters is carried out, which provide information on the behavior of the respective systems, when fed with an influent possessing sunflower oil or fats and Oils.

2. Materials and Methods

There are two clearly differentiated systems and therefore the applied methodology is conditioned by each empirical situation studied. It is pertinent to point out that the similarity between these two plants is the substitution of the flotation by biological treatment to remove fats and oils. Furthermore the similarity will be given at the process level by the aeration tank of the active sludge plant at laboratory scale and by the digester + aeration tank, in the real scale plant. Those are the facilities of both plants in which the charge of fats and oils is eliminated by biodegradation.

In both cases, a balance of matter is made to estimate the fraction of fats and oils biodegraded, then the corresponding plants studied are described and the development of the respective balance of matter is exposed.

2.1 Test y parameter performed

- 2.2.1
- Total Suspended Solids (TSS), TSS was determined by sample filtration of a known volume through Whatman 4.7 cm GF/C glass fiber filters and drying at 103-105°C. The difference in

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weight of the filter before and after filtration is used to estimate the TSS, 209C method [13]. [15].

2.1.2 Fats and oils

For determination of fats and oils, groups of substances with similar characteristics are qualitatively measured on basis of their common solubility in a suitable solvent. Gravimetric / Soxhlet Test Method (Method 213E, Standard MethodS 14 TH).

2.1.3 Chemical Oxygen Demand (COD)

COD has been determined using a variation of the potassium dichromate method [14]. [16]. This method uses a much smaller amount of sample and reagents. The sample is chemically oxidized through the action of potassium dichromate at a temperature of 150 °C for two hours. Silver sulfate is used as the catalyst and mercury sulfate to avoid potential chloride interference. Measurements are done by spectrophotometry at 600 nm.

2.1.4 Monitoring Parameter

ML= kg BOD applied /day] /[kg of total suspended solids in aeration tank] (1)

$$ML = Q \cdot BOD / (V \cdot MLTSS) \tag{2}$$

Alternatively $$ML = Q \cdot COD / (V \cdot MLTSS) \tag{3}$$

Where:

BOD : Biochemical Oxygen Demand
COD: Chemical Oxygen Demand
MLTSS : Mixed liquor total suspended solids
Q: Influent Flow rate
V: Volume of aeration tank

2.2 Laboratory scale plant

2.2.1 Description of equipment

The equipment used was BIOCONTROL, model MARK 2. The laboratory scale active sludge plant estimates the biodegradability of sunflower oil in wastewater. Experimental work is required to obtain information about parameters describing the dynamics of the active sludge process. The process will depend on the content of fats and oils present in the incoming wastewater.

2.2.1.1 Unit control of the equipment

It consists of a main switch, an air cylinder complete with a flow meter, a system flow control rate, as well as a feed pump for the waste water to be purified, complemented by a rate control system. A timer for intermittent operations, ON-OFF switch and a pump that recycle sedimentation tank sludge to the aerator tank.

2.2.1.2 Aeration tank of the equipment

Transparent Plexiglas® cylinder of 38 cm height and 20 cm diameter, it has outputs at various heights that are associated with different volumes: 7, 8, 9 and 10 liters. There are two inputs, on one hand: the recirculation sludge that are fed by the top and the influent to the lower level has in its upper part an outlet for the mixing liquor that goes to the secondary settler. In addition, there are two

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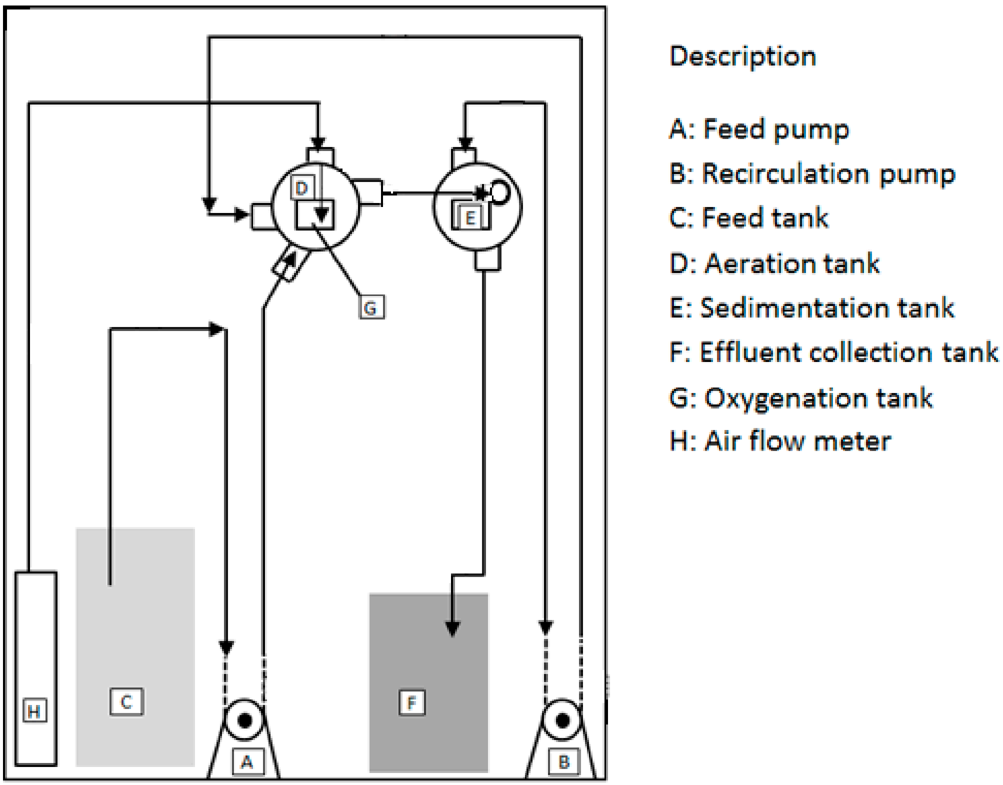
ceramic diffusers that are placed in the bottom, in a way that disperses the air in very small bubbles [15]. [13].

2.2.1.3 Sedimentation tank of the equipment

It consists of a transparent cylinder made of Plexiglas® such that the basal part has the shape of a cone in order to facilitate the sedimentation and thickening of the sludge. Receives the mixed liquor from the aeration tank by overflow, when it reaches the clarifier it gives rise to a downward flow, such that the sludge decants and is separated and recirculated by the bottom through a pump, the clarified water also uses the mechanism of Overflow to be evacuated to the accumulation tank.

Figure 1. Diagram of the experimental equipment.

Description:
A: Feed pump.
B: Recirculation pump.
C: Feed tank.
D: Aeration tank.
E: Sedimentation tank.
F: effluent collection tank.
G: Block of oxygenation.
H: Airflow meter.



2.2.2 Experimental methodology

2.2.2.1 Food preparation

The treatment system was fed with synthetic wastewater prepared in the laboratory according to the COD (Chemical Oxygen Demand) concentrations of urban residual water. The concentrations were in the range of medium to strong [16]. [14], with a C: N: P = 100: 5: 1 ratio. Food was prepared

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daily and the nitrogen and phosphorus were increased in accordance with the organic intake from the sunflower oil.

2.2.2.2 Determination of the relationship between COD and FAT

Determination of the relationship between fat and oils and COD, for sunflower oil and pork fat, is performed by linking the fat and oil concentration and the resulting COD using the test described in the methodology.

2.2.2.3 Operation modes

The synthetic wastewater was prepared daily and deposited in a 50 liter storage tank, where a stirrer was installed to disperse the oil or grease. Through a peristaltic pump, operated from the control unit, it drives the feed to the aeration tank. The oxygen supply and the recirculation flow rate are controlled from the control unit. The effluent from the process is collected in a tank of 30 liters of volume, from which the samples are removed for the analyzes that are made to this one.

2.3 Real scale plant

The real-scale plant of the Aerobic Digestor, consists of an active sludge sewage plant of conventional type or medium load, 0.6 (kg BOD / day) / kg MLTSS, which includes an aerobic sludge digester and where the fats and oils retained in the degreaser, are also sent and biodegraded. The plant has 3 similar modules with an aeration tank of 5108 m^3, a settler of 2400 m^3 and an aerobic digester of 5108 m^3, which has an average cell residence time of 25 days.
The full-scale plant consists of a Wastewater Treatment Plant that includes an aerobic digester (figure 2).

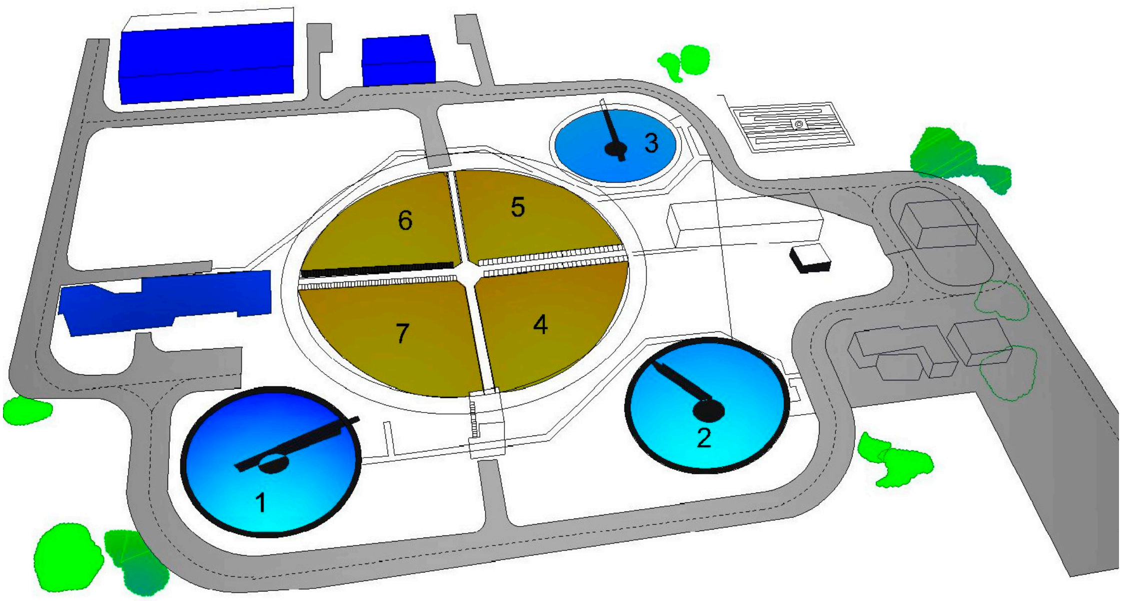

Figure 2. Served water treatment plant (WWTP).

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Where:

1, 2, 3 : Clarifier

4, 5, 7 : Reactor

6 : Aerobic digestor

3. Results

3.1 Characterizacion of fats and COD

It shows the relationship of fats and oils and chemical demand for oxygen, for sunflower oil and pork fat both highly consumed in Chile. From these relationships it is possible to estimate the COD loading associated with the presence of oils in wastewater.

The empirical values obtained for the correlation (COD / fats and oils) of vegetal and animal origin are consistent with the literature [17].

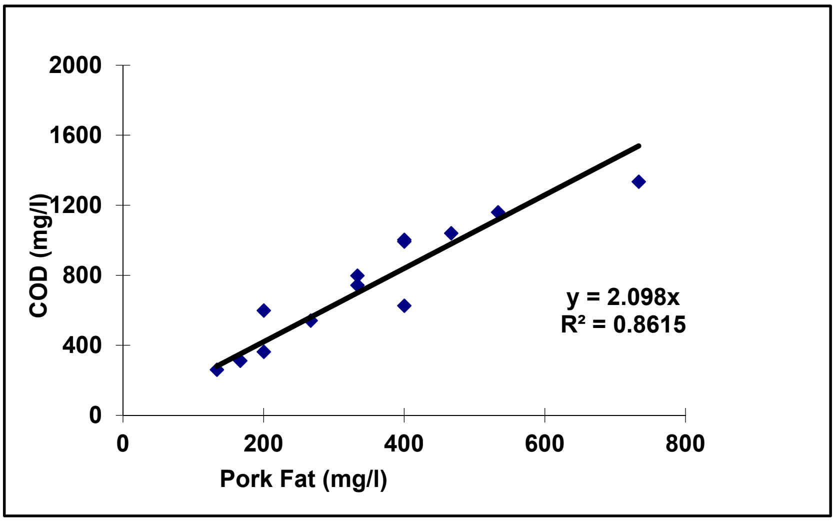

Figure 3. Relationships of COD vs Pork Fat.

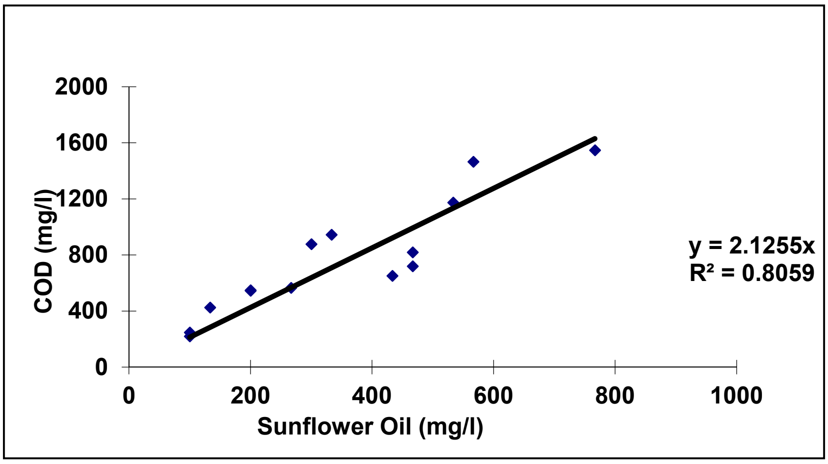

Figure 4. Relationships COD vs Sunflower Oil.

These relationships will be used as the basis of calculation for the estimation of the mass load.

3.2 Elimination of sunflower oil in the treatment of residual waters at a laboratory scale

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In this experiment, the water and oil are mixed in the feed tank by means of a mechanical type of agitation, part of the aggregate oil is accumulated in the oil tank, so the fraction of the oil that does not enter the aeration tank is determined.

The influent contains sunflower oil and the concentration thereof is gradually increased; on the other hand the initial concentration of the biomass present in the aerobic reactor is of the order 4000 mg / l of Total Suspended Solids.

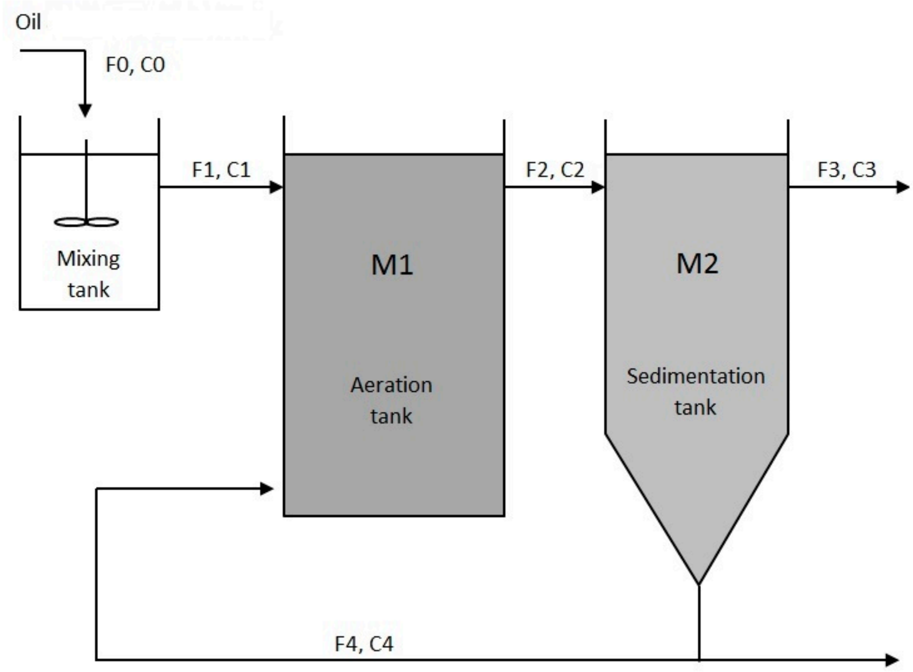

Figure 5. Process diagram of active river plant process.

Where:

F0, C0 : Flow and concentration of oil entering the mixing tank

F1, C1 : Flow and concentration of feed oil to the aeration tank.

F2, C2 : Flow and concentration of fats and oils leaving the aeration tank.

F3, C3 : Flow and concentration of fats and oil of the purified effluent.

F4, C4 : Flow and concentration of grease and oil in the recirculation flow rate.

M1 : Mass of oil that is contained in the mixing liquor of the aeration tank.

M2 : Mass oil that floats on top of the sedimentation tank and mass of oils that is at the bottom of the sedimentation tank by adhesion to the biomass.

3.3 *Balance of matter: determination of biodegradability:*

From the balance of matter, the mass of biodegraded sunflower oil is obtained which is part of the affluent that is fed to the treatment system, it is assumed that initially the system has no oil.

For aeration tank:

$$\Delta M_1 / \Delta t = F_1 \cdot C_1 - F_2 \cdot C_2 - r_A \cdot V + F_4 \cdot C_4 \qquad (4)$$

For Secondary sedimentation tank:

$$\Delta M_2 / \Delta t = F_2 \cdot C_2 - F_3 \cdot C_3 - F_4 \cdot C_4 - F_6 \cdot C_6 \qquad (5)$$

It is pertinent to point out that, $F_6 = 0$

M_1 : It corresponds to the oils and fats that are in the aerator tank.

M_2 : Corresponds to the oils and fats that are in the sedimentation pond.

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V : Reactor Volume.

r_A : Disappearance rate of vegetable oil.

The balance for the system as a whole is:

$$\Delta M_1 / \Delta t + \Delta M_2 / \Delta t = F_1 \cdot C_1 - F_3 \cdot C_3 - r_A \cdot V \tag{6}$$

From this expression we have to $r_A \cdot V$ Corresponds to the vegetable oil that disappears per unit of time, is the oil definitely biodegraded by the microorganisms, such that:

$$r_A \cdot V = F_1 \cdot C_1 - F_3 \cdot C_3 - \Delta M_1 / \Delta t - \Delta M_2 / \Delta t) \tag{7}$$

An important part of the oil floats and therefore does not biodegrade and passes to the secondary sedimentation pond in which it accumulates.

For reasons of technical feasibility, the balance of matter must be integral for a period of time, since it is possible to measure the accumulation of fats and oils caused by flotation, which allows measuring the level of biodegradation of oil containing the influent.

When performing the integral material balance for a certain period of time you have to:

$$M_1 + M_2 = F_1 \cdot C_1 \cdot \Delta_t - F_3 \cdot C_3 \cdot \Delta_t - r_A \cdot V \cdot \Delta_t \tag{8}$$

Where Δ_t : Time lapse

Each day is characterize by a subscript as the examples below:

For day 1:

$$M_{11} + M_{21} = F_{11} \cdot C_{11} \cdot \Delta_t - F_{31} \cdot C_{31} \cdot \Delta_t - r_A \cdot V \cdot \Delta_t \tag{9}$$

For day 2:

$$M_{12} + M_{22} = F_{12} \cdot C_{12} \cdot \Delta_t - F_{32} \cdot C_{32} \cdot \Delta_t - r_A \cdot V \cdot \Delta_t \tag{10}$$

For day n:

$$M_{1n} + M_{2n} = F_{1n} \cdot C_{1n} \cdot \Delta_t - F_{3n} \cdot C_{3n} \cdot \Delta_t - r_A \cdot V \cdot \Delta_t \tag{11}$$

Then the mass balance for a given number of days of operation:

$$\sum(M_{1i} + M_{2i}) = F_{1i} \cdot \Delta_t \cdot \sum(C_{1i}) - F_{3i} \cdot \Delta_t \cdot \sum(C_{3i}) - r_A \cdot V \cdot \Delta_t \tag{12}$$

Then the biodegradability is:

$$B = r_A \cdot V \cdot \Delta_t / F_{1i} \cdot \Delta_t \cdot \sum(C_{1i}) \tag{13}$$

$$B = \{F_{1i} \cdot \Delta_t \cdot \sum(C_{1i}) - F_{3i} \cdot \Delta_t \cdot \sum(C_{3i}) - \sum(M_{1i} + M_{2i})\} / F_{1i} \cdot \Delta_t \cdot \sum(C_{1i}) \tag{14}$$

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Table 3. Balance of matter in active sludge with influent oily agitation and biodegradation efficiency.

Days of operation Includes balance	Mass of oil fed (g)	Dough Of retained oil (g)	Dough Of oil in the effluent (g)	Dough Of biodeg. (G)	Dough Of sedimentation oil (g)	Biodegradation Efficiency (%)
1 to 8	79	12,3	5,4	54,8	6,5	75
9 to 16	120	28	8	65	19	71
17 to 23	157	70	10	56	21	64

3.4 Mass balance at Wastewater Treatment Plant (WWTP)

Mass balance was done on the real-scale treatment plant, which has a different structure in comparison to the laboratory-scale plant. In general, the entry of fats and oils corresponds to the load that transport the affluent; and the outputs of this contaminant correspond to the fats and oils that go out for the effluent of the active sludge plant and in the sludge line, the difference between the input and the output mass corresponds to the mass of biodegraded fats and oils (figure 6).

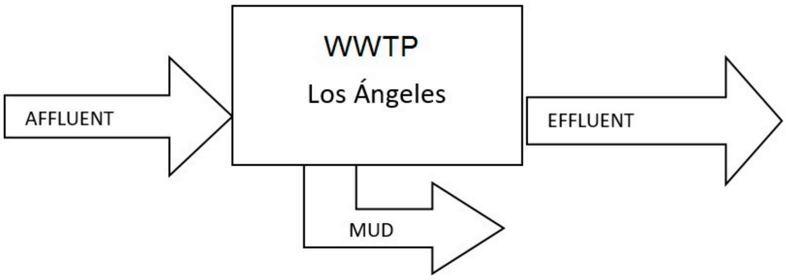

Figure 6. Flow diagram of aerobic digester.

The flow diagram of the Wastewater Treatment Plant Los Angeles, (Figure 6).

Mass balance at wastewater treatment plant (WWTP-LA)**:**

Mass of Biodegradable Oil = Mass of entry - Mass exiting by effluent - Mass coming out by sludge

$$M_{GYA} = Q_{af} \cdot C_{af} - Q_L \cdot C_L - Q_{ef} \cdot C_{ef} \quad (15)$$

Where:

Q_{af} : Flow of the affluent, l/day.

C_{af} : Concentration of fats and oils of the tributary, mg/l.

Q_L : Flow rate from the Digester to the Sludge Dehydrator, l/day.

C_L : Concentration of Fats and Oils of the Digester, mg/l.

Q_{ef} : Outflow from Effluent, l/day.

C_{ef} : Concentration of Effluent Fats and Oils, l/day.

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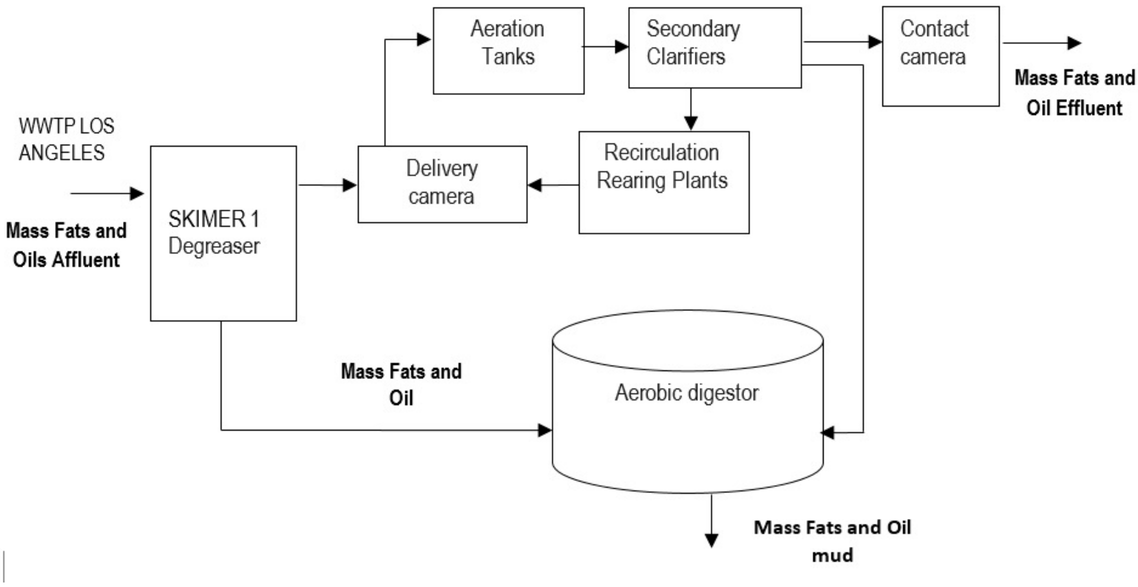

Figure 7. General flow diagram of the Los Angeles WWTP.

Table 4. Mass of fats and oils.

Period	**Affluent**	**Effluent**	**Mud**	**Biodegradable mass**	**% Biodegradation**
	(kg)	(kg)	(kg)	(kg)	
1	46.604	2.072	264	44.268	95
2	19.005	1.456	676	16.872	89
3	25.572	3.164	85	22.323	87
4	10.083	1.045	110	8.927	89
5	16.562	4.725	439	11.398	69
6	11.031	1.446	118	9.467	86
7	9.269	987	0	8.282	89
Total	138.126	14.895	1.693	121.538	

3.5 Operation parameters

3.5.1 Efficiency of elimination of fats and oils by biological means

In the lab-scale plant, there are three periods of 8 days each in which the oil concentration of the influent is practically constant. Initially the oil concentration is 333 mg / l, then it increases to approximately 460 mg / l and for the last days of operation, an oil concentration in the influent next to 500 mg / l is reached. The sunflower oil is eliminated by biodegradation and by flotation, it must be emphasized that it is the only carbon source. Figure 8 shows the oil leaving the effluent; on the other hand we have the curve that represents the oil of the effluent and to which is accumulated in the sedimentation, that is to say the non-biodegradable oil. We can observe that the effluent and accumulated oil increases with the concentration of the influent.

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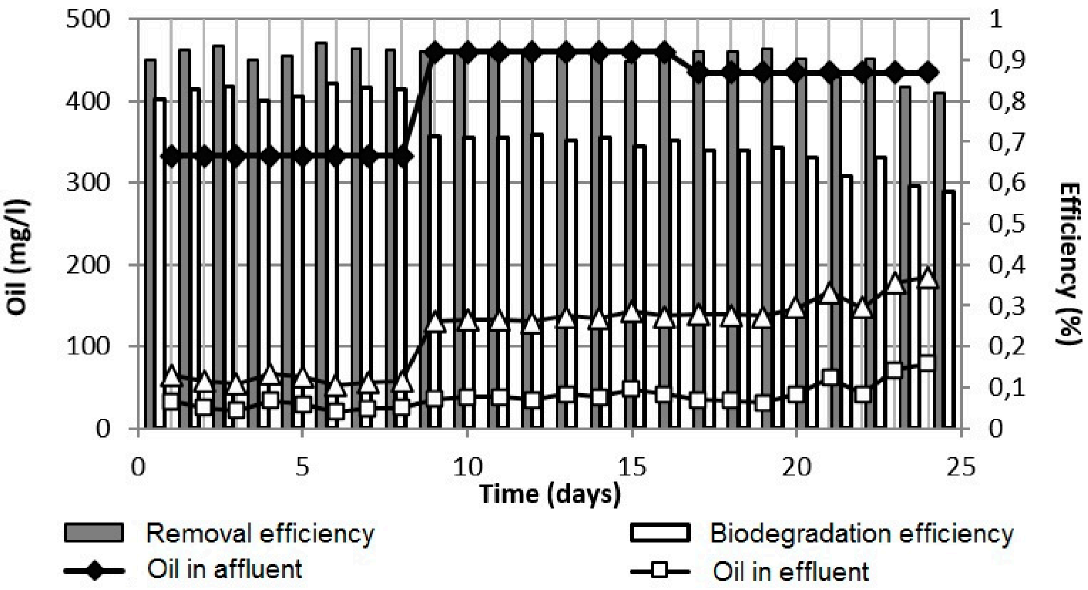

Figure 8. Efficiency of biodegradation and elimination as a function of the bulk load.

Given the configuration of the process of treatment of waste water in real scale, necessarily the fats and oils are retained in the degreaser and sent to the sludge digester. It constitutes an important structural variant with respect to the traditional solutions and the remaining fraction. What remains part of the wastewater is treated by biological treatment of active sludge in a conventional mode.

Therefore, the residue of fats and oils not eliminated becomes part of the contaminants of the effluent and the rest becomes part of the sludge leaving the filter.

The mass of fats and oils that leaves the effluent is greater than the mass that leaves in the sludge (figure 9).

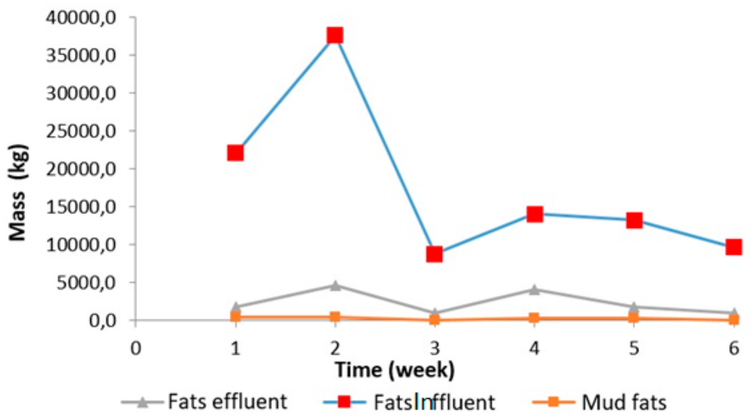

Figure 9. Efficiency of biodegradation and elimination as a function of the bulk load

Figure 9 shows the mass of fats and oils in the influent and effluent of the biological treatment plant and in the sludge leaving the digester, which shows optimistic results regarding the elimination of fats and oils at a global level. The fats and oils are retained in the degreaser and is subsequently subjected to biodegradation in the aerobic digester.

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The biodegradation efficiency of fats and oils in the digester and the plant at pilot scale allows adequate acclimatization by the biomass. The only source of carbon and energy are fats and oils, so there is no situation of competitiveness with other substrates.

3.5.2 Mass loading, biodegradation and oil and fat removal

At the laboratory scale, a considerable fraction of the sunflower oil accumulates in the secondary settler; the magnitude of this accumulation of oil mass is correlated with the oil concentration in the influent.

The values of eliminated vegetable oil in the effluent report that the sum of the phenomena of biodegradation and oil flotation reaches a high global elimination of vegetable oil. In addition, the biodegradation of oil does not depend on the mass loading (Figure 10).

Considering the values of the mass load, at an initial stage the conventional regime is conducted, later a regime of high rate are used (Figure 10). The value of the mass load does not affect the quality of the effluent, which is coherent with the theory and the experience of wastewater treatment.

The percentage of removal of vegetable oil is over 90% which is mainly due to the biodegradation of vegetable oil. About 70% and 20% corresponds to flotation, considering the balance of matter shown in Table 4. This is comparable with experience in the active sludge system, which achieved COD removals of 80%, for waste water from the olive oil refining industry [18].

For aerobic biological treatments we have experiences in plants on a real scale. An evaluation of 55 municipal water treatment plants was carried out in USA; it was mainly found that the concentration of fats and oils in the influent had an average value lower than 80 mg / l and a BOD of 300 mg / L. The effluent had a concentration of fats and oils lower than 10 mg / l and BOD less than 40 mg / effluent level. Furthermore the elimination of fats and oils does not present a seasonal variation [19]. Our results are consistent with those of the literature.

The amount of accumulated oil increases with the oil concentration in the influent and affects the quality of the effluent, which is corroborated by the results of the material balance, which establish a biodegradability of 75% for a concentration of 340 mg / l, from 71% to 460 mg / l and from 64% to 500 mg / l.

Aerobic experiments with granular sludge in a sequential batch reactor for the treatment of dairy effluents, rich in fats and oils, reached COD elimination levels of 90%, after separation of the biomass from the blend liquor [20].

Another experiment was performed to characterize the transformation of lipids into active sludge under aerobic conditions; the results showed that the total lipid content in the effluent would not be reduced to values below 300 mg / l from an initial 2000 mg / L [21].

In the same active sludge experimental plant of this work, 400 mg / l of saccharose were added to similar concentrations of fats and oils in the influent, the oil and fats concentration range was 100 to 850 mg/L, biodegradation was in the range of 60% to 51% [22], what show the competitive effect of other substrate, fact to consider.

Anaerobic biodegradation experiments reach a level of oil removal ranging from 81% to 97% [23], which is relatively similar to this system when considering flotation.

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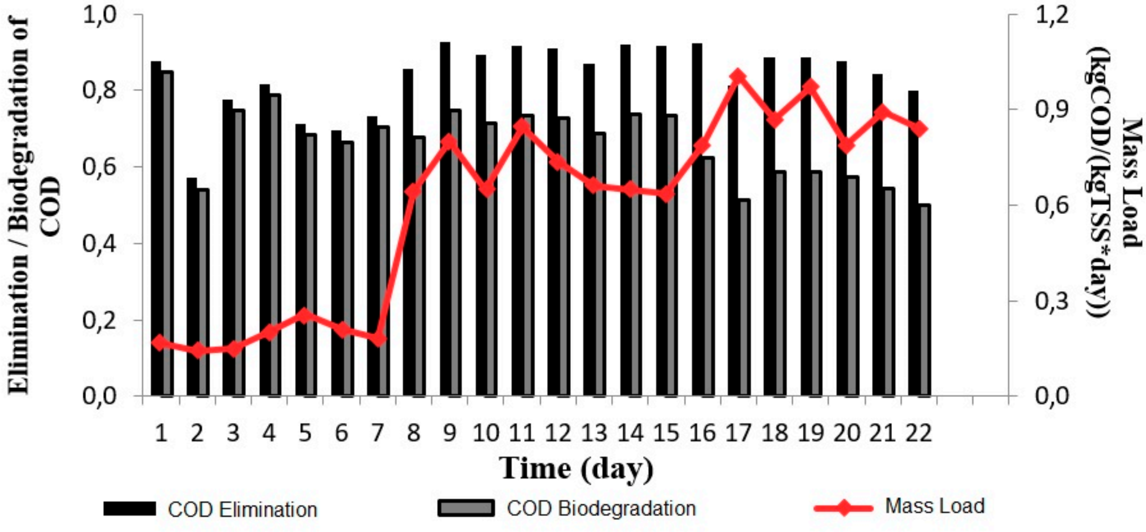

Figure 10. Efficiency of biodegradation and elimination as a function of bulk load.

Considering the empirical antecedents of the biological treatment of waste water, fats and oils are physically eliminated generating a considerable amount of waste that must be disposed in a landfill, with a high economic and environmental cost. For the case studied there is a degreaser, which eliminates 80% or more of the incoming fats and oils, obtaining concentrations in the effluent of the treatment plant of 10 mg / l. This is a conventional treatment with loading ranges High mass and therefore a considerable availability and variety of substrate, which compete with fats and oils advantageously as they possess simpler mechanisms of biodegradation. Both systems show high levels of biodegradation since they work with a single substrate, fats and oils, which favors the acclimatization of the biomass [24].

It should be noted that in the specific case of the Los Angeles treatment plant there is an aerobic sludge digester which also removes fats and oils, therefore the volume of fats and oils physically retained in the degreaser is finally treated biologically.

Figure 11 shows grease and oil removal efficiencies by biodegradation in the sludge digester and the overall efficiency resulting from both processes. The elimination efficiency in the sludge digester is well above that in the active sludge process, this difference is mainly explained by the high concentration of biomass in the sludge digester. Higher than the one of the aeration tank from the process of active sludge of the plant in a pilot scale. The results lead to a greater amount of active biomass, generating an extended aeration system. Therefore the quantity of substrate is poor in relation to the biomass, which stimulates the use of fats and oils as a substrate for the construction of cellular tissue and energy source by the biomass.

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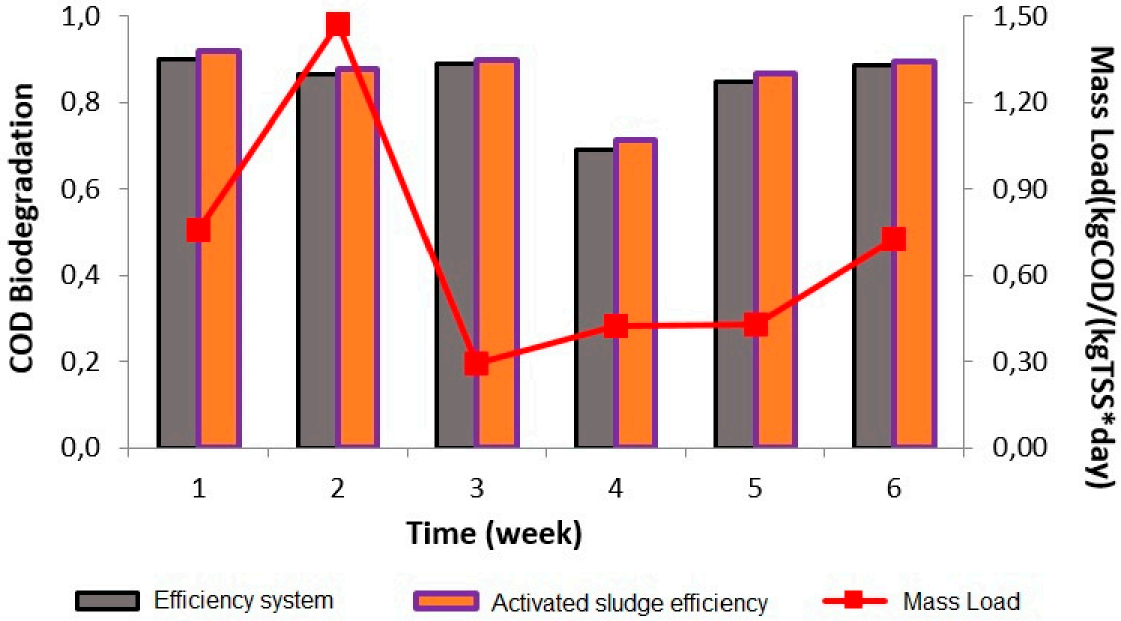

Figure 11. Efficiency of biodegradation and elimination as a function of the bulk load in WWTP.

Both systems have biomass, fats and oils, and both are the support for activity of the enzyme lipase. Biodegradation is measured using the lipase activity; the enzyme is extracted from the active sludge, after environmentally safe verification [25].

The digestion of sludge, fats and oils in the aerobic digester is close to a biological treatment of activated sludge in extended aeration for fats and oils, the only substrate present. Therefore this methodology, for the elimination of fats and oils, is an innovative experience and is considerably similar to the laboratory experience with which it is compared.

Real experience shows a result that is consistent with the one performed at the laboratory and does not generate fats and oils as final residue, which eliminates the problem of its final disposition.

4. Conclusions

- Sunflower oil is biodegradable and reaches a range of biodegradation between 64% and 75%, for a wide range of concentration of this type of substrates in the influent in Laboratory scale active sludge plant. The fats and oils are biodegraded between 69% a 92% in the aerobic real digester.
- The oil removed in the wastewater treatment process is by means of flotation and biodegradation mechanisms, and when added together the elimination becomes above 85% on the Laboratory scale active sludge plant.
- Elimination and the efficiency of biodegradation are between 69% to 92% with previous separation of fats and oils by flotation in aerobic real digester.
- The higher biodegradation efficiency (75%) for the experimental plant sludge active, and the biodegradation efficiency of the aerobic digester, 92%, corresponds to the lowest mass loading condition in both cases.
- The biomass presents great adaptability to the oil substrate, favored in this case for the lack of competitiveness being fats and oil the only source of carbon.
- Fats and oils should be removed by biological treatment, replacing the flotation and at most using it as an intermediate process

Conflicts of Interest: The authors declare no conflict of interest.

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