Contribution for the optimization of Matutano IWWTP performance in Carregado

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ABSTRACT

Management of industrial wastewaters is a challenge because they can include a huge range of physical, chemical and biological properties that can change with several production factors. The treatment is essential to ensure that ecological and environmental status of the receiving media is not disturbed.

The main objective of this thesis was to contribute to the optimization of the performance of Matutano industrial wastewater treatment plant. In this sense, the drainage systems of industrial, domestic and storm water were analyzed. An actual AutoCAD drawing of the sewage network was carried out based on all the information collected and the fieldwork carried out. The daily monitoring assessment allowed pointing out some improvement strategies in order to minimize problems, or incidences detected.

The overall annual performance of the facility, in 2016, confirmed the compliance of the emission limit values of Matutano license to use water resources for treated wastewater rejection despite the low removal efficiencies of TSS, COD and BOD_5 of the anaerobic digestion revealing an enormous potential for improvement instead of the aerobic treatment intensification.

A more detailed analysis of the UASB reactor performance from January 2015 to July 2017 was undertaken and discussed based on the state of the art for UASB performance and granular sludge formation and disaggregation, and the external factors that influence its functioning. Biogas production rate was found to be far from project values. A reduction of biogas production and a quality decrease might have been caused by VFA accumulation within the evaluation period of time.

Keywords: Anaerobic Digestion, Industrial wastewaters, IWWTP, Matutano, UASB Reactor.

INTRODUCTION

Treatment of wastewater is essential to ensure that the ecological and environmental status of the receiving media is not disturbed. Therefore, all companies in industrial sector must deal with management, treatment, and final disposal of their industrial wastewater.

Although there are a set of management measures that can be applied to all industries to prevent and control water pollution, regarding their treatment, each case is a case. Water saving strategies can be applied to all industries, thus reducing the volume of effluent to be treated. These can go from raising the worker's awareness, to changing habits in their day to day living, since that a part of industrial wastewater is from households. There is sectors of industry, namely food industry, where cleaning operations represent a large share of water consumption: in these cases delineating and scheduling cleaning plans are strategies to be applied. Recirculation of water in production processes and reuse should be also addressed. A predominant element in industrial wastewater are the raw materials being processed, so that the strategies to combat waste and promote recovery and reuse can be applied in the various phases of the production processes to minimize their presence on the effluent being treated.

Industries have two options regarding the treatment of their industrial wastewater. To have its own WWTP, where after effluent treatment, it is discharged to the water body nearby, complying with the emission limit values (ELV) of the parameters included in its water use permit for wastewater rejection, or send their wastewater to the public drainage system, municipal collectors. This discharge is authorized through several criteria, so that the capacity of the treatment plant and the public system can be protected. When it is possible to discharge into the municipal collectors, it is still necessary that the industries comply with the admission limit values (ALV), stipulated by the management entity of the public network. When the effluent does not comply with the LVA, it is necessary to carry out a pretreatment, correcting the parameters before it is sent off.

Initially a characterization of the generated effluent is carried out, which includes knowledge of the parameters included in the discharge permits (such as pH, BOD_5, COD, TSS, VSS, Oils and grease, among others). After comparing these values with the imposed ALV and ELV, it is possible to define the target parameters of treatment and select the unit operation or unit process most indicated.

Effluents from potato processing are characterized by high concentrations of biodegradable compounds such as starch and proteins, high concentrations of COD, TSS and total Kjeldahl nitrogen. Potatoes contain approximately 18% starch, 1% cellulose and 81% water. [9]

The year 2008 was considered the "Potato year" by the United Nations, stating that less than 50% of potatoes produced worldwide is consumed without being processed. In 2005, Europe was the region where there was the largest consumption per capita, 87.8 kg per capita [5]. The potato processing industry covers industries producing a variety of end products, such as potato chips, frozen potato chips, dehydrated potato flakes, potato starch, among others. In this dissertation a case study of a potato industry was approached. Figure 1 summarizes the production processes inherent to any industry in this field, and Table 1 presents the different wastewater treatment processes that are normally applied.

MATUTANO

Matutano is one of the production centers of potato chips, snacks, and croissants of the PepsiCo group. PepsiCo is a food and beverage company that is present in more than 200 countries around the world, with a net revenue in 2016 of more than 63 billion dollars. The food and beverage portfolio include 22 brands each generating more than 1 billion dollars in estimated annual sales.

In 2016, 26 118 tonnes of products were produced at Matutano, with 60% corresponding to potato chips, 30% to snacks and 10% to pastries. They have an installed capacity of about 35 thousand tonnes, with seven process lines: two potato chips lines (Pc42 and Kettle), an extruded line, a fried pellets line, two corn products lines and a pastry line.

PepsiCo holds a sustainability vision based on the "Performance with Purpose" motto, based on its three pillars, Products, People and the Planet, which mirror the ambitious goals of the 2025 sustainability targets. In terms of environmental sustainability, the following concrete objectives are highlighted:

i. To improve the water use efficiency of its direct production operations by 25% by 2025. This is coupled with the 25% improvement in the water use efficiency the company has achieved since 2006. This initiative will emphasize the areas of high risk of water supply;

ii. Replenish 100% of the water it consumes in its manufacturing operations within high-water-risk areas, ensuring that the water is replenished in the same watershed from which it was extracted;

iii. Reduce absolute greenhouse gas emissions across the company's value chain by at least 20% by 2030, with a focus on collaborating with suppliers, business partners and customers to reduce emissions related to agriculture, packaging and transportation;

iv. Achieve zero waste to landfill across its direct operations by 2025. [1]

In 2017, the Matutano plant expects to achieve a reduction of 8% in electricity consumption and 3% in natural gas consumption, in line with objective iii, and a 3% reduction in water consumption that contributes to the objective i set out in PepsiCo's sustainability agenda for the year 2025.

DESCRIPTION AND ANALYSIS OF EFFLUENT NETWORK

In 2016, the average monthly water consumption was 21,000 m^3 supplied by the public water supply network (21%), three water extraction holes in the factory site (28%) and the remaining water recovered from their IWWTP.
The lines with the highest water consumption in the process are the Pc42 line, the corn product line and the Kettle line, consuming respectively 22%, 17% and 12% of the total water consumed by the plant. The pastry zone represents about 1% of the water consumption of the factory, meaning that it is the production line with less water consumption.
The products to be produced and consequently the line that will be producing, influence the effluent, since each line generates an effluent with different volume and characteristics inherent to the raw material used. In addition to the processes, the type of equipment used is also an important factor, different equipment performing the same tasks with different efficiencies and equipment that requires higher water flow rates than those that allow water recirculation.

The effluent is essentially rich in starch, oils and fats; however, the cleaning done also contributes to the generation of effluent, influencing its composition. There are three types of cleanings: the red line cleanings (dry or with hot water), that are carried out whenever there is an allergen difference in the

Table 1. Treatment Units, Operation, Processes, and Systems for Potato Processing Wastewater. [9]

Treatment unit or subsystem	Unit operation/ unit process / treatment system	Remarks
In-plant	• Conservation and reuse of water • Process revision • Process control	• Reduction of waste flow and load
Pretreatment	• Screening	• 10-25% BOD_5 removal
Primary Treatment	• Sedimentation • Flotation • Earthen ponds	• 30-60% BOD_5 removal • 20-60% COD removal
Equalization	• Balancing tank /buffer tank	• Constant flow and concentration
Neutralization	• Conditioning tank	• pH and temperature corrections
Secundary Treatment		• 80-90% BOD_5 removal
1. Aerobic processes	• Natural systems: -Irrigation land treatment -Stabilization ponds and aerated lagoons -Wetland systems • Activated sludge • Rotating biological contactors • Trickling filters	• 70-80% COD removal
2. Anaerobic processes	• UASB Reactor • Expended granular sludge bed reactor (EGSB) • Anaerobic contact reactors • Anaerobic filters and fluidized-bed reactors	• 80-90% BOD_5 removal • 70-80% COD removal
Advanced treatment	• Microstraining • Granular media filtration • Chemical coagulation/ sedimentation • Nitrification-Desnitrification • Air stripping ion exchanging • Membrane technology (reverse osmosis, ultrafiltration)	• 90-95% BOD_5 removal • 90-95% COD removal (sometimes > 95%)

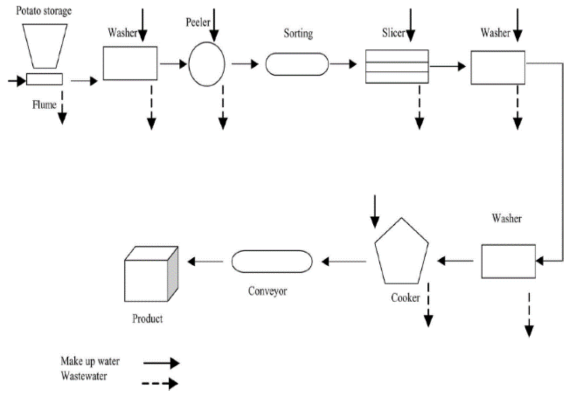

Figure 1. Typical potato chip plant. [9]

product to be produced next; the cleanings at each shift, without the use of chemical cleaners, only with water or compressed air; and sanitation, a deeper cleaning using chemicals and larger volumes of water (these chemically-contaminated waters could harm downstream biological processes) usually done at the end of the week, friday and saturday. The cleaning plan is not fixed and is adapted according to the production plan of each week for each line.

The starch extraction station, SES, operation, also influences the composition of the effluent arriving at the WWTP. The SES processes water from the peelers and slicers of the line PC42 and Kettle, and the water that transports the potatoes from the cutter to the entrance of the fryer, on PC42 line. The SES is only operational if the PC42 line is producing, i.e. when the PC42 is not producing, but the Kettle is, the water from the Kettle line is directed to the WWTP. In 2016 about 815 tonnes of starch were extracted, contributing to a positive financial return through its sale to the paper industry.

In addition to the effluent intrinsic to the production process, it is necessary to consider the domestic effluent from the bathrooms, bathhouses and canteen, whose generation rate depends, among other factors, on the number of workers in each shift. Lastly, the variation in both the flow rate and the effluent characteristics vary according to the day of the week and its working regime.

MATUTANO IWWTP

The treatment line is shown in Figure 2. Only the industrial effluent undergoes a pretreatment before it meets with the other types of effluent in the lifting station. The treatment line is composed of 4 stages: pretreatment, primary treatment (sedimentation), anaerobic treatment by UASB reactor followed by an aerobic activated sludge reactor.

In normal circumstances, all the effluent is sent to the anaerobic treatment, meaning, the effluent is removed at half height from the decanter by two centrifugal pumps of $60m^3/h$ each, which operate according to a level probe placed in the decanter, enabling the stabilization of the flow rate fed to the anaerobic reactor. In a situation of excess flow or failure of the anaerobic system, the decanter will overflow, discharging the effluent to the so-called biological reactor 1, by gravity.

The anaerobic treatment includes two structures: conditioning tank and UASB reactor. The effluent from the primary decanter is pumped into the conditioning tank equipped with a submersible agitator, which mixes the effluent with the recirculation flow rate, homogenizing the affluent organic load to the UASB reactor.

This feed promotes an upward flow and agitation of the anaerobic sludge in the reactor, which, together with the agitation caused by the biogas production, promotes the contact of the organic load of the effluent with granules, maximizing the degradation of the organic load. The effluent rises to the top of the reactor, where three-phase separators promote retention of sludge in the reactor (solid-liquid separation) and separation of the biogas bubbles from the treated effluent (gas-liquid separation). After the anaerobic treatment the effluent is fed to the aerobic reactor to biodegrade the remaining organic load.

Figure 2 shows the aerobic treatment, the way it was designed, in 2016 and in 2017. In recent years, aerobic treatment has not been carried out as designed, with only the biological reactor 1 being used and keeping biological reactor 2 deactivated but operational, which would allow an additional treatment capacity of 1050Kg BOD_5/day. There is no need for two reactors being used simultaneously, since only one is sufficient to ensure that the final effluent complies with the ELVs. This way, unnecessary energy costs associated with the operation of the surface agitators that provide aeration necessary for aerobic treatment are avoided. After the treatment steps are completed, the effluent is sent to three different destinations, water line, firefighting reserve, and reuse.

ANALYSIS OF EFFLUENT NETWORK

Initially, effluent flows were studied, from their origin to their destination. This study included a collection of all existing information on the current state of the plant's effluent network, namely, plants with the location of the industrial, domestic and storm effluent network. Next, the current state of the sewage network was verified, through the validation of the information contained in the plants with the reality. Subsequently, a new plant was executed based on the information collected through the fieldwork carried out (opening of manholes and checking their conditions), the plants available and information provided by the maintenance supervisor.

The daily monitoring operation of the IWWTP in the traineeship period allowed the identification of possible situations of improvement actions, both on safety and operational levels.

To take advantage of future hypothetic incidents, a tool has been created that will analyze each future incident, study and discuss internally what could have been done to avoid the problem. This tool is an internal reporting model. It will allow, over time, to be aware of the most frequent incidents and to study preventive measures that can be included in the preventive maintenance plan. On the other hand, it will highlight the fact that it is necessary to reinforce a certain task, changing the frequency of when it is performed, and to identify work orders that no longer make sense being carried out. Improving according current needs and, gradually, the preventive maintenance plan. It will also identify whether the persons involved responded in the most appropriate manner to the occurrence. And if necessary, provide training so that in the future the answer will be the most appropriate.

In this dissertation, measures were suggested, namely the acquisition of a biogas deposit that will benefit IWWTP in terms of better management of this resource and also, a biogas treatment system, which is mainly aimed at avoiding corrosion problems of pipes and equipment.

UASB REACTOR

The anaerobic digestion process is composed of 4 sequential biochemical reactions, hydrolysis, acidogenesis, acetogenesis and methanogenesis, each mediated by a specific group of bacteria.

The inflow to the reactor is uniformly introduced into the bottom of the reactor, moving from the digestion zone in an upward flow to the three-phase separator. It is essential to ensure a uniform distribution at the bottom of the reactor to avoid dead

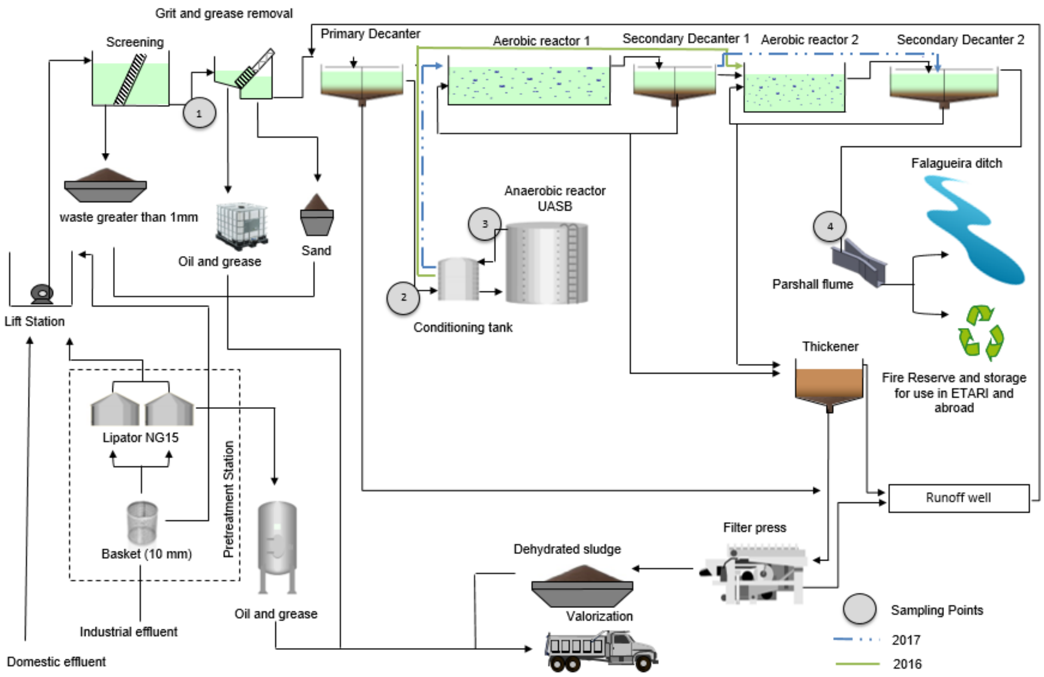

Figure 2. Schematic representation of Matutano WWTP, sampling points and changes made in the year 2016 and 2017.

zones, hydraulic short circuits, and preferred paths in the reactor. [9] The digestion zone is composed of two layers, granular sludge bed, and a fluidized zone. In the sludge bed occurs the degradation of the organic material, the production of the biogas and the growth of the biomass. The granules with good sedimentation capacity remain in the sludge bed, whereas flakes and dispersed bacteria end up leaving the reactor together with effluent. [11]

The biogas follows in an ascending trajectory with the liquid, towards the three-phase separator, Figure 3. The upward movement of the produced biogas creates suitable conditions of turbulence which allow the contact between the biomass and the wastewater to be treated, but can also cause a drag of the granules. The three-phase separator plays a very important role in separating the aggregates, which will float or ascend due to turbulence, and the biogas produced from the treated effluent.

In the UASB reactors, there is no biomass support material, the biomass immobilization is achieved due to the sedimentation quality of the aggregates, this sedimentation of the suspended solids occurs due to its density and the upward hydraulic flow, which ensures that the granules remain retained in the sludge bed. The maintenance of the granular structure is very important, because in certain conditions it can occur deterioration of the aggregates and in the worse scenario, a washout, meaning a loss of the viable biomass of the reactor, putting in question its stability.

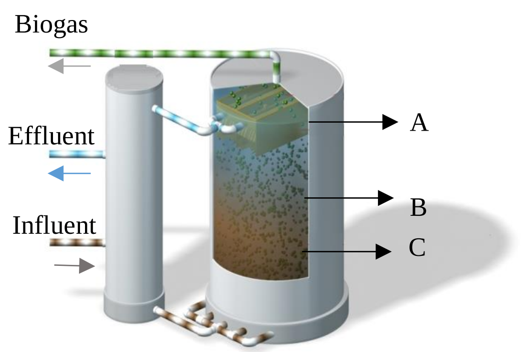

Figure 3. Schematic representation of UASB reactor: (A) three-phase separator; (B) fluidized zone (C) granular sludge bed;

Granulation is a process in which the dispersed biomass agglutinates to form well-defined granules. It is a complex process involving different bacterial trophic groups and their respective physicochemical and microbiological interaction [9]. According to the literature, the diameter of the granules varies between 0.4-5 mm depending on the type of effluent, the operating conditions, and the analytical method. Granules that grow on acidified substrates, such as acetate, are generally smaller than granules that grow on acidogenic substrates, such as glucose. These may vary widely in shape, depending on the conditions in the reactor, but usually have a spherical shape. [11]

The ash content, inorganic material, of samples collected on several occasions from the same reactor varied up to 100%, however, under mesophilic conditions, granules that grow in complex effluents have a lower ash content than those grown on simpler substrates, such as acetate, propionate and butyrate. Granules that grow on complex substrates are often larger than those grown on simpler substrates. Calcium, potassium and iron are described as the main components of ash. The effect of the stabilization of calcium and potassium precipitates on the granules were confirmed by experiments where these elements were removed from the granules by treatment with EDTA and therefore there was a decrease in their performance and in some cases the disintegration of the granules. [11]

According to Schmidt & Ahring, the granules can be interpreted as a spherical biofilm, since there are similarities between their formation. They describe the process of biofilm or granule developing in four steps: (1) transport of cells to the surface of an uncolonized inert material or other cells (substrate); (2) Reversible adsorption to the substrate by physicochemical forces; (3) Irreversible adhesion of the cells to the substrate by microbial appendages, for example the flagellum, and / or polymers attaching the cells to the substrate, (4) multiplication of the cells and development of the granules. [11]

The substrate may consist of aggregates of bacteria present in the sludge, but also of organic aggregates or inorganic materials such as precipitates or straws. The same authors also point out that some researchers have shown, through microscopic observations, that extracellular polymers surround the bacteria present in the granules, and it is commonly accepted that the formation of the granules is correlated with their production. Understanding the physical and biochemical characteristics of the extracellular polymer matrix is important to understand the structure and function of the granules. [11]

Although many researchers have studied this process, there is still no consensus on the mechanism that triggers it. Hulshoff Pol et al produced a review of the different granulation theories in UASB reactors, which were grouped into three groups, according to the main factor responsible for the formation of granules: physics (2), microbiological (11) and thermodynamics (4). Most of the theorists confirm that Methanoseata thermophila a methanogenic bacteria (that grows at 55ºC or higher), exclusively acetotrophic, plays a key role respecting granulation, having the ability to adhere to inert surfaces. And that Methanosarcina genus favors the formation of granules growing in aggregates due to the excretion of extracellular polymers. According to the same authors, there is consensus that the initial state of the granulation is bacterial adhesion, as it happens in the initial phase of biofilm formation.

In this sense, the presence of stabilized inert particles, which may serve as a surface, where bacteria can adhere is an advantage. It is further reported that optimizing the conditions for the growth of the key methanogenic bacteria, such as pH and temperature, granulation can improve significantly.[8]

RESULTS AND DISCUSSION

In 2016, was treated an average of 799 m³/d of effluent. Table 2 describes the sampling points and Table 3 shows the average concentrations recorded in 2016 of the parameters TSS, COD and BOD_5, our sampling spaces and respective ELV. When comparing SP-4 values with ELV, it is verified that IWWTP complies with the ELV in the three designated ones.

Table 2. Sampling point and brief description

Sampling Point	Description
SP-1	Affluent
SP-2	UASB Reactor Input
SP-3	UASB Reactor Output
SP-4	Treated Effluent

Table 3. Mean values and respective standard deviation of the year 2016 and respective ELV for the TSS, COD and BOD_5 parameters for sampling points SP-1, SP-2, SP-3 and SP-4.

	TSS	COD	BOD_5
SP-1	3894 ± 1991	7134 ± 2255	3328 ± 557
SP-2	1006 ± 577	3441± 766	2135 ± 373
SP-3	776 ± 560	1814 ± 972	1412 ± 528
SP-4	17±7	104 ± 37	25 ± 11
ELV	60	150	40

Pretreatment + Primary treatment

In the pre-treatment and primary treatment analysis, the data was collected in SP-1 and SP-2, Figure 4. They exhibited a 71% removal of TSS, which results in a COD and BOD_5 removal of 48% and 34% respectively. It obtained a standard deviation of 17% for the TSS and BOD_5 and 21% for the COD, where these values may be due to the fluctuation of the effluent characteristics over time and the consequent performance of the treatment.

Anaerobic Treatment
For the anaerobic treatment, SP-2 and SP-3, the efficiencies of this treatment are reduced, as verified by the mean removal of 29% for TSS, 51% for COD and 34% in BOD_5, comparatively to the percentage of expected COD removal in this type of reactor, 75-85% [3] and the expected 80-90% removal efficiency for parameter BOD_5, shown in Table 1. The standard deviation of 47 % of the TSS parameter shows possible problems that may have occurred in the period under review.

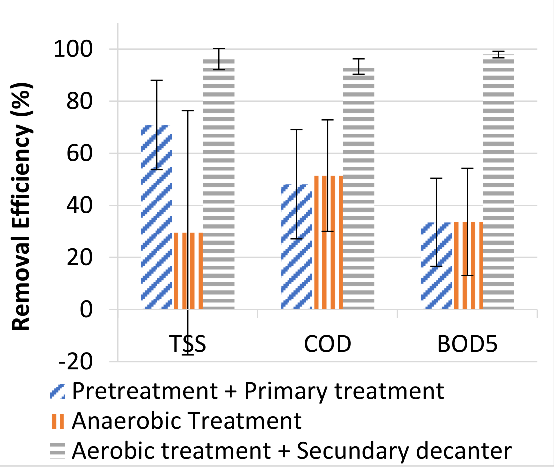

Figure 4. Removal efficiency observed in 2016 in pre-treatment and primary treatment, anaerobic treatment, and aerobic treatment together with the secondary decanters for the TSS, COD and BOD_5 parameters. Mean ± standard deviation (N ≥35).

Aerobic treatment + Secundary decanter
It is possible to verify that the aerobic treatment together with the secondary decanter were the ones that obtained the best removal values, 93% or higher, being the treatment where the standard deviation was lower, 4% for TSS, 3% for COD and 0.01% for BOD_5, demonstrating stability. For this treatment set, SP-3 and SP-4 data were used.

Performance of UASB reactor
To analyze the performance of the UASB reactor, graphs were made showing the evolution of certain parameters over time; in these graphs each point is the result of an average that includes the point itself and the two before and after it. This way, it was possible to highlight trends and eliminate outliers, allowing a clearer reading of the results.

This analysis comprised the realization of a boxplot for each parameter, where five statistical values are represented illustrating the diversity of the sample. The maximum and minimum values are shown at the ends of the vertical bar. The base of the lower block represents the first quartile, 25% of them being less than this value. The division between the lower and upper blocks indicates the median. The top of the upper block represents the third quartile, 25% of which are higher than indicated.

Figure 5 shows the temperature recorded in SP-2 and SP-3, the difference between them is insignificant and is almost always overlaid, except for the period from January to July 2015 and in the year 2016, when the boiler was working. The temperature variation mirrored the variation of the atmospheric temperature, registering lower temperatures in colder months and higher in the warmer months. The median of 2017 is higher than previous years, due to only having analyzed the first 6 months of the year, with fall and the beginning of winter contributing to lower this value. The ideal temperature for the critical phase of methanogenesis in the mesophilic case, range from 30 to 35 °C. [2]

In the reactor project a fixed temperature of 30ºC was considered. In fact, these conditions were only verified few times, highlighting a heating need. Since microorganisms, particularly methanogens, are sensitive to variations in this parameter, it is possible to predict that removal efficiencies and biogas production may not correspond to the maximum treatment capacity.

No reagent for pH correction was added, the median of SP-2 remained constant with 6.9 in 2015 and 6.8 in 2016 and 2017. While the values collected in SP-3 recorded a decrease of 7.2 and 7.1 in 2015 and 2016, to 6.7 in 2017. In 2017 the pH range in SP-3, from 5.8 to 7.4 shows the tendency of acidification of the reactor in relation to previous years. In 2017, pH values were often lower than the range considered optimal for the growth of most anaerobic bacteria, from 6.8-7. [7]

The average BOD_5 considered in design, 1771 kg/d, was always slightly exceeded, but never exceeding the maximum value of 3186 kg /d. The year of 2017 was the lowest dispersion in SP-2, 1500-2250 mg/L, and the highest SP-3, 1250-2500mg/L. The year of 2015 had better removal values, obtaining a greater difference between the values of SP-2 and SP-3, in following years was a loss of efficiency in the BOD_5 removal.

For the TSS, in Figure 6, 2016 obtained the greatest dispersion in results for SP-2, 220-7686 mg / L, but the median for 2015, 2016 and 2017 of 880 mg / L, 920 mg / L and 886 mg / L, respectively, did not reach a large variation in their order of magnitude. In SP-2 about 79% of the TSS are organic, volatile suspended solids (SSV). The maximum design

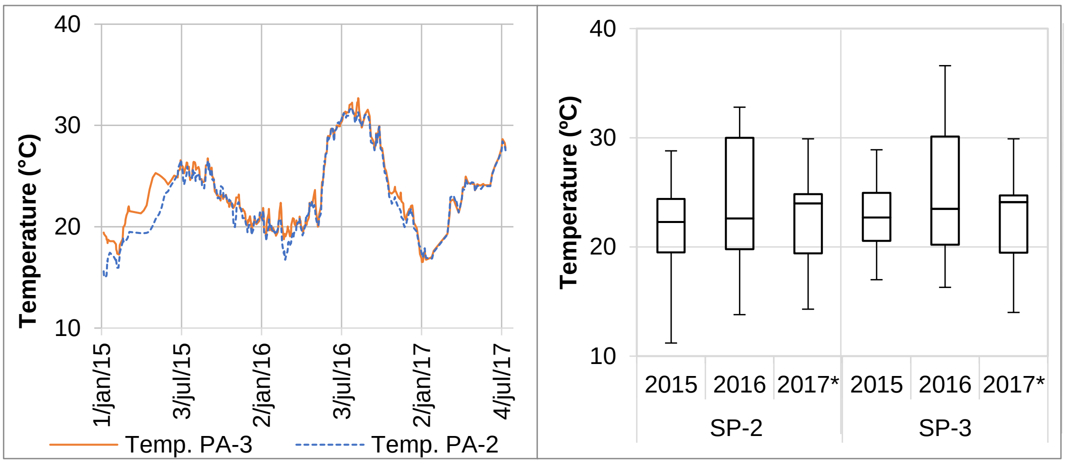

Figure 5. Temperature evolution in the analysis period (left) Boxplot of the temperature for each year and for each sampling point (right); * only the first 6 months of the year.

value, 1892 kg/d, was several times exceeded. The values of SP-3 exceeded SP-2 values, at which point there was loss of biomass and reactor washout. Figure 7 illustrates COD, in SP-2, 54% of COD is due to the presence of soluble organic matter. The mean values of SP-2 in the three years, 2405 kg/d, 3162 kg/d and 3237 kg/d are far from those indicated in the project, 6240 kg/d. The SP-2 median did not change much over the years, while SP-3 showed a tendency to increase over the study period, reflecting the loss of efficiency of the reactor.

Figure 8 shows the variation of the biogas flow rate and the methane quality in % CH4. The UASB reactor, in terms of biogas production, was inefficient, registering values well below the project range of 2650-3090 Nm^3/d. The maximum registered value, 1104 Nm^3/d, was obtained in 2015. Biogas production fell sharply in 2017, the median change from 375 Nm^3/d in 2016 to 111 Nm^3/d in 2017.

Methane quality declined slightly over the period under review, with a median value of 78% in 2015, 75% in 2016 and 71% in 2017. Even so, these values are high when compared to the median range of 50-75%. described by the bibliography. [4]

Related to the VFA, in the period from December 5, 2016, to February 9, 2017, the production registered the same behavior as COD, the concentration in SP-3 was higher than the concentration in SP-2, and there was accumulation of VFA in the reactor. This effect is reported in the literature as possibly responsible for the loss of efficiency or even failure of the reactor [10]. During the same period, biogas production fell sharply, and biogas quality also decreased slightly. The median SP-2 for the years 2015, 2016 and 2017 was 707 mg/L, 670 mg/L and 636 mg/L and for SP-3 it was 459 mg/L, 350 mg/L and 436 mg/L, respectively. For oil and grease, the 50 mg/L considered in project are largely exceeded. The years 2015, 2016 and 2017 recorded a median of 391 mg/L, 515 mg/L and 408 mg/L, respectively.

Regarding the Ca2+, although there is only data from July 2016, the median recorded in SP-2, in 2016 and 2017, of 110 mg/L and 196 mg/L, is in the recommended range of 100-200 mg/L considered beneficial for granulation. [12]

In Table 4, the average values for the Food to Microbes ratio, F/M, and Organic Loading Ratio, (OLR) were recorded for the period under study. Although in 2016 was registered 4.33 kg COD/(kg TSS.d), a rise compared to 2015, it is still far from the 5.94 kg COD/(kg TSS.d) considered in the project. In relation to the OLR, it increased year by year reaching 2.35 kg COD/(m^3.d) in 2017, but it was far from the project value, 5.25 kg COD/ (m^3.d). Both parameters presented a significant variation in all years, where the standard deviation is about 40% of the mean value. To obtain better results in the UASB reactor an increase of these parameters is necessary, close to the values considered in design. To increase the OLR it is necessary to increase the affluent COD.

Table 4. Mean value ± standard deviation of the parameters F / M and OLR in the years of 2015, 2016 and 2017; project value for the respective parameters; * only the first 6 months of the year.

	F/M (kg COD/ (kg TSS.d))	**OLR (kg COD/ (m^3.d))**
2015	3.70 ± 1.59	1.36 ± 0.65
2016	4.33 ± 2.46	1.93 ± 0.65
2017*	3.90 ± 1.04	2.35 ± 0.60
Project Value	**5.94**	**5.25**

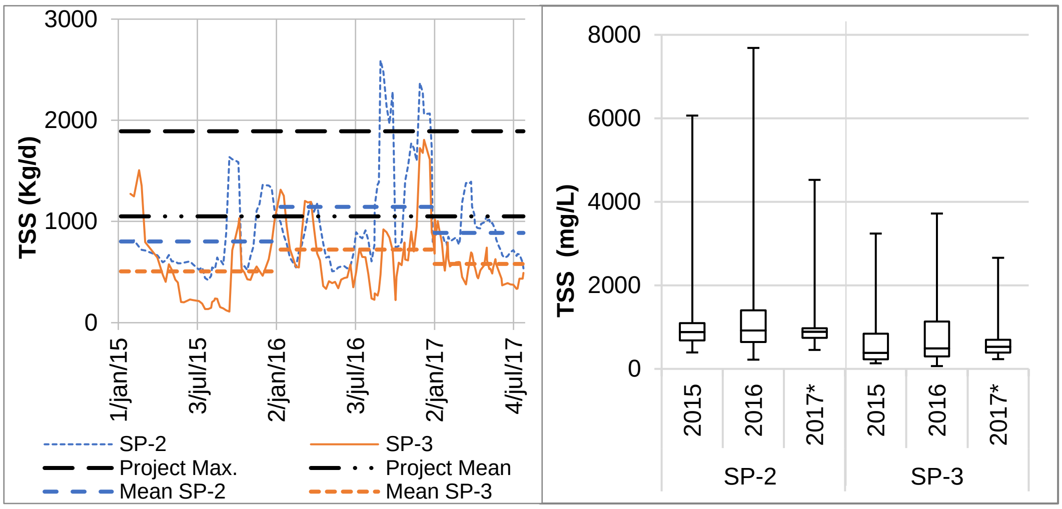

Figure 6. Evolution of TSS in the analysis period (left); TSS boxplot for each year and for each sampling point (right); * only the first 6 months of the year.

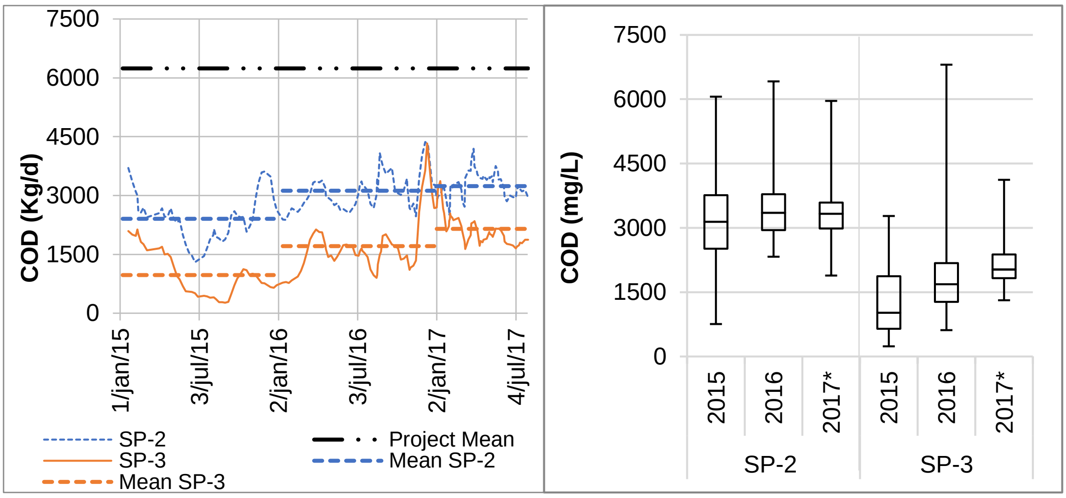

Figure 7. Evolution of COD in the analysis period (left) COD Boxplot for each year and for each sampling point (right); * only the first 6 months of the year.

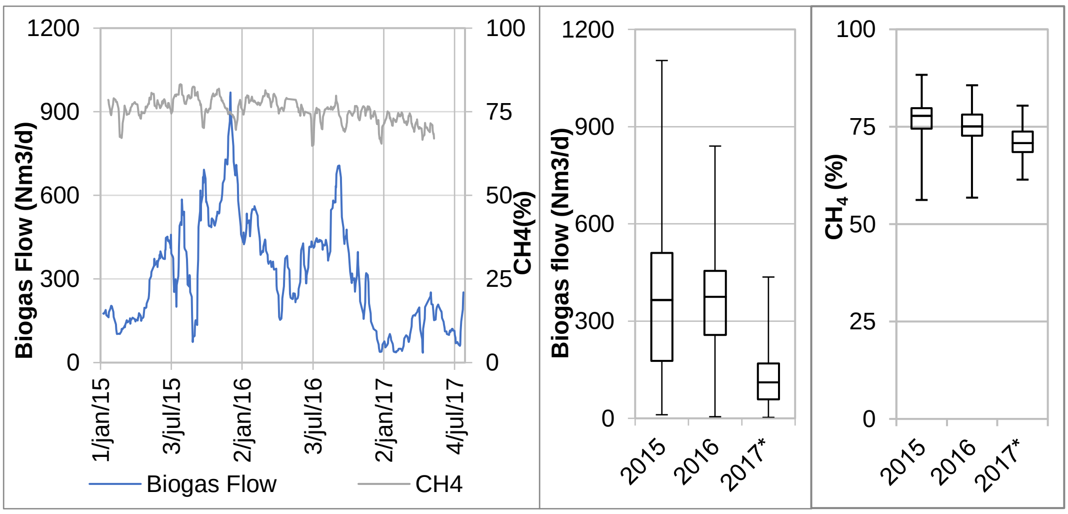

Figure 8. Evolution of the biogas flow produced and % CH4 in the analysis period (left) Boxplot of the biogas flow produced and% CH4 for each year and for each sampling point (right); * only the first 6 months of the year.

PUBLIC DRAINAGE SYSTEM

There is currently no connection from Matutano to the municipal collector. When comparing the mean values for 2016 of SST, COD and CBO_5 with the VLA to the municipal collector, it is verified that SP-1, SP-2 and SP- 3, are far from complying with the VLA. Therefore, it would not be feasible under current conditions to send to the municipal collector from the indicated sampling points. Another fact that makes the possibility of sending the effluent to the collector unfeasible is the price charged per cubic meter to be higher than the price that in the year 2016 Matutano paid for the treatment of the effluent in its IWWTP.

CONCLUSION

The fieldwork carried out during the training period allowed the identification of critical manholes and a new updated plant of sewage network.

Considering the analysis, it was possible to establish an approach that allows to take advantage of future incidents, namely through the internal reporting model, an analysis tool, which aims to improve according to current needs, and gradually improve the preventive maintenance plan. It was clear that preventive action should be taken, with a deliberate budgeting cost, instead of corrective actions, which usually involve a higher and unexpected cost.

Regarding the analysis made to the Matutano IWWTP, based on the 2016 values, it was concluded that the IWWTP complies with the ELV defined in the discharge license for the TSS, COD and BOD_5 parameters. It can obtain better results if the UASB reactor improves its efficiency to the expected interval.

In the analysis carried out to the UASB reactor, was showed its loss of efficiency in terms of biogas production, being very inefficient compared to the project values. To mention that the biogas quality was above the average referred in bibliography. A period of inhibition by VFA accumulation was identified, which coincided with the reduction of the biogas production and a small decrease of its quality, consequently a decrease of the pH was observed contributing to the acidification of the reactor.

One of the advantages of UASB reactor is to remove a higher organic load with a lower energy requirement compared to activated sludge. This way, all the strategies that promote its use, are strategies that meet the objective of reducing the consumption of electricity.

The operating temperature of the reactor is an extremely important parameter since the kinetics of the reactions of anaerobic bacteria, especially methanogenic bacteria, are extremely sensitive to small variations of this parameter. It is extremely important to continuously heat the reactor to operate at a design temperature of 30ºC.

Other factors that do not allow better results in the reactor are the organic load affluent to be below the average expected for this treatment and the high level of oil and grease registered. The control and operation of an anaerobic reactor is a very complex operation requiring a rigorous daily control of several parameters. It is advisable to proceed to pH correction whenever necessary, to optimize the pretreatment to reduce oil and grease, and to investigate ways to feed the reactor with a higher organic load without compromising the maximum TSS load.

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