UNIVERSIDAD DE LAS AMÉRICAS PUEBLA

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"Design of a Wastewater Treatment Plant and a Waste Separation Plant for Calpan, San Andrés Cholula & San Pedro Cholula municipalities of Puebla´s state"

Tesis que, para completar los requisitos del Programa de Honores presenta la estudiante

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Hoja de firmas

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To my father, mother and sisters. Who have and will support me everyday of my life.

Thanks to my colleagues; Eduardo Alvarez and Diana Gomez, who helped me on the realization of this essay.

Thanks to my professors that inspired me everyday of my career.

Caminante. Tu paso por aquí es momentáneo.

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1. General Description & Process Selection

1.1. Introduction

Wastewater treatment is a necessity that grows as the population increases. In 2016 the Sustainable Development Goals of the 2030 Agenda for Sustainable Development came into force. These goals apply to all country that is a United Nation (UN) member state. These seek the improvement in all global social, economic, political and ecological aspects, or in other words, an international sustainable development (UN, 2016).

One of the mentioned goals is to “Ensure access to water and sanitation for all” (UN, 2016). A great amount of diseases could be prevented through the access to safe water supplies. Diarrheal diseases are responsible for 3.6% of the global total daily diseases and cause the deaths of 1.5 million people every year, of which 842,000 are attributed to unsafe water supplies (mainly fecal contaminated water) and sanitation (most in low-income countries) (WHO, 2014).

The mentioned goal place developed and developing countries, like Mexico, in a very committed place regarding the water sector, in which these countries will need to invest a huge amount of resources (investigation, resources, equipment etc.) in order to meet the water quality standard norms and benefit their society.

In Mexico, only 47% of the wastewater that is collected is treated, and a much lower percentage (not possible to estimate because of the lack of monitoring and surveillance) accomplish the quality parameters established by the country´s norms (A.C., 2017). The commented data sustains that Mexico needs more projects of water treatment, so it can stand by the UN Sustainable Goals and provide its citizens a better water quality that yields into a better life.

Another important issue that the UN founds of concern is the recycle of materials. Recycling a ton of aluminum helps saving 1.3 tons of bauxite residues, 16 cubic meters of water and nearly 40 barrels of oil, it also prevents the emission of two tons of carbon dioxide and 11 kilograms of Sulphur dioxide (UN, 2013).

Puebla is the Mexican state with the most landfills in the country; it counts with 18 in its territory. From these landfills, only one meets the normativity related to this subject (NOM-083-SEMARNAT-2003) and the others do not accomplish its specifications and technical requirements. The most urgent issue of the mentioned landfills is that their volume capacity is very exceeded (IGAVIM, 2011). Besides this landfills, there are also at least 20 open dumping sites (where there is no control, hence no separation is made at all), and also the state has a poor recycling culture and difficult access for the waste recollection (IGAVIM, 2011).

“Open dumping, the most prevalent waste disposal method in many countries, can lead to acute health impacts for those living closest to dumping sites, most often the urban poor,” the UN Environment Programme (UN,2013) stablished. This confirms the necessity of a correct waste management and a more solid recycling culture, in order to provide the Puebla citizens a better life quality.

The project that will be proposed and described in this paper incorporates these Sustainable Development concerns in a local project. This project will reduce the river´s pollution which currently affects 1.2 million people because they live exposed on the surroundings of the stream (Greenpeace, 2013). It will also help reducing the volume of waste thrown into the states landfills, therefore lengthening their lifetime and reducing the generation of new materials (saving energy and water).

1.1.1. General description of the project

The project proposed consists in two plants that will be integrated in the same location to treat the waste water and separate the solid residues from three Puebla state municipalities.

A general sketch of these plants is observed in the figure 1; it is visualized the main input and output flows of each plant and the management of each outflow. The arrow that is labeled with "Used as fertilizer or raw material for biogas production" is an improvement that is aimed for the future of this project; another plant that would treat the organic matter for biogas and fertilizer generation.

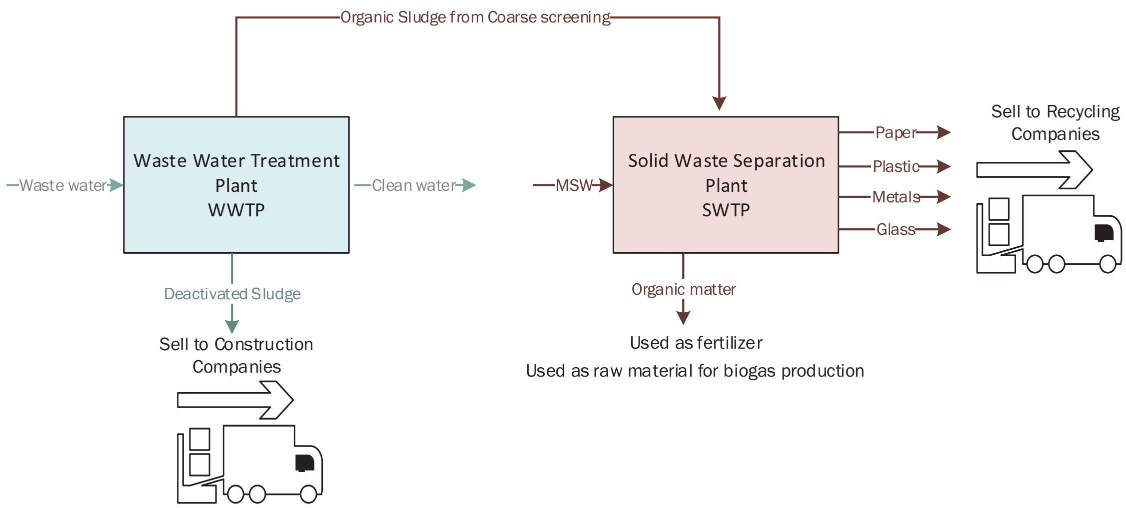


Figure 1: General description of the proposed project (own elaboration)

a) Waste water treatment plant (WWTP)

This plant will receive residential and commercial waste water to be cleaned by some mechanical operations, an aerobic process and a disinfection phase. Its main purpose is meeting the water quality established in the Mexican norms (described in section 1. 2.4) for the discharge in rivers.

The stream named "Organic sludge from coarse screening" in Figure 1 refers to the trash that comes into the WWTP and it is separated in the pretreatment, this will be sent to the solid waste separation plant

The "deactivated sludge" stream is going to be sold to construction companies at a lower price than the usual soil used to level the land on which their construction projects are stablished (Gómez, 2018).

b) Solid Waste Separation Plant (SWSP)

The plant will receive the solid urban waste and will consist on a separation phase, on which paper, plastic, metals and glass are going to be classified and sold to recycling companies like “Reciclacentro” or “Reciclaje Talismán” at Puebla City (2018).

For future improvements to the project, a biogas plant and/or the production of fertilizer (a MORE analysis needs to be done in order to see the viability of these) could be implemented to deal with the organic matter that comes into the separation plant. This would generate more income to the project and would increase the useful life of the landfill “Relleno Seco de Cholula” decreasing the volume of waste that goes to it (El Sol de Puebla, 2018).

1. 2. Context

1.2.1. Geographic Aspects

The municipalities to be considered for this work are Calpan, San Andrés Cholula and San Pedro Cholula (Figure 2), adjacent municipalities with a temperate sub-humid weather with summer rains, located in the region IV of Puebla state (INAFED, 2018).

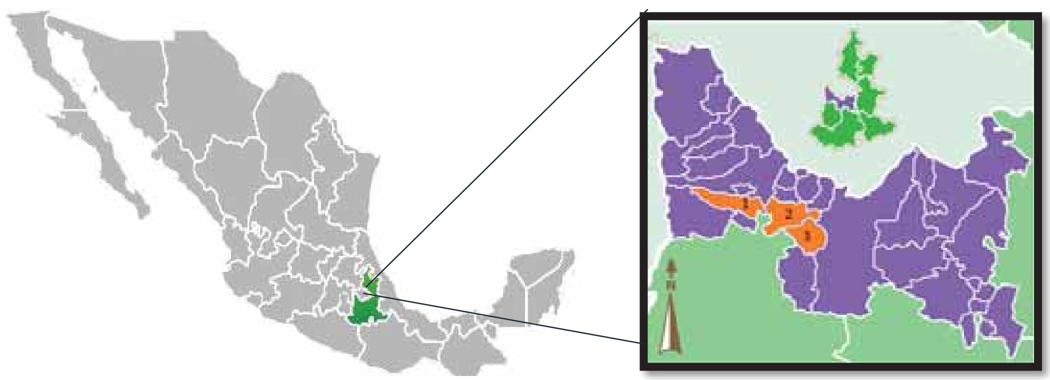


Figure 2: Region of Puebla considered. 1) Calpan, 2) San Andrés Cholula, 3) San Pedro Cholula.

The municipality of Calpan has areas that are part of the national biosphere protected area “Iztaccíhuatl-Popocatepetl” zone that belongs to the transverse volcanic axis of Mexico (CONANP, 2004). The rivers that cross the analyzed area are Presa, Prieto, Rabanillo, Ametlapanapa, Zapatero, Metlapanapa Alseseca and Actipan. This information is relevant because the project proposed is going to discharge its treated water in the “Presa” river and the natural protected areas must be clean in order to continue to be an ecological zone.

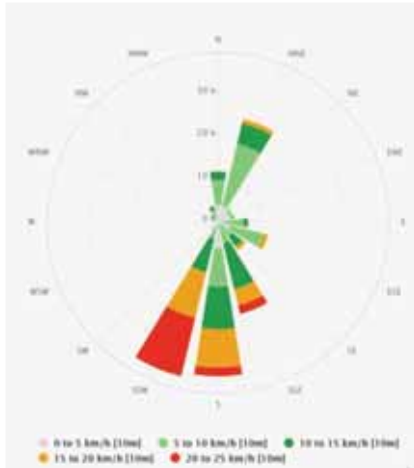


Figure 3: Puebla´s Windrose (Meteoblue, 2018).

The winds that blow in Puebla are directed towards the south and southeast with a speed of approximately 20-25 km/h as shown in Figure 3 (Meteoblue, 2018).

Figure 4: Topography of the territory of interest (GoogleMaps,2018)

An important aspect to highlight is the topography of the municipalities considered, Calpan is located at the interior slopes of Sierra Nevada (INAFED, 2018), and it can be observed in Figure 4 that the altitudes of the area considered are lower at the southeast direction.

1.2.2. Ecological Aspects

Puebla has many ecological resources that are not optimally managed. The ecologic resources on which this paper is based are water and soil management (Dale la Cara al Atoyac, 2017).

a) Water

Puebla has the 25% of the most contaminated rivers of the country. These rivers are "Atoyac", "Alseseca" and "Nexapa". The Atoyac and the Nexapa rivers are both considered the third most contaminated on the country, while Alseseca is the fourth (SEMARNAT, 2015).

In Puebla there are 23 wastewater treatment plants, from which only 8 operate meeting the corresponding normative of discharge to the river (NOM-001-SEMARNAT) (Dale la cara al Atoyac, 2017). Figure 5 shows the location of the plants that meet the normative or requirements (green circles), the location of the plants that don´t meet the quality parameters of the norm (red circles) and the ones that should have a wastewater treatment in their municipality because the Atoyac passes through them, but don´t have it.

Figure 5: Puebla municipalities with urban policy WTTP in the Atoyac basin (Modification of "Dale la Cara al Atoyac, 2017" image

Figure 5 demonstrates that there is something occurring on the management and surveillance of this kind of plants (is important to notice that none of these plants are private; they all correspond to the municipalities). Hence the importance of making a deep analysis of the context the project proposed will have.

The Valsequillo dam is the one that receives the water from the rivers previously mentioned, functioning as a big aerobic reactor on which a part of the contamination settles. Most of the time it accomplishes an acceptable concentration of pollution and can be used for irrigation, the problem comes when there is a lot of wind that disturbs the dam, mixing the sediment with the clean water which then is used for crops irrigation near the dam (Zambrano, 2015).

b) Soil

As mentioned before, most Puebla´s landfills are not meeting regulations and are exceeding their volumetric capacity. Besides these landfills, there are also some uncontrolled sites where people go and throw their residues when they do not receive an efficient cleaning service. There are approximately 20 of this kind of sites places registered, and affect approximately 40,000 m^2 of places that vary from green protected areas to rivers, lakes, etc. This cause undesired emissions to the atmosphere, like biogas and carbon representing 28% of the greenhouse gases emissions of the municipal solid waste of the entire state (IGAVIM, 2011).

The uncontrolled sites sometimes generate the optimal conditions for fires, like the combination of glass, sunlight and paper or paperboard, risking the biodiversity of the place (protected area of Popocatepetl-Iztaccíhuatl) (IGAVIM, 2011).

1.2.3. Social & Economic

The principal economic activities in the selected municipalities are commerce, agriculture, forge, seeds, floriculture, bricks and others (INAFED, 2018). Dung from small farms, vegetable residues and other farm wastes are rarely exploited currently (SAGARPA, 2015), this gives an opportunity for the project proposed, because with incentives and social programs, these materials could be used to produce fertilizer with or for biogas production.

The recycling culture in Puebla is scarce, the famous “pepenadores” are people that involve themselves into the waste separation activities, in 2011 a program changed the name from “pepenadores” to volunteer collectors, in order to dignify their work and to give them some social benefits from the government, and also this program intended the increment on the recycling culture. Currently the program has disappeared and “pepenadores” still make an independent work (IGAVIM, 2011).

The project proposed, could affect this situation, because a program for “pepenadores” could be developed in order to buy materials from them and provide them with facilities like a transport, or a closer recollection spot.

A very serious situation in the municipalities selected is the waste burn. This situation affects public health, biodiversity and the atmosphere (IGAVIM, 2011). It occurs because of the lack of clean services that government should provide to their citizens. The decrement of this situation is going to be a consequence of the project proposed, because it seeks to get to more places and give this service to more people.

1.2.4. Legal Aspects

The regulations that are related to the project proposed are going to be enlisted next;

a) Laws of interest
    - “Ley General de Equilibrio Ecológico y la Protección del ambiente (LGEEPA)”: The law that regulates and manages every ecological aspect of the country. It manages the states, municipalities and other government organisms and assign them the power of management and sanctions. This law concerns the project because it shows which organizations will be responsible for monitoring that the plant works properly.
    - “Ley General para la Prevención y Gestión Integral de los Residuos (LGPGIR)”: The law takes care of the surveillance of the generation, valorization and integral management of hazardous waste, special management waste and municipal solid waste. This law concerns the project because it proves that the special management and hazardous waste are not coming into this plant, because their generators are responsible of treating these types of residues (as the law establishes).

- “Ley de Aguas Nacionales”: The law takes care of the all the country´s water management, and controls the water exploitation and use. Its main purpose is the guarantee of a high water quality for every Mexican inhabitant. This law concerns the projects because it seeks the wellbeing of the Mexican population; it goes together with the UN goals mentioned before in section 1.

b) Norms of interest (supervised by PROFEPA & SEMARNAT organisms)
   - NOM-001-SEMARNAT-1996: Establishes the maximum permissible limits of contaminants in wastewater discharges in national waters and goods.

The water quality standards the project is using for the outflow concentrations of the WWTP were taken from this norm, as it is shown in table 1.

Table 1: Maximum limits permitted in discharges (NOM-001-SEMARNAT-2003)

Maximum permissible limits for basic contaminants	
Parameters	**Rivers**
mg/L	Use in agricultural irrigation
	(M.A.)*
Total Suspended Solids (SST)	150
Biochemical Oxygen Deman (BOD_5)	150
Total Nitrogen	40
Total Phosphorous	20

* M.A. Monthly Averaged

Table 1. Shows the basic parameters the WWTP is going to seek for the discharge on the Presa River.

- NOM-004-SEMARNAT-2002: Related to sludge and biosolids. - Specifications and maximum permissible limits of contaminants for their use and final disposal.

The standards the project is using for its final sludge concentrations coming from the WWTP were taken from this norm, as a class C sludge because of the usage it will have (sell as ground leveling) these parameters are visualized in Table 2, 3 & 4.

Table 2: Sludge classification by the final use it´s going to have (NOM-004.SEMARNAT-2002)

Type	**Class**	**Usage**
Excellent	A	Urban uses with direct public contact during its application
Excellent/Good	B	Urban uses without direct public contact during its application
Excellent/Good	C	Forest/ Soil or agricultural remediation

Table 3: Limits of pathogens and parasites in sludge from WWTP (NOM-004.SEMARNAT-2002)

Class	Bacteriological Pollution Indicator	Pathogens	Parasites
	Fecal coliforms (MPN/g dry basis)	Salmonella spp. (MPN/g on dry basis)	Helminth eggs/g dry basis
A	Less than 1000	Less than 3	Less than 1
B	Less than 1000	Less than 3	Less than 10
C	Less than 2 000 000	Less than 300	Less than 35

Table 4: Limits of toxic pollutants for the Class C sludge

Pollutant	Maximum Concentration (mg/kg)
Arsenic	75
Cadmium	85
Chrome	3000
Copper	4300
Lead	840
Mercury	57
Nickel	420
Zinc	7500

A neutralization treatment will be made in order to meet the specifications described on Table 1, 2 and 3. This treatment will be carried out with calcium hydroxide ($Ca(OH)_2$).

- NOM-083-SEMARNAT-2003: Establishes the environmental protection specifications for site selection, design, construction, operation, monitoring, closure and complementary works of a final disposal site. Solid urban waste and special handling.
- NOM-052-SEMARNAT-2005: Establishes the characteristics of hazardous waste, identification and classification and a list of the hazardous materials.
- NOM-161-SEMARNAT-2011: Establishes the criteria to classify Special Management waste and a list of these.

These last two norms are very related to the project, because the process will not treat hazardous waste nor special management, so it´s important to know which correspond to each classification to be disposed accordingly.

1.3. Objectives

In the framework provided by the previous contextual analysis and problem structuring, it is known, that the objectives the three plants seek to accomplish, are to consider the social, economic and legal aspects mentioned.

1.3.1. *Waste Water Treatment Plant (WWTP)*

The main purpose of the wastewater treatment plant proposed is to remove pollution from domestic and commercial waste water. Specifically;

- Treat about 20 million liters/year of waste water produced by 365,623 people of the people that lives on the municipalities considered (projection made for the 2030 year, see section 7.2) (IGAVIM, 2011) (INEGI, 2015).
- Reduce the concentration of important contaminants in Puebla Rivers (mainly "La Presa" and "Atoyac", specifically 180 mg/L of organic matter that without a treatment would go directly into the rivers. (UNAM, 2014).
- Improve public health of 1.2 million people that live near the rivers (Greenpeace, 2013).
- Provide a solid proof of concept that this kind of plant is technically and economically feasible

1.3.2. *Solid Waste Separation Plant (SWSP)*

- If the project of biogas and/or fertilizer production goes ahead it would reduce the organic matter (76.73 ton/d) that would go to volume exceeded landfills (IGAVIM, 2011)
- Separate the inorganic matter in paper, metals, plastic and glass to generate profits (sell to recycle companies) ((approximately $139,700 Mexican pesos per day) (IGAVIM, 2011)) and decrease the usage of energy, water and resources that would have been used for creating new materials

1.4. Main suppositions

In order to achieve the goals stated above (section 3) and facing the lack of information and resources to conduct the due research, some suppositions were made to enable the conceptual design of each plant (figure 1).

1.4.1. *Wastewater Treatment Plant*

- The density of the sludge obtained from the clarifiers is standardized to 1008 kg/m^3 with a 5% (weigh/volume) content of dry sludge (IWA, 2007).
- Population with access to sewage in the municipalities considered 256,730 (hab) (2.3% do not have access) (SEDESOL, 2017)
- Residential water demand in the municipalities considered is 42.5 (L-hab/day) (BUAP, 2014)
- Commercial water demand in the municipalities considered is 875 (L-establishment/day) (BUAP, 2014)
- Water that goes to sewage is 80% of residential demand & 100% of commercial demand in Puebla state (BUAP, 2014)
- Number of business establishments: San Andrés (6,560 establishments), San Pedro (9,690 establishments), Calpan (402 establishments) (INEGI, 2015)

- The population used was an extrapolation to the 2030 year made with data of two or three years (INEGI, 2015) (SEDESOL, 2017) (IGAVIM, 2011)
- The plants yield is of 74%. Considering the principal pollutants (BOD_5, COD TSS, N_{tot}, P_{tot}, and coliforms)[1]
- The sludge generation was taken of Metcalf & Eddy (2002) book but in future advances will be specifically calculated

1.4.2. Solid Waste Separation Plant

- An average waste density of 296.5 kg/m^3 (Gestión de RSU, 2018)
- The generators of residues that fall into the categories of special management waste or dangerous waste need to hire special companies to treat or dispose it as Mexican norms NOM-052- SEMARNAT-2005 & NOM-161-SEMARNAT-2011 establish. This is why the plant is only managing municipal solid waste (SEMARNAT, 2005 & 2011).

1.5. Location

1.5.1. Justification

The plant location was analyzed many criteria described in this part of the paper;

- Minimal distance of 500 m from population according to the NOM-083-SEMARNAT-2003 (SEMARNAT, 2003).
- Closeness to La Presa River for the discharge treated water.
- Easy road access (Google Maps, 2018).
- No founded record of flooding in the area (Síntesis, 2017).

1.6. Process options

1.6.1. Waste Water Treatment Plant

The main purpose of the waste water treatment plant proposed is to remove pollution from domestic and commercial waste water. In order to reach these goals, there are different kinds of processes that can be used. The main two variances in the plant are the use of an aerobic or an anaerobic reactor.

[1] Biochemical Oxygen Demand (sample during 5 day of incubation), Total Suspended Solids, Total Nitrogen, Total Phosphorous

a) Option 1: Anaerobic reactor

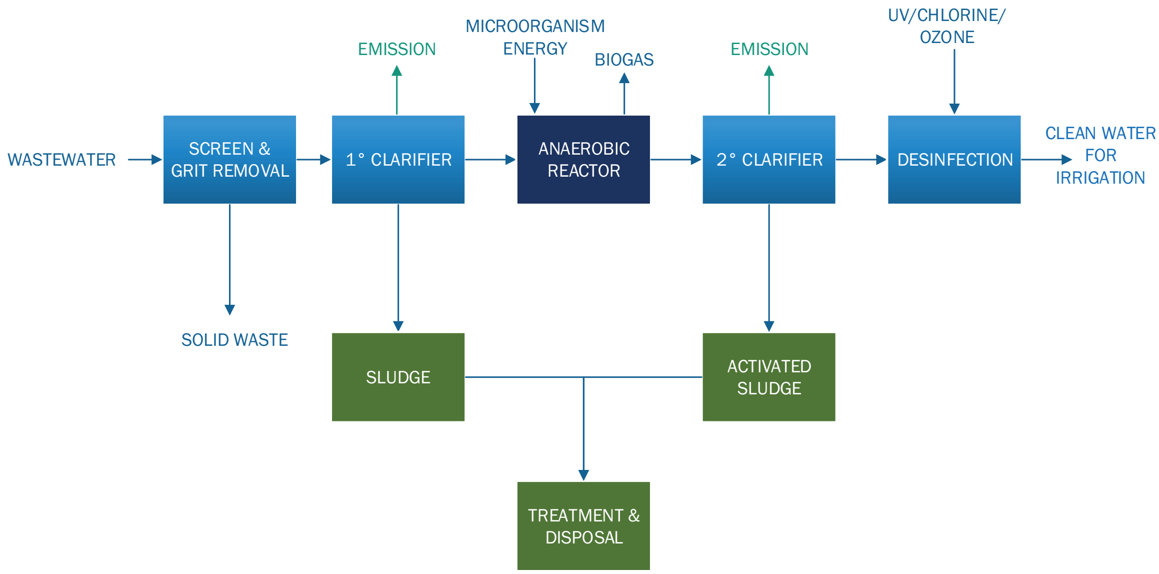


Figure 6: Block diagram of a waste water treatment plant which use an anaerobic reactor (Own creation)

Figure 6 shows the block diagram of a plant that uses an anaerobic process for the waste water treatment. The anaerobic reactor works in absence of air, anaerobic microorganisms and a temperature of around 37 - 40°C (SMAT, 2018). The anaerobic digestion produces biogas that can be used to generate electricity. The plant proposed could only generate enough energy to satisfy 50% of the plant requirements, because of the low organic charge of the influent 244 mg/L. In order to generate enough biogas to supply the whole plant, the concentrations should be higher than 400 mg/L (SMAT, 2018) (UNAM, 2014).

The anaerobic digestion, in addiction, can be affected by the possibility of toxic compounds (more detailed on section *2.1.1 a*), yielding to an incomplete reaction that could cause the decrease of biogas quality and the production of bad odors in the plant. Another inconvenient is that it removes only about 65% of the organic matter presented in the inflow (Metcalf & Eddy, 2002) (SMAT, 2018)

The only benefit this process presents for the proposed project is that it produces 1/6 of sludge compared with aerobic digestion (UNAM, 2014).

b) Option 2: Aerobic reactor

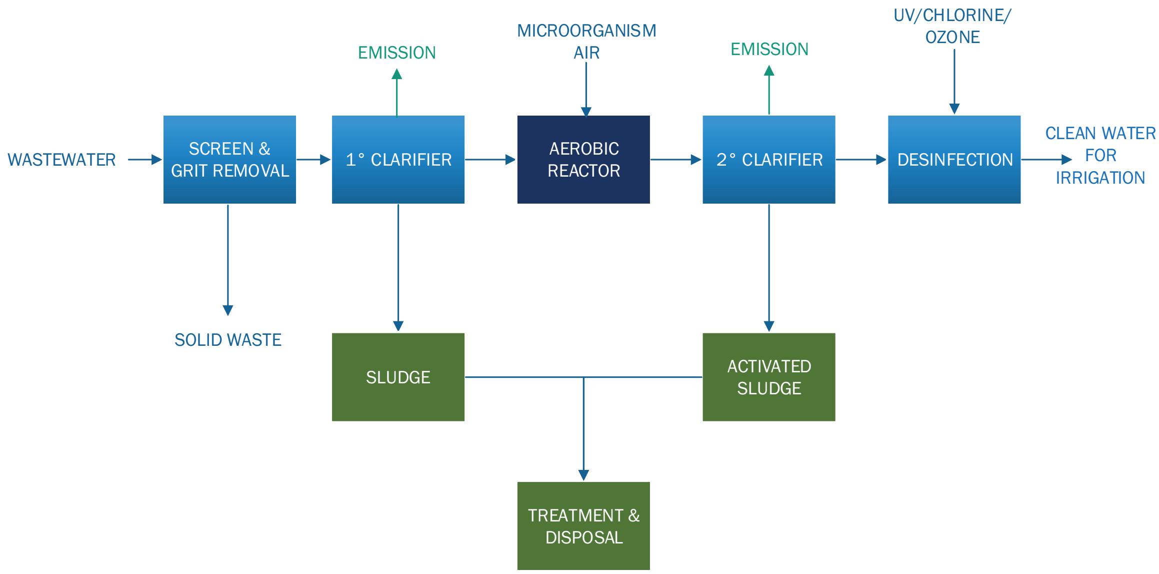


Figure 7: Block diagram of a waste water treatment plant that uses an aerobic reactor (Own creation)

The figure 7 shows a block diagram of a WWTP that uses an aerobic reactor. This reactor is cheaper and simpler than an anaerobic one and doesn't need as much of energy since it doesn't require very specific conditions in its process (temperature maintenance and pH). Besides, this process is not very sensible to toxic compounds and removes about 85% of the organic matter present in the inflow (UNAM, 2014). The main disadvantage of this kind of plant is that it generates six times more sludge compared to anaerobic digestion (UNAM, 2014).

c) Option 3: Anaerobic and aerobic combined reactors

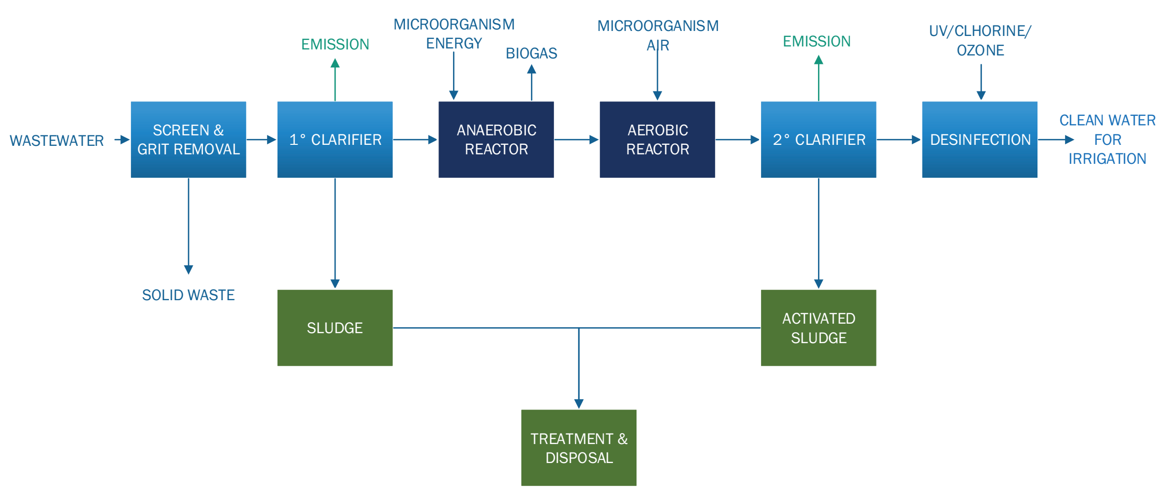


Figure 8: : Block diagram of a waste water treatment plant that uses an aerobic reactor combined with an anaerobic reactor (Own creation)

The figure above shows the block diagram of combined plant, a plant that contains both anaerobic and aerobic reactors. It was decided not to consider this option because the investment of two biological processes is too high (SMAT, 2018).

- Rational selection between aerobic and anaerobic process

In Table 5, a comparison regarding important aspects of each process is displayed. A score is assigned to each aspect in order to give a total numerical value and decide which one is better. The punctuation goes from one star (worst) to three stars (best).

Table 5: Comparison between anaerobic and aerobic reactor for the WWT (SMAT,2018)

Process	**Aspects to consider**					
	Economical	**Social**	**Technical**	**Energy**	**Ecological**	**Total**
Anaerobic	High costs for its construction and maintenance (*)	Toxic compounds affect the biological performance in biogas production (*)	Complicated equipment (*) A small change in conditions can be damaging to the process (*)	Produces only 50% of the plants requirements of energy (*)	Generates 1/6 sludge compared to aerobic digestion (***) Removes only 65% of the organic matter influent (*) Generates methane that when it´s not used to produce energy it can very harmful to the environment (-)	********* **(9)**
Aerobic	Low investment (**)	Not very sensible to toxic compounds (***)	Simple technologies (***)	Energy consumption (*)	Generates 6x more sludge compared to anaerobic digestion (*) Removes 85% of the organic matter (**)	************* **(11)**

Based the aspects of the Table 5, the process of choice is the aerobic digester (SMAT,2018).

d) Disinfection Methods

The exploration of three different disinfection methods is going to be described in this part of the paper.

- Chlorine

The main benefit of the use of this compound as a disinfectant is the low cost of operation and acquisition (except when dechlorinating is needed) (EPA, 1999).

The main negative aspects of this disinfectant are that chlorine residuals are highly toxic and corrosive. The combination with organic matter can generate hazardous waste like trihalomethanes. This proves the danger it represents to the people using the river water and the risks to the operators (EPA, 1999).

- Ozone

The benefits presented in ozone disinfestation are: that is more efficient destroying viruses and bacteria, requires a short time of contact (10-30 minutes) to disinfect and it doesn't generate harmful residuals that need to be removed after ozonisation because ozone decomposes rapidly (EPA, 1999).

The main negative aspects of this disinfectant are that the cost of treatment can be very high in capital and in energy use compared to the other three disinfectants, the need of more complex security measures for workers because of its irritable properties, it requires a complex plant for which a high skilled maintenance input is required and its corrosive properties that needs anticorrosive materials for its usage (EPA, 1999).

- UV disinfectant

The benefits presented in UV disinfection are: its effectiveness to deactivate spores, viruses and cysts, physical process that eliminates the need of a special materials for usage, no residues that can be harmful for to humans, no risk to operators, short exposure time (1-minute maximum).
The main negative aspects of this disinfectant are: the "dark repair" microorganisms could repair themselves from the UV effects in absence of light; turbidity on water could affect the effectiveness of the process (EPA, 1999).

- Rational Selection between Disinfection Methods

In Table 6, a comparison regarding important aspects of the disinfection processes is displayed. Punctuation is assigned to each aspect in order to give a total numerical value and decide which one is better. The punctuation goes from one star (worst) to three stars (best).

Table 6: Comparison between Chlorine, Ultraviolet and ozone disinfection processes (EPA, 1999)

Disinfection Process	Aspects to consider						
	Economical	**Social**	**Technical**	**Energy**	**Ecological**	**Application**	**Total**
Chlorine	Low (***)	Impacts on public health (-)	Simple technology (**)	No energy consumption (***)	Generates chlorinated hydrocarbons(-)	World-wide used, famous treatment (***)	**(11)**
UV	High cost (*)	No impacts (***)	Simple technology (***)	Electric consumption (***)	Generation of toxic residues from lamps (replaced each year)(*)	Since 1989 popularized (**)	**(14)**
Ozone	High costs (*)	Low risk to operators (*)	Complex technology (*)	Electric consumption (**)	No generation of toxic compounds (***)	Least used method on the USA (*)	**(9)**

Based on the Table 6, the process of choice is the Ultraviolet disinfectant (EPA, 1999).

1.6.2. Waste Separation Plant

For this plant it was not necessary a rational selection because with the technology available there are not many options for the process.

2. Plant design

2.1. Sections Design

In this part of the work the sections defined for the three plants are explained with the possible equipment to use and the purpose of them, the objective of this section is to have a clear idea of the process made in each plant to follow the whole project easily.

2.1.1. Wastewater Treatment Plant

This part of the paper will describe the sections and equipment of the wastewater plant. Figure 1 displays a general diagram with five defined section and the equipment in each one that will be explained in detail in this work.

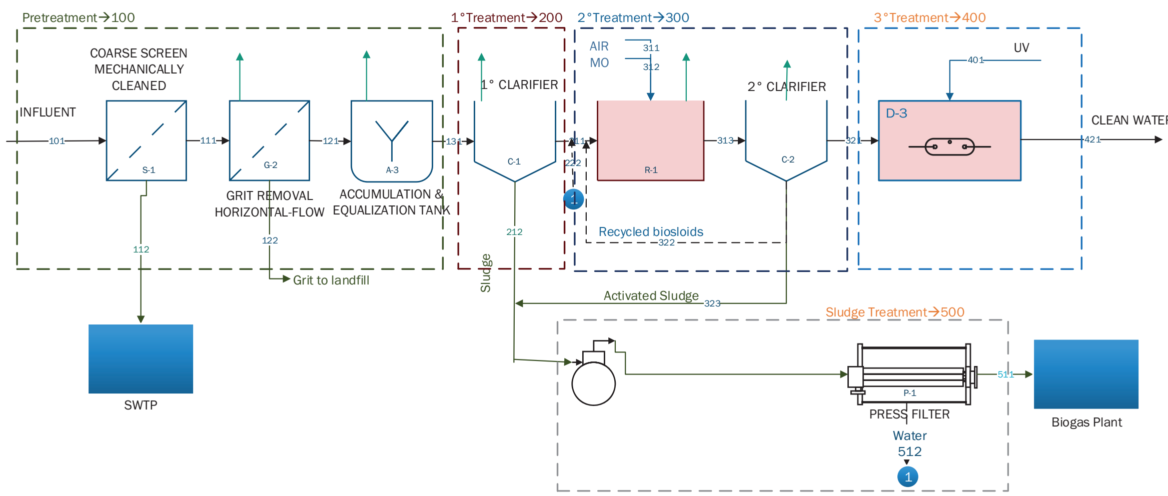


Figure 9: Diagram of the WWTP and its sections

This plant will:

- Treat about 20 million liters per year of wastewater produced on the municipalities considered (Plan nacional de desarrollo, 2013) (Greenpeace, 2013).
- Improve public health of 1.2 million people that live in the vicinity of the rivers affected by the three municipalities analyzed on this work that use water from the rivers for irrigation or personal use(Greenpeace, 2013).

a) Toxic Possibilities

There is a critical problem that may affect the quality of water; the presence of heavy metal ions that need to be removed or minimized systematically in the inflow. There are many existent methods for heavy metal removal as observed in table 7;

Table 7: Comparison between some heavy metal removal methods (Farooq, 2010)

(Plan nacional de desarrollo, 2013)	Advantage	Disadvantage
Chemical precipitation	• Simple • Inexpensive • Most of metals can be removed	• Large amount of sludge produced • Disposal problems
Chemical coagulation	• Sludge settling • Dewatering	• High cost • Large consumption of chemicals
Ion-exchange	• High regeneration of materials • Metal selective	• High cost • Less metal ions removed
Adsorption	• Most of metals can be removed • High efficiency (99%)	• Cost of activated carbon • No regeneration • Performance depends upon adsorbent
Membrane and ultrafiltration	• Less solid waste produced • Less chemical consumption • High efficiency (95%)	• High initial and running cost • Low flow rates • Removal % decreases with presence of other metals

Using the table above and evaluating the advantages and disadvantages of each process, the best options for the WWTP proposed would be the Chemical Precipitation and the Adsorption with Activated Sludge Biomass (ASB). Because the costs are not high, it has a high efficiency in comparison with other methods and most of the metals can be removed.

The ASB technology has been proven to be an effective and sustainable technique for the absorption of some specific metal ions like Cd (II), Pb(II) and Zn(II) that can come in the sewage wastewater. This technique can remove ions from wastewater to environmentally acceptable levels (IWA, 2011). For the design of the ASB it is necessary to have an accurate estimation of the wastewater composition and volume in order to have the highest efficiency in the process. (SSWM, 2017).

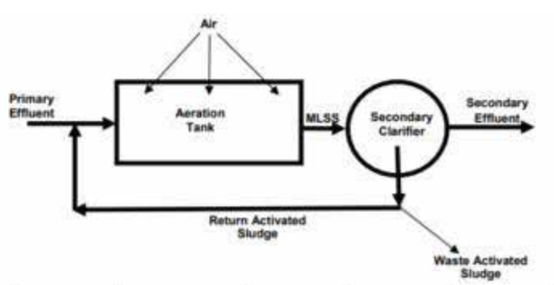


Figure 10: ASB equipment (SSWM,2017)

The problem that appears with this method is that the process requires a retention time of 4 to 8 hours and 4 to 6 days of cell residence time. The water inflow of the project proposed is 56,265.6 m^3/d; this means the project would need enormous tanks to complete the residence time of 6 days.

The chemical precipitation, on the other hand, uses an adsorption mechanism to remove heavy metals and it depends on the solubility product equilibrium constant (K_{sp}) of the metal, pH of wastewater and the concentration of the ions. The problem with this process is that in order to operate it requires a concentration of 100 mg/L of heavy metals for the process to be effective (IWA, 2011).

To design the chemical precipitation treatment first it is needed to choose between a batch and a continuous operation. Batch treatment is recommended only when the water flows are small because the equipment needed; two tanks with enough capacity to treat the total water volume, on which it is needed enough residence time to add and mix the chemicals (Wang, 2005). The process showed in Figure 11 requires a thickener, a second clarifier, an anoxic and aerobic zone, mixing tanks and tertiary clarifier, which means more inversion to the plant and its maintenance.

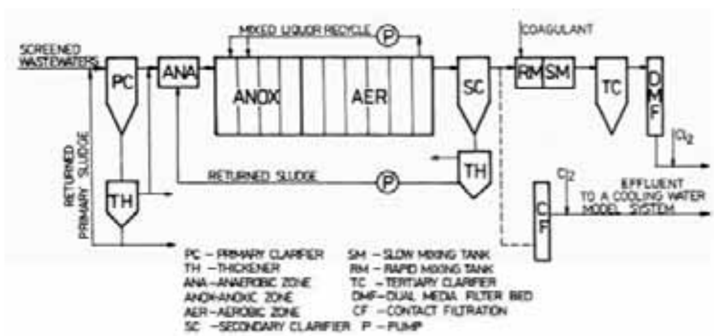


Figure 11: Diagram of a chemical precipitation process (Rybicki, 1992)

A problem on implementing this process is that the concentration of the toxic metals in the influent does not reach the minimum (100 mg/L) to make the process economical and efficient as seen in Table 8 (OLIVARES, 2013).

Table 8: Average of influent toxics of a WWTP in México City

Toxics	Influent (mg/L)
Arsenic	0.0065
Cadmium	0.055
Copper	0.045
Mercury	0.0012
Pb	0.086
Zinc	0.0876
Total	0.2813

WWTP in Mexico have tried to treat the heavy metals and toxics, but because of economic problems of maintenance the operation of most of the treatment plants are suspended (OLIVARES, 2013). Therefore the best option for the plant proposed is the implementation of a social program to create awareness in the society of the consequences that imply throwing contaminant products to the sewage and why it affects every citizen and themselves, this will be analyzed on the "Environment Impacts Assessment"

b) Pre-Treatment [Section W-100]

The general objective of this section is to separate big elements from the water and obtain a constant flow of water to the plant. For the pre-treatment section, three different types of equipment are required:

- Coarse screens: it removes big waste elements from the water;
- Grit removal: it removes, as the name suggest, grit, which includes "sand, gravel, cinder, or other heavy solid materials that are "heavier" than the organic biodegradable solids in the wastewater" (EPA, 2003); and
- Equalizers: this will capture the non-constant inflow water, retain it and deliver a constant flow to the next sections of the plant (Metcalf & Eddy, 2002)

The specific objectives of this section are;

- Remove 3.4 m^3/d of coarse solids 0.03 m^3/d of grit from the effluent
- Regulate the flow to a constant 2344.4 m^3/h

In figure 12 the flow diagram for the pre-treatment section is visualized with the possible sequence that will be followed. The installation of screening facilities before grit chambers makes operation and maintenance of grit removal facilities easier (Metcalf & Eddy, 2002).

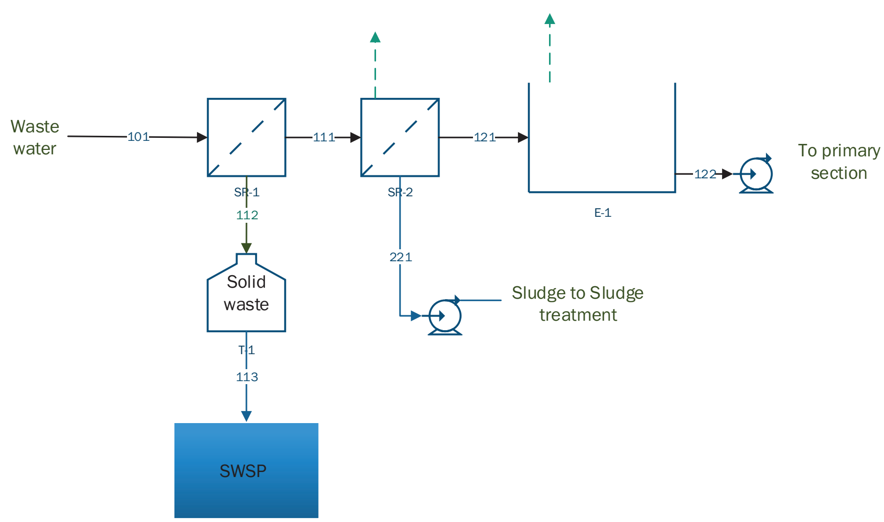


Figure 12: Pre-treatment Section W-100 (Own creation)

c) Primary treatment [Section W-200]

The principal objective for the primary treatment is to sediment in order to reduce organic matter and hence, design a smaller bioreactor. For the primary section, only a single equipment is required;

- Primary clarifier: this equipment is responsible of the sedimentation

The specific objectives of this section are to remove (Metcalf & Eddy, 2002) (SEMARNAT, 2015):

- 40% of the initial COD, mg/L
- 30% of the initial BOD5, mg/L

In figure 5 the flow diagram for the primary section is visualized.

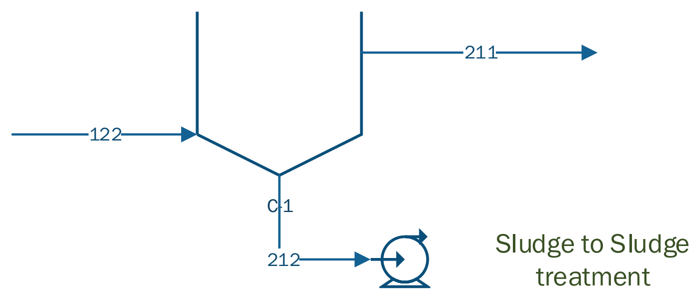


Figure 13: Pretreatment Section W-200 (Own creation)

d) Secondary Treatment [Section W-300]

The general objective of the secondary treatment is to decrease the organic matter concentration in order to meet Mexican norm NOM-001-SEMARNAT-1996 for irrigation and also, the concentration of the total suspended solids in order to meet UV requirements (tertiary section). For the secondary treatment, two different types of equipment are required:

- Aerobic reactor: this is one of the most important equipment of the WWTP, because is the one that makes that the plant reduces the organic matter concentration (main contaminant).
- 2nd Clarifier: Some activated sludge (alive aerobic microorganisms) is dragged with the water treated, the clarifier sediment this sludge so it does not go to the tertiary treatment.

The specific objectives of this section are:

- Remove (SEMARNAT, 2015):
  - 55% of the COD concentration
  - 17% of the BOD_5 concentration
  - 73% of the SST concentration
  - 38% of the N_{tot} concentration
  - 43% of the P_{tot} concentration

In figure 14 the flow diagram for the secondary section is visualized.

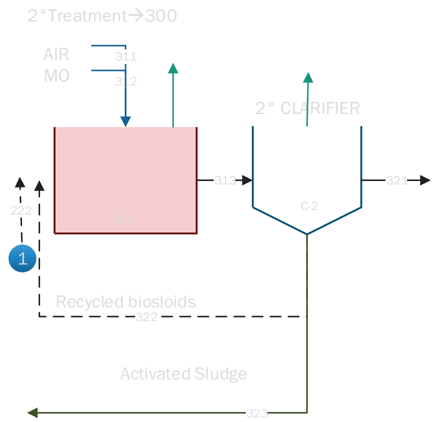


Figure 14: Secondary Treatment Section W-300 (Own creation)

e) Tertiary treatment [Section W-400]

The general objective of the tertiary treatment is to reduce the concentration of fecal coliforms to avoid the reproduction and infections by pathogens that came in the water and comply the NOM-001-SEMARNAT that refers with discharges on rivers or water bodies.

The specific objective of this section is:

- Reduce concentration of total coliforms to 1000NMP/100ml or lower (SEMARNAT, 2015)

In figure 15 the flow diagram for the tertiary section is visualized.

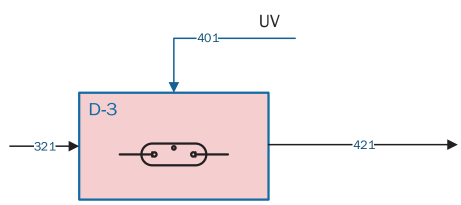


Figure 15: Tertiary Section W-400 (Own creation)

f) Sludge Treatment [Section W-500]

The general objective of the secondary treatment is to decrease the moisture of the sludge in order to reduce its volume, so it can go to the biogas plant. For the sludge treatment, two different types of equipment are required:

- Solid Pump: this is the equipment that transports the sludge and activated sludge from the primary and secondary clarifier to the press filter
- Press filter: here, in consequence of the applied force, the sludge dehydrates mostly and is suitable to use for ground leveling

The specific objectives of this section are:

- Remove 50% of the humidity present in the sludge (80% of the sludge is water) (Sanatana, 2009)

- Go from 64.4 m^3/day of humid sludge to 25.77 m^3/day of semi-humid sludge (50% of moisture removed) (Sanatana, 2009)

In Figure 8 the flow diagram for the tertiary section is visualized.

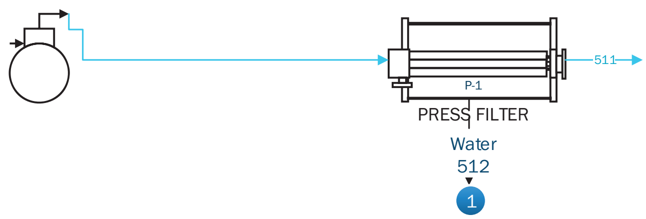


Figure 16: Sludge Treatment W-500 (Own creation)

2.1.2. Solid Waste Separation Plant (SWSP)

This plant is aimed to separate most of the waste coming in, principally organic matter, paper, paper board, plastics, glass and metals from which components can be recycled or converted to energy (biogas or fertilizer) (Tchobanoglous, Theisen, & Vigil, 1994). The plant consists in two principal sections: the pret-reatment and the separation section which will be described in the following sections;

a) Pre-Treatment Section [S-100]

The objective of this section is to prepare the waste to be easily separated, mainly because people in Mexico have the habit to put their residues into plastics bags (Estosdias, 2012). Three machines are required for this section:

- Feeding hopper, with the objective of storing waste.
- Elevator, its objective is to transport waste from the feeding hopper to the tearing bag with the right velocity to avoid damage to the tearing bag equipment.
- Tearing bag, as the name suggests its objective is to open the waste bags.

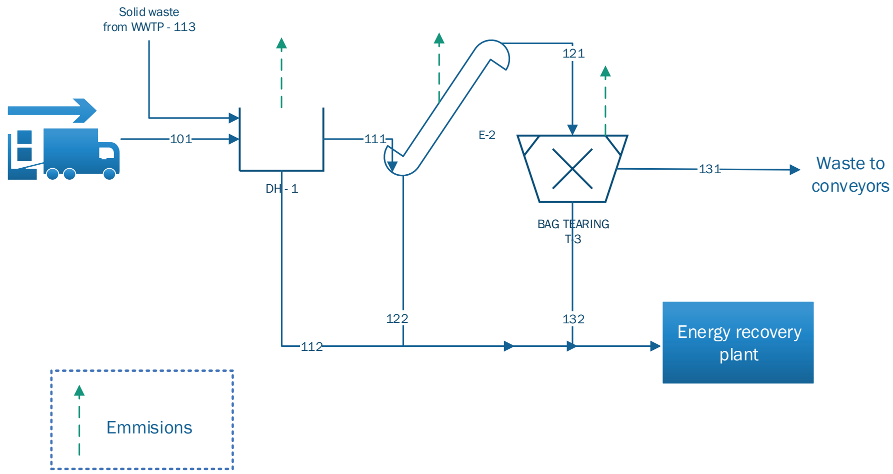


Figure 17: Pre-Treatment Section S-100 (Gómez, 2018)

b) Separation Section [S-200]

The heart of this plant is the separation which also includes the trituration of the final product, to be ready to use as raw material for a fertilizer or biogas production process, man work is important and will be explained in more detail in the equipment description section. The fundamental equipment is;

- Conveyor, to have easily distribution of the waste trough the separation process.
- Crushing machine, which will be feed by the organic matter left in the conveyors.

And the specific objectives of the plant are separating:

- 76.73 ton/d of organic matter
- 24.8 ton/d of paper and board
- 9.7 ton/d of glass
- 21.7 ton/d of plastic
- 2.8 ton/d of metals
- 11.9 ton/d of others

In Figure 18 these mentioned equipment can be observed. The stream number 131 comes from the pre-treatment section. Residues are separated in the conveyor and have three different destinies, organic matter to the crushing machine, useful waste that can be recycled will be stored and then sold, or in the case of collecting other materials not belonging to the categories of organic matter, paper and paperboard, glass, plastic or metals, they'll be sent to the landfill.

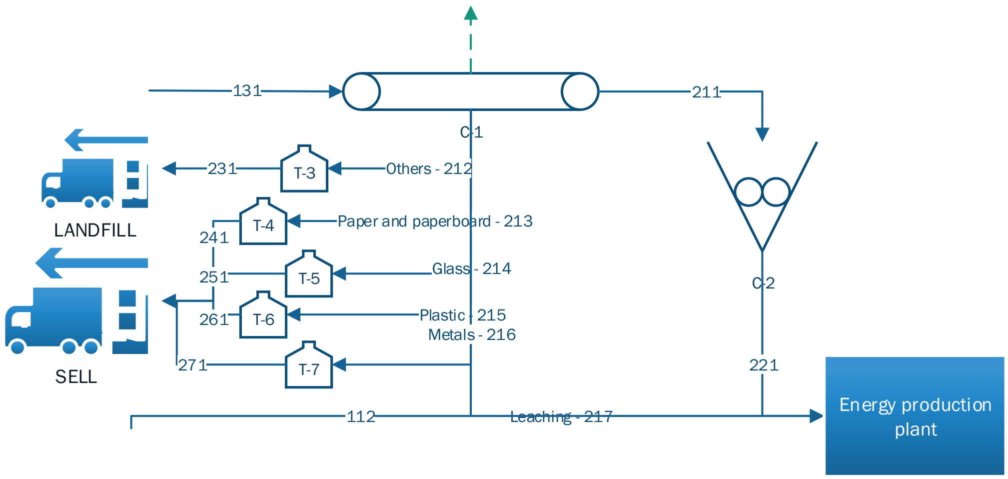


Figure 18: Separation Section S-200 (Gómez, 2018)

2.2. Equipment Selection

In this part of the document, a selection of most of the equipment is made. The rational selection is described and some important parameters to take in consideration for the design.

2.2.1. Waste Water Treatment Plant (WWTP)

As mentioned before, the total inflow of the waste water treatment plant is 56,256.4 m^3 of water per day; therefore, the plant is based on the average inflow of 2,344.4 m^3 per hour (all calculations made for the plant are based on this flowrate).

a) Coarse Screening

This first unit operation general objective is the retention of solids found in the inflow of the wastewater that could damage subsequent process equipment, reduce overall process effectiveness, or contaminate waterways (Metcalf & Eddy, 2002).

The specific objective of this equipment is to remove 3.36 m^3/d of coarse solids (Metcalf & Eddy, 2002) (Qasim, 1998) that are going to be sent to the SWSP, so they can be separated and send to the treatment that corresponds. There is no specific information of the amount of coarse solids in the wastewater of the plant proposed because it varies and depend on many factors like season, amount of garbage on the streets and the amount of garbage thrown to the toilet at in the area contemplated.

- Rational Selection

Figure 19 shows the multiple equipment options available for screening. This figure helped the selection decision process because it shows the general types of screenings.

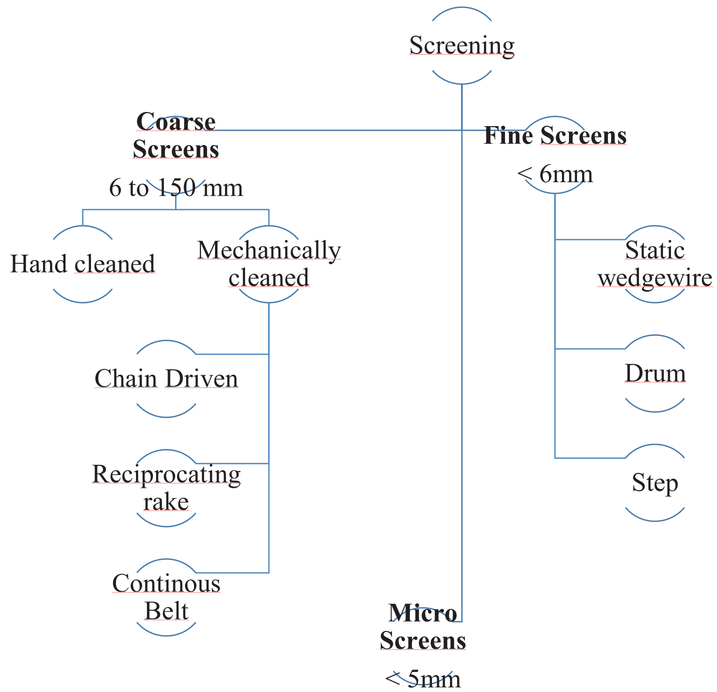


Figure 19: Types of screening equipment

The first selection made, was the coarse screening, because of the big objects available in the inflow of the plant (being a municipal wastewater treatment plant) (Metcalf & Eddy) (Qasim, 1999). The second selection made was a mechanically cleaned device, in order to reduce the risk of disease or accidents in operators. Besides, this type of coarse screen allows having a smaller space between the bars, collecting more and smaller solids.

For the last selection, the type of mechanically cleaned device, a more extensive analysis was made; Table 4 shows a comparison regarding important aspects of the types of equipment and the process of choice was the mechanically cleaned→ Chain driven→ Back return.

Table 9: Comparison of the mechanically-cleaned types of equipment (Metcalf, 2002)

Type of equipment	Advantages	Disadvantages	Total
Chain driven			
Back Return	Short cleaning cycle (***)	Rake teeth susceptible to break (*)	********* *** (10)**
	Submerged moving parts protected by bar racks (**)	Submerged moving parts: channel dewatering for maintenance (*)	
	Heavy duty applications (***)		
Front Return	Short cleaning cycle (***)	Fouling in submerged parts (-)	********* ** (9)**
	Little screenings carryover (**)	Submerged moving parts: channel dewatering for maintenance (*)	
	Heavy duty applications (***)		
Reciprocating Rake	No sumerged moving parts (***)	Requires more headroom than others (-)	********* * (8)**
	Can handle large objects (**)	Long cycle time (-)	
	Effective raking of screenings and effective discharge of screenings (***)	High channel water level can sumerge rake motor and cause it to burnout (-)	
Continuous Belt	Maintenance above operating floor (***)	Replacement of the screening elements can result very expensive and time consuming (-)	******** (6)**
	Difficult to jam (***)		

- Design

Before the design of the coarse screen, the flow channel should be designed. The selection of this channel was concrete, the width of the channel is one meter and the height is one meter. This was established because the velocity of the water flow entering the plant needs to be <0.9 m/s for mechanically cleaned screening (Echeverría, 2005);

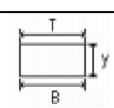
TIPO DE SECCIÓN	A_c	P_c	R_{Hc}	T_c
 Rectangular	By_c	$B + 2y_c$	$\frac{By_c}{B+2y_c}$	B

Figure 20: Rectangular channel dimensional aspects (Echeverría, 2005)

With the information given before, the dimensional aspects in **Error! Reference source not found.** and the Equation *1*, the area of the channel was; and the width and height were calculated, with an assumption of a squared channel with Equation *2*.

$$A = \frac{Q}{V} \quad \text{Equation 1}$$

$$Y = \frac{B}{A}$$ Equation 2

Where:
- A is cross sectional area of the channel, in m^2
- Q is the water flow, in m^3/s
- V is volume, in m^3
- Y is height, in m
- B is width, in m

Hydraulic radius was calculated as **Error! Reference source not found.** establishes. The slope of the channel was determined by the Equation 3, that uses the manning coefficient for concrete and dimension values;

$$S_0 = \frac{Q * n}{R_{HC}^{\frac{2}{3}} * A}$$ Equation 3

Where:
- S_0 is the slope of the channel, in °
- n is the manning coefficient for concrete
- R_{HC} is the hydraulic radius, in m

Table 10: Design of the water channel entering the plan

Q, m^3/s	0.65
A, m^2	1
V, m/s	0.7
B, m	1
Y, m	1
R_{HC}, m	0.33333
n	0.011
S, °	0.0222

With the channel dimensions established in Table 10, the coarse screen design is now possible. Figure 21 and Figure 22 shows the equipment design that was stablished by the channel dimensions and the type of coarse screen wanted.

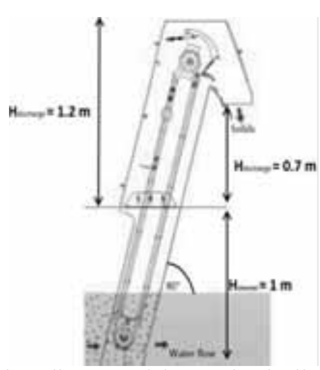


Figure 21: Side view diagram of the mechanically cleaned coarse screen.

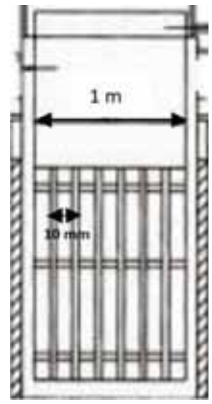


Figure 22: Front view diagram of the mechanically cleaned coarse screen.

Error! Reference source not found.11 shows the design information for this equipment. The values established in this section were first supposed from an average of the common values found in the reported mechanically cleaned coarse screen. (Metcalf & Eddy, 2002). Then these values were confirmed with a Mexican supplier of wastewater treatment equipment "Afromex". This information can be extensively visualized in Annex 10 (Qasim, 1998).

Table 11: Mechanically cleaned coarse screen information

Design Information	
Bars	
Width, mm	5
Clear Space Between bars, mm	10
Slope from horizontal º	80
Velocity of the affluent	
Maximum, m/s	0.9
Minimum, m/s	0.6
Allowable head loss, m	375

- Mass Balance

The composition of water is assumed to continue the same after the screen (BOD_5, COD, TSS, Total nitrogen and Total phosphorous) because the objective here is only to remove big coarse solids. Table 12 shows the mass balance of the screen. The amount of solids removed was obtained with a graph that shows the direct relationship between the amount of screening and the size of the spacing between bars (Metecalf & Eddy, 2002). The value of amount of screenings for 10 mm bas spacing is of 6 m^3/ 106 m^3 of wastewater (Qasim, 1998). With this value and the flowrate (0.65 m^3/s) the amount of solids removed per day was obtained.

Table 12: Mass Balance of the mechanically cleaned coarse screen

	INFLOW	OUTFLOW
Flow, m^3/s	0.65	0.65
BOD5, mg/L	244	244
COD, mg/L	557	557
Solids removed, m^3/d	-	3.36

b) Grit Removal

The general objective of the grit removal equipment is as its name say to remove grit. This grit normally consists in sand, gravel, cinders or any other heavy solid material that have specific gravities greater than organic putrescible solids in wastewater (EPA, 2003).

The specific objective of this equipment is to remove 0.03 m^3/d of grit that will be disposed into a landfill (Metcalf & Eddy, 2002).

- Rational Selection

Figure 23 shows the multiple options available for screening types of equipment.

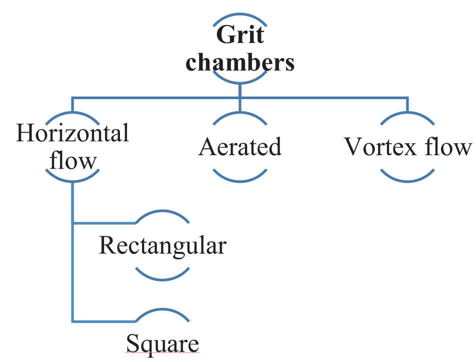


Figure 23: Types of grit removal equipment

A comparison between the equipment was made, where the simplicity of the design calculations was an important parameter because of the data available for these. **Error! Reference source not found.**13 shows a comparison of advantages and disadvantages. After a deep analysis, the decision was the rectangular horizontal flow chamber that obtained 12 stars. Its simplicity and low cost are the main reasons of the choice.

Table 13: Comparison of the different grit removal equipment (EPA, 2003) (Metcalf & Eddy, 2002)

Type of equipment	Advantages	Disadvantages	Total
Horizontal flow			
Rectangular	Oldest type (***) Simple calculations for design (***) Retention of all particles from 0.15 mm (***) Retention time: 1 min (***) Flexible: it allows performance to be altered by adjusting the flow control device (***)	Channels without effective flow control will remove excessive amounts of organic material; washing and classifying (-) Need of a velocity regulator (-)	************** **(12)**
Square	Used for over 60 years (**) Retention of 95% particles of 0.15 mm (**) Retention time: 1 min (***)	Channels without effective flow control will remove excessive amounts of organic material; washing and classifying (-) Need of a velocity regulator (-)	******* (7)**
Aerated	New technology (*) Retention of almost 100% particles from 0.21 mm (*) Versatile, allowing for chemical addition, mixing, pre-aeration, and flocculation (**)	Air requirement & maintenance requires more labor (-) Retention time: 2-5 min (*) More power requirement than other equipment (-) Harmful volatile organics and odors may be released (-)	***** **(5)**
Vortex flow	There are no submerged bearings or parts that require maintenance. (***) Horizontal dimension is small relative to other grit removal systems (**) Minimal head loss	Proprietary design; makes modifications difficult (-) Needs an extra pump to work (-) Paddles tend to collect rags (-) Deep excavation; High construction costs (-)	****** **(6)**

- Design

Figure 24 shows the principal dimensional elements of the horizontal flow grit chamber. These values were calculated with the equations described below.

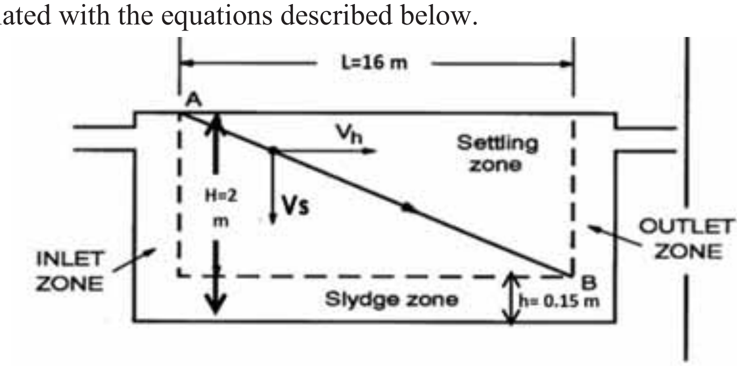


Figure 24: Principal dimensional elements of the horizontal flow grit chamber

The values supposed for this equipment design are; the horizontal velocity (Vh), 0.2 m/s that is the recommended value for design (Keller, 2001); the detention time (t), 60 seconds (Metcalf & Eddy, 2002) (EPA, 2003); the specific gravity of the particles (ρ_p) that are going to be removed, 2.65 (EPA: Ireland, 1995); the particle diameter, 0.15 mm, that was the smallest reported (Keller, 2001); the free board depth (h_f) and the accumulated grit depth (h_a), that are 0.6 m and 0.15 m respectively (Keller, 2001). With these values the design calculations can be performed.
The first value calculated was the Settling velocity;

$$V_p = \frac{g(\rho_p - \rho_w)d^2}{18\mu} \quad \text{Equation 4}$$

Where:

- V_p is the settling velocity of the particle, in m/s
- g is the gravitational force, in m/s^2
- ρ_p is the specific gravity of the particle
- ρ_w is the specific gravity of water
- d is the particle diameter
- μ is the dynamic viscosity of the water, in kg/m-s

Then the cross-sectional area was calculated with Equation 8, the dimensional value calculated was the ideal length, ideal because it was found that the actual length is always 35% bigger (Keller, 2001) (Equation 9 and Equation 10);

$$A_c = \frac{Q}{V_h} \quad \text{Equation 5}$$

$$L_i = V_h * t \quad \text{Equation 6}$$

$$L_A = 0.35 * L_i \quad \text{Equation 7}$$

Where:

- A_c is the cross-sectional area, in m^2
- V_h is the horizontal velocity of the particle, in m/s
- Q is the affluent, in m^3/s
- L_i is ideal length, in m

After this, the depth (ideal and real) of the grit was calculated with Equation 11 and Equation 12 and finally, for the grit chamber, the width was calculated with Equation 13;

$$H_i = V_p * t \quad \text{Equation 8}$$

$$H_{r=}H_i + h_{fb} + h_g \quad \text{Equation 9}$$

$$w_{gc} = \frac{A_c}{H_i} \quad \text{Equation 10}$$

Where:

- H_i is ideal depth, in m
- $H_r$is actual depth, in m
- h_{fb} is depth of the free board (Keller, 2001)
- h_g is the depth of the grit accumulated at the bottom of the chamber
- w_{gc} is the width of the grit chamber

The previous equations and the suppositions mentioned before made the dimensioning of this chamber possible. But it is important to mention that a velocity regulator should be implemented in this equipment, otherwise the velocity in the equipment could increment and the removal of grit could not happen.

A proportional weir was selected for these propose, because (Samiksha, 2018.);

- There are no converging or diverging sections (compared to Parshall flume)
- Raising of the floor may not be necessary, this prevents deposition of solid during low flows
- The velocity in the channel will remain uniform even at low flows

The dimensions of this proportional weir were also calculated. Figure 25 and Table 14 show how the proportional weir is going to be installed in the grit chamber and the dimensioning of this velocity reducer.

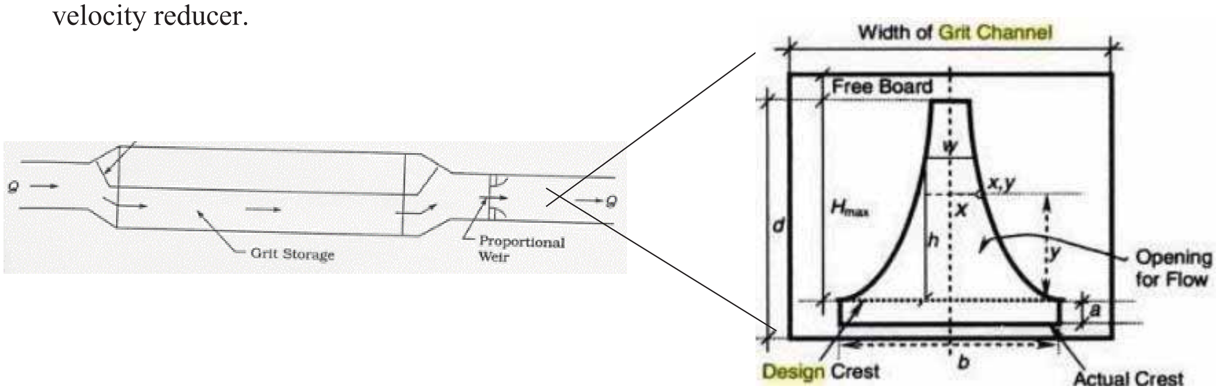


Figure 25: Dimensional values of the proportional weir for the grit chamber (Samiksha,2018.)

From the values visualized on Table 14, the ones displayed in red are supposed with the typical values used for wastewater treatment plants (Samiksha, n.d.) (Baner, 2018).

Table 14: Values supposed and calculated of the proportional weir

Cd	0.61
b, m	1.036
a, m	0.0375
w´, m	0.116

The last opening for the flow was calculated with the Equation 14 and the width of the weir was calculated with the Equation 15;

$$b = \frac{Q}{Cd * \sqrt{2*a*g}\left(H_i - \frac{a}{3}\right)}$$ Equation 11

$$w' = b\left(1 - \frac{2}{\pi}tan^{-1}\left(\frac{H_i}{a} - 1\right)^{1/2}\right)$$ Equation 12

Where:

- b is the last opening as visualized in figure 24, in m
- Cd is the typical drag coefficient used in WWTP
- a is the typical board used in WWTP, in m
- w´ is the width of the proportional weir as visualized in figure 21, in m

  - Mass Balance

The composition of water is assumed to continue the same after the grit removal (BOD, COD, Total nitrogen and Total phosphorous) because the objective here is only to remove grit (that doesn't contribute to the concentration of these compounds) (Baner, 2018). Table 15 shows the mass balance of the grit chamber. The amount of solids removed was obtained with a table that shows the average of the typical values found in this type of equipment of horizontal flow (0.00003 m^3 grit/m^3 water) (Metcalf & Eddy, 2002). With this value and the flowrate (0.65 m^3/s) the amount of grit removed per day was obtained.

Table 15: Mass balance of the grit removal chamber

	INFLOW	**OUTFLOW**
Flow, m^3/s	0.65	0.65
BOD5, mg/L	244	244
COD, mg/L	557	557
Grit removed, m^3/d	-	0.028

c) Equalizer

The objective of this equipment is to equalize the inflow and maintain the flow of water of 2,344.4 m^3/h.

The fluctuations of water over the day have been calculated as the Drinking Water, Sewerage and Sanitation Manual States (CONAGUA, 2015), which establishes that the average hour income must be multiplied by the coefficient of hourly variation. An extra consideration was made due the population density, the manual has hourly coefficients for small communities (less than 20,000 habitants) and cities in Mexico showed in Table 16 and 17. From the three municipalities considered in this work, Calpan falls into the small community category with a population of 17,748 (INAFED, 2018).

Table 16: Hourly coefficient variations for cities in Mexico.

t (h)	q/q_{med}	time (h)	q/q_{med}	time (h)	q/q_{med}
0	0.45	8	1.5	16	1.3
1	0.45	9	1.5	17	1.2
2	0.45	10	1.5	18	1
3	0.45	11	1.4	19	1
4	0.45	12	1.2	20	0.9
5	0.6	13	1.4	21	0.9
6	0.9	14	1.4	22	0.8
7	1.35	15	1.3	23	0.6

Table 17: . Hourly coefficient variations for small communities in Mexico.

t (h)	q/q_{med}	time (h)	q/q_{med}	time (h)	q/q_{med}
0	0.45	8	1.5	16	1.3
1	0.45	9	1.5	17	1.2
2	0.45	10	1.5	18	1
3	0.45	11	1.4	19	1
4	0.45	12	1.2	20	0.9
5	0.6	13	1.4	21	0.9
6	0.9	14	1.4	22	0.8
7	1.35	15	1.3	23	0.6

Doing the calculations with an average hour inflow for Calpan of 97.2m^3/h and for San Andres Cholula and San Pedro Cholula of 2,247.2m^3/h the final fluctuations in the inflow of this project are shown in Table 18.

Table 18: Fluctuations of inflow into the WWTP.

t (h)	Q (m^3)	time (h)	Q (m^3)	time (h)	Q (m^3)
0	1405.5	8	3082.9	16	2814.0
1	1428.0	9	3228.9	17	2703.2
2	1466.2	10	3163.8	18	2616.3
3	1475.2	11	3122.6	19	2470.2
4	1506.7	12	3011.0	20	2112.2
5	1919.0	13	2981.0	21	1849.3
6	2195.3	14	2868.7	22	1673.3
7	2825.6	15	2825.2	23	1521.2

Considered what is stated in Table 15, and the average hour inflow of 2,344.4 m^3/h; the optimum waiting time for the start-up of the plant to have enough water to supply the average is 3 hours. Figure 26 shows the water accumulation in the tank, giving a maximum required volume of 9254.8 m^3 (20% more is considered (Peters & Timmerhaus, 1991)), due to this great amount of water two options were considered in Table 18 and the construction of a lagoon was chosen.

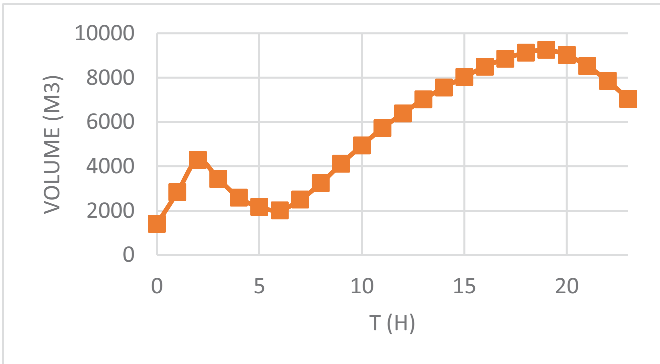


Figure 26: Tank accumulation of water for one day considering a constant outflow of 2344.4 m^3/h after 3 hours.

- Rational Selection

Table 18 shows a comparison of advantages and disadvantages. After a deep analysis, the decision was the lagoon that obtained six stars. Its simplicity and low cost are the main reasons of the choice.

Table 19: Rational Selection for the equalizer

Type of equipment	**Dimensions**	**Type of construction**	**Total**
Tank	At least 22m width, length and depth (*)	Need to look with suppliers, more than 1 equipment is required (*)	** **(2)**
Lagoon	No limits (***)	It can be constructed with cement and clay (***)	****** **(6)**

- Design

The following considerations are required for the lagoon (OPS, OMS & CEPIS, 2005):

- Construction of 4 lagoons to have a continuous operation during the maintenance time.
- 0.1m of clay and 0.3m of concrete to seal the lagoon and avoid leaching to the ground
- Maximum depth of 2.5m
- For every 10,000m^2, at least 4 lagoons are required
- Hydric balance

$$Q_e = Q_a + (Pr - Pc) - (E + Pe) \qquad \text{Equation13}$$

Where:

- Q_e: Effluent flow, in m^3/s.

- Q_a: Influent flow, in m^3/s.
- Pr: Precipitation falling on the lagoon.
- Pc: Groundwater infiltration into the lagoon (occurs when the water table is above the lagoon).
- E: Evaporation.
- Pe: Percolation losses (occurs when the water table is below the lagoons and these are not sealed).

    - Mass Balance

Following the hydric balance, the groundwater infiltration and percolation losses can be determined as zero due the consideration of clay and concrete to avoid the leaching, therefore the total effluent from the lagoons is 2,342.7 m^3/h considering 235.8 mm as the maximum precipitation in the year (Meteored, 2013) and an evaporation of 1780 mm as average per day (RBV, 2015).

The area needed for double the capacity is 8,884.6 m^2, so 4 lagoons have to be constructed with 47.13m for every side.

d) Primary Clarifier

The general objective of primary clarification consists of the removal of settable and floatable suspended solids from the influent wastewater so that the organic loading to downstream processes (in this case the bioreactor) is reduced.

The specific objective of the clarifier designed is (Metcalf & Eddy, 2002) (The Americcan Water Works Association (AWWA), 2012);

- Remove:
    - 40% of the initial COD, mg/L
    - 30% of the initial BOD_5, mg/L
    - 40% of the initial Suspended Solids, mg/L

    - Rational Selection

Figure 27 shows the different options available for clarifier types of equipment. This figure helped the selection decision process because it shows the general types of clarifiers (The American Water Works Association (AWWA), 2012).

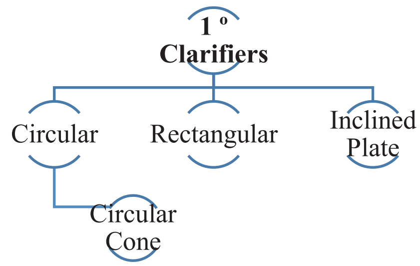


Figure 27: Types of clarifiers

To choose between the options represented in Figure 27, a comparison between the equipment was made; Table 20 shows a comparison of advantages and disadvantages (Voutchkov, 2017).

Table 20: Comparison between the different clarifiers

Type of equipment	Advantages	Disadvantages	Total
Rectangular clarifier	Low cost of construction (**) Used in big WWTP (***)	Constant maintenance (*) More retention time required (*)	******* (7)
Circular clarifier; Cone	Short retention time (***) Low maintenance required (***) Typical use for both 1° & 2° clarifiers (***) Simpler sludge collector (**)	Big headloss (-) Wind susceptible (-)	*********** (11)
Inclined Plate	Increases the efficiency of settlement of solids (**)	Small size, only used in industry (-)	** (2)

With the punctuation obtained visualized on the table 20, the choice of equipment was the circular clarifier→ Cone.

- Design

Figure 28 shows the principal dimensional elements of the primary clarifier. These values were calculated with the equations described below.

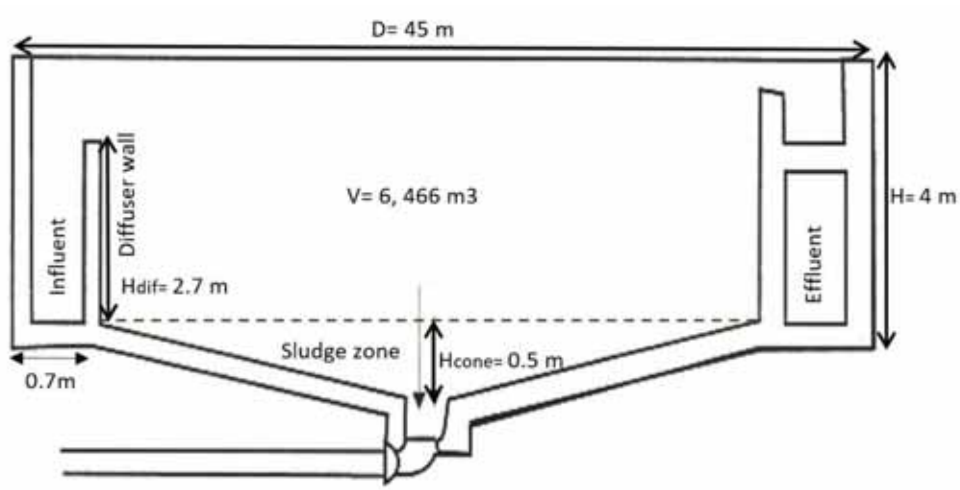


Figure 28: Principal dimensional elements of a 1° clarifier

The values supposed for this equipment design are; the height that needs to be between 3 and 5 m in seismic zones (Mazzoco, 2017) the typical overflow rate for circular primary clarifiers (Metcalf & Eddy, 2002) and the extra depth of primary sedimentation tank (were the sediment goes) (AWWA), 2012). With these values the design calculations can be performed.

First, the area of the clarifier was stablished with Equation 17 and the diameter with Equation 18;

$$a = \frac{Q}{OF_r} \quad \text{Equation 14}$$

$$D = \sqrt{\frac{4a}{\pi}} \quad \text{Equation 15}$$

Where:

- a is area of the 1° clarifier, in m^2
- OF_r is the overflow rate in m^3/m^2
- D is diameter of the 1° clarifier, in m
- a is the area of the 1° clarifier, in m

After the diameter, the total depth was calculated with the Equation 19;

$$H_T = h_s + h \quad \text{Equation 16}$$

Where:

- H_T is the total height of the 1° clarifier, in m
- h_s is the assumed extra depth of primary sedimentation tank (were the sediment goes), in m
- h is the height assumed for seismic zones, in m

  - Mass Balance

This equipment has an important reduction of the principal contaminants treated on the WWTP. Table 21 displays the change on the concentration of these pollutants (Metcalf & Eddy, 2002).

Table 21: 1st clarifier mass balance

	Inflow	Outflow
Q, m³/d	56,160	56,160
COD (mg/L)(g/m³)	557	334.2
DBO5 (mg/L) (g/m³)	257	179.9
SST (mg/L) (g/m³)	250	150
Sludge retained humid, ton/d	9.5	

e) Aerobic Reactor

The main objective of this process is to decrease the organic matter and suspended solids in order to meet Mexican normativity (NOM-001-SEMARNAT-1996) and meet concentration requirements for subsequent methods (UV disinfection) (SEMARNAT, 2015) (Levenspiel, 2012).

The specific objectives of the bioreactor to remove:

- 55% COD (180 mg/L)
- 17% BOD5 (30 mg/L)
- 73% SST (110 mg/L)
- 43% Ntot (17 mg/L)
- 73% Ptot (3 mg/L)

    - Rational Selection

Figure 29 shows the general different options available for aerobic reactors. This figure helped the selection decision process because it helps to visualize the alternatives.

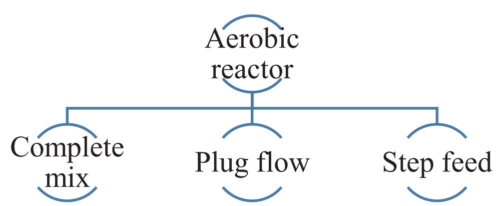


Figure 29: Types of aerobic reactors typically used in a WWTP

To choose between the options represented in figure 29, a comparison between the equipment was made; Table 22 shows a comparison of advantages and disadvantages (Levenspiel, 2012) (EPA, 1999). With the analysis of the options presented, the option selected because of its numerous benefits is the complete mix reactor.

Table 22: Comparison between the different types of aerobic reactors (Levenspiel, 2012) (EPA, 1999).

Type of equipment	Advantages	Disadvantages	Total
Complete mix	Tolerates pollution overloads and any short periods of toxic shocks (**) Most used in WWTP (***)	Has problems when low F/M (-)	***** **(5)**
Plug flow	Suitable for large chemical plants (*)	Not stable for microorganisms(-) Oxygen demand will vary along the entire length of the channel (-)	* **(1)**
Batch (SBR)	Minimal footprint (*) Potential capital cost savings by eliminating clarifiers and other equipment (***)	Used for flows< 0.20 m3/s (-) Higher level of sophistication required (compared to conventional systems), especially for larger systems (-)	**** **(4)**

- Design

Many suppositions were made for the design of this reactor. Typical values (Table 23) for the kinetic of microorganisms were used in order to get the dimensions and retention time of the reactor (Metcalf & Eddy, 2002)

Table 23: Activated sludge kinetic coefficients for heterotrophic bacteria at 20 °C (Metcalf & Eddy, 2002)

Coefficient	Unit	Range	Typical Value
μ_m	g VSS/g VSS-d	3.0-13.2	6.0
K_s	g bCOD/m^3	5.0-40.0	20.0
Y	g VSS/g bCOD	0.30-0.50	0.40
k_d	g VSS/g VSS-d	0.06-0.20	0.12
f_d	Unitless	0.08-0.20	0.15
θ values			
μ_m	Unitless	1.03-1.08	1.07
k_d	Unitless	1.03-1.08	1.04
K_s	Unitless	1.00	1.00

Table 24 shows the equations used in order to get the dimensions and retention time.

Table 24: Kinetic equations used for the dimensioning of the bio-reactor (Metcalf & Eddy, 2002)

$\mathrm{bCOD} = 1.6\mathrm{BOD}_5$	Equation 17
$\mathrm{nbCOD} = \mathrm{COD} - \mathrm{bCOD}$	Equation 18
$\mathrm{nbVSS} = \left(1 - {\mathrm{bCOD}}/{\mathrm{pCOD}}\right) * \mathrm{VSS}$	Equation 19
$\mathrm{P_{X,VSS}} = \dfrac{\mathrm{QY(S_0 - S)}}{1 + \mathrm{k_d} * \mathrm{SRT}} + \dfrac{\mathrm{f_d} * \mathrm{k_d} * \mathrm{QY(S_0 - S)} * \mathrm{SRT}}{1 + \mathrm{k_d} * \mathrm{SRT}}$	Equation 20
$\mathrm{S} = \dfrac{\mathrm{K}[1 + \mathrm{k_d} * \mathrm{SRT}]}{\mathrm{SRT}(\mu_m - \mathrm{k_d}) - 1}$	Equation 21
$\mathrm{P_{X,TSS}} = \dfrac{\mathrm{P_{X,VSS}}}{0.85} + \dfrac{\mathrm{Q(SST - N_T)}}{1000} + \dfrac{\mathrm{Q} * \mathrm{nbVSS}}{1000}$	Equation 22
$\mathrm{X_{VSS}} * \mathrm{V} = \mathrm{P_{X,VSS}} * \mathrm{SRT}$	Equation 23
$\mathrm{X_{TSS}} * \mathrm{V} = \mathrm{P_{X,TSS}} * \mathrm{SRT}$	Equation 24
$\tau = \dfrac{\mathrm{V}}{\mathrm{Q}}$	Equation 25
$\mathrm{Fraction\ VSS} = \dfrac{\mathrm{P_{X,VSS}}}{\mathrm{P_{X,TSS}}}$	Equation 26
$\mathrm{MLVSS} = \mathrm{Fraction\ VSS} * \mathrm{X_{TSS}}$	Equation 27
${\mathrm{F}}/{\mathrm{M}} = \dfrac{\mathrm{Q} * \mathrm{S_0}}{\mathrm{XV}} = \dfrac{\mathrm{Q} * \mathrm{BOD_5}}{\mathrm{MLVSS} * \mathrm{V}}$	Equation 28

Where:

- $bCOD$ is the biodegradable concentration of the chemical oxygen demand (COD), in mg/L
- $nbCOD$ is the nonbiodegradable concentration of the COD, in mg/L
- $nbVSS$ is the nonbiodegradable concentration of the volatile suspended solids (VSS), in mg/L (assumed)
- $pCOD$ is the particulate concentration of COD, in mg/L (assumed)
- $P_{X,VSS}$ is the net waste activated sludge produced each day in mg/d
- S_0 is initial substrate concentration (DBO_5), in mg/L
- S effluent substrate concentration, in mg/L
- SRT is sludge retention time, in days (supposed)
- $P_{X,TSS}$ is the waste activated sludge producing each day in terms of TSS, in mg/d
- N_T is the Total nitrogen concentration in the influent, in mg/L
- V si the volumen of biorreactor needed so the microorganisms can make the transformation, in m^3
- τ is the time needed so the microorganisms can make the transformation, in seconds
- $MLVSS$ is the mixed liquor volatile suspended solids
- X_{TSS} is the concentration of TSS in the reactor, mg/L
- ${F}/{M}$ is food to microorganisms' ratio

With the volume calculated (as visualized on table 24), the dimensions were now determined. The height of the reactor must be around 4 m, if it is taller, anaerobic sections could develop, making the process inefficient (Metcalf & Eddy, 2002) (Mazzoco, 2017);

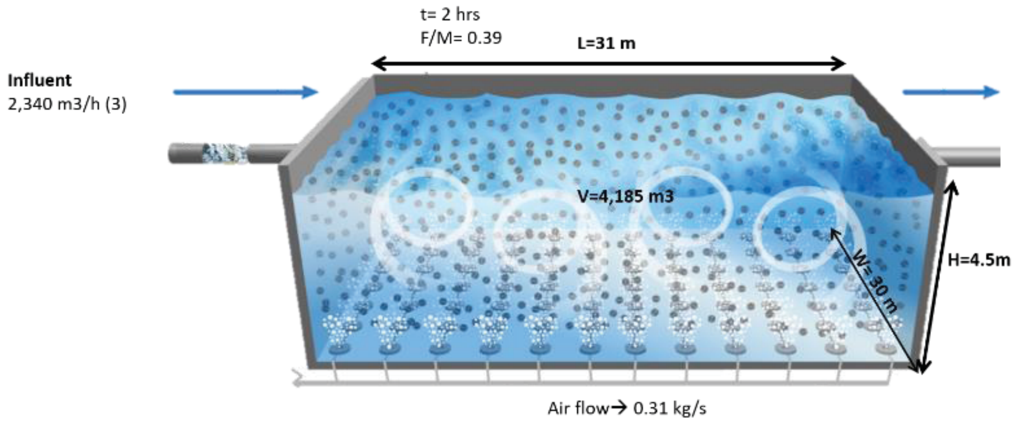


Figure 30: Bioreactor dimensions and principal characteristics

The volume that the equations in table 24 gave was very large. So, the project proposed will consist in four bioreactors, from which three will be operating continuously and the other one will be used in case of maintenance.

- Mass Balance

The results for the aerobic reactor and the secondary clarifier are calculated assuming a 70% energy consumer and 30% biomass producer microorganism as the University of the Americas Puebla uses (Lara, 2018), using this microorganism and the normal oxidation of domestic water (Equation 32) with water-oxygen (Equation 33) and cell synthesis components (Equation 34) (Rittmann & McCarty).

$$\frac{1}{50}C_{10}H_{19}O_3N + \frac{9}{25}H_2O \rightarrow \frac{9}{50}CO_2 + \frac{1}{50}NH_4^+ + \frac{1}{50}HCO_3^- + H^+ + e^- \qquad \text{Equation 29}$$

$$\frac{1}{4}O_2 + H^+ + e^- \rightarrow \frac{1}{2}H_2O \qquad \text{Equation 30}$$

$$\frac{1}{5}CO_2 + \frac{1}{20}NH_4^+ + \frac{1}{20}HCO_3^- + H^+ + e^- \rightarrow \frac{1}{20}C_5H_7O_2N + \frac{9}{20}H_2O \qquad \text{Equation 31}$$

The air requirement was calculated with the Equation 35 and 36 (Metcalf & Eddy, 2002).

$$\mathrm{F_{O2}} = 1.42(\mathrm{BOD_{5in}} - \mathrm{BOD_{5out}}) * \mathrm{Q} \qquad \text{Equation 32}$$

$$\mathrm{F_{air}} = \frac{\mathrm{F_{O2}}}{0.21} \qquad \text{Equation 33}$$

Where:

- F_{O2} is oxygen requirement, in g/s

- F_{air} is the air requirements, in g/s

In **Error! Reference source not found.**25 it can be observed the decrease in concentration of almost all the contaminants concerning the WWTP;

Table 25: Reactor mass balance (SEMARNAT, 2015) (Metcalf & Eddy, 2002)

Parameter	Influent	Effluent
COD mg/L	334	150
DBO5 mg/L	180	150
SST mg/L	150	40
Ntot, mg/L	40	25
Ptot, mg/L	7	4

A more detailed analysis of how the calculations of this reactor were made can be observed on annex 4.

f) Secondary Clarifier

The secondary clarifier rational selection was the same that the one for the primary clarifier.

- Design

The calculations for the design were also the same as the primary clarifier, but the results were different because the overflow rate cannot be used as the same, a typical value for secondary clarifiers was used for this design (Mazzoco, 2017) (The American Water Works Association (AWWA), 2012) Figure 31 displays the dimensional elements calculated for the secondary clarifier clarifier.

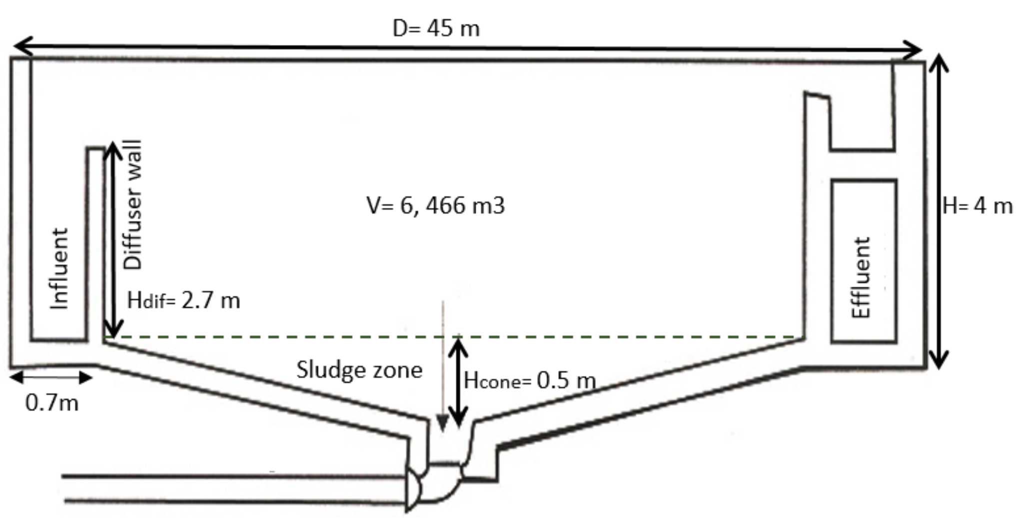


Figure 31: General dimensional elements for the secondary clarifier

- Mass Balance

The concentration of the wastewater is assumed to remain the same after it passes this equipment. The only solid that sediment is the inert mass that comes from the reactor. The amount of activated sludge generated per day is of 450 kg (average) (Metcalf & Eddy, 2002).

g) UV disinfection

- Design

The WWTP has an inflow of 56,265 m^3/d that needs a tertiary treatment with UV with a transmission of 60% at least, and will deliver an outflow with a concentration of 30 mg/L of SST, limit of 1000 Total Coliforms/100ml and a validation factor of 0.98 for the lamps life and 0.95 for the fouling factor.

With this data, the supplier gave the best equipment to use the "TROJANUV3000 Plus" (Alvarado, 2018) for the proposed plant. The design information can be visualized on table 26.

Table 26: Description of the equipment

CANAL	
# of canals	1
Length, m	6
Canal width, cm	152.4
Depth, cm	157.48
UV MODULES	
# of bedplates	1
# of modules per bedplates	12
# of lamps per module	8
Total number of UV lamps	96
Power of lamps	250 W/125 W
Maximum power demand, kW	24
UV PANELS	
Power distribution centers	1
Control systems center	1
Controller	1 microprocessor
ADDITIONAL EQUIPMENT	
Controller per levels	1
Controller type	1 ALC
Cleaning system	Trojan ActiClean
UV module elevation	Davit crane
Security kit	Included

The equipment dimensions are for the lamps a length of 1.55 meters and an outside diameter of 0.025 meters as observed on figure 31. The TROJANUV3000 Plus has a length of 3.1 meters and a height of 2.1 meters with the lamps and the operation system as observed in Figure 32.

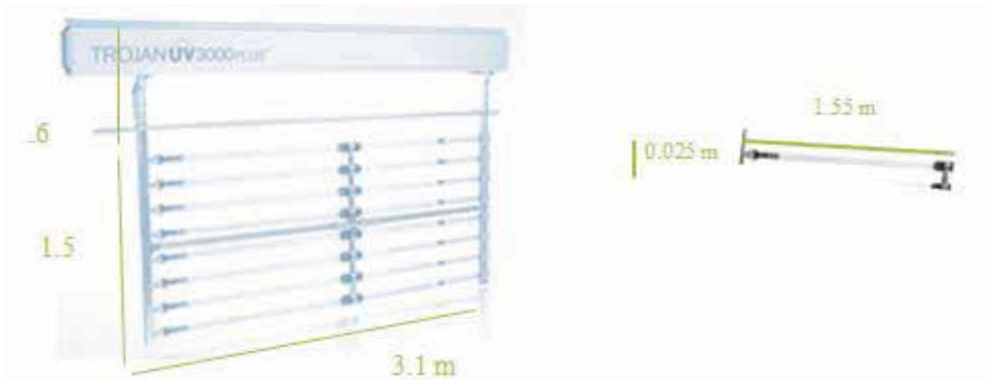


Figure 32: TROJANUV3000PLUS & UV lamp

There will be 12 modules, each one with 8 lamps, there will be 6 on each side of the canal, this means there will be 96 lamps in total, but the project has visualized an increase in the inflow so it counts with the possibility to expand the number of modules to 15, this means there can be 120 lamps working at the same time to disinfect a maximum inflow of 70,000 m^3/d.

With all these considerations, the purpose of the equipment can achieve the decrease of the total coliform concentration from 12 x 10^6 NMP/100ml to 1000 NMP/100ml or lower, and with these actions, the water quality will meet the Mexican normative NOM-001-SEMARNAT-1996.

h) Sludge Equipment

The general objective of this equipment is to reduce the moisture in the sludge in order to reduce its volume and go to the biogas plant to be treated anaerobically.

The specific objective is to remove:

- 25 m^3/day and get 15 m^3/day of semi-dry sludge (50% of the moisture is wanted to be removed; this type of sludge is composed of 80% of water (Metcalf & Eddy, 2002) (Sanatana, 2009).
    - Rational Selection

Figure 33 shows the general different options available for filtration method for sludge treatment. This figure helped the selection decision process because it helps to visualize the alternatives (Sanatana, 2009).

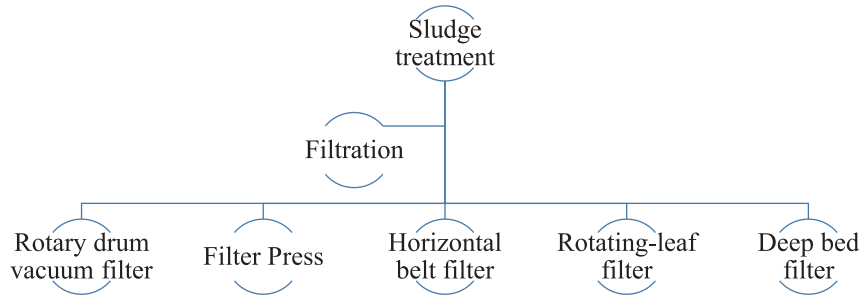


Figure 33: Types of filtration for removal of moisture in a WWTP

To choose between the options represented in figure 32, a comparison between the equipment was made (Table 27) (Sanatana, 2009); it was reached that the most beneficial option for the plant proposed is the filter press.

Table 27: Sludge treatment selection process

Type of equipment	Advantages	Disadvantages	Total
Rotary drum vacuum filter	Filter is entirely automatic (*). Large quantities can be filtered (***). Low maintenance cost (***)	Initial cost of filter and vacuum equipment is high (-) Inflexible & do not perform well if their feed stream conditions are changing (-)	******* (7)
Filter Press	High filtration velocities (***) Low moisture content in the filter cake (removes about 50%) (***) Most popular and used filter (***)	High labour requirements (-)	*********(9)
Horizontal belt filter	Production relatively clean (use of sedimentation basin)(*) Easy control of parameter (cake thickness or wash ratios) (**)	The odour of the feed sludge, volatile emissions and the chemicals used in treatment, may become a problem (-). Belt filters are less effective at processing some feeds (-)	*** (3)
Rotating-leaf filter	No spillage. (**) No use of filtered cloth (less costs)(**). High productivity (***)	Mostly used in industry (-) Highest cost of investment (-)	******* (7)

- Design

The only value calculated for this equipment was the filter capacity. The Equation 34 was used for this purpose (ACS Medio Ambiente: Sistemas para tratamiento de agua, 2018);

$$FC = \frac{TV * \%_S * V_c}{W_v} \qquad \text{Equation 34}$$

Where:

- FC is the filter capacity, in m^3/cycle

- TV is total volume per cycle (a typical cycle is 8 hours), in L/cycle
- $\%_S$ is solid percentage present in the sludge
- V_c is the mass per volume present in the sludge, in kg/L
- W_v is the mass per volume, in kg/m^3 (just for a conversion)

The value obtained from the Equation 37 is 2.06 m^3/cycle. Different suppliers were looked based on this capacity and only one had the information about this size of press; the supplier (Shuangfa) specifies that the motor power needed for this equipment is of 4.0 kW. The sheet of the supplier can be observed in Annex 4.

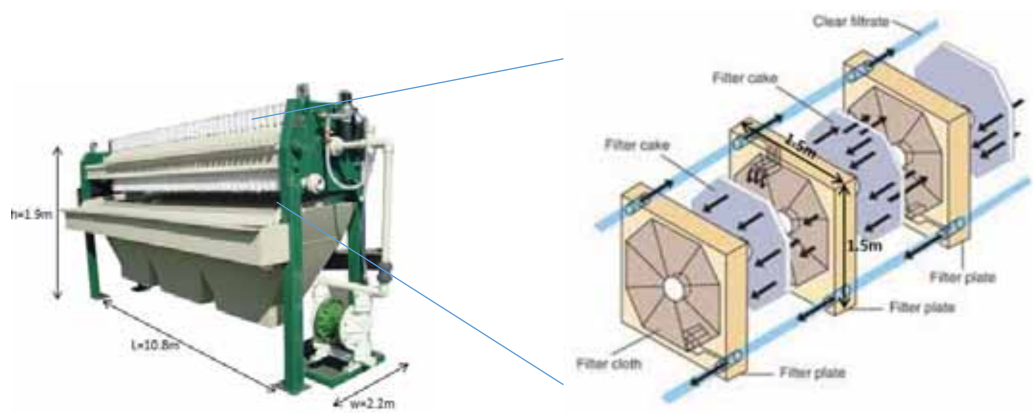


Figure 34: Press filter designed for the capacity obtained for the WWTP proposed

2.2.2. Solid Waste Separation Plant (SWSP)

The objective of this plant is to separate the residues coming from the municipalities considered: Calpan, San Andres Cholula and san Pedro Cholula. From the previous chapter it is known that the total inflow of waste is 176,395.15 kg/d plus 2,864.16 kg/d from the WWTP. It is important for this section that the waste does not come in a continuous way.

Trucks are necessary to transport the waste to the plant, for this, trucks of 15 m^3 capacity (Hbjnspa, 2018) are considered and the density of the waste is taken as 300 kg/m^3 with some compaction which means a total of 40 trucks coming each day.

A decision made for this plant is the man work operating hours, it was decided that the recollection of the waste will be at night shifts because there is less traffic and avoid bad odors for the population in general due to the increment of temperature during the day (Meteored, 2013). The Solid Waste Separation Plant (SWSP) will be operating on the day shift hours to take advantage of the day light and reduce the electrical costs. The working hours are seven for the night shift (22:00 to 06:00) and two day shift of 8 hours (6:00 to 14:00 and 14:00 to 22:00) as the article 61 from the Federal Law dictates (Díaz-Ordaz, 2015).

a) Discharge Hopper and elevator

The objective of this equipment will be the analogous to the equalizer in the WWTP. It will receive 179.3 tons every day in a discontinuous way.

The equipment selection is based on the provider and fundamentally on their capacity, as observed on table 25. The Zheng Ying equipment is not elevated in price, however, the elevator is not included and the shipment from China has to be considered. A better option is the Telestak equipment which has more than the capacity needed and is appropriate in the case of more storage and unexpected events. All the specifications for the equipment are available in annex 2.

Table 28: Rational selection for the discharge hopper.

Equipment brand	**Capacity**	**Operational management**	**Cost (MXN)**	**Origin country**	**Total**
Telestak (2016)	2100 tons (***)	Automatic with remote controls, elevator included (***)	$3,651,595.00 (**)	Port of Panama USA (**)	********** **(10)**
BRT HARTNER (2018)	10 and 12 tons (*)	Remote controls, elevator included (***)	$4,494,270.00 for 15 pieces (*)	Oaxaca, México (***)	******** **(8)**
Zhen Ying (2018)	40 to 700 tons (***)	Semi – automatic, elevator not included (*)	$180,726 (***)	Henan, China (*)	******** **(8)**

b) Bag Opener

The principal objective of the bag opener is to receive the bags and waste that will come from the discharge hopper, that will allow the opening and emptying of bags, this without cutting or damaging its content.

- Rational Selection

For this process there are two different types of bag openers from two different brands, to make the decision Table 29 is displayed.

Table 29: Bag Opener Rational Selection

Equipment brand	Capacity	Power	Includes conveyor	Origin country (shipment)	Cost	Total
COPARM (AS8 2000)	12 ton/h (**)	30 HP (*)	Yes (***)	Italy (*)	$140,000 USD (***)	********** (10)
CP MANUFACTURING	30 ton/h (*)	20 HP (**)	No (*)	United States of America (***)	$180,000 USD (**)	********* (9)

From Table 29 it can be observed that the total punctuation is close, but if it is taken in consideration that the capacity of SWSP needs to cover 11.1 ton/h, and that the cost of the COPARM bag opener is lower: it includes the installation of the conveyor to connect the discharge hopper and the bag opener, and also the shipping to México. Then the COPARM option is the best one (COPRAM, 2018).

- Design

The following design is for the COPARM 8 AS 2000 (COPARM, 2018), this bag opener has a great reliability and does not require frequent cleaning, and it also works with an efficiency of 98% and ensuring a constancy of production.

As observed on Figure 35, the conveyor will receive the waste in one side with a width of 2.46 m and usable of 1.98 m, the garbage will travel across 11.9 m before it reaches the bag opener, which can be observed on figure 35. The bag opener has a length of 3.93 m and a width of 2.66 m, and it can process up to 12 ton/h of garbage using a rotor with a diameter of 1.3 m., to process all the income waste, it needs to operate 15 hours meaning 2 shifts per day of labour..

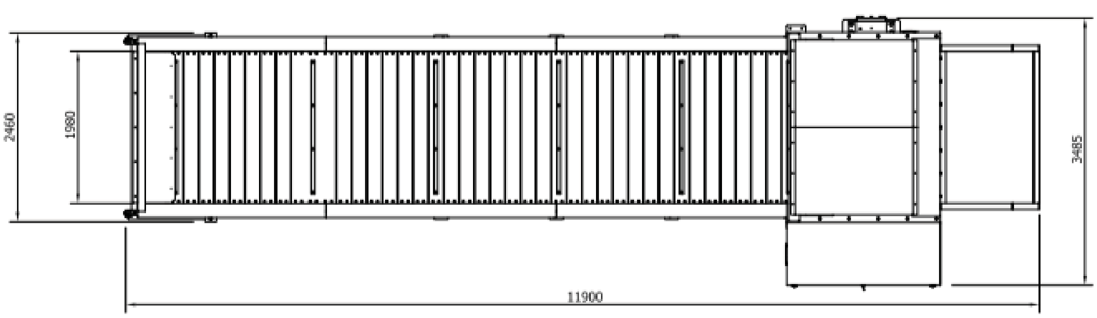


Figure 35: Conveyor for the bag opener

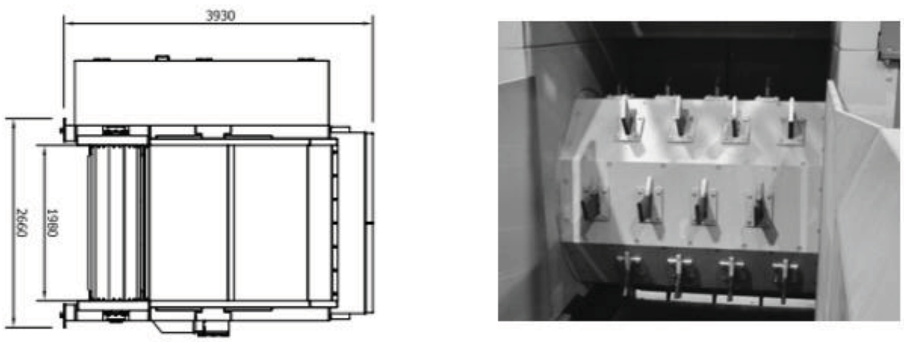


Figure 36: Bag Opener

c) Conveyors

The conveyors are important to facilitate the man working on the separation, the type of conveyor was based on water resistant material to transport the organic material without problem and avoid losses of material from possible spaces in the conveyors.

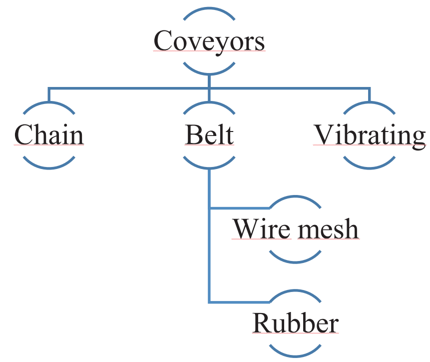


Figure 37: Types of conveyors

A rubber belt conveyor fits best for the process needed, three different suppliers were consulted, and the best conveyor selection was for a modular conveyor which has the advantage to make different arrangements. This analysis and comparison can be observed on Table 30.

Table 30: Conveyor selection.

Equipment brand	**Width (mm)**	**Flexibility for different arrangements**	**Cost (USD)**	**Length (m)/power (kW)**	**Total**
Conveyor Tek	600 and 1200mm (*)	Not modular, just the belt (*)	$80 for meter (***)	N/A	***** **(5)**
INTERQUIP (2018)	450, 600, **900** and 1200 mm (***)	Modules of 1.2 and 2.4m long (***)	$3,686 for every 7.2m modules (**)	8.8/4 = 2.2 (**)	********** **(10)**
SBM (2018)	400, 500, 650, **800**, 1000 and 1200mm (***)	Modules of 10m (**)	$5,000 for 10m (*)	25/12 = 2.1 (***)	********* **(9)**

For the plant, it is calculated a closed room with enough space for the workers to separate the waste and have time, INTERQUIP offers modules that can be arrange in different ways.

The conveyors should have an average velocity of 2 m/s, knowing that the bag opener can open 12 ton per hour, means a 3.33 kg per second "production". A supposition based on Tchobanoglous, Theisen, & Vigil (1994) is that a person needs an average of 0.55 minutes to pick a container of waste (4.2 kg average), it can be assumed that one person delays 8 second to separate 1kg of waste, taking the 7 hour per shift and not 8 (for any inconvenience with the man labor), one person can separate up to 3.15ton every day, this requires 60 persons in the separation section and they need to be at least 1.5m separated from each other to exploit the space (Funes, 2018) and there can be two persons in every spot, this means a minimum of 45m of conveyor needed.

d) Shredder

The purpose of having a shredder is to reduce the size of the solid waste, in case of the organic matter; it is easier to treat afterwards if it has a smaller size.

- Rational Selection

For this process there are two model shredders that can work for the plant, to make the decision both of the shredders are compared in table 31.

Table 31: Shredder selection

Equipment brand	**Capacity**	**Power**	**Shafts**	**Rotation speed**	**Cost, USD**	**Total**
COPARM (TR150)	6-12 ton/h (***)	110 kW (***)	2(*)	18-12 RPM (***)	$202,200 (*)	*********** (11)
Granutech (Dual-Shaft)	7-8 ton/h (*)	150 kW (*)	2 (*)	7-12 RPM (*)	$300,000 (***)	******* (7)

From the analysis the best option to select is the COPARM TR150 shredder, not only because it's more economical than the Granutech, but it also offers a wide capacity and using less energy and more rotation speed.

- Design

The shredder TR150 (COPARM, 2018) will receive 120 tons of organic matter and other materials that needs to be reduced in size so it can be used for energy production in the biogas plant, the shredder will be working for 16 hours in 2 shifts, this means the shredder will receive 7.5 ton/h.

The best design for the shredder will have a height of 2.2m, length of 3.8m and width of 2.16m, using blades with 100mm of thickness as observed in figure 38.

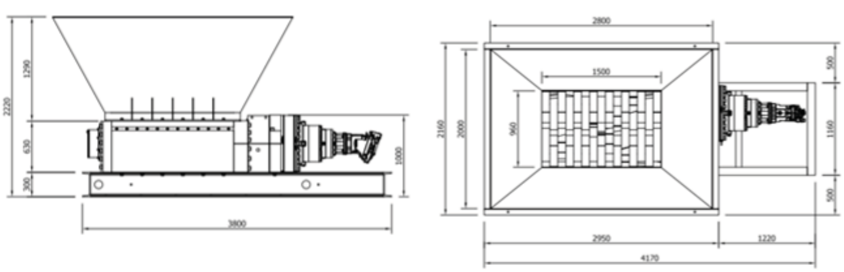


Figure 38: Shredder dimensions

3. Plant´s Finance

The plant´s finance was calculated with the supposition that this project will also include the production and sale of the organic matter that comes into the SWSP as fertilizer (compost).

3.1. Costs

3.1.1. Land

It was consulted with a real state and the cost of the land in the zone we are at, San Antonio Cacalotepec, the cost is \$81.35 dollars per m^2 (Gomez, 2018), the total land is 610,000 m^2 giving a total cost of \$284,713,180 dollars.

3.1.2. Equipment

The cost of the equipment is displayed in this section. A summary of these costs is displayed on Table 32;

Table 32: Equipment Costs

Equipment		
WWTP	**USD, $**	
Mechanically Cleanded-Chain driven	$	44,840.96
Horizontal Flow: Grit Chamber	$	6,594.57
Equalizer (4 tanks)	$	448,434.01
1° Clarifier	$	1,165,684.52
Aerobic reactor (4 reactors)	$	330,740.53
2° Clarifier	$	1,439,135.80
UV treatment	$	170,000.00
Press filter	$	1,432,086.98
SWSP		
Discharge hopper and elevator	$	159,000.00
Bag opener	$	140,000.00
Conveyors (6 modules)	$	22,116.00
Shredder	$	202,200.00
Total Equipment Cost	**$**	**5,560,833.97**

The mechanically cleaned-chain driven equipment cost was given by a Mexican supplier called “Aframex”; the priced details can be observed on annex 10. This quotation was made by giving them the design data described before in section 2.2.1 (AFRAMEX, 2018).

The horizontal Flow Grit Chamber was priced based on the quantity of high resistance concrete and support mesh that would need to be constructed (Gómez, 2018). This calculation can be observed on table 33.

Table 33: Calculation for the Horizontal Flow Grit Chamber Cost

Base, m^3	12.88	$ 2,371.88	m^2 base	42.92	33.88
Wall 1, m^3	3.22	$ 592.97	m^2 wall 1	10.73	8.47
Wall 2, m^3	19.2	$ 3,536.84	m^2 wall 2	64	50.53
Cost of High Resistance Concrete, USD/m^3	$ 184.2	$ 6,501.7	Cost of Mesh $/$m^2$	0.79	$ 92.9
Total Cost, USD	**$**				**6,594.57**

The equalizer cost was estimated with base on the clay price in Mexico and the high resistance concrete price (Gómez, 2018). This calculation can be observed on table 34.

Table 34: Calculation for the Equalizers Cost

Dimensions		**Requirements**					**Costs**		**Total, USD**
42	L, m	Clay	0.1	m	176.4	m^3	8.27	USD/m^3	$ 1,458.95
42	L, m	Concrete	0.3	m	529.2	m^3	184.2	USD/m^3	$ 97,478.64
		Mesh	Surface cover	-	1764	m^2	0.79	USD/m2	$ 1,392.63
							1 equalizer		$100,330.22
							4 equalizers		**$401,320.88**

The primary (red line) and secondary clarifier (yellow line) costs were calculated based on their area (Equation 17) and its relationship with the next graph;

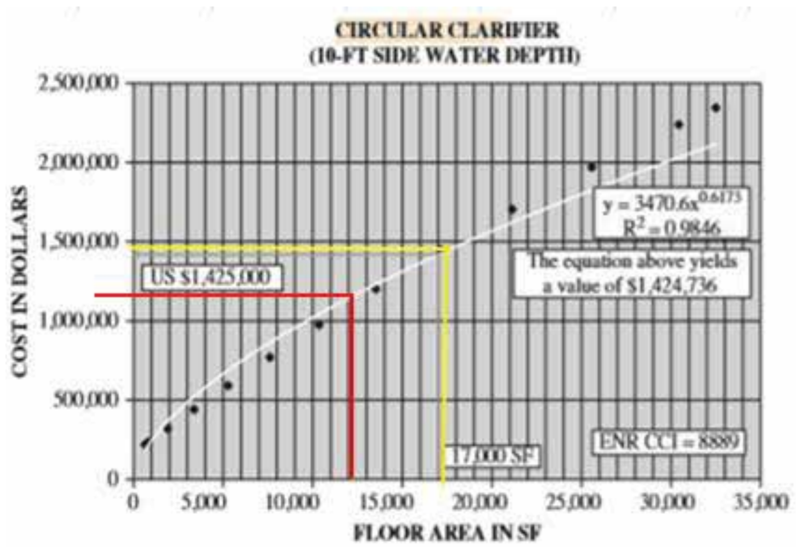


Figure 39: Cost Estimation for a circular clarifier (Kawamura, 2008)

This cost would probably be lower here in Mexico because of the current high U.S. dollar price.

The aerobic reactors cost was calculated in base on the high resistance concrete and mesh to support it that would be needed for their construction (Gómez,2018). This calculation can be observed on table 35;

Table 35: Calculation for the Aerobic Reactor Cost

Concrete Quantity, m3		**Concrete reactor costs, USD**	**Mesh quantity, m2**		**Mesh reactor costs, USD**
Base, m^3	270	$ 49,736.84	base, m^2	900	$ 710.53
Wall 1, m^3	81	$ 14,921.05	Wall 1, m^2	135	$ 106.58
Wall 2, m^3	81	$ 14,921.05	Wall 2, m^2	135	$ 106.58
Cost of High Resistance Concrete, USD/m^3	$ 184.2	$ 79,578.9	Cost of Mesh, USD/m^2	0.79	$ 923.7
1 Reactor Cost, USD	**$**				**82,685.13**
Total Cost, USD	**$**				**330,740.53**

For the UV disinfection treatment the cost was directly priced with a Canadian supplier named TROJANUV. The characteristics of water leaving the secondary clarifier were given to them and they did the calculations and offered the equipment described on section 2.2.1. (g). the supplier gave the initial investment cost (170,000.00 USD) and the cost of the exchange of lamps that needs to be done once a year (23,572.00 USD). The maintenance cost (that was also given by the supplier) was not taken into account because a general calculation (for all the equipment) was made.

The press filter price was estimated by its filter capacity with the following graph (275 gal/h);

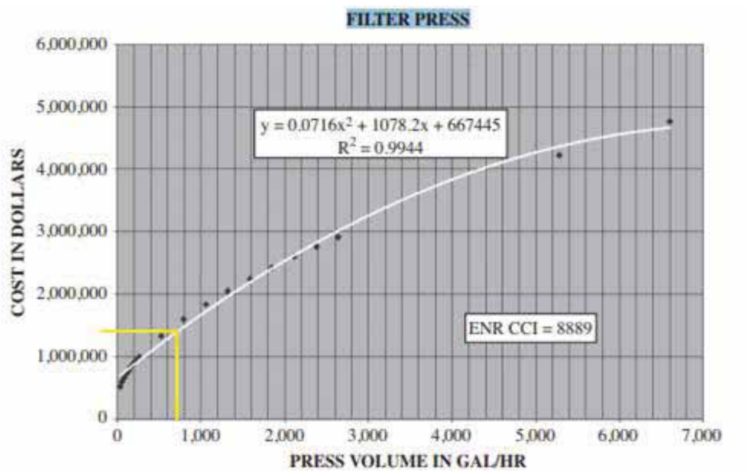


Figure 40: Cost Estimation for a filter press (Kawamura, 2008)

This cost would probably be lower here in Mexico because of the current high U.S. dollar price.

The discharge hopper and elevator were priced directly with a supplier. The equipment was chosen based on its flow and storage capacity (more details can be observed on section 2.2.2 a) and its cost is 159,000.00 USD (Telestak, 2016).

The Bag opener was priced directly with two suppliers. The decision was made based on the lowest cost between the two suppliers. It was also based on the fact that the price of COPRAM, a very recognized Italian supplier in Europe, includes the installation of the conveyor to connect the discharge hopper and the bag opener, and also the shipping to México; 140,000.00 USD (COPRAM, 2018).

For the conveyors, a rubber belt type fits best for the process proposed;, three different suppliers were consulted, and the best conveyor selection was for a modular conveyor which has the advantage to make different arrangements (in case the plant needs more capacity). As mentioned on section *2.2.2 c)* the supplier INTERQUIP was chosen and it gave the following price for six sets of the equipment: 22,116.00 USD.

For the Shredder the same supplier of the Bag Opener was chosen; because it has more capacity range, uses less energy and has more rotation speed, besides the fact that using less providers keeps the process more controlled (Rojas, 2018). The equipment price was of: 202,00.00 USD.

3.1.3. Other costs

In a plant installation there are other costs besides equipment, like costs of installation, piping, administration, etc. This can be observed on table 36 (Kawamura, 2008);

Table 36: Investment Cost

Equipment , USD	$	5,560,833.37
Equipment installation, USD	$	1,390,208.34
Yard Piping, USD	$	1,112,166.67
Site work Landscaping, USD	$	1,112,166.67
Site electrical & controls, USD	$	1,112,166.67
Administrative cost, USD	$	1,167,775.01
Land cost ($81.35 x m2), USD	$	49,678,552.06
Investment, USD	**$**	**61,133,868.80**
Project Duration, years	30.00	
Contingencies , USD	$	6,113,386.88
Total Investment, USD	**$**	**67,247,255.68**

This means that the total investment ascends to $ 67,247,255.68 USD which is the sum of money needed to start the Project. From this investment there are some costs that will become assets, which means that the costs become an inversion (something that could be sold later) and are not counted as losses. Table 37 shows the costs of inversion that are considered as assets (Rojas, 2016).

Table 37: Assets of the plant

Assets, USD	
Total Equipment	$ 5,560,833.37
Yard Piping	$ 1,112,166.67
Site electrical & controls	$ 1,112,166.67
Land cost ($81.35/ m^2)	$ 49,678,552.06
Total Assets	**$ 57,463,718.78**

On the other hand, annually considering the maintenance, the administrative, labour and other costs are costs that can be considered as a loss and they sum up $4,536,687.53 USD as seen on table 38.

Table 38:Annual Costs

Production costs		
Manufacturing cost		
Direct, USD/ year $		
Labour	$	896,623.40
Maintenance	$	2,017,417.67

Indirect[2], USD/year	$ 1,748,424.64
Others (Lubricants, etc.)	$ 201,741.77
Lamp Reposition	$ 23,572.00
Annual Cost USD/year	**$ 4,752,197.88**

For the earnings per year, the main services of the plant proposed are the wastewater treatment and the recycled materials (separated and sold). This data will give the total earnings of the plant and with these, the return of investment (ROI) and the Payback time can be calculated, as observed on Equation 38 & 39. The information for the income, ROI and payback time can be visualized on Table 39 and 40. Level land income is not going to be taken into account for the plant´s finance because it is a very low profit.

$$ROI = \frac{P_{net}}{I_{total}} (Rojas, 2018) \qquad \textit{Equation 35}$$

$$Payback\ Time = \frac{I_{total}}{P_{net}} \ (Rojas,\ 2018) \qquad \textit{Equation 36}$$

Where:

- P_{net} is the net profit, in USD
- I_{total} is the total inversion of the project, in USD

Table 39: Plants Income

Income	
Sells	
Main Services USD/year	
Water treatment, USD	$ 6,464,489.36
Solid waste treatment; Recycled materials	$ 2,718,085.11
Secondary Services USD/year	
Compost	$ 2,979,409.57
Total Income, USD/year	$ 12,161,984.04

Table 40: Return of investment (ROI) and payback time (PBT) of the plant proposed with compost production

ROI	12.895%
Payback time, year	0.78

If the plant earnings are considered only by the activities proposed on this project (Material recycle and waste water treatment) the ROI and payback time would be;

[2] Laboratory analysis, fix, depreciation, insurance, etc.

Table 41: Return of investment (ROI) and payback time (PBT) of the plant proposed without compost production

ROI	7.71%
Payback time, year	1.27

It can be observed on table 41 that the Return of Investment is a little bit low, but still profitable. This can be taken as a justification to plan the production of compost and later a biogas plant.

4. Plant´s Layout & Location on the Map

4.1. Waste water treatment plant

The location of the Waste Water Treatment Plant was decided based on the topology (as mentioned on section 1.5), reducing pumping costs and water dynamics which considers possibility of flooding. The plant will be located in the highest point above the water phreatic level of the Presa River to avoid possible contamination as observed on Figure 41; this point also gives the advantage of a downstream process which reduces pumping cost. Furthermore, considering the lack of information on the sewage system, it was assumed that the entire network will be connected to this point. Notably this location is approximately 657 m below the majority (83%) of the communities served (INEGI, 2015).

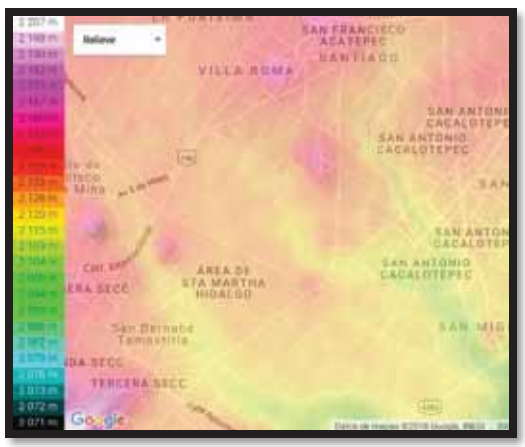


Figure 41: Topographic map of the site

From the topography it’s observed an approximate 6 to 10 meters difference in height of the land; therefore the plant layout is more convenient to the south east direction close enough to the river in the case of the equipment flooding. The layout in the land considered is showed in Figure 42. This figure also shows the final decision on the equipment distribution. All the sections are labeled in the layout, the administrative offices are planned for around 40 persons (including visit places or else) and there is enough space for future expansions (Sánchez, 2018).

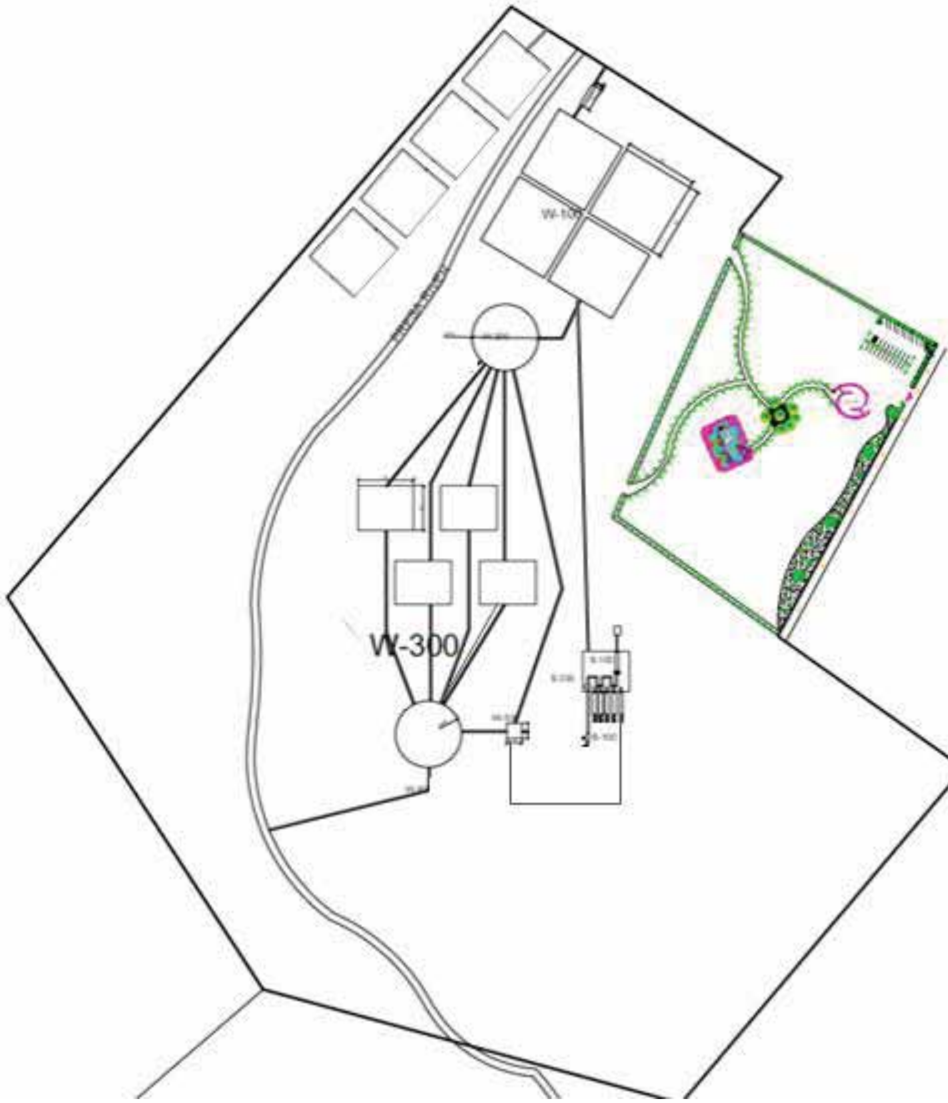


Figure 42: Plant´s Layout (65 Ha)

As observed on figure 42, The Presa river pass at the left of the plant and the waste water is assumed to come from the north point as explained before. It can be seen in the southeast corner the SWSP which will be explained in the next section.

4.2. Solid Waste Separation Plant (SWSP)

With the dimensions of all the equipment, the solid waste separation is relatively smaller than the waste water treatment plant; it is convenient to place it next to the WWTP to receive the solid waste from the WWTP primary treatment.

Figure 43 shows the plant layout starting from the north with the feeding hopper, entering to the separation building section where trucks will receive the materials recovered. Here is also the truck that will distribute the landing leveling soil that come from the filter press. The B-100 section is observed at this figure because this is the organic fraction of the waste that is aimed to be treated on future projects.

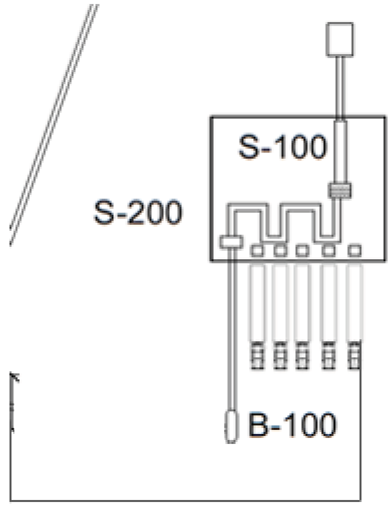


Figure 43: Solid Waste Separation Plant

4.3. Administrative and Recreational Zona

The building is planned for 40 persons at the center, the parking lot is at the east corner with the entrance to the plants and a cafeteria is also placed close to the parking lot and away from the plants. The distribution of these areas can be observed on figure 44.

Figure 44: Administrative and Recreational Zone

5. Conclusions

With the project proposed it can be observed that the minimum needed to treat correctly the domestic wastewater is \$6.00 MXN per m^3 (without the charge of "sewage system" and the charge that the water companies apply for their business). Water in Puebla costs \$22.00 MXN pesos per m^3 of water for domestic use; from which \$4.44 MXN is for the sewage system, \$2.99 MXN is for the actual treatment and \$14.81 MXN for the business (Agua de Puebla, 2018). The mentioned rate is one of the most expensive of the entire country, but still none of the state´s plants reach the water quality standards (IMTA, 2017). The reasons for this must be analyzed by the reader.

The material recycle is another part of the project that is very important. For the future a "pepenadores" program should be included, in order to employ this people and to give them law benefits, because currently the small percentage of recycling carried on is in part their money source. A deep environmental assessment should be made for this aspect because besides avoiding the volume exceed on landfills, the resource savings for new materials should be taken into account (this includes; raw materials, energy and time).

Another improvement this project may have is the comparison with a simulating wastewater treatment program like "GPS-X Premium Water & Wastewater Modelling and Simulation Software". This in order to corroborate and confirm the analysis made in this paper.

It should be recalled that to actually make reality this kind of project, water analysis has to be made (by experimentation) in order to understand its nature (microorganisms kinetics, toxic variations, etc.).

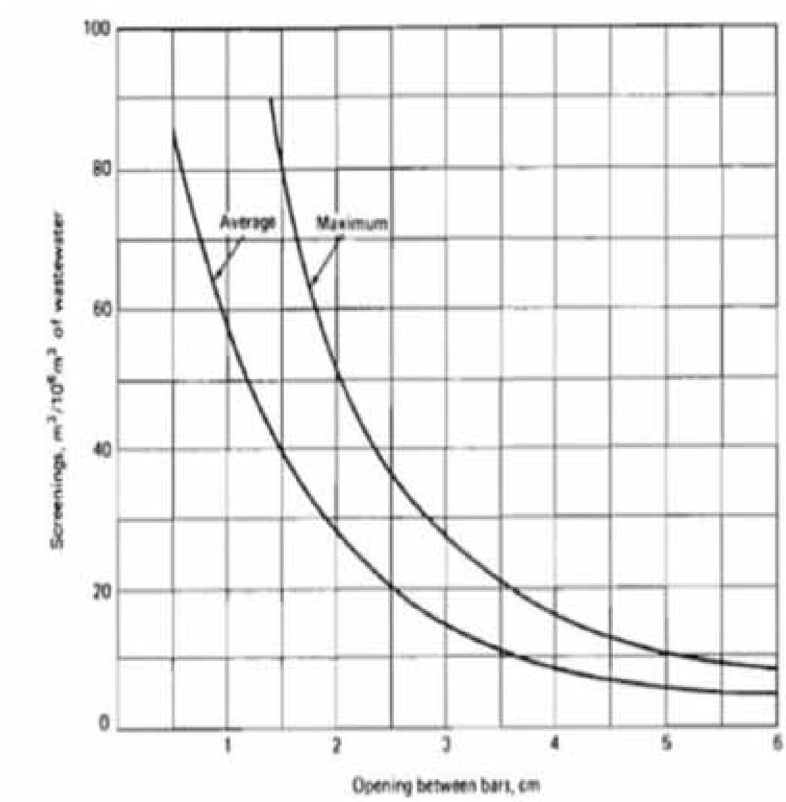
The lessons learned from this paper vary from the social and economic aspects; like the poverty, the misdirected resources on Mexico, the lack of information (especially data manipulation from government entities) and unemployment in the country. To engineering aspects like the viability of these kind of projects, the complexity of the design (the design and construction require a lot of disciplines combined) and the lack of suppliers of excellent quality in Mexico. Even to some philosophical questions like; if government is undervaluing a resource that is necessary to survive, who is going to act? On the future who will have the benefit to live, only the ones with enough resources to pay for extremely polluted water treatment?

6. Annexes

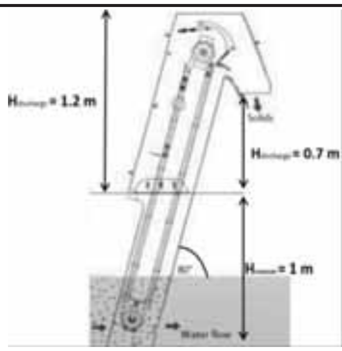
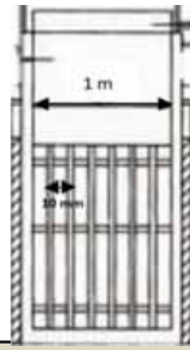
Annex 1 "Parameters used for calculations of coarse screening"

Table 42: Typical design information for manually and mechanically cleaned bar racks (Metcalf & Eddy, 2012)

		Cleaning method	
Parameter	**Unit**	*Manual*	*Mechanical*
Bar Size			
Width	mm	5 - 15	5 - 15
Depth	mm	25 - 38	25 - 38
Clear Spacing between bars	mm	25 - 50	15 - 75
Slope from vertical	°	30 -45	0 - 30
Approach velocity			
Max	m/s	0.3 - 0.6	0.6 - 1.0
Min	m/s	-	0.3 - 0.5
Allowable headloss	mm	150	150-600



Annex 2 “Information sheet of the equipment”

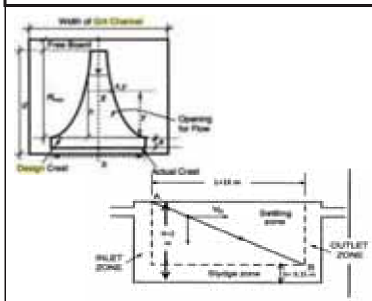
COARSE SCREEN INFORMATION SHEET			
 		**Model: AFR-RC-AC800-PC800-AD2000-AE2000-EH12**	
		OBJECTIVE	
		General: Remove coarse solids, protect pumps and other mechanical equipment	
		Specific: Remove 2,864.16 kg/d of big solids from the water entering the plant	
DESIGN INFORMATION		**GENERAL DESCRIPTION**	
Bar Size		Type Coarse screen; Mechanically cleaned; Chain driven: Back clean	
Width, mm	10		
Clear Space Between bars, mm	10		
Slope from horizontal º	80	**OPERATIONAL CONDITIONS**	
Velocity		T°, °C	25
Maximum, m/s	0.9	P, atm	1
Minimum, m/s	0.6		
Allowable headloss, m	375		

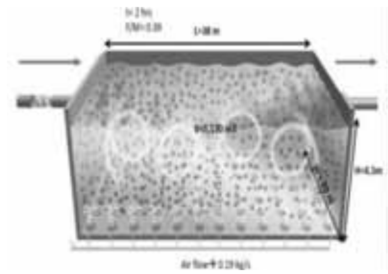
MATERIALS	
Frame	Stainless steel AISI304
Rack	Stainless steel AISI305
Gears	Special steel
Conveyor chain	Galvanised steel
Hubs	Galvanised steel

PRICE		
Price per unit, USD	$	42,600.00
Number, units		2
Total, Mexican pesos	$	85,200.00

SECURITY MEASURES
The equipment will be totally removed and replaced with the other equipment when maintenance is needed For operators: Obligatory use of masks, gloves, for the storage and displacement of the screens . The equipment needs to be turned off in order to give it maintenance

REFERENCES	SUPPLIER			
Origen especificado no válido.	**AFROMEX**	Naucalpan Edo de Mexico		
Origen especificado no válido.	Model: AFR-RC-AC800-PC800-AD2000-AE2000-EH12			

GRIT REMOVAL INFORMATION SHEET			
		**Horizontal flow grit chamber**	
		OBJECTIVE	
		Remove grit in order to protect subsequent treatments and equipment	
DESIGN INFORMATION		**GENERAL DESCRIPTION**	
Principal chamber		**Settling velocity V_p, m/s**	0.02019274
Length, mm	16	**Horizontal velocity V_h, m/s**	0.2
Htotal	2	**Detention time, s**	60
hsludge	0.15	**d particle, mm**	0.15
Proportional weir		**MATERIALS**	
b, m	1.04	Reinforced concrete & iron rods	
a, m	0.04		
w', m	0.12		
PRICE			
Price per unit, USD		$	6,558.88
Number, units		1	
TOTAL		$	6,558.88
SECURITY MEASURES			
For the grit removal: obligatory use of gloves and mask			
REFERENCES			
(Keller, 2001) (EPA, 2003) (Kawamura, 2008)			

AEROBIC REACTOR: INFROMATION SHEET	
	**Aerobic: Mixed fluid reactor**
	OBJECTIVE
	General: Decrease organic matter and total suspended solids
	5 Reactors needed: 4 working in paralel and the other in case of maintenance

DESIGN INFORMATION		GENERAL DESCRIPTION	
Microorganisms		Coarse screen; Mechanically cleaned; Chain driven: Back clean	
F/M	0.39		
MLVSS, mg/L	1294		
Reactor		**OPERATIONAL CONDITIONS**	
V, m3	5,130	T°, °C	25
H, m	4.5	P, atm	1
W, m	30	Retention time, h	2
L, m	38	Air flow, kg/s	0.7

MATERIALS
Reinforced concrete and iron rods

PRICE	
Price per unit, USD	$ 96,340.66
Number, units	5
Total, Mexican pesos	$ 481,703.29

SECURITY MEASURES

The equipment will be totally removed and replaced with the other equipment when maintenance is needed

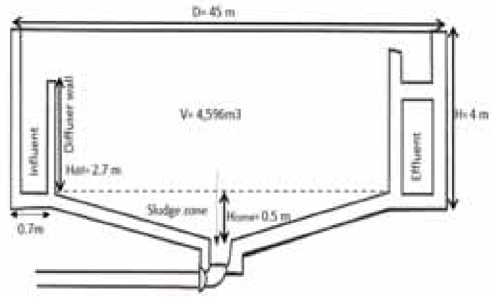
For operators: Obligatory use of masks, gloves, for the storage and displacement of the screens .

The pH and temperature must be closely observed because a small change can affect the reactor efficiency

REFERENCES

(Metcalf & Eddy, 2002)
(Mazzoco, 2017)
(Levenspiel, 2012)
(SEMARNAT, 2015)

1º CLARIFIER INFORMATION SHEET



Circular: Cone 1º Clarifier
OBJECTIVE
General: Reduce organic matter concentration in order to maximize the efficiency of bioreactor
Specific: Remove 2,864.16 kg/d of big solids from the water entering the plant

DESIGN INFORMATION	
Overflowrare, m3/m2 h	2.04
h, m	4
h cone, m	0.5
htot, m	4.5
Thickness, m	0.3

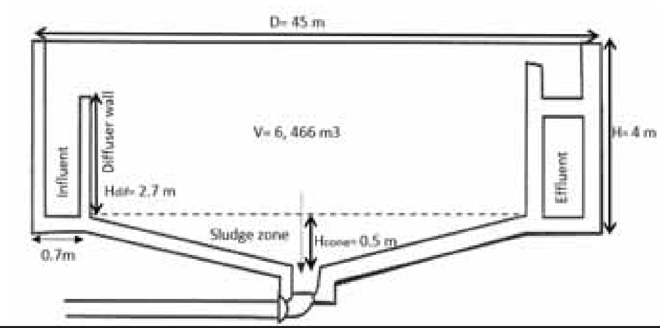
OPERATIONAL CONDITIONS	
T°, °C	25
P, atm	1
*Atmosferic conditions	

MATERIALS
Enforced concrete & iron rods (mesh)

PRICE	
Price per unit, USD	$1,165,684.52
Number, units	1
Total, USD	1,165,684.52

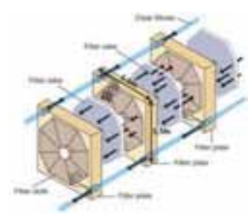
SECURITY MEASURES
The equipment needs to have a mirror in its surface in order to function correctly For operators: Obligatory use of masks, gloves, for the storage and displacement of the screens.

REFERENCES
(The American Water Works Association (AWWA), 2012)
(Metcalf & Eddy, 2002)
(Voutchkov, 2017)
Origen especificado no válido.

2º CLARIFIER INFORMATION SHEET			
 		**Circular: Cone 1º Clarifier**	
		OBJECTIVE	
		General: Reduce organic matter concentration in order to maximize the efficiency of bioreactor	
		Specific: Remove 2,864.16 kg/d of big solids from the water entering the plant	
DESIGN INFORMATION		**OPERATIONAL CONDITIONS**	
Overflowrare, m3/m2 h	1.45	T°, °C	25
h, m	4	P, atm	1
h cono, m	0.5	*Atmospheric conditions	
htot, m	4.5	**PRICE**	
Thickness, m	0.3		
MATERIALS		Price per unit, USD	$1,439,135.80
Enforced concrete & iron rods (mesh)		Number, units	1
		Total, USD	1,439,135.80

SECURITY MEASURES
The equipment needs to have a mirror in its surface in order to function correctly For operators: Obligatory use of masks, gloves, for the storage and displacement of the screens .

REFERENCES
(The American Water Works Association (AWWA), 2012)
(Metcalf & Eddy, 2002)
(Voutchkov, 2017)

FILTER PRESS INFORMATION SHEET	
 	**Press filter** **OBJECTIVE** The general objective of this equipment is to reduce the moisture in the sludge in order to reduce its volume and go to the biogas plant to be treated anaerobically

DESIGN INFORMATION	
h, m	1.90
L, m	10.8
w, m	2.2
Filter plate l,m	1.5

OPERATIONAL CONDITIONS	
T°, °C	25
P, atm	1
*Atmosferic conditions	

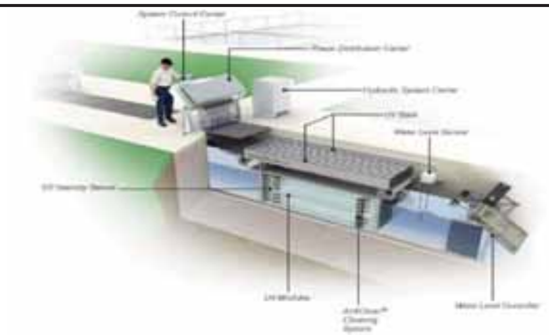
MATERIALS
Reinforced concrete & iron rods

PRICE	
Price per unit, USD	$1,560,388.67
Number, units	1
Total, USD	1,560,388.67

SECURITY MEASURES
For operators: Obligatory use of masks, gloves, for the storage and displacement of the sludge.

REFERENCES
SUPPLIER: Shuangfa
(ACS Medio Ambiente: Sistemas para tratamiento de agua, 2018)

UV TREATMENT INFROMATION SHEET

	TROJANUV3000PLUS
	OBJECTIVE
	General: Reduce fecal coliforms and total suspended solids concentrations.
	Specific: Reduce the fecal coliforms to 1000/100ml, and 30 mg/l of SST.

DESIGN INFORMATION		GENERAL DESCRIPTION	
Lamp Size		Type	
Length, mm	1550	UV treatment with 250W lamps and 125W of germicide potency	
Diameter, mm	25		
Potency, W	250	OPERATIONAL CONDITIONS	
Module size		Inflow, m3/d (min, max)	56000-70000
Length, mm	1.55	UV Transmission	60% min
Height, mm	1.5	Lamp life factor	0.98
Number of lamps	8	Fouling factor	0.95

MATERIALS	
Lamps	4 Pin Step SingleAmalgam
Lamps Output	Amalgam

PRICE	
Price of unit, USD	$ 170,000.00
Operation and maintenance, USD	$ 67,975.00
Total (First year), USD	$ 237,975.00

MASS BALANCE	INFLOW	OUTFLOW
Flow, m3/d	56265	56265
SST, mg/L	264	30
CF, NMP/100mL	12000000	1000

SECURITY MEASURES

The equipment must be used after having the proper capacitation from TROJANUV

For operators: Obligatory use of gloves for the storage and displacement of the screens.

The equipment needs to be given maintenance once each year with a max of 1 year 3 months of delay.

REFERENCES	SUPPLIER	
TROJANUV3000PLUS	TROJANUV	TROJANUV MEXICO

FEEDING HOPPER AND ELEVATOR INFROMATION SHEET	
 	Telestak HF 520 **OBJECTIVE** General: Receive all the waste and move it to the bag opener Specific: Receive 179 tons of waste every day.

DESIGN INFORMATION		GENERAL DESCRIPTION	
Elevator		Design to receive the impacts during the feeding process	
Discharge Height (m)	9		
Belt Width Incline (m)	1		
Belt Width Incline (m)	1		
Incline Conveyor Length (m)	20		
Hooper		OPERATIONAL CONDITIONS	
		Ton/h	Up to 2,000
Stockpile Volume (m3)	1,315	Rotor Power (Kw)	Dual power (Diesel and electric)
Stockpile Mass (ton)	2,100		

MATERIALS	
Hopper	Stainless steel
Conveyor belt	Rubber

PRICE		
Price of unit, Dollars	$	159,000.00

MASS BALANCE		
	INFLOW	OUTFLOW
Flow, ton/h	11.1	11.1

SECURITY MEASURES

The equipment operates safely in earthquake zones.
Telestak can give detailed training for the operators

For operators: Obligatory use of helmet and protection boots and googles.

REFERENCES	SUPPLIER	
Telestak	Telestak	Port of Panama City (USA)

BAG OPENER INFROMATION SHEET

AS8 2000	
OBJECTIVE	
General: Remove the bags from the garbage that arrives the SWTP	
Specific: Remove 98% of the bags from the garbage that enters the bag opener.	

DESIGN INFORMATION		GENERAL DESCRIPTION	
Conveyor size		Removes the plastic bags that enter the equipment	
Length, mm	11900		
Width, mm	1980		
Bag opener size		OPERATIONAL CONDITIONS	
		Max inflow, Ton/h	12
Length, mm	3930	Rotor Power (Kw)	22
Width, mm	2660	Production vol.(mc/h)	300
Weight, kg	21900		

MATERIALS		
Conveyor	Metallic plates	
Bag Opener	Steel	
PRICE		
Price of unit, Mexican pesos		$ 140,000.00
MASS BALANCE		
	INFLOW	OUTFLOW
Flow, ton/h	11.1	11.1

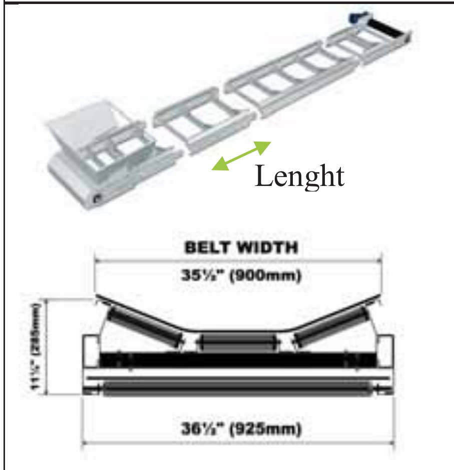
SECURITY MEASURES

The equipment must be used after having the proper capacitation from COPARM

For operators: Obligatory use of helmet and protection googles.

REFERENCES	SUPPLIER	
AS8 2000	COPARM	COPARM

CONVEYOR INFROMATION SHEET



EASIKIT EK900
OBJECTIVE
General: Transport the waste through the plant facilities
Specific: Transport the organic waste to the biogas and fertilizer plant while the operators take all the waste not belonging to this category.

DESIGN INFORMATION		GENERAL DESCRIPTION
Module size		Removes the plastic bags that enter the equipment
Length, mm	1200	
Width, mm	900	
Weight, lb	115	**OPERATIONAL CONDITIONS**
		Max inflow, Ton/h

MATERIALS	
Belt	Rubber
Supporter	Mild steel

PRICE		
Price per 1 unit of 7 modules, Dollars	$	3,686.00
Number of equipments		6
Total price, Dollars	$	22,116.00

MASS BALANCE		
	INFLOW	OUTFLOW
Flow, ton/h	11.1	6.7

SECURITY MEASURES
For operators: Obligatory use of helmet, overall, protection googles and face masks with respirators against particles.

REFERENCES	SUPPLIER	
INTERQUIP	INTERQUIP	

<table>
<tr><td colspan="4">SHREDDER INFROMATION SHEET</td></tr>
<tr><td colspan="2" rowspan="4"> </td><td colspan="2">TR 150</td></tr>
<tr><td colspan="2">OBJECTIVE</td></tr>
<tr><td colspan="2">General: Reduce the size of the organic matter and other materials that can’t be recycled</td></tr>
<tr><td colspan="2">Specific: Reduce the size of the material shredded to at least $10cm^2$</td></tr>
<tr><td colspan="2">DESIGN INFORMATION</td><td colspan="2">GENERAL DESCRIPTION</td></tr>
<tr><td colspan="2">Shredder size</td><td colspan="2" rowspan="3">Equipment that reduces the size of material while crushing and breaking it</td></tr>
<tr><td>Length, mm</td><td>3800</td></tr>
<tr><td>Width, mm</td><td>2160</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">OPERATIONAL CONDITIONS</td></tr>
<tr><td>Max inflow, Ton/h</td><td>12</td></tr>
<tr><td>Height, mm</td><td>2200</td><td>Rotor Power (Kw)</td><td>110</td></tr>
<tr><td>Blades, mm</td><td>100</td><td>Rotation speed (RPM)</td><td>18-12</td></tr>
<tr><td colspan="4">MATERIALS</td></tr>
<tr><td>Shredder</td><td colspan="3">Steel</td></tr>
<tr><td>Blades</td><td colspan="3">Steel</td></tr>
<tr><td colspan="4">PRICE</td></tr>
<tr><td colspan="3">Price of unit, Mexican pesos</td><td>$ 202,200.00</td></tr>
<tr><td colspan="4">MASS BALANCE</td></tr>
<tr><td></td><td colspan="2">INFLOW</td><td>OUTFLOW</td></tr>
<tr><td>Flow, ton/h</td><td colspan="2">7.5</td><td>7.5</td></tr>
<tr><td colspan="4">SECURITY MEASURES</td></tr>
<tr><td colspan="4">The equipment must be used after having the proper capacitation from COPARM

For operators: Obligatory use of helmet, metallic gloves and protection googles.</td></tr>
<tr><td>REFERENCES</td><td colspan="3">SUPPLIER</td></tr>
<tr><td>TR 150</td><td>COPARM</td><td colspan="2">COPARM</td></tr>
</table>

Annex 3 “Estimation of cost operation fro the UV”

TROJANUV3000PLUS™

ESTIMACIÓN DE COSTES DE OPERACIÓN

Condiciones de Operación

Caudal medio: 46 620 m3/d
Utilización anual: 8 760
Transmitancia UV: 60 %

Requisitos de Potencia		**Sustitución de Lámparas**	
Demanda media de potencia:	**20.3 kW**	Número de lámparas por año:	71
Costo per kWh:	$ 0.25 (USD)	Precio por lámpara:	$ (USD)
Costo anual de la potencia:	$ 44 403 (USD)	**Costo anual de reposición de lámparas:**	$ 23 572 (USD)
Total Anual de Costo de O&M: $ 67 975 (USD)			

Esta estimación de costos se basa en el caudal medio y la transmitancia UV indicados más arriba. Los costos reales de operación pueden ser inferiores debido a la rutina automática de ajuste de dosis del TrojanUV3000Plus™. Conforme la demanda UV disminuye, debido a cambios en las condiciones de operación, disminuye, en consecuencia, el nivel de potencia de la lámpara. La rutina de ajuste de dosis disminuye los niveles de potencia del equipo conservando la dosis UV objetivo para asegurar la desinfección en todo momento.

Annex 4 “Supplier sheet of specifications for the press filter”

型号 Type	过滤面积 Filter area (m^2)	滤板尺寸 Filter plate size (mm)	滤饼厚度 Filter cake thickness (mm)	滤室容积 Filter chamber volume (L)	滤板数量 Filter plate number (PCS)	过滤压力 Filtrating pressure (MPa)	电机功率 Motor power (KW)	整机重量 Weight (Kg)	外形尺寸 Dimension (mm) (L×W×H)
XY50/1000-30U	50	1000×1000	30	752	28	0.6	4.0	4072	4040×1500×1400
XY60/1000-30U	60			914	34			4468	4460×1500×1400
XY70/1000-30U	70			1063	40			4863	4760×1500×1400
XY80/1000-30U	80			1219	46			5259	5120×1500×1400
XY100/1000-30U	100			1505	57			5985	5800×1500×1400
XY120/1000-30U	120			1816	69			6776	6500×1500×1400
XY100/1250-30U	100	1250×1250		1479	36	0.6	4.0	6728	5020×1880×1600
XY120/1250-30U	[illegible]			[illegible]	43			[illegible]	5740×1770×1600
XY140/1250-30U	140			2034	51			[illegible]	5990×1770×1600
XY160/1250-30U	160			2381	58			8205	6450×1770×1600
XY180/1250-30U	180			2669	65			10044	6905×1770×1600
XY200/1250-30U	200			2965	72			10851	7360×1770×1600
XY220/1250-30U	220			3285	80			11765	7880×1770×1600
XY250/1250-30U	250			3737	91			12834	8600×1770×1600
XY200/1500-30U	200	1500×1500		3025	49	0.6	7.5	19530	6400×2200×1900
XY250/1500-30U	250			3739	61			22478	7225×2200×1900
XY300/1500-30U	300			4413	74			25526	8130×2200×1900
XY350/1500-30U	350			5210	86			28720	8570×2200×1900
XY400/1500-30U	400			6007	99			32074	9880×2200×1900
XY450/1500-30U	450			6743	111			35086	10820×2200×1900
XY500/1500-30U	500			7478	123			38106	11560×2200×1900

Annex 5 “Calculation for WWTP reactor”

	Influent		Yield	Efluent		
	Q, m3/d	56160	650	50.194%		
	COD (mg/L)(g/m3)	330	55%	COD (mg/L)(g/m3)	150	180
	bCOD, mg/L (g/m3)	287.84	17%	DBO5 (mg/L) (g/m3)	150	29.9
o/nbvss.htm	nbCOD, mg/L (g/m3)	42.16	73%	SST (mg/L) (g/m3)	40	110
	nbVSS, mg/L (g/m3)	20	40%	Ntot (mg/L) (g/m3)	25	17
	DBO5 (mg/L) (g/m3)	179.9	43%	Ptot (mg/L) (g/m3)	4	3
	SST (mg/L) (g/m3)	150	73%	VSS, mg/L	25	-25.00
	Ntot (mg/L) (g/m3)	42	0%	olifromes totales, NMP/	12000000.00	
	Ptot (mg/L) (g/m3)	7				
	SRT, d	3	Tabla 8-6			
	Colifromes totales, NMP/ml	12000000				
	Y, g VSS/ g bCOD	0.40				
	S0, g bCOD/m3	287.84				
	kd@20, gVSS/gVSS-d	0.12				
	o, k@20	1.04				
	kd@25, gVSS/gVSS-d	0.15				
	μ_m 20°C	1.07				
	Ks, g bCOD/m3	20.00				
	S, g bCOD/m3	16.23				
	Px,vss, kg/d	4521.78				
	f_d	0.15				

Solids Retention Time. The SRT, in effect, represents the average period of time during which the sludge has remained in the system. As presented previously in Chap. 7, SRT is the most critical parameter for activated-sludge design as SRT affects the treatment process performance, aeration tank volume, sludge production, and oxygen requirements. For BOD removal, SRT values may range from 3 to 5 d, depending on the mixed-liquor temperature. At 18 to 25°C an SRT value close to 3 d is desired where only BOD removal is required and to discourage nitrification and eliminate the associated oxygen demand. To limit nitrification, some activated-sludge plants have been operated at SRT values of 1 d or less. At 10°C, SRT values of 5 to 6 d are common for BOD removal only. Temperature and other factors that affect SRT in various treatment applications are summarized in Table 8–6.

	aeration basin			
				37524.68027
	Px,vss, kg/d	5644.98		
	Px,tss, kg/d	12508.23	eq 8-15	
	Xtss, mg/L (g/m3)	3000.00	eq 8-16	
	V,m3	12508.23		
	retention time t, h	1.78		
justfy	fraction VSS	0.45		
	MLSS, mg/L (g/m3)	1354		
	F/M	0.60		
	4 reactores	4169.41		
1 por mtto	c	4.50		
	b	30.00		
	a	31.00		
	Grosor de pared, m	0.30		
	V, m3 c/uno	4185.00		

9. Design MLSS X_{TSS} concentration = 3000 g/m³; values of 2000 to 3000 g/m³ can be considered

a. Determine the aeration tank volume using the relationship from Step 3b.

$(V)(X_{TSS}) = 25{,}405$ kg

At $X_{TSS} = 3000$ g/m³

$$V = \frac{(12{,}064\ \text{kg})(10^3\ \text{g/kg})}{(3000\ \text{g/m}^3)} = 4021\ \text{m}^3$$

a. Determine the aeration tank volume using the relationship from Step 3b.

$(V)(X_{TSS}) = 25{,}405$ kg

At $X_{TSS} = 3000$ g/m³

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FLUJO AIRE U OXÍGNEO NECESARIO P/BIOREACTOR		
Flujo oxígeno, g/s	27.5977	p 817 para aireadores
Flujo aire, g/s	131.417619	
Flujo aire, kg/s	0.13	

Table 8–28 Typical aeration tank dimensions for mechanical surface aerators

Aerator size hp	Aerator size kW	Tank depth ft	Tank depth m	Tank width ft	Tank width m
10	7.5	10–12	3–3.6	30–40	9–12
20	15	12–14	3.6–4.2	35–50	10.5–15
30	22.5	13–15	3.9–4.5	40–60	12–18
40	30	12–17	3.6–5.1	45–65	13.5–20
50	37.5	15–18	4.5–5.5	45–75	13.5–23
75	56	15–20	4.5–6	50–85	15–26
100	75	15–20	4.5–6	60–90	18–27

Table 5.1.1 Design Parameters of Activated Sludge Process

	MLSS mg/l	F:M kgBOD/KgSS/Day	Reactor Depth m	Reactor Shape	HRT h	Primary Sedimatation
CAS	1,500–2,000	0.2–0.4	4–6 (10: Deep Aeration)	Rectangular	6–8	yes
OD	3,000–4,000	0.03–0.05	1–5	Racetrack	24–36	no
EA	3,000–4,000	0.05–0.10	4–6	Rectangular	16–24	no
SBR	1,500–2,000 2,000–3,000	0.2–0.4 0.03–0.05	4–5	Rectangular	Varied	no
PO	3,000–4,000	0.3–0.6	4–6	Rectangular	1.5–3	yes

MLSS: Mixed Liquor Suspended Solids
F:M: Food Microorganizm Ratio
HRT: Hydraulic Retention Time
CAS: Conventional Activated Sludge
OD: Oxydation Ditch
EA: Extended Aeration
SBR: Sequence Batch Reactor
PO: Pure Oxygen

	CAS	
MLSS	1750	
F:M	0.3	
REACTOR DEPT	4.5	igual que el clarificador
REACTOR shap	rectangular	
hrt,h	7	

$$S = \frac{K_s[1 + (k_d)\mathrm{SRT}]}{\mathrm{SRT}(\mu_m - k_d) - 1}$$

Use μ_m and k_d from Table 8–10.

$$P_{X,VSS} = \frac{QY(S_o - S)}{1 + (k_d)\mathrm{SRT}} + \frac{(f_d)(k_d)QY(S_o - S)\mathrm{SRT}}{1 + (k_d)\mathrm{SRT}}$$

Define input data for above equation.

$Q = 22{,}464\ m^3/d$

$Y = 0.40$ g VSS/g bCOD (Table 8–10)

$S_o = 224$ g bCOD/m^3 (see Step 1)

Annex 6 “Calculation for Grit Removal”

http://www.bvsde.ops-oms.org/tecapro/documentos/agu

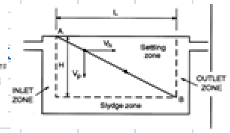
https://www3.epa.gov/npdes/pubs/final_sgrit_rer

Horizontal			
izontal velocity Vh,	0.2		http://web.deu.edu.tr/atiksu/ana52/gritdetail.pdf
Detention time, s	60		
Q, m3/s	0.65		
ettling velocity Vp, m	0.02		
ecific gravity of parti	2.65		https://www.epa.ie/pubs/advice ... ninary.pdf
pecific gravity of wat	1		
d particle, mm	0.15		
d particle, m	2E-04		
g, m/s2	9.81		surface area, m2
n, kg/m s	0.001		
oss sectional Area,	3		
Theoretical L, m	12	L=Vh*t	http://web.deu.edu.tr/atiksu/ana52/gritdetail.pdf
Actual L, m	16		http://web.deu.edu.tr/atiksu/ana52/gritdetail.pdf
liquid depth h, m	1	h=Vp*t	
Free board depth m	0.6		
Depth of accumulated gr	0.15		
actual height H, m	2		To mantain velocity a flow control is placed at the end of the channel
Width	2.682		Proportional weir

$$V = \left[\frac{\gamma_s - \gamma_w}{18\mu}\right] D^2$$

where

V = terminal velocity
γ_s = unit weight of spheres
γ_w = unit weight of liquid
μ = viscosity of liquid
D = diameter of sphere



Proportional weir		
Cd	0.61	http://www.yourarticlelibrary.com/water-pollution/primary-treatment-of-waste-water/78661
b, m	1.036	
a, m	0.038	
w', m	0.117	

TABLE 4 HORIZONTAL FLOW GRIT CHAMBER DESIGN CRITERIA

Item	Design Criteria Range Metric (English)	Design Criteria Typical Metric (English)
Detention time	45-90 s	60 s
Horizontal velocity	0.24-0.4 m/s (0.8-1.3 ft/s)	0.3 m/s (1.0 ft/s)
Settling velocity[1]:		
50-mesh	2.8-3.1 m/min (9.2-10.2 ft/min)	2.9 m/min (9.6 ft/min)
100-mesh	0.6-0.9 m/min (2.0-3.0 ft/min)	0.8 m/min (2.5 ft/min)
Headloss (% of channel depth)	30-40%	36%[2]
Inlet and outlet length allowance	25-50%	30%

[1]If the specific gravity of the grit is significantly less than 2.65, lower velocities should be used.
[2]For Parshall flume control.

Proportional Weir Design:

$$Q = 0.61\, b\, \sqrt{2\ ag}\left(h - \frac{a}{3}\right)$$

$Q = 0.2875\ m^3/s$

$h = 1.1m,$

a ranges between 25 to 50 mm.

Assumed a = 50 mm = 0.05 m.

$$b = \frac{Q}{0.61\ \sqrt{2\times0.05\times9.81}\ (1.1 - \frac{0.05}{3})}$$

$$= \frac{0.2875}{0.6545} = 0.439 = 0.44m$$

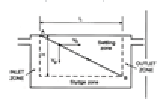
The profile of the curved edges of the weir is calculated using Eq. (9.7).

$$W' = b\left(1 - \frac{2}{\pi}\tan^{-1}\left(\frac{h'}{a} - 1\right)^{1/2}\right)$$

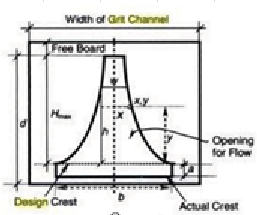
b = 0.44 m, a = 0.05 m.

The calculated values of w' corresponding to the several assumed values of h' are listed below :

h', m	0.05	0.10	0.15	0.20	0.30	0.40	0.50	0.60	0.70	0.80	1.00	1.10
w', m	0.44	0.22	0.172	0.147	0.118	0.101	0.090	0.082	0.076	0.071	0.063	0.060



- The particle will travel vertically from A to B in the same time as it takes to travel horizontally from A to B
- This is the detention time and is given by $t_r = \frac{H}{v_s} = \frac{L}{v_h}$
- Furthermore, $v_h = \frac{Q}{BH}$ (continuity)



a and b = weir constants
x = weir width at liquid surface
y = liquid depth
d = total liquid depth
= H_{max} + a + grit storage depth

$$x = b\left(1 - \frac{2}{\pi}\tan^{-1}\left(\frac{y}{a}\right)^{0.5}\right)$$

$$b = \frac{Q_{max}}{H_{max}^{1.5}\, 0.62\left[2g\frac{Q_{min}}{Q_{max}}\right]^{0.5}}$$

$$Q = 4.97a^{0.5}b\left(h + \frac{2a}{3}\right)$$

$$Q = C_d b (2ga)^{0.5}\left(h + \frac{2a}{3}\right)$$

$$a = \frac{Q_{min}}{Q_{max}} H_{max}$$

C_d value is 0.6 to 0.65

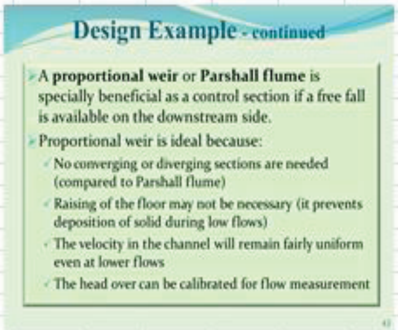
b is taken as ‘channel width – 150 mm’!

Proportional weir (Sutro weir)

no-desare.pdf

Balance grit removal

Q, m3/s	0.651219763
30 m3/ 10^6 m3	
m3 grit/m3 water	0.00003
m3 grit/s	0.0000195
m3 grit/h	0.001172196
m3 grit/d	0.028132694



Wastewater Treatment

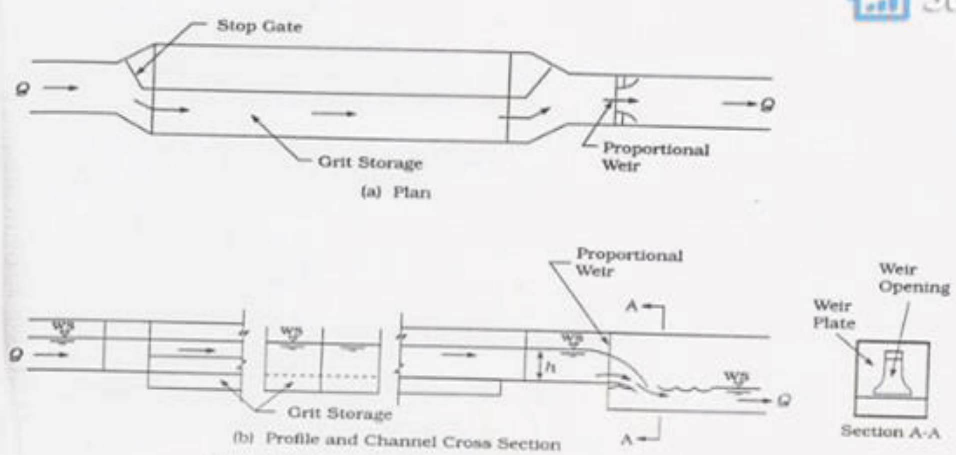
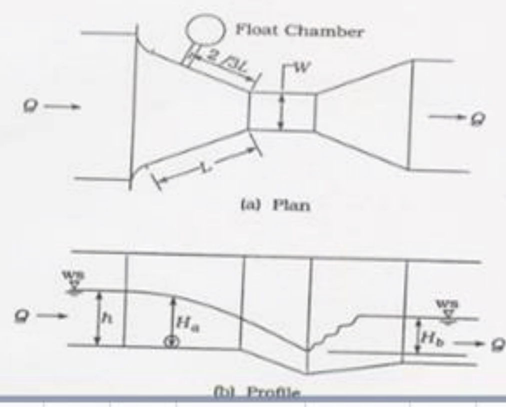


FIGURE 7.7 *A Horizontal-Velocity Grit Settling Chamber with a Proportional Weir Control Section*



Annex 7 "Calculation for 1°/2° Clarifier"

file:///E:/Material/735735ded23d4d28db9cc4f879e8da24.pdf

Extra depth of primary sedimentation tank shall be around 50 cm.

Table 4.3.1 Typical Removal Rate at Primary Sedimentation Tank

BOD	SS	COD
30–50%	40–60%	30–50%

flujo entrada, m3/h	2344.00
Overflowrare, m3/m2 h	2.04
área clarif , m2	1149.02
Diámetro clarif, m	38.25
Radio, m	19.12
h, m	4
h cono, m	0.5
htot, m	4.5
v, m3	4596.078431

Balance de materia	Entrada	Salida
Q, m3/d	56160	56160
COD (mg/L)(g/m3)	557	334.2
DBO5 (mg/L) (g/m3)	257	179.9
SST (mg/L) (g/m3)	250	150
Ntot (mg/L) (g/m3)	42	42
Ptot (mg/L) (g/m3)	7	7
VSS, mg/L	60.00	36.00

Table 8.2. Typical Sedimentation Surface Loading Rates for Long, Rectangular Tanks and Circular Tanks Using Alum Coagulation

Application	m/day	gpd/ft^2	
Turbidity removal	33 to 49	800 to 1,200	2.0416667
Color and taste removal	24 to 41	600 to 1,000	
High algae content	20 to 33	500 to 800	

https://www.accessengineeringlibrary.com/browse/water-treatment-plant-design-fifth-edition/c9780071745727ch08#ch08lev1sec03

Table 4.10 Preferred overflow rates ($m^3/m^2 \cdot h$ [gpd/sq ft]) (WEF, 1998).

	Circular clarifiers		Rectangular clarifiers	
Flow	Range	Average	Range	Average
Average	0.68–1.19	0.95	0.68–1.19	0.95
	(400–700)	(560)	(400–700)	(560)
Peak	1.70–2.72	2.09	1.70–2.72	2.10
	(1000–16 000)	(1230)[a]	(1000–16 000)	(1240)[b]

[a] 10 of 15 firms use 2.04 $m^3/m^2 \cdot h$ (1200 gpd/sq ft).
[b] 8 of 13 firms use 2.04 $m^3/m^2 \cdot h$ (1200 gpd/sq ft).

Table 4.3

http://www.assettler.com/COKTURME%20TANKLARI%20TASARIMI.pdf

flujo entrada, m3/h	2344.00	
Overflowrare, m3/m2 h	1.45	
área clarif , m2	1616.55	
Diámetro clarif, m	45.37	(max. 46 m)
Radio, m	22.68	
h, m	4	
h cono, m	0.5	
htot, m	4.5	
v, m3	6466.2069	

Tabla 6.2 Información para el diseño de sedimentadores secundarios (Metcalf & Eddy, 1996)

Tipo de tratamiento	Carga de superficie, m^3/m^2		Carga de sólidos, kg/m^2-h		Profundidad, metros
	Media	Punta	Media	Punta	
Sedimentación a continuación del proceso de lodos activados	0.678 - 1.356	1.695 - 2.035	3.9 - 5.85	9.76	3.6 - 6.0

Annex 8 "Calculation for Filter Press"

				Sludge	ciclo 8 hrs	HUMEDC	SECO
p/ obtener			Tipo de lodo	% sólidos por peso (base seca)	Peso humedo m3/ ciclo	kg/m3	kg/m3
la capacidad del filtro			1°/2°	15%	21.475	0.3375	0.135
			Cal				
					L/ciclo	kg/L	
					21475	0.0003	
	0.2 Peso Humedo=Peso Seco						
	(0.5)(0.8)Peso Humedo= Peso Seco					8.0531	m3/ciclo
	Peso seco	m3/d	64.425	10.95225	http://www.acs	8053.1	L/ciclo
					https://www.l enntech.es/filt ro-de-prensa-		
	COSTOS	m3/h	2.684375				
		gal/h	709.136713			32.213	

Características y producción de lodos residuales

Proceso	Gravedad especifica lodo	Peso seco Kg/1000 m³
Sedimentación primaria	1.02	110-170 (150)

Tipo de Lodo	Porcentaje de Sólidos por Peso (Base Seca)	Peso promedio por ft³ (Base Seca)
Biológico	15 – 25%	15 lbs
Hidróxido metálico	25 – 40%	25 lbs
Lodo de Cal	30 – 60%	35 lbs

Tabla 1.- Tipos de Lodos más comunes

CICLO: Tiempo de llenado y compactación de lodo dentro de un Filtro Prensa.

$$\frac{Total\ de\ galones}{por\ ciclo} \times \frac{Sólidos}{por\ peso} \times \frac{Peso\ en\ libras}{por\ galón\ de\ líquido} \div \frac{Peso\ (lbs)}{por\ ft^3} = \frac{Capacidad\ (ft^3)}{por\ ciclo}$$

Ecuación 1.- Capacidad del Filtro Prensa

Un ejemplo puede ser: si se requiere procesar 1,000 gal /ciclo, y el contenido de sólidos es de 10%, donde el peso en libras por galón de agua líquida es de 8.34 lbs/gal y el tipo de lodo fuera Hidróxido Metálico con 25 lbs de peso seco/ft^3, se tiene:

$$1{,}000\,\frac{gal}{ciclo} \times 0.01 \times 8.34\,\frac{lbs}{gal} \div 25\,\frac{lbs}{ft^3} = 3.3\,\frac{ft^3}{ciclo}$$

Ejemplo 1.- Cálculo de la Capacidad del Filtro Prensa

El resultado interior indica que se requiere un Filtro Prensa capaz de procesar 3.3 ft^3/ciclo.

Annex 9 “Calculation for the entry channel”

Q, m3/s	0.65121976
A, m2	2.25
V, m/s	0.9
B,m	1.5
Equipment Name	1.5
Rh,m	0.5
n	0.011
S	0.0026%

Annex 10 "Quotation Coarse Solid"

AFRAMEX®

Naucalpan, Edo. de Méx. a 3 de Marzo de 2018 **Ref: RMB0030318-UDP**

UDLAP
Tel: (222) 217 5243
Correo: andrea.arredondono@udlap.mx

At´n : Ing. Andrea Arredondo N.:

Sometemos a su consideración nuestra siguiente cotización por el suministro de los siguientes equipos en su proyecto de referencia:

Hola ing. buena tarde. Claro que sí. A continuación enlisto los datos que me solicita;

Caudal: 0.65 m3/s

Ancho del canal: 1m

Alto del canal: 1 m

Apertura de malla: 100-150 mm (es para sólidos medios- grandes)

Partida 1 **(Rejilla automática de medios)**
Cantidad 1 pza. Suministro de un sistema de rejilla automática autolimpiable de posición inclinada, tipo cadena. para cribado de medios de agua residual, con apertura de cribado de 10 mm. marca AFRAMEX, Modelo: **AFR-RC-AC800-PC800-AD2000-AE2000-EH12** manufacturada en acero inoxidable AISI 304, con las siguientes características:

REJA DE CADENAS

Caudal:	650 l/s
Velocidad:	0.88 m/s
Ancho de canal:	1000 mm.
Alto de canal:	1000 mm.
Apertura de la reja:	10 mm.
Altura de descarga:	1200 mm (Desde el fondo del canal)
Inclinación:	80º.
Número de peines:	2 UD
Número de coronas:	4 UD
Acccionamiento:	Motoreductor de velocidad
Rodillos:	50/60

MATERIALES:

Bastidor:	Acero inoxidable AISI304
Rejilla:	Acero inoxidable AISI304
Engranes conducidos:	Acero especial
Cadena transportadora:	Acero galvanizado
Bujes:	Acero galvanizado

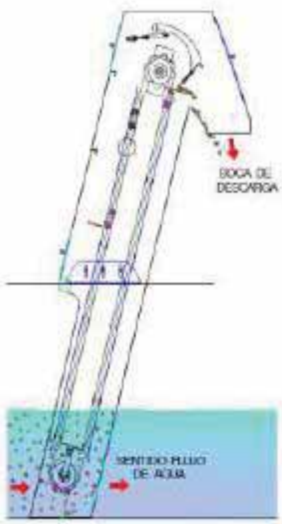
TABLERO DE CONTROL
Tablero de control a pie de rejilla, aislamiento IP55 (NEMA 4X), material acero inoxidable AISI 304, con los siguientes elementos de operación:

- Modo local, capacidad de operar en modos manual
- Semiautomático (continuo)
- Marcha forzada y automática con sistema de detección de pérdida de carga regulable a través de boya de nivel.

Pafnucio Padilla No. 26-3B, Col. Cd. Satélite, Naucalpan Edo de México.
CP 54080 Tel +52(55)1515 0202, www.aframex.mx , raul.barreraera@aframex.mx 1/3

Precio unitario sistema de rejilla incluyendo tablero de control: **38,656 USD**

Precio unitario menos 5% de descuento: **36,723 USD**



Esquema de Funcionamiento

Condiciones Comerciales:

Precios
Los precios cotizados deberán de incrementarse con el 16% de IVA a su cargo.

Lugar de entrega: LAB Nuestra planta ubicad en Querétaro, no incluye embalajes.

Tiempo de entrega: 8-10 semanas, se considera a partir de la fecha de recepción de su anticipo y fecha de su autorización de dibujos certificados para manufactura.

La entrega de dibujos certificados para manufactura para su autorización será en un plazo máximo de diez días hábiles siguientes a la recepción de su anticipo.

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CP 54080 Tel +52(55)1515 0202, www.aframex.mx , raul.barreraera@aframex.mx

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