UNIVERSITAT POLITÈCNICA DE VALÈNCIA

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Process to obtain organic fertilizer from wastewater

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“Persistence is very important. You should not give up unless you are forced to give up”

– Elon Musk

Summary

In this project, titled: Process to obtain organic fertilizer from wastewater, it is shown the manufacturing process from two different plants: sewage plant and composting plant. It is divided mainly into 2 big parts. In the first one will be explained how the plants work, the necessary machinery needed to make it possible, and the maintenance that must be done to keep the machines working properly longer time. In the second part, it is going to be calculated the sizing of the fertilizer line depending on a specific amount of sludge. For that, first it has been calculated which machines shape the specifications, then an industrial plant has been searched and finally the consumption and installation of the compressor and compressed air grid have been calculated.

KEY WORDS

Circular Economy, maintenance, wastewater process, composting process, compressed air installation.

Resumen

En este proyecto, titulado: Proceso para obtener fertilizante orgánico a partir de aguas residuales, se muestra el proceso de fabricación de dos plantas diferentes: planta depuradora y planta de compostaje. Se divide principalmente en 2 partes. En la primera, se explicará cómo funcionan las plantas, la maquinaria necesaria para que sea posible su procesamiento y el mantenimiento que se debe hacer para que las máquinas trabajen correctamente durante más tiempo. En la segunda parte, se calculará el dimensionado de la línea de fertilizante en función de una cantidad específica de lodo. Para ello, primero se ha calculado qué máquinas se adaptan a las especificaciones, luego se ha buscado una planta industrial y finalmente se ha calculado el consumo e instalación de aire comprimido.

PALABRAS CLAVE

Economía circular, mantenimiento, proceso de aguas residuales, proceso de compostaje, instalación de aire comprimido.

Resum

En aquest projecte, titulat: Procés per obtenir fertilitzant orgànic a partir d'aigües residuals, es mostra el procés de fabricació de dos plantes diferents: planta depuradora i planta de compostatge. Es divideix principalment en 2 parts. En la primera, s'explicarà com funcionen les plantes, la maquinària necessària per a què siga possible el seu processament i el manteniment que s'ha de fer perquè les màquines treballen correctament durant més temps. En la segona part, es calcularà el dimensionat de la línia de fertilitzant en funció d'una quantitat específica de fang. Per a això, primer s'ha calculat quines màquines conformen les especificacions, després s'ha buscat una planta industrial, i finalment s'ha calculat el consum i la instal·lació d'aire comprimit.

PARAULES CLAU

Economia circular, manteniment, procés d'aigües residuals, procés de compostatge, instal.lació d’aire comprimit.

ABBREVIATIONS

(º): Inclination, degrees

μ= medium viscosity

CF: Concentration Factor

cm: centimetre

d= particle diameter

ft^2: square feet

g= gravity

H: height

h: hour

HP: Horsepower

Kg: kilogram

KN: kilo Newton

kw: Kilowatts

L: length

lb: pound

m: meters

m^2: square meter

m^3: cubic meter

Min: minutes

mm: millimetres.

ºC: Celsius degrees

rmp: revolutions per minute

t: tones

T: torque

Vs= Stokes velocity

W: width

WWTPs: Wastewater treatment plants.

ρ=water density

ρs= particle density

1. CONTENTS

REPORT

Objective

It is imperative to make collective awareness of climate change in our communities; the irresponsible usage of resources has led to the perennial waste of useful materials. For that reason, throughout this project, the author will be describing concepts such as Circular Economy, organic products, and environmental sustainability to make it easier to understand why the author has chosen this topic. From the mechanical engineering point of view, two different processes will be taken into account. First the wastewater treatment plant and then the composting plant. In both cases how the process is carried out, the needed maintenance and the change that the material suffers will be explained. The intention of the author has been to explain and introduce the concepts and the processes with a simple and easy vocabulary in order to make it unchallenging to the reader without technical knowledge, because for the author is more important to reach as many people as possible, and introduce these concepts to them, that maybe in the university environment are common but outside it, there are people that are not conscious about the environmental problem in which we are getting in.

For the technical part, the author has sized a composting plant with the mission to show how a composting plant can be.

Process diagram

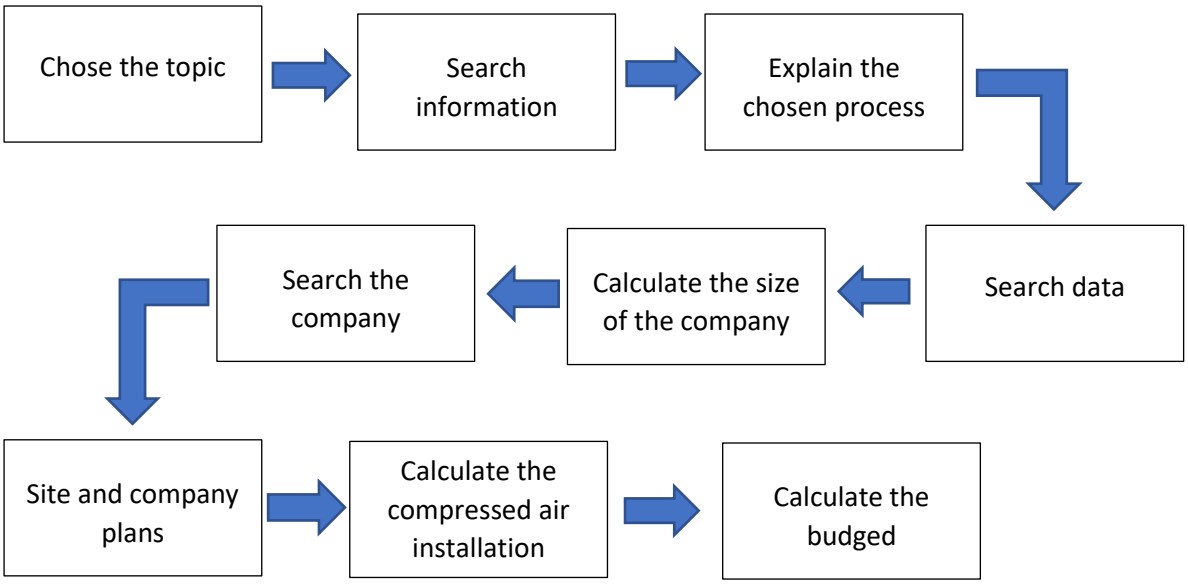

Figure 1 Flowchart

INTRODUCTION

1 CIRCULAR ECONOMY

" «A Europe that uses resources effectively» is one of the seven flagship initiatives that are part of the Europe 2020 strategy that aims to generate smart, sustainable and inclusive growth. It is currently Europe's main strategy for generating growth and employment, with the backing of the European Parliament and the European Council. " (F. Ellen MacArthur , 2014)

This was the plan in 2014 for Europe. Starting with this paragraph is to give an example of how important the Circular Economy is, that one of the most powerful economic power in the world wants to implement it.

This project aim is to have an efficient economy where carbon emission and sources are improved:

- Guarantee the essential resources.

- Increase the economic power of Europe boosting the innovation.

- Reduce the use of the sources while the results are improved.

- Fight against climate change and limit the environmental impacts of the use of resources. (F. Ellen MacArthur , 2014)

Circular Economy is strongly related to the concept of sustainability. Its objective is to keep the sources longer in the consumption cycle in order to reduce pollution and the trash generation. It is about to close the cycle and does not have an open line use of the sources which make the life of the materials shorter.

It is the intersection between the social, environmental and social aspects. (F. Ellen MacArthur , 2014)

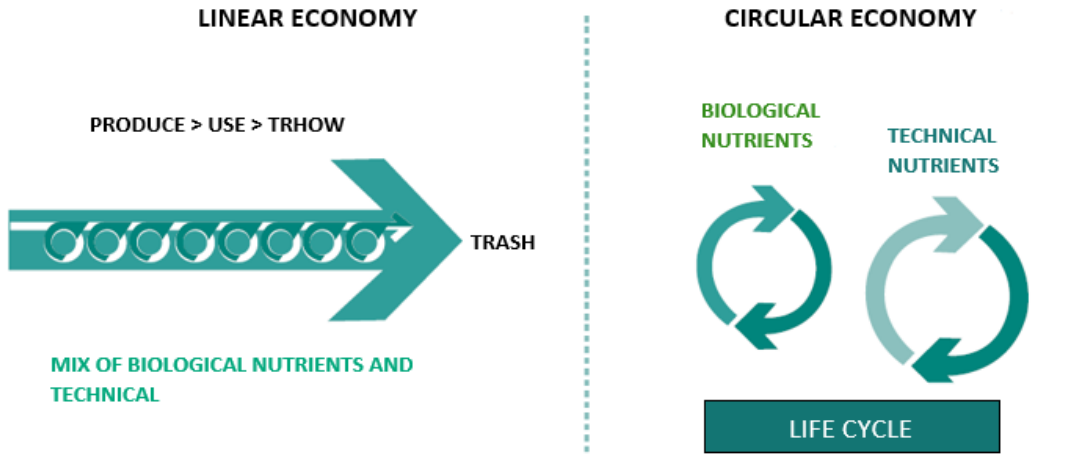

Figure 2 Comparison between linear and circular economy Source: (MacArthur, 2014)

1.1 PRINCIPLES

The circular economy has 3 main principles:

1. Increase and preserve natural assets by using renewables sources and finite stocks.
    - When sources are needed, the circular economy chose them carefully and use processes and technologies which utilize high performance or if possible, renewable sources. It also reuses the natural sources, making possible to manipulate them and apply them on the ground.
2. Optimize the sources yield, to keep the material, products, and pieces circulating at their highest utility level.
    - It means, it is necessary to design a system to recycle, rework and relaborate to keep everything as much as possible inside the loop. The preference in this closed-loop is to keep rather than recycle to reduce the usage of energy.
3. Demonstrate the effectiveness of the Circular Economy, protecting the system against external adversities.
    - This include reduces the damage caused by areas and systems which affect the people and manage to control or reduce the effect from the external facts such as pollution, emissions, and noise. (E. Cerdá, 2016)

1.2 CLOSING LOOPS

Circular Economy tries to rebuild any kind of capital which guarantees improved flows of goods and services. It would mean a change in the logistics of the economy because it changes the way to behave with the products, reuse as much material as possible, recycle when it cannot be reused, repair what is broken and if it can't be repaired, remanufacture it.

"A study of seven European nations found that a shift to a circular economy would reduce each nation's greenhouse-gas emissions by up to 70% and grow its workforce by about 4%" (Stahel, 2016)

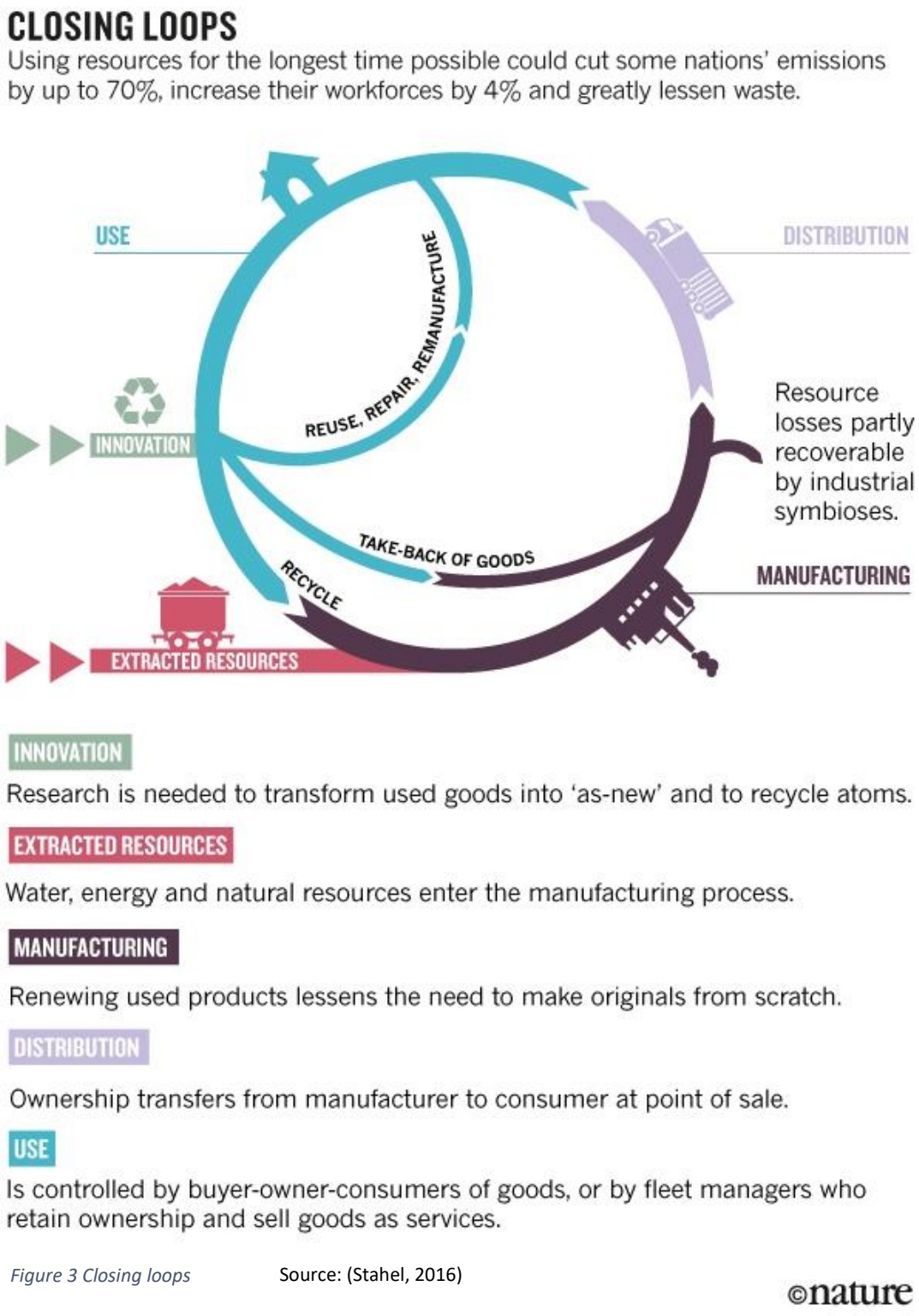

Figure 3 Closing loops Source: (Stahel, 2016)

2 ORGANIC PRODUCTS

2.1 ORGANIC PRODUCTION

“Organic production is a system that integrates "cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity” - (National Organic Program, 2019)

It seems like the concept of sustainable development is between us for centuries, but it was not until 1992 when in the United Nations Conference about the Environment and Development they started to use it. The goal was to use the natural sources carefully without negatively affecting future generations and achieving the economic proposals.

Apparently, consumers start to be aware of the effect that their daily habits have repercussion in their health and to the environment, that’s why the companies have had to adapt to the new demands of the society.

Consumers perceive these products like more respectful with the environment, healthier and higher quality. (L. Beltrán, 2009)

2.2 ORGANIC AND INORGANIC FERTILIZERS

Now it is going to be explained the main differences between the organic and inorganic fertilizer and compare their advantages and disadvantages.

The first one, organic fertilizer is made by natural ingredients from animals or plants discarding any chemical.

On the other hand, the chemical fertilizers, are composed of synthetic chemicals or manufactured minerals.

Both feed the ground, but there are some significant differences in how they affect it. (Lenahan, 2019)

2.3 ORGANIC FERTILIZER ADVANTAGES AND DISADVANTAGES

2.3.1 Advantages

1. Non- toxic food products: The obtained products are non-toxic what ensures healthy consumption.
2. On-farm preparation and production: it doesn’t need complex processes to obtain it.
3. Low investment capital.
4. Enhance soil fertility and improved soil texture, drainage, and aeration: Organic fertilizers ensure that the soil stays fertile much longer.
5. Competitive economy: It contributes to a competitive economy, low-carbon emission, sustainable and efficient source.
6. Safe environment: it helps to keep the circular economy because it helps to keeps the environmental sustainability and its continuity.

2.3.2 Disadvantages

1. Not all products are created equally: It is important to ensure that the product that you are buying has been studied and checked that they have the components they say it has.
2. Nutrients levels are low: in comparison with the chemical fertilizer, the concentration of the nutrients is lower. (Holganix, 2018)

2.4 INORGANIC FERTILIZER ADVANTAGES AND DISADVANTAGES

2.4.1 Advantages

1. Application: the application of inorganic fertilizer can be much easier.
2. Cost: it is cheaper in the short term.

2.4.2 Disadvantages

1. Nutrients availability: inorganic fertilizers provide nutrients constantly, which can cause the burn of the plant.
2. Composed by chemical and non-organic compounds.
3. Environmental impact: it harms our environment and generates chemical imbalances. (Miller, 2018)

Sewage plant

3 INTRODUCTION

3.1 TREATMENT METHODS

The main goal of treating the wastewater is to clean the water and be able to through it again to the river without causing any damage to the environment. The water is cleaned by three different (or combination of them) ways: biological, physical, and chemical treatments.

3.1.1 Biological process

In this process, the contaminants are removed by the biological oxidation of the organic matter. It will be explained for the secondary treatment using the activated muds.

3.1.2 Physical process

Physical strength is used to produced changes to the water. Some examples which will be explained are the screen and grit removal.

3.1.3 Chemical process

In this process, some substances are added in order to create chemical reactions. The main ones are used to control pH, disinfection, and coagulation. (E. V. González, 1993)

3.2 MAINTENANCE IN THE WASTEWATER TREATMENT PLANT

In any industry with machinery, it is necessary to have preventive maintenance. It is the regular maintenance used to ensure the proper function of all the equipment in the industrial plant. It is the implementation of programmed work routines with the main goal to prevent damages.

Table 1 Maintenance of distribution pipes

Task	Frequency	Requirements
Check the entrance pipes to avoid obstructions on the system	Diary	Employee
Remove the solids that are clogging the normal water flow	Diary	Rakes and shovels
Check the access gates to the treatment plant	Weekly	Employee
Clean and maintain the pipes	Monthly	Pipe Cleaners
Gate lubrication	Biannual	Lubricant

Table 2 Maintenance of screens

Task	frequency	Requirements
Bring the solid materials to the drying beds	Diary	Wheelbarrows
Disposed the dried material to be removed by the cleaning company	Weekly	Cleaning company
Check if there is any corrosion	Biannual	Employee

Table 3 Maintenance of grit removal

Task	Frequency	Requirements
Check the grit removal performance	Diary	Employee
Verification the sedimentation grade	Monthly	Employee
Gates lubrication	Biannual	Lubricants
Grit removal	Annual	Machinery and shovel

Table 4 Maintenance of stabilization pools

Task	Frequency	Requirements
Check the correct working process from the system	Diary	Employee

Retire the mud and floating material to dispose them in the drying pools	Diary	Machinery, wheelbarrows and shovel
Withdraw the vegetation	Diary	Screens and rakes
Check the pool level	Diary	Employee
Check the pool degree sedimentation	Biannual	Employee
Collect and retire the mud and all the sediments and dispose in the sludge drying pool	Annual	Machinery, wheelbarrows and shovel

Table 5 Maintenance of sludge drying pools

Task	Frequency	Requirements
Check the correct working process from the system	Diary	Employee
Put down the retired material onto the anaerobic pools and cover with lime	Diary	Wheelbarrows, shovel and lime
Retire the material from the sludge drying pools	Biannual	Machinery and shovel

Source: (C. Valledupar, 2012)

4 PRELIMINARY TREATMENT

The key goal of the preliminary treatment is to prepare the water for the following steps to prevent (or reduce) any possible damage on the next steps machinery. It is also used to stabilize the flow and avoid floating materials.

The most important preliminary treatments (and the ones that will be explained in this project) are the screen and grid processes. (J. A. S. Mesa, 2017)

4.1 SCREENING

In a wastewater treatment plant (WWTPs) is the first operation that can be observed. It is used to wash the water from plastics, metals, trunks, and rags (between others). In the modern WWTPs is easy to find fine and coarse screens.

4.2 COARSE SCREENS

The coarse screen can be manually and mechanically cleaning bars. The typical opening is about 6 mm, but it can be bigger.

4.3 FINE SCREEN

They are found after the coarse screens and main purpose is to eliminate the material that could be meaning or create a maintenance and operation problems on the next processes. The typical opening sizes are from 1'5 to 6 mm or for very fine screens, from 0'2 to 1'5 mm (EPA, 2003).

4.3.1 Inclined bar screens: how it works

As the name indicates, the inclined bar screen is not perpendicular to the flow. The screens from the mechanically cleaning bars are permanently raked back or front thanks to the cleaning tines assembled on a chain mechanism

4.3.2 Design

The bar screens should be designed with the aim that the velocity will be enough to avoid the obstruction or excessive dropping. The shape of the bars might be designed also to avoid stuck. (EPA, 1995)

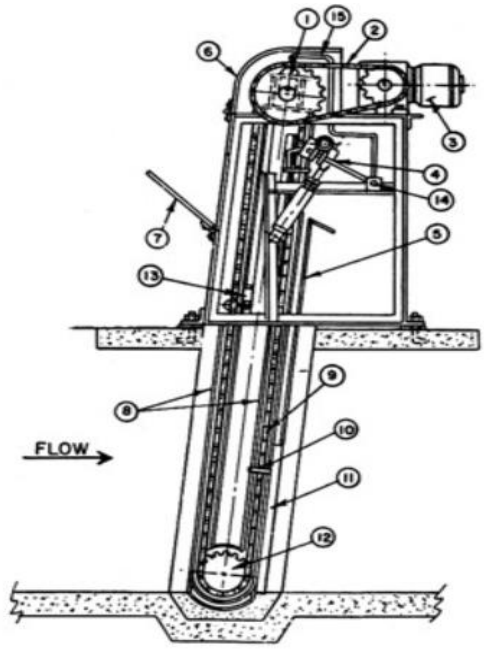

Figure 4 Screen bar Source: (N. Black, 2016)

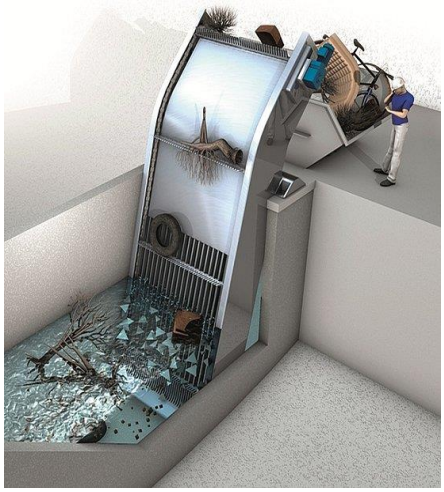

Figure 5 Coarse Screen Source: (HUBER, 2019)

1. Head shaft take-up screw
2. Drive chain
3. Speed reduction unit
4. Rake wiper mechanism
5. Dead plate
6. Head shaft housing
7. Inspection door
8. Cleaning rake chain guides
9. Cleaning rake chain
10. Cleaning rakes
11. Bar rack
12. Booth shaft sprockets
13. Limit switch
14. Grease fitting
15. Grease tubing

5 GRIT REMOVAL

5.1 PROCESS

The grit removal can be:

- Constant flow: it keeps a constant flow around 0'3 m/s independently from the water flow on them.
- Variable flow: the grit is removed manually from a longitudinal channel with a storage capacity for 4 to 5 days. It is used in small wastewater plants. (A. P. L. Moya, 2013)

The grit removal has the goal to remove the grit (sand, glass, small metal particles…) above 0'20 mm with a density of around 2'65 kg/l. For that, the water flow speed is reduced to favour the deposition of the heavier particles. This will happen always that the velocity is smaller than the one obtained from the Stokes law:

$$V_s=\frac{1}{18} * g * \left(\frac{\rho s-\rho}{\mu}\right) * d^2$$

- Vs= Stokes velocity
- g= gravity
- ρs= particle density
- ρ=water density
- d= particle diameter
- μ= medium viscosity (Pérez, 1981)

This process is carried out in the preliminary step because it is used to avoid a future problem with the machinery in the next treatments such as abrasion, the formation of deposits in hydraulic channels and pipes and mechanical equipment wear. (S. Aguirre)

5.2 GRIT REMOVAL PARTS

a. Entrance

It connects the fine screen with the grit removal screen. Its main function is to generate a uniform distribution to have a constant speed in the next zone.

b. Sedimentation zone

It's the place where sedimentation occurs. It should incline to make easier the cleaning.

c. Exit

It is composed of a horizontal landfill with free discharge, it is placed in the entire area of the desalination zone and its function is to avoid the resuspension of sedimented material by keeping the velocity constant.

d. Deposited material

It has a hopper which makes it easier for the deposition of the material in the collector. (S. Aguirre)

5.3 AERATION GRIT REMOVAL

There are different ways to make this process, but the chosen one is the grit removal with air.

The final goal is the same for all the available systems, but the aeration offers some interesting advantages:

- If the grease percentage in the water is low, it is possible to clean it in this step.
- The discharge loses is very small.
- Constant yield for different water flow.
- Reduce or even avoid bad odours.
- When the air is well controlled, the removed grit has small content of organic matter. (A. A. R Fernández, 2011)

5.3.1 Basics of the process

The water flows inside the channel with a helicoidal movement generated by the aeration.

The rotation speed is determined by the amount of injected air through the diffusers so how much more air is injected, the speed will be higher, but it is essential to not forget that it's important to not exceed the Stokes's velocity.

Any particle inside the aeration region is suffering two opposite forces, the gravity one and the one generated by the air going up. With this technique what is achieved is that the heavier particles will go to the bottom and the lighter ones will be dragged by the water flows.

As it was mentioned before, degrease is also possible with this method but for that, the speed needs to be reduced a bit so some organic matter goes also to the bottom beside to the sludge so it is necessary to clean this grit from it and it is carried out by sending the grit and the organic matter to a sand washer.

The collected sand is removed by pumping and when it is cleaned from the grease, this grease is sent to an authorised waste manager. (A. A. R Fernández, 2011)

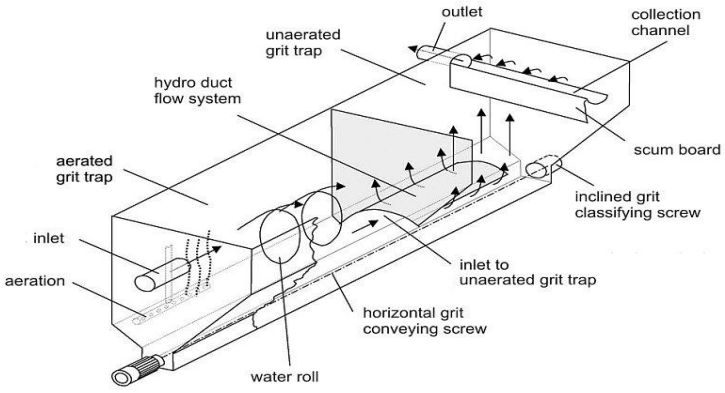

Figure 6 Aeration grid removal Source: (Huber, 2019)

6 PRIMARY TREATMENT

After the preliminary treatment, this is the next one in the WWTPs. While preliminary treatment removes the grit and the inorganic matter, the primary treatment aims is to remove as much suspended solids as possible. As it is explained at the beginning of the project, the sewage plant treatments can be divided into 3: Biological, physical and chemical, so it is possible to say that here we can find another physical process.

In the primary clarifiers, it is achieved that the organic particles go to the bottom by reducing the speed. As a result, on the top is obtained the floating solids and the grease and, on the floor, it is got the mud that will be picked up and moved to the handling process. (K. Gernaey, 2001)

6.1 PRIMARY CLARIFIERS

The main purpose of the primary clarifier is to detach as much as possible the floatable and settleable material. It is very important to eliminate the organic material because it requests a lot of oxygen in the next biological treatments.

Some factors such us, detection time, temperature, solids loading, surface loading rate, and temperature are important, but the most important one for the clarifier design is the settling characteristics of suspended particles.

6.2 CIRCULAR PRIMARY CLARIFIER

After leaving the aeration tank, the water enters the clarifier from the top through a vertical pipe and it fills the tank radially. The sedimentation is directed to the sludge hopper by the sludge plow. The floating solids are retained by a screen placed facing the dump output. The sludge is retained by a skimmer equipped at the arms and the floating material is drained through the foam channel. (J. P. Guyer, 2011)

6.2.1 Clarifier parts

The most used clarifiers are the circular and rectangular ones and they both can be divided into five zones:

a. Influent zone

   It is the entrance to the clarifier. Both are equipped with a baffle, more specifically, the circular one has a collar-type which through the water onto the bottom. The main porpoise to equip the clarifier with it is because stops the short-circuiting which would produce an irregular sludge distribution.

b. Settling zone

   It is the largest part of the clarifier. The water flow velocity is reduced in other to make the sludge goes down while the water is removed from the top.

c. Skimming zone

   It is at the top of the clarifier; the kimmer arm is connected to it. It glides the surface while the clarifier rotates.

d. Effluent zone

In this segment, it is where the water is sent to the secondary treatment. In both types of clarifiers, the water leaves from the edge of the tank.

e. Sludge zone

It is where the mud is found and when it is needed, recovered and condensed. (Ragsdale, 2004)

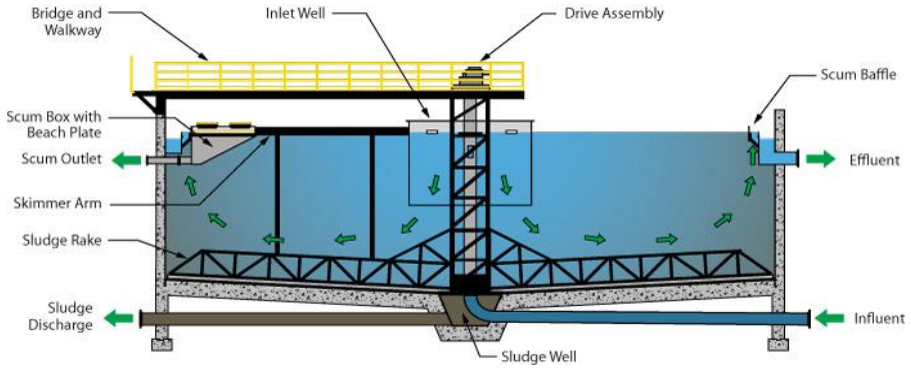

Figure 7 Circular clarifier Source: (Monroe, 2019)

7 SECONDARY TREATMENT

In this phase, the organic matter is removed by biological treatment together with the physical, instead of only physical like the previous ones.

This process is carried out with the aeration tanks, which is based on an aerobic treatment by biological oxidation. In the aeration tanks, microorganisms are used to degrade the organic matter as they feed by it. In this process it is necessary the presence of oxygen, that's why it is done in the aeration tanks and have a uniform result.

When the biological process takes effect, the result is a suspended mud and that's why it is called activated sludge. It will be removed from the water by sedimentation what it is made in the secondary clarifier. (Fabregat, 2017)

7.1 AERATION TANK

In this project is going to be explained the activated sludge method but just remark that there are some other methods available such us: Contact Stabilization, Aeration System and Prolongated Aeration which have the same aim as the activated sludge.

7.2 ACTIVATED SLUDGE

It is the most used method; a biological reactor is utilized to make it possible and the material is suspended around 4 to 8 hours on the water surface.

It is divided into two steps: first, the oxidation and secondly, the dissociation between solid-liquid.

The oxidation takes place in the aeration tank where the water enters in contact with the microbes which make the oxidation possible. The microbes percentage on the water need to be controlled carefully in order to remove the desired organic matter.

The air is needed to contribute with the oxygen and shaking it which will allow the reactions and homogenization. For this, agitators are used, and they achieve both at the same time.

Once the reaction has taken place, the result is transported to the secondary clarifier where the split is carried out. Some of the sludge is transferred to be treated and the other one is redirected to the biological reactor. (Pardo, 2012)

From the aeration tank is important to underline: the electric motor, settling compartment, sludge return, mixing return, air discharge, aeration compartment and the vent which is possible to say that are the main parts. (Cloud Zone, 2015)

Figure 8 Aeration tank Source: (Argueda, 2013)

7.3 SECONDARY CLARIFIER

Comparison between primary and secondary clarifier

They work nearly identically; the principal distinction is the type of sludge the are working with. Secondary sludge is usually lighter than the primary one and the effluent is usually clearer than the one that can be found in the primary sludge.

The secondary clarifier is needed because as it has been explained before, in the biological reactor (aeration tanks) it is generated more solids and they need to be separated. (Anonymous)

7.4 SECONDARY SEDIMENTATION TANKS

The main use for the secondary clarifier is to produce concentrate biological sludge which will be sent either to the biological tank again or to the sludge treatment (mentioned before). It is usually the last step to clarify the water in a biological treatment plant. (I. Dominguez, 2002)

As the process is identical to the primary sedimentation tank, it is not going to be explained again but just mention that also in this step rectangular or circular tanks can be used, and the main clarifier parts are the same as in the primary treatment.

7.5 SLUDGE TREATMENT

7.5.1 Treatment line

The sludge line is mostly formed by:

1. The thickener.
2. Sludge digester.
3. Dehydration.

8 THICKENER TREATMENT

It will be found 2 different treatments, thickening by gravity and flotation and it is because the first one is used for the sludge coming from the first clarifier and flotation is used for the one coming from the biological treatment, basically because they have different densities. (J. S. Guillamón, 2014)

Advantages and disadvantages of the methods are going to be explained:

Gravity thickening:

- It is the most simple and older method for drying the sludge. The advantages are the low operation cost and energy consumption and the principal drawback is that the solid content it only between 5 to 8 %.

Flotation thickening:

- It is used when the density is lower so it cannot be accomplished in the gravity thickener, so the main advantage is that it processes concentrations that the other treatments are not able to do it. (J. J. Peirce, 1998)

8.1 GRAVITY THICKENING

The main goal for the thickeners is to increase the solid collection to make it easier to handle in the next steps such as transportation, dehydration and drying, and for that it is needed to split the water from the solid. (J. S. López, 2015)

To know if the process is being efficient or not, it is just enough looking the removed sludge to make sure the performance is correct. Good execution will reduce the amount of recirculate sludge going back at the beginning of the plant. To determine the effectiveness of the process next concentration factor can be used:

$$CF = Concentration\ Factor = \frac{Thickened\ Sludge\ Concentration\ \%}{Feed\ Sludge\ Concentration\ \%}$$

8.1.1 Main components

The main component in the gravity thickeners are:

- Outlet piping and overflow weir.
- Vertical pickets attached to the rake mechanism.
- A scum removal mechanism.
- An inlet and distribution baffle assembly.
- A sludge rake to move settled solids to a sump for removal. (P. H. Klopping, 1980)

8.1.2 Design and working process

Clarifiers and gravity thickeners are very similar. They can be rectangular, but the most used shape is the circular one. The material is fed through a central pipe to a height which doesn't affect either the compression or compaction base zone.

One characteristic from this machine is that it has a very strong ground scraper, its function is to bring the sludge to the pickets which are placed on a central tank.

The supernatant liquid is accumulated by perimeter weir and redirects to the primary treatment or plant head.

The correct clarifier design considers the septic condition development and the potential of having overloads. (J. S. López, 2015)

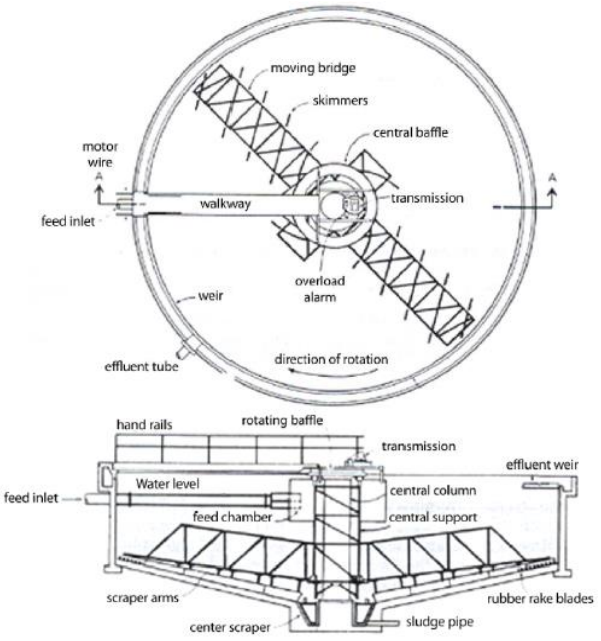

Figure 9 Gravity thickener plan and height Source: (J. S. López, 2015)

8.2 FLOTATION THICKENING

8.2.1 Process

As with gravity thickener, the main goal for the flotation, is the same, reduce the water content on the solid. In this case, it operates using air which produces tiny bubble and the solids remain attached and then go to the surface.

The achieved solid concentration range between 3 to 12%. The process usually takes around 40 min and bad odours are avoided because it is executed with air which avoids the anaerobic process.

The sludge removal must be gradual and regular which is an important step in the process. Something that must be designed carefully is the scraper mechanism as it is essential it is made strong to carry the removal process without any problems and anything unexpected. (J. J. Peirce, 1998)

8.2.2 Main components

Flotation thickeners are mostly circular tanks with the vertical flow, scraper arms attached to the sweepers in the background, and the collector for the material on the ground and another one for the floating one. The distribution hood aim is to stabilize and split homogeneously the flow. The movement must be slow to produce more and bigger floating material. The access ramp must be designed in other to keep the contact always with the scraper. (A. Jiménez, 2018)

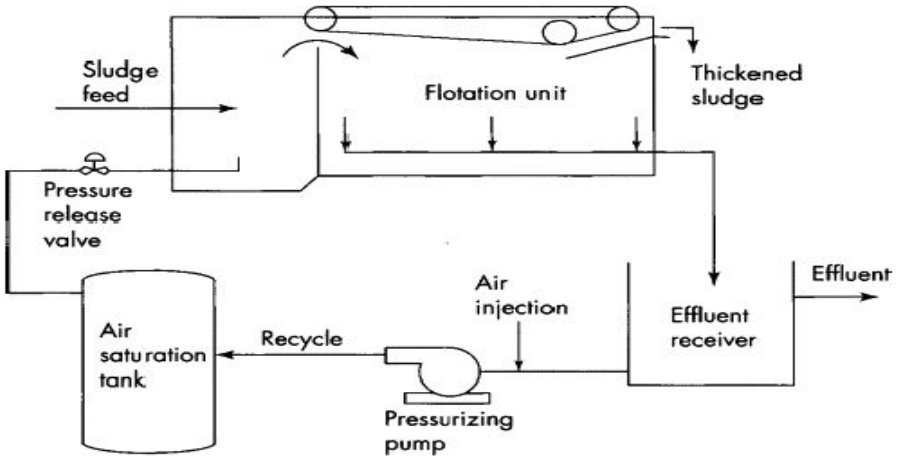

Figure 10 Flotation thickener Source: (J. J. Peirce, 1998)

9 SLUDGE DIGESTION

For this step, there are many different methods to do it, but the chosen one is the anaerobic digestion.

The anaerobic digestion is one of the oldest processes used for the sludge digestion and is the degradation of the material in a closed system without oxygen. In this step, the primary and secondary sludge have been mixed already which are introduced in the closed reactor. They can be introduced continuously or intermittently, and they stay inside during long periods. Once the mixed sludge is taken out, there are few pathogenic microorganisms alive.

9.1 ANAEROBIC GENERATOR

The process can be divided into low and high load but in this project is going to be explained only the high load because it is used in big sewage plants and the time needed is shorter.

The high load digestor mix and heat the sludge through mechanic mixers, pumping, mixers with suction or gas recirculation tubes and it is heated to make the process shorter, usually less than 15 days. (F. Fernandes, 2007)

9.1.1 Advantages and disadvantages

Advantages:

- Pathogen elimination.
- Makes easier the dehydration.
- Produce biogas which is used as a fuel.
- Odours are avoided because it is carried in a closed system.

Disadvantages

- High retention times.
- The installation is more expensive.
- The environmental factor can affect the process. (Pichel, 2012)

9.1.2 Anaerobic digester design

The digestors are made either from steel or concrete. The design of the digestor can change depending of some different parameters such as the amount of sand and foam that need to me removed, the mix conditions and the area available. Usually they have 1:3 conical bottom slopes and between 8 to 40 m diameter. Heat losses must be considered specially in the cold areas. (F. Fernandes, 2007)

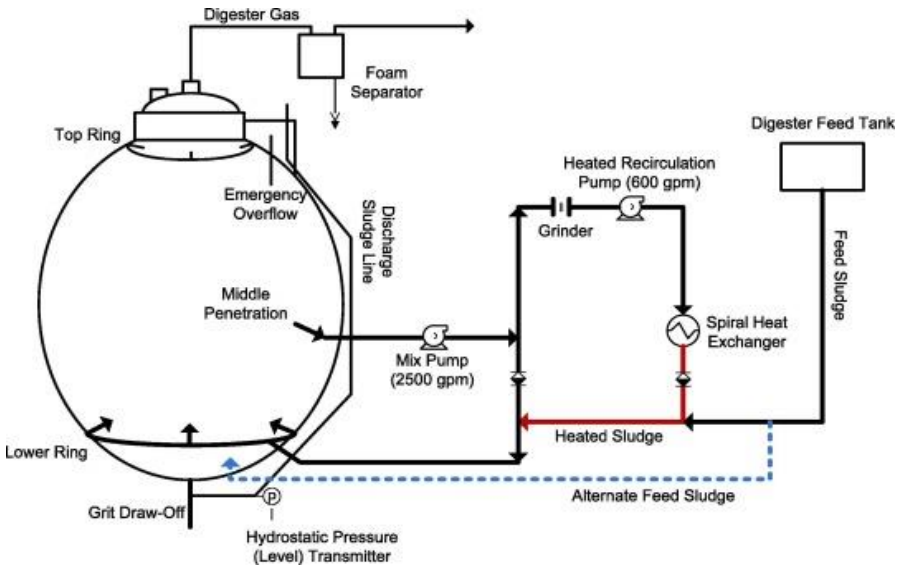

Figure 11 Anaerobic Digester Source: (Klibert, 2015)

10 DEHYDRATION

10.1 PROCESS

Dehydration is a physic process which is used to reduce the water content and the volume of the sludge. This operation makes the handling and transportation easier and cheaper.

There are two types of dehydration process: natural and mechanical. The last one can be carried out with different methods such as centrifuges, press filters, band filters, and vacuum filters. (J.S. López, 2015)

10.2 PRESS FILTERS

Press filter is a mechanic press which compresses the sludge to split the water from the solid. The sludge is pumped into the plates and the pressure between 690 to 1550 KN/m^2 is used between 1 to 3 hours forcing the liquid going through the filters and the holes on the plates. Then the plates are separated, and the solid sludge is obtained. The obtained liquid usually is redirected to the head of the plant

The camera consists of an empty space where to introduce the product and filter elements which will help to have a solid piece at the end of the process. When the pressure is exerted, the water leaves the space through the filters.

It has a cyclic operation:

- Press is closed.
- Filters are filled.
- Filtration.
- Clean the feeder channel.
- Open the press.
- Compacted sludge is taken out. (Vázquez, 2008)

10.2.1 Main problems

Press filters have some maintenance and operational problems.
It is important to consider the next aspects:

- High cleaning system pressure.
- Have a sludge shredder before the conditioning tank.
- Include a breaking system for the sludge cake after the filter press.
- The necessary equipment to make the extraction and maintenance of the plates.
- Adequate ventilation of the dehydration building. (J.S. López, 2015)

10.2.2 Components

The main components:

- Plate transportation system: it is responsible for carrying out the transport plate to plate or a set of plates, to perform the unloading of the cake.
- Frame: it is used to accommodate some other mechanism which will make possible the work process.
- Filter package: It is the set of filter plates which are mostly made by polypropylene.
- Hydraulic power station: with the help from the hydraulic pump is what causes the plate movement.

And the accessories:

- Security elements.
- Automatic fabric washing system
- System of suspension or agitation of fabrics.
- Drip trays (Vázquez, 2008)

Figure 12 Press Filter Source: (Fresh, 2019)

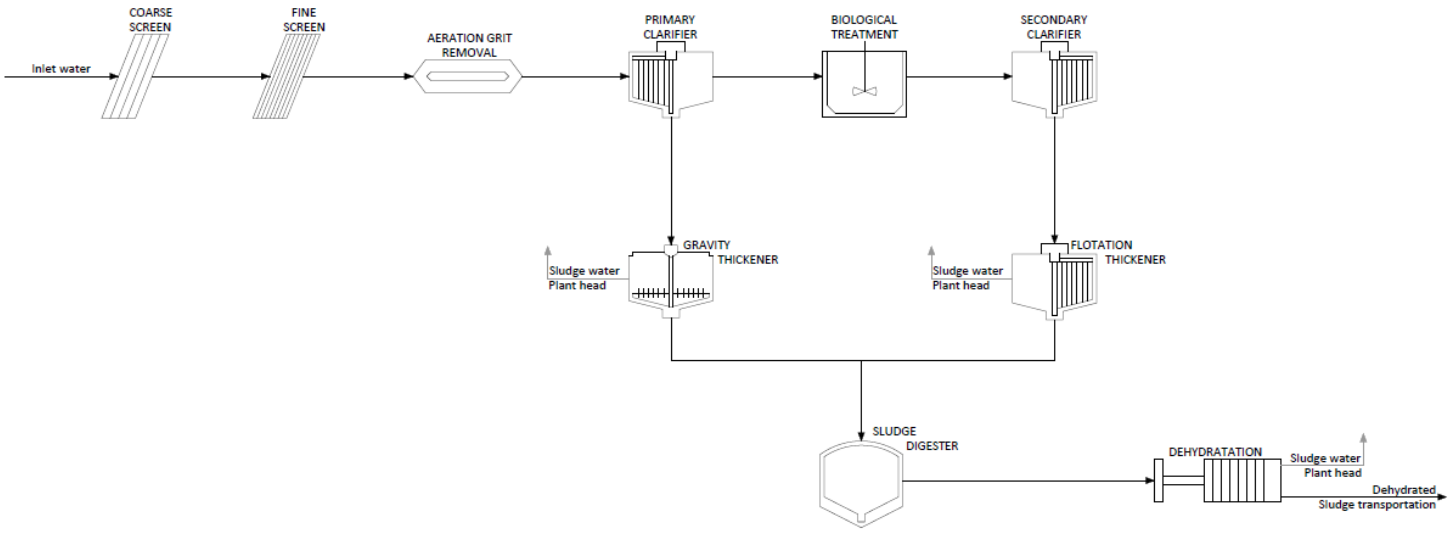

Figure 13 Diagram of the sewage plant process

Manufacturing process

11 COMPOSTING PROCESS

11.1 INTRODUCTION

Composting is a natural process where mineralisation and biodegradation of organic material are achieved thanks to the aerobic, self-heating and solid-phase biological acceleration of the organic matter. (Beffa, 2002)

11.2 COMPOSTING SYSTEMS.

Composting can be done in either open or closed method.

11.2.1 Open systems

Dynamic windrow

The organic material is left directly on the ground without too much pressure to allow the air to keep inside the pile. It is preferable to do an elongated and not high windrow because the last parameter is the one that can affect the quality of the process. If there is not enough oxygen, the aerobic change will not be good but if the pile is too short, it will not reach the optimum heat.

Once the pile is made, it needs to be turned when the process demands it. The turning of the windrow is used to homogenize the material and the temperature to control the humidity, increase the ventilation and eliminate the excess of heat. After turning it, the temperature decreases from 5 to 10 ºC, and in the case the process has not finished yet, the temperature will increase again.

Figure 14 Open Windrow Source: (Enrich, 2014)

Figure 15 Forced Ventilation Source: (Gil Pérez, 2017)

Forced ventilation

The material, in this case, is left on a set of perforated tubes.

When the temperature is not at the optimum point, the sensors activate the fans which cooldown the material and inject new fresh air.

This process lasts from 4 to 8 weeks and consequently, the maturation period comes.

11.2.2 Closed systems

The concept is the same as the open system, the compost is also turned and the air is forced or a mix of both but this time, the process is carried in digestors. The process is more expensive than open systems. However, everything can be controlled better and therefore the periods are sorter and less space is needed.

Nevertheless, the compost that is produced in the digesters needs to have a maturation period afterwards, leading to needing a windrow.

Composting in tunnel

The composting process is made inside a closed tunnel, which is usually made of concrete, and the oxygen is controlled by air impulsion or aspiration. The compost stays static.

Composting in a container

Similar to composting in a tunnel but instead of concrete, it is made of steel containers. It is usually a continuous process, where the raw material comes from the top and the ready one leave from the bottom.

Composting in an industrial hall

The composting process is placed in a closed industrial plant. The modern plants are fully automated with the turning machines. The ventilation process is done by the turning machines and/or a plate in the base.

Composting in a drum

In this method, the organic material is treated inside a drum with slow rotation. The process can be made continuously or separately. (Solans, 2008)

In the open-air method, the composting process can be achieved thanks to the turner machine which makes the right and uniform turning of the compost and allows to control some parameters that interfere in the maturation period such as temperature, humidity, odour and oxygenation.

Once the pile is made, a metabolic process starts, where the microorganism transforms the organic product into compost, increasing the temperature inside the pile. (C. Archer, 2009)

There are other parameters very important such as the size and shape form of the windrows. It must not be higher or smaller than the optimum range to achieve the desired fermentation.

The composting process can be either aerobic (with oxygen) or anaerobic (without oxygen). To keep the composting process aerobic, oxygenation is needed, which is controlled by the turning. Depending on the maturation period of the windrow, the turning will be more or less frequent.

The odour and temperature will determinate when the turning of the windrow is needed. When the temperature is low, it means that the windrow needs to be turned because the metabolic activity has decreased and there is no heat generation and consequently odour appears.

Curing it is considered completed when the temperature of the pile is near to the ambient temperature.

The turning machine is used on a great scale in order to reduce the time required for the maturation process. It makes the work easier, faster and it has also a positive impact on the company, reducing the process costs in the way they save economic and human sources. (GOUIN, 1992)

11.3 COMPOST TURNER MACHINE

This type of compost tumblers machines is the most widely used due to its size and ease of anchoring, using and operating. It consists of modular equipment, based on chassis, counterweights and rotor. Here is where pallets are found, pulled and driven by an agricultural tractor that gives it the driving force. These machines are highly efficient and versatile equipment in composting operations of very different sizes.

When the tractor confers the forces by the cardan system, the rotor from the turner machine moves and the material in the windrow is lifted, keeping suspended in the air and falling back to form the pile again. The rotor must have space from 7 to 15 cm with the back of the pile to guarantee the oxygenation of the compost. During the previous process, the material is mixed, air-conditioned and cooled uniformly favouring an aerobic degradation of the organic materials.

The progress of the machine is through the piles and the tractor moves along the street side, working both at 90º (Montero Avendaño, 2006)

Table 6 Technical characteristics (model: Agraris 2.0)

Weight	1000 Kg
Required Tractor	40-50 HP with reducer
Dimensions	2´2x1´10 m.
Endless Screw speed	240 rpm
Tires	7´50x 16 (x2)
Yield	350 m^3
Height variation	0-40 cm

Source: (S.A, 2019)

Figure 17 Windrow Compost Turner Source: (HCL)

Figure 16 Compost Turner Tumbler Source: (Outdoor-Decoration)

12 CRUSHING

12.1 CRUSHING MACHINE

The crushing machine is used to convert macro particles into smaller ones. There are many different reasons to crush the material. In this case, it is used either to make the decomposed or the mixing process easier.

The main components of the shredder are: a motor fixed at the base, a cutter/s, a shaft, gear and a pulley. (S. B. Pavankumar and others, 2018)

12.2 WORKING PRINCIPLE

The crushing machine works on the principle of hammering and shearing. First, the material (fertilizer in this case) is fed into the machine through the hopper. Then it comes in contact with the cutting members while these are rotating. The cutting blades and the hammers are located on the roll shaft. The hammer pushes the material to the knife blades to be cut. There are also stationary blades and hammers. The stationary hammer provides a hindrance, but the aim of the stationary blades is the same as for the other blades.

When the compost enters in contact with these three elements, the shredding process starts. The engine makes the shaft rotate which is mounted on the mainframe beside to their corresponding pulleys, supports and bearings. (A. S. Hande, 2015)

12.3 PRE-MAINTENANCE

The shredding is a process where the wear is high.

Wear is complex to understand and to avoid it, but it is possible to try to lengthen it happens.

Some ways to try to minimize it are, to increase the surface hardness and resistance, even though it is not possible to have both at the same time or to add a very hard surface layer on it.

12.4 MAINTENANCE

In general, all the machines need to be maintained to make them live longer and work better.

Some maintenance tasks must be done daily, such as, cleaning the machine, verifying the tension on the pulleys, the electric connexions and controlling the conditions of the blades. Quarterly tasks are, for example, lubrication, to change the blades or to check everything is fixed properly. And annually or long period tasks are to change bearings and other parts of the machine. (López, 2006)

Table 7 Technical characteristics smallest and biggest machines

Model	Overall dimensions LxWxH (mm)	Production Capacity (t/h)	Motor Power (kw)	Maximum Size Entering Granule (mm)	Size After Crushing (mm)
AZS-LSFS-60	1000x730x1700	1-5	15	≤60	< ø 0’7
AZS-LSFS-80	1250x1000x2100	2-8	22	≤60	< ø 0’7

Source: (AZEUS, 2018)

Figure 18 Crushing machine Source: (Sulta, 2019)

13 MIXING

Mixers are used in the industry to homogenize the material, to keep solids suspended in a fluid and to promote the mass transfer and/or heat. (Moran, 2017)

In the case of the fertilizer industry, the mixing process is used to have a good homogenize compost.

Mixing is an easy concept, but some parameters need to be treated carefully, for instance: the optimum mixing time, the speed and the order that the material is introduced in the mixer. The mixers must be tested separately to program them properly for each case. (aapfco.org)

13.1 HORIZONTAL FERTILIZER MIXER MACHINE

This system is composed of a tank with either U or V section and an endless screw placed in the central part. The machine can be used to mix different materials such as pulverized or granular material or even tar, as long as the blades are changed (different geometry).

The horizontal mixer is composed of a transmission part, mixing part and a frame. While the material is flowing inside the tank, water is injected with a certain pressure onto the raw material. The fertilizer is mixed while the blades are rotating. When the optimum material is obtained, the tank is opened and then the material is transported to the fertilizer granulator. (Allance, 2019)

13.2 MAINTENANCE

In any kind of solid mixers, it is necessary to have space to clean the mixer and, in the case, it would be needed, be able to remove the agitator to do the maintenance.

Depending on the type of mixer, the requirements will be a bit different. However, it is necessary to make the machine capable of disassembling to do the maintenance work and to have the security measures to keep the workers safe. (Moran, 2017)

Table 8 Technical characteristics

Model	Overall Dimensions (LxWxH) (mm)	Output (t/h)	Power (kw)
Twin shaft mixer			
FY-SZJB-40	3800x1250x750	3-7	11
Single shaft mixer			
FY-WSJB-70	2330x1130x970	2-3	11

Sources: (FanWay)

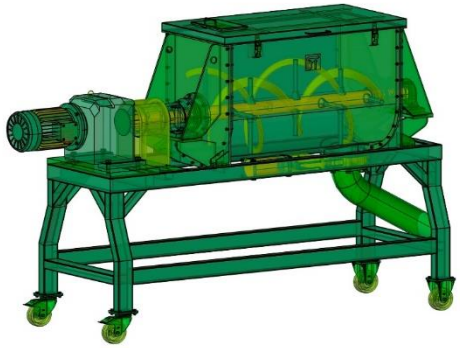

Figure 19 Transparent model of horizontal mixer Source: (Kresisch, 2013)

14 GRANULATING

Granulating is a process where the particles are adhered together by creating bonds between them. The conglomeration is achieved using compression or binding agents. The main goal of the granulation process is to make the product easier to carry and to save, controlling the particle size and preventing the segregation of the material.

There are two types of granulation, wet and dry. In the first one, a liquid is added and in the second one, there is no liquid on it.

For the dry granulating process, there are two main types of machines: roller compactor and slugger. The roller compactor uses two rollers to compress the powder and form ribbons. The slugger compactor produces large slugs after the material has been compressed. The use of roller compactors is more advisable, as the parameters can be controlled easily, it is a continuous and simpler process and with a higher production capacity.

"Independently of being wet or dry, the main processes used are:

- Process with an ammonize granulator and drying drum.
- Process with drum granulator dryer.
- Process with granulator tower (the chosen one)." (A. Norov and others, 2017)

14.1 ROLLER COMPACTOR

After the material has finished in the mixer, the material is transported to the rotating rollers and then it is used high pressure to create the ribbons. Then de-aeration is introduced, and the compaction occurs when the relative movement stops between the compost and the surface of the roll. Due to the slip zones, the de-aeration is needed, as some difficulties are found. To have

the desired granules size, the ribbon must be broken by milling. After the granules have been obtained, they go through the sieving process to keep the desired granules and to discard the others. The discarded ones will be returned to the feeder, is possible to say that is a recycled system.

14.2 COMPONENTS

The roller compactor is composed of four parts named in order: feeder system, rollers, milling and the screen.

The material can be fed with three different systems: single screw, double screw and gravity transport. The reason for this is the material's density, being the material pushed in the first two types and not in the gravity system, as it is denser and can flow by itself.

Something similar happens with the rollers. Different rollers will be used depending on the desired final result.

While compaction process is being carried on, the roller is divided into three different parts: slip region, nip region and extrusion region. The first one is known as the feeding zone, and it is where the compost powder slips at the roll surface. The slip occurs because the particles' speed is lower than the tangential speed of the rollers.

The compaction zone is where the powder is trapped between the two rollers and the extrusion zone is where the particles are discharged from the rollers. (V. Fai)

Table 9 Technical characteristics (model: TFC-220)

Model number	Capacity (Kg/h)	Roll width x Diameter (mm)	Roll speed (rpm)	Roll Force (T)
TFC-220	20	20x200	1 to 17	5´6

Source: (Freund Vector)

Figure 20 Roller Compactor

Source: (Freund Vector)

15 DRYING

The drying process consists in the removal of a liquid from a different material state, such as liquid, semisolid or solid, to have a solid product by heating them. It is used to make easier the storage, preservation of the product, easier/cheaper transportation, etc. (Mujumdar, 2011).

15.1 ROTARY DRYER

The rotary dryer machine combines a cascade material motion with mass transfer and heat. It is an expensive process and it is used in different industries such as cement, pharmaceutical and fertilizer between others. The holes can oscillate from 0´3 to 5 mm and the machine length can be from 2 to 90 m. (Mujumdar, 2011).

In comparison with the other available dryer machines in the industry, the rotary dryer machines have some advantages due to their flexibility, their large capacity and simplicity. They are the most expensive ones to construct but on the other hand, this type of dryer machine has the lowest operation cost.

The rotary dryer can work continuously while rotating and injecting heat air. The flow rate can be used to control solid moisture and temperature.

Especially in a process that uses heat, it is very important to control the parameters and respect them as much as possible in order to avoid economic loses. In this case, if the rotary dryer is working with a very high temperature, it produces a more brittle material, which leads to having more dust in the system and a fire risk. However, a low temperature produces high moisture content material, which affects the quality of the final product. (Shahhosseini, 2010)

15.2 MAIN COMPONENTS

- Dryer Shell
    - It is the main body of the system and can be made of different materials. The most important factor is that it must be well manufactured in order to avoid premature failures, which would affect the process efficiency and the final result.
- Combustion Chamber
    - It is where the combustion reaction takes place and the hot air goes directly to the drum.
- Burner
    - It is the part which determines the output of J/s in the system and it can use different types of fuels. (Joules/second)
- Raw Material Feed
    - It is where the raw material is introduced. The characteristics required to avoid material accumulation are good design, wear resistance and robustness.
- Air Seal
    - Its function is to keep the air inside the system from the discharge breeching to the rotating drum.
- Dry Assembly
    - It is what allows the drum to rotate. Depending on the size and HP (horsepower) the dry assembly will use different systems.

- Riding Ring
    - Its main function is to absorb the pressure suffered and it can be found in the support structure.
- Trunnion Wheels
    - They are used to ensure concentric and smooth rotation.
- Flights
    - The material is picked up and dropped by the flights while the air is flowing, and the drum is rotating. This maximizes the heat transfer between the drying air and the material.
- Discharge Breeching
    - It is the last step inside the dryer, and it is where the product comes out. (Feeco International, 2015)

Table 10 Technical characteristics smallest and biggest machines

Model	Drum Dimension	Typical Output Rate (ft^2/h)	Typical Evaporate Rate (lb/h)	Typical Power Required (HP)
SD 45-12	4'5ø x 12'	45 - 50	500-1.000	25
SD 130-60	13'0ø x 60'	1.800 – 2.000	19.000 – 33.300	330

Source: (Baker Rullman, 2019)

Figure 21 Rotary Dryer Drum

Source: (Powder & Bulk Solids, 2015)

16 COOLING

The granulated material should be cooled before the next process for temperature resistance of the follow-on equipment, packaging containers or the heat recovery from the hot product. (ALLGAIER, 2016)

After being dried, the granules must be cold down, and for that, they go through a cooling process. The cooling can be considered the most or one of the most important steps in all process because it allows the correct transport and storage.

Fertilizer tends to absorb the humidity from the environment, so in order to avoid an excess of absorption, the cooling process has a relevant influence. If the product has proper cooling, the product quality will be kept until the product is sold.

Usually, the cooling process is carried on by fluid bed or direct contact air coolers (indirect contact is also possible), depending on the machine's capacity and height, the product processed at the same time will vary. (Solex, 2016)

16.1 WORKING PRINCIPLE

The coolers work by bonding material in a rotating drum with the presence of air. Gravity has an important paper in this process in order to make the material move through the drum. Lifting flights helps to maximize the heat transfer efficiency by lifting the material and then dropping it.

16.2 MAIN COMPONENTS

The main components that can be considered are the flights, feeder, product discharge, mainframe, riding ring, ring gear guarding, girth gear, gear reducer, drive assembly trunnion wheel and the graphite block lubrication. (Feeco, 2019)

Table 11 Technical characteristics smallest and biggest machines

Model	Overall dimensions L x W x H (mm)	Product capacity (t/h)	Power (kw)	Feed Temperature (ºC)	Discharge Temperature (ºC)	Shell inclination (o)
FY-LQJ-O'8	10800x2210X1700	1-2	5'5	60-80	<40	2-5
FY-LQJ-1'8	21500X4170X2600	8-14	22	60-80	<40	2-5

Source: (Fanway, 2012)

Figure 22 Rotary Cooler Source: (GEA)

17 SCREENING

Screening is an ancient method used by the Egyptians to prepare the food. It was far simpler, made of woven but the main goal, which was sieving the material, was achieved. (Allen, 2007)

It is a process in which its main component is the effect of the gravitational force. Its purpose is to separate the material in different sizes. For this grouping, the screen can be equipped with either one or various sieves. For that reason, besides the gravitational forces, sieves are crucial for this process. They must be chosen correctly depending on the material and the desired result. Even when the concept is very simple, several parameters need to be controlled and monitored. The unit operation can be affected by different parameters. The most important ones are the sieves mesh size, the sieve direction movement, the quantity of material in its surface, and shape and size of the particles.

Throughout the screening process, a blocking of the sieve can occur easily. It is an event that should be avoided, as it is an incident which decreases the performance of the screen, reducing consequently the effective screening area. (K. Lawinska, 2016)

17.1 CLASSIFYING THE SCREENS

There are two main screen types, which are classified depending on the material direction flow. These two types are the ones with either spiral or radial flow and the screens with linear material flow. The first group depends on the design configuration, for example, fluid-flow screening machines, screens with vibrating sieves or rotary screens. The main element in the screening is the vibrator.

The vibration system can be done in two different ways, continuously or periodically (K. Lawinska, 2016)

17.2 WORKING PRINCIPLE

The horizontal screening machine works with slotted mechanism and on an arm base. The drum is fixed at the bottom where the stockpile moves on it. The stockpile is fixed with the arm shaft in order to move together. The sieving box is placed inside it and then the machine is ready. The sieving process is performed when the collecting box (stockpile) moves in the reciprocating motion. (S. Mohanavelan, 2016)

17.3 MAIN COMPONENTS

- Mainframe: It is the part of the machine where all the other components are holding up. It is made in order to be rigid and strong to avoid vibrations.
- Hopper: It is where the material is fed. The material will be introduced to the machine by gravity.
- Sieving chamber: It must be made of a non-corrosive material.
- Pulleys: They are used to transmit the power/motion between the shafts.
- Electric motor: it determines the power and rpm of the whole machine.
- Bevel gears: It is used to transfer the power from the lump to the sieving chamber.
- Shafts: they are the elements that allow the transmission of the power from one place to another (it can be applied for any machine). (Ogbeche, 2018)

17.4 SCREENING PROBLEM

The main problem that it can be found in this process is the particles get embedded on the screen. This can happen mainly due to the following reasons:

- The number of particles on the sieve.
- The physical properties of the particles.
- The particle sizes.
- The way the sieve is shaking.
- Particles shape.
- The geometry of the sieving surface. (Allen, 2007)

Table 12 Technical characteristics smallest and biggest machines

Model	Capacity （t/h）	Length （mm）	Power (kw)	Diameter of Outer Screen (mm)
ZJ 1240	3-5	4000	4	Ø1200
ZJ 2040	20-28	4000	7’5	Ø2000

Source: (Whirlston, 2019)

Figure 23 Rotary Drum Screen

Source: (FanWay, 2019)

18 PACKAGING

Fertilizer can be packaged at different moments. The most common takes place at the factory but there is also an option to package it at the port or at the receiving port, at an intermediate distribution point or at the railway station.

Bagging the fertilizer is basically to:

- Identify different types and fertilizer specifications.
- Protect the product against the humidity, transport, climate, and handling consequences.
- Make easier to know the number of fertilizer units.

The bag may contain the following information:

- Physical: type of fertilizer, density, quantity, etc.
- Chemical: The concentration, the form and the nutrients the fertilizer has. (H.S.S Few, 1981)

18.1 PACKAGING PROCESS

1. The machine must be cleaned and checked before using it.
2. Calibrate and inspect balance accuracy.
3. Inspect that the bags that are going to be used are well codified and tagged.
4. Until the machine does not achieve the optimum working conditions, if the bags do not have the correct amount of material, they should be checked and set aside if necessary.
5. Control during the whole process that the weight is the correct one. (Departamento de Pesca de la FAO, 2003)

18.2 PACKAGING MACHINE

There are different types of packaging machines, but the ones that are most used in the fertilizer process are the vertical ones.

The main component that can be found is the hopper with a sensor to control the amount of product that is going to be introduced on the package. Then the machine is composed of a system of chains, a gear motor, a pinion and rollers, which makes the fertilizer granules (in this case) capable to be introduced in the bags.

Depending on the material the machine is going to work with, the components will vary a bit but all of them will have these pieces. (F.J. García, 2009)

Table 13 Technical characteristics smallest and biggest machines

Model	Speed (Bag/min)	power (kw)	Weight (kg)	Overall dimensions L x W x H (mm)
MF 52	60	6	2200	1100x2200x1700
MF 62	30	8	3000	2250x2400x3500

Source: (MF Tecno, 2017)

Figure 24 Bagging

Source: (Sigma, 2019)

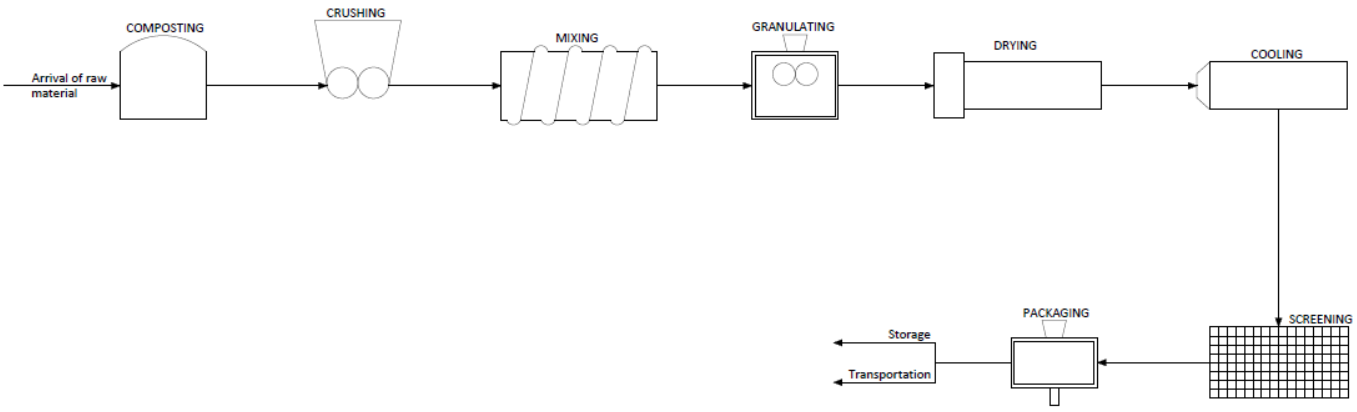

Figure 25 Diagram of the composting process

19 SUMMARY

Summarising all the project, regardless the kind of company and its machines, it is very important to have a preventive maintenance in order to avoid corrective maintenance. The last one would suppose more time consuming and higher cost, because preventive maintenance is planned, so the production stops as little as possible and the needed materials are ready, but for the corrective maintenance is unforeseen, so between the time reaction, checking if the piece is available or not and repairing it, generally it suppose more effort, time and money than the first one.

In this project, the purpose has been to give an example of circular economy industry, which includes the sewage plant, a company that works thanks to water coming from the cities (among others), and the organic fertilizer plant that works because of providers such as the sewage plant, animal farms or vegetables.

The circular economy and organic products concepts have been developed to make it easier for the readers to understand the point of view of the author and his goal with his thesis.

The made calculations show and want to introduce how careful and methodical must be to not commit any fail, other ways, the process would fail, and this is something that cannot be considered.

20 BIBLIOGRAPHY

A. A. R Fernández. 2011. ESTUDIO Y DISEÑO DE UNA E.D.A.R PARA EL MUNICIPIO DE MULA (MURCIA). [Online] 09 2011. [Cited: 05 04 2019.] http://webcache.googleusercontent.com/search?q=cache:KJ12qWTlXX8J:ftp://ceres.udc.es/ITS_Caminos/2_Ciclo/Ingenieria_Sanitaria_Ambiental/Presentaciones12-13/isa-Tema%252028%2520-%2520PRETRATAMIENTOS%2520-%2520desarenado%2520desengrasado%2520%25202012-2013%.

A. Jiménez, J.C. Valcárcel,. 2018. Tratamiento de lodos . *Universidad Carlos III.* [Online] 05 11 2018. [Cited: 17 04 2019.] http://ocw.uc3m.es/ingenieria-quimica/ingenieria-ambiental/material-clase/MC-F-218.pdf.

A. Norov and others. 2017. EQUIPMENT FOR THE CLASSIFICATION AND CRUSHING SECTION IN FERTILIZER. *Mgu.bg.* [Online] 2017. [Cited: 02 04 2019.] http://www.mgu.bg/sessions/17/02/18-Norov%20A%20et%20all-2017.pdf.

A. P. L. Moya. 2013. BASES PARA EL DISEÑO HIDRÁULICO DE LA ESTRUCTURA DE LA ESTRUCTURA DE SALIDA, CANAL DE RECOLECCIÓN Y TANQUE DE CARGA. [Online] 2013. [Cited: 11 04 2019.] http://www.dspace.uce.edu.ec/bitstream/25000/2209/1/T-UCE-0011-73.pdf.

A. S. Hande, V. Padole. 2015. Design & Fabrication of Portable Organic Waste Chopping Machine to Obtain Compost. *Ijirst.* [Online] 08 2015. [Cited: 02 04 2019.] http://www.ijirst.org/articles/IJIRSTV2I3005.pdf.

aapfco.org. aapfco.org. [Online] http://www.aapfco.org/pdf/blender_testing_protocol.pdf.

AENOR. 2019. AENOR. [Online] 2019. [Cited: 21 06 2019.] https://www.aenor.com/normas-y-libros/buscador-de-normas.

Allance. 2019. Allance Fertilizer Machine. [Online] 2019. [Cited: 25 03 2019.] https://www.fertilizer-machine.net/product/fertilizer-mixer/horizontal-fertilizer-mixer.html.

Allen, T. 2007. Particle size analysis by sieving. [Online] 09 05 2007. http://www.itam.nsc.ru/users/libr/eLib/3/2003/Allen/06_Ch04_Particle2_pp208-250.pdf.

ALLGAIER. 2016. Cooling hot bulk materials. *ALLGAIER Process Technology.* [Online] 03 2016. https://www.allgaier-process-technology.com/sites/default/files/downloads/en/allgaier_apt_tro_indirectrotarydrumcoolers_en.pdf.

Anonymous. CHAPTER 6: SEDIMENTATION . *Operation of Wastewater Treatment Plant .* [Online] https://www.env.nm.gov/swqb/FOT/WastewaterStudyManual/06.pdf.

Argueda, A. M. 2013. Parámetro de control de un sistema biológico. *Serquisma.* [Online] 05 2013. [Cited: 15 04 2019.] http://www.serquimsa.com/articulo-informativo-mayo-2013/.

AZEUS. 2018. Fertilizer Chain Crusher. *Azeus Fertilizer Machinery.* [Online] 2018. [Cited: 03 04 2019.] https://fertilizer-machines.com/product/fertilizer-crusher/fertilizer-chain-crusher.html.

Baker Rullman. 2019. Rotary Dryer Specifications. *Baker Rullman.* [Online] 2019. https://baker-rullman.com/rotary-drum-dryer-machine/rotary-drum-dryer-specs/.

Beffa, T. 2002. The composting biotechnology: A microbial aerobic solid substrate fermentation complex process. *Madep-sa.* [Online] 07 2002. https://www.madep-sa.com/wp-content/uploads/2018/05/THE-COMPOSTING-BIOTECHNOLOGY-T.Beffa-MADEP-Complete-2002.pdf.

C. Archer, K. Evanylo, and W. Pease. 2009. On farm composting: A guide to principles, planning and operations. *ResearchGate.* [Online] 2009. https://www.researchgate.net/publication/237698064_ON_FARM_COMPOSTING_A_GUIDE_TO_PRINCIPLES_PLANNING_AND_OPERATIONS.

C. Valledupar. 2012. MANUAL DE OPERACION Y MANTENIMIENTO DEL SISTEMA DE TRATAMIENTO DE AGUAS RESIDUALES. [Online] 03 2012. [Cited: 05 04 2019.] http://webcache.googleusercontent.com/search?q=cache:OWNysK4nXDQJ:www.emdupar.gov.co/index.php/la-entidad/sistema-integrado-de-gestion/Planeacion/Manuales/MA-GM-01%2520MANUAL%2520DE%2520OPERACION%2520Y%2520MANTENIMIENTO%2520PTAR.pdf/download+&cd=1&hl=es&c.

Climate. 2018. Climate-Data.ORG. [Online] 2018. [Cited: 06 07 2019.] https://es.climate-data.org/europe/espana/comunidad-de-madrid-266/.

Cloud Zone. 2015. Engineering . *The power of technology .* [Online] 11 2015. [Cited: 15 04 2019.] http://www.cloud-zone.in/index.php?pg=engineering.

Departamento de Pesca de la FAO. 2003. Desarrollo de la Acuiculturra. *FAO.* [Online] 2003. [Cited: 01 04 2019.] http://www.fao.org/3/y1453s0d.htm.

E. Cerdá, A. Khalilova. 2016. Economía circular, estrategia y competitividad empresarial . *Mincotur Gob.* [Online] 2016. [Cited: 08 05 2019.] https://www.mincotur.gob.es/Publicaciones/Publicacionesperiodicas/EconomiaIndustrial/RevistaEconomiaIndustrial/401/CERD%C3%81%20y%20KHALILOVA.pdf.

E. V. González, J. G. R. Hernánadez. 1993. ALTERNATIVAS DE TRATAMIENTO DE AGUAS. *http://www.ptolomeo.unam.mx:8080/xmlui/bitstream/handle/132.248.52.100/9781/decd_1830.pdf?sequence=1.* [Online] 1993. [Cited: 05 04 2019.] http://www.ptolomeo.unam.mx:8080/xmlui/bitstream/handle/132.248.52.100/9781/decd_1830.pdf?sequence=1.

Enrich. 2014. Windrow Compost Facility. *Enrich Environmental limited.* [Online] 2014. http://www.enrich.ie/composting-2/composting/.

EPA. 1995. WASTE WATER TREATMENT MANUALS PRELIMINARY TREATMENT. [Online] 1995. [Cited: 07 04 2019.] https://www.epa.ie/pubs/advice/water/wastewater/EPA_water_treatment_manual_preliminary.pdf.

EPA. 2003. Wastewater Technology Fact Sheet Screening and Grit Removal. *EPA.* [Online] 06 2003. [Cited: 10 04 2019.] https://www3.epa.gov/npdes/pubs/final_sgrit_removal.pdf.

F. Ellen MacArthur . 2014. Economía Circular. *Economía Circular .* [Online] 10 2014. [Cited: 08 05 2019.] https://economiacircular.org/wp/?page_id=62.

F. Fernandes, C. V. Andreoli, M. Sperling. 2007. Sludge Treatment and Disposal. *IWA publishing .* [Online] 2007. [Cited: 07 04 2019.]

https://sswm.info/sites/default/files/reference_attachments/ANDREOLI%20et%20al%202007%20Sludge%20Treatment%20and%20Disposal.pdf.

F.J. García, A.J. González. 2009. Elaboración y automatización de una máquina empacadora a escala. *Universidad Pontífica Bolivariana.* [Online] 18 09 2009. [Cited: 01 04 2019.] https://repository.upb.edu.co/handle/20.500.11912/595.

Fabregat, E. B. 2017. Optimización del mezclado y la homogeneización en reactores anóxicos de EDAR mediante agitadores sumergibles. [Online] 07 2017. [Cited: 06 04 2019.] http://repositori.uji.es/xmlui/bitstream/handle/10234/170074/TFM_2017_BarredaFabregatEnric%20.pdf?sequence=1&isAllowed=y.

FanWay. FanWay Fertilizer Machinery. [Online] [Cited: 25 03 2019.] https://fertilizer-machinery.com/equipment/fertilizer-mixer/horizontal-fertilizer-mixer.html.

Fanway. 2012. Rotary Drum Cooler . *FanWay Fertilizer Machinery .* [Online] 2012. https://fertilizer-machinery.com/equipment/rotary-drum-cooler.html.

FanWay. 2019. Rotary Drum Screen. *FANWAY.* [Online] 2019. [Cited: 31 03 2019.] https://fertilizer-machinery.com/equipment/rotary-drum-screener.html.

Feeco International. 2015. Rotary Dryer Construction. *SlideShare.* [Online] 28 10 2015. https://es.slideshare.net/feeco/rotary-dryer-construction.

Feeco. 2019. Rotary coolers. *Feeco international.* [Online] 2019. [Cited: 02 04 2019.] https://feeco.com/rotary-coolers/.

Fresh. 2019. Deshidratadores de lodos filtro prensa. *HIDRO FRESH.* [Online] 2019. [Cited: 20 04 2019.] http://hidrofresh.cl/index.php/productos/detalle_otro_producto/1.

Freund Vector . Freund Vector. [Online] [Cited: 26 03 2019.] https://www.freund-vector.com/products/tfc-220-roll-compactor/.

Freund Vector. FREUND VECTOR. [Online] [Cited: 26 03 2019.] https://www.freund-vector.com/products/tfc-220-roll-compactor/.

GEA. Rotary Coolers. *GEA engineering for a better world.* [Online] [Cited: 29 03 2019.] https://www.gea.com/en/products/rotary-cooler.jsp.

Gil Pérez, B. 2017. Horticulutura de Altura. *DocPlayer.* [Online] 2017. https://docplayer.es/38906840-Curso-de-horticultura-de-altura.html.

GOOGLE EARTH. 2019. GOOGLE EARTH. [Online] 2019. [Cited: 12 06 2019.] https://earth.google.com/web/.

GOUIN, F. R. and others. 1992. On-Farm Composting Handbook. *campus.extension.org.* [Online] 06 1992. https://campus.extension.org/pluginfile.php/48384/course/section/7167/NRAES%20FarmCompost%20manual%201992.pdf.

H.S.S Few, B.C. Hilton, J.Steedman. 1981. Fertilizer Procurement. *Fao.* [Online] 1981. http://www.fao.org/3/aq350e/aq350e.pdf.

Habitissimo. 2019. Habitissimo. [Online] 2019. [Cited: 06 06 2019.] https://www.habitissimo.es/presupuestos/limpieza-local-industrial?utm_expid=78183681-155.-1syRjjyRLa9Ci3vVFb8Yg.0&utm_referrer=https%3A%2F%2Fwww.google.com%2F.

HCL. 2019. HCL Machine Works. *Agriculture xprt.* [Online] 2019. https://www.agriculture-xprt.com/products/hcl-machine-model-ct-10-windrow-compost-turner-339392.

Holganix. 2018. Why use organic fertilizer=. *Holganix, Soil nourishing root stimulating.* [Online] 2018. [Cited: 11 05 2019.] https://www.holganix.com/blog/8-advantages-and-disadvantages-of-using-organic-fertilizer.

Huber. 2019. Aeration Grit Removal. *HUBER Technology Waste Water Solutions .* [Online] 2019. https://www.huber.de/huber-report/ablage-berichte/grit-separation-and-treatment/new-grease-separation-and-removal-system-in-our-hydro-duct-grit-traps.html.

HUBER. 2019. Coarse Screen. *HUBER Technology Waste Water Solutions.* [Online] 2019. [Cited: 11 04 2019.] https://www.huber.de/products/screens-and-fine-screens/perforated-plate-and-bar-screens/huber-coarse-screen-trashmaxr.html.

I. Dominguez, A. Martín, M. Herrera,. 2002. DISEÑO CONCEPTUAL DE UNA PLANTA PILOTO DE TRATAMIENTO DE AGUA. *ResearchGate.* [Online] 1 2002. [Cited: 09 04 2019.] https://www.researchgate.net/publication/304783979_DISENO_CONCEPTUAL_DE_UNA_PLANTA_PILOTO_DE_TRATAMIENTO_DE_AGUA_RESIDUAL_MUNICIPAL.

Indeed. 2019. Indeed. [Online] 2019. [Cited: 08 07 2019.] https://www.indeed.es/salaries/T%C3%A9cnico/a-instalador/a-Salaries?period=hourly.

IVE. 2018. IVE-Instituto Valenciano de la Edificación. [Online] 2018. [Cited: 02 07 2019.] http://www.five.es/productos/herramientas-on-line/visualizador-2018/.

J. A. S. Mesa, B. B. S. Mancipe. 2017. GUÍA Y HERRAMIENTA COMPUTACIONAL PARA EL DISEÑO HIDRÁULICO DE UN SISTEMA DE TRATAMIENTO PRELIMINAR (CRIBADO Y DESARENADOR) DE AGUAS RESIDUALES. [Online] 04 2017. [Cited: 07 04 2019.] https://repositorio.escuelaing.edu.co/bitstream/001/564/3/Sierra%20Mesa%2c%20Javier%20Alexander%20-%202017.pdf.

J. J. Peirce, P. A. Vesilind. 1998. Environmental Pollution and Control. *ScienceDirect.* [Online] 1998. [Cited: 17 04 2019.] https://www.sciencedirect.com/book/9780750698993/environmental-pollution-and-control.

J. P. Guyer. 2011. Introduction to Primary Wastewater Treatment. *CED Engineering .* [Online] 2011. [Cited: 07 04 2019.] https://www.cedengineering.com/userfiles/Primary%20Wastewater%20Treatment.pdf.

J. S. Guillamón. 2014. Línea de fangos de una EDAR . [Online] 2014. [Cited: 17 04 2019.] https://www.intecsa-inarsa.com/images/BLOG/TRATAMIENTOS_DE_FANGOS_UCAM_2014.pdf.

J. S. López, A. J. Burgos, P. U. Rodríguez,. 2015. SLUDGE THICKENING. *Water action plan.* [Online] 09 2015. [Cited: 17 04 2019.] https://www.wateractionplan.com/documents/177327/558166/Sludge+thickening.pdf/00be9544-6935-6501-1b59-d65901ff3876.

J.S. López, A.J. Burgos, P.U. Rodríguez. 2015. Tecnologías de deshidratación de fangos. *Water action plan.* [Online] 09 2015. [Cited: 17 04 2019.] https://www.wateractionplan.com/documents/177327/558161/Tecnolog%C3%ADas+de+deshidrataci%C3%B3n+de+fangos.pdf/50ea3d5e-f094-7bff-97af-5573fef89055.

K. Gernaey, P. A. Vanrolleghemen, P. Lessard,. 2001. Modeling of a reactive primary clarifier. [Online] 2001. [Cited: 06 04 2019.] https://modeleau.fsg.ulaval.ca/fileadmin/modeleau/documents/Publications/pvr272.pdf.

K. Lawinska, R. Modrzewski. 2016. Analysis of sieve holes blocking in a vibrating screen and a rotary and drum screen. *Journal System.* [Online] 06 09 2016. http://www.journalssystem.com/ppmp/Analysis-of-sieve-holes-blocking-in-a-vibrating-screen-and-a-rotary-and-drum-screen,65082,0,2.html.

Klibert, C. 2015. Shaped Digester . *Picswe.* [Online] 09 2015. [Cited: 19 04 2019.] https://www.picswe.com/pics/shaped-digester-aa.html.

Kresisch, T. 2013. Libróptica. [Online] 2013. [Cited: 25 03 2019.] http://libroptica.com/MezcladorDeCintas.html.

L. Beltrán, M. Subirá, L. Beltrán. 2009. Problemas del desarrollo. *Scielo.* [Online] 04 2009. [Cited: 11 05 2019.] http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0301-70362009000200008.

Lenahan, M. 2019. The Use of Organic and Inorganic Fertilizers. *The nest.* [Online] 2019. [Cited: 11 05 2019.] https://budgeting.thenest.com/use-organic-inorganic-fertilizers-31296.html.

López, A. R. 2006. Diseño y construccion de una maquina desmenuzadora de turba y/o tierra para vivero. *Dspace.* [Online] 23 02 2006. http://dspace.espoch.edu.ec/handle/123456789/2336.

MacArthur. 2014. Circular Economy. *Ellen MacArthur Fundation.* [Online] 2014. [Cited: 10 05 2019.] https://www.ellenmacarthurfoundation.org/es/economia-circular/caracteristicas.

MF Tecno. 2017. Empaquetadoras Embaladoras. *MF Tecno Packaging system.* [Online] 2017. [Cited: 01 04 2019.] https://www.mftecno.com/images/pdf/confverticali-es_pt.pdf.

Miller, R. 2018. Inorganic Fertilizer vs Organic Fertilizer. *SFGATE.* [Online] 17 12 2018. [Cited: 10 05 2019.] https://homeguides.sfgate.com/inorganic-fertilizer-vs-organic-fertilizer-39528.html.

Monroe. 2019. Circular Clarifier and Thickenesers . *Monroe Environmentall.* [Online] 2019. [Cited: 14 04 2019.] https://www.monroeenvironmental.com/water-and-wastewater-treatment/circular-clarifiers-and-thickeners/.

Montero Avendaño, J. E. 2006. Diseño de máquina volteadora de compost. *cybertesis.* [Online] 2006. http://cybertesis.uach.cl/tesis/uach/2006/bmfcim778d/doc/bmfcim778d.pdf.

Moran, S. 2017. Sciencedirect. [Online] 2017. https://www.sciencedirect.com/science/article/pii/B9780128033555000251#!.

Mujumdar, A. S. 2011. Drying: Principles and Practice. [Online] 7 6 2011. http://www.kmutt.ac.th/dtrl/pdf/Drying_Principles%20and%20Practice.pdf.

N. Black. 2016. Fundamentals of Wastewater Treatment Wastewater Treatment Plant Operator Training. *SlidePlayer.* [Online] 2016. [Cited: 11 04 2019.] https://slideplayer.com/slide/5731767/.

National Organic Program. 2019. National Organic Program. *USDA.* [Online] 2019. [Cited: 11 05 2019.] https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program.

Nieto C., López R., Galvis O. 1985. Elementos de máquinas. *Sena.* [Online] 10 1985. [Cited: 18 07 2019.] https://repositorio.sena.edu.co/sitios/elementos_maquinas/vol18/pdf/18-movilizacion-y-fijacion-de-maquinaria.pdf.

Ogbeche, S. 2018. Development and Performance Evaluation of a Motorized Gari Sieving. *ResearchGate.* [Online] July 2018. https://www.researchgate.net/publication/326942817_Development_and_Performance_Evaluation_of_a_Motorized_Gari_Sieving_Machine.

Outdoor-Decoration. Outdoor Decoration. *Compost Turner Tumbler .* [Online] http://www.coolsparta.com/useful-compost-turner/compost-turner-tumbler/.

P. H. Klopping. 1980. Gravity Thickening. *files.eric.ed.gov.* [Online] 08 1980. [Cited: 17 04 2019.] https://files.eric.ed.gov/fulltext/ED230399.pdf.

Pardo, C. P. 2012. DISEÑO Y CÁLCULO DEL TRATAMIENTO SECUNDARIO MEDIANTE AIREACIÓN PROLONGADA DE UNA EDARU. [Online] 07 2012. https://orff.uc3m.es/bitstream/handle/10016/16081/PFC_Carlos_Perez_Pardo.pdf;jsessionid=280CC01CE90CB8FB51C3B1521AA5C12C?sequence=1.

Pérez, J. A. 1981. Sedimentación. *bdigital.* [Online] 1981. [Cited: 13 05 2019.] http://bdigital.unal.edu.co/70/5/45_-_4_Capi_3.pdf.

Pichel, J. J. P. 2012. DISEÑO DE UN DIGESTOR ANAERÓBICO DE UNA DEPURADORA DE TRATAMIENTO DE AGUAS RESIDUALES CON APROVECHAMIENTO ENERGÉTICO. *Universidad pontífica de Madrid.* [Online] 07 2012. [Cited: 07 04 2019.] https://www.iit.comillas.edu/pfc///resumenes/5006e6166d5e4.pdf.

Plan territorial. 2010. Plan Territorial Especial de Ordenación de Residuos de Tenerife. [Online] 2010. [Cited: 30 05 2019.] https://www.tenerife.es/planes/PTEOResiduos/adjuntos/Anexo01_Info05.pdf.

Powder & Bulk Solids. 2015. Things to Consider When Selecting a Rotary Dryer. *POWDER & BULK SOLIDS.* [Online] 17 12 2015. https://www.powderbulksolids.com/article/Things-to-Consider-When-Selecting-a-Rotary-Dryer-12-17-2015.

Ragsdale. 2004. PRIMARY TREATMENT. *Ragsdale and Associates Training Specialists, LLC.* [Online] 2004. [Cited: 06 04 2019.] http://users.rowan.edu/~jahan/env.enggI-fall2004/Chapter%203%20-%20Primary%20Treatment.pdf.

Rinkesh. What are Organic Fertilizers? *Conserve energy future.* [Online] [Cited: 10 05 2019.] https://www.conserve-energy-future.com/benefits-and-types-of-organic-fertilizers.php.

Royo, Enrique Carnicer. 1994. *Aire comprimido.* Madrid : Paraninfo, 1994.

S. Aguirre, D. Castro, L. Ramirez,. Canales y desarenadores como tratamiento preliminar en el agua para consumo humano. [Online] [Cited: 06 04 2019.] https://www.academia.edu/26630595/Canal_y_desarenador.

S. B. Pavankumar and others. 2018. Design and Fabrication of Organic Waste Shredding Machine. *Ijesi.* [Online] 06 2018. [Cited: 02 04 2019.] http://www.ijesi.org/papers/Vol(7)i6/Version-3/F0706032631.pdf.

S. Mohanavelan, A.K. Nachimuthu. 2016. DESIGN AND FABRICATION OF HORIZONTAL SIEVING MACHINE. *ResearchGate.* [Online] 08 2016. https://www.researchgate.net/publication/305357251_DESIGN_AND_FABRICATION_OF_HORIZONTAL_SIEVING_MACHINE.

S.A, Kaiser. 2019. Kaiser S.A Maquinaria agrícola. [Online] 2019. http://www.kaisercr.com/index.php/equipo-agricola/volteadoras/volteadora-de-compost.

Shahhosseini, Sh. , Sadeghi, M. T. , Golsefatan, H. R. 2010. Dynamic Simulation of an Industrial Rotary Dryer. [Online] 2010. https://pdfs.semanticscholar.org/197e/e1ed5926f3955e8d86c5e79c590b6ad406b7.pdf.

Sigma. 2019. Weighing And Bagging Machine. *Sigma Instrumentation.* [Online] 2019. [Cited: 01 04 2019.] https://www.sigmainstrumentation.com/weighing-and-bagging-machine.html.

Solans, X. Gadea, E. Mansilla, A. 2008. Residuos sólidos urbanos: riesgos laborales en plantas de compostaje (I). *Nota técnica de prevención.* [Online] 2008. http://www.insht.es/InshtWeb/Contenidos/Documentacion/FichasTecnicas/NTP/Ficheros/786a820/NTP-805%20web.pdf.

Solex. 2016. Fertilizer Production and Storage. *Solex Thermal Science.* [Online] 14 06 2016. https://www.solexthermal.com/resources/articles/fertilizer-production-and-storage/.

Stahel, Walter R. 2016. The circular economy. *Nature.* [Online] 23 03 2016. [Cited: 08 05 2019.] https://www.nature.com/news/the-circular-economy-1.19594.

Sulta. 2019. Crushing and Blending Manufacturer Parts and Equipment. *Sulta Custom steel fabricator.* [Online] 2019. [Cited: 03 04 2019.] http://www.sultamfg.com/crushing-blending-equipment/.

V. Fai, T. Jong, L. Keng, W. Shaaban, M. Kher. DESIGN OF UREA GRANULATOR WITH ENERGY OPTIMIZATION. [Online] http://eprints.utem.edu.my/15120/1/Design%20of%20urea%20granulator%20with%20energy%20optimization210.pdf.

Vázquez, E. M. 2008. Filtración de lodos industriales. [Online] 2008. [Cited: 17 04 2019.] https://webcache.googleusercontent.com/search?q=cache:fcyDiGdpWC4J:https://www.eoi.es/es/file/18361/download%3Ftoken%3D5LBHBPhP+&cd=1&hl=es&ct=clnk&gl=us.

Whirlston. 2019. Fertilizer Rotary Drum Screening Machine. *Whirlston.* [Online] 2019. [Cited: 31 03 2019.] https://www.fertilizer-machine.com/product/Fertilizer_Rotary_Screening_Machine.html.

21 FIGURES

22 TABLES

ANNEXES

Annex I: Tender document

It is a mandatory document. All the standards are included in it.

Annex II: Plan

It contains the graphic representation of the company, the air compressed distribution and the diagram of both processes.

Annex III: Calculations

It contains the required calculations to make the installation possible.

Annex IV: Budget

It represents the cost that it would have to start a fertilizer plant.

Total cost: 655.953,87 €

Annex V: Catalogs

Include the specification of the chosen material.