# Higher College of Technology
# Department of Engineering
## Mechanical and Industrial Engineering section

# Aerobic & Anaerobic Industrial Wastewater Treatment

*Submitted in partial fulfillment of the requirements for the degree of*

Bachelor

*by*


| Name: | ID: |
|---|---|
| **Nadhem Mohsen Maalawi** | **12A163** |


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## ABSTRACT

The project work of wastewater treatment is operated through several complicated processes and has three stages: analysis, experiment, and post analysis where these difficult and complicated processes are carried out in three stages that must be successfully and correctly completed. The process operation of the wastewater treatment is obtained from the operation sector and the analysis monitored data and the composition data is obtained from the water sample are through the laboratory. The aerobic part of the operation is done in the college using the aerobic digester, but the anaerobic part is done in another facility where the operation will be done by bacteria and enzymes as the catalyst. Finally, both the operation treated sample will be compared to check the efficiency of the two experiments.

## ACKNOWLEDGEMENT

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**Place: Muscat**

**Date: 31/Mar/2020** **Signature of the Candidate**

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Chapter 1

# Introduction

## ❖ *WATER TREATMENT:*

With the huge increasing in population around the world, the demand on water increased too but, the pure water resources are limited like rivers, wells, and underground water. Because of that, water treatment is used to cover the needs of pure water and cover that demand. Water treatment refers to the operation where all of the contaminants (impurities) are removed or reduced to a lower concentration in the water which convert it to a useable state. For example: (1)

1- Sea water goes under treatment and become drinkable water.
2- Sewage water is treated and become useable for agriculture purposes.

The process of treatment is depending upon the quality of the water which is desired to be purified. As an example, sewage water contains lots of organic and inorganic impurities (such as animal dung, urea, oil, nitrates and phosphates) and because of that it requires more treatment than underground water which is containing less impurities (such as iron and manganese).

The major priority of water treatment is processing wastewater and clean it from all kinds of harmful impurities and reproduces it as a drinkable water which is the best-case scenario or at least usable for agriculture uses.

For all wastewater sources like seawater, underground water and sewage water, they contain bacteria and nutrients, which will be introduced then to a biochemical reaction which measures their biochemical oxygen demand (BOD). This reaction will discover chemicals needed to be removed from the water using strong oxidizing agents and, after doing that we get another reading which is chemical oxygen demand (COD). Relative oxygen-depletion effect of a waste contaminant and a measurement of pollution effect is measured through COD and BOD tests. Oxygen demand of biodegradable pollutants are measured by BOD and COD analyzes the oxygen demand of oxidizable pollutants.

Depending on the type of the water desired to be treated, different process plants and reactions are used to converted it and purify it from polluted water to a usable clean water. (1)

## *CLASSIFICATIONS OF WASTEWATER:*

What is wastewater? Wastewater is any kind of water which has been contaminated due to mankind usage, in other words polluted water. Under the category of Wastewater there comes (2)

1- Sewage water and wastewater from households (bath tubes, dishwashers, sinks, black water, and flush toilets)
2- Industrial wastewater (water that is used in industrial process and it's comes out as undesired biproduct such as in food industries and power plants)
3- Seawater
4- Rainfall water
5- Underground water
6- Fecal sludge

### ➢ *TREATMENNT PLANT:*

WASTEWATER TREATMENT PLANTS (WWTP): In wastewater treatment plants the feed water goes under physical, chemical, and Biochemical processes. (3)

1- Phase Separation: Transferring impurities into non-liquid phase. It may occur at any point between oxidation or polishing to remove generated solids
2- Sedimentation: It is used to separate solids like stones and sand from water using gravity where it occurs due to the difference in density between the solids and water by using turbulence. Grit channel used to get an ideal flow rate that allows the solids to settle. The unit used for this process is called primary settling tank
3- Oxidation: In this stage, the biochemical oxygen demand of wastewater as well as the toxicity is reduced, and it is called primary treatment.

4- Biochemical oxidation: this step is the primary treatment where the conversion of organic materials to $CO_2$, water, or biodiesel.
5- Chemical oxidation: it is used to remove the remaining persistent organic pollutants and leftovers from biochemical oxidation. Ozon and Hypochlorite are used in this step.
6- Polishing: this is the last step where the removing of contaminates and impurities by chemical absorption using an active carbon, sand and fabric filters are used. (3)

SWAGE TREATMENT PLANTS (STP) :

Sewage water coming from municipal wastewater is taken to the plant to remove the human waste and other contaminant using physical, chemical and. Biochemical processes.

1. **Pre - treatment:** is the stage where the all materials that can be easily removed such as trash, tree limbs, leaves, branches, and other large objects are discarded. An automated mechanically raked bar screen is used for this stage.
2. **Grit removal:** This step is used to:

- heavy deposits in tanks or pipeline's chance is reduced.
- decrease the amount of digester cleaning caused by extra accumulations of grit.
- protect moving mechanical equipment from abrasion and accompanying abnormal wear.

3. **Flow equalization:** In this stage, sewage water is stored in a temporary storage then undergoes diluting and distributing batch outputs of high-strength, toxic wastes.
4. **Primary and Secondary treatment:** In primary treatment a sewage water flow through huge tank which is used to make it settle making trees and oil rise to the surface. While secondary treatment is made basically to remove the biological contaminants of the sewage coming from mankind waste, food waste and soaps. Most of municipal plants are made to treat the settled sewage liquids using something called aerobic biological processes.
5. **Tertiary treatment:** More than one tertiary treatment may be used. It is. The final process of purifying to further increase as well as improve the quality of the

produced treated water before it discharges. Nitrogen and phosphorus removal are the most common example of tertiary treatment.

6. **Fourth treatment stage:** This stage is to ensure the removal of any chemicals left in the water after primary, secondary and tertiary treatment regardless their concentration is it low or high just to ensure that there will be no harmful effects when it is used. (3)(4)

## ➢ *AEROBIC TREATMENT:*

**Aerobic water treatment:** A process for treating water by digestion in a reactor. The breakdown of organic waste suspended in water using enzymes in the presence of oxygen. This process produces a high-quality effluent that makes it easier for further processing and increases the efficiency of sterilization. The process is very stable, less complex and cost effective. The end product can be utilized for agricultural needs since it is odor free and obeys all the environmental regulations, though potable water is never produced from this process. (5)

Aerobic water treatment process:

1. The process will start by preparing the water in the "pre-treatment" stage, where physical processing of the waste water will occur through the removal of large solids suspended and all the waste that's floating at the surface, grease and heavy inorganic matter. The main objective from this step is to prevent clogging or damage that could potentially occur to the instrumentations and devices such as flow equalizers, grit chambers, screens, and racks. At this point, the water quality isn`t improved drastically yet.

2. The next stage is the Primary Treatment system (PTS), where the velocity of water will be dropped down to a level that allows for heavier substances to be gathered so they can be removed. The water shall pass through a course of screens and racks that will act as filters for solid substances that are smaller in size, then fed to grit chambers to be removed to prevent clogging of pipes and improved fluidity of the process.

- The second stage from the PTS is sedimentation, water velocity will drop drastically to allow for settling down of solid waste to the floor due to force of gravity, usually occurs in a settling tank. Coagulation will also occur, it's a technique that can be thought of as a clotting process for smaller lighter particles that won't settle as fast/easily as the larger particles, this will allow for lesser time taken for all solids to settle at the bottom.

- Other steps are followed such as Neutralization of the water to natural pH values, Equalization which will ensure the water consistency and prevent solid suspensions within it, Chemical precipitation that will gather all the small metallic substances using different coagulants such as Aluminium sulphate, Ferric chloride and lime. Removal of toxic matter also occurs as well as grease and oil that could cause difficulties if they form emulsions that will be annoying to break.

3. Secondary stage is biological, where organic waste such as human waste, food and cleaning products are metabolized using algae and bacteria and are broken down. Different approaches are relied on for this process: (Fixed fil – Suspended fil – Lagoon) systems

❖ Fixed films: a bed supported by a biomass layer, that comes to contact with the wastewater and air to cause biodegrading. The system can move along with the wastewater or it can be stationary but exposure to air as well as wastewater are crucial for the breakdown to occur.

❖ Suspended film system: The microorganisms are fed directly to the wastewater while being stirred to ensure consistency and uniform spread in the medium. The degraded materials will eventually settle on the floor due to gravitational forces where they can be fetched and processes further to undergo pH stabilization, and further to be supplied for agricultural needs.

- Lagoon systems: Rely on longer periods of time, where a tank containing both wastewater and biological microorganism to biodegrade in the long run without any external forces or stirring occurring.

4. Tertiary treatment: similar to the secondary stage but more advanced and using more complex technique to remove impurities and undesired substances such as micro screening, nano filtration, coagulation and wedge wire screens.

Dissolved solids within the water can be removed using activated carbon, due to its high porosity and large surface area, it will allow for more water to pass through while collecting the impurities by absorption phenomenon due to the higher forces of attraction provided by the activated charcoal in comparison to the solvent which is water in our case.

- Ultra-filtration: is also another technique that utilizes hydrostatic pressure applied on filters and semi permeable barriers.
- Purification through Reverse osmosis can also be used, using this technique, wastewater will pass through a membrane driven by a pressure that allows the dissolved substances to stack on one side, while purified water emerges to the other.
- Chlorination is also very common as the disinfectant will destroy bad bacteria, parasites, and microorganisms. (5)

## *ANAEROBIC TREATMENT:*

Anaerobic water treatment: A process for treating water by breaking down the organic waste present in water using enzymes without the presence of oxygen inside the reactor. It is similar to fermentation in the mechanics of changing the chemistry of a solution by becoming a substrate through the activity of enzymes. This technique is mainly utilized for streams with higher organic material concentrations labeled “BOD”, “COD” and “TSS”, as a result of agricultural, paper and pulp, municipal waste and dairy industries effluent.

The process is split into two major stages, Acidification phase followed by a Methane production phase. (6)

1. In the first stage, a biomass in the form of anaerobes which are microorganisms such as bacteria that do not require the presence of oxygen to grow in population will be fed to the effluent stream. The contact between the wastewater and such organisms will cause breakdown of toxic material and substances like heavy organic compounds into much less complex, short-chained more volatile organic acids.

2. The next stage is called Methane production phase. It is split into two sections. The first being acetogenesis, where anaerobic organisms synthesize the organic materials in the wastewater by reducing them to acetate, hydrogen gas and carbon dioxide. Acetogens are species used to finalize the mention process. Following that, methanogenesis, done by the aid of methanogens, which is a type of microbes that will be used to act upon the previous stage`s synthesized matter to produce methane and carbon dioxide. Once separated, the gases produced can be utilized for energy purpose like burning fuels and the water is routed to further processing and filtration.

The equipment and plants used for completing anaerobic digestion of wastewater organic matter is dependent on the size of the operation itself, taking in consideration the location, conditions and the capacity of water that is targeted for treatment. Common anaerobic water treatment systems are as mentioned:

- **Anaerobic sludge blanket reactors:**
  Layers of anaerobic microorganisms or sludges of particles are put to contact with continuously flowing wastewater. Throughout the breaking down of organic materials, the population of the anaerobes multiplies and increases as they gather into bigger groups and eventually settle to the bottom flow of the reactor, to then be gathered and possibly used for future operations.

**Different Types of Anaerobic sludge blanket systems:**

1. Up-flow anaerobic sludge blanket (UASBs): Using pumps to force wastewater down and Countering it with an upward flow.
2. Expanded granular sludge beds (EGSBs): Water circulation is used.
3. Anaerobic baffled reactors (ABRs)**:** Utilizing semi-closed chambers for greater contact.

- Anaerobic filter reactors: Tanks fitted with single or multiple filtering mediums comprised of a layer of anaerobic microorganisms allowed to settle on the surface and grow in population and establish through the area by allowing flow of wastewater through it. The biofilm formulated will take some time to form ranging from months to even years depending on its size to be considered ready for use. Gravel, certain polymers and pumice or bricks are materials that can be considered a home for the microorganisms to grow on. Once ready, wastewater flowing through the biological mesh will exit but with the organic particles previously dispersed being captured within the filters and broken down eventually to less harmful substances. Overtime, the biofilm must be monitored for potential clogging due to prolonged exposure to the organic waste and overpopulation of anaerobes. Maintenance is necessary. (6)

- *ADVANTAGES AND DISADVANTAGES OF AEROBIC AND ANAEROBIC:*

*AEROBIC:* (6)

**Advantages:**

1. More efficient when it comes to dealing with non-organic substances.
2. Less odors produced in comparison to the bulk of gases emitter by anaerobic process.
3. Better yield of treated water
4. Less complex in operating.

**Disadvantages:**

1. Higher operating costs (equipment, energy, personnel)
2. More maintenance and monitoring required

*ANAEROBIC:*

**Advantages:**

1. Energy efficient.
2. Area of operation (size of reactor) is relatively smaller than aerobic.
3. Less materials used (chemicals).
4. Lower waste handling costs.

**Disadvantages:**

1. Low efficiency and ability for dealing with non-organic matter.

- *Objectives of Aerobic and Anaerobic treatment:*

  ***General Objectives:*** aerobic and anaerobic wastewater main objective is to obtain usable or drinkable water from different sources other than the pure water. This method creates all the needed water for all the human race and the most important alternative sources are:

1. **Ground water:** The water content present within the lithosphere (the surface of the earth). Usually found in between rocks, accumulated in water beds, saturated soil that feed eventually to wells, springs and lakes on the surface of the earth.
2. **Surface water:** Water found on the surface of the earth. Lakes, seas, oceans and man-made dams are examples of surface water. Surface water can also be subjected to evaporation due to high temperatures which will cause it`s level to decrease.
3. **Gray water:** Wastewater expelled from all sources like houses, buildings and industrial plants excluding faecal contamination.
4. **Storm sewage:** Wastewater as a result of storm disturbing different dirty water reservoirs and exposing them to cleaner reservoirs causing vital contamination

across the medium. Examples on that include sewage water from pipes, footpaths, roofs, and roads.

5. **Domestic sewage:** All wastewater expelled from residential sources including faecal, detergents and food contamination.
6. **Industrial sewage:** Wastewater expelled from industrial sectors, usually highly toxic and contaminated with non-organic heavy substances. (6)

***Specific objective:*** the specific objective is the method used to complete the treatment operation such as distillation, desalination and other methods. The completion of the operation depends on what is used in the aerobic and anaerobic stage:

1. **Enzymes:** is one of the most useful ways to complete the wastewater treatment so that it is possible to specify the objective of the operation and the product that is produced from it.
2. **Bacteria:** is the other efficient alternative where it can complete the operation of treatment to get a useful product but the bacteria are highly dependent on temperature.

**Chapter 2**

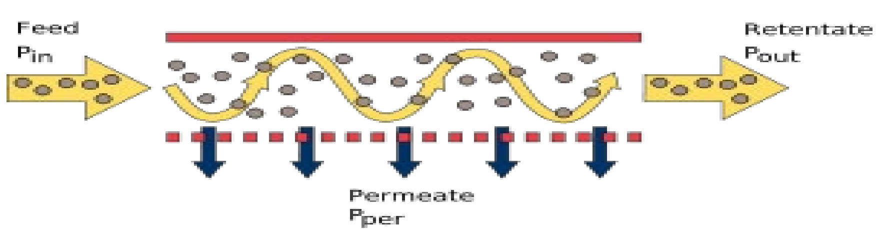
# Literature Review

- **COMPARISION OF COST BETWEEN AEROBIC AND ANAEROBIC PORCESS**

A research article done by P. RANTALA and P. VANANEN in 1985, it illustrates the difference in cost of the operation if the wastewater was treated aerobically or anaerobically or combined. The results are made using activated sludge as waste and it showed that both processes to conduct the treatment, aerobic process as post-treatment and anaerobic process as pre-treatment and that makes the operation more economical and more efficient. In my opinion, I agree to this article results, as known, both processes save money, gets better results and consumes less energy and more environmental. (7)

- **AEROBIC DOMESTIC WASTEWATER TREATMENT IN A PILOT PLANT WITH A COMPLETE SLUDGE RETENTION BY CROSS-FLOW FILTRATION**

E.B. Muller and A. H. STOUTHAMER Decided to Do Experiment in 1994, to investigate about treatment of wastewater aerobically in a pilot plant with a complete sludge retention time using cross - flow filtration. they did it because the usual aerobic treatment of wastewater back then causes problems, the main one is that the water produced from the usual operation will have low nutrients. complete sludge retention time meaning is that the average time at which sludge solids will activate in the system. Cross - flow filtration is process in which the water will flow tangentially in a membrane surface. this process took more than ten months, where the sludge was completely retained.




(Figure 2.1 treatment in a pilot plant)

the scientists illustrated that at high loading rates of wastewater, aerobic treatment may be efficient when the sludge was completely retained. the decreased in the sludge element means that the water produced came purer, and it showed better results than the normal or usual wastewater treatments. in my opinion, this experiment is very costly because the aeration of the membrane has to be increased if the sludge was at high concentration. also, it consumed a lot of energy during the ten months of the process. (8)

- **USE OF PROTOZOA AND METAZOA FOR DECREASING SLUDGE PRODUCTION IN AEROBIC WASTEWATER TREATMEN**

In 1996, NATUSCKA M, LEE & THOMAS WELANDER investigate about how to decrease sludge production using PROTOZOA and METOAZOA in aerobic wastewater treatment. Protoza and Metoazoa are both a form of eukaryotic animals and they both depend on the organization in the body. the difference between them is that protozoa classify as Uni-cellular (contain single cell) primitive group, whereas the Metoazoa are multi-cellular (contain multi cell) group. The experiment went well according to the results that NATUSCKA M. LEE & THOMAS WELANDER got, based on acetic acid and methanol which represents the dissolved organics that tested in the wastewater, both decomposed in about 90%, and the production of biomass dropped down to almost 80%. as these results are good, there were high carbon sources releases during and after the process, (nitrate more than 7mg, phosphate more than 2.5mg). in my view as the results been obtained, this experiment is not suitable for major used. it showed the sludge production decreases, the nitrate and phosphate percentage with respect to the amount of wastewater taken is high, and it would cause environmental problems if we kept using this process. also, the water quality produced is not suitable for drinking, it needs more filtration. (9)

- **AEROBIC AND ANAEROBIC WASTEWATER TREATMENT**

ROBINSON. D. G, WHITE. J. E and CALLIER. A. J in 1997 did a research to investigate the difference in both aerobic and anaerobic processes to treats the wastewater produced from industries. the difference based on three categories, composition of components of the wastewater, degree of stabilization that is essential for environmental compliance and which on is more economical. in terms of economics, anaerobic process is more to be economical than aerobic process, that's because it doesn't consume energy a lot and no need to afford chemicals to used it in the treatment process but, aerobic process is superior to anaerobic process in term of degree of stabilization and it is more efficient, because chemical can be used and filters to make the water produce has more purity and drinkable. (10)

- **HIGH - RATE ANAEROBIC WASTEWATER TREATMENT AT LOW TEMPERATURES**

Industrial Wastewater Is That Made by Making Commercial or Desired Products in Industries Which Will Made Unwanted Wastes Like Water. This Is One of the Major Problems That Humans Face Every Year Which How to Treatment Such Waste Like Wastewater. In 1998, G. LETTINGA, S. REBAC, S. PARSHINA, A. NOZHEVNIKOVA, JULES B. V. LIER AND, ALFONS J. M. STAMS, in Moscow, Russia, done an experiment of high-rate anaerobic wastewater treatment at low temperatures. the aim of it is to treat diluted wastewater under psychrophilic conditions (organisms that thrive in cold temperature). the reactor used in this operation is called expanded granular sludge bed reactor (EGSB), which mainly used for high performance anaerobic treatment process. this process carried out in two stages of expanded granular sludge bed reactor that was operated in series, while the mixture used for this operation was a volatile fatty acid (VFA) mixture. (10)

anaerobic treatment of this mixture was tested under psychrophilic conditions of " $3° - 8°C$", using the two stages of expanded granular sludge bed reactor that operated in series, its good removal of the mixture fatty acid. in the first stage it showed high level of propionate (short chain of fatty acid). but in the next stage the short chain of fatty acid got removed completely. that because of the low hydrogen partial pressure and low concentration of acetate became an advantage here for oxidization of the propionate. in my opinion, this experiment is very complicated and in is not suitable for many countries because the conditions that need to perform these experiments like for example the weather or the temperature. (11)

- **CHARACTERISATION OF SOLUBLE RESIDUAL CHEMICAL OXYGEN DEMAND (COD) IN ANAEROBIC WASTEWATER TREATMENT EFFLUENT**

In 1999, DUNCAN. J. BARKER, GIANNI. A. MANNUCCHI, SANDRINE. M. L. SALVI and DAVID. C. STUCKEY wrote an article in a book called water research, that the effect of component has high or low molecular weight on the effluent. the date was presented by using Freundlich model and showed that low mw component is difficult to be degraded aerobically, and difficult to adsorb the activated carbon than the high mw components. (14)

- **COMPARISINE BETWEEN AEROBIC AND ANAEROBIC WASTEWATER TREATMENT TECHNOLOGYS in GREENHOUSE GAS PRODUCTION**

In 2004, a book was published that discussed a bout "water research". It provides research about water and its characteristics, properties and the processes in which water can be treated if it was waste. Which is our topic to discuss. greenhouse gases are gases that found in earth atmosphere, which it blocks the heat that reflected from earth surface to flee out which leads to increase the earth temperature, which is a problem so it needs to be reduced. The book mentioned that, aerobic process is more efficient than the anaerobic process when dealing with wastewater, but in terms of production of greenhouse gases, anaerobic process is more favorable because no need to use chemicals. (12)

- **EVALUATION OF ANAEROBIC-AEROBIC WASTEWATER TREATMENT PLANT OPERATIONS**

In 2004, E. GAŠPARIKOVÁ, Š. KAPUSTA, I. BODÍK, J. DERCO, K. KRATOCHVÍL, did a research to study if both anaerobic-aerobic processes will have different results to treat wastewater comparing to the results obtained if they did it individually, also to find better solution that need less energy consumption. they illustrate that the aerobic treatment is better, but it cost money and energy. the anaerobic is suitable in most countries because it is simple and low energy consumption. they have showed a difference between both technologies as table:

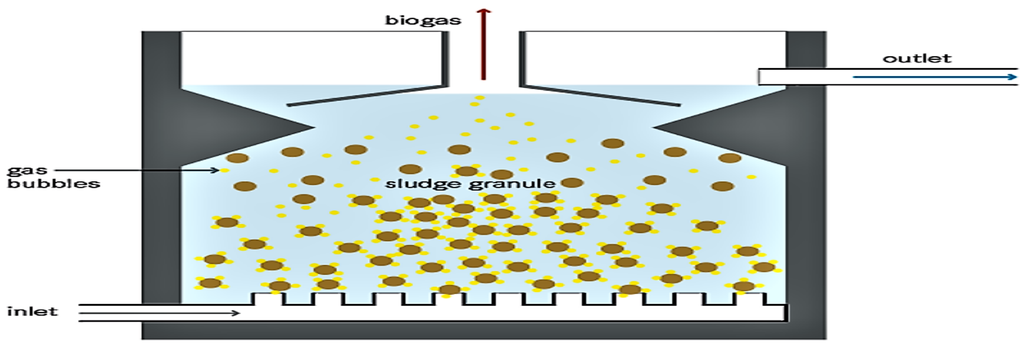
| PARAMETER COMPARING | ANAEROBIC SYSTEM | AEROBIC SYSTEM |
|---|---|---|
| Consumption of energy | Lower | Higher |
| Construction | Simple | Complex |
| Production of Biomass | Less | More |
| Demand of Nutrients | Less | More |
| Speed of Reaction | Lower | Higher |
| Removal of Nutrient | Minima | Very Good |
| Initiating Period | Higher | Lower |

(Table 2.1 parameter comparison)

so, they come up with a solution which is combining both the processes together under one process. which mean using the anaerobic process as pre - treatment and the aerobic process as post - treatment. according to them, this will provide greater efficiency in decreasing the organic matter as well as decreasing the nutrients, low specific energy requirements, a relatively short detention time (due to the relatively small volume of the tanks), and low specific production of excess sludge. this process operated in two stages, the post-treatment and pre-treatment Proseccos containing each stage of two reactors. it showed good results. for example, the energy consumptions decreased by 40% and the removal of organic waste and undesired solids is achieved. in my opinion, this was a good experiment because, it uses the same equipment's and almost same procedure, but from the results obtained it provides better results, less energy consumption and efficient process. (13)

- **THE EFFECT OF CONCENTRATION IN ANAEROBIC DAIRY WASTEWATER TREATMENT USING UASB REACTOR**

In 2005, DENISE M. G. FREIRE, and GERALDO L. SANTANNA JR. did an experiment to determine the effect of concentration of wastewater using Up flow anaerobic sludge blanket reactor. Up flow anaerobic sludge blanket reactor is a type of reactor in which the waste water is entering a tank from the bottom to the top, where it will form sludge granular, then it will be separated with the help of microorganisms to water and other contaminates. This reactor is very helpful to treat water at fast rates.




(figure 2.2 UASB reactor)

The aim of this experiment was to treat the synthetic dairy wastewater which it contains large amount of oils. The experiment done in two different reactor methods, one reactor was fed by normal waste water, and the other reactor was fed with waste water that has generated from enzymatic hydrolysis, and the results obtained are in terms of %COD removal and both of the reactors are operated at same conditions, 35℃ and for 14 hours straight. So, both of the reactors got the same result at lower concentrations in about 600 mg/L, but as the concentration increase in about 1000 mg/L, the rector with waste water that has generated from enzymatic hydrolysis got a batter results. In fact, the removal of COD was 90% compared with 82% in the normal wastewater. In my opinion, the Up flow anaerobic sludge blanket reactor got good results in both methods, but to generate waste water from enzymatic hydrolysis is very difficult process and it takes time, but overall, the Up flow anaerobic sludge blanket reactor is very efficient reactor. (13)

- **BEST CONDITIONS FOR METHANOGENIC BACTERIA IN ANAEROBIC WASTEWATER TREATMENT**

In 2005, R. BLASZCZYK & N. KOSARIC did an experiment to investigates the best conditions for the methanogenic bacteria in microbial aggregate. Methanogenic bacteria are a type of bacteria that found in mainly everywhere on earth and it can live at hot and cold places. It has many benefits to the environment like braking complex organic components in wastewater processing and convert the dangerous gas emissions that along these processes into methane so that it can be used as energy source. This process is done in two different wastewater streams to obtain the best concentration needed with respect to the conversion of the dangerous gas emissions. The conditions are based on three parameters, power of hydrogen (PH) and temperature, composition of the wastewater and the hydrodynamic conditions. As the results that the two scantiest represents, the best conditions for converting the dangerous gas emissions are reported as, for the temperature it should be maintained between $32℃ - 50℃$, and for the ph is between 6.5-7.5. The composition of wastewater must be soluble and maintained at a loading rate of 1 kg COD. As for the hydrodynamic conditions it can affect the process, at low waste water stream there is it took long time that the braking of complex organics is slow but at high waste water stream the pure water produced may need further filtrations because it is fast loading and the complex organics may not all be removed but that is small possibility or rarely to happen. In my opinion, this operation is very complicated to be run on, because all of the conditions that needed so that the gases produced from the process must be converted into methane and it took too much time and effort, and there are many other methods that can do that type of work with less time and simple conditions to be maintaining. (11)

## THE EFFECT OF DIFFERENT CONCENTRATIONS OF SUSPENDED SOLIDS TO ACTIVATE ENZYME IN AEROBIC WASTEWATER TREATMENT

In 2007, B. RODELAS, J.M. POVATOS, M. MOLINA and E. HONTORIA did an experiment to find out if the uses of different concentrations of selected solids can activate enzymes and the spread of bacteria among the sludges. The reactor used her is called pilot scale submerged membrane bioreactor, which is used mainly in wastewater treatments processes, it consists of both a membrane filtration which can be ultrafiltration membrane or microfiltration membrane, and suspended growth biological treatment technology. The process done in two different times, in winter and in summertime to illustrate if the temperature can also be effective factor. From the results obtained, as the volatile suspended solids concentration increases, the bacteria start to shift as biomass has been accumulated. Also, the activation of enzymes is lower at wintertime compared to the summertime. (11)

- **ANAEROBIC WASTEWATER TREATMENT**

JULES B, V. LIER, N. MAHMPUD & G. ZEEMAN Did a Research in 2008, about definition and environmental advantages of anaerobic processes. in general, they did this research to illustrate how anaerobic process is superior to aerobic process and did give an introduction and did some calculations about this topic. they define anaerobic process as it is a process in which organic composition got degraded and biogases like methane and carbon dioxide produced. also, they support their claim about the anaerobic system is superior to aerobic system by mentioning these points in their research: (12)

- up to approximately 90% reduction of sludge production.
- on the usage of expanded sludge bed reactor, this will free space in about 90% of space required.
- required simple and smaller reactor.
- no fossil fuels are required for treatments.
- it produces 13.5 mj of $CH_4$energy, which (if assumed that 40% electric conversion is efficient) gives in about 1.5 kwh of electricity.
- using granular anaerobic sludge as a seed material will speed up the start up in about less than one week.
- chemicals are rarely used in this type of process.
- simple technology with better results will be given.
- excess sludge produced is desired and will have a market value.

they provide calculations and methods to show that anaerobic process is more efficient and it can rely on it than the aerobic process, and they conclude their research be telling that anaerobic wastewater treatments provide technical solution and better alternative to treat large amount of demotic and municipal wastewater. in my opinion, the world now is going to decrease emissions of the greenhouse gases, production of methane in this process will be advantage. also, it is simple process, required less energy than aerobic process which consume energy and it is very complex process. so, I think anaerobic wastewater treatment is better solution for treating polluted wastewater flows. (13)

- **ANAEROBIC WASTEWATER TREATMENT DONE AT THERMOPHILIC CONDITION**

In 2008, R. TAMARA & E. PANTEA did an experiment to investigate the benefits of treating wastewater anaerobically in thermophilic process. they compare the results they got with the results of mesophilic process. this anaerobic process done in two different stages, where the first stage is the important one in which the complex waste water will get decompose by using some bacteria (microorganisms), where the second stage is producing desirable products from the produced components which can be done using other operations, desirable products like biogases which can be used as renewable energy sources. according to the scientists, achieving the best results is obtained when the thermophilic conditions is applied, which maintaining the temperature at a range from 40℃ to 70℃, especially at high loading rate. the two scientists prefer thermophilic condition rather than mesophilic condition for many reasons such as:

1. it can be treating high to moderate wastewater concentrations.
2. provide better outflow quality.
3. can handle excess sludge easily.
4. specific components can be removed at high rates.

in my opinion, temperature is the most important factor that can affect the process performance. meaning that at high temperatures, complex material can be decomposed easily especially if it was a liquid. there are other factors also like the mixing technique or the complex waste properties. (14)

- **USING OF ULTRASONIC PRETREATMENT TO REDUCE SLUDGE PRODUCTION IN SLUDGE AEROBIC DIGESTION**

L, SHAO. H, Ping, G, HIU YU & Y, ZHU did an experiment in 2008, to investigate if the ultrasonic pretreatment can improve aerobic digestion which can lead to reduce in sludge produced. ultrasonic pretreatment process is a modern technology in which it is an ecofriendly process, it uses the principle of transmitting ultrasonic waves that it causes no effects to the humans or to the environment. The role enzymes in this operation are to know if it will be affected in the aerobic sludge digestion after the ultrasonic pretreatment is applied. The enzymes are EXTRACELLULAR-PROTEINS, POLYSACCHARIDES, HYDROLYTIC ENZYMES such as:

1. protease
2. $\alpha$- amylase
3. $\alpha$-glucosidase
4. Alkaline phosphatase
5. Acid phosphatase

To illustrate the principle if the process aim is achieved, the sludge flocs divided into four layers, slime layer, loosely bound extracellular polymeric substance layer, tightly boned extracellular polymeric substance layer and pellet layer. The results showed that all enzymes are presents in to main layers only which are pellet layer and tightly boned extracellular polymeric substance layer, and the benefit of ultrasonic pretreatment is that to promote the enzymes to shift from the inner layer of the sludge to the outer layer and that to improve the efficiency of the aerobic digestion. In my opinion, the results are good and the process as it mentioned above is ecofriendly process, but it is not compatible when we use it in high rates or it cannot be counted on most of the times to reduce sludge. (16)

- **HIGH - RATE OF ANAEROBIC TREATMENT OF COFFEE PROCESSING WASTEWATER USING THE UPFLOW ANAEROBIC HYBRID REACTOR**

M. SELVAMURUGAN, P. DORAISAMY, M. MAHESWARI and N.B. NANDAKUMAR in 2019, did an experiment about treating of coffee processing wastewater using up - flow anaerobic hybrid reactor. the process was operated at different times, 24h, 18h, 12h and 6h, that to illustrate how efficient the reactor will be and if it can depend on it. the methane and the total gas production must be evaluated and presented in terms of biochemical oxygen demand (bod) and chemical oxygen demand (cod). as the results obtained, the reactor showed excellent results at two different times only, 24h and 18h. very little difference between bod and cod between them. however, the results at 18h that reactor preformed is better in terms of cod and bod production, in fact it reduced 61% and 66% respectively, and good removal of pollutant elements at this time. (15)

| No | Year | NAME OF THE EXPERIMENT | ADVANTAGE | DISADVANTAGE |
|---|---|---|---|---|
| 1 | 1985 | comparison of cost between aerobic and anaerobic process | economical to use both processes and more efficient | required large area and high-cost operation |
| 2 | 1994 | aerobic domestic wastewater treatment in a pilot plant with complete sludge retention by cross-flow filtration | cross-flow filter provide purer product (water) | operational cost is high and it consume a lot energy |
| 3 | 1996 | use of protozoa and metazoan for decreasing sludge production in aerobic wastewater treatment | 90% of the organics decomposed | harmful to the environment as releasing of $No_3\ and\ Po_4$ |
| 4 | 1997 | aerobic and anaerobic wastewater treatment | anaerobic is better in terms of economy | anaerobic product required more filtration |
| 5 | 1998 | high-rate anaerobic treatment of wastewater at low temperatures | experiment condition gave advantage to remove fatty acid | not suitable in many countries due to low temperature |
| 6 | 1999 | characterization of soluble residual chemical oxygen demand (cod) in anaerobic wastewater treatment effluent | the reactor her provide more contact time due to the baffles | reactor produce low effluent quality and greenhouse gas emission |
| 7 | 2004 | comparison between aerobic and anaerobic wastewater treatment technologies in greenhouse gas production | anaerobic process is preferred because no greenhouse gases produced | anaerobic process is less efficient compare to aerobic process |
| 8 | 2004 | evaluation of anaerobic-aerobic wastewater treatment plant operations | reduction of energy consumption and sludge productions | cannot handle large amount of wastewater due to the reactor small volume |
| 9 | 2005 | the effect of concentration in anaerobic dairy wastewater treatment using uasb reactor | no energy consumption | enzymatic hydrolysis is complicated technique |
| 10 | 2005 | best conditions for methanogenic bacteria in anaerobic wastewater treatment | help to convert dangerous gases to methane as energy source | the conditions obtained are difficult to be maintained most of the time |
| 11 | 2007 | the effect of different concentrations of suspended solids to activate enzyme in aerobic wastewater treatment | the method done here is not efficient and not costly | cannot be used at lower temperatures |

| | | | | |
|---|---|---|---|---|
| **12** | **2008** | **anaerobic wastewater treatment** | **anaerobic process is simple and no need to use chemicals** | **not stable and use the product (water) need more filtration** |
| **13** | **2008** | **anaerobic wastewater treatment done at thermophilic condition** | **lower sludge yield** | **need high heater energy and getting bad quality of water is obtained after more use** |
| **14** | **2008** | **using of ultrasonic pretreatment to reduce sludge production in sludge aerobic digestion** | **ecofriendly operation** | **not suitable for high-rate sludge reduction** |
| **15** | **2019** | **high-rate anaerobic treatment of coffee processing wastewater using up flow anaerobic hybrid reactor** | **achieving best results in terms id cod and bod** | **need time to provide best results** |

(Table 2.2 advantages & disadvantages)

- From the comparison table shows the **anaerobic wastewater treatment done at thermophilic condition** was picked for many reasons that can be justified.

**1.** It uses one of the interesting yet most useful condition which is bacteria to complete the treatment operation.

**2.** As batches the first batches of product have a great quality as the efficiency of this treatment is very high

**3.** The operation is flexible as the only condition that is needs to vary to change the operation is the temperature to select the suitable bacteria or enzyme to attack the pollutant the make the reaction.

**Chapter 3**

# Objective and Research Methodology

- The aim of objective of this project mainly in obtaining the best outcome of purity from the treated water through enzymes and bacteria as it was introduced in the specific objective.

- ***MATERIALS:***

1. Beaker
2. Pipit
3. Calorimeter
4. Aerobic and Anaerobic digester
5. Chlorine
6. Titration automatic machine
7. Wastewater (the sample)
8. Enzymes (based to temperature)
9. Bacteria (based to temperature)

- ***ANALYSIS:***

A known volume of wastewater is brought to laboratory to undergo chemical analysis, where the composition, physical, and chemical characteristics of the sample will be measured and noted. conductivity is measured by using calorimeter. From this result TDS can be obtained. Moreover, the most important factor is the temperature of the sample and the operation as the temperature is the factor that decides the enzyme or the bacteria that can activates the reaction. Then alkalinity, total hardness, calcium, and magnesium are obtained by titration. Finally, the quantitative method is used to obtain the data of the contaminants in the wastewater sample.

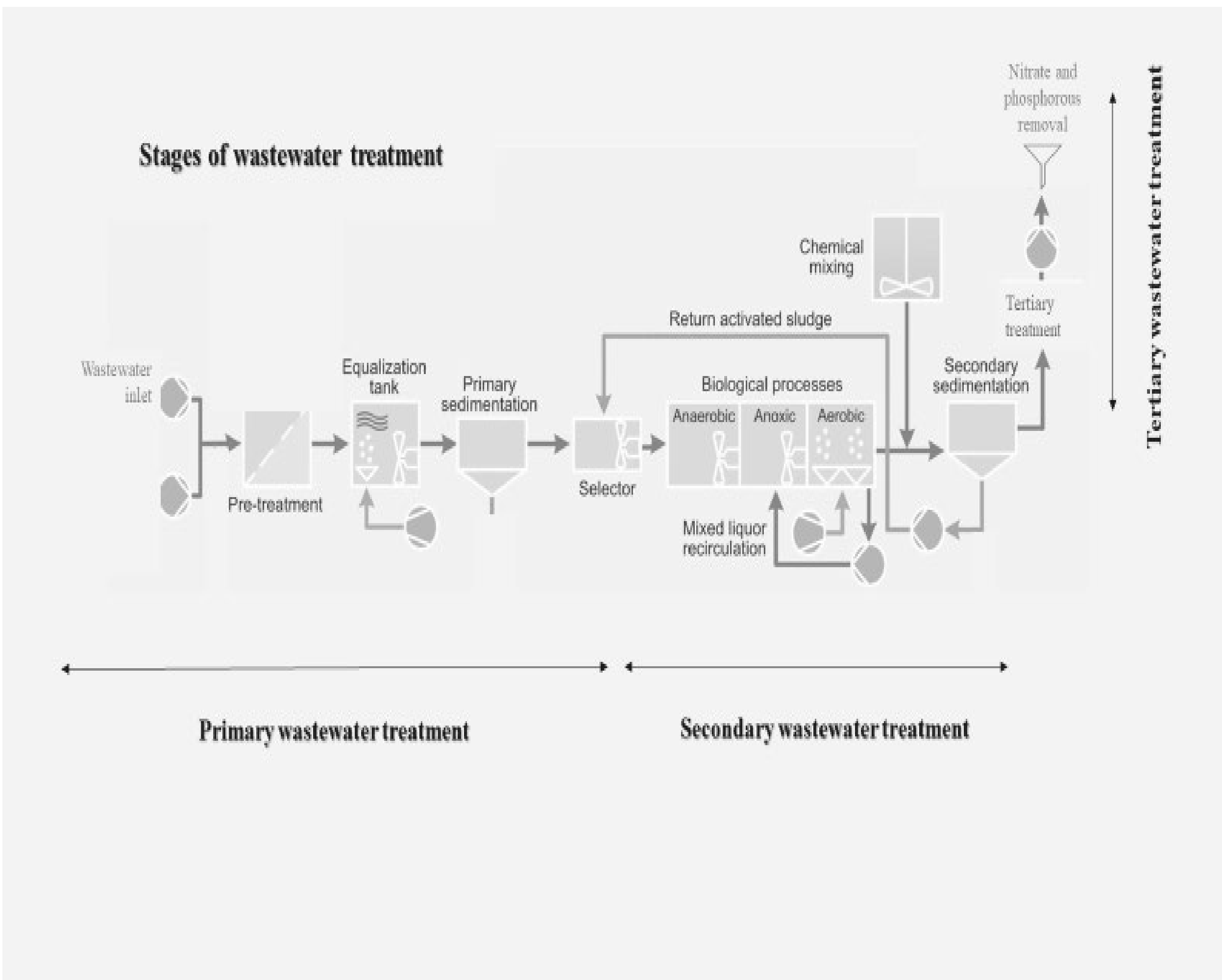
- ***EXPERIMENT:***

Treatment of wastewater is done through aerobic and anaerobic digester. The main difference is that the aerobic experiment is done in the presence of oxygen while on the other hand, the anaerobic is done in vacuum or the absence of oxygen. The selection of the proper enzyme or the bacteria is the essential step to start the experiment. The operation goes through the 3 steps: primary, secondary, tertiary treatment to obtain the best purity possible. Finally, the sample is sent to the final stage which is post experiment analysis.

- ***POST-EXPERIMENT ANALYSIS:***

As in the analysis step the study of the sample is done again, so the treated wastewater is sent to the laboratory again to be analyzed where the changes in contaminants concentration of each one of the alkalinities and each of the impurities to make sure of the treated wastewater sample purity but if some salts (impurities) are still present in the sample it goes to forth stage where it focusses on removal of phosphorus and nitrogen as well as treating the sample with chlorine.

**General Flowchart:**




(figure 3.1 treatment flow chart)

## Chapter 4

# Project Work

The analyzed sample (industrial wastewater) were sent through the treatment stages to attain the purified and usable water. Initializing the operation in the primary stage with $1000\,\frac{kg}{hr}$ of sample was taken and sent to pretreatment tank where the treatment started by the 2 types of the screening (fine and course screening) to decrease the amount of the larger solid particles in the sample. Following the screening the equalization of the flow was done in the equalization tank where the $O_2$ was increased and adjusted to the desirable quantity. Then, the primary sedimentation takes place. In this stage only physical operation is done where the solid particles settle in the base of the tank due to the gravity as the sample is in motionless state. After that, the secondary treatment stage starts from the selector sending the sample to the anaerobic, anoxic, and aerobic digestors where the chemical reactions start to clarify and purify the sample as the bacteria in each of the conditions and the digester will attack the impurities differently to create the best chemical purity in the sample. Then the sample undergoes through proper mixing so the chemical mixing can give the best efficiency possible before the sending the water to the secondary sedimentation. Due to the bacteria attack on the impurities in the chemical reactions and the mixing some solids are formed in the treated sample which lead to the sample being sent to the secondary sedimentation where the same physical operation in the primary sedimentation is done in the secondary sedimentation tank is done. The velocity is reduced to motionless state so that the formed solids are settled at the base of the tank but in the secondary sedimentation there are 2 things ejected from the tank the sample that will move on to the tertiary treatment stage and the sludge which will be sent to the selector to undergo through the secondary treatment stage to acquire more efficient product. Finally, the sample that was sent through the secondary sedimentation tank will be processed in the tertiary treatment stage where the activated carbon is filtered and removed from the purified water. The phosphorus and nitrate will be removed after the tertiary treatment and the concentration of the contaminates will be adjusted through some operation like titration.

Size calculation

1. **Pre-treatment tank (rectangular Dimension):**

Length (L) × Width (W) × Depth (D)= $6 \times 3 \times 3 = 54\ ft^3$

2. **Equalization tank (rectangular Dimension):**

Length (L) × Width (W) × Depth (D)= $5 \times 3 \times 2.5 = 37.5\ ft^3$

3. **Sedimentation tank (Cylindrical Dimension):**

($\pi$) × radius ($r^2$) × Length (L) = $3.14 \times (1.5)^2 \times 6 = 42.39\ ft^3$

4. **Digester tank (Cylindrical Dimension):**

($\pi$) × radius ($r^2$) × Length (L) = $3.14 \times (1.3)^2 \times 6 = 31.8396\ ft^3$

5. **tertiary tank (rectangular Dimension):**

Length (L) × Width (W) × Depth (D)= $5 \times 2.5 \times 2.5 = 31.25\ ft^3$

- ***Primary treatment***

Screening recovery

Course screen recovery = 1000 $\frac{kg}{hr}$ × 70% = 700 $\frac{kg}{hr}$

Fine screen recovery = 1000 $\frac{kg}{hr}$ × 30% = 300 $\frac{kg}{hr}$

Flow equalization =

$O_2$ concentration is 20 $\frac{kg}{hr}$ the needed $O_2$ is 100 $\frac{kg}{hr}$ so, 80 $\frac{kg}{hr}$ is added

Sample recovered after chemical operation (digester)

Fine solid moisture = 200 $\frac{kg}{hr}$

- ***Secondary treatment***

Secondary sedimentation sample recovery = 2%

Sample recovery = $\frac{sample\ recovered}{fine\ solids\ moisture}$

Sample recovered = 200 × 0.02 = 4 $\frac{kg}{hr}$

For single operation

Sludge = fine solids moisture − sample recovered = 200 − 4 = 196 $\frac{kg}{hr}$ , which is 98%

For cycle operation (repetition)

After repetition of secondary for the sludge maximum sample recovered = 125 $\frac{kg}{hr}$ which is 62.5%

- ***Tertiary treatment***

Treated sample recovery was 98.5%

Treated sample recovery = $\frac{treated\ sample}{sample\ recovered}$ so, treated sample = 125 × 0.985 = 123.125

The sample mass overall recovery = $\frac{treated\ sample}{sample\ initial\ amount} = \frac{123.125}{1000} \times 100 = 12.31\%$

| | Raw wastewater | primary wastewater | secondary wastewater | tertiary wastewater |
|---|---|---|---|---|
| **Mass of Wastewater $\frac{kg}{hr}$** | 1000 | 200 | 125 | 123 |

(Table 4.1 Mass recovered)

- Composition material balances:

➢ ***Calcium:***

1000 L = 1 m3 → 1000 m3 = $10^5$ L

1 L = 78.8 mg of Ca

$10^5$ L = 78.8×$10^5$ mg

Efficiency= $(\frac{78.8-60.9}{78.8}) \times 100 = 22.72\%$

$78.8\times10^5 \times 0.2272 = 17.9\times10^5 \frac{mg}{L}$

➢ ***Manganese:***

1000 L = 1 m3 → 1000 m3 = $10^5$ L

1 L = 25.6 mg of Mg

$10^5$ L = 25.6 × $10^5$ mg

Efficiency= ( $\frac{25.6-21.3}{25.6}$) ×100 = 16.8%

$25.6\times10^5\ \times 0.168= 43\times10^5\ \frac{mg}{L}$

- ***Sodium:***

1000 L = 1 m3 → 1000 m3 = $10^5$ L

1 L = 357 mg of Na

$10^5$ L = $357\times10^5$ mg

Efficiency= ($\frac{357-283.6}{357}$) ×100= 20.56%

$357\times 10^5 \times 0.2056= 73.4\times 10^5\ \frac{mg}{L}$

- ***Potassium:***

1000 L = 1 m3 → 1000 m3 = $10^5$ L

1 L = 19 mg of K

$10^5$ L = $19\times10^5$ mg

Efficiency= ($\frac{19-16.8}{19}$) ×100 =11.58 %

$19\times10^5 \times 0.1158= 22\times 10^5\ \frac{mg}{L}$

- ***Sulphate***

1000 L = 1 m3 → 1000 m3 = $10^5$ L

1 L = 270 mg of $SO_4$

$10^5$ L = $270\times10^5$ mg

Efficiency= ($\frac{270-236.5}{270}$) ×100 =12.40 %

$270\times10^5 \times 0.124= 33.48\times10^5\ \frac{mg}{L}$

- ***Chlorine:***

1000 L = 1 m3 $\longrightarrow$ 1000 m3 = $10^5$ L

1 L = 397 mg of Cl

$10^5$ L = $397\times10^5$ mg

Efficiency= $\left(\frac{397-283.7}{397}\right)\times100 = 28.53\ \%$

$397\times10^5 \times 0.2853= 11.32\times10^5\ \frac{mg}{L}$

- ***Free Energy balance:***

| Reaction | G'$_o$ (kJ/mol substrate) |
|---|---|
| Aerobes | |
| $H_2 + 0.5\ O_2 \longrightarrow H_2O$ | -229 |
| Denitrifiers | |
| $CH_3COO^- + 2\ O_2 \longrightarrow 2\ HCO^- + H^+$ | -845 |
| $H_2 + 0.4\ NO^- + 0.4\ H^+ \longrightarrow 0.2\ N_2 + 1.2\ H_2O$ | -272 |
| $Fe^{3+}$ reducing bacteria | |
| $CH_3COO^- + 1.6\ NO^- + 0.6\ H^+ \longrightarrow 2\ HCO^- + 0.8\ N_2 + 0.8\ H_2O$ | -768 |
| $H_2 + 2\ Fe^{3+} \longrightarrow 2\ Fe^{2+} + 2H^+$ | -282 |
| Sulphate reducing bacteria | |

$CH_3COO^- + 4\ Fe^{3+} + 4\ H_2O \longrightarrow 4\ Fe^{2+} + 5\ H^+ + 2\ HCO_3$ -325

$H_2 + 0.25\ SO^{2-} + 0.25\ H^+ \longrightarrow 0.25\ HS^- + H_2O$ -9.8

Methanogens

$CH_3COO^- + SO_4^{2-} \longrightarrow HS^- + 2\ HCO^-$ -46

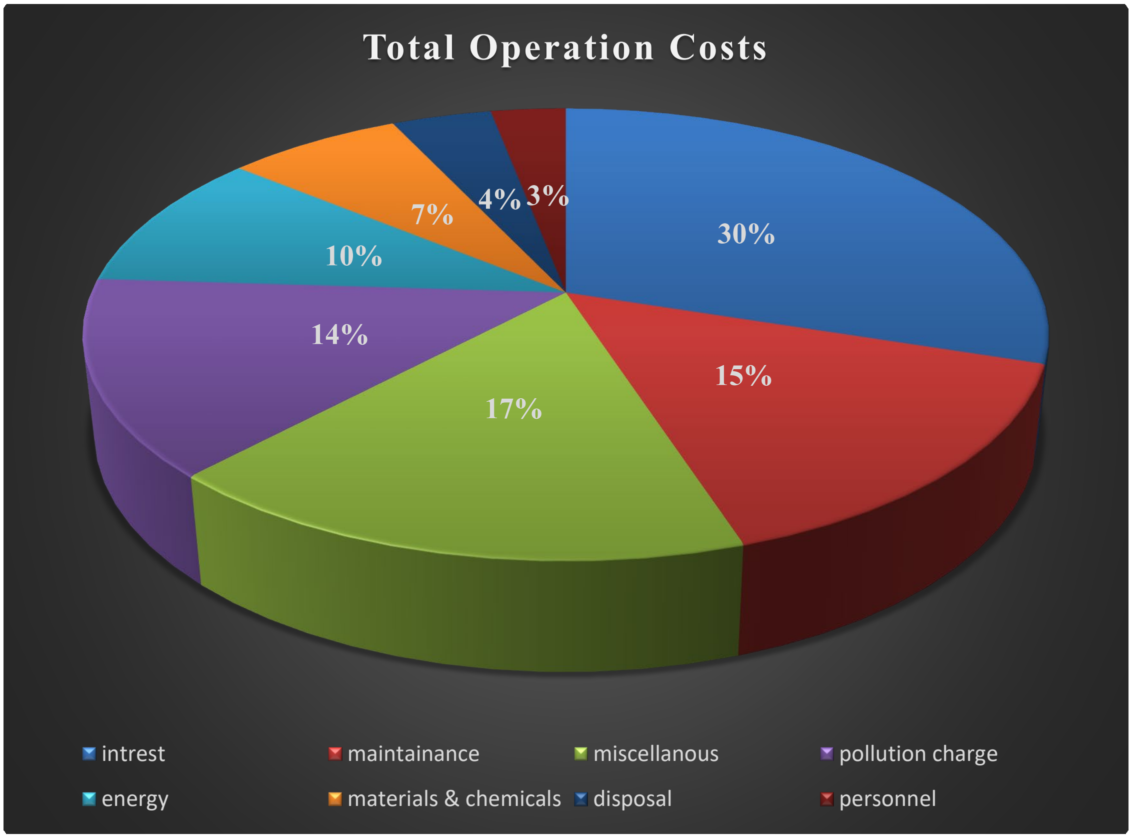
$H_2 + 0.25\ HCO^- + 0.25\ H^+ \longrightarrow 0.25\ CH_4 + 0.75\ H_2O$ -8.7

$CH_3COO^- + H_2O \longrightarrow CH_4 + HCO$

| Energy consumption | | |
|---|---|---|
| Treatment stages | Consumption of | Consumption (kWh/L) |
| Primary treatment | Pumping | 0.012-0.017 |
| | Screening | 0.5-0.7 |
| | Equalization | 2-2.5 |
| | Primary sedimentation tank | 0.7-0.9 |
| Secondary treatment | Aerated & Unaerated tank | 18.3-27.4 |
| | Secondary sedimentation tank | 1.7-2.7 |
| | Thickening | 0.6-1.0 |
| | Sludge recycles | 2.7-3.9 |
| | Digesters | 2.7-3.3 |
| Tertiary treatment | Nitrate & phosphorous removal | 1.1-1.3 |

(Table 4.2 Energy Consumption Data)

## TOTAL OPERATION COST




(figure 4.1 Total operation costs)

### *OPERATION COSTS EFFECTING FACTORS*

1. Load and size of the operation
2. Wastewater characteristics and discharge norm
3. Selected treatment process and the technologies used
4. The treatment type of the sludge and the disposal methods
5. The energy supplied and the energy of the recycle
6. Equipment usage in operation
7. Liberation cost

Total annual cost = 1,600,000 R.O

Total operation cost = 800,000 R.O

1. Interest = 800,000 × $\frac{30}{100}$ = 240,000 R.O
2. Miscellaneous = 800,000 × $\frac{17}{100}$ = 136,000 R.O
3. Maintenance = 800,000 × $\frac{15}{100}$ = 120,000 R.O

| Maintenance with respect to 15% | | |
|---|---|---|
| **Parameter** | Percentage % | Cost % |
| **Electrical equipment** | 35% | 420,00 |
| **Mechanical equipment** | 35% | 420,00 |
| **Renewal of construction** | 20% | 240,00 |
| **Construction work** | 10% | 120,00 |

(Table 4.3 Maintenance distribution data)

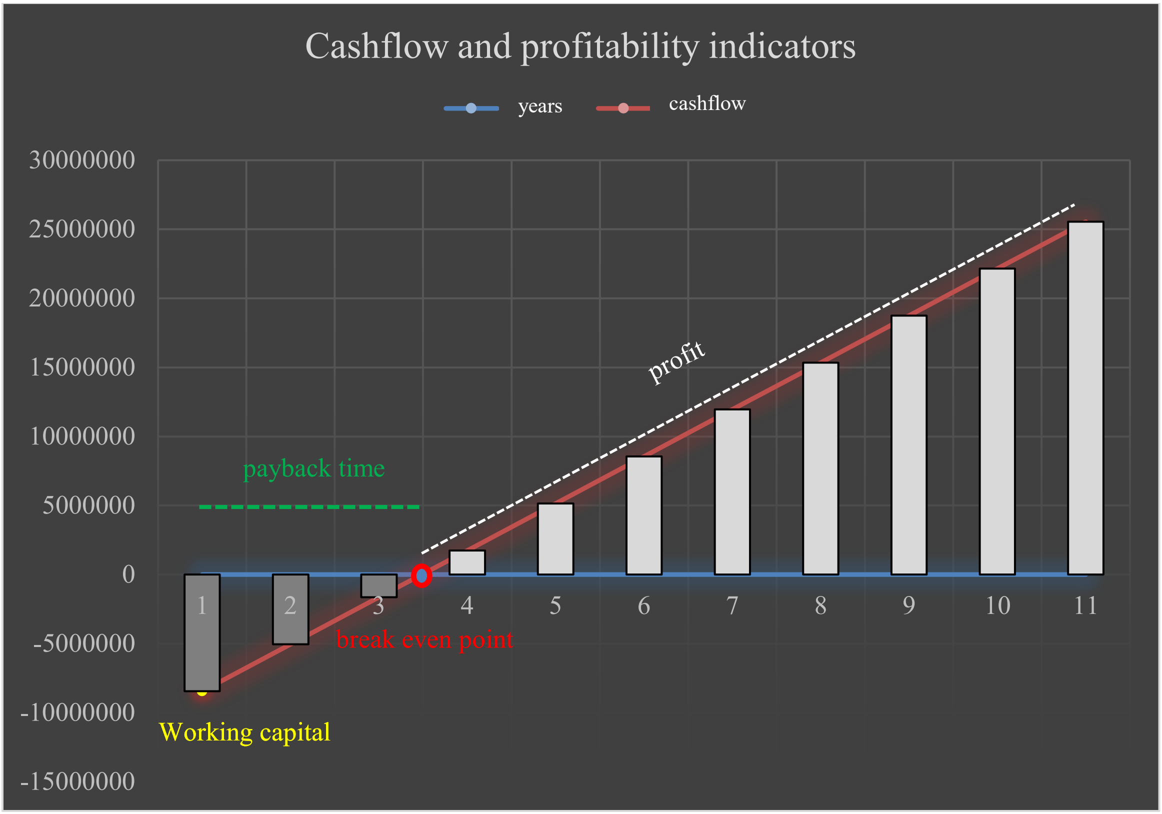
4. Pollution charge = 800,000 × $\frac{14}{100}$ = 112,000 R.O
5. Energy = 800,000 × $\frac{10}{100}$ = 80,000 R.O
6. Chemical & material = 800,000 × $\frac{7}{100}$ = 56,000 R.O
7. Disposal = 800,000 × $\frac{4}{100}$ = 32,000 R.O
8. Personnel = 800,000 × $\frac{3}{100}$ = 24,000 R.O

| Startup Costs | | |
|---|---|---|
| Treatment stages | Cost | Cost (R.O) |
| Primary treatment | Pumping | 300000 |
| | Screening | 200000 |
| | Equalization | 200000 |
| | Primary sedimentation tank | 400000 |
| Secondary treatment | Aerated & Unaerated tank | 500000 |
| | Secondary sedimentation tank | 400000 |
| | Thickening | 150000 |
| | Sludge recycles | 300000 |
| | Digesters | 5000000 |
| Tertiary treatment | Filtration | 300000 |
| Government | Working capital | 700000 |
| Total cost | | 8450000 |

(Table 4.4 Startup Cost)

| years | Net profit<br>(Profit – A. cost) | Cash flow |
|---|---|---|
| **0** | (5,000,0000 – 1,600,00) = 3,400,000 | -8450000 |
| **1** | 3,400,000 | -5050000 |
| **2** | 3,400,000 | -1650000 |
| **3** | 3,400,000 | +1750000 |
| **4** | 3,400,000 | +5150000 |
| **5** | 3,400,000 | +8550000 |
| **6** | 3,400,000 | +11950000 |
| **7** | 3,400,000 | +15350000 |
| **8** | 3,400,000 | +18750000 |
| **9** | 3,400,000 | +22150000 |
| **10** | 3,400,000 | +25550000 |

(Table 4.5 Cashflow Data)

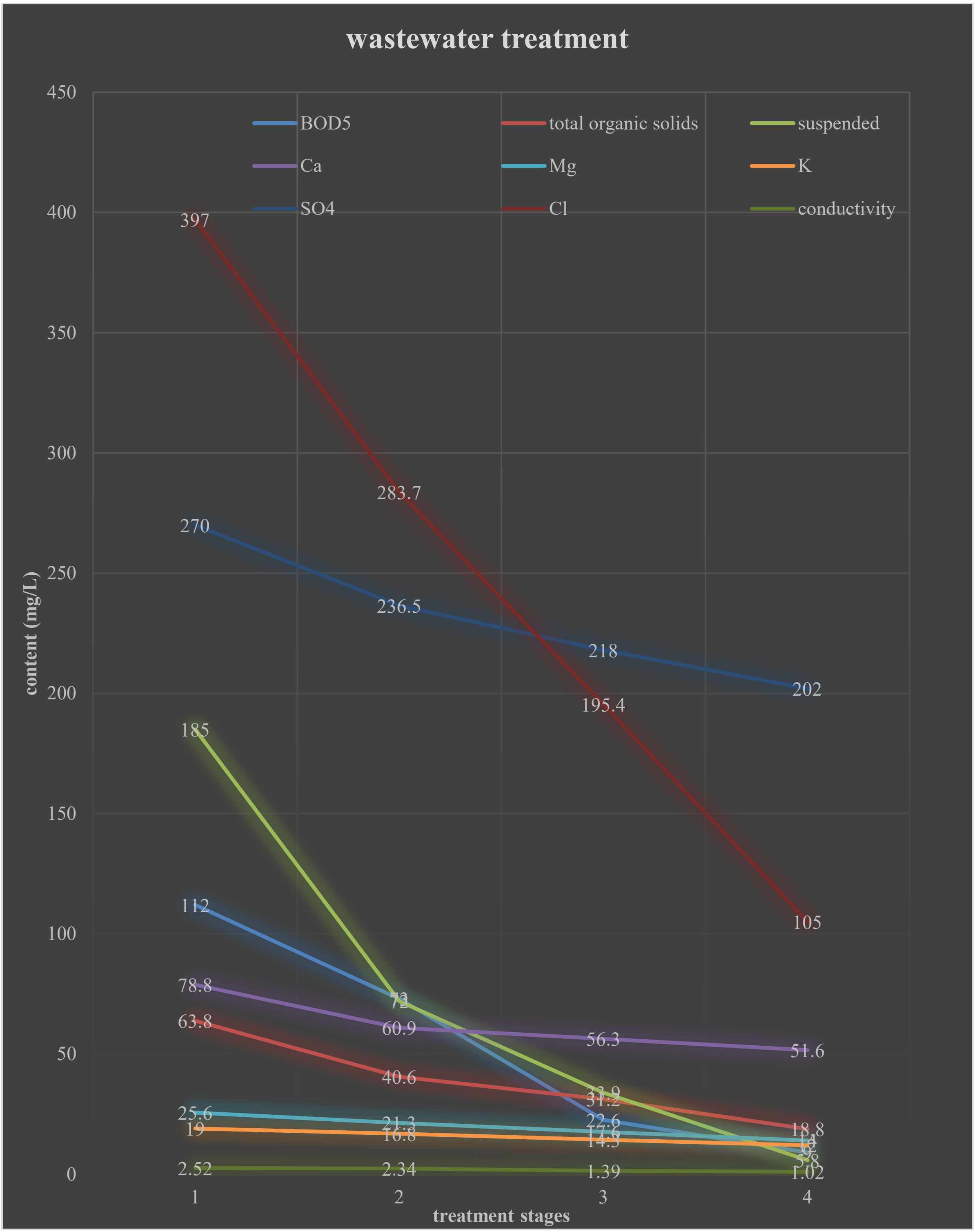



(Figure 4.2 cashflow graph)

The operation costs data represent a profitable as well as a great cost to value relative ratio. The 1,600,000 annual cost is considered very efficient as the operation produces 123.125$\frac{kg}{hr}$ in every single operation even though it shows a somewhat weak recovery percentage of 12.31% but it does not affect the operation badly due to that the disposed materials cost is only 4% of the operational costs. Moreover, the recovered amount is in good quantity and great quality which lead to the approval of the treatment operation.

# Chapter 5

## Results and Discussion




(figure 5.1 pure water data)

| Contents (mg/L) $\times 10^5$ | Raw sewage water | Primary Treated sewage water | Secondary treated sewage water | Tertiary treated sewage water |
|---|---|---|---|---|
| **Biochemical organic carbon, $BOD_5$** | 112 | 73 | 22.6 | 9 |
| **Total organic solids** | 63.8 | 40.6 | 31.2 | 18.8 |
| **Suspended solids** | 185 | 72 | 33.9 | 5.8 |
| **Calcium (Ca)** | 78.8 | 60.9 | 56.3 | 51.6 |
| **Manganese (Mg)** | 25.6 | 21.3 | 17.6 | 14 |
| **Sodium (Na)** | 357 | 283.6 | 201.1 | 186 |
| **Potassium (K)** | 19 | 16.8 | 14.3 | 12 |
| **Sulphate ($SO_4$)** | 270 | 236.5 | 218 | 202 |
| **Chlorine (Cl)** | 397 | 283.7 | 195.4 | 105 |

(table 5.1 wastewater composition)

As the table shows, the decrease variate from one content some content has huge decrease such as (Cl, $SO_4$, suspended, and $BOD_5$). some other contents have moderate decrease like (Ca, and total organic solids) while the other composition such as (conductivity, K, and, Mg) shows slight decrease but in common the raw waste water or the sewage water had a high contamination in all the content but after the three treatment steps the water quality has greatly improved where at least it reached the quality to be used in agriculture and can be even drinkable.

| Contents (mg/L) $\times 10^5$ | Raw sewage water | Primary Treated sewage water | Secondary treated sewage water | Tertiary treated sewage water |
|---|---|---|---|---|
| **Biochemical organic carbon, $BOD_5$** | 135.2 | 78.3 | 25.2 | 6.9 |
| **Total organic solids** | 65.2 | 43.2 | 32.1 | 10.8 |
| **Suspended solids** | 192.3 | 75.7 | 36.5 | 5.1 |
| **Calcium (Ca)** | 79.6 | 62.9 | 59.6 | 48.6 |
| **Manganese (Mg)** | 28.6 | 24.6 | 19.5 | 12.8 |
| **Sodium (Na)** | 378.8 | 304.5 | 209.2 | 176.3 |
| **Potassium (K)** | 22.6 | 18.6 | 16.5 | 10.6 |
| **Sulphate ($SO_4$)** | 292.7 | 246.9 | 223.8 | 186.6 |
| **Chlorine (Cl)** | 405.8 | 290.2 | 197.6 | 98.9 |

(Table 5.2 literature review wastewater composition)

**Comparison between table 5.1 & 5.2:**

| Contents (mg/L) $\times 10^5$ | Raw sewage water | | final readings | |
|---|---|---|---|---|
| | Table 5.1 | Table 5.2 | Table 5.1 | Table 5.2 |
| **Biochemical organic carbon, $BOD_5$** | 112 | 135.2 | 9 | 6.9 |
| **Total organic solids** | 63.8 | 65.2 | 18.8 | 10.8 |
| **Suspended solids** | 185 | 192.3 | 5.8 | 5.1 |
| **Calcium (Ca)** | 78.8 | 79.6 | 51.6 | 48.6 |
| **Manganese (Mg)** | 25.6 | 28.6 | 14 | 12.8 |
| **Sodium (Na)** | 357 | 378.8 | 186 | 176.3 |
| **Potassium (K)** | 19 | 22.6 | 12 | 10.6 |
| **Sulphate ($SO_4$)** | 270 | 292.7 | 202 | 186.6 |
| **Chlorine (Cl)** | 397 | 405.8 | 105 | 98.9 |

(Table 5.3 Comparison data)

as the comparison data shows, there is difference between both readings. The data that is shown from the literature review operation (table 4.2) has better results compared to our data (table 4.1). the difference in the presented data is due to:

1. The quality of the constructed plant
2. The operation used and the selected process
3. The wastewater sample quality and quantity
4. The equipment used

## Chapter 6

# Conclusion and recommendation for future work

- There are many operations to recover pure water from the wastewater and all these goes through the same mainly steps that are concluded in primary treatment, secondary treatment, and tertiary treatment followed by some additional final treatment if needed.

- Bacteria and enzymes showed some of the best results of pure water recovery as the quality is very high with the best operation cost as well as minimum labour. In addition to the large production to time ratio.

- The down comes of the aerobic and anaerobic operation through the bacteria and enzymes is that the condition has to be satisfied to complete the operation and the most important condition is the temperature as the selection of the enzyme or the bacteria solely depend on this parameter to attack the contaminants so that the operation is initiated.

- Try to use more methods and operations that utilize the aerobic and anaerobic digestion treatment. as the industrial wastewater data showed that it can reach to agriculture quality but it is more complicated to reach drinkable water quality. That is caused by the contaminations and the salinity existed in the wastewater that cannot be removed easily and some of them contain hazardous effect on water that is not fully known up to this day

| Gantt chart and Action Plan | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Description | Sep-18 | | Oct-18 | | | | Nov-18 | | | | Dec-18 | |
| | WK1 | WK2 | WK3 | WK4 | WK5 | WK6 | WK7 | Wk8 | Wk9 | WK10 | WK11 | Wk12 |
| Selection of supervisor | | | | | | | | | | | | |
| Search on various projects | | | | | | | | | | | | |
| Discussion on title of project | | | | | | | | | | | | |
| Introduction on the decided project | | | | | | | | | | | | |
| Literature review on decided project | | | | | | | | | | | | |
| Preparation for mid report and presentation | | | | | | | | | | | | |
| Project midterm | | | | | | | | | | | | |
| Conclusion & future work on the project | | | | | | | | | | | | |
| Recheck all the chapters | | | | | | | | | | | | |
| Submission of first draft report for plagiarism check | | | | | | | | | | | | |
| Submission of final report | | | | | | | | | | | | |
| Preparation of final project presentation | | | | | | | | | | | | |

# References


1. PURE-H2O PROJECT. (2020),"WHAT IS A DRINKING WATER TREATMENT PLANT?". AVAILABE AT:https://pure-h2o-learning.eu/electrical-technicians/lo-1#:~:text=Water%20treatment%2C%20as%20a%20word,clarifying%2C%20softening%20or%20deodorizing%20it.&text=783%20million%20people%20do%20not,safe%20and%20clean%20drinking%20water (1)
2. (CDC). (2015). "COMMUNITY WATER TREATMENT", WATER TREATMENT, 48(50), PP1141. AVAILABLE AT: https://www.cdc.gov/healthywater/drinking/public/water_treatment.html (2)
3. H. K. KARAPANAGIOTI, (2016). WATERMANAGEMENT, TREATMENT AND ENVIRNOMENTAL IMPACT. AVAILABLE AT: https://www.sciencedirect.com/referencework/9780123849533/encyclopedia-of-food-and-health (3)
4. BOYUAN (2015)." COAL WASHING ORGANIC FLOCCULANT AGENT", ABAILABLE AT: https://www.sciencedirect.com/referencework/9780123849533/encyclopedia-of-food-and-health (4)
5. CORCORAN, E. C. NELLEMANN, E. BAKER, (2015) "SICK WATER", AVAILABLE AT: https://web.archive.org/web/20151218043021/http://www.unep.org/pdf/SickWater_screen.pdf (5)
6. DR. LUTHI. C, (2020) "COMPEMDING OF SANITATION SYSTEM AND TECHNOLOGY 2AN EDITION". AVAILABLE AT: https://www.eawag.ch/en/department/sandec/publications/compendium/ (6)
7. P. RANTALA AND P. VANANEN (1985), " COMPARISION OF COST BETWEEN AEROBIC AND ANAEROBIC PORCESS", "WATER SCIENCE & TECHNOLOGY", 17(1), PP. 255. (7)
8. E. B. MULLER *L, A. H. STOUTHAMER L, H. W. VAN VERSEVELD L AND D. H. EIKELBOOM (1995) AEROBIC DOMESTIC WASTE WATER TREATMENT IN A PILOT PLANT WITH COMPLETE SLUDGE RETENTION BY CROSS-FLOW FILTRATION, AVAILABLE AT: HTTP://CITESEERX.IST.PSU.EDU/VIEWDOC/DOWNLOAD?DOI=10.1.1.584.8524&REP=REP1&TYPE=PDF (8)
9. LEE, N.M., WELANDER, T. USE OF PROTOZOA AND METAZOA FOR DECREASING SLUDGE PRODUCTION IN AEROBIC WASTEWATER TREATMENT. BIOTECHNOL LETT 18, 429–434 (1996). HTTPS://DOI.ORG/10.1007/BF00143465. (9)
10. ROBINSON. D. G, WHITE. J. E AND CALLIER. A. J. (1997)" AEROBIC AND ANAEROBIC WASTEWATER TREATMENT", AVAILABLE AT HTTPS://WWW.OSTI.GOV/BIBLIO/465162 . (10)

11. GATZE LETTINGA, SALIH REBAC, SOFIA PARSHINA, ALLA NOZHEVNIKOVA, JULES B. VAN LIER AND ALFONS J. M. STAMS (1998) 'HIGH-RATE ANAEROBIC TREATMENT OF WASTEWATER AT LOW TEMPERATURES', (), PP. [ONLINE]. AVAILABLE AT: HTTPS://AEM.ASM.ORG/CONTENT/AEM/65/4/1696.FULL.PDF . (11)

12. DUNCAN. J. BARKER, GIANNI. A. MANNUCCHI, SANDRINE. M. L. SALVI AND DAVID. C. STUCKEY (1999) "CHARACTERISATION OF SOLUBLE RESIDUAL CHEMICAL OXYGEN DEMAND (COD) IN ANAEROBIC WASTEWATER TREATMENT EFFLUENT" AVAILABLE AT HTTPS://WWW.SCIENCEDIRECT.COM/SCIENCE/ARTICLE/ABS/PII/S00431354050044197 . (12)

13. E. GAŠPARIKOVÁ, Š. KAPUSTA, I. BODÍK, J. DERCO, K. KRATOCHVÍL (2004) *EVALUATION OF ANAEROBIC-AEROBIC WASTEWATER TREATMENT PLANT OPERATIONS,* AVAILABLE AT: *HTTPS://D1WQTXTS1XZLE7.CLOUDFRONT.NET/42642431/EVALUATION_OF_ANAEROBIC-AEROBIC_WASTEWAT20160213-4845-HQ8FZ7.PDF?1455364454=&RESPONSE-CONTENT-DISPOSITION=INLINE%3B+FILENAME%3DEVALUATION_OF_ANAEROBIC_AEROBIC_WASTEWAT.PDF&EXPIRES=1605360809&SIGNATURE=U7MD6Z8OKOQUARLA9U7GIMULPGIP5UDJOLL2AKPR5PQQPWMTEHP2QLA2CEWZEHFQ31LNYXWIDGO03QYVMY61X9M7NHLFGAG3MG0UQ-DR0BSQDOAO7VWLYGEHVQ8CAFODHOLMFLSWNNXCASWW3GQS6QZ7FH6FL7A33Z8ET7RNQ42PNGHJ0FSZTXP0RKWGVJ56I93PUNJWX4~NTF8TNSRINLXTTL790S-Z0OHY3NYEBAYYEMW7S09X1WLWI94HMNN7GKOYON5BTPONTM6GMD84RR9QQM1UFKT5BH8NDLFX8C67ZU~JDOQ4RFI78I~Z~Q0DF-OT4XUE2BDKKYMWN7BLYW__&KEY-PAIR-ID=APKAJLOHF5GGSLRBV4ZA* (13)

14. TAMARA. R, PANTEA. E, (2008) "THERMOPHILIC ANAEROBIC WASTWATER TREATMENT", AVAILABLE AT: http://protmed.uoradea.ro/facultate/anale/protectia_mediului/2008/im/Pantea%20Emilia.pdf (14)

15. M. SELVAMURUGAN, P. DORAISAMY, M. MAHESWARI AND N.B. NANDAKUMAR (2019) 'HIGH-RATE ANAEROBIC TREATMENT OF COFFEE PROCESSING WASTEWATER USING UPFLOW ANAEROBIC HYBRID REACTOR '. (15)

16. LI-MING SHAO, PIN-JING HE, GUANG-HIU YU & YI-SHU ZHU, (2008), "WATER RECEARCH", available at: https://www.sciencedirect.com/science/article/abs/pii/S0043135407007166 (16)