

## WASTE WATER TREATMENT AND CIRCULAR ECONOMY

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**Abstract.** *This article will present a study made in relation to sewage treatment using a biodigester in integrated biosystems and later using salt water, also seeking to relate it to the theme of circular economy. As in the year 2021 the project did not carry out any practical experiments, the article will not bring concrete and physical results, but more theoretical results than what was found in articles and books. In addition, there was a break in the theme in the middle of the year, which implies that the article shows 2 moments, one in the first semester with research on integrated biosystems and circular economy reviewing the literature on these two themes, and in a second moment where it appears the opportunity to research together with Ilha dos Arvoredos about sewage treatment using high salinity wastewater.*

**Keywords.** *Waste Treatment, Saline Water, Circular Economy*

### Introduction

In this article, will be presented the development of a research carried out by a GCSP student on the subject of sewage treatment using high salinity wastewater and at the same time linking with concepts of circular economy.

After 1 year of research, some conclusions and insights were obtained. As it was not a project with an experimental scope during that first year, the results obtained were more theoretical, such as insights and conclusions based on books as Unicamp's one, articles from Scielo, Science direct, BDTD, etc.

The theme was divided into 2 phases throughout that year. In the first semester, research was carried out with the aim of reviewing the literature related to conventional and isolated communities sewage treatment and the circular economy. In the second semester, the project took a different path. A "partnership" emerged together with the "Ilha dos Arvoredos" located in Guarujá, where research was being carried out to use a biodigester using salt water. As a result, the second half of this year 2021 was focused on research related to the use of salt water in discharges and its treatment.

This project was created with the aim of bringing new technologies and means of sewage treatment to, for example, more isolated communities or communities with low access to decent sewage treatment. In addition, it is a project that manages to bring, with this new proposal for treatment with salt water, an alternative to the use of household discharges, which use thousands of liters of fresh water each time it is used. With that in mind, it is an essential project both for these communities and for a better alternative for the environment, generating less impact.

In one of the surveys carried out from an article called "Treatment of saline wastewater using physicochemical, biological, and hybrid processes: Insights into inhibition mechanisms, treatment efficiencies and performance enhancement" found at

ScienceDirect, it was found that the unregulated release of saline wastewater into water bodies without any prior treatment can cause serious environmental impacts and pose a serious risk to aquatic and human life.

With these objectives being taken into account, the purpose of solving a problem including technical, economic, environmental and social aspects becomes very important, since the topic being addressed has a great technical complexity, involving many disciplines and cultures, in addition of being a super focused project on the environmental and social side as mentioned, which promotes a positive impact on the world in which we live.

The project that will be discussed in this article is closely related to the NAE's vision on the Grand Challenges of Humanity and in relation to the IMT Grand Challenges Program, which seeks to impact the planet and people, with the purpose of continuing the life on the Planet, making our world more sustainable, healthy, safe and pleasant to live. This relationship is very clear with the proposed objective, as it manages to solve the problems of many communities by promoting better safety and a more pleasant life and also bringing a sustainability footprint, as it proposes an alternative with less environmental impact, or impact nil, which only offers benefits such as the return of clean and treated water after its use and also an alternative for not depleting the planet's freshwater as quickly, as it uses salt water for flushing.

## **Objectives**

The overall objectives of the project throughout this last year of 2021 were, firstly, to study the sewage treatment process, especially sewage treatment alternatives for isolated communities and the principles of circular economy. For this, a literature review was carried out using some books so that the concepts were well aligned.

A second objective, which emerged in the middle of the year, was to meet the demand of Ilha dos Arvoredos, from which it brought a proposal to verify the feasibility of using a biodigester to treat effluents with a high concentration of salt. With that, the researches were directed towards this new objective, using scientific articles researched in reliable bases.

The objective at the end of the project would be to bring a study on this system using the biodigester with water with a high concentration of salt for a practical application, for communities which have a low efficiency in the treatment of sewage in their region, and which at the same time they have little stock of fresh water, being able to use with this system, salt water from the sea near their homes.

This final objective seeks to bring a theme very focused on sustainability, as it brings a good use to salt water, saving fresh water, without harming the environment, in addition to bringing the theme of Joy of living addressed by the GCSP, as it provides better conditions for communities for example.

## **Development**

For this section, the work carried out throughout the year was divided into 3 parts: the first and second will deal with the research carried out based on the first semester, during which a literature review was carried out in relation to sewage treatment and also on the circular economy and in the third part, it will be treated on the research carried out in the second semester when the "partnership" with the Ilha dos Arvoredos for the research using high salinity wastewater had already taken place.

A division that can be made is:

1st semester:

- Water Waste Treatment: literature review (biodigester and integrated biosystems)
- Circular economy: literature review

2nd semester:

- Partnership with Ilha dos Arvoredos: high salinity wastewater

**1st semester:**

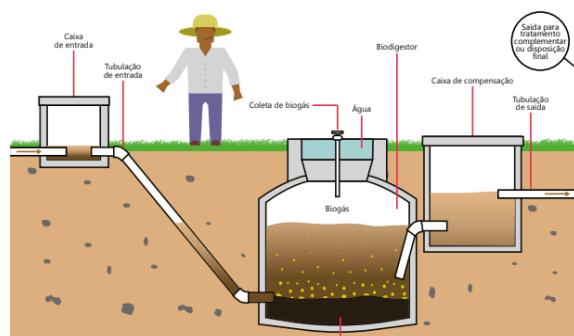
## **Water Waste Treatment**

At the beginning of the year, surveys were carried out to level knowledge in relation to sewage treatment and the circular economy. For the first subject mentioned, some materials were used for a better deepening of the subject, which will be mentioned below and also what was studied in each one of them.

The first was a book published by Unicamp called "Treatment of domestic sewage in isolated communities" (Tonetti et al, 2018) which deals with different ways of treating domestic sewage in these places. The research was more focused on the topic it addressed about the biodigester and on integrated biosystems, which were the main topics of research.

Regarding the biodigester, its operation was basically analyzed and a basic document was made with notes, insights and images so that the study could be better absorbed and summarized. According to the book, the biodigester (Figure 1) consists of a closed chamber where the anaerobic digestion of organic matter takes place (in the absence of oxygen) and a gasometer that stores the biogas produced. Biogas can be used as cooking gas as mentioned above, using a pipe installed on top of the gasometer. For the treatment of domestic sewage with the biodigester, the sewage enters through the side wall of the biodigester and is deposited at the bottom of the container. Inside the biodigester, the anaerobic degradation of organic matter present in sewage and organic waste occurs, and with this, biogas is generated, which is a combustible gas, which proved our hypothesis that it can be used by communities, for example, for the stove, as the biogas is retained in the biodigester's gasometer and a pipe installed at the highest point transports the gas for energy use.

Figure 1 - Diagram of how a biodigester works



Font: Tonetti et al, 2018.

In relation to integrated biosystems, it was something that would be implemented in the project in the foreground. In this file published by Unicamp, the content was used to better understand the system and its functioning.

The concept is based on the total use of sanitary sewage through a treatment cycle integrated with local production activities, recycling the energy potential (with the

use of biogas), water and nutrients.

The system is represented in Figure 2. It is started by a biodigester that can receive all the sewage or just the water from toilets. In it, the anaerobic digestion of organic material takes place. Afterwards the sewage can be sent to an Anaerobic Filter which continues to carry out the anaerobic digestion of the organic matter. After the filter, the sewage goes to the stage where part of the nutrients present in the sewage is absorbed by the plants and part of the water is evaporated to the environment through the transpiration of the plants.

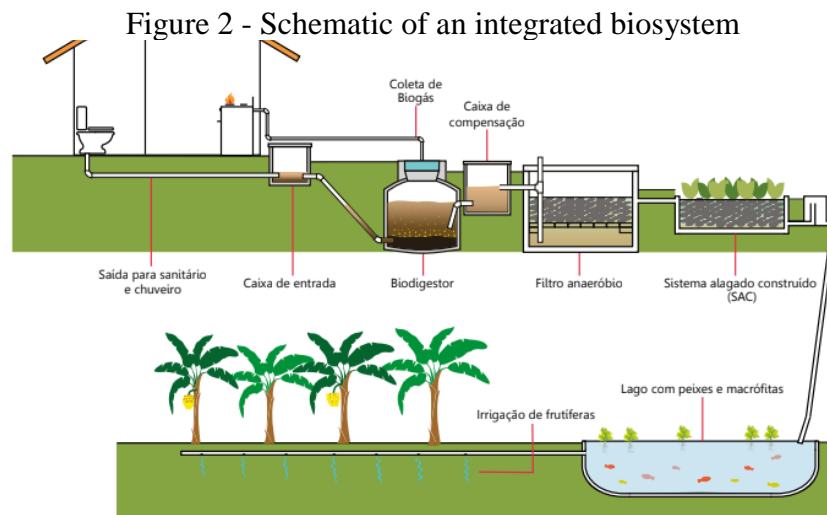


FIGURA 1. Esquema de biosistema integrado (BSI).

Font: Tonetti et al, 2018.

As an opportunity arose in June to help with a research on the Ilha dos Arvoredos located in Guarujá, but with a different objective of using salt water inside a biodigester that will be soon approached, the project was stalled in relation to the study and implementation of integrated biosystems, and with this, the study made was just based on this material published by Unicamp, websites and images illustrating the process.

### Circular Economy

Regarding the study of circular economy, in the first semester a PAE with the theme of Smart Cities was carried out in order to go a little deeper into the area of urban sewage treatment. As it was a comprehensive course, unfortunately this topic was not addressed, but it was worth having carried out this activity, because an opportunity to talk about the circular economy appeared, and the student did a didactic video based on an article read by her and provided by the teacher, which addressed the circular economy, and this helped to deepen and better understand the subject.

In addition to this PAE, in order to be able to study more about the theme of circular economy, two books from Projeto Ideia Circular, which broadly addresses this theme, were read. The first document was "28 case studies, design and innovation for the circular economy" which covered several example projects of the application of the circular economy using the concepts of cradle to cradle, which is a concept that is much discussed when we talk about the circular economy, which means "from the cradle to the cradle", taking away the idea that a product must go from the "cradle to the grave", that is, that the material goods we consume must be discarded and not reused, for example. The other

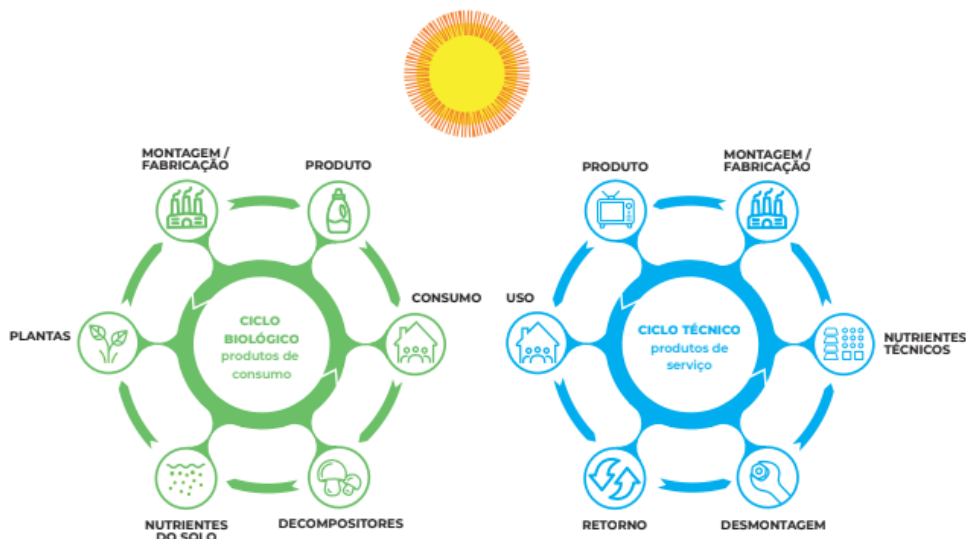
book studied by the IDEIA CIRCULAR was "The 3 principles of circular design cradle to cradle" which discusses what is circular economy and talks a little about the biological and technical cycles (more related to material consumption).

These two books were important for a better understanding of the subject, and even served as the basis for the study carried out in the second semester on this subject.

The circular economy takes the phrase "from cradle to cradle" as an illustration of what it believes. This is an idea that the trajectory of a product must be considered from cradle to grave – an expression used in life cycle analysis to describe the linear process of extraction, production and disposal. For an industry from cradle to cradle, the central idea is that resources are managed in a circular logic in which each cycle passage becomes a new cradle for a given material. In this way, the linear model is replaced by a cyclical model allowing resources to be used infinitely and circulate in safe and healthy flows - for human beings and for nature.

There are 2 classifications of materials, of which are represented by Figure 3 below found in the book "The 3 principles of circular design cradle to cradle" (2021) on page 9 from IDEIA CIRCULAR:

Figure 3 - Illustration of the 2 rankings



Font: IDEIA CIRCULAR, 2021

First we have the cycle of biological nutrients which was designed to safely return to the biosphere what is consumed and also the cycle of technical nutrients designed to circulate in high quality in the technosphere, without entering the biosphere, the technosphere being seen as a species of the Earth's new layer, which is growing at an accelerated rate from what can be understood as the sphere or realm of technological activity, it encompasses all the structures constituted by human work in the space of the biosphere.

The study on the circular economy was used to make a connection with the sewage treatment system that was being studied in the GCSP project, even bringing a more sustainable view of this cycle, as the intention was to be able to generate no impact or only positive impacts for the environment and the populations in need.

## **2nd semester**

### **High salinity wastewater**

Talking about the second half of 2021 when the opportunity for the project to help with a research related to sewage treatment but using salt water at Ilha dos Arvoredos Guarujá, the project took a slightly different direction from July onwards, and for that, the student and the mentor decided that the best way to study about this topic was using a methodology. With the opportunity to carry out research different from what was already being done, the theme was adapted to this new objective of studying more about sewage treatment using salt water, and with that in the month of July until November, the project was dedicated to studying more on this subject.

Scientific bases such as ScienceDirect, BDTD, Scielo and CNPQ were used to research and go deeper into the subject.

The methodology used was basically to use keywords to find articles related to this theme. The keywords most used were all in english and portuguese, and a mix between them were made, the most used were “waste treatment”, “Salt water”, “wastewater”, “sea water”, “salt flush”, “biodigestor”, “salinity”. This study was a very big challenge, as this type of treatment is not very common, and with that the researches were very restricted, the keywords had to be very well selected to give any results. In the end, what was found were 3 studies done related to the treatment of saline water from industries, for example.

The research results were compiled in a document from which it tried to summarize the researched articles. As the level of knowledge about chemistry started to get higher, details of the experiments were not studied much, only the more theoretical results.

The articles found were: "Treatment of saline wastewater using physicochemical, biological, and hybrid processes: Insights into inhibition mechanisms, treatment efficiencies and performance enhancement", "Biological treatment of saline domestic wastewater by using a down-flow hanging sponge reactor" and " Performance, sludge characteristics and microbial community in a salt-tolerant granular aerobic SBR by seeding anaerobic granular sludge".

In the second semester, the study on circular economy was also continued. A course with several classes was provided by Enactus Brazil, a world organization of social entrepreneurship, which discussed the subject in more detail, and with that the topic was continued until the end of 2021.

### **Competencies**

All activities carried out throughout 2021 helped the student to improve various skills such as: the multidisciplinary of which the student had to understand and study several topics, some more focused on chemistry with the study of sewage treatment with high salinity wastewater, on the part of systems, with the integrated biosystem, also with part of the circular economy of which he addressed other very important topics to complement the project, in addition to contacting engineerings and researchers from Ilha dos Arvoredos who are researchers and understand about various subjects.

It was also possible to develop the social awareness part, as the project addresses both a more social and an ecological and sustainable part for the planet, the student had to understand a little about how the water in a sewage treatment system cycle should be dumped into the ocean again, including the social impact that the mismanagement of this

waste is discarded incorrectly, as well as addressing the concept of circular economy and how the lack of healthily affects needy communities, bringing various diseases and a lower quality of life for them.

Finally, the multicultural part was also addressed, since the project intends to work with communities that have low access to quality sewage treatment, affecting their health and quality of life.

## Results and Discussion

As said, the results obtained in this project were theoretical and based on researches, since no practical experiments were done.

The results obtained from research carried out to achieve the proposed objectives for the semesters throughout the year 2021 will be presented below.

In the first semester the focus was researches for the literature review in relation to the sewage treatment with integrated biosystems, biogester and also on the circular economy. Regarding the first topic, a research was carried out in an article published by Unicamp which dealt with sewage and different ways of treating it.

This type of sewage treatment using an integrated biosystem was little explored throughout the year, as with the change of topic in the second semester, this topic could not be related to the treatment with high salinity wastewater studied later, and with that, the results obtained were only related to the research carried out using the book published by Unicamp which explained its functioning. The existing relationship with the circular economy was not well propagated in relation to this topic either, so research was more directed towards understanding the processes that occur in this system and also about the concept of circular economy.

The results from the first semester are more related to what the student has learned during the period, so there are no physical or theoretical results.

In the second semester, when the theme got a different path by studying about saline water used in flush and a good waste treatment for that, the student found some articles that already had studied about this topic. The articles found, as said previously, were: "Treatment of saline wastewater using physicochemical, biological, and hybrid processes: Insights into inhibition mechanisms, treatment efficiencies and performance enhancement", "Biological treatment of saline domestic wastewater by using a down-flow hanging sponge reactor" and " Performance, sludge characteristics and microbial community in a salt-tolerant granular aerobic SBR by seeding anaerobic granular sludge".

The keywords most used to find the articles were all in english and portuguese, and a mix between them were made, the most used were "waste treatment", "Salt water", "wastewater", "sea water", "salt flush", "biodigester" and "salinity", and what was found in general in relation to the treatment of saline water, were more punctual things, such as studies carried out on this subject, but none related to the use of biodigesters, which was something that Ilha dos Arvoredos would like to use for the treatment of this type +of water.

The results obtained were compiled in a document, and what was observed was that the reason why the treatment of this water becomes very difficult is that the microorganisms that are used inside, for example, a biodigester do not survive environments with high salinity as said at "Treatment of saline wastewater using physicochemical, biological, and hybrid processes: Insights into inhibition mechanisms, treatment efficiencies and performance enhancement": "However, biological processes

are also often inhibited by high salinity in wastewater. The high salt content disrupts the metabolic functions of heterotrophic bacteria involved in biological wastewater treatment processes and further decreases the efficiency of the treatment process. This interference of salt with biological treatment is considered a major challenge. Therefore, it is necessary to identify salt tolerant microorganisms that can perform efficiently even under saline conditions”, but according to this same article there are some bacterias that are able to live in this kind of environment: “Halophilic archaea and halophilic bacteria can adapt to changes in extracellular environment. Likewise, halophiles can adapt to the

highly saline environment through salt input and output strategies. The salt-in strategy is used by halophilic archaea in which the pressure difference across cell membranes is controlled by the accumulation of Na + and K + in the cell body.“

In the article "Biological treatment of saline domestic wastewater by using a down-flow hanging sponge reactor" it was found that: "The efficiency of the treatment of pollutants in the bioreactor was inversely proportional and they followed a linear relationship with the concentration of salt in the influent." what basically says that the more salt in the water, less the water is treated.

With that in mind, some things were found related to the treatment having saline water, but there aren't many studies related to it, using a biodigester as well for example.

## Conclusion

The project developed throughout this year with the theme of Sewage Treatment using primarily integrated biosystems and from half the year onwards using salt water instead of focusing on the integrated biosystem due to the partnership made with Ilha dos Arvoredos, had many insights but no experimental results, as stated throughout the article.

The conclusions that can be drawn throughout this year are in relation to what was researched about using salt water in a sewage treatment, which was concluded to be difficult, but not impossible, because there are microorganisms resistant to this type of environment, but with nothing experimental and tested, just based on the literature.

Furthermore, the studies carried out on the circular economy were very important, as they brought the project to a side that was also very interesting and related to sustainability, which was also good for relating to the objectives of the GCSP. This topic has not yet been related to the topic of sewage treatment using salt water, as the system using this type of water is still being studied, as well as its cycle and how it would occur, but only the study on the circular economy brought a good differential.

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