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CHALLENGES IN INSTALLING A WASTEWATER TREATMENT PLANT IN A HYDROGRAPHICALLY STRESSED BASIN

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Abstract: This research on the problem of wastewater and the challenge of building a treatment plant in the municipality of San Quintín, B.C. Mexico, was carried out with the purpose of documenting the impact and challenges to overcome to promote the development of a region that has long been stressed by excessive water use and to propose the installation of a wastewater treatment plant (WWTP) that helps minimize this stress. Due to the large number of inhabitants found in urban centers and which is constantly growing, there is an urgent need, on the part of the government, to begin planning for a project that provides a solution to the problem of water sanitation.
Keywords: wastewater, population center, planning, treatment plant.

INTRODUCTION

WASTEWATER TREATMENT IN BAJA CALIFORNIA (BC)

The state of Baja California has 7 municipalities: Tijuana, Mexicali (state capital), Tecate, Ensenada, Playas de Rosarito, San Quintín and San Felipe (created in July 2021), in all of them there is a shortage of water so that it is important to treat your wastewater.

At the end of 2018, there were 2,540 municipal treatment plants in operation registered in the country, with a total installed capacity of 181,152 l/s, which treated 137,698 l/s, equivalent to 64% of the wastewater generated and collected. in the country's municipal sewer systems. At the end of 2019, the record of plants in operation increased to 2,642 installations in relation to the previous year with an installed capacity of 194,715 l/s and a treated flow of 141,479 l/s, which means increases that allowed us to achieve national coverage of waste treatment. municipal wastewater almost 66% in the year. Of the municipal wastewater treatment plants in operation, in Baja California there are 45 of them, which have an installed capacity of 7,683 l/s (CONAGUA, 2019).

In Mexicali, the State Commission of Public Services (CESPM), a water management body, is a pioneer at the national level in the treatment and reuse of treated wastewater, with few resources and little technology it has managed to implement a treated wastewater supply system. for direct and indirect use, complying with the official Mexican standard NOM-ECOL-003, which allows them to be included in the so-called purple line for the irrigation of green areas in charge of the municipality, such as ridges (Piñera, 2011). Although Mexicali has 31% of the total wastewater treatment plants installed in the state of Baja California (CONAGUA, 2019), Tijuana has 42% of the total but its hydraulic infrastructure does not allow it to reintegrate this water for reuse. . Navarro et al (2016) mention that the initiative "the purple project" which planned to take advantage of 20% of the treated wastewater in BC, by 2010 had only achieved the reuse of 4% with the consequent discharge into the Pacific Ocean of the unused volumes, which leads to water resources in their natural conditions being overexploited and treated wastewater resources being totally wasted, contributing to the loss of important economic resources due to water waste and investment costs in sanitation. In the other municipalities of the state, water treatment data is scarce or non-existent.

DEFINITION AND WAY IN WHICH WASTEWATER IS TREATED

Wastewater treatment is the set of operations and unit processes that are carried out in the different units of the plant, to remove contaminants present in the water, such as organic matter, suspended solids, nutrients, pathogenic organisms and heavy metals whose concentrations exceed the maximum permissible limits established in the Official Mexican Standards.

Wastewater is treated by physical, chemical and biological methods or by combining them. Physical treatment consists of the removal of contaminants without changing their conformation, through unit operations, such as screening, sanding and degreasing, sedimentation and flotation.

For chemical treatment, reagents are added which remove contaminants from wastewater. The most common are flocculation and coagulation. The processes in which the microorganisms contained in the wastewater degrade soluble contaminants or those present in colloidal form are known as biological. On the other hand, wastewater treated with the aforementioned processes can be subjected to additional processes known as tertiary treatment, which improves the quality of the effluent and increases its added value and the possibilities of reuse and exchange, including for the recharge of aquifers. (CONAGUA, 2020).

TYPES OF TREATMENTS

Wastewater can be treated in various ways in order to reduce the levels of contaminants present. They can be classified as:

- • **Physical treatments:** They are those methods in which a physical separation is applied, generally of solids. These methods usually depend on the physical properties of the contaminants, such as viscosity, particle size, buoyancy, etc., among them are sieving, precipitation, separation and filtration of solids.

- **Chemical treatments:** They are those methods that depend on the chemical properties of the contaminant or reagent incorporated into the water. We can highlight the elimination of iron and oxygen, the elimination of phosphates and nitrates, coagulation, electrochemical processes, oxidation, ion exchange, etc.

- **Biological treatments:** In these methods, biological processes are used, so that the aim is to eliminate colloidal contaminants. They are microorganisms that act on suspended matter, transforming it into settleable solids. They can be aerobic or anaerobic processes, such as activated sludge, trickling filters, anaerobic biodigestion or aerated lagoons (Rodríguez de Jorge, 2020).

Generally, the treatment methods used to achieve this removal are called unit processes, which can be grouped together to provide the required treatment. The various levels of treatment can be classified as follows:

Preliminary: Removal of coarse solids such as fabrics, plastics, pieces of wood, sand, grease that can cause operational problems in subsequent treatment units.

Primary: Removal of a fraction of suspended solids and organic material from wastewater.

Advanced Primary: Addition of chemical compounds and/or filtration in order to achieve improved removal of suspended solids and organic material from wastewater.

Secondary: Removal of soluble and suspended biodegradable organic matter, and suspended solids. Disinfection is

usually also carried out in conventional secondary treatment.

Secondary with nutrient removal: Removal of biodegradable organic compounds, suspended solids and nutrients (Nitrogen and/or phosphorus).

Tertiary: removal of remaining suspended solids (after secondary treatment). Disinfection is usually also carried out in this treatment, as well as the removal of nutrients.

Advanced: Removal of dissolved and suspended material that remains after standard biological treatment (Ramírez & Mendoza, 2005; CMAS, 2018).

IMPORTANCE OF WASTEWATER TREATMENT

Every community has an impact on the natural environment that surrounds it, whether in the form of air emissions, solid and/or liquid waste. Liquid waste is called wastewater and is the result of the use of piped water in the home, industry and commerce. The decomposition of wastewater produces offensive gases, such as hydrogen sulfide (H2S), which is responsible for the "rotten egg" smell, as well as methane. Likewise, a large number of pathogenic microorganisms are present in wastewater, which can be a potential health risk. Therefore, by its nature, wastewater contains a variety of biological and chemical compounds in concentrations such that they can cause contamination in receiving natural waters, so they must be removed.

For many years, treated and untreated wastewater has been discharged into natural bodies of water such as seas, rivers, lakes and lagoons, adversely and often irreversibly affecting their natural characteristics. Natural bodies of water have their own purification capacity, through which they are capable of assimilating and removing solids, organic matter and even some toxic chemical compounds. Such removal capacity is attributed to the microorganisms naturally present in bodies of water and in the wastewater itself. However, this process takes time. Thus, the purpose of treatment plants with processes that provide the necessary conditions for the accelerated degradation of polluting substances in wastewater to occur to a lesser extent impact natural water bodies, recipients of the water. residuals (Ramírez & Mendoza, 2005).

WASTEWATER IMPACT

The impact produced by wastewater is multifactorial, such as on the soil, water, health, among others.

- **On the floor**

The use of wastewater in the soil for agricultural purposes can increase the entry of organic matter and nutrients into cultivated soils, which contributes to maintaining and increasing its fertility, but it can also bring harmful environmental effects that deteriorate soil quality. That is, the dynamics of organic matter in the soil is important since its decomposition influences the release of organic and inorganic molecules linked to it. Therefore, the input of wastewater sludge for several years can influence the chemical and fertility characteristics of the soil.

Without prior treatment it can cause problems due to the high salt content, contamination with heavy metals and the presence of some microorganisms that are pathogenic to humans. Therefore, it is necessary to evaluate its use by quantifying its effect on the chemical properties of the soil, in order to guarantee that its use not only improves the fertility and productivity of the soil, but also leads to maintaining the quality of this resource, guaranteeing that it does not cause environmental problems (Zamora et al., 2008).

- **In water**

The discharge of untreated domestic, industrial, agricultural and livestock wastewater causes contamination of receiving water bodies, reducing the quality of surface and groundwater.

Water sources (rivers, aquifers, lakes, sea) are incapable of themselves to absorb and neutralize the contaminant load, and therefore these bodies of water lose their natural conditions of physical appearance and their ability to support adequate aquatic life, which responds to the ecological balance expected of them to preserve bodies of water. As a result, they lose those minimum conditions that are required for their rational and adequate use (Rodríguez, 2017).

- **In the health**

Health is understood as the optimal physical and mental conditions of every human being that guarantee healthy people without illnesses or ailments that prevent the development of all their functions (Alfaro & Salas, 1997).

Pollution of rivers by wastewater can cause the transmission of diseases such as:

- Epidemic infectious hepatitis.
- viral gastroenteritis.
- Poliomyelitis
- Anger
- Typhoid and paratyphoid fever
- Bacillary dysentery

The prevention and treatment of these diseases has meant an increase in budgeted health expenses for governments. The above in order to maintain control of those diseases caused by the effects of pollution, as well as in the treatment of secondary effects and those diseases caused indirectly by contact with water (ibid.).

MEXICAN REGULATIONS FOR WASTEWATER TREATMENT

Each country has legislation to regulate the maximum concentrations of these contaminants allowed in wastewater. In general, the maximum permissible limit of contaminants will depend on the final destination of the wastewater or the use to which it would be subject. In Mexico, the discharge of wastewater is regulated by the following official Mexican standards (NOM):

- NOM-001-Semarnat-1996. That establishes the maximum permissible limits of contaminants in wastewater discharges into national waters and assets (Official Gazette of the Federation, 1996)
- NOM-002-Semarnat-1996. That establishes the maximum permissible limits of contaminants in wastewater discharges to urban and municipal sewage systems (Official Gazette of the Federation, 1996)
- NOM-003-Semarnat-1997. That establishes the maximum permissible limits of contaminants for treated wastewater that is reused in public services (Official Gazette of the Federation, 1997)

These standards indicate the various parameters whose concentration must be controlled in wastewater.

PERSPECTIVE OF WASTEWATER TREATMENT IN URBAN AREAS

The characteristic features of the urban space are its largest population, its high population density, its extension and its greater provision of all types of infrastructure; especially the economic ones, with activity and employment concentrating in the secondary and tertiary sectors, with the primary sector being insignificant (Soloaga et al., 2021). In Mexico, an urban area is called any locality in which more than 2,500 inhabitants live.

The discharge of urban wastewater comes from homes, public buildings and urban runoff that is collected in the drainage. Its main contaminants are nitrogen, phosphorus, organic compounds, fecal coliform bacteria, organic matter, among many others (Jiménez et al., 2010). For the removal of contaminants in municipal wastewater, there are various treatment processes including activated sludge, stabilization lagoons, advanced primary, aerated lagoons, biological filters, dual and others. In Mexico, only 35.5% of the wastewater is treated by which represents an area of opportunity to carry out this activity, even in urban areas (CONAGUA, 2013).

PERSPECTIVE OF WASTEWATER TREATMENT IN RURAL AREAS

According to the National Water Commission (CONAGUA), sewerage and sanitation coverage in rural areas shows a significant deficit with respect to the coverage achieved in urban areas; In order to achieve greater coverage in rural areas, CONAGUA is implementing a series of actions that allow wastewater treatment through treatment systems that are easy to use and apply.

- Septic tank (septic tank).- Septic tanks have been used in individual homes or in small groups of homes with between 10 and 100 inhabitants (PAHO, 2005), in areas where there is no drainage or pipe to remove sewage such as as shown in figure 1.

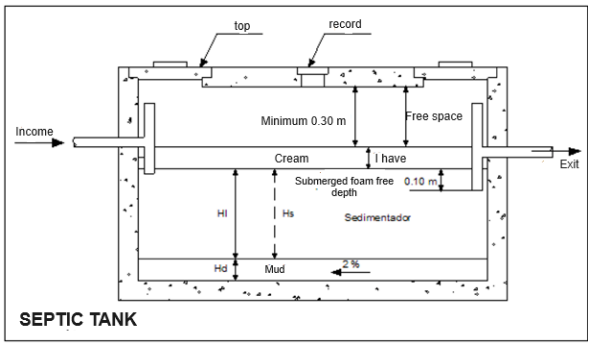

Figure 1: septic tank

Taken from: https://sswm.info/sites/default/files/reference_attachments/OPS%202005.%20Gu%C3%ADa%20para%20el%20diseño%20de%20tanques%20sépticos.pdf

- Imhoff Tank: The Imhoff tank is an anaerobic process in which the sedimentation of solids is carried out (figure 2). This process can be applied to treat wastewater of up to 5,000 inhabitants and inside it, sedimentation and sludge digestion occur separately, in different compartments. The tanks are built with reinforced concrete, they are square or rectangular in shape.

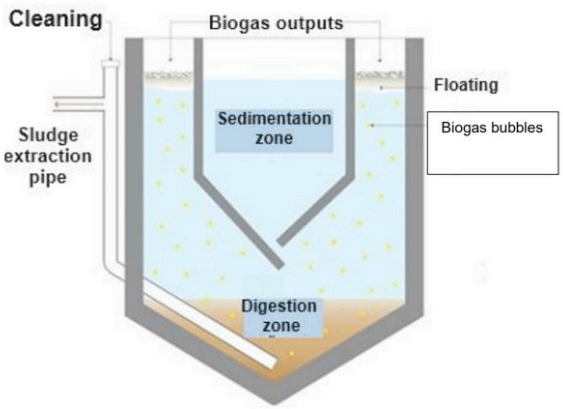

Figure 2: Imhoff tank

Taken from:https://www.iagua.es/blogs/juan-jose-salas/modesto-tanque-imhoff-fundamentos-y-diseno

- Biodigesters: Anaerobic biodigesters consist of an organic matter inlet tube, fermentation chamber or digester body, gas storage chamber, stabilized or fermented matter outlet chamber, and in cases where biogas is used., has a gas conduit and gasometer (CONAGUA & SEMARNAT, 2016).

- Upflow anaerobic reactors (RAFA).- In the RAFA, the wastewater to be treated is conducted from the top of the reactor (tank) to the bottom of it through tubes (figure 3). The effluent flows upward through a blanket of sludge (anaerobic microorganisms), which carries out the treatment that can be used both in a small town and in a home. The feasibility of this reactor is that it must have with constant water and electricity, things that are sometimes a luxury for small towns (CONAGUA & SEMARNAT, 2016).

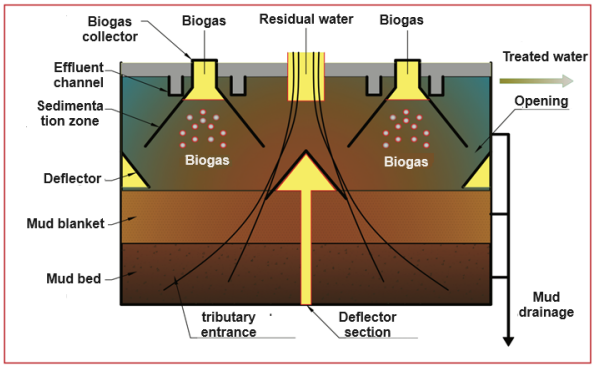

Figure 3: Upflow anaerobic reactor. Taken from: https://files.conagua.gob.mx/conagua/mapas/SGAPDS-1-15-Libro49.pdf

In Mexico, septic tanks are the most common, especially in rural and peri-urban areas. Septic tanks or pits allow the removal of solids and the biological treatment of wastewater through anaerobic processes. These flow through the pit and heavy particles settle to the bottom, while foam (especially oil and grease) floats to the surface. Over time, the solids that settle to the bottom are anaerobically degraded. However, the rate of decomposition is lower than the rate of accumulation, so the sludge and scum that accumulates must be removed periodically. In a well-designed and maintained septic tank, removal of 50% solids, 30% to 40% BOD, and a 1-log reduction of E. coli can be expected, although efficiency varies greatly depending on operation and maintenance, as well as as well as climatic conditions. When the water table allows it, the septic tank provides a primary treatment that conditions the wastewater so that it can infiltrate the subsoil through an absorption well or infiltration bed, without affecting its absorption capacity (CONAGUA, 2015; Tilley et al., 2018). It can also be transported to another treatment technology through a solids-free sewer, although in Mexico this situation is rare, since pits are usually used as an in situ sanitation option, in places where there is no drainage.

Septic tanks are not efficient at removing nutrients or pathogens. However, under normal operating conditions, users do not come into contact with the influent or effluent. In any case, users must be careful when opening the tank to avoid the release of flammable and toxic gases, both the effluent, the foam and the sludge have to be handled with care, as they contain high levels of pathogenic organisms (Tilley et al., 2018).

METHODOLOGY

The objective of this documentary research is to collect information on wastewater treatment to prepare a proposal for the installation of a WWTP in San Quintín, B.C.

The steps to follow were the following:

- On-site visits
- Consultation of information sources
- Analysis of the information
- Challenges to installing a WWTP

RESULTS

San Quintín comprises an extensive territory that ended up being consolidated as the sixth municipality of Baja California in February 2022 (POE-BC, 2020) with an approximate area of 21 thousand total hectares (figure 4). Before this, the region was part of a cluster of dispersed populations in what was the south of the municipality of Ensenada, BC.

The rapid demographic growth of the San Quintín region, added to the lack of a short, medium and long-term projection of an urban development plan, caused the majority of population settlements to not have basic public services; these settlements became in large population centers that number their inhabitants today in the thousands. Some services arrived almost at the same time as the beginning of population growth (such as drinking water and electricity) and others were gradually incorporated (education, telecommunications, etc.) but ultimately the service for the proper disposal of wastewater is the one that Today it has marginalized the entire region.

Figure 4: On-site visit and location of the municipality of San Quintín (source: https://www.enlineabc.com.mx/2020/01/18/el-gobernador-jaime-bonilla-y-el-alcalde-de-ensenada-avalaron-la-municipalizacion-de-san-quintin/)

Although the population has adopted methods to deal with the lack of this public service, generally through the use of septic tanks, this only solves part of the entire problem.

Wastewater represents a serious problem that threatens not only people's health but also the environment since the disposal of sewage is not carried out properly, even being non-existent.

This municipality is part of the set of rural areas where the poor (or no) disposal of this material begins to affect the area due to the large population growth that has occurred in recent years, this growth has caused an increase in the amount of wastewater. that is generated and that is not treated for better use, which translates into significant changes in the ecosystem in addition to representing a risk to the health of the population (figure 5).

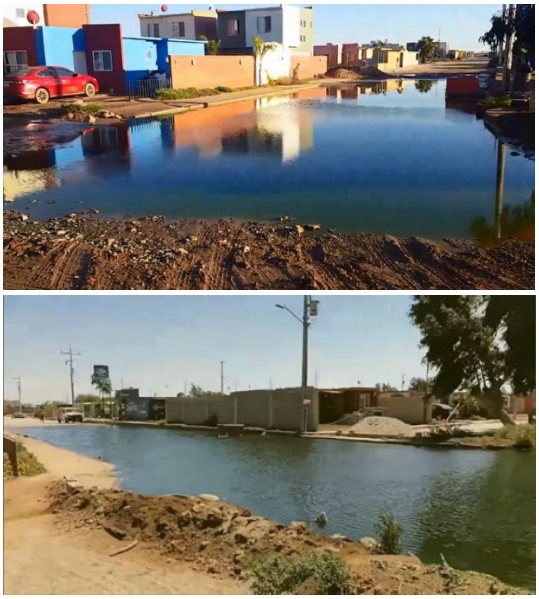

Figure 5: Problems with wastewater in the city. (Own source)

CHARACTERISTICS OF THE REGION

The population centers of the municipality of San Quintín, collectively known as the San Quintín Valley, stand out for being a place where agriculture thrives and is characterized by the production of strawberries, cherries, tomatoes, among others. The annual agricultural production generates many jobs both for the region and for temporary day

laborers who come from the southeast of the country and, lately, from Central America; Migration for work is not the only factor that affects the growth of the Valley, but it is key. This is reflected in the demographic growth of the population, which has grown from 38 thousand inhabitants in 1990 to 117 thousand inhabitants in 2020; Most of the people who arrive in BC are from the states of Sinaloa, Chiapas and Guerrero (INEGI, 2020). The population data, by itself, indicates that the San Quintín valley already requires having a WWTP, according to "The PAHO/CEPIS Guides for the design of sewers" where they mention margins to begin planning a sewer network. which starts from 1000 to 15000 inhabitants. Although a sewage project for a population settlement must be considered in the urban projection of the property, since the majority are settlements that were founded and grew without these provisions, it is necessary to mitigate the impact of this problem in the area as soon as possible. to raise the quality of life of the population that lives in said region, in addition article 115, section III of the political constitution of the United Mexican States mentions that the municipalities are in charge of the public functions and services of drinking water, drainage (wastewater), sewage, treatment and final disposal, which, in practice, is contradicted by the lack of strategic planning to be carried out (Political Constitution, 2020).

Many of the settlements of the population in San Quintín were a by-product of the transformation of camps controlled by an employer to keep labor available in time and quantity, into colonies independent of the workplace and the bosses. Therefore, they are housing developments that grew informally and lacked an urban planning projection, therefore, they barely contemplate basic services such as drinking water and electricity. In 2015, the "Program for the Care of the San Quintín Region 2015-2019" was announced, which contemplates projects that would be developed in the region during the period from 2015 to 2019, which include a water desalination plant, a regional water distribution tanks in addition to a wastewater treatment plant. Until 2021, there is little or no news regarding the development and start-up of the wastewater treatment plant mentioned in said program.

In 2017, a document "Proposal for certification and financing: Desalination plant in San Quintín, Baja California" mentions that the **0% of the population** The San Quintín Valley has access to a centralized sewage system and approximately 42% of the population uses septic tanks and the rest uses cesspools (COLEF, 2021).

RETOS A ENFRENTAR
CHALLENGES TO FACE

1. Due to the large territorial extension of the region in addition to the wide dispersion of the population, it is necessary to locate population centers greater than 2,500 inhabitants; In the San Quintín region there are at least three large population centers that, due to the distance between them, each could host its own wastewater treatment plant. The municipal authorities, with these three populations, can begin the installation of the WWTPs.

Water treatment is divided into three stages or actions.

- Collection.
- Treatment.
- Restitution.

2. To carry out the **collection** process it is necessary to have a sewage network. Therefore, it is necessary to plan, design and implement a system that meets the necessary characteristics for water collection.

3. For water **treatment**, it is necessary to take into account aspects regarding planning, design and implementation of a WWTP that complies with Primary Treatment, Secondary Treatment and Tertiary Treatment as indicated by the standards and statutes for the implementation of this, in addition to training qualified personnel to carry out this action.

4. Once the water has been treated, it is necessary to restore it either through rivers, lakes, lagoons, aquifers or the sea, which means another task of planning, design and implementation of the works necessary to carry out this purpose.

The treatment of wastewater in dispersed population settlements, in addition to not being economically feasible to install a WWTP, the municipal government must promote and assist residents so that they themselves treat the wastewater that they themselves generate, such as:

Promote the importance of wastewater treatment and the impact it has on their quality of life, as well as the ecosystem,

Promote the use of sustainable and accessible solutions for wastewater treatment, described in "Technical guidelines: Wastewater treatment system at home level in rural areas" by CONAGUA.

Commit as a municipal administration to maintain constant inspection of the appropriate use of these technologies through the bodies in charge of water sanitation.

CONCLUSIONS

The key to any great work is organization, something that seems to be quite logical and simple to carry out, unfortunately for underdeveloped or developing countries, such as Mexico, it is a common practice that there is little planning for settlements. population, whether due to the lack of the same organization or lack of economic resources, in any case the situation has a significant impact on the quality of life of citizens.

It can be seen that, although there are rigorous norms, laws, plans and even rights embodied in the constitution itself (which we do have - in writing -), it is difficult for these to end up being executed satisfactorily in reality, either as mentioned above., due to lack of economic resources or because these circumstances do not represent immediate importance in current political agendas.

Due to the large number of inhabitants found in urban centers and which is constantly growing, there is an urgent need to begin planning for a project that provides a solution to the problem of water sanitation.

As a result of the dispersion of homes in the most rural areas and the little or no coverage of public services, it is necessary to develop particular solutions to treat this problem on a more individual basis to provide basic water sanitation.

A work of this magnitude requires a lot of planning, investment and interest on the part of the citizens, as well as their rulers; This must not become a condemnation, it is also the responsibility of the citizens themselves to look for alternative means or technologies that combat the problem more immediately as well as get more involved in urban development, increasingly choosing their representatives better, so that they can position and manage the prompt solution to this environmental problem.

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