

Comparison of Sanitary Sewage Treatment Systems: Nereda in Relation to the Stabilization Pond Treatment System in the Legal Amazon

Ericles Bruno Muniz Novais, Diogo Pedreira Lima

Department of Civil Engineering, ITPAC Porto Nacional, TO, Brazil

Abstract—The difficulty that great nations often suffer in relation to the lack of efficient basic sanitation for their entire population has, over the years, become a concern of global proportions. Although the rate of service with sewage collection corresponds to a high percentage of active water connections in suitable areas in Porto Nacional in the state of Tocantins, (City and therefore, state belonging to the legal Amazon) when we look at the total scenario of the Amazon Legal, only a small percentage of people living in these areas are served with sewage collection and treatment. Knowing then that the percentage of a given population served with collection and an effective sewage treatment system is directly related to the quality of life and health of its population, this work set out to present the innovative Dutch sewage treatment system that emerged on the NEREDA patent, compared to the conventional sewage treatment system used in the city of Porto Nacional - TO. Finally, the objective of this study was to present this Dutch technology based on public domain data presented by Brazilian bodies and entities, as well as other studies already carried out and the data of the company that owns the patent. Although still little known in the world, this technology presented great potential both qualitatively and economically because it presented a greater amount of treated sewage per second with quality equal to or greater than other methods, in addition to low implementation value due to the possibility of use most of the existing treatment plants.

Keywords— Sanitation, Sewage treatment, Conventional WWTP, Nereda, WWTP.

I. INTRODUCTION

With the exponential growth of the global population, one of the major concerns that arises and is directly related to the health and wellbeing of this same population is basic sanitation. Brazil, for example, has long been experiencing problems involving this subject. The report of the United Nations (UN) registered by UNESCO [1] that deals with the global development of water, more than 2 million people around the world are not served by any form of sewage collection and treatment. Data from the Brazilian Institute of Geography and Statistics (IBGE) [2] report that a large number of epidemics and endemics that plague Brazilians are closely linked to the precariousness of the country's sewage collection and treatment system, which serves only about 60,2% of the population and can manage only about 46% of it.

ABCON and SINDCON (Brazilian Association of Private Service Concessionaires and National Union of Concessionaires) [3] bring data in one of their latest published surveys that show that Brazil, when compared to

other countries, is in 106th place in terms of access to basic sanitation, even having a lower performance than their neighbors in South America. The same survey points out that about 14% of children and adolescents in the country do not even have the right to treated water guaranteed, of these, 7,5% even have water at home, but not processed or filtered, which confirms the great need that Brazil still has for heavy investments in this area. A brief comparison comparing Brazil to other countries in terms of access to treated water and the sewage collection and treatment system is illustrated in Table 1.

Table. 1: Comparative of access to Basic Sanitation.

Country	Access to treated water	Access to Sewerage Services
Netherlands	100%	100%
BRAZIL	83,00%	60,20%
JORDAN	96,90%	98,60%

IRAQ	88,60%	86,50%
MOROCCO	85,40%	76,70%
SOUTH AFRICA	93,20%	66,40%
CHINA	95,50%	76,50%
BOLIVIA	90,00%	50,30%
CHILE	99,00%	99,10%
MEXICO	96,10%	85,20%
PERU	86,70%	76,20%

Source: Adapted from ABCON and SINDCON,(2019).

Data from the Sanitation Company de Porto Nacional - TO [4] confirm that in the municipality of Porto Nacional approximately R\$44,587,595.45 have already been invested between the years 1999 to 2018, of which 38% were invested in the system production and water supply, 57% in the sewage collection and treatment system and 4% in other investments that were necessary.

The city has a sewage system that consists of a treatment unit that is in the urban perimeter of the city, approximately 12km from the water treatment plant. Data from the Municipality of Porto Nacional - TO [5] reveal that the city has rugged characteristics, which is why the local sanitation company opted for dividing the area of the city in several sub-basins, totaling today 14 sewage pumping stations that facilitate transportation of collected sewage to the treatment plant.

City Hall data [5] also reveals that the entire operational area of the sewage treatment plant currently stands at approximately 188,900 m², and of this, the total operating structure occupies approximately 40,000m² and has the capacity to treat 68 liters of effluents. per second.

When we talk about sanitary sewage, the Sanitation Atlas carried out by IBGE [6] points out that in cities or even states that have a low sewage collection rate, the treatment does not even exist, it only comes into existence, in most cases, when cities have at least 100,000 inhabitants.

With this information in mind, this study aimed to present a comparative analysis of the sewage treatment system developed in the Netherlands in recent years that was registered under the NEREDA patent, with the conventional sewage treatment system used in the legal Amazon, more specifically the one used in the city of Porto Nacional.

The main purpose of this comparison is related to the search for knowledge about this new system that is

beginning to be implemented in Brazil and in other countries in order to identify possible advantages in relation to the current conventional systems of Brazilian sewage treatment, more specifically in city of Porto Nacional - TO, city belonging to the legal Amazon.

II. METHODOLOGY

Porto Nacional is a municipality located in the State of Tocantins, northern region of Brazil and is located 64km from the capital Palmas. The city has an area of 4,449.917km². Figure 1 better illustrates the location of the city in relation to the state and country.

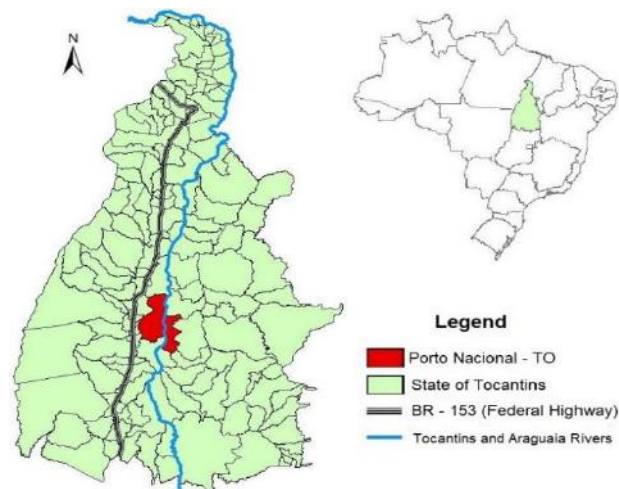


Fig. 1: Location of the municipality of Porto Nacional.

Source: Adapted from the Porto Nacional City Hall, (2018).

Porto Nacional according to the last IBGE census [7] carried out in 2019, has an estimated population of 53,010 people living in its regions and is the 4th largest city in the State, therefore, one can imagine that it is a city that produces a lot of sewage and that, as it is a city surrounded by many hydrographic basins, the need for adequate sewage collection and treatment is of fundamental importance so that these sources are not contaminated.

The facilities of the city's Gross Sewage Treatment Station are located at the end of Avenida Tocantins, just after the city's agricultural exhibition park, as shown in Figure 3 below.



Fig. 2: Location of the STP of the Porto Nacional – TO.

Source: Adapted from Google Earth - CNES Airbus Satellite - Zone 23 DATUM WGS 84, (2019).

The main information that was the target of the comparison proposed by this study was the efficiency values related to the volume of effluent treatment per second in both forms of treatment in relation to the volume of the treatment plant facilities themselves.

In order to carry out this work, we carried out an on-site visit to the facilities of the sewage treatment plant in Porto Nacional - TO to get to know you and thus check if the facilities matched the data provided by the city hall and the sanitation company.

With the data in hand, the effectiveness of the current sewage treatment in Porto Nacional - TO was verified in relation to the percentage of the population served.

The data regarding energy expenditure, type of biomass used, BOD reduction and sedimentation time obtained from the Nereda system were compared to the data from the sewage treatment system in Porto Nacional - TO and a table was constructed with the summary of the comparative analysis, the results obtained are described below.

III. RESULTS AND DISCUSSIONS

3.1 Porto Nacional

The sewage treatment system of Porto Nacional - TO, consists of a preliminary treatment that consists of the use of a mechanized curved grid, mechanized sander, mechanized helical screw and a parshall flow meter with $W = 1$ throat. Subsequently, after preliminary treatment, a pumping station within the WWTPs operational area launches the effluent into an anaerobic up flow reactor which, after treatment, proceeds to a post treatment in series stabilization ponds of the optional and maturation types. A burner for the gases from the treatment process connected to the treatment system exists in the vicinity of the Reactor. After the entire treatment process, the treated

effluent is then discharged into the Luiz Eduardo Magalhães hydroelectric lake. The treatment station area can be better verified in Figure 4.



Fig. 3: Location of the STP of the Porto Nacional – TO.

Source: Adapted from Google Earth - CNES Airbus Satellite - Zone 23 DATUM WGS 84, (2020).

According to city hall data, through the municipal water and sewage plan [5], in Porto Nacional, the rate of service with sewage collection corresponds to 91% of active water connections in suitable areas, with 100% of the collected sewage being fully treated. The so-called apt areas are defined as those areas of population agglomeration that have a density equal to or greater than 16 inhabitants per hectare, meeting this requirement, the sector has the technical feasibility of service for the local sanitation company.

3.2 Nereda

Information from the Nereda Community [10] reveals that currently, 16 countries around the world have Nereda plants in operation, including Brazil, which currently has 11 of these plants in operation, 1 in Tocantins (In Araguaína starting operations in 2019, with a treatment capacity of 60 liters of effluents per second, working with a peak flow of up to $2,196\text{m}^3/\text{h}$), 1 in Goiás, 3 in São Paulo, 2 in Rio de Janeiro and 4 in Pernambuco.

Royal HaskoningDHV (RHDHV) information [11] reports that Nereda technology for wastewater treatment uses only aerobic granular biomass as a resource that is used inside tanks where the entire treatment process occurs (shown in Figures 5 and 6), pointing out that this technology is extremely economical because in addition to requiring only about two fifths of the area of conventional reactor installations followed by a pond, the process consumes about 50% less electricity in its Processes (reactors followed by pond consuming on average

0.60kWh/m³ of treated effluent and the Nereda system consuming an average of 0.28kWh/m³).

In this technology, biomass develops as a granular sludge with rapid stabilization, these granules have an enormous capacity for sedimentation, which means that there is no need for a slow phase (decantation of the USB reactor and slowness of the optional ponds and maturation of the system sewage treatment plant in Porto Nacional - TO) and separated for decantation as is commonly the case with conventional methods, therefore, in this process, all phases of treatment can occur simultaneously in a single tank that receives granular biomass which in turn controls the biochemical oxygen demand and causes all the suspended matter in the tank to settle, leaving only the treated effluent, which is then pumped out of the tank, which may or may not need some other treatment phase depending on the laws in force. each city or state.

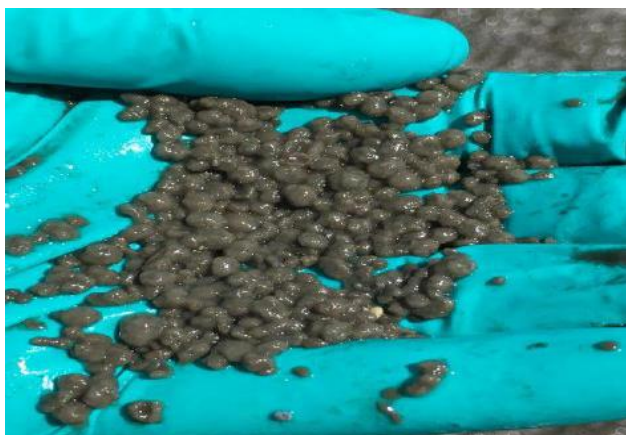


Fig. 4: Pure biomass granules.

Source: (RHDHV, 2018).

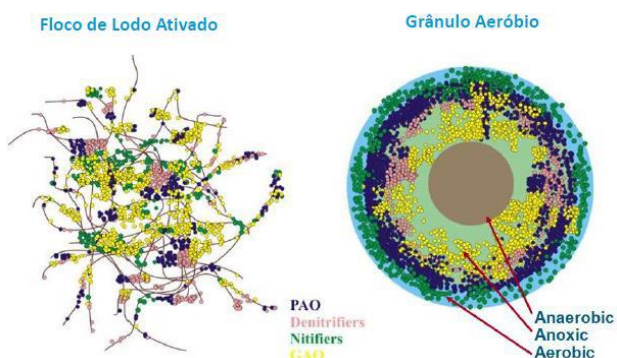


Fig. 5: Comparison of the structure of flakes and granules.

Source: (RHDHV, 2018).

The sanitation company of Porto Nacional - TO [4], which also has concessions throughout the country, is one of the pioneers in the use of Nereda technology in Brazil. The same points out on its website that this technology

considered as revolutionary, uses instead of flake structures as in the conventional process, a structure in granules, which have an extremely higher sedimentation speed and do not need to add any chemicals, while in the sewage treatment plant of Porto Nacional - TO, the structure of the formed sludge is more flocculated and after its treatment in the anaerobic upstream reactor, a continuous flow flotation process with physical chemical treatment is necessary for the complete effluent treatment.

The same sanitation company continues to reinforce that the choice for this type of bacteria has many advantages, because in addition to removing all organic matter in a much more timely manner, this process also manages to remove excess phosphorus and nitrogen from wastewater (It manages to achieve a reduction in BOD in the order of 85 to 90% while the sewage treatment plant in Porto Nacional - TO was designed to have a BOD reduction in the order of 85%), that is, the entire primary process, secondary and tertiary boils down to a single system that works at a speed far exceeding all of these combined. Giancarlo Ronconi, Chief Technology Officer of the company concludes by saying on the website that the gain in space savings, electricity consumed in the process (about 50% less when compared to other conventional systems), chemical products (The Nereda system does not use products chemicals) and maintenance equipment are some of the main advantages of the Nereda treatment system.

In order to have an idea of the proportions of space savings in the project, Figures 7 and 8 below make a comparative plan sketch of the space occupied by the old conventional system used in the WWTP Deodoro located in Rio de Janeiro - RJ (Reactor followed by lagoons) and the current Nereda system implemented, both for operation with a constant flow rate of 750 liters per second.

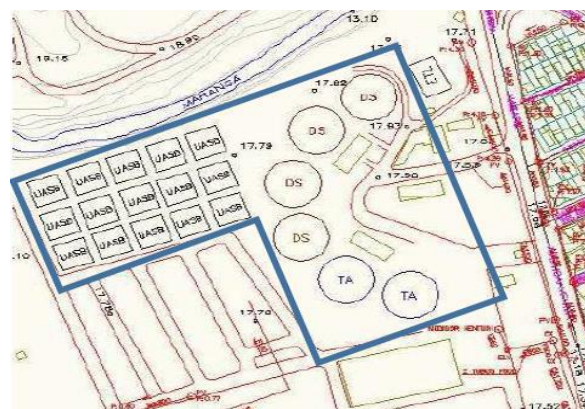


Fig. 6: UASB + Stabilization Ponds - Total Reactor Volume = 41.000 m³.

Source: National Meeting of Waters (2018).

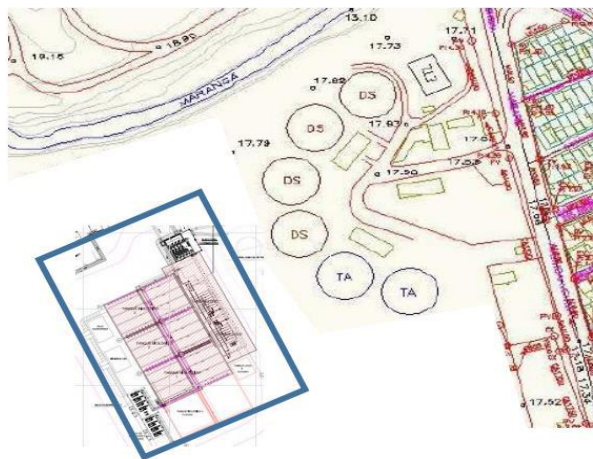


Fig. 7: Nereda - Total Reactor Volume =21.500m³.

Source: National Meeting of Waters (2018).

Figure 9 below shows the sedimentation speed that this new method presents when observed over a period of 30 minutes. According to the sanitation company of Porto Nacional - TO [4], the city's sewage treatment plant can present its treatment results within 8 to 10 hours.



Fig. 8: Sedimentation process in 30 minutes.

Source: (RHDHV, 2018).

The Nereda Community [10] brings information that says that because its technology is very flexible, plants with both activated sludge and anaerobic up flow reactors can easily be converted to use Nereda technology. It is also stated that when this happens, both the biological and hydraulic capacity of the plants are significantly increased, this is since the treatment speed will be increased. With the technology, a plant with a volume of 1000m³ will easily be able to carry out all the treatment of effluents at a speed of approximately 35 liters per second while to obtain this same volume with a conventional technology associating UASB reactors + stabilization ponds, at least a plant of approximately 2000m³ would be needed. Table 2 illustrates a brief result of the comparative analysis between Nereda

technology and the reactor treatment system followed by lagoons in Porto Nacional - TO.

Table. 2: Comparison of raw sewage treatment systems.

Reactor followed by Lagoons		WWTP Nereda	
Average energy consumption	0,60 (kWh/m ³)	Average energy consumption	0,28 (kWh/m ³)
Type of Biomass used	Flake	Type of Biomass used	Granule
BOD reduction	Up to 85%	BOD reduction	Up to 90%
Sedimentation Time	8 to 10 hours	Sedimentation Time	30 minutes

Source: Prepared by the Author.

The average energy consumption is a point to be analyzed due to the great need that we usually have to save this resource so that the operating costs do not become too high. The type of biomass present in the treatment systems here defines the speed of sedimentation of suspended matter and consequently the speed of treatment. The BOD reduction levels are analyzed to make sure that the treated effluent has the minimum characteristics of reducing the biochemical oxygen demand necessary for the treated effluent to be released into a receiving body. The sedimentation time was analyzed because this factor is crucial for saving time in the treatment process of both systems.

The information provided by the Nereda Community [10] reports that there is also the possibility of using Nereda technologies in conjunction with conventional technologies just to speed up their process by reducing the time for systems that take 6 to 10 hours to complete the process. treatment of a certain amount of sewage for 3 to 5 hours, which brings to this use in hybrid extension the additional advantage of increasing the quality and speed resulting in improved sedimentation characteristics, greater capacity and greater biological removal of nutrients from the activated sludge. reach 90% removal of these due to interference from granular sludge from Nereda technology.

In terms of reducing Biochemical Oxygen Demand, the Nereda system also shows great efficiency, as can be seen in Table 2 below.

Table. 3: Efficiency of some of the main sewage treatment systems.

Sanitary sewage treatment system	Efficiency in BOD Removal (%)
Septic tanks	35 - 60
Upstream Flow Anaerobic Reactors (UASB)	55 - 75
Conventional Activated Sludge	75 - 95
Activated Sludge with Extended Aeration	93 - 98
Nereda	80 - 90

Source: Adapted from the Ministry of the Environment (2018).

IV. CONCLUSION

As the main objective of this study was to compare one of the most used sewage systems in the legal Amazon (Reactor followed by series stabilization ponds), more specifically in Porto Nacional - TO with the Nereda wastewater treatment system, the main results obtained in quali-quantitative and economic terms follow.

The Nereda system in fact allows for fast and efficient treatments in compact and uncomplicated projects. The system uses a much smaller amount of mechanical equipment than in conventional processes. All these facts are capable of significantly reducing the direct costs of implementing a plant of this model or even in relation to the possible extension of capacity that may become necessary in existing conventional plants (CAPEX). Operation and maintenance costs (OPEX) are also much lower due to the reduction of the mechanical equipment, chemical-free operation and the relatively high energy efficiency that the process promises.

The costs of implementing the Nereda system in relation to installations of conventional systems composed of reactors followed by lagoons or activated sludge systems can lead to savings ranging from 20 to 30%.

Bearing in mind the fact that the Nereda system by the present reports demonstrates results in construction costs lower than those of conventional technology, for example in relation to the volume of the tanks being up to four times smaller and having a lesser need for equipment, its great ease of use. if converting or even joint use with conventional methods, we can infer that the use of this new method, despite the precise investment savings are obviously specific to each location and vary according to the project, the country, the climate of each location, and the characteristics of local effluents, which makes it difficult to provide a generalized response, requiring further studies to do so, however, focusing on the places where the studies prove their economy and effectiveness, this system will indeed be of great relevance.

We therefore encourage the sanitation companies to seek more information and make the necessary studies of the needs that the cities where they operate have a system that can work with a greater amount of effluent per second, the effectiveness of the treatment of the type of effluent with which handle beyond the values for implantation or hybridization of the system in order to obtain the possible advantages of this new system so that the population can benefit from a more efficient system, including, in Porto Nacional - TO the local sanitation company can obtain lower costs using in a future expansion the current technology for hybridization with the Nereda system, so that it can also serve a larger percentage of the population, being more easily able to reach 100% of the population.

Other works can also be carried out in order to better ascertain the effectiveness of Nereda technologies in conjunction with conventional Brazilian technologies.

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