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Analysis and Efficiency of an Affordable in-house Anaerobic Digester for Water Treatment

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ABSTRACT

The present research aims to analyze to evaluate the efficiency of removal of the physicochemical and microbiological parameters of an affordable in-house anaerobic digester for water treatment. The biodigester is a system whose operation is given by means of anaerobic digestions and removal of the different parameters of the residual water. The digester was implemented and installed in a 600 L capacity tank with continuous flow. The research is quantitative with a pre experimental design, pre and post-test. Technique for data collection was based on experimental observation. Data was collected and analyzed over 90 days. Python was used as a tool for data processing and analysis. The average efficiency of the digester was over 97% for the primary treatment of domestic wastewater, which presents evidence of being a viable and sustainable alternative to minimize environmental impacts (water, air and soil) and contribute to the collective health of the population.

Key words : digester, water treatment, wastewater, environment

1. INTRODUCTION

Water is a source of life for human survival, as it turns out to be a basic element for health. However, as population increases, this resource becomes increasingly scarce and difficult to access. On the other hand, water residual that were used in homes, factories, livestock activities contain oils and fats, organic matter, detergents, industrial waste, livestock, agricultural, among others. These wastewaters should be subsequently conducted to treatment plants where they undergo an adequate treatment to return the water to nature in the best possible conditions for its subsequent reuse [1].

Domestic wastewater is generated by people's daily activities, where large amounts of fecal coliforms, fats, oils, detergents, among others, are abundant, which come from toilets, dishwashers, washing machines and showers. Moscoso [2] mentions that domestic wastewater contains 70% solid matter and 30% inorganic matter.

According to the Ministry of Housing, Construction and Sanitation [3] It states that in Peru about 11 million people lack sewerage and only 62% of the sewage is captured by the Service Providers (EPS), in addition SUNASS [4] mentions that 30% of the EPS have poor maintenance and operation of its plants; It is worth mentioning that there is limited control of wastewater discharges by the competent authorities and bodies (insufficient legal standards) that entails inadequate management of these issues.

Removal of pollutants present in the water is very important not only in Peru but worldwide and with it, having a good quality, enough water to satisfy the needs of the population [5]. The alteration of the natural properties of water, air, soil and the proliferation of infectious foci are related to the lack of wastewater treatment and as a consequence we will have a poor quality of life. The consumption of water with chemical and / or biological pollutants generates various diseases that significantly affect the lives of millions of human beings and their prospects [6]. Therefore, for the treatment of sewage and its subsequent reuse, various extensive and intensive technologies are carried out [7]. Thus, highlighting treatments such as: wetlands in general, absorption systems and biodigesters.

A digester is an anaerobic wastewater processor that is located below ground level like septic tanks, the difference is that biodigesters contain organic matter inside, whether of anthropic, animal and plant origin, it is decomposed by the action of bacteria [8]. After passing this process, the final liquid is free of pathogens [9]

A digester is used in places that do not have a sewage system for wastewater treatment, the activity of this system does not require electrical energy but occurs due to the action of anaerobic bacteria [10]. The biodigester sludge serves as fertilizer for the plants, which is why the use of a biodigester is considered an environmentally friendly technology, applied to home [11]. In addition, according to Lizama [12] a digester has an efficiency of more than 50% to remove the organic matter present in the water.

The implementation of the digester as primary treatment for application on rural and/or poor areas will be an option to combat the problem of waste effluents discharged into the receiving body without treatment.

Consequently, the population will benefit both in the environmental aspect, reducing the load of both physicochemical and microbiological contamination for a second treatment and thus be able to minimize environmental impacts (water, air and soil), for the protection of flora and fauna [13]. In a social aspect, good collective health of the population will be obtained, reducing intestinal diseases, among others which are related to the alteration of the properties of water [14].

Finally, in the economic aspect, the costs of the services will be reduced, since the anaerobic treatment technology represents the most economical solutions in terms of operation and maintenance costs [15], all these aspects indicated will generate the improvement of the quality of life of rural areas where water treatment is not available.

2. METHODS

The present study follows a quantitative approach under a pre experimental design, pre and post-test study. As indicators five physicochemical and microbiological parameters were selected. Table 1 shows parameters and units that will be measured on the pre and post study.

Table 1: Physicochemical and microbiological parameters

Parameters	Units
Oils and fats	mg/l
Total coliforms	NMP/100
Thermotolerant Coliforms	NMP/100
Biochemical oxygen demand	mg/l
pH	-

Parameters were measured over 90 days to analyze significant difference and variation on the parameters.

Parameter removal efficiency was calculated through:

$$Efficiency\,\% = \frac{Afluent\ - Efluent}{Afluent} * 100$$

A normality test was performed to discriminate data distribution form. Data treatment was for a non-normal distribution. Mann-Whitney U test was applied to establish significant difference over 90 days for the physicochemical and microbiological parameters measurements.

3. RESULTS

Over 90 days, physicochemical and microbiological parameters were tested. Table 2 shows average values for all 5 parameters

Table 2: Physicochemical and microbiological parameters

Parameters	Pre test	Post test
Oils and fats	108	21
Total coliforms	9.4*10^7	1.5*10^6
Thermotoler ant Coliforms	2.6*10^7	6.9*10^5
Biochemical oxygen demand	2632	393
pH	8.6	7.4

There was a significant reduction on total coliforms as shown on Figure 1.

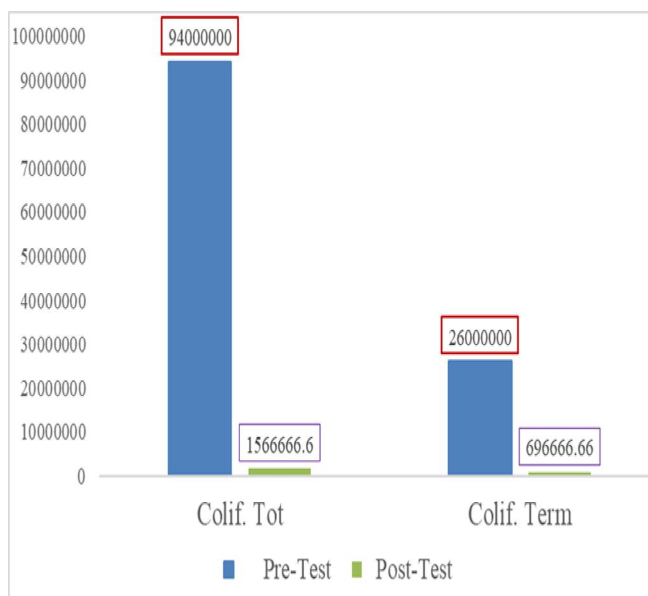

Figure 1: Total and thermotolerant coliforms present on pre and post test.

Regarding total coliforms, according to some studies, in anaerobic treatments a total coliform removal of 60% or greater is considered acceptable for digesters [16]. The reproduction of total coliforms outside the animal intestine is because it is favored by the existence of suitable conditions such as organic matter and pH and as the system had a large amount of organic matter and a neutral pH had good adaptability [17].

Similarly, coliform thermotolerant showed at the beginning a high number of microorganisms, this is due to the high concentration of organic load coming directly from domestic use because the sample was taken from a multi -family dwelling. These microorganisms are coliforms that contain a large group of bacteria that normally live in the digestive tract of humans and animals, for this reason a high amount was found in the sampled waters [18]. In both cases the digester shows a significant reduction on coliforms present on water samples.

Regarding the pH, fermentation and methanogenesis in principle have different optimal pH. The fermentation phase is faster in an acidic environment, in the methanogenic phase it works better in neutral pH [19].

The behavior of the pH in the biodigester effluent is 8.6 and 7.4, these values are in the appropriate range for the development of methanogenic activity, which is 6.5 to 8 [10]. Also according to Mendonca [20], after the anaerobic treatment system the pH values are between 6.5 to 8.

Regarding temperature, Miqueleto [21] argue that this parameter is important in bacterial operation or digestion, which is related to the speed of the reactions involved in the process. In addition, this parameter is part of the microbial characteristics such as survival, growth and species competition.

Torres, Rojas, Bautista and Iturbe [22] indicate that the factor that most influences the biodegradation of organic matter is Temperature. Increasing this can improve microbial growth and its activity therefore stimulates the rate of biodegradation, so at low temperatures the degradation would be slow [23]

To evaluate removal efficiency for total coliforms and thermotolerant coliforms, efficiency equation was applied as described on the methods section.

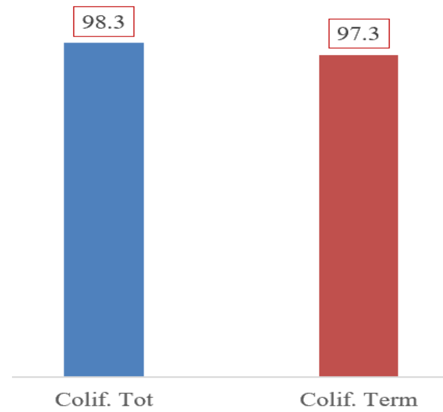

Figure 2: Removal efficiency for coliforms present on wastewater

Figure 2 shows removal efficiency for total and thermotolerant coliforms. As seen in the figure, the digester has an efficiency of over 97% in removal of parameters.

Finally, regarding the efficiencies of the physicochemical and microbiological parameters, it occurs due to the degradation of organic matter within the system, in order to obtain a good efficiency it is necessary to have a good pH, temperature and a good substrate of organic matter.

$$Eff = \frac{Efi.Coli.Tot + Efi.Coli.Term}{2}$$

$$Eff = \frac{98.3\ \% + 97.3\ \%}{2}$$

$$Eff = 97.8\ \%$$

The efficiency in the entire system was calculated as average of both removal efficiency summing up to a digester efficiency of 97.8%. This coincides with [23], an study stating that a digester in general has an efficiency of more than 50% to remove the organic matter present in the water for the primary treatment of domestic wastewater, being this effective and viable with the environment

4. CONCLUSION

An affordable in-house digester for treatment of domestic wastewater was analyzed to get removal efficiency on total coliforms and thermotolerant coliforms. The pre experimental study took 90 days to gather information of coliforms present before and after the digester.

Both total coliforms and thermotolerant coliforms measurements revealed a high number of microorganisms present on wastewater. This is due to the high concentration of organic load coming directly from domestic use because the sample was taken from a multi-family dwelling. These microorganisms are coliforms that contain a large group of bacteria that normally live in the digestive tract of humans and animals, for this reason a high amount was found in the sampled waters. In both cases the digester shows a significant reduction on coliforms present on water samples.

The characterization of the physicochemical and microbiological parameters of the domestic wastewater was carried out by means of pre and post analysis tests at a 95% confidence level. A normal distribution test was applied to data, finding a non-normal distribution for the studied dataset. Therefore, Mann-Whitney U test was applied to establish significant difference over 90 days for the physicochemical and microbiological parameters measurements.

Considering that the average levels of the three monitored sessions were of high concentration, due to the excessive amount of organic matter used in the house was obtained in the pre and post analysis, total coliforms (9.4 * 10 ^ 7 and 1.5 * 10 ^ 6 NMP / 100 ml) and thermotolerant coliforms (2.6 * 10 ^ 7). Likewise, the removal efficiency of the physicochemical and microbiological parameters was analyzed: total coliforms (98.3%) and thermotolerant (97.3%). Obtaining a total of 97.8% in the entire treatment system. The results indicate that the digester is a good alternative for the removal of the physicochemical and microbiological parameters as primary treatment.

In conclusion, an efficiency of above 90% for a digester shows initial evidence of its potential use in wastewater treatment. The results are congruent with several studies [24-27] stating that a normal functioning digester in general has an efficiency of more than 50% to remove the organic matter present in the water for treatment primary domestic wastewater, being effective and viable with the environment, reducing the load of both physicochemical and microbiological pollution for a second treatment and thus be able to minimize environmental impacts (water, air and soil), for the protection of flora and fauna and therefore the good collective health of the population will be obtained, reducing intestinal diseases, among others which are related to the alteration of the properties of the water.

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