e-ISSN:2706-6800

Evaluation of the performance of the wastewater treatment plant in a community in the province of Cotopaxi

Evaluación del desempeño de la Planta de Tratamiento de Aguas Residuales en una comunidad de la provincia de Cotopaxi

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Published
Instituto Tecnológico Superior Edwards Deming.
Quito – Ecuador

Periodicity
July - September
Vol. 1, Num. 22, 2024
pp. 92-100
http://centrosuragraria.com/index.php/revista

Dates of receipt
Received: January 09, 2024
Approved: February 18, 2024

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Abstract: The objective of this experimental study was to analyze the performance of the wastewater treatment plant located on the bank of a river in the province of Cotopaxi, Ecuador. To begin the evaluation, essential information was collected such as the socioeconomic activity of the community, the location and size of the plant, the population served, and the available treatment units, among other data. Field work was then carried out, which included measuring the treatment units and the inflow and outflow using the volumetric method to identify the time of highest demand. Samples were taken, whose laboratory analysis revealed that some physicochemical parameters did not comply with the standards established by TULSMA (Unified Text of Secondary Environmental Legislation) for discharges into freshwater bodies, especially in the levels of surfactants and actual color. With all the information gathered and the theoretical calculations for sizing the treatment units performed, it was concluded that the FAFA (Ascending Flow Anaerobic Filter) system was not working properly and that there were cracks in the septic tank.

Keywords: Physical parameters, chemical parameters, surfactants, septic tank

Resumen El objetivo de este estudio experimental fue analizar el desempeño de la planta de tratamiento de aguas residuales situada a la orilla de un río en la provincia de Cotopaxi, Ecuador. Para comenzar la evaluación, se recopiló información esencial como la actividad socioeconómica de la comunidad, la ubicación y tamaño de la planta, la población atendida, y las unidades de tratamiento disponibles, entre otros datos. Después, se llevó a cabo un trabajo de campo que incluyó la medición de las unidades de tratamiento y el caudal de entrada y salida utilizando el método volumétrico para identificar el momento de mayor demanda. Se tomaron muestras, cuyos análisis de laboratorio revelaron que algunos parámetros físico-químicos no cumplían con las normas establecidas por TULSMA (Texto Unificado de Legislación Segundaria de Medio Ambiente)

para descargas en cuerpos de agua dulce, especialmente en los niveles de tensoactivos y color real. Con toda la información recopilada y los cálculos teóricos de dimensionamiento de las unidades de tratamiento realizados, se concluyó que el sistema FAFA (Filtro Anaerobio de Flujo Ascendente) no funcionaba correctamente y que había grietas en el tanque séptico.

Palabras clave: Parámetros físicos, parámetros químicos, tensoactivos, tanque séptico

INTRODUCTION

Water, one of the essential resources for human life, has been under threat in recent years due to the various uses to which it is put, whether domestic, industrial, agricultural or livestock. After use, it often does not receive adequate treatment and, when discharged back into bodies of fresh or salt water, causes environmental pollution due to its high load of different physicochemical parameters, such as phosphorus, nitrogen and fecal coliforms, among others. This situation is aggravated because treatment plants do not receive adequate maintenance, largely due to the high cost of these operations. In rural areas, the entities often have economic limitations and sometimes do not even have treatment systems (Martínez, 1967). (Martinez, 1967)..

Inefficient management of domestic water can cause serious health problems in the population. Among the most prominent diseases are digestive disorders, cholera and parasitic infections. These problems are aggravated by other deficiencies, such as the lack of a potable water system, sewerage and inadequate waste management. Therefore, it is essential to conduct talks and training on health and environmental conservation, especially in the communities where these diseases are most common. (Pallares & Guaicha, 2014)..

In Latin America and the Caribbean, access to safe drinking water and basic sanitation is a clear problem. According to a publication by the Pan American Health Organization (PAHO, 2011), access to safe drinking water and basic sanitation is a clear problem in Latin America and the Caribbean. (PAHO, 2011)for 109 years, PAHO has collaborated with the countries of the Americas in promoting the prevention and control of waterborne diseases. The organization has highlighted the precarious conditions of access to water and basic sanitation, underscoring the need for a serious commitment on the part of governments and communities. This is because no public health intervention has a greater impact on the development of a nation and on individual and collective health than the provision of safe drinking water and adequate excreta disposal.

The lack of safe drinking water and basic sanitation has serious consequences for development. These factors are the second leading cause of morbidity and mortality in children under five years of age in the region and constitute the main component of the burden of environment-related diseases. However, combined water, sanitation and hygiene interventions can reduce the prevalence of waterborne diseases and associated deaths by up to 80% and diarrhea by 50%.

In Ecuador, access to potable water and sanitation has improved considerably in recent years due to population growth. According to INEC data (INEC, 2010)in 2006, 82.6% of households nationwide had an adequate excreta disposal system. By 2014, coverage increased to 91.4%, representing an increase of 8.8 percentage points. The largest increase was observed in rural areas, where sanitation service coverage improved by 18.3 percentage points between 2006 and 2014.

According to INEC, in the province of Cotopaxi, the public sewerage network increased from 24.38% in 2001 to 36.52% in 2010. (INEC, 2010)..

In the Moraspungo parish, wastewater management has been deficient due to lack of attention from previous administrations. This has caused a significant environmental impact on the two bodies of freshwater that flow through the parish: the Piñanato River and the Angamarca River. Currently, the Moraspungo parish has three wastewater treatment plants in the urban area and an additional one in the Las Juntas precinct, which covers 98% of the population in these areas. However, in the rural area, there is no wastewater treatment system, which means that only approximately 10% of the parish's population is served.

MATERIALS AND METHODS

To carry out this experimental work, it was divided into four phases to evaluate the performance of the wastewater treatment plant in the Moraspungo parish, Pangua canton, Cotopaxi province.

Phase 1: Information gathering

This initial stage is crucial and focuses on collecting detailed information about the wastewater treatment plant (WWTP) under study. This includes data such as year of construction, dimensions, and available treatment units. In addition, a topographical survey of the

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WWTP is carried out and socioeconomic information is collected from the population.

Phase 2: Analysis of flow behavior in situ

In this phase, the inlet and outlet flow rates of the WWTP are measured using the volumetric method. It is carried out during six consecutive days, measuring every hour from 7:00 am to 7:00 pm. The day and hour with the highest and lowest amount of wastewater is identified, and samples are taken for physical-chemical analysis in the laboratory.

Phase 3: Laboratory analysis of samples

Wastewater samples taken at peak load times are analyzed in a certified laboratory. Physicochemical analyses are performed, including parameters such as oils and grease, BOD5 and COD, phosphorus, ammonia nitrogen, total nitrogen, pH, suspended solids, among others.

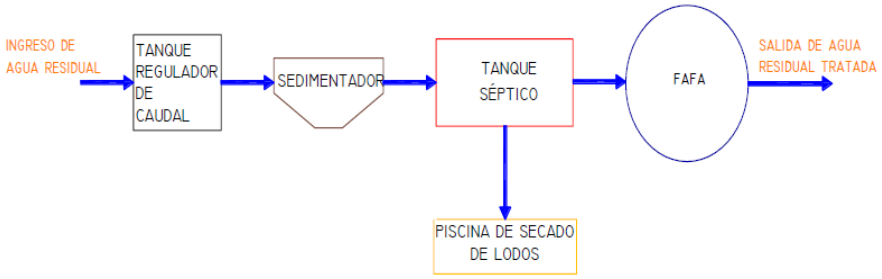
Phase 4: Analysis and verification of the operation of the WWTP

Based on the results of the laboratory analyses, they are compared with the standards established by Ecuador's TULSMA regulations for discharges into freshwater bodies. The condition and operation of the existing structures at the wastewater treatment plant are also evaluated. This phase concludes with recommendations to improve the operation of the WWTP.

RESULTS

The wastewater treatment plant is composed of several treatment units, including a flow regulating tank, a settling tank, a septic tank, a sludge drying bed and an upflow anaerobic filter. These structures are detailed in the corresponding diagram (Figure 1).

Figure 1. Treatment train units



The most relevant characteristics observed in each of the aforementioned structures are detailed below:

Sedimenter:

Defects have been observed in the maintenance of this unit, as can be seen in Figure 2. The accumulation of debris due to these defects is affecting the functional efficiency of the structure.

Figure 2. Visual diagnosis of the settler

Septic Tank:

Figure 3 shows leaks in the wall adjacent to the sludge drying bed, caused by the water pressure accumulated in this unit. In addition, Figure 4 shows suspended solids that have passed through the settler,

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as well as the water level that is about to reach the edge of the slab of this structure, which, according to plant operators, often causes the water to overflow.

Figure 3. Seepage in the septic tank

Figure 4. Diagnosis of the septic tank

Anaerobic Upflow Filter:

This structure is the cause of the failures in the previous units, since it is located at a higher level than the septic tank, as shown in Figure 5. This arrangement prevents the water from rising and completing its process before being discharged into the nearby freshwater body, the Piñanato River.

Figure 5. FAFA diagnosis

Sludge drying bed:

This structure is as deteriorated as the others in the WWTP, as shown in Figure 6, which prevents it from performing its function effectively. The water coming from the septic tank causes the sludge to stagnate, keeping it always saturated and preventing this infrastructure from adequately performing the task for which it was designed.

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Figure 6. Diagnosis of the sludge drying bed

CONCLUSIONS

The Moraspungo parish wastewater treatment plant is located at UTM coordinates 697857 East and 9870036 North, near the Piñanato River, where treated water is discharged. There is no exact information on the year operations began due to the lack of documentation provided by the GAD Provincial de Cotopaxi, which was responsible for its construction and has not provided it to the GAD Municipal de Pangua.

Due to its remote location, maintenance of the treatment plant has been irregular, especially the septic tank structure, which is in poor condition.

After determining the critical time as Saturday from 11:00 am to 12:00 pm, samples were taken for laboratory analysis. The results revealed that certain physicochemical parameters, such as surfactants (4.59 mg/l) and actual color (10.78 color units), exceed the maximum limits allowed by TULSMA regulations for discharge into freshwater bodies (0.5 mg/l and 1/20 color units, respectively).

A complete structural repair of the WWTP is recommended, focusing especially on the waterproofing of the septic tank and the removal of the FAFA stone bed to avoid blockages in the pipes. In addition, it is proposed to implement a periodic maintenance plan to ensure the proper functioning of all plant units.

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