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# Study for the treatment of industrial effluent from organic agrochemical insecticides

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**ABSTRACT:** The present study focuses on the treatment of industrial effluent from the manufacturing of organic insecticides based on vegetable oil in the Guayas province, Yaguachi canton. Flow rates and composite samples were collected to determine the physicochemical characteristics and contaminant load based on the chemical oxygen demand (COD) and biochemical oxygen demand (BOD). A pilot treatment was developed using an investigative method, and based on the data obtained from the analyses, the treatment processes were determined, including a grease trap, an activated sludge biological reactor, tertiary treatment through filtration, and a sludge drying bed.
The study demonstrated that applying these treatability processes ensures that the effluent complies with the discharge limits for marine water bodies as per the Unified Text of Secondary Legislation on the Environment (TULSMA).

**KEYWORDS:** treatment plant, wastewater, organic insecticides, permissible limits, laboratory.

## 1 INTRODUCTION

Environmental contamination, particularly in the area of agrochemicals, refers to the biotic and abiotic by-products generated by industrial activities, which lead to the degradation of the environment and ecosystems. Under this concept, agrochemical industries began producing organic insecticides and pesticides. However, the waste from this activity contains organic matter that is easily decomposed, promoting the growth of aerobic bacteria that consume oxygen and favor the growth of anaerobic bacteria, which release toxic substances into the environment.

The treatment of industrial effluents containing organic insecticides can be challenging, as it is crucial to manage chemical waste effectively to avoid and prevent negative impacts on the environment and human health. In the Yaguachi canton, specifically at Km 7, there is no sewage system, so it is necessary for the effluent generated by the factory to be treated appropriately to mitigate the pollutant load before it is discharged into a branch of a creek. Based on the analyses conducted on the sampling discharge, we will propose processes for treatment that comply with the reduction of the pollutant load while meeting the permissible discharge limits indicated by the regulations

### LOCATION OF THE STUDY AREA

The study was conducted in Yaguachi Km 7 road, in the city of Guayaquil, Ecuador.

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*Ilustración 1: Ubicación del terreno- Yaguachi KM 7 vía el pan*

*Fuente: Google earth*

***Fig. 1. Location of Chanchan River***

*Organic matter + Microorganisms + nutrients + O2 → Final products + new microorganisms + energy.*

*Fuente: (Ronzano, Eduardo Dapena, Jose luis, 1995)*

## 2 METHODOLOGY

### METHODS

The present study was carried out considering the following:

#### CHARACTERIZATION OF THE EFFLUENT

Before implementing a treatment system, it is crucial to conduct a thorough characterization of the wastewater to determine its composition and concentration of organic insecticides and other pollutants present. This allows us to determine the most effective treatment.

#### PRE-TREATMENT – GREASE TRAP

In wastewater treatment plants, especially those handling industrial effluents containing fats and oils, grease traps are implemented as part of the pre-treatment process. Their use helps prevent problems in the system, such as the formation of foam in biological reactors, and improves overall efficiency.

**Homogenization Tank:** This tank is used in wastewater treatment to mix and homogenize the components present in the effluent before additional treatments. This process is carried out in the absence of oxygen, decomposing part of the organic matter into simpler compounds, with a working capacity of 1 day, as indicated by the applicable standards.

**Biological Reactor:** A biological activated sludge reactor is used for the treatment of organic pollutants. This type of reactor utilizes microorganisms, such as bacteria, to decompose the organic matter present in the wastewater.

**Inoculation of the system:** This involves introducing an initial population of microorganisms into the biological reactor to begin the treatment process. These microorganisms are responsible for breaking down the organic matter.

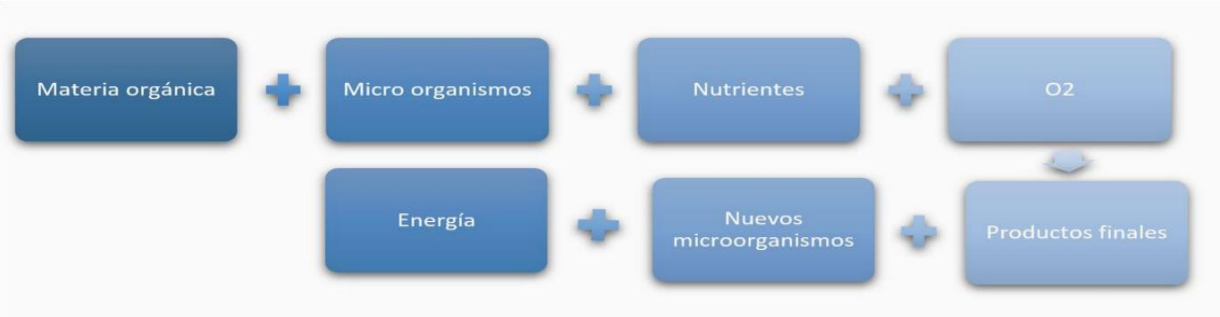
**Microorganism growth:** The microorganisms develop and multiply within the reactor, forming a mass of activated sludge.

**Aeration:** Oxygen is introduced into the system through aeration. The presence of oxygen promotes the growth of aerobic microorganisms.

**Biological digestion**: This process involves converting the decomposed organic matter into carbon dioxide, water, and biomass.

**Secondary Decantation:** After biological digestion, the water is separated from the sludge through the secondary decantation process. These sludges formed during the process are recirculated to the reactor to maintain an active population of microorganisms.

Organic matter + Microorganisms + nutrients + O2 → Final products + new microorganisms + energy.




*Fuente: (Ronzano, Eduardo Dapena, Jose luis, 1995)*

**Sedimentation:** The sedimentation process uses the force of gravity to separate solid particles from water. The water is introduced into a tank or clarifier and allowed to rest. During this time, the heavier particles settle at the bottom.

#### TERTIARY TREATMENT

Coagulation involves destabilizing colloidal particles, meaning that the coagulant neutralizes the negative electric charges present in suspended and colloidal particles in the water, allowing them to group together and form larger clumps. The water from the biological reactor will be mixed with the coagulant (polyaluminum chloride) through rapid agitation to ensure uniform dispersion in the water.

**Flocculation** – Flocculation is the process that follows coagulation, involving the mixing of a chemical substance called a flocculant with the water. The clumps formed group together into larger particles called flocs, which settle more easily and quickly. This step is carried out at slower speeds to prevent the breaking of the flocs, as once they break apart, it is difficult for them to reaggregate (AGUILAR, 2002).

#### FILTRATION

Filtration is commonly used in the treatment of industrial effluents. It involves removing solid particles and suspended matter present in the water. The process consists of a closed tank that contains a filter medium, such as sand, activated charcoal, gravel, or other materials, depending on the contaminants to be removed. The water enters through a pipe and is evenly distributed over the filter medium. As the water passes through the filter, the solid particles are trapped, resulting in cleaner, clearer water.

#### METHODOLOGICAL DEVELOPMENT

The methodology used is both qualitative and quantitative, employing a trial-and-error approach. Pilot tests of primary, secondary, and tertiary treatments were conducted, characterizing each to determine contaminant removal and the appropriate treatment.

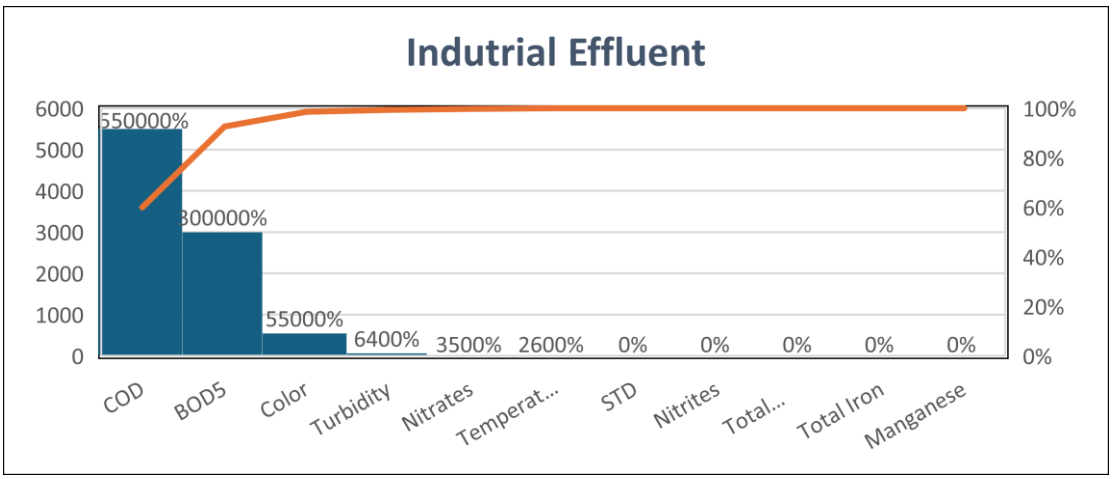
## CHARACTERIZATION OF THE TREATMENT

*Table 1. Description of the characterization of the Industrial Effluent*

| Parameters | Expressed as | Industrial Effluent | Limits Permissible |
|---|---|---|---|
| pH | pH | 7,94 | 5 a 9 |
| Temperature | ° C | 26 | Condición natural ± 3 |
| STD | mg/l | 1921,5 | - |
| Color | Pt - Co | 550 | Inapreciable en dislucion 1/20 |
| Turbidity | NTU | 64 | 0 |
| COD | mg/l | 5500 | 250 |
| BOD5 | mg/l | 3000 | 100 |
| Nitrites | mg/l | 0,658 | 10 |
| Nitrates | mg/l | 35 | 10 |
| Total Phosphorus | mg/l | 2,06 | 10 |
| Total Iron | mg/l | 1,09 | 10 |
| Manganese | mg/l | 0,123 | 2 |

Raw Wastewater

*Fuente: Sanitary chemistry laboratory*




## BIOLOGICAL TREATMENT

By applying enzymes in the biological reactor and extended aeration 24/7, we remove the organic load (COD, BOD5), increase color, turbidity, nitrites, and nitrates [1].

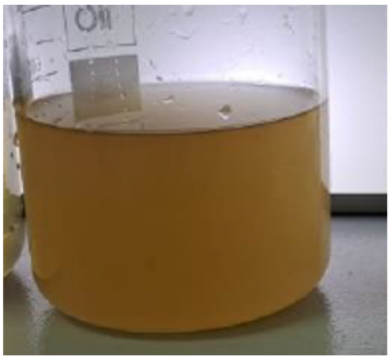
## REACTION OF THE TREATMENT

$$CH_2O\ (ac) + O_2\ (ac) \longrightarrow CO_2(g) + H_2O\ (ac)$$

Hidrato de carbono

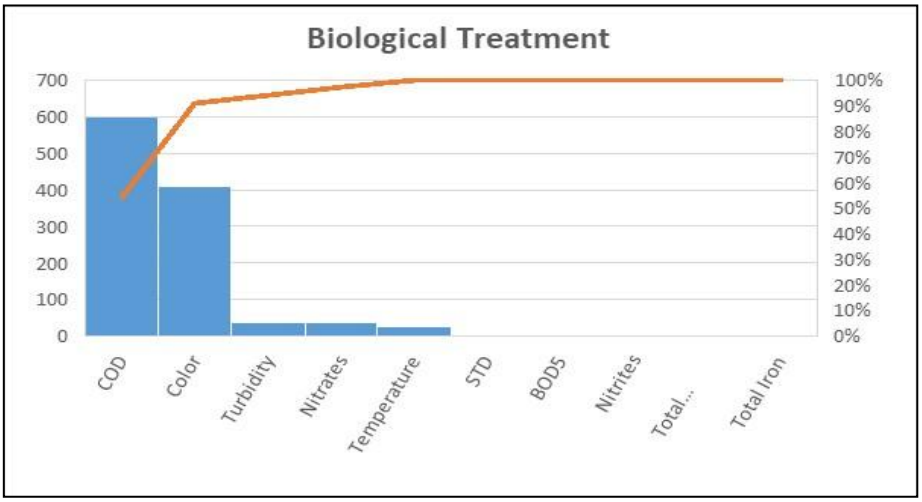
*Table 2. Characterization of the Biological Treatment*

| Paraneters | Indutrial Effluent | Biological Treatment | Tertiary Treatment | Limits Permissible |
|---|---|---|---|---|
| pH | 7,94 | 8,14 | 6,69 | 6 a 9 |
| Temperature | 26 | 26 | 26 | Condición natural ± 3 |
| STD | 1921,5 | 1.505 | 636,3 | - |
| Color | 550 | 410 | inapreaciable | Inapreciable en dislucion 1/20 |
| Turbidity | 64 | 35 | 11 | 0 |
| COD | 5500 | 598 | 50 | 250 |
| BOD5 | 3000 | 358 | 22 | 100 |
| Nitrites | 0,658 | 1,2 | 1,1 | 10 |
| Nitrates | 35 | 35 | 35 | 10 |
| Total Phosphorus | 2,06 | 2,06 | 1,3 | 10 |
| Total Iron | 1,09 | 0,7 | 0,16 | 10 |
| Manganese | 0,123 | 0,08 | 0,003 | 2 |



Sample of Biological Treatment

*Fuente: Sanitary chemistry laboratory [1]*

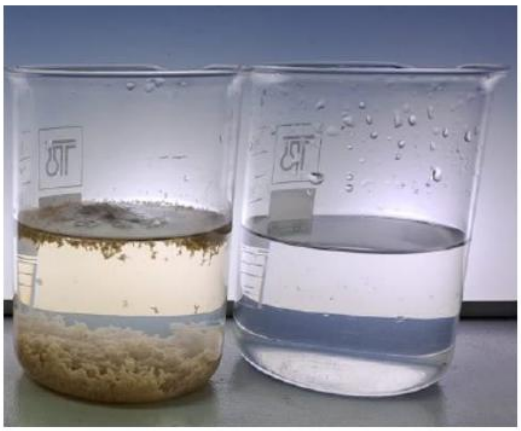



**TERTIARY TREATMENT**

Once the organic matter is degraded, the process of coagulation, flocculation, sedimentation, and filtration is carried out.

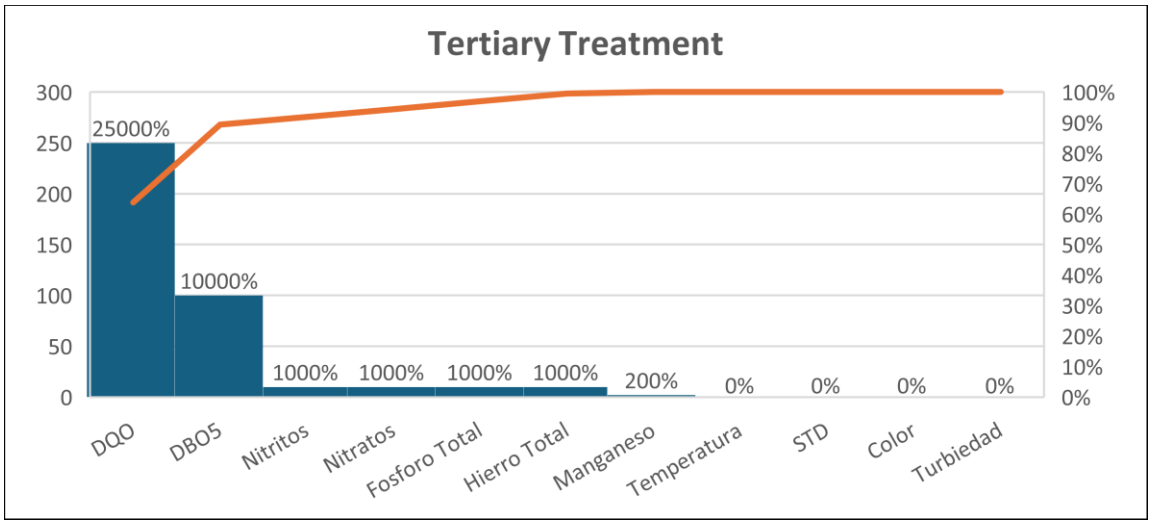
*Table 3. Chemical Precipitation*

| Paraneters | Expressed as | Tertiary Treatment | Limite Permisible |
|---|---|---|---|
| pH | pH | 6,69 | 6 a 9 |
| Temperature | ° C | 26 | Condición natural ± 3 |
| STD | mg/l | 636,3 | - |
| Color | Pt - Co | inapreaciable | Inapreciable en dislucion 1/20 |
| Turbidity | NTU | 11 | 0 |
| COD | mg/l | 50 | 250 |
| BOD5 | mg/l | 22 | 100 |
| Nitrites | mg/l | 1,1 | 10 |
| Nitrates | mg/l | 35 | 10 |
| Total Phosphorus | mg/l | 1,3 | 10 |
| Total Iron | mg/l | 0,16 | 10 |
| Manganese | mg/l | 0,003 | 2 |



Precipitated and filtered sample

*Fuente: Sanitary chemistry laboratory [1]*

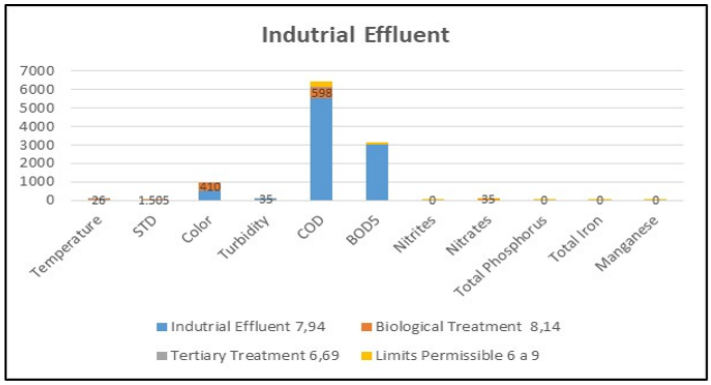



## 3 DISCUSION DE RESULTADOS

Los resultados obtenidos del efluente de insecticida orgánico, nos indica que este tipo de efluente presenta un pH alcalino, no hay presencia de solidos suspendidos en la muestra, que el agua residual requiere un tratamiento biológico con un tiempo de residencia de 3 días, la precipitación química ayuda con la eliminación de la carga orgánica, la filtración y cloración finalmente el efluente disminuye la carga orgánica llegando a los limites permisibles para descarga al cuerpo de agua del sector.

*Table 4. Caracterización del tratamiento del agua residual*

| Parámetros | AGUA CRUDA | Tratamiento Biologico | Tratamiento Terciario | Limite Permisible |
|---|---|---|---|---|
| pH | 7,94 | 8,14 | 6,69 | 6 a 9 |
| Temperatura | 26 | 26 | 26 | Condición natural ± 3 |
| STD | 1921,5 | 1.505 | 636,3 | - |
| Color | 550 | 410 | inapreaciable | Inapreciable en dislucion 1/20 |
| Turbiedad | 64 | 35 | 11 | 0 |
| DQO | 5500 | 598 | 50 | 250 |
| $DBO_5$ | 3000 | | 22 | 100 |
| Nitritos | 0,658 | 1,2 | 1,1 | 10 |
| Nitratos | 35 | 35 | 35 | 10 |
| Fosforo Total | 2,06 | 2,06 | 1,3 | 10 |
| Hierro Total | 1,09 | 0,7 | 0,16 | 10 |
| Manganeso | 0,123 | 0,08 | 0,003 | 2 |



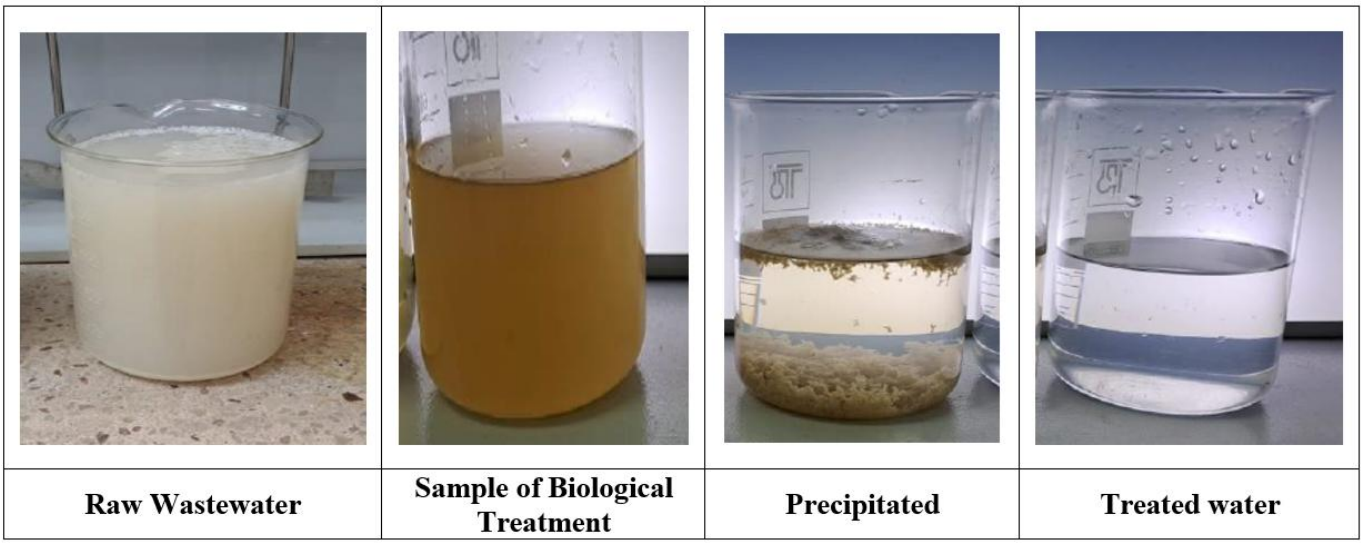




*Fig. 2. Reduction of pollutant load*

## 4 CONCLUSIONS

The company generates a daily flow of Q = 3.4 $m^3$/d. Through sampling tests and analysis of the raw water provided, we found that the organic load is high based on BOD5 (biochemical oxygen demand) and COD (chemical oxygen demand). The concentration of total dissolved solids fluctuates at 1921.5 mg/l, indicating it is above the permissible limits for discharge into a water body.

A pilot test of 10 liters was conducted, to which air was added using a blower, along with enzymes and nutrients. Daily characterizations were carried out, resulting in the formation of biomass and the degradation of organic matter within 2 weeks. The chemical oxygen demand had a removal percentage of 90% compared to the initial value. We also concluded that the retention time is 3 days, followed by tertiary treatment (clarifier). Afterward, the process moves on to coagulation-flocculation, filtration, and then storage for disposal or reuse. Daily treatment will handle 5$m^3$.

The treated water meets the maximum permissible limits for discharge into the water body in the sector, according to the Unified Text of Secondary Legislation (TULMA).

### RECOMMENDATIONS

Man Maintain the design flow rate of the treatment plant and the retention times in the biological reactor for the degradation of organic matter.

The tertiary treatment is very important, as it removes the degraded organic matter and ensures filtration to retain solids that were not filtered.

The residual sludge, where the concentration of organic load eliminated from the water is found, must undergo drying bed treatment and final disposal.

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