

# A New Alternative for Flocculation with *Moringa Oleifera* in Ecuador

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**Abstract:** Even if Ecuador is a country with one of the highest concentration of rivers per square kilometer, there is a poor quality of its water resources as well as a lack of drinking water and sewage systems for its population. In 2013, only 34% of the rural population had access to drinking water and 25% to sewerage services. This is because of a lack of infrastructure and the necessary budgets allocated to them. This paper deals with a proposal for water purification that consists of the use of the *Moringa oleifera* plant to facilitate the flocculation process, considering that its use reduces the costs associated to the water treatment and minimizes the concentration of metals in the residual sludge. The dosage effects of the plant seeds during the flocculation processes were explored with Jar tests using a solution of it in doses from 250 to 350 mg per liter of water and then evaluating COD and turbidity as selected response variables. The COD reduction goes from the 45 to the 55% while the turbidity reduction goes from the 77% to the 81% making the use of the plant possible and feasible.

**Keywords:** Drinking water; Flocculation; *Moringa oleifera*; alternative treatment

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## 1. Introduction

Ecuador is a country where there are problems of access to drinking water and sewage systems for its population because of the lack of infrastructures and the necessary budgets allocated to them.

In this country, the most adopted treatment in drinking water works consists in the flocculation-coagulation steps by means of ferric and aluminum salts. This treatments leads to the production of potable sludge containing these metals and thus it is necessary to treat it, before its disposal.

*Moringa oleifera* Lam. is a native plant of South Asia which is well spread throughout the Tropics for its uses especially in the medical and cosmetical fields [1,2]. Recently its use in the environmental sector, due to its promising adsorption properties, is increasing and is becoming common in drinking water treatments in coagulation and flocculation steps [3,4].

In this work, the influence of the dosage of *Moringa oleifera* Lam. seeds during coagulation-flocculation processes is explored using Jar tests with the goal to find if this plant seeds are efficient in the water treatment making it an economical and a sustainable solution to suggest in developing countries, including Ecuador [5].

This evaluation takes into consideration one of the four rivers of Cuenca city in Ecuador: Machangara river which is characterized by a high pollution levels due to the near industrial area of the city.

Collected results show a high efficiency of the *Moringa oleifera* Lam. seeds in the flocculation-coagulation processes, making possible a partial or complete substitution of traditional chemicals (ferric and aluminum salts) used during clarification treatments for drinking water in Ecuador.

## 2. Results

The evaluated parameters after the Jar tests to prove the efficiency of *Moringa oleifera* seeds were Chemical Oxygen Demand (COD) and Turbidity.

### 2.1. COD Removal

The initial concentration of COD was around 500 mg/l. It was found that the COD reduction varies from 45% and 55% (Figure 1). It can be concluded that the optimum dose of Moringa is 250 mg/l leading to 55% of COD reduction. Doses higher than 300mg/l of Moringa seeds have the same removal efficiency of the organic substance.

Even if there is a good efficiency in the reduction of COD, the collected results do not respect the Ecuadorian regulations (TULSMA).

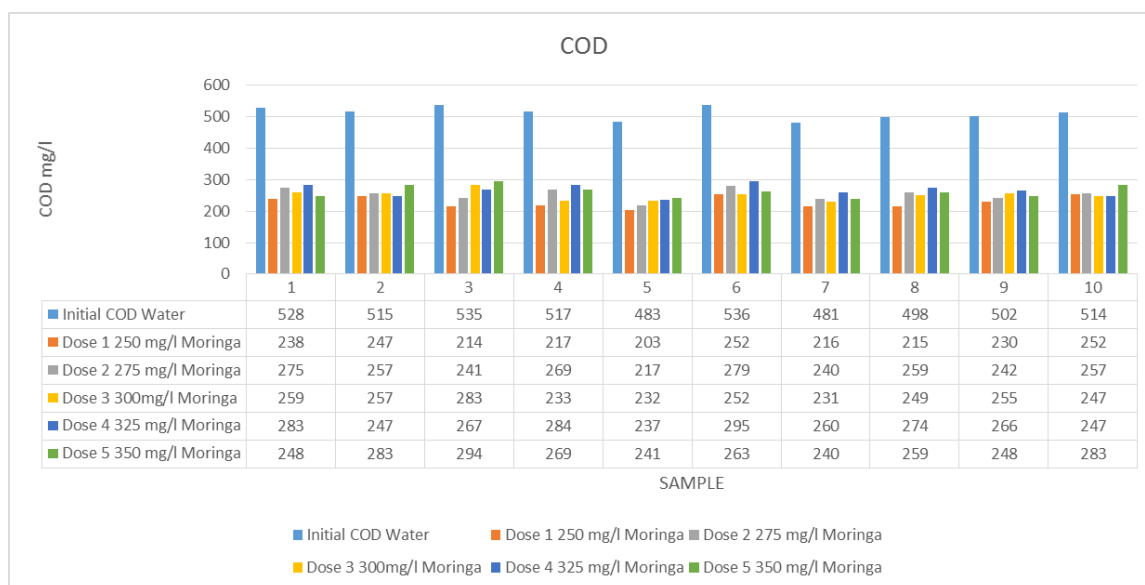


Figure 1. Removal of COD by adding different dosages of *Moringa Oleifera*.

### 2.2. Turbidity

The initial concentration of the turbidity was 9-11 NTU (Figure 2). The removal achieved by the different dosages of seeds varied from 77% to 81%. It can be concluded that the optimum dose of Moringa is of 250 mg/l leading to, 81 % of turbidity reduction.

According to the Ecuadorian regulations (TULSMA), a maximum value of turbidity of 10 NTU is requested for human consumption and domestic uses and values in the range 0-10 NTU for flora and fauna preservation. All the applied doses reached this requirement.

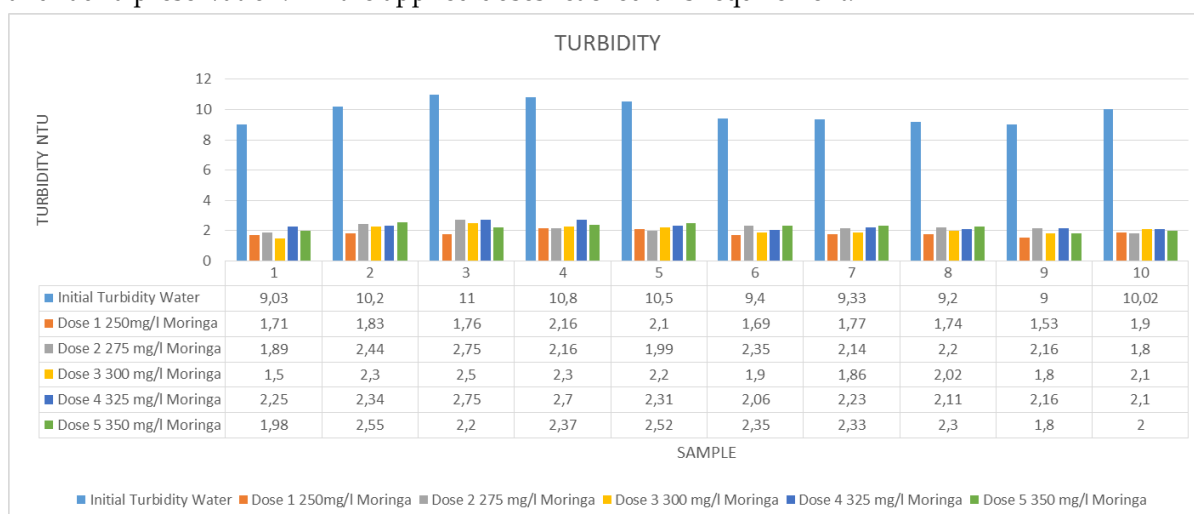


Figure 2. Removal of turbidity by adding different dosages of *Moringa Oleifera*.

## 3. Materials and Methods

### 3.1. Water Source

The Machangara River is one of the four rivers that crosses Cuenca city and supplies 60% of the city's rural population with drinking water.

It is a water source characterized by a high level of contamination with an average value of COD on an annual basis of 540 mg/l. The main causes of the bad water quality of the river is placed near an industrialized area which interact with the river, by water withdrawals and above all release of industrial effluents.

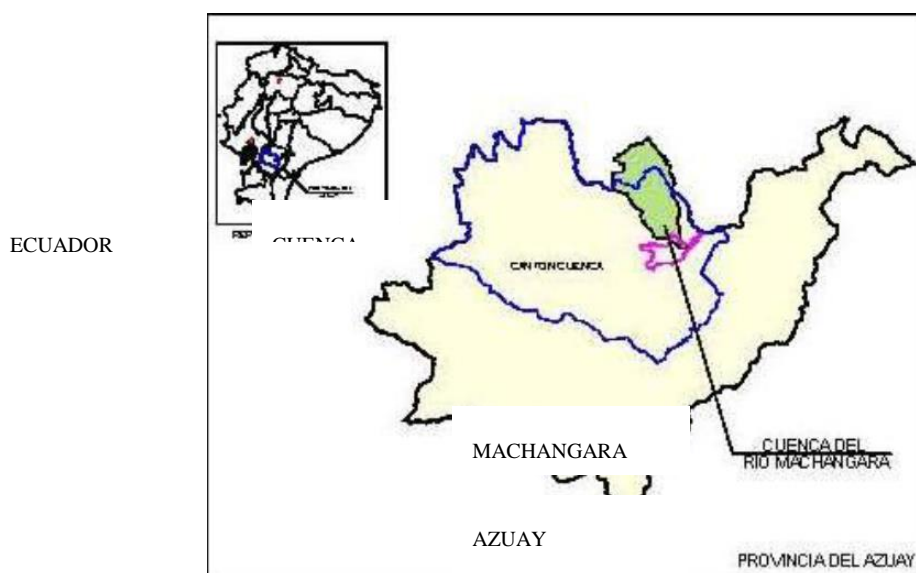


Figure 3. Water source localization.

### 3.2. Sampling Campaign

Water samples used for the evaluation of the *Moringa oleifera* seeds efficiency in the flocculation process were divided into 10 sample sets. Each set corresponds to a sampling month and the presented values as "initial" for the response variables are the average monthly values.

The sampling campaign took place from September 2018 to July 2019.

### 3.3. Dosage Variations

Previous studies involving the effect of *Moringa oleifera* Lam. seeds have shown that a dosage of 250 mg/l was sufficient to obtain good removal of COD and turbidity.

In this study, the dosages were increased: doses from 250 mg/l to 350 mg/l of *Moringa oleifera* Lam. seeds were tested with variations of 25 mg/l, having in this way 5 different doses.

### 3.4. Jar Tests

Jar tests were performed to evaluate the coagulation- flocculation processes using a solution of *Moringa oleifera* Lam. seeds in doses from 250 mg to 350 mg per liter of water.

Real surface water was used: 900 ml of (polluted) water withdrawn from the river were mixed with 100 ml of a solution containing *Moringa oleifera* Lam. Seeds. In each test these conditions were applied: 1 minute of agitation at 100 rpm, and then 25 minutes agitation at 20 rpm.

After this time, all jars rested for 2 hours and then COD and turbidity were evaluated as selected response variables.

## 4. Conclusions

The use of *Moringa oleifera* Lam seeds in the process of coagulation-flocculation in the evaluated parameters (COD and turbidity) shows good results with a reduction of 50 and 80% respectively, so it could be an environmentally viable alternative in the treatment of drinking water.

As to the analyzed parameters in this study (COD and turbidity), the dose of *Moringa oleifera* Lam seeds that presents the highest efficiency is the one of 250 mg/l.

With regard to COD, the investigations show that the removal achieved does not produce an effluent fulfilling the limits set by the Ecuadorian regulation. This means that pre- or post-treatments the tested coagulation-flocculation process should be added in order to respect the limit.

It is important to investigate the behavior of other parameters such as *E. coli*, TSS, total nitrogen among others and analyze the efficiency of *Moringa* for their removal. These parameters were not evaluated in this study due to the lack of availability of financial resources in this investigation.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Abbreviations

COD: Chemical Oxygen Demand

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