# Evaluation of Yausa as a Natural Coagulant in the treatment of waters for human consumption

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## Abstract

Water in its natural state has characteristics that can be harmful to humans; one of the most relevant are turbidity and color, which are mainly caused by very small particles. These micro particles remain suspended in the water for a long time; for their elimination the coagulation process is used. Currently, to carry out the coagulation process, chemical coagulants such as aluminum sulfate, ferric chloride and aluminum polychloride are commonly used; its use can present disadvantages in the short and long term; for this reason is intended to determine by means of laboratory tests, the properties of the Yausa (Abutilon Insigne Planch) as coagulant, because it is a mucilaginous plant that has clarifying properties; this, in order to evaluate the substitution of chemicals in the water treatment process for human consumption, complying with Colombian regulations. For this research, factors such as pH, color, turbidity, alkalinity, the necessary coagulant dose and the optimal velocity gradient should be taken into account; the initial characteristics of the water to be treated and the final characteristics after the application of the coagulant.

**Key words:** water, Yausa, microbiological characteristics, turbidity, color, treatment.

## Introduction

Currently there is a very big problem that directly affects the developing countries such as Colombia: the contamination of water which is causing diseases and deaths in humans; therefore, a set of processes called potabilization of water for human consumption should be made, which must be conditioned to meet the needs of coverage and water quality, taking into account that the purification of water comprises the coagulation process where the particles that are in the water are grouped forming flocs and thus sediments, obtaining the removal of suspended materials and having water with optimal physical, chemical and microbiological characteristics for human consumption.

There are different chemical coagulants such as aluminum sulfate, aluminum polychloride and iron sulphate which are the most used in the coagulation process, because of their efficiency in the removal of suspended matter, but considering the environmental problems that these chemical coagulants do not have in respect of a facility at the time of degrading, thus having a difficult handling of sludge; for this reason the natural coagulants or also called organic polymers or polyelectrolytes that are usually used, are the derivatives of starch and cellulose.

Given the need for caring the environment and optimization of all treatment processes, we have the option of using natural plant extracts for the coagulation process; in this case, the idea is to assess the efficiency of the mucilaginous plant called Yausa (Abutilon insigne Planch).

With the evaluation to be carried out to the plant, it is expected to have results both in the economy and in having great benefits for the environment, since the waste generated by this type of plant would be biodegradable and thus have a more convenient and easier handling of muds than the one that should be foreseen for the chemical coagulants. On the other hand, it would have the advantage of being a plant that is native in Colombia. Besides, its collection and attainment is not expensive, thus being able to fulfill the purification needs of water in a conventional system for rural or urban sectors.

**Objectives**

**General objective**

To evaluate the efficiency and feasibility of the use and harnessing of the Yausa (Abutilon Insigne Planch) as a natural coagulant in the treatment of drinking water.

**Specific objectives**

- To determine the physicochemical properties of Yausa as a coagulant.
- To characterize physically and chemically the water taken at the Mijitayo plant, chosen for a more realistic study.
- To analyze through laboratory tests the possibility of replacing chemical coagulants with an extract of mucilaginous plant that acts as a natural coagulant to destabilize the particles in suspension and facilitate their agglomeration.
- To implement the corresponding procedure and the optimal dose for the application of the Yausa in the water purification treatment plant.

**Description of the Problem**

Is the implementation of natural coagulants such as Yausa for the purification of water for human consumption in Colombia feasible and efficient?

The metallic and inorganic coagulants can generate environmental and health problems for the consumer, due to the contamination and coagulant residues present in the water consumed and because they are more difficult to treat. For this reason, there is a necessity to implement and evaluate the removal efficiency that can be obtained using natural polymers which reduce the possible problems generated with commonly used coagulants that are more offensive and need a specific treatment with specialized operators being much more expensive.

The Yausa (Abutilon insigne Planch) has presented excellent results of turbidity removal in the clarification of sugarcane juice. Being it is a mucilaginous plant native to Colombia, this makes it easier and more economical to obtain; for this reason, it has been decided to evaluate the viability of its use as a natural coagulant and to be able to use this organic compound because, being natural, it will be more easily biodegradable and with a more environmentally friendly handling of sludge.

## Methodology

The evaluation of the efficiency of the Yausa (Abutilon Insigne Planch) in the coagulation process for the treatment of water for human consumption was developed by means of a research project which was carried out through the execution of four stages in order to reach the objectives set, taking into account Figure 1:

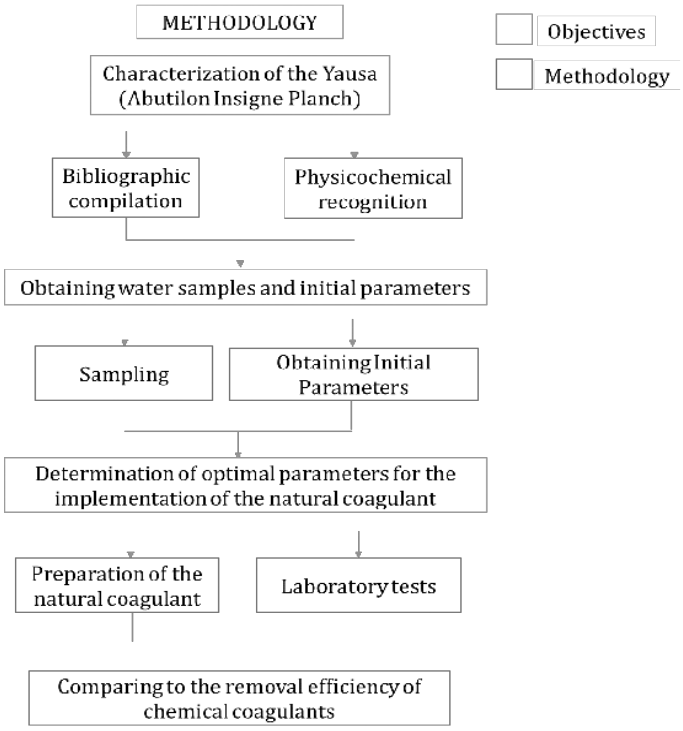


*Figure* 1. Methodology.

**Characterization of the plant (Abutilon Insigne Planch)**

For this stage of the methodology, different methods were used, which made possible to arrive at the characterization of said plant. These methods and the property found of the plant for its respective characterization are presented in Table 1.

Table 1. *Characterization of the plant*

| Property | Method |
|---|---|
| Physical state | Appreciated by observation |
| Organoleptic | Appreciated by observation |
| pH | pH digital meter |
| Type of plant | Bibliographic compilation |
| Toxicity | Bibliographic compilation |

**Obtaining the water sample and taking initial parameters**

For the development of this investigation, samples of raw water were taken from the drinking water treatment plant of Mijitayo, located in the city of San Juan de Pasto. Sampling was done in the stilling chamber, which was selected as a fixed point since it is located before beginning the coagulation process in the Parshall channel, in order to obtain the water in real conditions and therefore more realistic results.

*Figure* 2. Obtaining raw water simple

The implements used for sampling were:

- 20 liter plastic drums
- A sampling bucket with a grip
- Latex gloves

Sampling was done manually by introducing the sampling bucket to a specific depth, avoiding the alteration or collection

of suspended solids. Once it was completely filled, the water was deposited in the drum until it was completely filled, without leaving any air inside. It should be noted that before purging the sample, three purges were made to both the bucket and the drum. Once the necessary amount was collected, it was transported immediately to the laboratory for its respective tests.

*Figure* 3. Manual Sampling

The initial water parameters were obtained by Empopasto Company and confirmed in the chemistry laboratory in the Alvernia campus of Mariana University.

**Preparation of the natural coagulant**

For the preparation of the natural coagulant it was necessary to make a technical visit to the municipality of Consacá, Nariño department, where the plant is in a wild way. The viticulture was carried out in one of the panela industries since they use this plant for the clarification of the juice of cane and panela, and it was possible to observe how it is used, in addition to the bibliographic collection with which the following procedure could be reached, in order to prepare the natural coagulant.

- **Crushing of the plant**

This is the first step where a crushing machine is used, placing the Yausa (Abutilon Insigne Planch) and proceeding to obtain the crushed plant.

*Figure* 4. Crushing the plant.

- **Dilution of the plant in distilled water**

Continuing in the preparation of the coagulant, the already crushed plant is diluted in distilled water, as observed in the technical visit and in the bibliographic compilation.

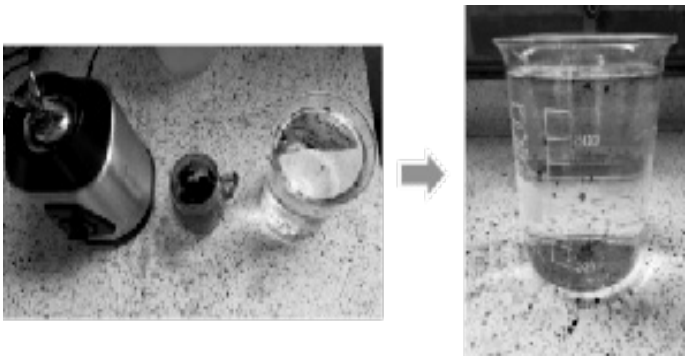

*Figure* 5. Dilution of the plant in distilled water.

- **Filtration of the solution and obtaining the natural coagulant**

Finally, after diluting the plant in distilled water, filtration of the solution is carried out by means of a filter with a 2 mm opening to retain larger particles and the use of filter paper for the retention of the smallest particles, thus obtaining the natural coagulant.

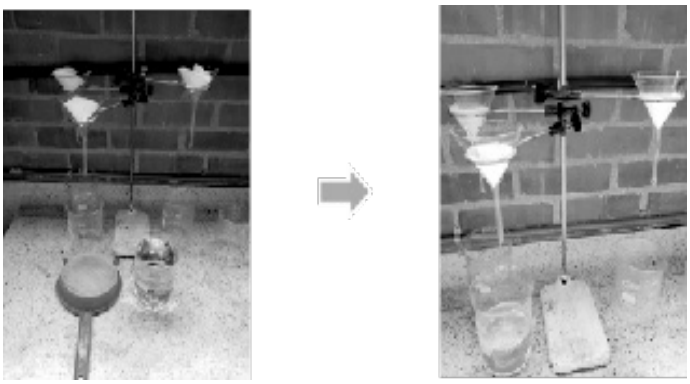

*Figure* 6. Filtering and obtaining the natural coagulant.

- **Jar test**

For this investigation this is the main test to perform the simulation of the different processes that are carried out in the treatment of water for human consumption in a conventional plant. The procedures that this test simulates are coagulation, flocculation and sedimentation. The two first are initial and essential processes in the water purification system. Coagulation consists of destabilizing the colloidal particles in suspension; these are microparticles that do not settle easily by the action of gravity, and they are the main cause of turbidity and color in the water. This is based on the generation of a fast mixture with a high velocity gradient with the addition of an opposite charge substance called coagulant, which has the function of reacting chemically in order to neutralize the electric charge of the colloid, canceling the repulsive forces. Once the colloidal particles in the coagulation are destabilized, the flocculation process follows, which consists of generating a slow agitation for the agglomeration of destabilized particles forming stable

flocs to later perform their removal by means of gravity in the sedimentation unit.

This research project was followed by the NTC 3903 of 1996, where the initial parameters of water, color, turbidity and pH are determined to begin the test.

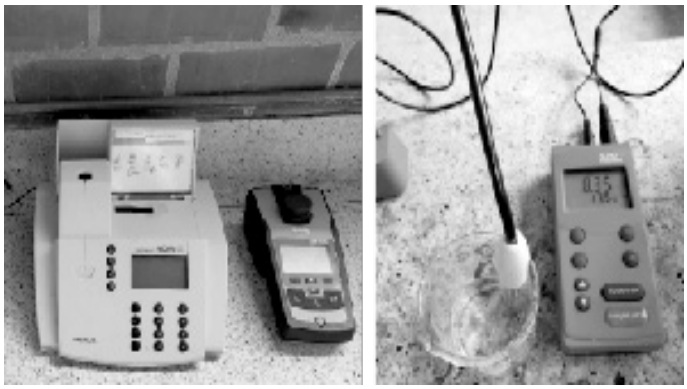

*Figure* 7. Colorimeter, turbidimeter and pH meter.

It is proceeded to make the layout of the equipment, where the jars are organized; the equipment used are six jars which were filled with 1 to 2 liters of water according to the regulations and in which they rotate paddles controlled by means of an electronic board.

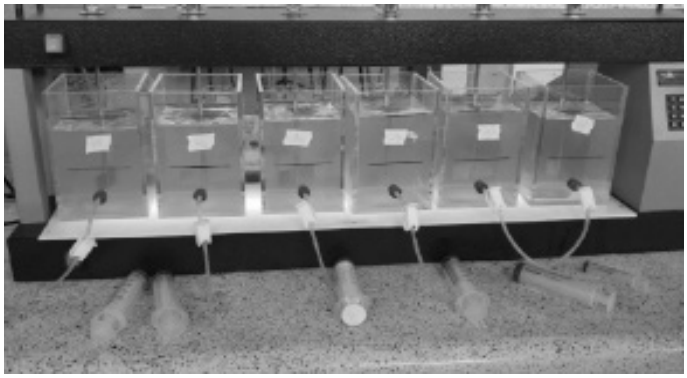

*Figure* 8. Jar test.

Finally, once the test where coagulation, flocculation and sedimentation are simulated, the final parameters of color, turbidity and pH are measured, in order to find the efficiency of the Yausa (Abutilon Insigne Planch).

## Results and Discussion

This section shows the results obtained thanks to the jars test and with which the optimal parameters of the coagulant and therefore the efficiency of the Yausa (Abutilon Insigne Planch) as a natural coagulant in color removal and turbidity were obtained.

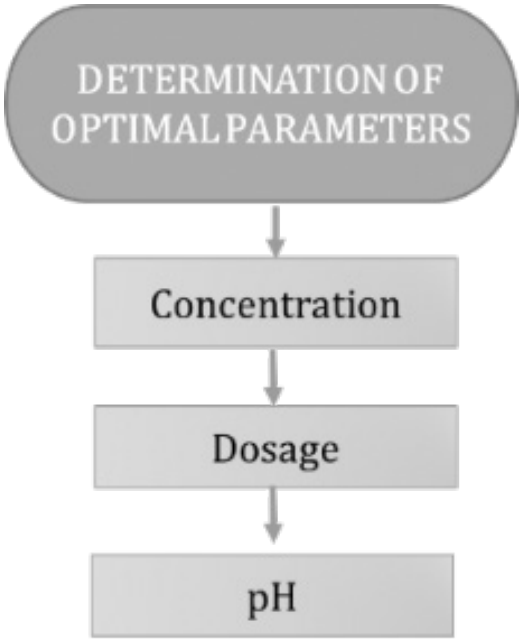


*Figure* 9. Determination of optimal parameters.

Next, the results obtained from the characterization of the Yausa (Abutilon Insigne Planch) will be presented in Table 2 and the plant in Figure 10.

Table 2. *Results of the characterization of the plant*

| CHARACTERIZATION OF THE YAUSA | |
|---|---|
| Property | Value |
| Physical state | Solid |
| Color | Green |
| pH | 7,09 |
| Toxicity | Absent |
| Type of plant | Mucilaginous |

*Figure* 10. Yausa (Abutilon Insigne Planch).

It can be seen that this plant is suitable for carrying out the natural coagulant since it is not toxic, very important factor since it would not contaminate the water and would not have any adverse effect on health, in addition to it is also a wild plant and, easy to obtain.

The optimum concentration is found by means of the jar test, obtaining the efficiency in turbidity and color, and the best of all is the optimum concentration, as Figures 11 and 12 show.

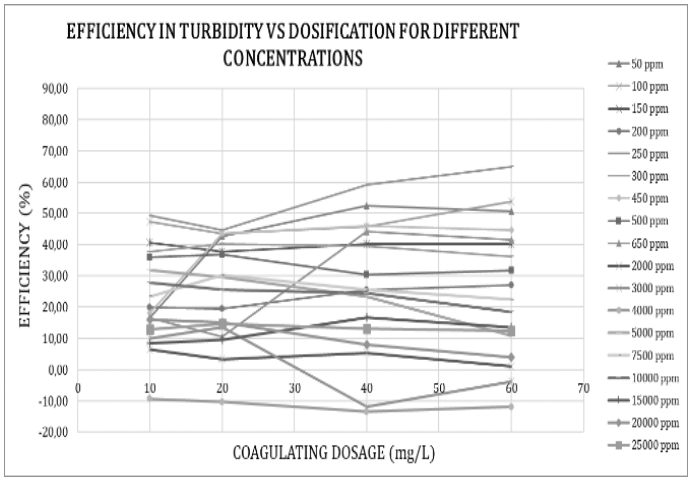


*Figure* 11. Efficiency in turbidity vs. dosage for different concentrations.

Table 3. *Most important results in the optimum concentration test for turbidity*

| Optimum concentration test | | |
|---|---|---|
| Number of concentrations | 18 | Unity |
| Range in concentrations | 50 - 25000 | ppm |
| Greater efficiency in removal | 64,98 | % |
| Less efficiency in removal | -11,43 | % |
| Optimum concentration | 250 | ppm |

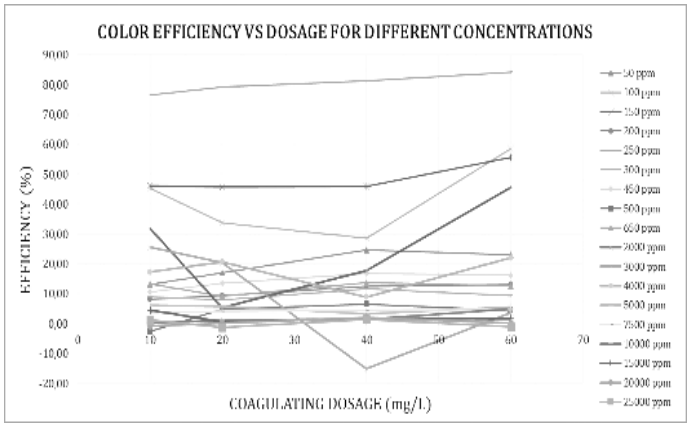


*Figure* 12. Efficiency in color vs. dosage for different concentrations.

Table 4. *Most important results in the optimal concentration test for color*

| Optimum concentration test | | |
|---|---|---|
| Number of concentrations | 18 | Unity |
| Range in concentrations | 50 - 25000 | ppm |
| Greater efficiency in removal | 84,15 | % |
| Less efficiency in removal | -11,90 | % |
| Optimum concentration | 250 | ppm |

Results for the optimal dosage are shown in Figures 13 and 14.

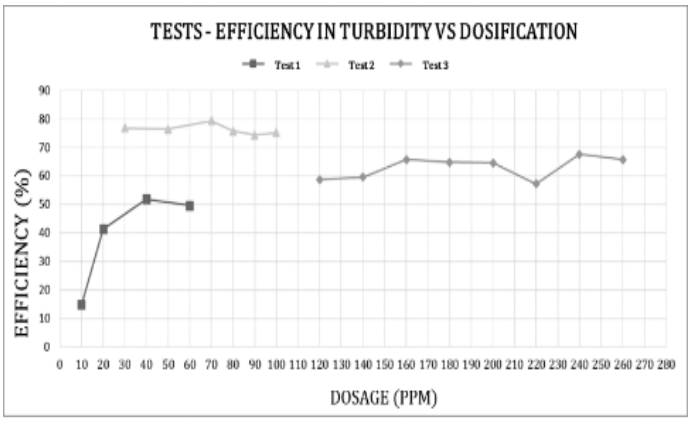


*Figure* 13. Efficiency in turbidity vs. dosages.

Table 5 shows the most important results in the optimal turbidity dosing test:

Table 5. *Optimum dosing results for turbidity*

| Optimal dosage test | | |
|---|---|---|
| Number of dosages | 18 | Unity |
| Range in dosages | 10 - 260 | mg/L |
| Greater efficiency in removal | 79,36 | % |
| Less efficiency in removal | 14,81 | % |
| Optimal dosage | 70 | mg/L |

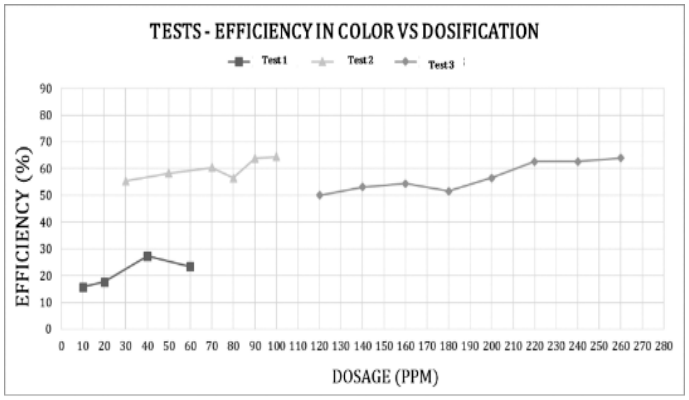


*Figure* 14. *Efficiency in color vs. dosages*

## Conclusions

Obtaining the optimal parameters such as concentration, dosage and pH of the natural coagulant generated by the Yausa (Abutilon Insigne Planch) are highly relevant quantifications, taking into account the entire experimental procedure which includes obtaining the results of the parameters of quality of the water in study treated with the natural coagulant and with the synthetic coagulants to measure if the efficiency of the natural coagulant is equal to the efficiency obtained with the chemical coagulant. In this case there are efficiencies with the natural coagulant in terms of turbidity greater than 70% and for color efficiencies greater than 80%, obtaining an optimum concentration of 250 ppm, an optimal dosage of 70 mg / L and an optimum pH of 3.83. With these optimal parameters of the natural coagulant it is possible to know whether the Yausa (Abutilon Insigne Planch) can be implemented as a natural coagulant knowing its efficiency when comparing the results obtained from the water treated with Yausa and the water treated with synthetic coagulants, reducing costs, thus acquiring a natural and friendly alternative to the environment in the treatment of drinking water for human consumption, these efficiencies obtained with the previous optimal parameters of the natural coagulant are very important since they are high efficiencies.

In addition the pH factor is of great influence after of applying the coagulant; normally the chemical coagulants tend to reduce the pH, making necessary at the end of the treatment have a process of stabilization of pH to comply with the accepted range of the standard, that is from 6.5 to 9; on the contrary, with this natural coagulant can be seen that the pH tends to neutralize and can have a water suitable for human consumption taking into account that they do not have purification procedures that are filtration and disinfection.

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