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Comparison of the efficiency of biopolymer derived from Melocactus sp and Aluminum Polichloride (PAC) in the process of crude water flocculation

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Beginning to use new coagulants and flocculants for the treatment of drinking water is a necessity, to diminish the remains of metals in drinking water and in the residual sludges of the purification process; Aluminum sulfate, iron chloride and aluminum polychloride are currently used for the coagulation and flocculation processes of the water, of these compounds the aluminum polychloride (PAC) is the one that has shown less affectation of metal residues in water and sludge Residual, it is additionally a compound that does not significantly change the pH, this causes the removal of color and turbidity of the water, with minimal changes in the process.
Different tests have been carried out with natural plant extracts, including species such as Moringa oleifera, Aloe vera, Melocactus sp, Opuntia sp and other plants, demonstrating that they are efficient in the removal of turbidity and color of natural water. In the present study, a comparison between an extract of Melocactus sp and Aluminum Polychloride (PAC) is presented in the jar test tests, determining its removal capacity, in order to comply with the Colombian drinking water standard.
The capacity of a natural flocculant obtained from a species of cactus (Melocactus sp) to remove turbidity and color present in raw water was evaluated, contrasting the result with that obtained with aluminum polychloride (PAC). The data collected during jar tests carried out in the environmental engineering laboratories of the Universidad de Santander UDES, Bucaramanga Sede, are shown. After being analyzed this information served to confirm the efficiency as flocculant of this extract of Melocactus sp; In addition, these final measurements of turbidity, color and pH were compared with the values accepted by the regulations in Colombia. The obtained results allowed to conclude that the conditions managed during the tests were able to remove the turbidity and the color, using only small doses of the natural coagulant, extract of Melocactus sp, the pH remained unaltered, thus demonstrating that the flocculant obtained From a species of cactus I do not alter this parameter.

Key words: coagulation, flocculation, natural flocculants, Potabilization

1. Introduction

The need to remove the impurities found in surface water as suspended matter and colloidal matter are requirements so that they can be considered potable after treatment. Colloidal species include clay, silica, iron, other metals and organic solids (Metcalf & Eddy Inc, 1979). The removal of a large proportion of these impurities is carried out by sedimentation, based on simple gravity (Wang L.K., 2005); But some of these impurities are too small to obtain an efficient removal process, because of this, it would require a lot of time to remove the suspended solids, so it is necessary to use processes of clarification, which consist of any process or combination of processes, Whose purpose is to reduce the concentration of materials suspended in water (Ángel, 2013).

In order to eliminate small non-sedimentable particles, coagulation and flocculation processes are used which cause an increase in the size of the floccules and its rapid agglomeration, thus reducing the sedimentation time of the particles (Nishi Leticia, 2011). To carry out this type of process are added chemical salts mostly positively charged (aluminum salts, iron salts or poly electrolytes) that displace the negative ions and effectively reduce the size of charge. Flocculation aims to promote the contact between the destabilized particles with the aid of slow mixing. These particles agglutinate to form a floc that can be easily removed by the decantation and filtration procedures (Guzmán Luis, 2013).

The most studied genera of cacti for water treatment are the Opuntia, associated with its medicinal properties and source of food, and the cactus latifaria, which has also been used successfully as natural coagulant (Yin, 2010), attributed the clotting ability of Opuntia the presence of mucilage, a complex with viscous large water retention capacity, made of carbohydrate molecules such as arabinose, galactose, lrhamnose, xylose and galacturonic acid, and stored in internal and external parts of the cactus (Sáenz c., 2004). Cactáceas having cladodes (modified stems that can make the gas exchange with the environment, since the leaves are adapted for minimal loss of water in photosynthesis) containing mucilage.

According to (Miller M., 2008). The ability Opuntia spp coagulation occurs through the mechanism of forming chemical bridges, through hydrogen bonds or dipole interactions. The flakes formed in the study are long and thin, mucilage derived from the common species of cactus, aloe vera and okra. The authors attribute the polygalacturonic acid, component present in mucilage, as responsible for the formation of chemical bridges in flocculation.

Melocactus sp is a genus of cactus with about 40 species originating in Mexico and the northern part of South America. They grow in diverse countries of Central America and South America, even in some islands of the Caribbean (Fernández, 2002). They are slow growing, when the plant is mature, the body stops its growth and produces a crown in the upper part called cefalio, which can be in permanent growth for many years, and in some species can exceed the height of the body of the plant. In this part is where the small flowers of pink or red shades, blooms abundantly during spring or autumn, for non-tropical species and with more favorable growth in subtropical and tropical areas.

From the economic point of view, inorganic flocculants are expensive; because it is a chemical compound that destabilize the electrical charges of the particles that the water to be treated (Vijayaraghavan G., 2011). The problem with the costs of conventional flocculants is that they are less accessible to isolated populations, where money is a major factor in carrying out water clarification processes. On the contrary, using natural flocculants made from bases of extracts of plants such as Melocactus sp, for small populations, where this type of plants are present, as in La Guajira (Colombia) and other desert and semi-desert areas where this Species of plant is present and also in several of these sites a great crisis is experienced by the scarcity of drinking water, this way they would have more access to this type of flocculants and with very low costs and with efficiencies similar or better to those of The conventional ones, because these plants are currently considered weeds in these lands.

In addition to the above, the negative environmental impacts caused by the use of inorganic flocculants are added, since in its manufacturing process, which translates into production costs; also generate pollution to the environment (De Souza Aloisyo, 1999) and alter the original chemical properties of water and produce sludge loaded with high concentrations of aluminum or iron, pollutants in agricultural soils (Germán Rueda Saa, 2011).

However, if your text contains complicated mathematical expressions or chemical formulae, you may need to increase the line spacing. Running text should be justified. Do not use bold or italics in the text. They are reserved for headings. The core terminology of Process Integration as e.g. Pinch, Composite Curves should be capitalised. This is a critical requirement for keeping the high standard of the journal.

2. Metodology

In this work a series of tests were carried out, which were based on the measurement of three parameters, pH, color and turbidity, which were determined as established (American Public Health Association, 1995):

TABLE 1: Measured Parameters

Parameter	**Units**	**Analytical technique**
pH		Standar Methods 4500 H+
Color	Pt-Co	Standar Methods
Turbidity	NTU	Standar Methods

In Table 1 presents the variables evaluated and the techniques used in their analysis.

The pitcher test was performed according to the established technical standards in force and applicable in this case (ICONTEC, 2010).

The jars tests were carried out in the Laboratory of Environmental Engineering of the University of Santander; the pH measurements were carried out with the Mi 180 Bench Meter equipment, the color was determined by the HACH 2010 (HACH, 2000) spectrophotometer at 455 nm and the turbidity was determined with the HACH 2100Q turbidimeter.

The measured parameters were compared with that established in the Colombian legislation (Resolución 2115, 2007) (Ministerio de Protección Social, 2007), for drinking water quality, where the following limits are established.

TABLE 2: shows the limits allowed by Colombian legislation

Parameter	**Units**	**Limit**
pH		6,5 – 9
Color	Pt-Co	15
Turbidity	NTU	2

Table 2 shows the different parameters required by Colombian regulations so that water can be considered suitable for human consumption.

The jar tests were performed with different concentrations of the two coagulants, with each sought adequate concentration and were performed in two phases, preliminary trials and final trials, to establish the dose data were taken from previous trials with Melocactus sp (HACH, 2000) preliminary tests were performed between 15 and 40 mg / l, the final tests were performed between 42 and 52 mg / l; For PAC, the manufacturer's suggestions were taken, which specified between 10 and 60 mg / l with preliminary tests between 10 and 40 mg / l and final tests between 35 and 60 mg / l.

The problem water was taken from a natural source attached to the University of Santander, in the village of Santa Bárbara, in the suburban area of Bucaramanga; in the season of beginning of drought, considering that can have colors and haze not very high.

3. Results

The data obtained from the experiment were collected and plotted, comparing each parameter, and establishing that the appropriate value is determined by Table 2.

The tests that showed a better performance were the final tests, within the intervals that showed the best performance, to reduce the values of color and turbidity.

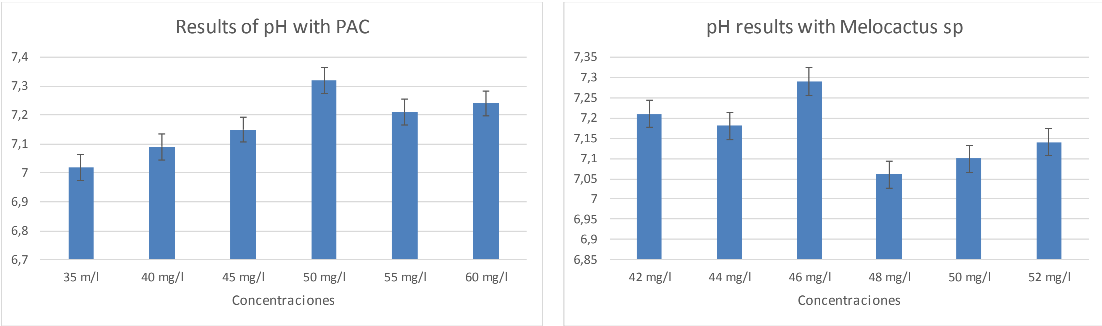
In order to establish the initial characteristics of the problem water, the analysis corresponding to the raw water were carried out, which are presented in the following table.

TABLE 3: Raw water results

Parameter	**Result**	**Limit value**	**Units**
pH	7,26	6,5 – 9	
Color	21	15	Pt-Co
Turbidity	4,87	2	NTU

Table 3 summarizes the results obtained with the flocculant which are purchased with the limits required by Colombian regulations. The results of raw water are common in low rainy season, as they are in the months of June and July. The comparative results for the pH of the final tests are:

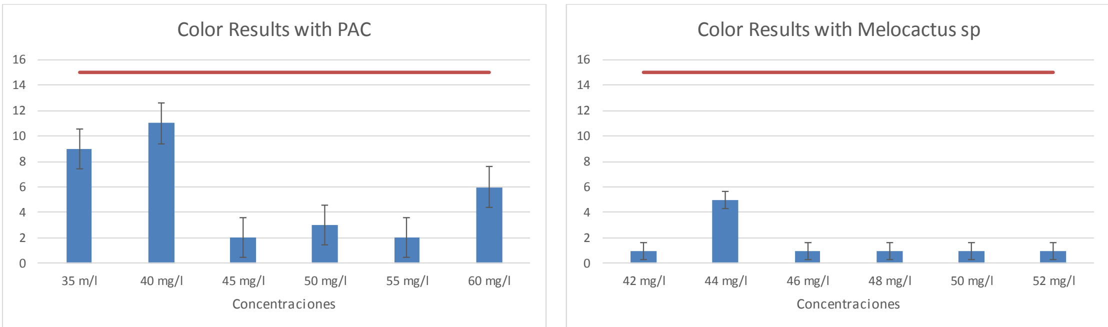
Graph 1: Results of the pH analysis of the waters with PAC and with extract of Melocactus sp



In graph 1 we can observe, the pH parameter shows that the aluminum polychloride and the extract of Melocactus sp did not modify the value of this variable beyond a few hundredths of the result of the crude sample.

The pH values recorded by the coagulants evaluated are within the range suggested by the Colombian standard (6.5 - 9) to be used as potable water. For this case the coagulants do not alter the pH of the natural water. The comparative color results in the final tests are:

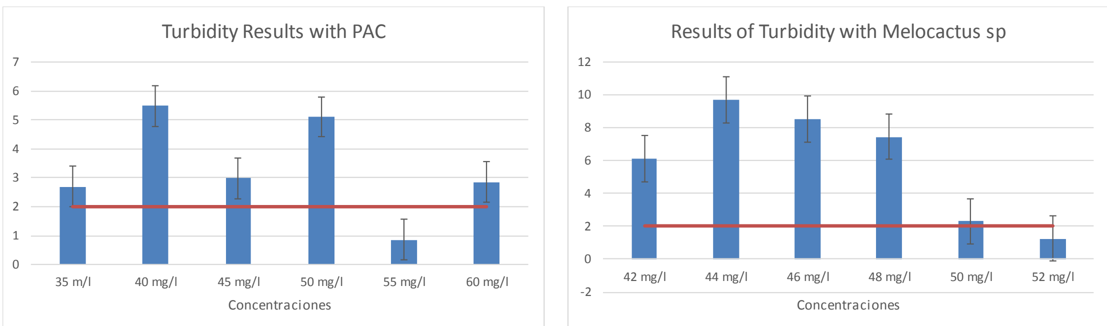
Graph 2: Results of the color analysis of the waters with PAC and with extract of Melocactus sp



The color parameter shows that in all concentrations of polychlorinated aluminum and Melocactus sp extract the final tests satisfactorily fulfilled the standard for this parameter; it is evident in the extract of Melocactus sp a better performance, because all the results had below 5 units of color; As shown in graph 2.

The comparative results of the turbidity in the final tests are:

Graph 3: Results of the turbidity analysis of the waters with PAC and with extract of Melocactus sp



In graph 3, the behavior of the turbidity parameter showed several values, even some above the initial measurement, because the formation of flocs that do not precipitate in the time determined by the technique will generate an increase of this particular value.

In the case of the PAC it is shown that the appropriate value is 55 mg / l, so that the water can comply with the Colombian standard, which is the only value below 2 turbidity units.

In the case of trials with Melocactus sp it is evident that the dosage that complies with the Colombian standard of turbidity in water is 52 mg / l; this is the only value that has the appropriate value.

4. Conclusions

The adequate concentrations of aluminum polychloride and Melocactus sp extract are similar in relation to compliance with the Colombian standard for pH, color and turbidity parameters (Resolución 2115, 2007) (Ministerio de Protección Social, 2007).

The coagulants showed effectiveness in the removal of color and turbidity of the problem water, without affecting the pH.

The extract Melocactus sp proved to have the ability to remove color and turbidity in raw water; this makes it an alternative to be used in water treatment, in areas where this plant is present.

The characteristics of Melocactus sp as a coagulant make it an alternative to be used in water treatment, because its sludge does not present polluting metals, which facilitates the safe disposal of waste from the treatment process of raw water.

The activity of extract of Mellocactus sp is effective in the separation of several types of substances of the water, with behaviors similar to the one found in the valuation of other species like Moringa oleifera (Nishi Leticia, 2011).

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