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Evaluation of the Efficiency of Bio-Polymers Derived from Desertic Plants as Flocculation Agents

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In the treatment of wastewater, flocculation is one of the most used processes, which aims to eliminate colloidal particles cannot be removed by other methods; Traditionally it has been used aluminum or iron salts and synthetic polymer, which generate little biodegradable sludge; moreover biopolymers, have coagulation and flocculation properties which can remove over 80-90% of solids contaminated; additionally, the use of natural polymers produce sludge increased biodegradability.
The present work analyzes the efficiency of a biopolimer based on 6 endemic plants (*Opuntia dilleni*, *Stenocereus griseus, Cereus forbesii, Melocactus sp. Aloe arborescens and Aloe vera*) found at the desertic indian reservation “Kululumana”.

1. Introduction

The demand for drinking water in developing countries is growing, in line with the Millennium Development Goals (UN - United Nations, 2014); however, this activity require large amounts of chemical, particularly inorganic salts such as ferric chloride ($FeCl_3$) and aluminum sulfate (Al_2SO_4).
This salts once mixed with sewage sludge raw water, produce an aqueous solid enriched with iron and aluminium, which are disposed in landfills, and sometimes discharged into water bodies. This practice transforms sludge source of iron and aluminum deposited on the bed of water bodies (Metcalf & Eddy Inc, 1979).
The presence of these metals in the environment has consequences that have been recorded, such as fish affectation affectations on balance, susceptibility to diseases; on benthic populations suffer significant variations in structure, distribution and abundance in water bodies and various effects in humans as conditions in kidney cells (De Souza Aloisyo, 1999). One possibility is to replace these salts with polymers derived from organic sources, which act as flocculants or coagulants in addition hold characteristics of biodegradability and generate no harmful deposits of metals, and semi-desert communities (Fernández, 2002), which have no efficient treatment systems drinking water, can use it efficiently.
Natural coagulants are used in water with low to medium turbidity (50-500 NTU) and have similar performance to its chemical counterparts (Yin, 2010). Flocculants derived from plants posess polyelectrolytes (mainly polysaccharides and protein compounds) that can affect the stability of ionic charges in aqueous solution (Vijayaraghavan G., 2011). Plants of the genus *Opuntia* sp (family Cactaceae) produce a hydrocolloid (or mucilage) with highly branched structures that can retain water (Medina Torresa L, 2000). According to Guzmán (2013) plant-based bioflocculant can act as co-coagulant with aluminum sulphate.
The present work analyzes the efficiency of a biopolimer based on 6 endemic plants (*Opuntia dilleni*, *Stenocereus griseus*, *Cereus forbesii*, *Melocactus* sp. *Aloe arborescens* and *Aloe vera*) found at the desertic indian reservation “Kululumana”.

2. Methodology

2.1 Sampling

Samples from six plant species (*Opuntia dilleni* sp, *Stenocereus* sp, *Cereus forbesi*, *Melocactus* sp, *Aloe arborescens*, and *Aloe vera*). were collected at the indian reservation “Kululumana” located at the the

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municipality of Maicao (Guajira, Colombia) and at Pescadero (Santander, Colombia) This methodology was guided by the Faculty of Engineering University of Zulia (Daimarys Martinez 2003).

2.2. Production of Flocculants

Samples were subjected to cutting, grinding with ball mill and sun drying.

In order to prove the ability of extracts, and to find the appropriate concentrations of flocculant a jar test assay was performed on a sample of crude water usign each of the extracts; samples were processed and measurements on variable water quality were applied to match Colombian legislation (Resolution 2115, 2007) (Ministry of Social Protection, 2007) (Table 1). The selected variables were pH (Standard Methods 4500H+), conductivity (Standard Methods 2510), color (Standard Methods 2120B) and turbidity (Standard Methods 2001) (American Public Health Association, 1995). Each of the tests were done only with the flocculant, without pH change or prior modification on the media on water, in no case be used for pH neutralization or flocculation aid (Wang L.K., 2005).

Table 1: Standard for drinking water (Resolution 2115, 2007).

Property	Unit	Value Standard
Color	UPt-Co	≤15
pH		6,5-9,0
Turbidity	NTU	≤ 2
Conductivity	µs/cm	50 – 1000

3. Results

The results are presented for the jar tests in the best characteristics given by the results of standard variables for drinking water in Colombia, and are presented for each. Figure 1 shows the turbidity removal capacity of each of the extracts and their comparison with the standard sample, were the best performance was obtained using *Mellocactus* sp and the commercial PAC, with an average reading of 1.9 NTU, in addition this was the only sample that fulfil the standard for drinking water.

To develop the study started from a sample of raw water from the creek May 10, within the premises of the University of Santander, characterized and results for the 4 variables were observed:

Table 2: Features raw water

Property	Unit	Value Standard
Color	UPt-Co	375
pH		7
Turbidity	NTU	44,5
Conductivity	µs/cm	302

Figure 1 shows that the best performance of turbidity removal was made by *Melocactus* sp, with an average reading of 1.9 NTU measurements, we observe that the only one that meets the standard for drinking water. Data from the same PAC treated water shows that the *Melocactus* sp, had a similar value.

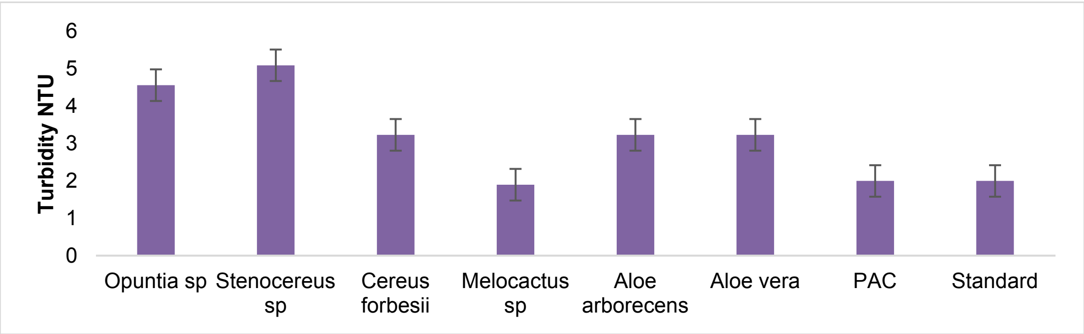

Figure 1: Change on Turbidity using the different samples

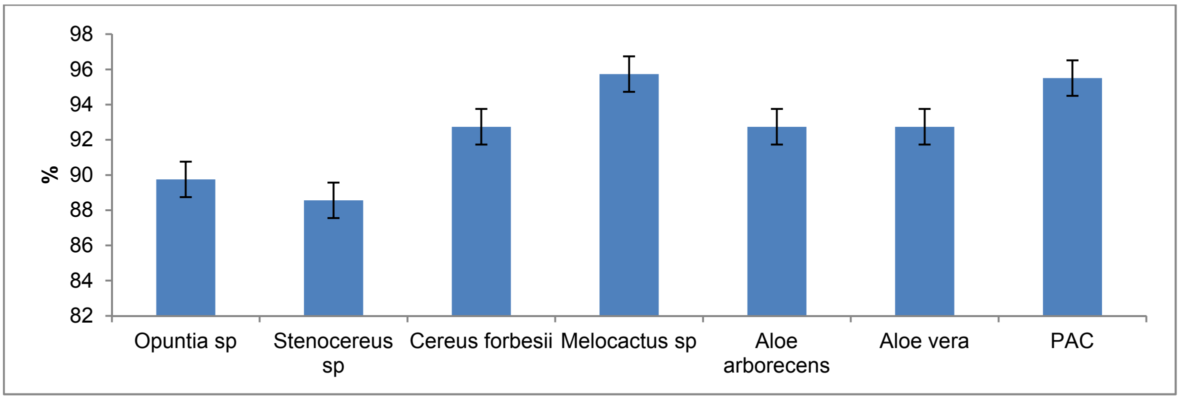

Figure 2: Percentage of turbidity removal

Figure 2 shows the percentage of turbidity removal from plant extracts and polyvinyl aluminum, being the best removal percentage of *Melocactus* sp the sp, with 95.73%.

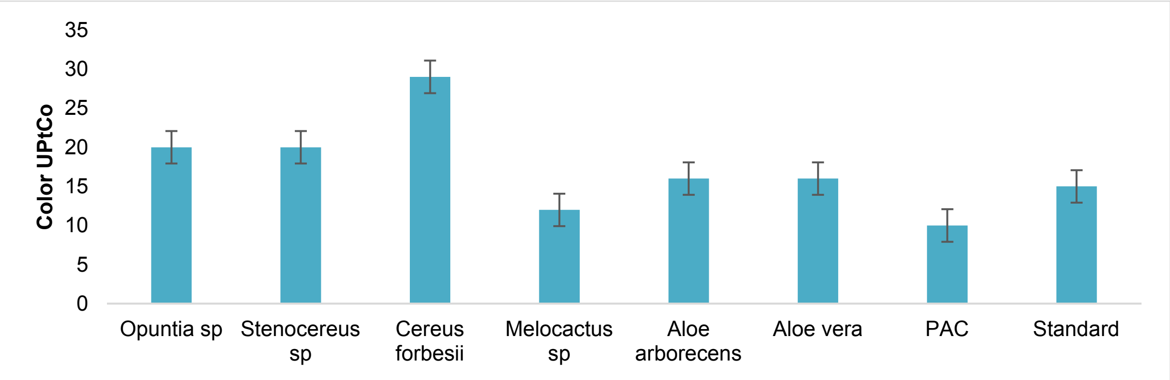

Figure 3: Change on Color using the different samples

On the results on color removal (Figure 3), results shows that the best value for color removal on crude water was made by *Mellocactus* sp, which showed an average value of 12 UPT-Co, being the only one that meets the specification standard for drinking water for this parameter.

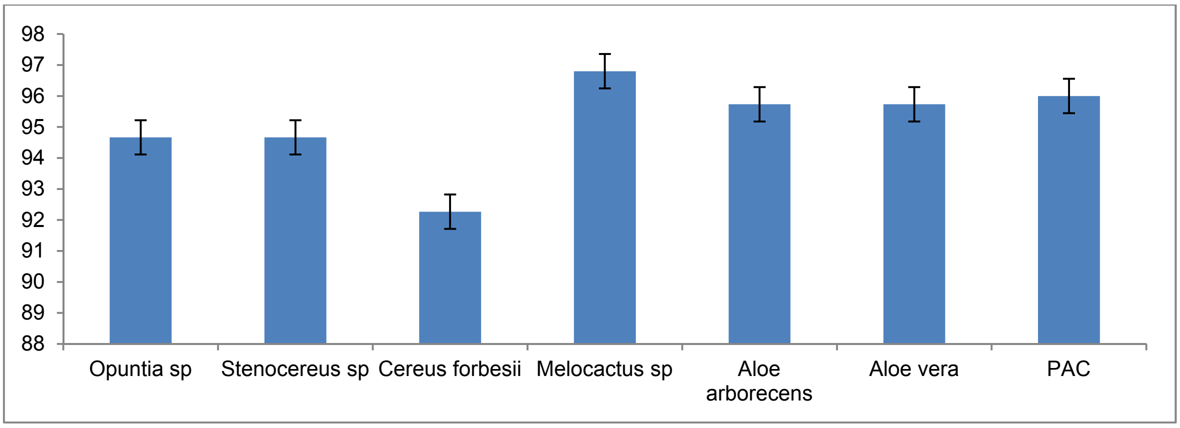

Figure 4: Color removal percentage

Figure 4 shows the percentage of color removal from plant extracts of the flocculant and aluminum polychloride, showing that the removal rate corresponds best to extract *Melocactus* sp, with 96.80%

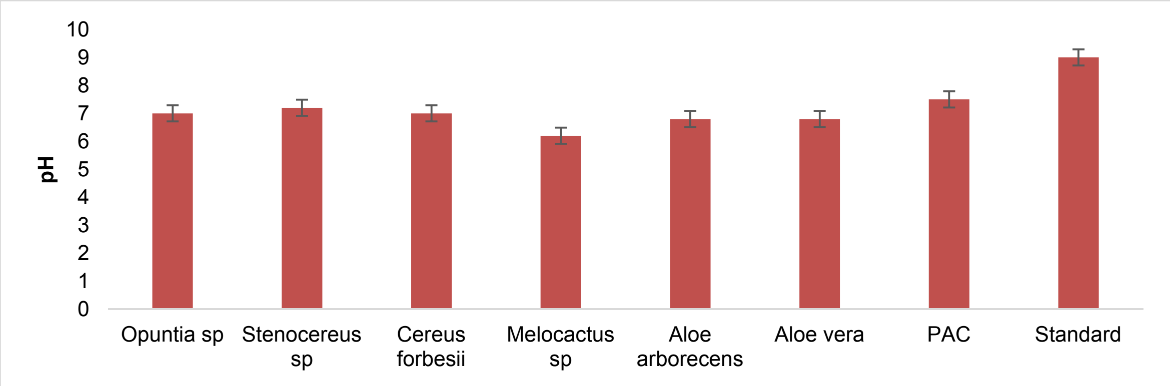

Figure 5: Change on pH using the different samples

At pH results of tests of coagulation-flocculation (Figure 5), shows that all plant extracts meet pH parameter for the case of drinking water, also it shows that the performance of the plant extracts are similar to the commercial coagulant-flocculant.

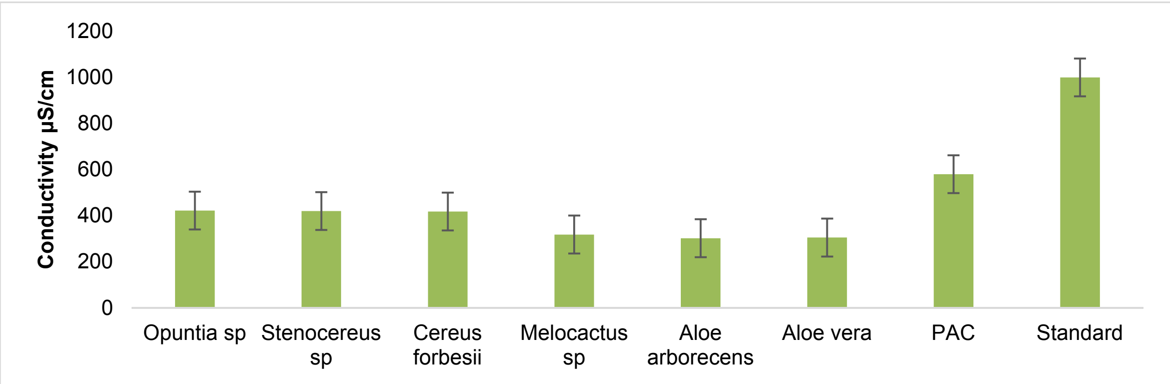

Figure 4: Change on Conductivity using the different samples

On the other side, conductivity results (Figure 4) shows that all plant extracts meet the parameter of conductivity in the case of drinking water. It was observed that, the coagulant-flocculant has above commercial plant extracts of values.

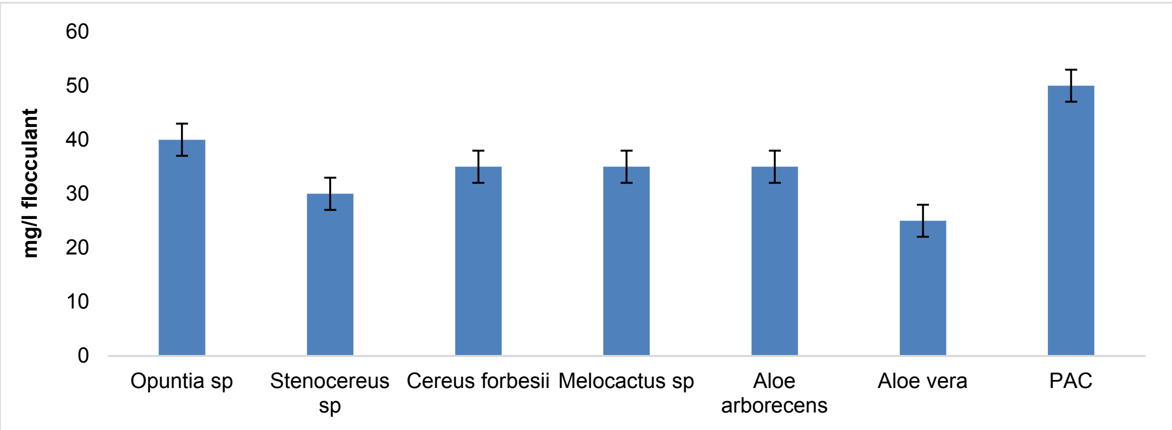

Figure 5: Concentrations of flocculant

Figure 5 shows the concentrations of natural flocculants, flocculant compared to conventional aluminum polychloride shown, concentrations correspond to more efficient for removing turbidity and color of raw water.

*Table 3: **% Turbidity Removal***

Plant species	% Turbidity Removal
Opuntia sp	88,56
Stenocereus ps	88,58
Cereus forbesii	88,31
Melocactus sp	97,15
Aloe arborecens	92,74
Aloe vera	92,74

Table 3 shows the results measured as turbidity removal percentage shows that the more efficient the flocculant is derived melocactus sp, corresponding to 97.15%, followed by species and Aloe vera Aloe arborecens, 92 are shown, 74% using less than 50mg / liter, this removal is better than that reported with Moringa oleifera, which required concentrations of 125 mg / l to 250 mg / l (Nishi Leticia, 2011)

*Table 4: **% Color Removal***

Plant species	% Color Removal
Opuntia sp	94,67
Stenocereus ps	94,67
Cereus forbesii	92,27
Melocactus sp	96,8
Aloe arborecens	95,73
Aloe vera	95,73

Table 4 variable color displays and shows that the greater efficiencies correspond to Melocactus sp species and species of Aloe and Aloe vera arborecens with 96.8% and 95.73% respectively.

4. Conclusions

The evaluation of coagulants-flocculants natural shows that the performance of natural extracts has similar to those given by aluminum polychloride (PAC), which is a commercial product used in Colombia conditions.
Removal efficiencies reported for turbidity and color in Mellocactus sp, Aloe and Aloe vera arborecens species are better than those reported for Moringa Oleifera.
The best plant extract proved the *Mellocactus* sp, which showed meet the requirements of drinking water standard in Colombia.
Mellocactus sp and aluminum polychloride (PAC) yields are very close and the two met for the drinking water standard, however the amount of bioflocculant required is lower than the inorganic sample.

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