Natural Bio-Flocculant in water Treatment:
Investigation of the Performance of Cactus Extracts as a Natural Flocculant

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ABSTRACT: The focus of this study was to find a new technology for purification of wastewater reuse. The effluent which is discharging after primary treatment mainly contains organic mineral, dissolved and suspended particles etc. In order to remove these impurities many chemicals have been used such as alum (aluminum sulphate), ferric chloride etc, and it’s a promising method for removing impurities by coagulation and flocculation method. However these chemical coagulants have their own disadvantages such as sludge which is generated by this chemical coagulants are not biodegradable and precautions should be taken for residual concentration for these chemical coagulants which is harmful to human health and cause neurological problems. An evaluation was made on the cladode of Opuntia Ficus Indica (OFI), in which bioflocculant was extracted by different solvents by using different methods was investigated, as coagulant. Experiments were conducted to determine optimum conditions for treating the turbid water loaded by organic matter from Dalvoy Lake in Mysuru city. The turbidity removal efficiency was greater than 95% and can achieve 99% at optimal conditions of dosage and pH.

KEYWORDS: Coagulation-Flocculation, Water Treatment, Cactus, Pectin’s, Mucilage.

I. INTRODUCTION

The genus opuntia is the largest under the Cactaceae family with more than 250 endemic species from Central America. The opuntia species chosen as natural bio flocculant source for this project was Opuntia ficus-indica, also named chumbera in Spain, cactus pear in North America and nopal in Mexico. The nopals are succulent plants which grows up to 3-5 meters, many times in a dense and tangled structure. It is recognized by its green thick long pads that look like sports rackets. They grow one linked to the next and can be considered as both leaves and stalks. The plant surface is covering by spines which help to conduct water and reduce water loss. Opuntia ficus-indica a cactus that grows naturally in South America is also a source of viscous natural polyelectrolyte’s bearing negative surface charges. Below figure 1.0 shows the Cactus plant (OFI) which was used for current project work.
The flocculation process induced by anionic polyelectrolyte’s such as the natural polyelectrolyte’s extracted from Opuntia ficus-indica is greatly facilitated by the presence of low concentration of metal ion (Al\(^{3+}\)) capable of binding with the functional groups on the polyelectrolytes. The positive metal ion serves to form a bridge among the anionic polyelectrolyte’s and negatively charged functional groups on the colloidal particle surface. Due to its hydrophilic character, several hydrogen bonds are formed among polyelectrolyte’s and water molecules. This association tends to occupy larger surface area causing it very high viscosity.

Water, starch, cellulose, hemicelluloses, pectin, lignin’s and chlorophyll are the main constituents of cactus. After extraction of polyelectrolyte’s, the remaining solids residues of the cactus are peels, cellulose, hemicelluloses and starch that could be used as substrate for fermentation with filamentous fungi [7]. The proximate composition of cactus is given in Table 1. Because of rich in carbohydrates and proteins its flocculating efficiency is very effective.

Table 1: Mean chemical composition of Opuntia cladodes [7]

<table>
<thead>
<tr>
<th>Components</th>
<th>Dry matter basis (g/100g)</th>
<th>Fresh weight basis (g/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>_</td>
<td>88-95</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>64-71</td>
<td>3-7</td>
</tr>
<tr>
<td>Ash</td>
<td>19-23</td>
<td>1-2</td>
</tr>
<tr>
<td>Fibers</td>
<td>18</td>
<td>1-2</td>
</tr>
<tr>
<td>Protein</td>
<td>4-10</td>
<td>0.5-1</td>
</tr>
<tr>
<td>Lipids</td>
<td>1-4</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Bioflocculants have received much more importance and biotechnological awareness in recent years due to their biodegradability, benign nature and not have any secondary pollution of their degradative intermediates [10, 11]. Flocculation is one of the important treatments given to the industrial effluents before discharging them into nearby water bodies such as rivers and lakes to eliminate toxic waste. Organic polymeric flocculants have been used in water purification for several decades.

II. MATERIALS AND METHODS

A batch of fresh leaves of Cactus (OFI) was obtained from sampling point. Harvesting of cladodes was carried out in May 2016. The cladodes were washed thoroughly with water in order to remove dirt from the materials used before mucilage and pectin’s extraction. The chemicals used in the experiment were of analytical grade. Samples were collected from Dalvoy Lake water which is located in Mysuru city samples were collected in the mid day for every analytical process.

Preparation of Natural Coagulant (Extraction from cactus)

**EXTRACTION OF GELLING EXTRACTS (4)**

1. Fresh cactus pads were cleaned (thrones were removed)
2. Diced into 1cm width and boiled in demonized water for 30 minutes to inactivate enzymes and heating the pad also cause high potential for mucilage secretion and allowing it to flow easily
3. The mixture was then liquidized with help of household blender
4. pH was alter to 7-7.5 with 1.0 M NaOH and the resulting mixture was centrifuged at rpm 4000 for 10 minutes
5. The supernatant was separated from solids and solids were reserved for extraction of gelling mucilage
6. 1.0 Normality NaCl was added to supernatant which was highly viscous until filtration through regular filter paper this filtration remove any remaining pad tissue from the Non-gelling extract (NE) mucilage solution.
7. After filtration NE was precipitated from water using acetone
8. Precipitation begins immediately and NE is accumulated at acetone-air interface
9. The extracted mucilage was washed with isopropanol approximately 10 minutes and drawn out.
10. The mucilage was spread on sterile Petri dish and dried in fume hood at room temperature for 48 to 60 hours.

**EXTRACTION OF GELLING EXTRACTS (4)**

1. The solid residue which is retained from the centrifugation step were transferred into beaker
2. To which 50mM NaOH solution containing 75% Sodium-hexa-metaphosphate was added and stirred for 30 minutes
3. Then pH was adjusted to 2.0 with HCL, and solution was centrifuged at 4000 rpm for 10 minutes
4. After centrifugation supernatant was discarded and precipitate was covered with deionized water and pH was increased to 8.0 with 1M NaOH
5. Solution was filtered using cloth sheet and solids were discarded
6. Acetone was added to isolate gelling extract (GE)
7. The extracted mucilage was washed with isopropanol approximately 10 minutes and drawn out.
8. The mucilage was spread on sterile Petri dish and dried in fume hood at room temperature for 48 to 60 hours. As shown in below figure 2 [a, b, c, d and e].
OPTIMIZATION OF pH AND COAGULANT DOSAGE

1. The optimum dosages of the natural coagulants can be evaluated by using jar test apparatus.
2. 1000 ml of water samples was put in to each 6 one-litre beakers and placed under jar test apparatus.
3. The paddles were inserted in the jars, the apparatus was switched on and the speed of mixing was set to 150 rpm.
4. The required dose of previously prepared bio coagulant was added at varying dosage of 0.5, 1, 1.5, 2, 2.5 and 3 mg/L.
5. The speed of mixing was reduced to 50 rpm and allowed for slow mixing for varying contact period i.e. multiples of 5 and continued till 30 minutes and allowed for settling.
6. After 30 minutes, the supernatant was pipette out from each beaker to record the final turbidity and thus optimum dosage of natural coagulant was recorded. The jar test apparatus (Model- Cal. NO.SECOR 41) is as shown in figure 3.
III. RESULTS AND DISCUSSION

For Dominguez et al. (2007) [6], within all the factors involved in coagulation-flocculation process, those that most affect the process efficiency are pH and coagulant dose, since influence in the hydrolysis equilibrium of coagulant species. Jar test experiments were performed to assess turbidity removal as well as coagulation flocculation kinetics at various pH values. This was achieved by varying flocculants dosage. Graphical representation of obtained results is shown in the below figure 4.

![Graphical representation of turbidity removal efficiency](image)

**Fig 4: Turbidity removal efficiency after treatment with natural bio coagulant for Dalvoy Lake water for various dosages**

From the above figure 3.0 concludes that the turbidity removal efficiency of the bio-flocculants was excellent and satisfies WHO’s limit. Initially Lake Water had an initial turbidity concentration of 27 NTU and pH around 7-7.5 which
was alkaline state. Bio coagulant which was extracted was added in various dosages to each six beakers, with varying dosages from 0.5 mg/L to 3 mg/L and it was seen that maximum turbidity removal efficiency was found at dosage 2 mg/L which is having residual turbidity of 5 NTU. However bio coagulants-floculants has many advantages, one obvious advantage of using renewable materials is, the net effect on global warming minimal. Other advantages include sludge produced after treatment will not cause any secondary pollution and it is easily biodegradable and sustainable.

IV. CONCLUSION

The use of natural coagulants like cactus (OFT), MoringaOleifera and other bio coagulants are receiving attention for their effectiveness in water treatment. Natural bio flocculants are economical, traditional, and easy to implement and decrease morbidity and mortality from water borne diseases and thus, improve public health in rural areas. It is observed that use of natural bio flocculants extracted from cactus shows a promising technology for treating highly turbid water. Use of naturally available bio flocculants has been found very effective solution in the treatment of highly turbid water. Natural bio coagulants is freely available in nature in which bio coagulants from these plants can be isolated in a effective manner and can be used to treat turbid water which is economic and eco-friendly when compared to the use of synthetic coagulant such as alum, as the sludge produced by the natural bio flocculants which is easily biodegradable when compared to the sludge produced from the synthetic coagulants which is not easily bio degradable and the use of synthetic coagulant in-appropriate manner can lead to many problems such as Alzheimer’s disease and other neurological problems.

REFERENCES

[4] Audrey Lynn Buttice “Aggregation of Sediment and Bacteria with Mucilage from the Opuntiaficus-indica Cactus” January 2012