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A Study on Use of *Moringa oleifera* in Wastewater Treatment

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***Abstract*— This study aims to evaluate the potential of Moringa oleifera (Sehjan) plant parts (seeds and leaves) in suspended solids and Biochemical Oxygen Demand (BOD) removal. When M. oleifera seeds were applied to wastewater, more than 99% turbidity removal and more than 96% suspended solids removal was observed. Reduction in total volatile solids of the order of 78% was achieved. BOD removal efficiency of the seeds was found to be low. Also, no change in pH was seen between control sample and those treated with M. oleifera seeds. In case of M. oleifera leaves, no positive results were obtained in any of the parameters tested.**

***Keywords*— Moringa oleifera, oiled seeds, de-oiled seeds, M. oleifera leaves, Wastewater treatment**

I. Introduction

Wastewater treatment is a key process in sanitation system. Disposal of wastewater directly into natural water bodies or land surface can cause degradation due to its Biochemical Oxygen Demand (BOD), high concentration of suspended solids and various other impurities. The main aim of treatment is to remove the contaminants from wastewater and to permit the remainder to be discharged in receiving water or land without interfering with its proper usage. New innovative techniques in wastewater treatment are currently being developed that use environmentally friendly materials, such as natural organic polymers, which have a variety of benefits such as cost reduction, preventing variations in the pH, low sludge volume and higher biodegradability [1].

One of the major challenges that wastewater treatment processes face is the removal of hydrophobic colloids having high specific surface area and negative charge on their surface. Due to the presence of charge on their surface they mutually repel each other and mostly remain in suspension which makes it impossible to remove them by sedimentation without the aid of coagulant [2]. *Moringa oleifera* is a bio coagulant consisting of significant quantities of low molecular weight water-soluble proteins, which in solution carry an overall positive charge and is very effective in removing these colloids [3].

M. oleifera is a tree variety native to India and is a highly valued plant, distributed throughout tropics and subtropics [4]. It belongs to the genus Moringaceae. *M. oleifera* is a single genus with 14 known different species. *M. oleifera* Lam is the most widely known and cultivated species of these. Almost all parts of this plant are high in nutritional values, consumed as food and have medicinal applications [5]. Wastewater treatment is also one of the significant use of *M. oleifera*. Many studies have successfully reported the removal of pollutants from various aqueous medium using different parts of *M. oleifera* commonly known as drumsticks [6]–[10]. Some studies have also discussed the use of *M. oleifera* on BOD of water and wastewater [11]-[13]. Results shown by different studies were in contradiction with each other. Also, no firm reason for the decrease or increase in the BOD values was given by any of those.

Thus the objectives of this work are to study the potential of *Moringa oleifera* seeds (oiled and de-oiled) and leaves in various wastewater treatment processes (removal of turbidity, suspended solids, total volatile solids and BOD).

II. Materials and Methodology

A. Sampling site

The type of wastewater used in this study was domestic sewage. Samples were collected from Diggian Sewage Treatment Plant, Sec 66 SAS Nagar Phase 11 Mohali (Punjab). Table 1 shows the data on annual average wastewater characteristics for the year 2018 procured from Centre Pollution Control Committee, Chandigarh.

Table 1: Typical characteristics of wastewater

S. No	Parameter	Value
1	pH	7.2
2	Turbidity (NTU)	648
3	TSS (mg/L)	364
4	DO (mg/L)	Nil
5	BOD (mg/L)	257
6	COD (mg/L)	470
7	NH_3-N (mg/L)	33
8	PO_4-P (mg/L)	3.10

(*Source- CPCC Chandigarh)

B. Moringa oleifera pre-treatment

In the study *M. oleifera* seeds (oiled and de-oiled) and leaves were used for various wastewater treatment processes i.e. removal of turbidity, suspended solids and BOD. *M. oleifera* pods were obtained from local grain market. Pod shells were removed manually, good quality seeds were handpicked, grounded granularly in domestic blender and were kept for further use. Oil extraction was done by passing peeled *M. oleifera* seeds through domestic cold press oil extraction machine. De-oiled seed cake obtained was then sun dried and converted into granules with the help of domestic blender. *Moringa oleifera* leaves used in this study were procured from the Punjab Engineering College campus. Leaves were handpicked and sun dried for three days. Dried leaves were then crushed and then kept in air tight container and stored at room temperature for further use.

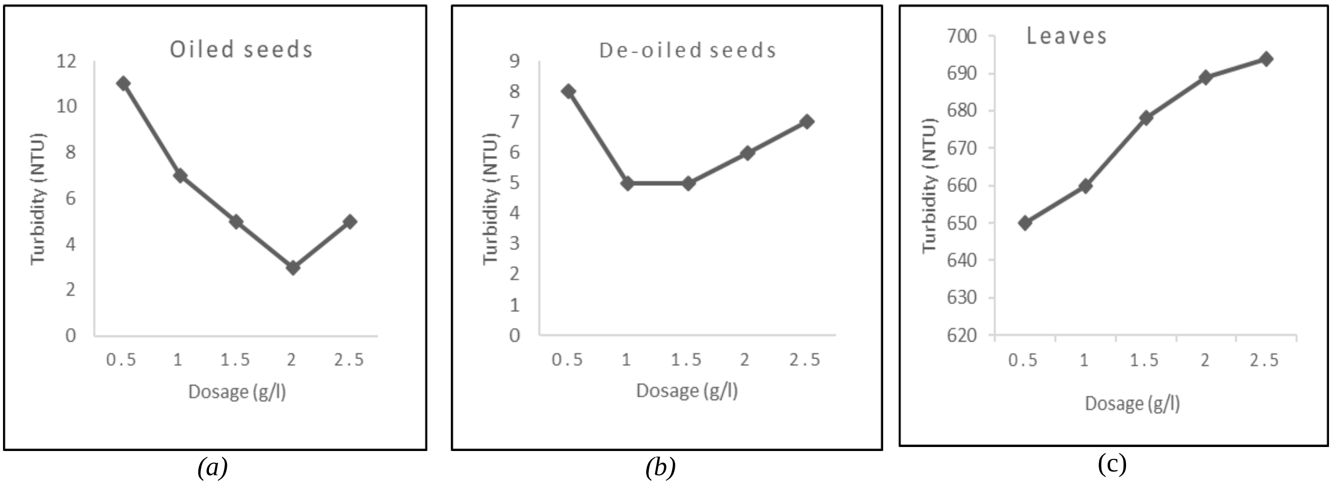
C. Experimental Procedure

Fresh sample was collected each day and mixed thoroughly to ensure the homogeneity of sample. Firstly, contact time and optimum dosage of coagulants were determined for that 800 mL of homogenised wastewater was taken in each beaker of Jar Test apparatus (PB-700) of capacity 1 L and known amount of coagulant dosage was added to each beaker keeping the paddle rotating at initial speed of 30 rpm. After addition of coagulant dosages rapid mixing was conducted at 100 rpm for 2 minutes. Then, the speed was reduced to 20 rpm and continued for 30 minutes to promote flocculation of suspended particles present in wastewater. The paddles were stopped and the water was left to settle for 1 hour. This criterion was established after varying both slow mixing and settling time simultaneously from 15 minutes to 1 hour and taking turbidity readings on NTU scale. Following the same procedure optimum dosage was also determined. After establishing contact time and optimum dosage, samples were collected from mid-height of each beaker with the help of pipette and transferred into conical flask for further analysis.

Turbidity was measured before and after treatment with the help of digital turbidity meter (nephlometer) and was expressed in nephlometric turbidity units (NTU) [14]. Suspended solids were determined by using gravimetric method by passing the sample through a weighed filter paper Whatman No. 41 (pore size 1.25 µm) and drying the filter paper at 103°C for 24 hrs [15]. pH was also measured using pH meter (MT-103) before and after the addition of coagulant to wastewater [16]. Total volatile solids were also measured using gravimetric method [17]. Dissolved oxygen was measured with the help of Winkler's method [18]. For detection of BOD in the wastewater, 2.5 mL wastewater sample before and after the treatment was taken in BOD bottles of capacity 300 mL and diluted with dilution water prepared 24 hours prior. Besides that, another BOD bottle containing diluted water was kept as control. BOD bottles were incubated in incubator for 5 days at 20°C and their DO value were measured after 5 days [19].

III. RESULTS AND DISCUSSIONS

Jar test experiments that were performed for all the three forms of *M. oleifera* helped in the determination of optimum dosage. This was the dosage of coagulant corresponding to highest removal efficiency of turbidity, suspended solids, total volatile solids and BOD. In case of oiled seeds maximum turbidity removal efficiency i.e. 99.5% was achieved after applying dosage of 2 g. For de-oiled seeds maximum turbidity removal efficiency achieved was 99.2% at the applied dosage of 1 g. It was observed that both oiled and de-oiled seeds started inducing turbidity beyond the optimum dosage. The possible reason for this could be, due to cationic nature of *M. oleifera*. Increase in dosage will result in saturation of polymer bridge sites which will lead to reversal of charges and destabilized particles will stabilize again finally resulting in increased residual turbidity [1]. However, when leaves of *M. oleifera* applied as a coagulant no reduction in turbidity was observed. The possible reason for this could be the characteristic color which was imparted by leaves in sewage sample. Variation in turbidity removal at different dosages for seeds and leaves have been represented by figure 1.



(a) *(b)* (c)

Figure 1: Turbidity vs Dose variation for (a) Oiled seeds (b) De-oiled seeds and (c) leaves

Also, no alteration in pH values were noticed before and after addition of coagulant dosages to sewage sample. Almost same trend was observed in suspended solids removal as observed in case of turbidity removal. Removal efficiency of 96.7% was achieved in case of oiled seeds at an optimum dosage of 2 g as shown in. When supplemented with de-oiled seeds efficiency achieved was 96.4% at optimum dosage of 1 g. Beyond the optimum dosage efficiency of suspended solids removal was decreased in both the cases. The possible reason of this decrease can be explained by theory of charge neutralization as suspended solids are destabilised at optimum dosage but beyond the optimum dosage restabilization may have occurred resulting in the increase of suspended solids in the sewage sample. Another possible reason could be, beyond the optimum dosage oiled and de-oiled seeds themselves start acting as suspended solids in the sample. Also, when *M. oleifera* leaves were applied as a coagulant to sewage sample no reduction in the amount of suspended solids was noticed at any of the applies dosage.

When oiled *M. oleifera* seeds were applied to sewage sample, reduction up to 78.8% for total volatile solids was observed at an applied optimum dosage of 2 g. Reduction was up to 76.8% in case of de-oiled seeds at applied dosage of 1.5 g. It was observed that after increasing the dosage the removal efficiency did not increased in both the cases. The possible reason of this could be when *M. oleifera* seeds applied to the sewage sample sweep coagulation may have occurred. Flocs formed may have enmeshed the solid particles of small sizes present in suspension and resulted in the settlement. When leaves were applied to the domestic sewage sample no change in the values of total volatile solids was noticed at any of the applied dosage. When DO of sewage sample was checked, white precipitates were observed after addition of $MnSO_4$ and KI to the BOD bottle containing raw domestic sewage which indicated the absence of DO in sewage sample. Also, no change in DO was observed when the sewage sample was supplemented with the dosages of *M. oleifera* oiled seeds, de-oiled seeds and leaves.

After supplementing wastewater with the optimum dose of 1 g of oiled and de-oiled seeds a decrease in the DO initial values from 8.9 mg/L to 8.4 mg/L and 8.9 mg/L to 8.5 mg/L. Initial BOD value of sample was determined which came out to be 288 mg/L. When applied with the optimum dosage of 1 g a slight decrease in the BOD values from 288 mg/L to 252 mg/L in case of oiled seeds and from 288 mg/L to 240 mg/L in case of de-oiled seeds was observed, making it total percentage removal of 12.5% and 16.6% respectively. Decrease in DO levels may be because of presence of natural and organic compounds present in *M. oleifera* seeds. High level of BOD value has detrimental effects on the aquatic life therefore it is a good sign to observe the decrease in BOD values but the mode of action of *M. oleifera* seeds in decreasing BOD values is still ambiguous. When DO initial values were investigated for *M. oleifera* leaves it was found that dissolved oxygen which was present in sample got depleted instantaneously. After 5 days when BOD was measured for the samples increase in values was observed. The possible reason of increase in BOD values could be the leaves used in the study maybe acting as a biomass which is increasing the organic load in the sewage sample and ultimately resulting in higher oxygen demand. Variation in BOD after applying oiled seeds, de-oiled seeds and leaves have been shown in figure 2.

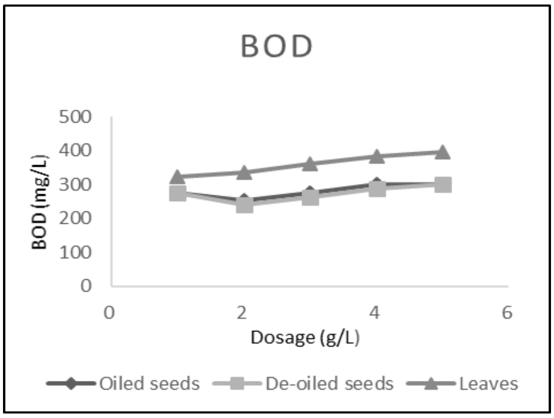


Figure 2: Variation in BOD after application of oiled, de-oiled seeds and leaves of *M. oleifera*.

IV. CONCLUSIONS

Three *M. oleifera* parts namely oiled seeds, de-oiled seeds and dried leaves of have used in the present study. Based on the experimental results of the study conducted following conclusions have been drawn.

- Among the three coagulants (leaves, oiled seeds and de-oiled seeds) that have been used in the present study, oiled and de-oiled seeds achieved maximum turbiditry removal efficieny of 99.5% and 99.2% at their repective optimum dosages of 2 g/L and 1 g/L.
- The variation in pH was minimal and the results proves that *M. oleifera* could be used as an effective coagulant as no post treatment will be required.
- The removal efficiency of oiled and de-oiled seeds in case of suspended solids has been observed as 96.7% and 96.4% at their respective optimum dosages of 2g/L and 1g/L.
- Removal efficiency for volatile solids has been achieved up to 78.8% and 76.8% from oiled and de-oiled seeds at the optimum dosages of 2 g/L and 1.5 g/L.

- The results were also encoraging when reduction in BOD was observed as 12.5% and 16.6% at optimum dose of 1 g/L for both oiled and de-oiled seeds.

The study has revealed that oiled seeds have maximum removal efficiency but the required dosage is also high as compared to de-oiled seeds. The potential of de-oiled seeds for wastewater treatment is promising although the removal efficiency is slightly lower than that of oiled seeds, but lesser dosage requirement and lower cost compensates this. However, results were discouraging in case of *M. oleifera* leaves as no positive results have been obtained after their supplementation to wastewater. The intend of using *M. oleifera* leaves was to determine their effect in wastewater treatment as none of the study have reported the direct use of *M. oleifera* leaves on wastewater treatment.
Despite the encouraging results for using *M. oleifera* to treat wastewater, the number of information gaps identified in this research area are significant. Therefore, systematic research should be carried out to provide insight into the interaction between phytochemical constituents of *M. oleifera* with constituents of wastewater.

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