RECOVERY OF MICROALGAL BIOMASS USING MORINGA OLEIFERA AS A LOW-COST BIOCOAGULANT

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ABSTRACT

This study reveals the influence of some physical and chemical parameters in the recovary process of microalgal biomass by coagulation and flocculation process using a natural coagulant, Moringa Oleifera (locally known as shojne in Bangladesh). It is locally available, cheap, non-toxic, and environmentally friendly. Moringa oleifera seeds were used as coagulant to remove microalgae cultured in photobioreactor (PBR). Jar-test has been carried out in order to evaluate the efficiency of this natural coagulant agent. The variables studied in this test were coagulant dose, mixing time and mixing rate. The dose was varied from 10 mg/L to 70 mg/L. It was observed that higher dose of moringa resulted in higher removal of microalgae. Mixing rate and mixing time also had significant impact on treatment. Low mixing rate and time gave more acceptable results. Highest 83% of microalgae was removed using 70mg/l of coagulant dose mixed at a rate of 20 rpm for 10 minutes. The optimum dose for Moringa Oliefera seeds as a coagulant was also determined.

Keywords: *Microalgae, Moringa oleifera, Coagulation, Recovery rate, Optimum dose.*

1. INTRODUCTION

Water is an unevenly distributed essential natural resource on our planet. Only 2.5% of global supplies of water is freshwater. From this amount, less than 1%, is easily accessible to the various uses for development (Yéwêgnon et al., 2016). Natural waterbodies like lakes and reservoirs & other surface water sources get affected by the eutrophication phenomenon frequently which, according to the definition of the Organisation for Economic Co-operation and Development (OECD), is an enrichment of nutrients in the water which leads generally to symptomatic changes such as increased algae production and other aquatic plants, degradation of fisheries and deterioration of water quality in general (Barrado-Moreno et al., 2016).

It is well known that microalgae have a huge potential for wastewater treatment as well as bioenergy (e.g. biofuel) production. Concerning environmental ones, microalgae can play an important role in bioremediation of wastewater and carbon dioxide sequestration. Furthermore, these photosynthetic microorganisms have been considered as a potential renewable energy source. Although microalgae have a huge application opportunity but the production is still not economically viable due to the difficulties of the separation process.

Mostly common used separation methods are filtration and centrifugation. For large microalgal cells, such as *Arthrospira sp.*(Papazi et al., 2010), filtration is effective. But for cells of smaller dimensions, it is not at all suitable. Again, by centrifugation, the separation of the microalgae can be done independent of size, although this process requirs high gravitational force by which cell structure can be damaged. A huge amount of energy is required in this method (Benemann and Oswald, 1996) which makes the process more costly (Knuckey et al., 2006). Moreover, the process is not very environmentally friendly (Walsby, 1995). Again, for wastewater treatment, usage of coagulants/flocculants is worldwide. A negative surface charge is always carried by the particles if the pH of water is around 5–9. As a result, the particles are colloidally stable and show resistant to aggregation. By adsorbing counter ions these particles are destabalized. Coagulent may be used for this purposes. Biological flocculants can be used as coagulents. They can interect with contaminents as they have bio macromolecular structures (Sharma et al., 2006). Hence, the use of natural coagulant would be an alternative solution. In this situation, *Moringa Oleifera* (locally known as shojne in Bangladesh) is a natural coagulant which can be used instead of chemical coagulants. Moreover, it is locally available, cheap, non-toxic, and environmentally friendly (Keogh et al., 2017).

The main objective of this reasearch is to analyze the efficieny of moringa oleifera as a naturant coagulant. Three basic parameters were choosen- coagulant dose, mixing rate & mixing time. By variation of this parameters in different condition, the influence of this parameters were observed. The optimum dose was also determined on the basis of highest recovary rate and efficiency of the system.

2. METHODOLOGY

The research method was mainly of three parts- 1) Microalgae culltivation & preparation of coagulant, 2) mixing the microalgae suspension & coagulant in jar test apparatus & 3) study the obtained result. The overall research methodology is presented in Figure 1 as a flowchart.

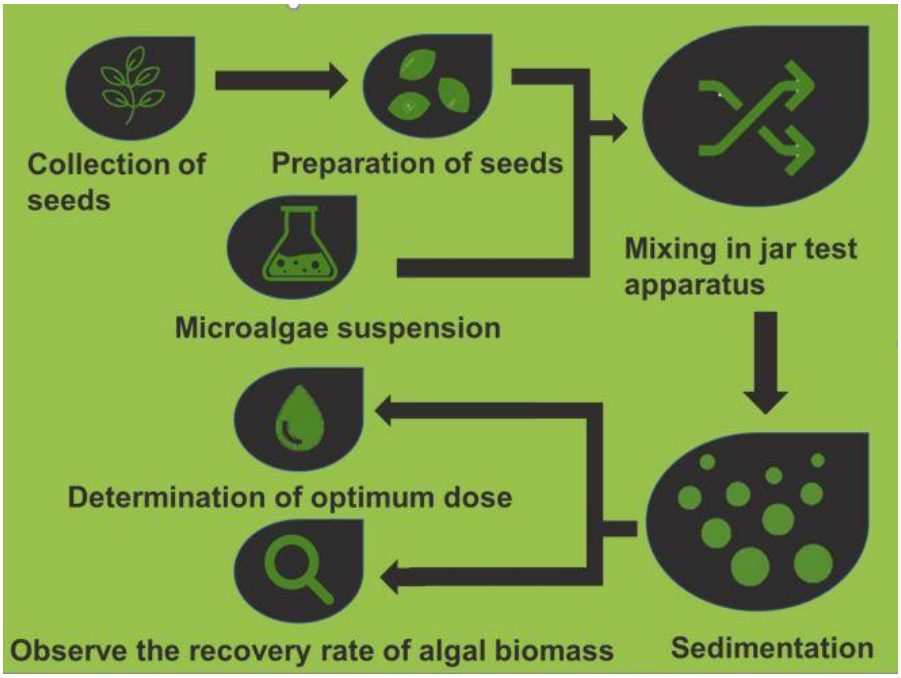

Figure 1: Research Methodology applied for using Moringa Oleifera as biocoagulant

2.1 Microalgae Cultivation

A photobioreactor (PBR) was used to produce microalgal biomass. It was constructed using locally available clear water container having capacity of 8L. For being transperant, it recieves more sunlight, which improves the microalgal growth. The reactor was seeded with Chlorella vulgaris as it has good tolerance in saline water. Moreover, the research area (Khulna) is located in costal zone with high salinity. An air pump was installed to supply CO2 in PBR for microalgae growth. The system was operated by a timer, which was programmed at 10 min/hr (at day) during the 8 day of cultivation period.

Figure 2 (a): Microalgae cultivation in photobioreactor (PBR)

2.2 Preparation of Coagulant

Moringa oleifera was collected from locally available trees. The seeds were separated and dried in natural sunlight for 3 days. After careful removal of seed coats and seed wings, the white kernels were reduced to powdered by a mechanical grinder. Then the powder were sequentially sieved through No #300 sieve in order to obtain the seed flour.

2.3 Jar Test

The experiment was carried out in nine batches, each batch containing five jars of microalgae suspension. the concentration of coagulant were 10, 25, 40, 55 & 70 mg/l in each batch. The suspension was mixed for three different time sets 10, 30, 50 mins in a mixing rate of 20, 60, 100 rpm. The sedimentation time and room temparature was constant, 30 min and 28 degree C respectively.
The microalgae removal efficiency was determined using the following equation:

$$Algae\ removal(\%) = [(Co - C_1)/Co] * 100$$

Where,
Co= Initial algae concentratrion
C_1= Final algae concentratrion

Figure 2 (b): Jar test

3. RESULTS & DISCUSSION

The variation of parameters has the following influence:

3.1 Dose

Coagulant dose was considered an important parameter for such research. From Fig: 1-6 we can see that the recovary rate increased with higher dose. For any mixing time & mixing rpm the rate of microalgae recovary is proportional to the coagulant dose. Which means higher dose of moringa oleifera will recover higher amount of microalgae.

3.2 Mixing Rate

Mixing rate can be an important parameter for an efficient treatment. For 10 mins mixing time (Fig 2), the inreasing rate of mixing had no significant impact on recovery rate. But for 30 & 50 mins mixing time, the removal rate reduced with higher rpm (Fig:3 & Fig:4). 60 & 100 rpm mixing rate resulted in similar resulted for higher mixing time (Fig: 3B, 3C, 4B, 4C). Best results obtained at 10 minutes mixing time at every mixing rate.

A B C

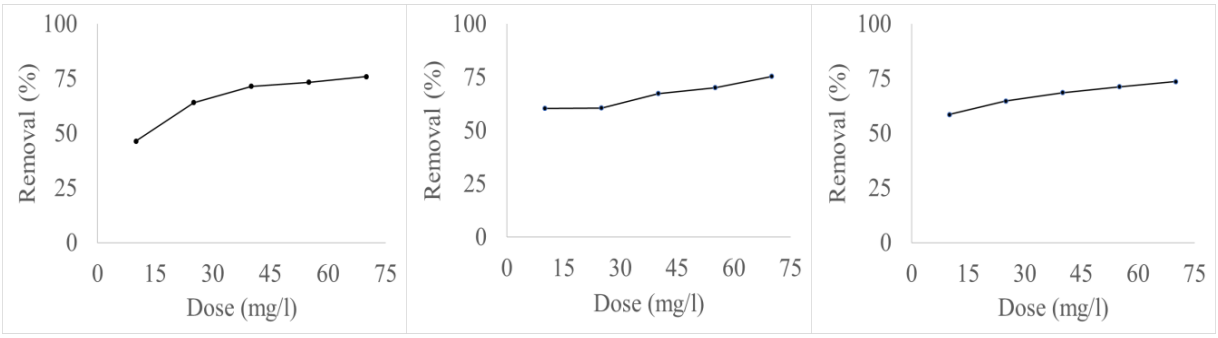

Figure 3: Influence of mixing rate for 10 min mixing time at (A)20rpm (B)60rpm (C)100rpm

A B C

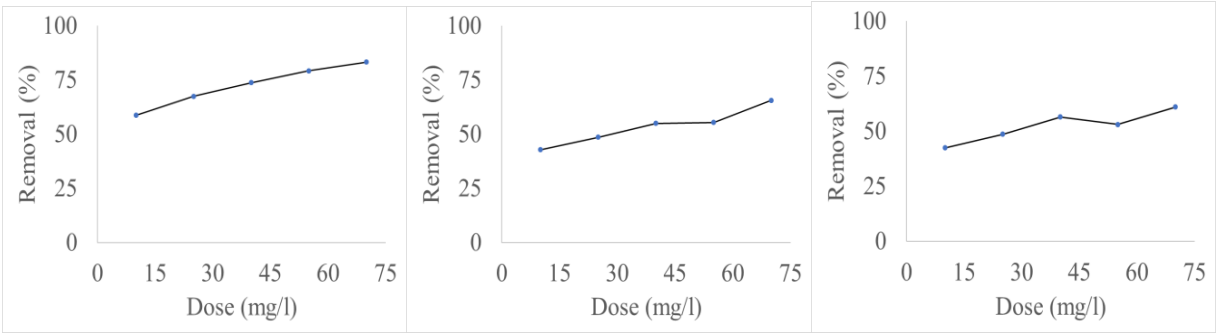

Figure 4: Influence of mixing rate for 30 min mixing time at (A)20rpm (B)60rpm (C)100rpm

A B C

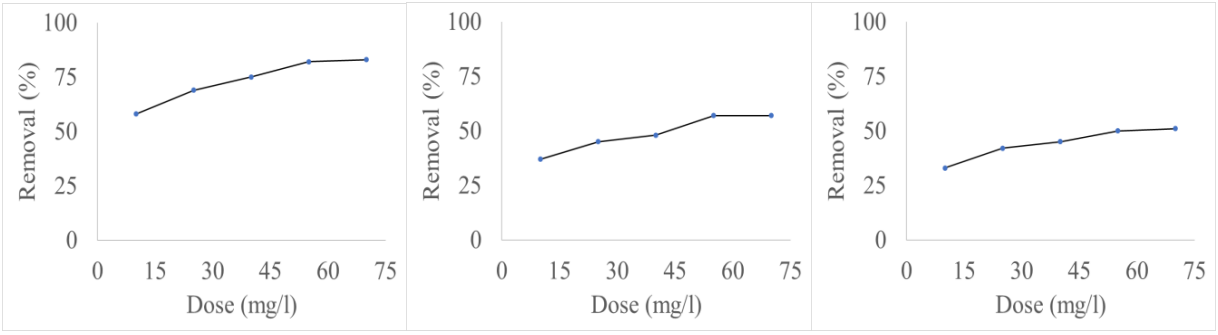

Figure 5: Influence of mixing rate for 30 min mixing time at (A)20rpm (B)60rpm (C)100rpm

3.3 Mixing Time: To evaluate the impact of mixing time, three mixing time was tested for three varyng mixing rate. As shown in the Fig: 4, 5 & 6, higher mixing time does not increase the removal rate. Rather low mixing time shows better results.

A B C

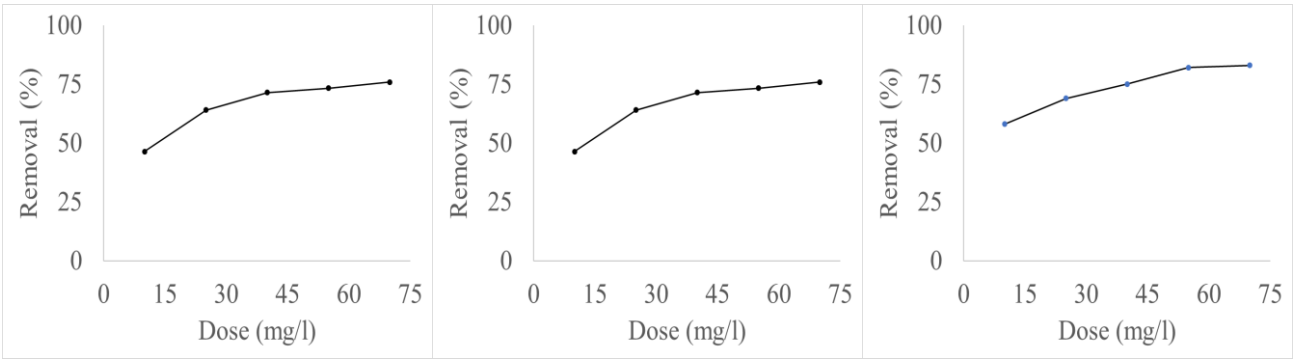

Figure 6: Influence of mixing time for 20 rpm mixing rate at (A)10 minutes (B)30 min (C)50 min

A B C

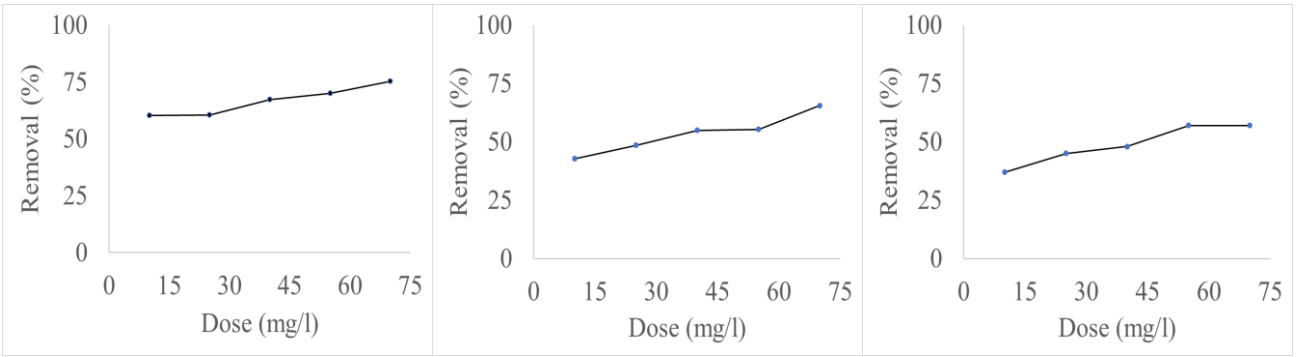

Figure 7: Influence of mixing time for 60 rpm mixing rate at (A)10 minutes (B)30 min (C)50 min

A B C

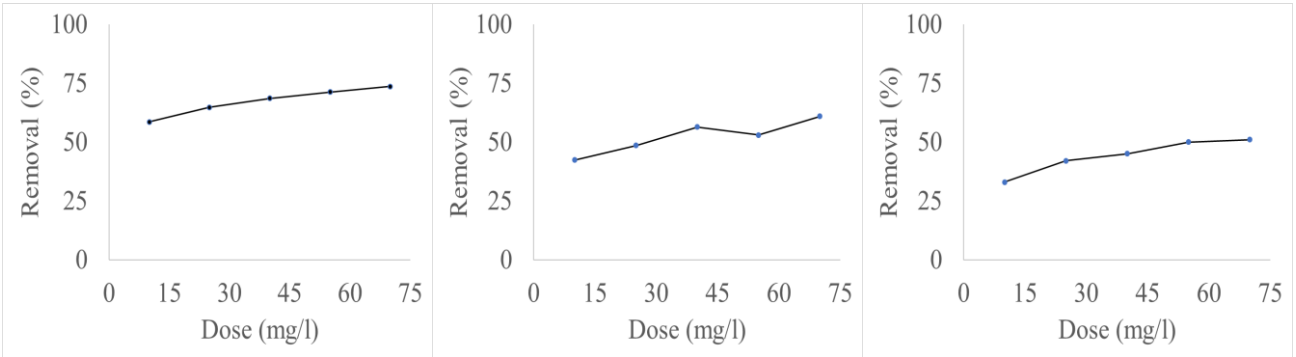

Figure 8: Influence of mixing time for 100 rpm mixing rate at (A)10 minutes (B)30 min (C)50 min

3.4 Optimum Dose

Higher dose of *moringa oleifera* resulted in higher removal rate. Mixing rate has no significant impact if the mixing time is low. But for higher mixing time, the mixing rate should be kept low to reach optimum. If the mixing time is low, any mixing rate can be choosed. But in case of higher mixing time, low mixing rate will give the best results.

4. CONCLUSIONS

The following conclusions were revealed from the present studies:
Coagulant dose has a positive impact on the microalgae removal rate. But higher dose of coagulant results in higher cost. In such circumstances higher mixing rate & lower mixing time can be adopted, where low dose of coagulant gives almost similar result as high ones. Low mixing time & mixing rate always had a positive impact with better economy.

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