Preliminary Study of Waste-Delivered Biosorbents to Remove Nutrients from Rice Mill Wastewater

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Abstract

The objective of this study was to compare the performance of waste derived biosorbents - rice hull and peanut hull in removing nutrients from rice mill wastewater. Batch adsorption experiments were conducted for both biosorbents separately for varying doses (0–6 g/L) and contact times (0–300 min) under uniform experimental conditions to determine the optimum dosage and optimum contact time respectively. The efficiencies of the biosorbents were tested in terms of removal (%) of nitrates and phosphates from wastewater. Results revealed, the rice hull and the peanut hull do significantly remove nutrients from the wastewater (p-value<0.05). The optimum doses of rice hull and peanut hull were 3 g/L and 4 g/L respectively, and the optimum contact time were 120 mins and 180 mins at their optimum doses and shaking of 150 rpm.

Keywords: **biosorbents, peanut hull, rice hull, rice mill, wastewater**

Introduction

In Sri Lanka, about 95% of the population consume rice as their staple food. The increase of population increases the number of Rice mills to supply rice to meet the demand. This resulted to the huge volumes of wastewater generated. The Rice mill wastewater contains high concentration of nutrients such as Nitrates and Phosphates. The direct discharge of the wastewater into the environment without treatment becomes challenging as this may cause several environmental issues (Pradhan and Sahu, 2004).

The similar studies have been reviewed that the biosorbents derived from sodium alginate seagrass *(Cymodocea rotundata)* beads effectively remove 62% of nitrates and 71% of phosphates from wastewater (Soumya *et al.,* 2015). The banana peel removes nearly 80% of nitrates from contaminated groundwater (Reddy, Prashanthi, Babu and Mahale, 2015).

Problem Statement

The Central Environmental Authority (CEA) emphasize the need of a proper wastewater treatment system for every Rice mill, however most of the Rice mill industries do not contain a proper effluent treatment system. This could be due to the lack of knowledge and the cost incurred for the construction of chemical treatment plant is not affordable.

This study was conducted to assess the use of waste derived bio sorbents to remove nutrients from the rice mill wastewater, as this treatment requires low maintenance, renders less toxic (Ahalya *et al.,* 2003) and cost effective (Shakoor *et al.,* 2016).

Materials and Methods

Materials

- Wastewater - Rice mill wastewater collected from one of the rice mills from Vavuniya was used as feed water for the experiments.
- Biosorbents – Peanut hulland Rice hull were collected from the local market in Vavuniya

Preparation of Biosorbents

The biomasses were washed with tap water and dried in shade at room temperature (28 ± 2°C) for 15 days to remove moisture. The dried biomasses were ground by using a kitchen blade grinder. The ground biomasses were washed with distilled water three times and again dried as mentioned above to remove moisture. Then, it was sieved by using a sieve with 1 mm pore size to obtain the uniform size of less than 1 mm, and stored in air tight containers for experiments.

Batch Adsorption Experiments

Batch adsorption experiments were conducted to determine the optimum doses and optimum contact time with the wastewater to achieve optimum removal.

Determination of Optimum Dose

Different dosages of peanut hull and rice hull biosorbents (0.5, 1, 2, 3, 4, 5, 6 g/L) were added into 250 ml glass-stoppered, Erlenmeyer flasks containing rice mill wastewater separately and they were placed on mechanical shaker at 150 rpm agitation speed for 4 hours contact time. The biosorbents with 0 g/L were considered as control for the experiments. Then the samples were filtered through Whatman grade 1 filter papers and the filtrates were analyzed for Nutrients and Phosphates. A plot was developed for the varying dosage (x-axis) against the removal of nutrients (y-axis), and the optimum dosage was determined by observing the trend of graph.

Determination of Optimum Contact Time

The optimum doses (as determined above) of peanut hull and rice hull were added into 07 Erlenmeyer flasks containing 250 ml of rice mill wastewater and were placed on mechanical orbital shaker at 150 rpm agitation speed. Samples were collected at different times as 5, 15, 30, 45, 60, 120, 180, 240 and 300 mins. The samples were filtered through Whatman grade 1 filter papers and were analyzed for Nitrates and Phosphates.

A plot was developed for the varying contact time (x-axis) against the removal of nutrients (y-axis), and the optimum contact time was determined by observing the trend of graph. Adsorption equilibrium time was considered as the optimum contact time as the contact time required for such biosorbents to absorb nutrients.

Laboratory analysis

Nitrate was determined by the Phenol Disulphonoic Acid method and the intensity of colour was determined by spectrophotometer (Jenway, Model: 6305, UK made) at 420 nm wave length. Phosphate concentrations were measured by Ammonium Molybdate-Ascorbic acid method and the absorbance was determined by spectrophotometer at 660 nm wave length.

Statistics Analysis

The efficiency of both biosorbents were analyzed ($\alpha = 0.05$, CI = 95%) using statistical method: Independent sample t-test was used to assess the influence of biosorbents in removing nutrients at chosen experimental conditions on Minitab 17.

H_O: The biosorbent does not influence on the removal of nutrients
H_1: The biosorbent does influence the removal of nutrients.

Results and Discussion

Characteristics of Rice Mill Wastewater

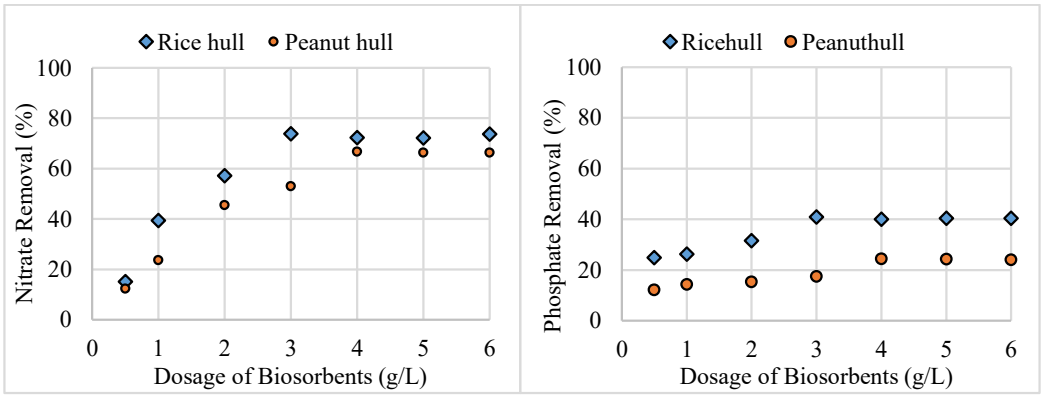
The detail characteristics are illustrated in the Table 01.

Table 01: Characteristics of Rice Mill Wastewater

No	Water Quality Parameters	Values
1	pH	8.0 ± 0.25
2	EC (mS/cm)	3.6 ± 0.36
3	Nitrate (ppm)	7.8 ± 0.48
4	Phosphate (ppm)	29 ± 1.4

Determination of the Optimum Dose of Adsorbents

As per the batch adsorption results shown below (Figure 1 (a) and (b)) that the optimum dose of Rice hull was noticed to be 3 g/L and the peanut hull be 4 g/L. The reductions of Nitrates (%) were 74% and 67% respectively for rice hull and peanut hull whilst the respective reductions of Phosphates (%) were nearly 41% and 24%.



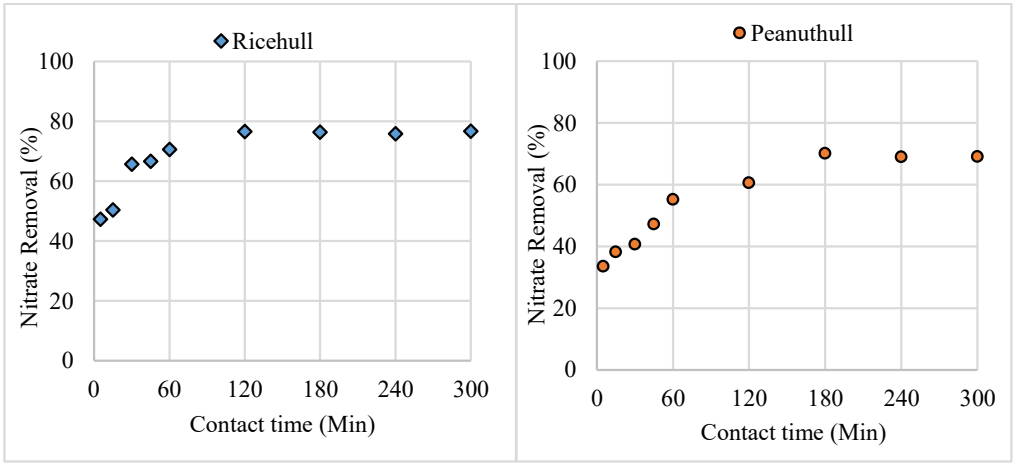
(a) (b)

Figure 1: Removal of Nutrients from Rice mill wastewater by Rice hull and Peanut hull [dosage 0-7 g/L; contact time of 4 hours at 150 rpm; Particle size <1 mm] (a) Nitrate Removal (b) Phosphate Removal.

The two-way t-test performed on Minitab 17 showed, there is a significant difference between the experiment and the control in terms of the reduction of Nitrates and Phosphates (p-value < 0.05). It reveals the rice hull and peanut hull are significantly removes nitrate and phosphate at its optimum doses from rice mill wastewater. Therefore, it rejects the null hypothesis and accepts the alternative hypothesis.

Determination of the Optimum Contact time

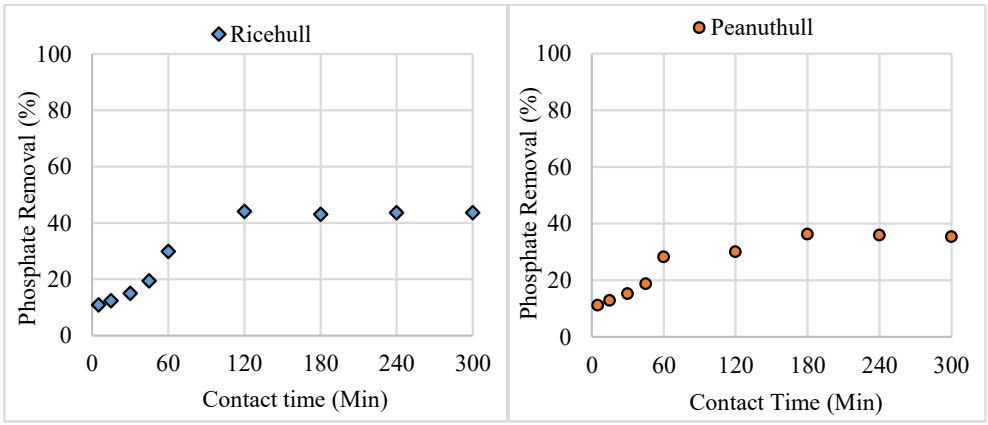
As shown below (Figure 2), the optimum removal of nitrate by the rice hull (3 g/L) and peanut hull (4 g/L) was observed at the contact time of 120 mins and 180 mins respectively. Beyond the limit, the removal reaches almost unchanged, could be due to the overlapping of adsorption sites as a result of over-crowding of adsorbent particles (Kumar & Kirthika, 2009).



(a) (b)

Figure 2: Nitrate Removal from Rice mill effluent by the biosorbents for different contact time (shaking: 150 rpm, Particle size < 1 mm), (a) Rice hull (3 g/L) (b) Peanut hull (4g/L).

In the context of the removal of phosphate, the optimum contact time of rice hull and peanut hull is noticed to be same as 120 mins and 180 mins at their optimum doses (Figure 3 (a) and (b)). As this preliminary study has been emphasized about the potential removals of nitrates and phosphates at the presence of waste-derived biosorbents in their optimum dosages and optimum contact times, further studies can be developed through models such as Langmuir and Freundlich.



(a) (b)

Figure 3: Phosphate Removal from Rice mill effluent by waste derived bio sorbents for different contact time (agitation speed: 150 rpm, Particle size < 1 mm), (a) Rice hull (3 g/L) (b) Peanut hull (4 g/L).

Conclusions

According to batch adsorption studies, the waste derived biosorbents - rice hull and peanut hull do significantly remove nutrients from rice mill wastewater. The optimum dose of rice hull and peanut hull were 3 g/L and 4 g/L respectively in terms of removing nitrate and phosphate at 150 rpm of agitation speed. The optimum contact time of rice hull and peanut hull were 120 mins and 180 mins at its optimum doses. As the results revealed on statistical test in two-way t-test, the rice hull and the peanut hull do significantly remove nutrients from the wastewater (p-value<0.05). The results showed that 77% of nitrates and 44% phosphates removals were obtained by the rice hull whilst 70% of nitrates and 36% of phosphates by peanut hulls at their optimum removals. Considering cost effectiveness as well as promoting waste to resource concept, the rice hull and peanut hull could be used as potential waste derived biosorbents to remove nitrate and phosphates from rice mill wastewater. This is a win-win eco-friendly approach in treating wastewater in order to safeguard the environment.

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