Treating rice mill effluent using waste rice hull

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Introduction

In Sri Lanka, about 95% of the population consume rice as their staple food. The increase of the population leads to an increment of the number of rice mills to meet the demand. This resulted in the generation of huge volumes of waste rice hull and effluent. Rice mill effluent contains high concentration of organics, inorganics and nutrients (especially nitrates and phosphates). The direct discharge of these effluents to the environment causes several environmental impacts. The standards and criteria for the discharge of industrial effluents set by the Central Environmental Authority (CEA) emphasizes the need of a proper wastewater treatment system for rice mills industries. The use of conventional treatment technologies in treating industrial wastewater has been extensively studied in previous researches. However, the recent researches focused on the development of non-conventional and low-cost adsorbents due to natural abundance, locally obtainable and non-toxicity.

Several researchers have found that the modified rice husk can be effectively used for the removal of heavy metals [1-3]. However, the researches on the utilization of rice husk to treat rice mill wastewater, in terms of removing organics and nutrients, are not extensively studied. Therefore, the aim of this study was to evaluate the performance of waste rice husk in removing organics and nutrients from rice mill effluent.

Methodology

1. Materials. Rice mill effluent, rice hull and granular activated carbon (Particle size ≤ 1mm).

2. Preparation of biosorbents. The rice hull was washed with tap water and dried under shade at room temperature (28 ± 2 °C) for 15 days to remove moisture. The dried rice hull was ground and again washed with distilled water three times and dried as mentioned above for 15 days. Then, the biomass was sieved through 1 mm pore size sieve and stored in air-tight containers.

3.Batch adsorption experiments. The experiments were conducted to estimate the removal efficiency of BOD, COD, nitrates and phosphates against the dosage and the contact time of adsorbents to determine optimum dosage and optimum contact time with the wastewater, respectively. The said experiments were done for rice hull and GAC under similar experimental conditions.

4. Effect of dosage of biosorbents. A varying dosages of rice hull (0.5, 1, 2, 3, 4, 5, 6 g/L) were added into 250 ml glass-stoppered, Erlenmeyer flasks containing rice mill wastewater and placed on mechanical shaker at 150 rpm agitation speed for 4 hours contact time. The treated water was filtered through Whatman grade 1 filter paper (pore size of 11 μm) and the filtrates were analyzed for BOD, COD, nitrates, and phosphates. A control experiment was done without biosorbent with the same wastewater under similar experimental conditions. The same experiment was conducted for GAC separately.

5. Effect of contact time of biosorbents in treating wastewater. A fixed amount of rice hull of 3 g/L was added into Erlenmeyer flasks containing 250 ml of rice mill wastewater and were placed in a mechanical orbital shaker at 150 rpm agitation speed. Samples were collected at different times as 5, 15, 30, 45, 60, 120, 180, 240, 300 minutes and immediately filtered through Whatman grade 1 filter papers and the filtrates were analyzed for the same parameters. The same experimental procedure was done for 1g/L GAC.

6. Data analysis. Paired t-test and 2-sample t-test were performed ($\alpha = 0.05$) on Minitab 17. Paired t-test was initially done to assess the efficiency of rice hull and GAC against untreated wastewater. Then, 2-sample t-test was done for rice hull and GAC to select better adsorbent.

Results and Discussion

Table 01. Characteristics of rice mill effluent.

Water quality parameters	Values
pH	8.0 ± 0.25
EC (mS/cm)	3.6 ± 0.36
TDS (ppm)	2275 ± 232.2
Nitrate (ppm)	7.8 ± 0.48
Phosphate (ppm)	29 ± 1.4
BOD_5 (ppm)	189 ± 6.7
COD (ppm)	627.5 ± 43

Effect of adsorbent dosage. The 3g/L of rice hull found to be optimum and removed BOD, COD, nitrate and phosphate 73%, 70%, 74% and 41% respectively whilst GAC, at its optimum dose of 1g/L removed the same 90%, 75%, 56% and 24% correspondingly.

Effect of adsorbent contact time. Rice hull (3g/L) showed optimum removals at 120 minutes contact time where as in GAC (1g/L) showed 45 minutes.

Accordingly, rice hull removed BOD, COD, nitrate, and phosphate respectively as 80%, 69%, 77% and 44% whereas GAC showed 95%, 73%, 58% and 26%.

The paired t-test showed that the rice hull and the GAC significantly remove BOD, COD, and phosphates, while rice hull showed significant removal of nitrates than GAC from the rice mill wastewater (p-value <0.05) at $\alpha = 0.05$. As per the results of two sample t-test, there is no significant difference between rice hull and GAC in terms of removing contaminants except BOD.

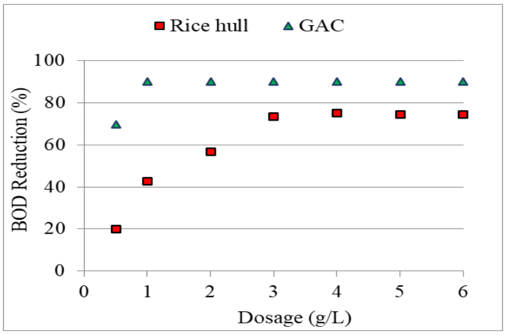

Figure 1. Reduction of BOD (%) from rice-mill wastewater by Rice hull and GAC (dose ranging 0-7 g/L, 4 hr contact time at 150 rpm, < 1 mm particle size).

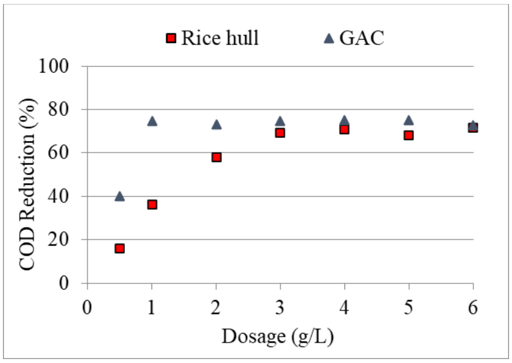

Figure 2. Reduction of COD (%) from rice-mill wastewater by Rice hull and GAC (dose ranging 0-7 g/L, 4 hr contact time at 150 rpm, < 1 mm particle size).

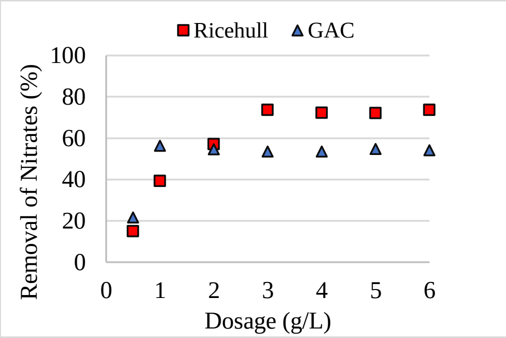

Figure 3. Reduction of Nitrates (%) from rice-mill wastewater by Rice hull and GAC (dose ranging 0-7 g/L, 4 hr contact time at 150 rpm, < 1 mm particle size).

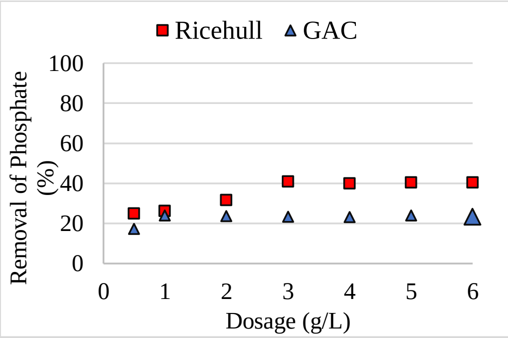

Figure 4. Reduction of Phosphates (%) from rice-mill wastewater by Rice hull and GAC (dose ranging 0-7 g/L, 4 hr contact time at 150 rpm, < 1 mm particle size).

Conclusion

The optimum dosage of rice hull and GAC were 3 g/L and 1 g/L, respectively, at 4-hour contact time and 150 rpm agitation speed (particle size < 1mm) and the optimum contact time were 120 mins and 45 mins. The rice hull and GAC are effective in removing organics from rice mill effluent, however GAC is more efficient in removing organics whilst rice hull is effective in removing nutrients. Therefore, considering cost effectiveness as well as promoting waste to resource concept, waste rice hull can be used as potential biosorbent for a win-win approach to adapt cleaner production techniques in rice mill industries.

References

[1] Vieira, M., Ambrósio, N., Silva, M., Candice, C., Antonio, F., Adsorption of lead and copper ions from aqueous effluents on rice hull ash in a dynamic system, Brazilian Journal of Chemical Engineering, 2014. 31: pp. 519-529.

[2] Ahmaruzzaman, M., Gupta, V.K., Rice hull and its ash as low-cost adsorbents in water and wastewater treatment, Industrial & Engineering Chemistry Research, 2011. 50(24): pp.13589-13613.

[3] Chandrasekhar, S., Pramada, P.N., Rice hull ash as an adsorbent for methylene blue-effect of ashing temperature, Adsorption, 2006. p.12.