*2014 5th International Conference on Food Engineering and Biotechnology*
*IPCBEE vol.65 (2014) © (2014) IACSIT Press, Singapore*
*DOI: 10.7763/IPCBEE. 2014. V65. 3*

# Treatment Comparison Efficiency of Microbial Amended Agro-waste Biochar Constructed Wetlands for Reactive Black Textile Dye

Beenish Saba[1,2+], Madeeha Jabeen [2], Tariq Mahmood[2] and Irfan Aziz[3]

[1]Department of Civil and Environmental Engineering and Geodetic Science, The Ohio State University Columbus Ohio, USA

[2]Department of Environmental Sciences

[3]Department of Agronomy, PMAS Arid Agriculture University Rawalpindi

**Abstract.** Textile effluents are chief industrial polluters because of color content, salts and high chemical oxygen demand. The intensive release of dyes leads to diffuse contamination of non target environments. For instance contamination of ground water, nearby irrigation land and surface water bodies threaten human, animals and plants health. The primary objective of this study is to explore potential of rice husk as an agricultural waste and biochar of rice husk as natural adsorbent to sorb color from effluent and efficiency of constructed wetlands (CWs) in dye contaminated water treatment. The experiment was divided into four levels. Study 1 was a lab scale study in which we study the adsorption of reactive black dye on rice husk and biochar. Study 2 was done to determine comparative dye removal in constructed wetland system. Study 3 was done to evaluate the dye removal ability of Ks-23, Ks-26 and I-15 in laboratory. Study 4 was taken in constructed wetland for evaluating the microbial assisted dye removal efficiency of the system.The results of study reveal that there was significant reduction in COD of the systems leading up to 40% to 50% with maximum reduction in constructed wetland containing microbes and biochar as medium. Color is the major problem regarding wastewater textile effluents. A considerable color reduction was observed in CWs. The color removal increases with the passage of time. 70% to 90% color removal was observed in this study with an HRT of 30.24hours. A strong negative correlation was observed between COD and color removal. Maximum removal was observed at the end of the two months duration. Rice husk system has a COD of 95 mg/L with 78.74% color removal (-0.36359) compared to 93mg/L COD and 75% color removal (-0.56083) in Biochar system. Similar trend was observed in systems containing microbes along with rice husk and biochar. Ricehusk+ks-23 have a COD of 373mg/L with 90.069% color removal (-0.6652) and biochar+ks-23 have 358mg/L COD and 94.062% color removal (-0.85642).

**Keywords:** rice husk, constructed wetlands, reactive black, dye removal

## 1. Introduction

Industrial activities are releasing a number of hazardous chemical species polluting wastewater effluents. Dyes must be treated as they account for the most part of perilous chemical present in industrial effluents lessening light penetration, hence disturbing the photosynthetic activity and biological processes of aqueous flora [1]. The technologies available for dye removal such as physicochemical and biological are very expensive and resulted in sludge formation which cause secondary pollution. Adsorption is the most appropriate and proficient method for dye removal in effluents [2]-[4]. A significant role was played by phytoremediation in contaminant removal through filtration, adsorption, cation exchange, and throughout plant-induced chemical transformations in rhizosphere [5]. Plants generally have optimistic outcome on decontamination and play a promising role in CWs [6]. Rice husk is a key agricultural waste throughout the world; therefore its appropriate management is very indispensable to lessen its effect on environment. Rice

[+] Corresponding Author: Tel.: +92-51-9290757; fax: +92-51-9290160.
*E-mail address*: beenishsaba@uaar.edu.pk

husk, rice bran and rice ash was used to destroy a number of dyes including methylene blue [3], crystal violet [7], Brilliant Vital Red [8], Direct Red-31 and Direct Orange-26 [9] and Congo red [10]. So a combination of microbes, plants and constructed wetland would establish itself as an efficient system.

The objectives of the study will be as follows.

1. To compare rice husk media and biochar on treatment of wastewater.
2. To evaluate adsorption, removal and degradation of the dye related contaminants
3. To assess dye removal efficiency at different level of studies
4. To reuse the treated wastewater for irrigation purpose

## 2. Materials and Methods

In this study two systems of wetland were constructed and assigned as system 1 and 2. System 1 consisted of mixture of soil and ricehusk in 1:1 and system 2 contained of soil and biochar of ricehusk in the same ratio. Wetland encompassed of plastic boxes with a height and volume of 28cm and 15.12L respectively. *Prescaria barbata* was planted in both systems and acclimatize with water before application of synthetic dye wastewater. Plant density in both systems was 12 plants/system. The graduated influent container was positioned at height of 1 foot above these systems. The treated wastewater was collected in another container with a capacity of 10 liters. Wetland (system 1) was constructed with horizontal layer of gravel at the bottom, mixture of soil and ricehusk (1:1) as the main substratum and then again covers with fine gravel at the top. System 2 was also constructed in the same way having soil and biochar of ricehusk. Soil and ricehusk was sieved with a mesh size of 0.5 mm. Effluent samples were taken on every tenth day; on twelfth hour when dye wastewater was fed to the systems. Water samples are collected in plastic bottles and transferred to laboratory and kept at 4 ℃.

## 3. Result and Discussion

This study was conducted to determine the degradation of synthetic dye wastewater by using constructed wetland system comprising of ricehusk and its biochar as a substratum. The COD of the influent was 167mg/L which was greatly reduced to 95mg/L in case of rice husk and 93mg/L in case of biochar. A significant reduction of COD was observed in the constructed wetland systems with the passage of time till end of two months ($P<0.000014$). Similarly the COD of the influent and yeast was 672mg/L which was decreased up to 373mg/L in case of inoculated ricehusk wetland and 358mg/L in inoculated biochar system. A negative gradient was observed with the passage of time ($p<0.006$). There was significant reduction in COD of the systems leading up to 40 percent to 50 percent with maximum reduction in constructed wetland containing microbes and biochar as medium (figure 1).

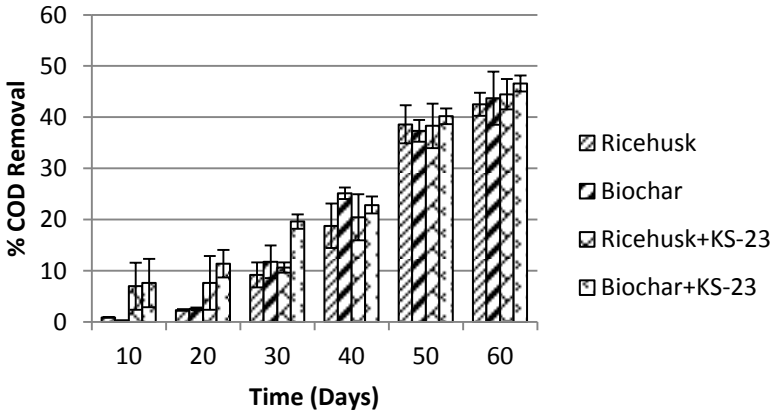


Fig. 1: Comparison of percent COD removal of the systems

Color is the major problem regarding wastewater textile effluents. A considerable colour reduction was also observed in CWs. The color removal increases with the passage of time. 70 percent to 90 percent color removal was observed in this study with an HRT of 30.24 hours (figure 2) with maximum colour removal was observed in biochar system assisted with KS-23. [11] also noted that the decolorization of Reactive Black was maximum by bacterial strains at 250 mg/L dye liquid medium when yeast extract was applied at the rate of 0.4 percent as a cosubstrate.

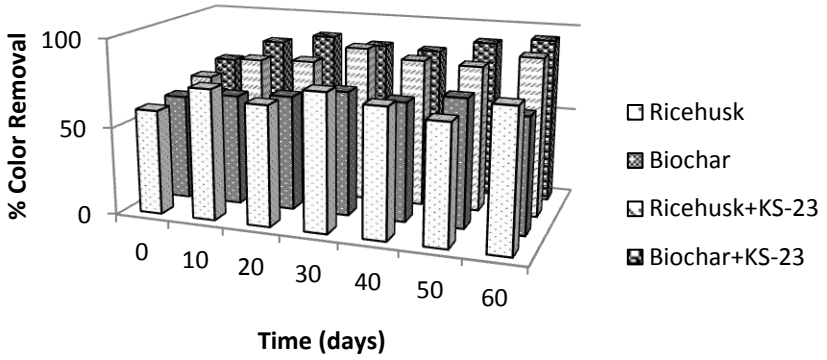


Fig. 2: Colour removal rate of the four CWs at different time interval

A strong negative correlation was observed between COD and color removal in all the four systems (figure 3). Maximum removal was observed at the end of the two months duration. Rice husk system has a COD of 95mg/L with 78.74 percent color removal (-0.36359) compared to 93mg/L COD and 75percent color removal (-0.56083) in Biochar system. Similar trend was observed in systems containing microbes along with ricehusk and biochar. Ricehusk+ks-23 have a COD of 373mg/L with 90.069 percent color removal (-0.6652) and biochar+ks-23 have 358mg/L COD and 94.062 percent color removal (-0.85642). In another study maximum decolorization of Reactive Black was 80 to 100 percent in 24 hours by using selected strains of bacteria at 250 mg/L dye concentration assisted with 4 g/L yeast [12]. Another study showed a great COD reduction up to 88 percent when a combination of bacterial communities was used as compared to 36 percent and 48 percent for individual strains. He also analyzed that the consortium could nearly completely mineralize the dye with nontoxic residual metabolites evaluated by phyto toxicity and microbial toxicity tests. The Consortium was tested to decolorize and mineralize mixture of reactive dyes and actual dye wastewater shows significant efficiency in the color removal as well as the reduction of TOC and COD. The ability of consortium to utilize cheap cosubstrate such as rice husk and rice straw for dye decolorization represents an advantage for treatment of textile industry wastewaters [13].

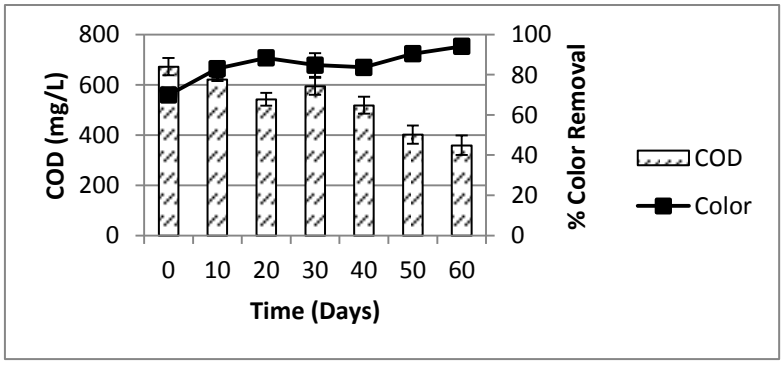


Fig. 3: Comparison of COD and colour removal in effluents obtained from CW system containing Biochar+KS-23

The following conclusion can be drawn from this study:

- The dye removal rate is directly affected by pH, adsorbent dose, contact time, agitation rate and initial dye concentration.
- Highest efficiency was observed in a system containing microbes and biochar with 90 percent colour removal.
- A strong negative correlation was observed between COD and colour removal for all the systems.

## 4. References


[1] Y. S. Al-Degs, M. I. El-Barghouthi, A. H. El-Sheikh and G. M. Walker. 2008. Effect of solution pH, ionic strength, and temperature on adsorption behavior of reactive dyes on activated carbon. *Dyes Pigments*, 77(1): 16-23.

[2] M. Anbia, and S. Salehi. 2012. Removal of acid dyes from aqueous media by adsorption onto amino-functionalized nanoporous silica SBA-3. *Dyes Pigments*, 94(1): 1-9.

[3] M. N. Ashiq, M. Najam-Ul-Haq, T. Amanat, A. Saba, A. M. Qureshi and M. Nadeem. 2012. Removal of methylene blue from aqueous solution using acid/base treated rice husk as an adsorbent. *Desalination Water Treatment*, 49(1-3): 376-383.

[4] W. Zhang, H. Yang, L. Dong, H. Yan, H. Li, Z. Jiang, X. Kan, A. Li and R. Cheng. 2012. Efficient removal of both cationic and anionic dyes from aqueous solutions using a novel amphoteric straw-based adsorbent. Carbohydrate Polymers.

[5] J. Nouri, N. Khorasani, B. Lorestani, M. Karami, A. Hassani and N. Yousefi. 2009. Accumulation of heavy metals in soil and uptake by plant species with phytoremediation potential. *Environmental Earth Sciences*, 59(2): 315-323.

[6] L. Kong, Y. B. Wang, L. N. Zhao and Z. H. Chen. 2009. Enzyme and root activities in surface-flow constructed wetlands. *Chemosphere*, 76(5): 601-608.

[7] T. Depci, A. R. Kul, Y. Onal, E. Disli, S. Alkan, Z. F. Tukmenoglu, 2012. Adsorption of crystal violet from aqueous solution on activated carbon derived from gölbaşi lignite. *Physicochemical Problems in Mineral Processing*, 48(1): 253-270

[8] R. Rehman, J. Anwar, T. Mahmud, M. Salman and U. Shafique. 2011a. Influence of Operating Conditions on the Removal of Brilliant Vital Red Dye from Aqueous Media by Biosorption using Rice Husk. J. Chem. Soc. Pak., 33(4): 515.

[9] Y. Safa, and H. N. Bhatti. 2011. Kinetic and thermodynamic modeling for the removal of Direct Red-31 and Direct Orange-26 dyes from aqueous solutions by rice husk. *Desalination*, 272(1): 313-322.

[10] X. S. Wang, and J. P. Chen. 2009. Biosorption of Congo Red from Aqueous Solution using Wheat Bran and Rice Bran: Batch Studies. *Separation Science and Technology*, 44(6): 1452-1466.

[11] D. Mahne, 2012. Combination of constructed wetland and TiO2 photocatalysis for textile wastewater treatment. Unpublished Doctoral Thesis. Univerza v Novi Gorici, podiplomski študij.

[12] M. Shah, K. Patel, S. Nair and A. Darji. 2013. Optimization of Environmental Parameters on Microbial Degradation of Reactive Black Dye. J. Bioremed. *Biodeg*, 4(183): 2.

[13] R. Saratale, G. Saratale, J. Chang, and S. Govindwar. 2010. Decolorization and biodegradation of reactive dyes and dye wastewater by a developed bacterial consortium. *Biodegradation*, 21(6): 999-1015.