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Equilibrium Studies on Sorption of Basic Fuchsin Dye Using Living Biomass of *Aspergillus niger* and *Humicola grisea*

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Abstract:

Textile effluents are among the most difficult to treat wastewaters, due to their considerable amount of recalcitrant and toxic substances. Fungal biosorption is viewed as a valuable additional treatment for removing pollutants from textile wastewaters. In the present study fungal biomass of *Aspergillus niger* and *Humicola grisea* were used for the biosorption of basic fuchsin dye from aqueous solutions. The maximum biosorption percentage of 46.09% and 32.66% were observed at 100 ppm concentration of dye by *Aspergillus niger* and *Humicola grisea*, respectively. The biosorption capacity of basic fuchsin dye by *Aspergillus niger* biomass was more efficient than the biomass of *Humicola grisea*. Adsorption of dye by *Aspergillus niger* followed Langmuir isotherm model while by *Humicola grisea* followed Freundlich isotherm model.

***Keywords*:** Textile wastewaters, biosorption, basic fuchsin dye, fungal biomass, adsorption isotherms.

INTRODUCTION

The textile industry worldwide has witnessed tremendous growth over the years in the use of synthetic dyes (Pandey *et al*., 2007). This however comes with attendant increase in pollution from wastewater disposal. Indiscriminate discharge of synthetic dyes as industrial effluents constitutes pollutant menace in our environment (Eichlerova *et al*., 2006). Pollutants indiscriminately discharged into our environment poses great threat to the survival of flora and fauna in the ecosystem. Textile dyes makes significant portion of textile effluent and municipal sewages in most developing nations (Khandare *et al*., 2013).

The dyestuffs discharge into water bodies reduces water transparency and thus the dissolved oxygen concentration, affecting aerobic organisms (Vijayaraghavan *et al*., 2008). The presence of dyes or their degradation products in water, even at very low concentrations, can also cause human health disorders (Oliveira *et al*., 2007). Dyes have been known as toxic, teratogenic, carcinogenic, mutagenic and allergic (Gunturu *et al*., 2018).Dyes in the environment are always difficult to degrade or decolorize by many known chemical and physical methods. Dyes complex chemical structure confers on them the ability to remain stable/recalcitrant to degradation in water and soil (Rane *et al*., 2014). To quench the negative effect of dye pollutant, there is a need for the development and application of ecofriendly biological treatment techniques.

Biosorption can be seen as one of the most valuable choice for the removal of pollutants from wastewaters. Biosorption is a physico-chemical process, defined as the removal of substances from solution by biological material. The main purpose of biosorption is the high efficiency, cost effectiveness and good capacity of removing pollutants from large volumes (Gadd, 2009).Fungal biomass proved to be suitable biosorbents, due to chemical and physical characteristics of their cell wall, which might be exploited in the binding of different pollutants. In addition, they easily grow and produce high yields of biomass on different sources with low nutritional requirements and biomass separation from the growth liquid medium constitutes a simple operation (Kaushik and Malik, 2009).There are various fungi, such as *Aspergillus niger*, *Aspergillus terreus*, *Rhizopus arrhizus*, *Rhizopus oryzae*, *Penicillium* sp., *Trichoderma harzianum* and *Haematonectria haematococca*, which can also remove diverse dyes through biosorption (Zhou and Banks, 1991; Gallagher *et al*., 1997; Fu and Viraraghavan, 2000, 2001, 2002b; O'Mahony *et al*., 2002; Yang *et al*., 2011; Almeida and Corso, 2014).

Adsorption of dyes by living and dead fungal biomass is dependent on dye properties, such as molecular structure and type or the number and position of substituent's in the dye molecule (Reife and Freeman, 1996). However, decolorization with active biomass provides better results, most likely due to the parallel dye compound removal (Aretxage *et al*., 2001).

The aim of this study was to evaluate the sorption capacity of living biomass of *Aspergillus niger* and *Humicola grisea* for basic fuchsin dye. Freundlich and Langmuir isotherm models were used for the evaluation of biosorption equilibrium data.

MATERIALS AND METHODS

Isolation and identification of fungal strains: *Aspergillus niger* and *Humicola grisea* were isolated from soil collected from dye polluted sites of Partapur Industrial Area, Meerut and the identification of the fungal species was done on the basis of their morphology and cultural characteristics following Gilman (1957), Ellis (1971) and Nagamani *et al*. (2006). The fungal cultures were maintained on Potato Dextrose Agar (PDA) plates.

Preparation of fungal biomass: A liquid growth medium was prepared, composed of 3g Malt extract, 10g Glucose, 3g Yeast extract and 5g Peptone in one liter of distilled water. After autoclaving and cooling, the medium containing flasks were inoculated with the fungal spores of *Aspergillus niger* and *Humicola grisea* and then placed in a rotary shaker for 10 days at 27±1°Con 150 rpm rotation speed. After 10 days of incubation, the obtained biomass was filtered, well washed with distilled water and finally dried in an oven at 55°C, dried biomass crushed using a mortar and pestle and used as biosorbent for biosorption studies.

Biosorption of Basic Fuchsin Dye: Biosorption experiments were performed in 250 ml Erlenmeyer flasks by using 10 mg biomass of *Aspergillus niger* and *Humicola grisea* for 100 ml solutions of 50ppm, 100ppm, 200ppm and 400ppm concentrations of basic fuchsin dye in triplicates and a repetition without the fungal biomass was used as control. Thesamples were placed on shaker at constant speed of 150 rpm at room temperature. After the treatment time of 10 minutes, samples were sieved and the supernatants were analyzed to determine the concentrations of remained dye in solution using visible spectrophotometer at 550 nm wavelength. The amounts of basic fuchsin dye biosorbed onto biomass were calculated using the following equation: $Qe = (C_i\text{-}Cf)V/W$, Where, C_i was initial dye concentration, C_f was final concentration of dye in solution, W is the weight of biomass and V is the volume of dye solution (Santhi and Manonmani, 2009).

Isothermic model to dye sorption: The Langmuir equation is expressed by the following relation (Langmuir, 1918):

$$1/q_e = 1/K_a q_m C_e + 1/q_e$$

where, q_e is the amount of dye adsorbed at equilibrium time (mg/g), C_e is the equilibrium concentration of dye in solution (mg/L), q_m is the maximum adsorption capacity (mg/g) and K_a is the isotherm constants for Langmuir (L mg^{-1}).

The Freundlich adsorption isotherm model is represented as follows (Freundlich, 1906):

$$\ln q_e = \ln K_f + 1/n (\ln C_e)$$

where, q_e is the amount of metal ion adsorbed at equilibrium time(mg/g), C_e is the equilibrium concentration of dye in solution (mg/L),K_f is the capacity of the adsorbent and n is the intensity of adsorption constant for Freundlich. The plot of ln q_e versus lnC_e is employed to determine the K_f and n from intercept and slope respectively. Generally, the value of the linear regression coefficient R^2 gives an indication to which model can be chosen to give the best-fit.

RESULTS AND DISCUSSION

Comparison of Biosorption Capacity of *Aspergillus niger* and *Humicola grisea*:

Different concentrations of basic fuchsin dye were prepared to determine their influence on biosorption capacity of *Aspergillus niger* and *Humicola grisea*.Biosorption percentage of basic fuchsin dye increases from 23.26% and 22.52% to 46.09% and 32.66%, respectively by both fungal biomasses with an increasing dye concentration from 50ppm to 100ppm but increasing dye concentration from 100ppm to 200ppm decrease in biosorption percentage of dye from 46.09% and 32.66% to 14.13% and 29.5% was observed, respectively. Further increasing dye concentration from 200ppm to 400ppm led to further increase in biosorption percentage of dye from 14.13% and 29.5% to 35.31% and 31.25%, respectively by both fungal biomass *i.e. Aspergillu sniger* and *Humicol agrisea*. Maximum biosorption upto 46.09% and 32.66% for *Aspergillus niger* and *Humicola grisea* were recorded, respectively (Fig. 1). It was found that the biosorption performance of *Aspergillus niger* biomass was better than *Humicol agrisea* fungal biomass. The specific uptake of basic fuchsin dye was maximum obtained through living biomass of *A. niger* in comparison to *H. grisea* at all the studied dye concentrations but exceptionally, it was found almost double through living biomass of *H. grisea* biomass in comparison to *A. niger* biomass at 200 ppm dye concentration (Fig. 2).

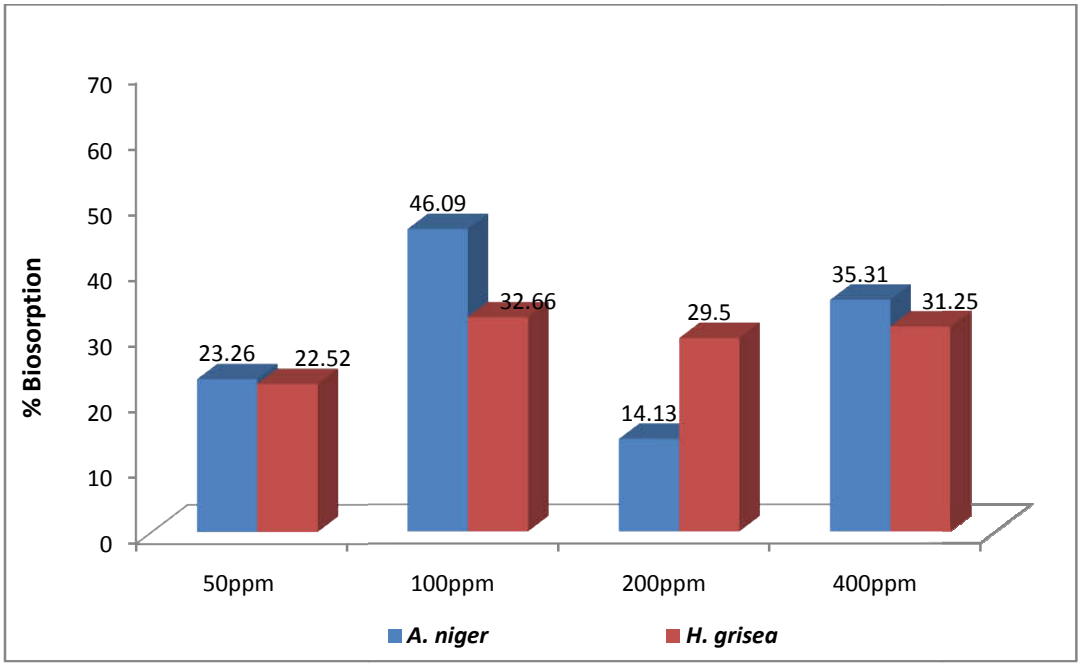

Figure 1: Percentage biosorption of basic fuchsin dye by living biomass of *Aspergillu sniger* and *Humicola grisea*

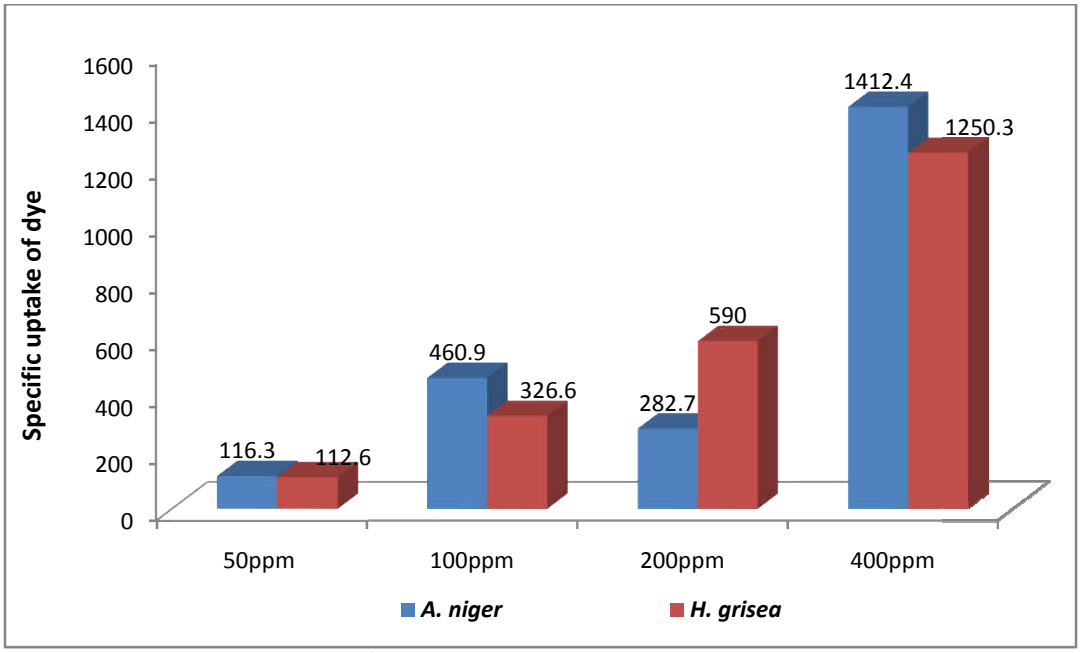

Figure 2: Specific uptake (Q-value) of basic fuchsin dye by living biomass of *Aspergillus niger* and *Humicola grisea*

The mycelium ability to absorb synthetic dyes and other colored compounds found in industrial sewage, dyestuff and pulp or paper mills has been indicated by many authors (Anastasi *et al*., 2009; Karthikeyan *et al*., 2009; Sadhasivam *et al*., 2010; Grainger *et al*., 2011). Living biomass of *Aspergillus niger*, *A. lentulus*, *A. fumigatus, Trichoderna harzianum*, *Fusarium* sp., *Penicillium* sp., *H. haematococca*, *Peyronellaea prosopidis* should be particularly considered as effective sorbents of dye substances (Fu and Viraraghavan, 2000; Sadhasivam *et al*., 2005, 2007; Seyis and Subasioglu, 2008; Xin *et al*., 2010; Yang *et al*., 2011; Rybczynska-Tkaczyk and Kornillowicz-Kowalska, 2016; Mathur *et al*., 2018; Bankole *et al*., 2018).

The effect of the initial dye concentration on biosorption depends upon the interaction between the dye molecules and binding sites available on the surface of biomass. Khan *et al*. (2009) observed an increase in the adsorption of methylene blue, malachite green and rhodamine B with increase in their initial concentration in the solution. Bulut *et al*. (2006) believed that at a low concentration there will be unoccupied active sites on the adsorbent surface and an increase in initial concentration will cause an increase in the loaded capacity in the adsorbent. Acemioglu *et al*. (2010) showed that when increasing the concentration of methylene blue (MB) from 4 to 16 mg/L, the maximum amount of dye biosorbed by *A. wentii* increases from 1.48 to 6.38 mg/g and the augmentation of the concentration leads to an increase in the amount of methylene blue (MB) biosorbed by *A. fumigates* from 1.56 to 5.92 mg/g.

Bisorption isotherms:

The adsorption isotherms are important in describing how solutes interact with adsorbents, and is critical in optimizing the use of adsorbents (Tan *et al*., 2008). The Langmuir adsorption isotherm has been successfully applied to many sorption processes of monolayer adsorption. The model depends on the assumption that intermolecular forces decrease rapidly with distance and consequently predicts the existence of monolayer coverage of the adsorbate at the outer surface of the adsorbent (El-Geundi *et al*., 2012). The Freundlich equation is an empirical equation employed to describe heterogeneous systems and reversible adsorption (Chan *et al*., 2008).

Based on the value of regression factor (R^2), the best fit isotherm model was determined (Table 1). It was inferred that in case of *A. niger* biomass, the adsorption fit well with the Langmuir model with high regression factor (R^2) of 0.596 than Freundlich model with 0.546 R^2 value (Fig. 3-4) and in case of

H. grisea biomass the adsorption fit well with the Freundlich model with high regression factor of 0.969 than Langmuir model with 0.951 R^2 value (Fig. 5-6). However, *H. grisea* showed better regression factor for both the tested models in comparison to *A. niger* (Table 1).

de Castro (2017) revealed that waste beer yeast slurry can be used as biosorbent to remove three anionic textile dyes (RR239, RBB, DB85) from aqueous solution and the biosorption equilibrium was well described by the Langmuir model. Souza *et al*. (2018) was studied the biosorption of reactive red 120 dye (red-120) onto fungal biomass (FB) of wild *Ganoderma stipitatum* basidiocarps, and they found that the biosorption equilibrium data were best fitted by Langmuir isotherm model presenting maximum monolayer biosorption capacity of 44.44 mg g^{-1}.

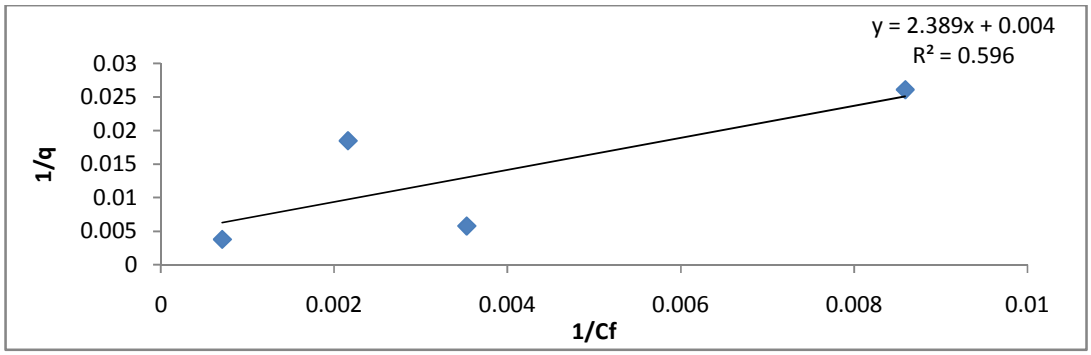

Figure 3: Langmuir model for sorption of basic fuchsin dye by living biomass of *A. niger*

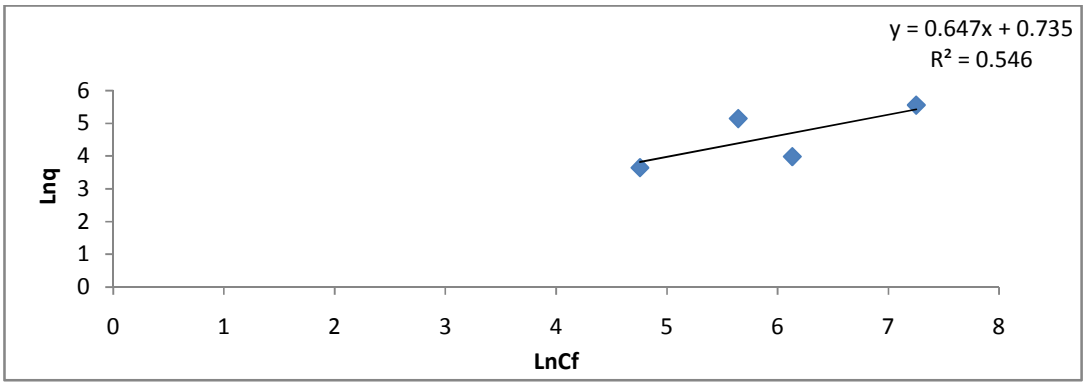

Figure 4: Freundlich model for sorption of basic fuchsin dye by living biomass of *A. niger*

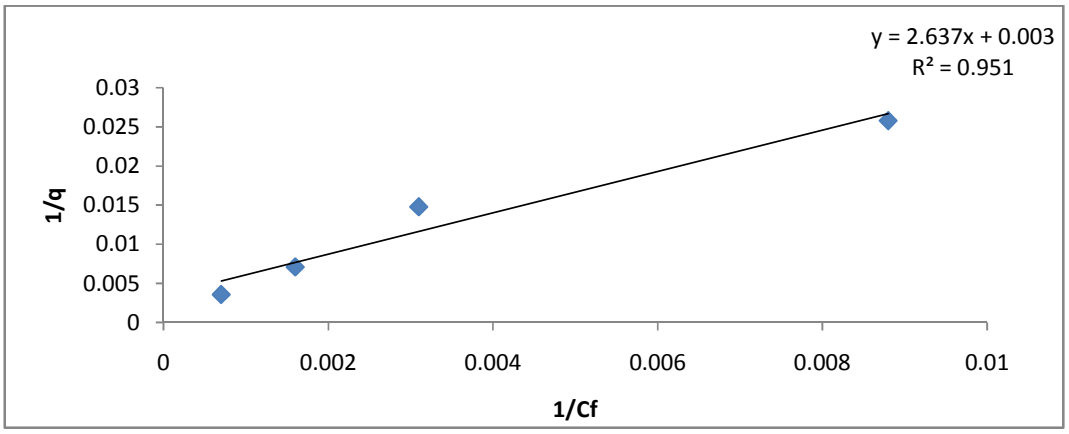

Figure 5: Langmuir model for sorption of basic fuchsin dye by living biomass of *H. grisea*

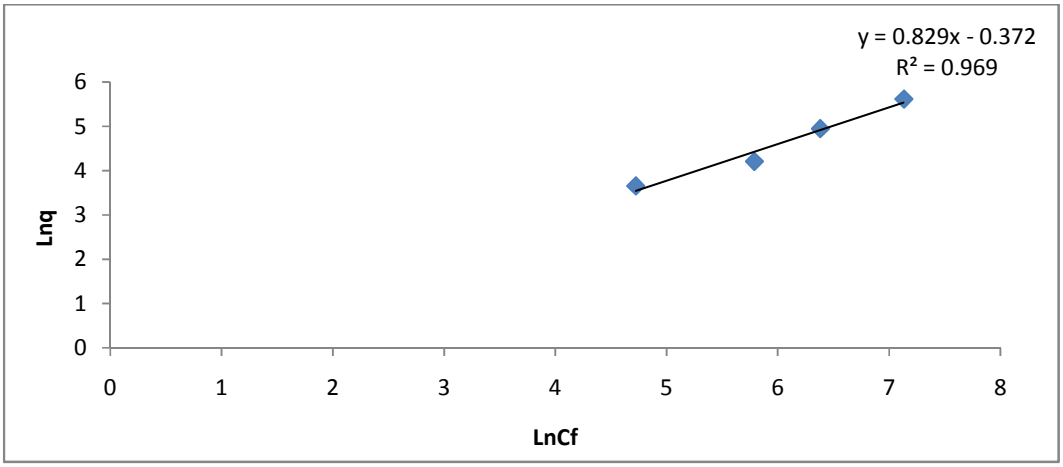

Figure 6: Freundlich model for sorption of basic fuchsin dye by living biomass of *H. grisea*

Table 1: Isothermic values of basic fuchsin dye sorption by *A. niger* and *H. grisea*

Langmuir isotherm				
Biomass type	**a**	**B**	**1/ab**	**R²**
A. niger	2.637	0.0007	555.55	0.596
H. grisea	2.389	0.0007	625	0.951
Freundlich isotherm				
Biomass type	**n**	**l/n**	**Kf**	**R²**
A. niger	1.545	0.647	2.085	0.546
H. grisea	1.206	0.829	1.451	0.969

CONCLUSIONS

Aspergillus niger and *Humicola grisea* can be used as potential cost effective biosorbent for the removal of basic fuchsin dye from aqueous solutions. In the present study, living biomass of *Aspergillus niger* was more efficient for the removal of basic fuchsin dye as compare to *Humicola grisea.* Maximum biosorption percentage of basic fuchsin dye was observed at 100ppm concentration by both fungal biomasses. Adsorption of dye by *Aspergillus niger* followed Langmuir isotherm model, suggesting a monolayer adsorption and adsorption of dye by *Humicola grisea* followed Freundlich isotherm model, suggesting a multilayer adsorption of basic fuchsin dye.

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