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DECOLORISATION OF NAVY BLUE DYE USING A PLANT BIOMASS -*ALBIZIA AMARA* (SILK TREE)

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ABSTRACT

Textile processing industries discharge enormous amount of chemical compounds mainly dyes into soil and water bodies. It is the major cause of water and soil pollution that results in reducing the soil fertility, plant growth and unregulated and disrupted food chain. Using a plant material to absorb the discharged dye will effectively reduce the contaminant level and biodegradability can be enhanced ecofriendly. In the present investigation, *Albizia amara*-AA (silk tree or oil cake tree) leaf biomass was used as a natural adsorbent for removal of navy blue dye, commonly employed for coloring fabrics. In order to decide toxicity evaluation of dye, the dye was prepared in different concentrations with a range of 0.25, 0.50, and 1.00%. Column binding study and FTIR analysis showed that *Albizia amara* (A A) leaf biomass can bind to navy blue dye and decolorize it upto 1% and the thus obtained remediated soil can be reused for vegetation.

KEY WORDS: plant biomass, adsorbent and adsorbate, column binding, FTIR and decolorisation.

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INTRODUCTION

Textile processing industries produces a large amount of effluent wastewater which is highly polluting and a major cause of soil and water pollution. Synthetic chemical dyes used in industries are many types viz., acid dyes, azo dyes, basic dyes, direct dyes, reactive dyes, sulfur dyes, vat dyes etc[21].Generally synthetic dyes are believed to be toxic or carcinogenic to animals and human. They affect the water bodies including ground water which in turn affect the soil fertility and make the soil barren for plant growth[2].Textile dyeing effluents are intensely colored and cause extreme changes in pH and temperature, high COD and dissolved solids of water bodies[13]. The color and concentration of the textile wastewater is a serious problem of concern for treatment of effluent and pose serious threat to the environment resulting in unproductive agricultural land and affecting health as they enter the food chain[14, 23].A number of physio-chemical methods such as adsorption, coagulation, precipitation, filtration, and oxidation are used for reclamation of dye contaminated soil[12].Among the numerous techniques dye removal adsorption techniques provides best results since it can remove different types of coloring materials[3]. Adsorption process has an edge over the other methods due to its sludge free clean operation and can completely remove dyes even from diluted solutions [17].The major advantages considered in adsorption treatment for the control of water pollution are: less investment in terms of initial development costs, simple design, easy operation and free form or less generation of toxic substances[5]. Many researchers have studied the applicability of low cost alternative materials like saw dust, baggasse, rice husk, coir pith, olive stone, coconut shell, etc as a phytoremediator which is said to be a green technology to remove contaminants [19].Phytoremediation is the use of plant or plant material to remediate selected contaminants in contaminated soil. Use of plants for uptake, sequestraion, detoxifcation or volatization of inorganic and organic pollutants from soils, water, sediments, and air is possible[6]. Phytoremediation requires resources and time, involves low-cost, biodegradable, eco acceptable alternate to other remedial technologies at contaminant sites. *Albizia amara* is a deciduous tree belongs to the family Fabaceae and sub family Mimosaceae (leguminosae). It is an endemic plant found widely in India and Sri Lanka. The leaves of *Albizia amara* was found to be eco friendly inhibitor of mild steel corrosion in acid media, it was also found to have nitrogen fixing capacity and could make a significant nitrogen input to tropical agro ecosystem.[21] The aim of this study is to remediate dye simulated soil using leaf biomass *Albizia amara*(AA) which enhance soil health and plant growth.

MATERIALS AND METHODS

Selection and characterization of dye

Navy blue dye (adsorbate) purchased from the local market in Tirupur (Tamil Nadu) was selected for the study ,due to its wide use in textile and fabric industries. It is an organic dye with UV visibility around 620nm, has a specific gravity of 0.835 and its melting point is above 400^{o}c, is highly soluble in water and has a pH of 10.5. Different concentrations of the blue dye were prepared with a range of 0.25, 0.50, 0.75 and 1.00% using distilled water and was used for column binding adsorption study.

Plant biomass used as adsorbent

Albizia amara (AA) leaf biomass was used as adsorbent for dye binding. The dried leaves of *Albizia amara*(AA) w*ere* shade dried, powdered and used as biomass for adsorption study. Botanical Survey of India (BSI), verification was ensured for the plant material and had an authenticated index of BSI/SRC/5/23/13-14/Tech-2055.

Soil selection and characterization

Virgin-red soil was collected from a field in Sulur-Coimbatore(Tamilnadu) for the study. Physical and chemical properties like pH, electrical conductively, texture, lime, N, P, K, copper, manganese, iron and zinc was assessed.

Soil calibration study

In this study moisture content, retention of dye by the soil and the depth at which dye penetrates were taken into consideration for deciding the relative changes in water content. This was carried out in a square wooden box with 15cm height, in which 500g of soil was added, and metric tube was inserted in the centre of soil, three different concentrations of dyes 0.25%, 0.50% and 1.00% were subjected. Dye penetration was studied by dividing the 15cm depth wooden box into three layers, top layer 5cm, middle layer 5cm and the bottom layer 5cm. Soil calibration study was done by removing 1gm of soil from the top layer mixed with 5ml of water and filtered through muslin cloth, similarly it was carried out for the other two layers. The dye penetration in each layer was represented in the filtrate and read spectrophotometrically at 665nm (shimadzu UV-spectrophotometer). Similarly moisture content of the three layers was also evaluated[4].

Adsorption study

Adsorption was carried out in batch and column modes. The study was done with soil (control), plant biomass and a mixture of equal proportion of soil and plant biomass in the ratio 1:1.

Batch mode experiments

Batch mode adsorption study is carried out with three different concentrations of dye ranging from 0.25%, 0.50% and 1.00%. Leaf biomass (*Albizia amara)* and soil was used in the ratio of 1:1 with a constant volume of dye for adsorption study. The samples were placed in an orbital rotator shaker at 150 rpm and the adsorption rate was assessed after every hour, upto 5 hours maximum. At the end of each time interval the adsorbate was read at 665nm. A dye control was maintained. The percentage removal of dye is defined as the ratio of difference in dye concentration before and after absorption (C-t/c*100)[26].

Column adsorption study

To confirm the batch mode experiment, column adsorption study is carried out. Column study was carried out with (a). 10g of soil, (b). 10g powdered leaves of plant biomass *Albizia amara*(AA) and (c) a mixture of1:1 ratio of soil and *Albizia amara* plant biomass. 10ml of dye solution in various concentration were used for elution. The eluent was collected, volume was measured and concentration of eluted dye adsorbed in column was read at 665nm[20].

Phytochemical Analysis

The plant biomass *Albizia amara*(AA) was screened for phytochemical constituents such as alkaloids [28],flavanoids[10] steroids, phenols[8,] glycosides, triterpenoids, saponins[1] and tannins[27].

FTIR analysis

A validation analysis was done to detect the presence of functional groups through spectral studies using FTIR by KBr pellet method. Spectra were recorded from 4000 to 400cm^{-1}. using Perkin-Elmer Fourier Transform Infrared Spectrometer . FTIR was done for the three adsorbents- soil, navy blue dye and plant biomass.

RESULTS AND DISCUSSION

Physio-chemical characterization of soil before and after dye contamination

Table 1
Physio-chemical characterization of soil

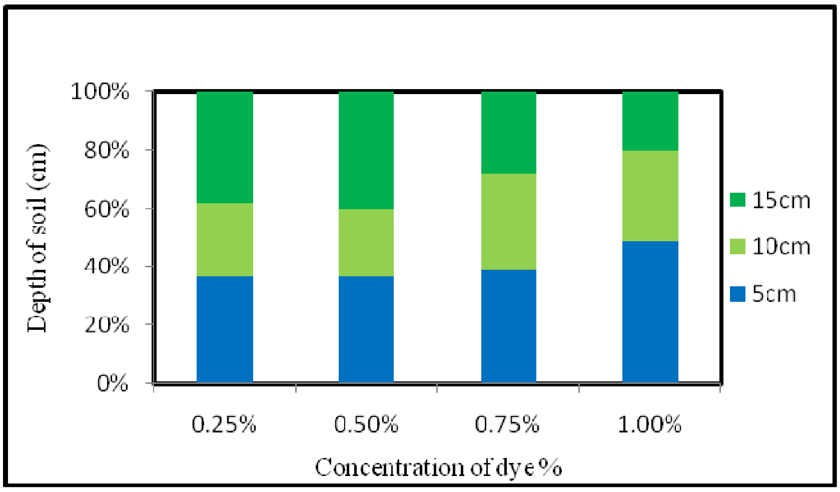
Parameters	Control soil	Dye Contaminated soil
P^H	7.70	8.84
Electrical Conductivity (dSm^{-1})	0.26	0.28
Texture	Sandy loam	Sandy loam
Lime	Slightly calcareous	Calcareous
Available N	200(kg ha^{-1})	199(kg ha^{-1})
Available P	51.6(kg ha^{-1})	25(kg ha^{-1})
Available K	983(kg ha^{-1})	140(kg ha^{-1})
Copper	1.07(ppm)	2.86(ppm)
Manganese	2.03(ppm)	3.77(ppm)
Iron	439.4(ppm)	207(ppm)
Zinc	2.2(ppm)	1.95(ppm)

From table 1 the results expressed that the chemical characterization of dye contaminated soil significantly varied from uncontaminated soil. There was slight change in the physical properties like pH and electrical conductivity whereas texture remained constant in both contaminated soil and uncontaminated soil. The lime content of the soil increased in contaminated soil when compared to uncontaminated soil. The macronutrients such as phosphorus and potassium were drastically affected in dye contaminated soil. When compared to uncontaminated soil the availability of phosphorous and potassium content in dye contaminated soil was reduced from 51.6 to 25 kg $ha^{-1}$and 983 to 140kgha^{-1} respectively. The micronutrients such as copper and manganese increased from 1.07 to 2.86 ppm and 2.03to 3.77 ppm, whereas iron and zinc decreased from 439.4 to 20.77ppm and 2.2 to 1.95ppm respectively. Thus soil characteristics analysis showed that dye contamination in soil can affect the macro and micro nutrient content which could inhibit the plant growth [12].

Soil calibration study

Soil calibration study was done to assess the penetration of the dye into the soil and the damage it can cause to the soil crust. It has been reported that the top layer of the soil influences plant growth and its physiological health (Savoy HJ, 2007). As seen in fig.1 dye adsorption occurs between 30-40% levels at a depth of 5cm in all the four different concentrations of the dye tested. As concentration increases retention of the dye is reduced to the top most layer between 5-10cms. ie. At 0.25% concentration, 40% adsorption occurs at 15cms depth whereas only 20% adsorption occurs at 1.00% concentration.This study explains that the dye is retained in the top soil in comparison to the sub soil and prevents the plant growth causing non availability of nutrients and alters the stability of soil, therefore phytostabilisation of top soil becomes important in maintaining soil health.

Figure 1
Soil calibration study of dye to soil



FTIR analysis

Figure 2a
FTIR analysis for soil

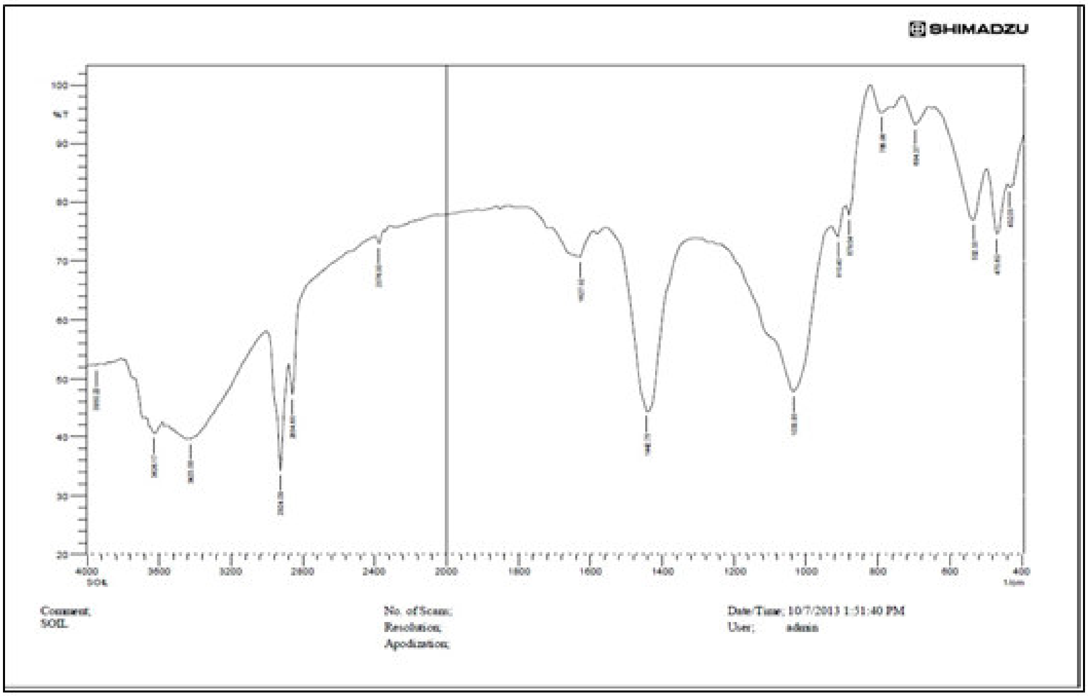


Figure2b
FTIR analysis for dye

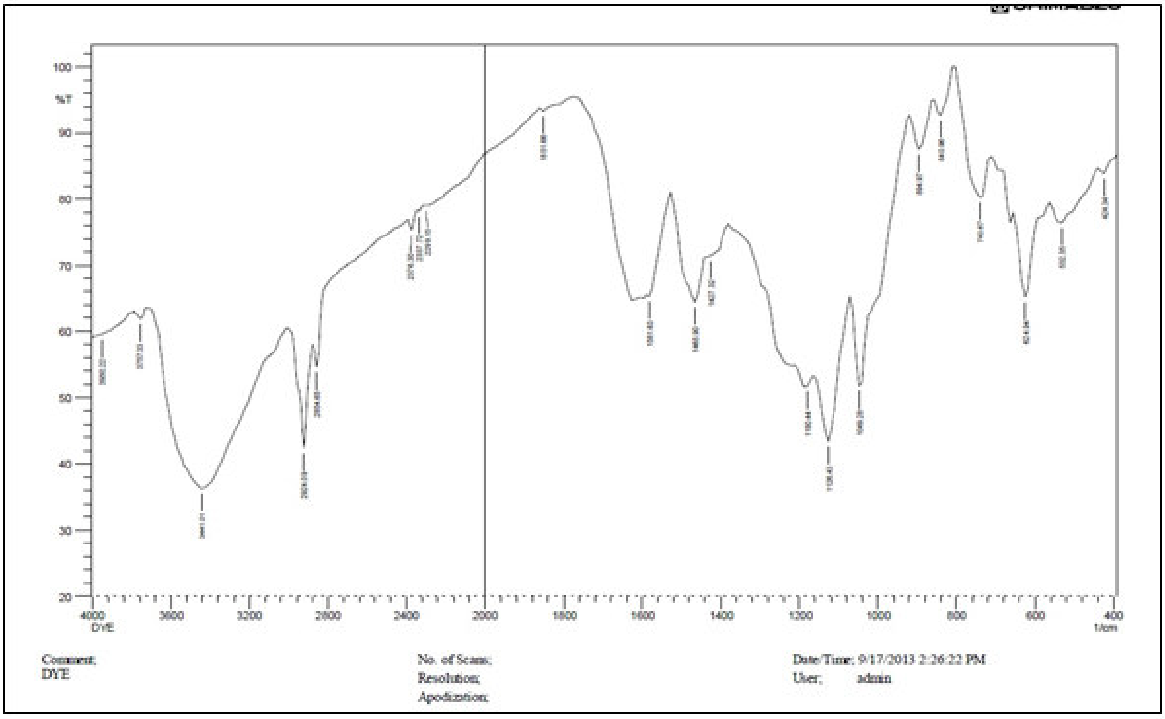
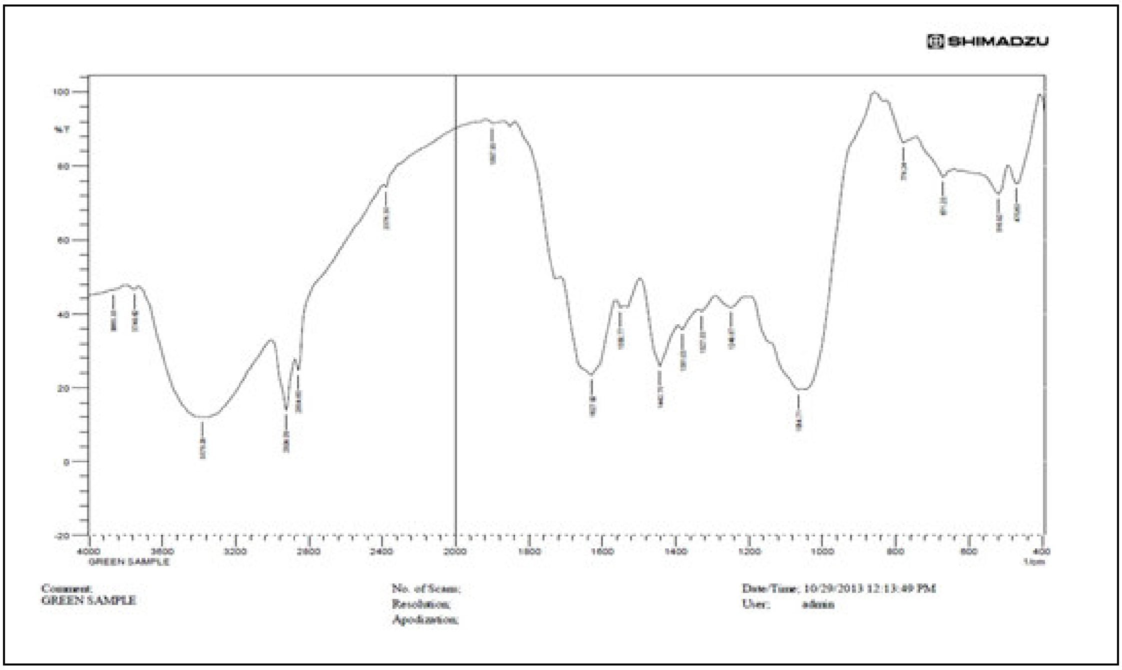


Figure 3c
FTIR analysis of Albizia amara(AA)



Soil is enriched with macro and micro nutrients and gives characteristic spectral patterns which is unique to each of the soil types. Any change in the chemical composition will alter the spectral pattern Use of FTIR analysis allows us to focus on single particle and absorption bands related to those compounds in agreement with reference values. It reveals the adsorption pattern of adsorbants based on their porosity as well as their chemical reactivity of the functional group on the adsorbent surface. Figure 2a,2band 2c highlights the peak reflectance of soil,soil contaminated with navyblue dye and soil and plant biomass *Albizia amara*.The reflectance shows the shift in the wave number of dominant peak associated with the groups present in them.Fig 2a reveals soil analysis result,a broad peak at 3425cm^{-1} could be due to the presence of primary and secondary amines,peak at 2924cm^{-1} indicates alkanes, a large band width at 2376cm^{-1} to 1624cm^{-1} due to the presence of carboxylic group and that of 1442cm^{-1} to 1033cm^{-1} could be due to the presenceof aromatic and aliphatic amines. The shifting and change in banding frequency in dye contaminated soil was altered when compared with soil reflectance in the range from 3400-2700cm^{-1},2376-2299cm^{-1} and 1800-1200cm^{-1} as seen in fig 2b.The shifts in the wave length of soil and dye showed that binding process takes place at the surface of adsorbant due to the presence of amines, alkyl halides and carboxylic groups. In fig 2c. there were altered reflectances in 3400-3200cm^{-1}, 2400-1800 cm^{-1} and 1600-1000 cm^{-1}.The spectral study of soil and plant biomass had the presence of aldehyde group and alkynes with a peak at 2924 cm^{-1} . This peak was absent with the dye as alkyl halides could be responsible for binding of dye from soil to the plant biomass. Presence of amines in the dye alters the spectral pattern in the soil and addition of plant biomass has partially reverted the change[14].

Phytochemical analysis of plant biomass Albizia amara

Table 2
Phytochemical screening of Albizia amara

S.No	Phytochemicalconstituents	Indication
1.	Alkaloids	+
2.	Flavanoids	+++
3.	Tannins	+
4.	Terpenoids	+
5.	Phenols	++
6.	Saponins	++

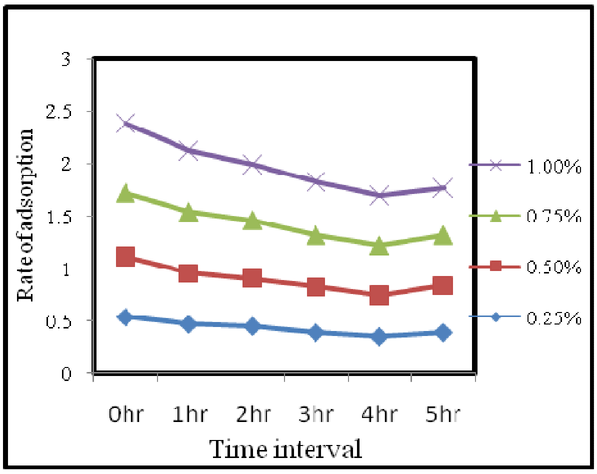
Table: 2 reveals the presence of phytochemicals present in plant biomass *Albizia amara* indicates the presence of secondary metabolites such as alkaloids, flavanoids, tannins, terpenoids, phenols and saponins. (+) sign indicates the presence of phytochemicals. These phytochemicals present in this plant *Albizia amara* might be responsible for some medicinal activity in treatment of many ailments.

Batch mode experiments

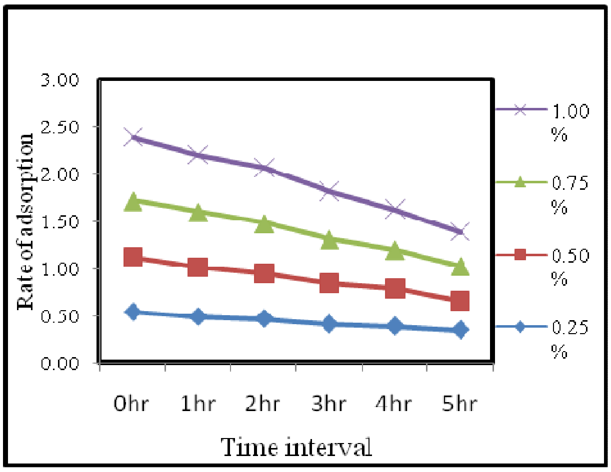
The rate of absorption of dye to by the soil is concentration dependent with respect to time as seen in fig:3. Maximum binding occurs between 3-4 hours after which a steady state occurs. Comparing the binding pattern of dye to plant biomass there was reversible change in presence of plant biomass. Binding of dye decreased in relation to time as seen in figure 3b. This proves that the plant can adsorbs the dye and reduce dye toxicity in soil. Thus alleviating soil fertility and the plant growth could be enhanced using *Albizia amara* (Aa) as remediator[15].

Figure 4
Batch adsorption binding study of dye to soil and plant biomass

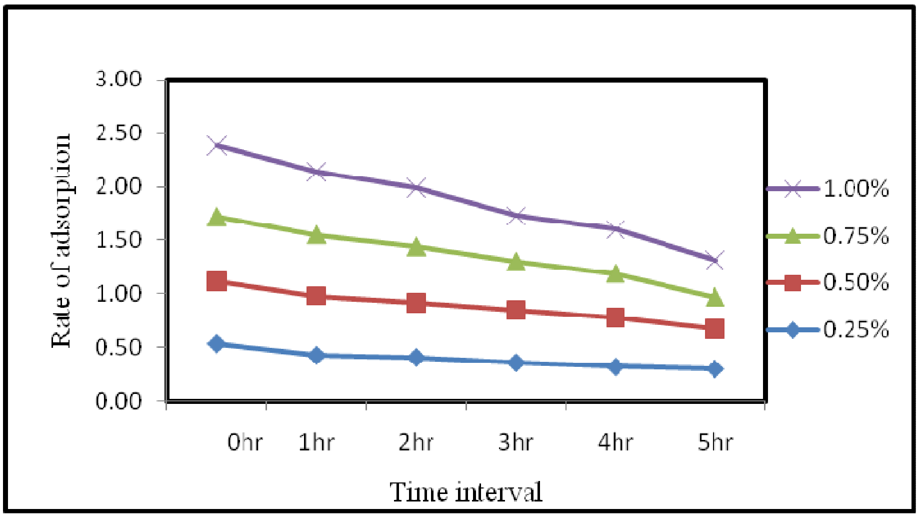
3a: Binding study of dye to soil



3b: Binding of dye to plant biomass



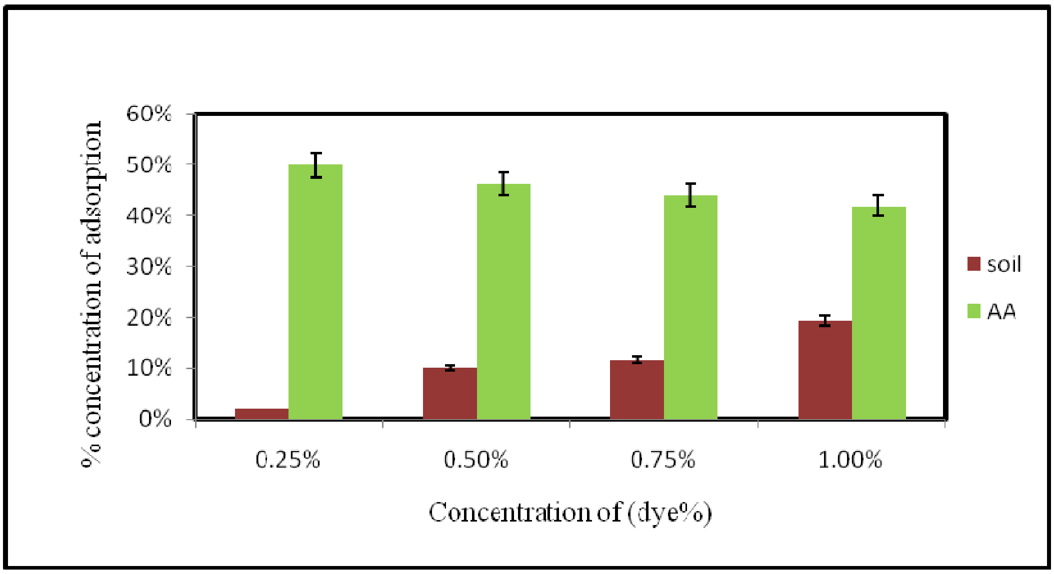
3c Binding of dye to mixture of soil and plant biomass(1:1)



Column experiments

Column experiment study was done to assess the volume of dye eluted and dye adsorbed.. Fig 4. Reveals the percentage retention of dye with soil and plant biomass. It can be seen that the plant biomass adsorbed the dye at all concentrations at a greater level than soil. The blue dye binds at about 25% to the soil and 45% to the plant biomass at a maximum percentage of 1. At all concentrations the dye binds to the plant biomass between 40-50% in a concentration dependant mode to the soil. This observation suggests that the plant biomass - *Albizia amara* has a high capacity for removing blue dye in aqueous form. Thus it reveals the efficiency of plant biomass-Albizia amara (AA) to phytostabilise the dye in contaminated soil[29].

Figure 4
Percentage retention of dye with soil and plant biomass



The experimental results reveal the soil characteristics and its adsorption to different concentrations of dye with a minimum of 0.25% to maximum of 1 %. Thus, indicating that the blue dye can bind to the soil very easily and can contaminate the soil and affect the health of soil. The binding studies of *Albizia amara* (AA)- plant leaf biomass used in the study to decolorize the dye present in the soil was found to be effective and had the potential to remediate the soil contaminated with dye in a linear dependant concentration. Column adsorption experiments demonstrate the potential capability of *Albizia amara* (AA)- plant leaf biomass to remove the dye upto 50%.

CONCLUSION

The above study identifies the possibility of using *Albizia amara* plant biomass as a decolorant of navy blue dye which is widely employed in textile processing unit. *Albizia amara* plant biomass was able to decolourise the navy blue dye upto a concentration of 1%. The use of other adsorbents like activated charcoal or baggasse along with *Albizia amara* biomass could enhance the binding capacity of blue dye to a great extent and reduce the phytotoxicity of the dye upon soil.

CONFLICT OF INTEREST

The authors declared there is no conflict of interest.

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