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Adsorption Studies of Water Hyacinth Ash with Methylene Blue, Carmine Red and Industrial Effluent

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ABSTRACT:

The potential application of water hyacinth ash as adsorbent is explored in the present study. The adsorption capacity of water hyacinth ash on selected dyes like methylene blue, carmine red and industrial effluent are studied. Adsorption studies of water hyacinth (0.5g) was carried out with methylene blue solutions of concentrations varying from 0.1 µM to 100 µM. The results of this study indicate that 0.5 g water hyacinth ash is sufficient to adsorb almost 100% methylene blue from 5 µM solution. Adsorption studies of water hyacinth (0.5g) was carried out with carmine red solutions of concentrations varying from 10 µM to 100 µM and it was observed that the ash adsorbed 93% carmine red from 75 µM solution. The adsorption study with industrial effluent shows that water hyacinth ash is capable of adsorbing about 90% of the colouring matter from the effluent.

Keywords: Water hyacinth, adsorption, methylene blue, carmine red, effluent.

INTRODUCTION:

Dyes like methylene blue, Congo red, crystal violet, malachite green, carmine red etc. are extensively used in industries including textile, food, leather, paper and pulp. The sewage from these industries contaminates the water body and pose serious threat to the ecosystem. Various physical and chemical treatment processes such as coagulation, flocculation, membrane filtration, etc. are often employed commercially for removing dyes from sewage. These methods are undesirable in the economic point of view due to huge cost, production of large amount of sludge and its disposal. From these perspectives, adsorption is one of the most effective and cheaper method to remove dyes from wastewater [1,2].

The phenomenon of higher concentration of any molecular species at the surface than in the bulk of a solid or liquid is known as adsorption. The forces involved are mainly, intermolecular forces like van der Waals forces [3]. Solids, when finely divided, have a large surface area and therefore, show adsorption to a large extent. The solid that takes up a gas or vapor or a solute from a solution, is called the adsorbent while the gas or vapor or the solute, which is held to the surface of the solid is called adsorbate. Colloids, on account of their extremely small dimensions, possess enormous surface area per unit mass and are, therefore,

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good adsorbents. The examples are charcoal, Silica gel, alumina gel, clay, fuller's earth, etc [4].

Adsorption of a solute from a solution onto a solid adsorbent is more difficult to treat theoretically than the corresponding adsorption of gases on solids. It appears, however, that in this case too, like the gas – solid adsorption, a monomolecular layer is formed. The solvating power of the solvent inhibits the formation of a multilayer. For adsorption from solutions, a commonly used isotherm is the Freundlich adsorption isotherm. If x is the mass of the solute adsorbed and m of adsorbent and c is the concentration of the solute in the solution, then Freundlich adsorption isotherm is expressed as

$$x/m = a = k\, C^{1/n}$$

where k and n are empirical constants. Taking logs,

$$\ln a = \ln k + 1/n \ln C$$

This logarithmic form is convenient to use. If we plot ln a versus ln C, the plot would be a straight line with slope equal to 1/n and intercept equal to ln k [5,6].

Activated carbons have been extensively utilised in various industrial adsorption and separation processes because of its efficient adsorption of the organic compounds. Recently, a considerable amount of research has been undertaken to find cheaper substitutes to activated carbon like rice husk, wood dust, wheat bran, banana and orange peel, tree bark powder, peat, lignin, brown sea weed, fly ash, pineapple stem waste, tuberous pulp, sugarcane pulp, coconut pulp etc [7-14]. However, the search for simple, economic, eco-friendly and highly effective adsorbents are still challenging. From these perspectives, water hyacinth was selected as a bio-adsorbent in the present study.

Water hyacinth (*Eichhornia crassipes*) is an invasive plant floating freely on the water, native to tropical and sub-tropical South America, which is widely spread in tropical and subtropical regions. These plants which were introduced into India for their lovely flowers have caused havoc by their excessive growth by causing blocks in waterways [15,16]. It drains oxygen from the water, which leads to the death of fishes. It can propagate vegetatively at a phenomenal rate and spread all over the water body in a short period of time, it is very difficult to get rid of them. Thus, developing an adsorbent from this biomass is expected to be an economically viable solution for its proliferation [17,18].

Bio adsorption of various industrial dyes like methylene blue, Congo red, crystal violet, and malachite green from aqueous solution has been performed in the water hyacinth using lab-scale batch bioreactor where maximum percentages of removal of the dyes were found to be 90%, 88%, 92%, and 90% for methylene blue, Congo red, crystal violet, and malachite green, respectively [19-21]. The adsorption kinetics suited with the pseudo second order and Langmuir isotherm described the equilibrium dye uptake. Studies on adsorption of carmine

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red, used in the cosmetics industry for hair- and skin-care products, lipsticks, face powders, rouges, and blushes, with water hyacinth is lacking.

In case of heavy metal removal from aqueous solution, water hyacinth showed great potentiality. Water hyacinth has the ability to uptake copper, cadmium, chromium, and zinc from textile wastewater with high efficiency [22-25]. In this study, the potential application of water hyacinth as bio adsorbent to remove dyes from wastewater is explored. The extent of adsorption from solutions depends upon a number of factors like nature of adsorbents, nature of adsorbate, concentration of adsorbate etc. The adsorption capacity of water hyacinth ash on various adsorbates like methylene blue, carmine red and effluent are studied.

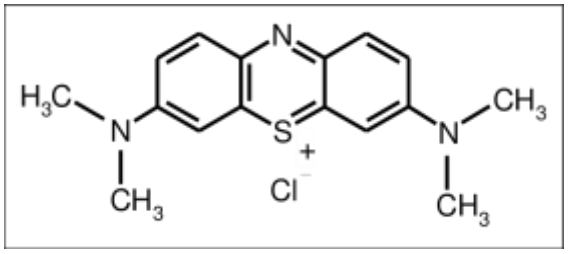
MATERIALS AND METHODS:

2.1 Materials

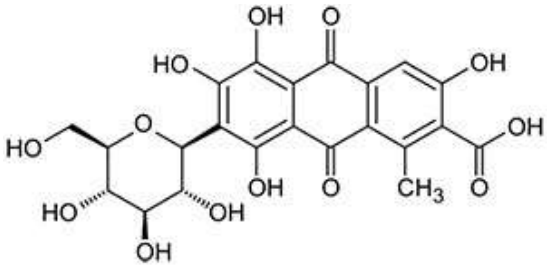
The water hyacinth was collected from the local ponds in Changanacherry, Kerala and washed thoroughly with water for several times to remove earthy matter and all the dirt particles. It was then dried under sunlight. The dried plants were then burned, crushed, sieved and stored in plastic bottle for use.

2.2 Chemicals

Aqueous solutions (0.1µM to 100 µM, respectively) of methylene blue and carmine red were prepared by adding known amount of dye in de-ionized water. Methylene blue (MB) and carmine red supplied by, Merck India Private Limited was used as adsorbate and was not purified prior to use. Double distilled water was used for preparing all the solutions and reagents.



Methylene blue



Carmine red

2.3 Methodology

Methylene blue and carmine red solutions of varying concentrations were prepared. 0.5gm each of water hyacinth ash is added to 10 ml of methylene blue solutions taken in an iodine flask. It is then shaken for 2 hours in a KEMI heavy rotary shaker. Then solutions are centrifuged in a REMI R-4C centrifuging machine. Absorbance of clear solutions is measured using UV spectrophotometer 1800 pharmaspec at 660 nm. Likewise carmine red of varying concentrations is prepared and same procedure is done followed by measuring

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absorbance using UV Spectrophotometer 1800 pharmaspec at 520 nm. The effluent is collected from HINDUSTHAN NEWSPRINT LIMITED, VELLOOR, a government company in the Indian Central Public Sector. Varying amounts of water hyacinth ash (0.25 g to1.5 g) was added to 10 ml of effluent, centrifuged and absorbance was measured at 500 nm. Graphs were plotted with concentrations on x-axis and x/m on the y-axis. Extent of adsorption, x can be obtained from the difference in absorbance of methylene blue and carmine red solutions before and after adsorption.

RESULTS AND DISCUSSION:

3.1 Effect of adsorbent concentration on the adsorption of methylene blue

Adsorption studies of water hyacinth ash (0.5g) was conducted with methylene blue solutions of varying concentration from 0.1 µM to 100 µM. Percentage adsorption (C_0-C x 100/C_0) vs concentration of methylene blue is plotted (Fig.1). For a concentration of 0.1 µM methylene blue, 88% dye was adsorbed by the ash. Almost 100% adsorption of dye was achieved by water hyacinth ash for a concentration of 5 µM methylene blue. Percentage adsorption remains almost steady from 5-100 µM methylene blue. The results of this study indicate that 0.5 g water hyacinth ash is sufficient to adsorb almost 100% methylene blue from 5 µM solution.

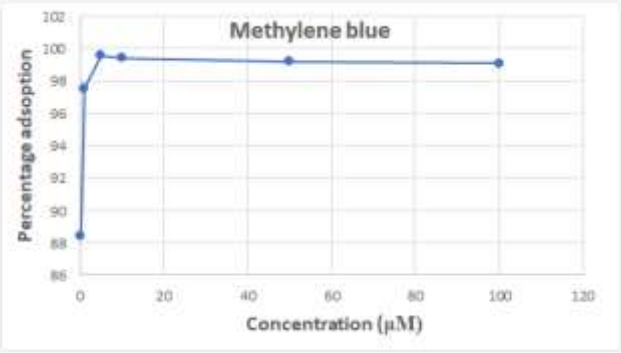

Fig. 1: Percentage adsorption vs Concentration of methylene blue

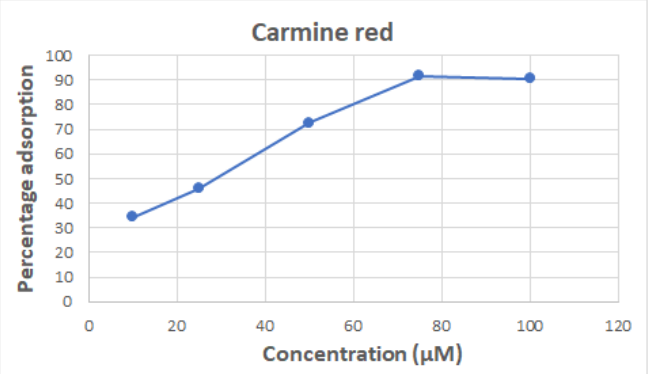

Fig. 2: Percentage adsorption vs Concentration of carmine red

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Adsorption studies of water hyacinth (0.5g) was carried out with carmine red solutions of concentrations varying from 10 µM to 100 µM. Percentage adsorption vs concentration of carmine red is plotted (Fig. 2). With 10 µM solution, 34% carmine red was adsorbed by the ash and the percentage of adsorption goes on increasing almost linearly up to 75 µM concentration of carmine red with 93% adsorption and then it remains steady for higher concentrations of carmine red.

3.2 Adsorption isotherm

The amount of methylene blue and carmine red adsorbed at equilibrium on different adsorbent parts of water hyacinth, qe (mg g^{-1}) was calculated by mass balance according to Equation, qe= (C_0-Ce) x V/m.

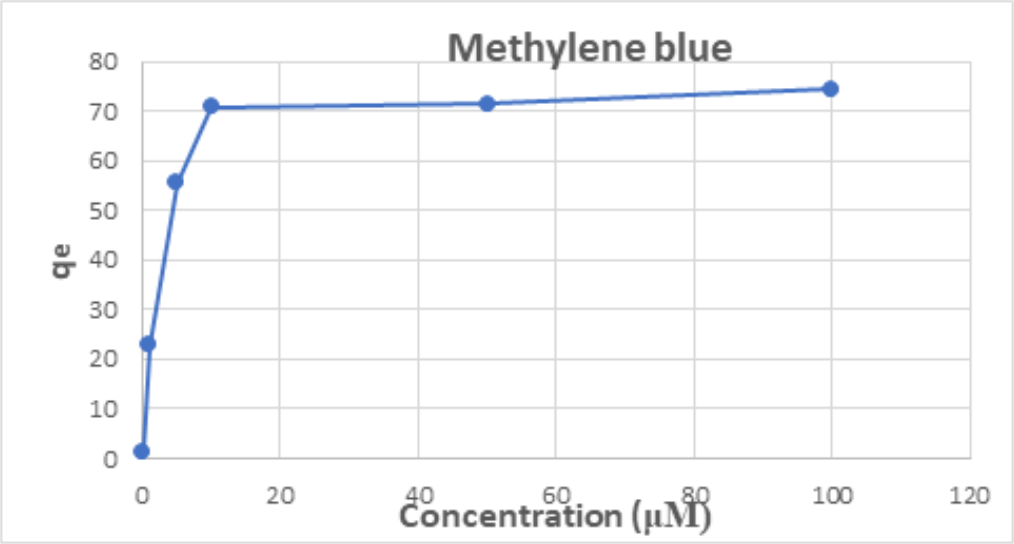

Fig. 3: Equilibrium adsorption Vs concentration of methylene blue

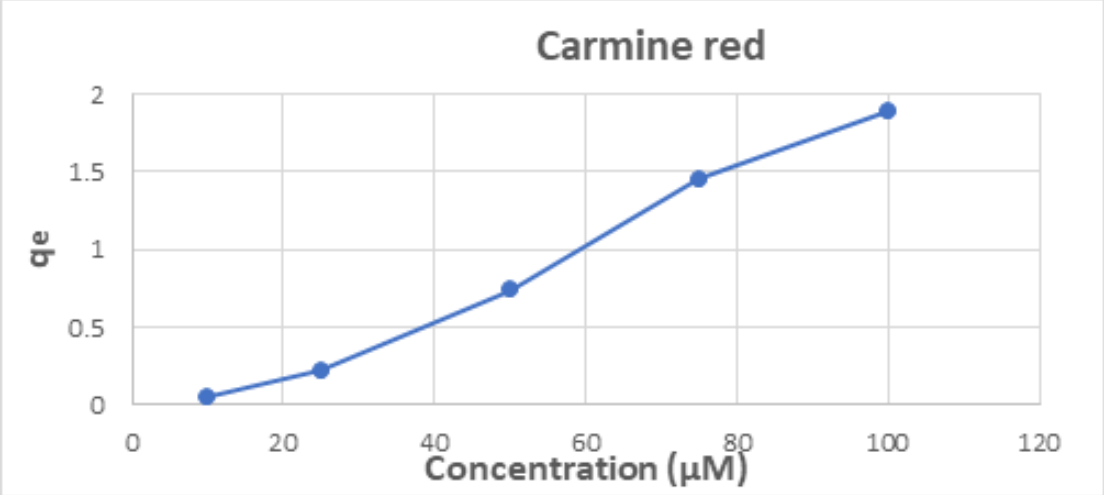

Fig. 4: Equilibrium adsorption Vs concentration of carmine red

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Adsorption studies of water hyacinth ash was conducted with effluent. Varying amounts of ash were added to 10 ml of effluent. Percentage of adsorption against weight of water hyacinth is plotted in fig. 5. Percentage of adsorption goes on increasing linearly with increasing amounts of ash up to 1.25 g and it remains almost constant thereafter . About 90% of the dye in the effluent was adsorbed by 1.25 g of the ash.

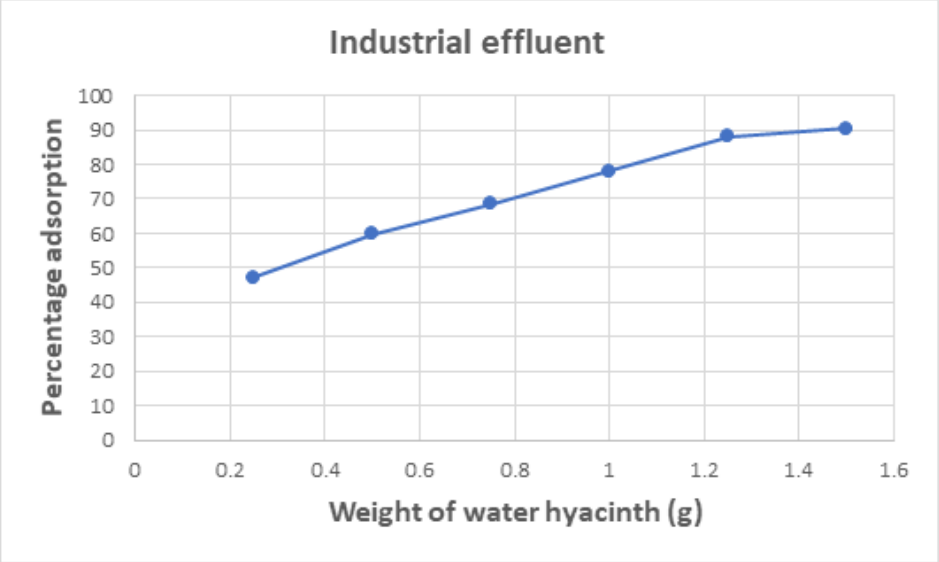

Fig. 5: Percentage adsorption Vs weight of water hyacinth

In another experiment, variation of percentage adsorption with increasing time was conducted. Percentage adsorption increases with time and after 2 hours, percentage of adsorption remains almost constant.

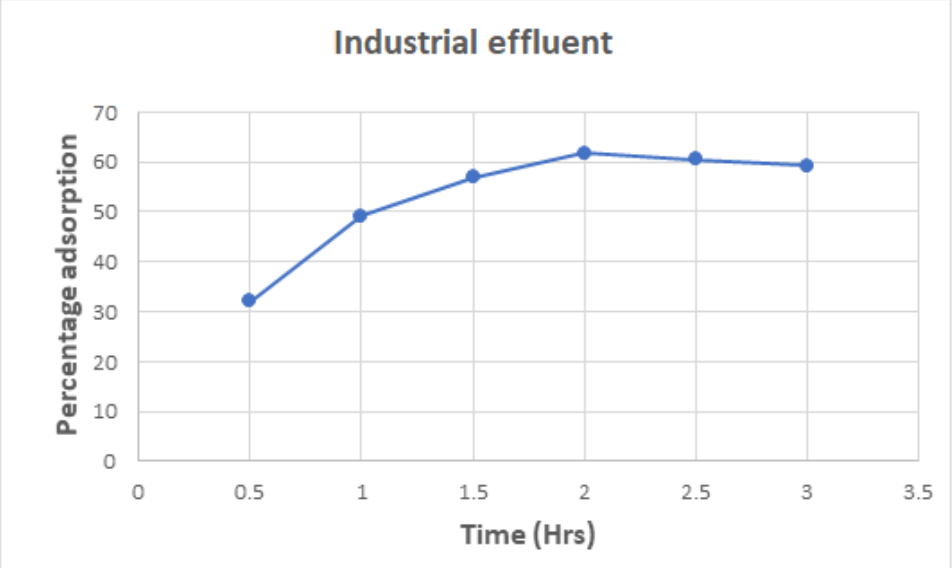

Fig. 6: Percentage adsorption Vs time of adsorption

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CONCLUSIONS:

Water hyacinth is now considered as a threat to the biological diversity. As a preliminary study, this work opens a way to convert the plant into a useful form thereby reducing its hazards. From the present study, it is clear that methylene blue gets adsorbed to a greater extent on water hyacinth ash than carmine red. Water hyacinth is a potential weed in aquatic systems. The present study shows that it can be used as an adsorbent for the removal of methylene blue, carmine red and coloured matter of effluent from their aqueous solutions.

ACKNOWLEDGEMENTS: Nil.

CONFLICTS OF INTEREST: No.

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