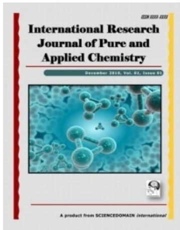

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Removal of Colour from Textile Effluent by Adsorption Using Low Cost Adsorbents

C. R. Ramakrishnaiah[1*] and D. N. Arpitha[2]

[1]Department of Civil Engineering, (PG- in Environmental Engineering), BMS College of Engineering, Bull Temple Road, Bangalore –560019, India.
[2]Department of Civil Engineering, BMS College of Engineering, Bangalore-560019, Karnataka, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author CRR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author DNA managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

Short Research Article

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ABSTRACT

Aims: The present study was aimed to investigate the adsorption capacity of Granular activated carbon (GAC) of coconut shell and coal ash for acidic dye.
Methodology: Acid orange 7 dye is used as an adsorbate for the present study. Operating parameters such as pH, effective dosage, and contact time were optimized by conducting batch experiment. Column studies were conducted in order to determine the saturation time by using column Break-through curve.
Results: Colour removal of about 94% and 85% were obtained at pH 6 for an adsorbent dosage of 1.5g /100ml of 50 mg/l and 100 mg/l dye concentration respectively for Granular activated carbon and Colour removal of about 80% and 75% were obtained at pH 6 for an adsorbent dosage of 1.5 g/100ml of 50 mg/l and 100 mg/l dye concentration respectively for Coal ash. GAC got saturated in 218 hours for 100 mg/l and coal ash got saturated in 96 hours for 100 mg/l respectively. Results obtained on industrial wastewater showed the results were in par with the synthetic sample.
Conclusion: From the batch and column studies it can be concluded that increase in adsorbent dosage increased the percentage removal of dyes and higher initial

**Corresponding author: Email: rama_bmsce@yahoo.com;*

concentration resulted in shorter column saturation time respectively. Langmuir isotherm was found to be best fit for both the adsorbents.

Keywords: Adsorption; colour removal; granular activated carbon; coal-ash and Isotherms.

1. INTRODUCTION

Our earth is the only planet in the whole universe accredited to have life. One of the prime reasons, which support life in our mother-planet, is water. But, anthropogenic activities have caused a great harm to the quality of our lifeline, i.e. water. Because of fast depletion of the freshwater resources, there seems to be a crisis of the same [1]. Presently, it was estimated about 10,000 of different commercial dyes and pigments exist and over 7 x 105 tones are produced annually worldwide [2]. Dyes are widely used in industries such as textile, rubber, paper, plastic, cosmetic etc. Among these various industries, textile ranks first in usage of dyes for coloration of fibre [3]. The colour in the effluent is mainly due to unfixed dye. The concentration of unused dyes in the effluent depends upon the nature of dyes and dyeing process [4]. One of the major problems concerning textile effluent is coloured effluent. The release of the colored dyes into the ecosystem is a dramatic source of aesthetic pollution, of eutrophication, and of perturbations in aquatic life [5]. In addition, colour interferes with the transmission of sunlight into the stream and therefore reduces photosynthetic action [6]. Dyes even in low concentrations affect the aquatic life and food web. Since many organic dyes are harmful to human beings, the removal of colour becomes important [7].

Conventional methods for removing dyes include adsorption, electrocoagulation, ozonation, ultrafiltration, reverse osmosis, flocculation, oxidation, ion-exchange, etc. [8]. Adsorption has been found to be highly efficient for the removal of colour in terms of ease of operation, initial cost, simplicity of design [9] and sludge free process [10]. The most commonly used adsorbent for colour removal is activated carbon, because of its capability for efficiently adsorbing a broad range of different types of adsorbate [11,12]. Available abundantly, high biosorption capacity, cost-effectiveness and renewability are the important factors making these materials as economical alternatives for water treatment and waste remediation. This paper presents a state of the art review of Coconut-based biosorbents used for water pollution control, highlighting and discussing key advancement on the preparation of novel adsorbents utilizing Coconut wastes, its major challenges together with the future prospective. It is evident from the literature survey that Coconut-based biosorbents have shown good potential for the removal of various aquatic pollutants. However, still there is a need to find out the practical utility of such developed adsorbents on commercial scale, leading to the superior improvement of pollution control and environmental preservation.

In the present study the adsorption of acid orange 7 dye onto GAC of coconut shell and coal ash have been investigated. The adsorption isotherms were evaluated in batch tests by using synthetic dye solution. Saturation time for both the adsorbents has been determined by conducting column studies.

2. MATERIALS AND METHODS

2.1 Materials

In the present study, two different materials were used as low-cost adsorbents. Granular activated carbon of coconut shell used in the study was procured from Enviro Extreme, Bangalore, India. The GAC was sieved and particles size of 1.18mm were used as adsorbent in the study. Coal-ash was collected from Raichur Thermal Power Plant, Raichur, India. The coal-ash was sieved and the particles of size 2.36 mm were used as an adsorbent for removal of colour. Adsorbents used are of different size and selected randomly as available in the sample to investigate the adsorption capacity. Acid orange 7, an anionic dye is used as an adsorbate for the present study. Fig. 1 shows the chemical structure of acid orange 7 dye. Table 1 shows the general specification of Acid Orange 7 dye. Stock solution of acid orange 7 was made using distilled water. All working solutions were prepared by diluting the stock solution with distilled water.

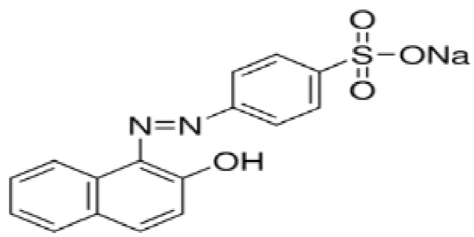

Fig. 1. Chemical structure of Acid Orange 7 dye

Table 1. General specification of Acid Orange 7 dye

Molecular weight Physical appearance	350.32 g/mol Orange powder
UV absorption	λmax 490nm
Storage	Store at room temperature

2.2 Batch Studies

Batch experiments were carried out to measure the colour adsorption by two different adsorbents. Different adsorbent dosages were added to 100ml of synthetic dye solutions. The experiments were carried out by shaking each adsorbent of different dosages (0.5, 1 and 1.5 grams) with 100ml of dye solution of having initial concentration of 50 mg/l and 100 mg/l respectively. In order to mix the solution, the samples were placed in Rotary orbital shaker and samples were mixed for different contact times (5, 10, 15 and 20 min respectively) at pH values of 4, 6 and 8 with the speed of 150 rpm. The supernatant was withdrawn and analysed for colour concentration using colorimeter at 490nm. The tests give the optimum dosage, pH and contact time. Isotherms were also developed. The pH of the synthetic sample was maintained by 0.1N HCl and 0.1N NaOH.

2.3 Column Experiments

Depending on the optimum conditions obtained by batch studies for different adsorbents, column studies were performed to determine the saturation time and to obtain break-through curve. The following experimental set up has been made for the continuous removal of colour from dye solution. A column, 2.5 cm diameter and 15 cm bed height, filled with two different adsorbents was employed for this study. The column was charged with synthetic dye solution of initial 100mg/l concentration and industrial wastewater. The column was run with an average flow rate of 7ml/min. Samples were collected at specific interval hours and residual dye concentration was measured using colorimeter at wavelength of 490nm. The column was operated in up-flow mode without effluent recycle.

3. RESULTS AND DISCUSSION

3.1 Batch Study

3.1.1 Effect of pH

pH is an important controlling parameter in the adsorption process [11]. To study the influence of pH on the adsorption capacity of GAC and Coal-ash adsorbents for colour removal, experiments were performed at room temperature, for several contact times, using various initial solution pH values 4, 6 and 8 and dye solution with initial concentrations 50 and 100 mg/l. The relation between the pH of the synthetic sample and percentage removal of colour by GAC and Coal-ash adsorbents for initial concentration of 50 mg/l and 100 mg/l respectively at optimum contact time of 15 minutes are shown in Figs. 2-5. It is observed that there is no much influence of pH on percentage colour removal by adsorption on GAC and coal ash. Since, removal of colour was found to be almost same in all pH ranges of pH4, pH6, pH8. As the economical point of view removal of colour with less dosage and less time was found in pH6. So, pH6 was considered as optimum pH for further column study.

3.1.2 Effect of adsorbent dose

To investigate the effect of adsorbent dosage on colour removal onto the various adsorbent surfaces, experiments were carried out with initial dye concentration of 50 and 100 mg/l and varying adsorbent dose at room temperature and at a constant stirring speed of 150 rpm for different contact time. The results show that the percentage removal increased with increasing adsorbent dose due to the increase in the total available surface area of the adsorbent particles. Figs. 6-9 shows the effect of adsorbent dosage on colour removal using GAC and Coal-ash adsorbents for initial concentration of 50 mg/l and 100mg/l respectively at optimum contact time of 15 minutes for both the adsorbents.

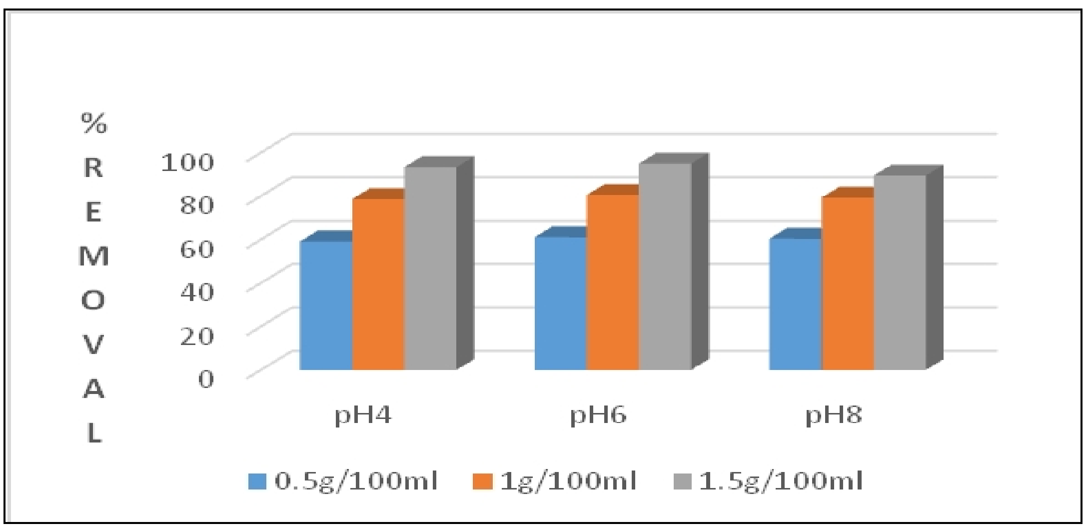

Fig. 2. Effect of pH on colour removal for initial concentration of 50 mg/l at contact time of 15 minutes and at different dosages of GAC

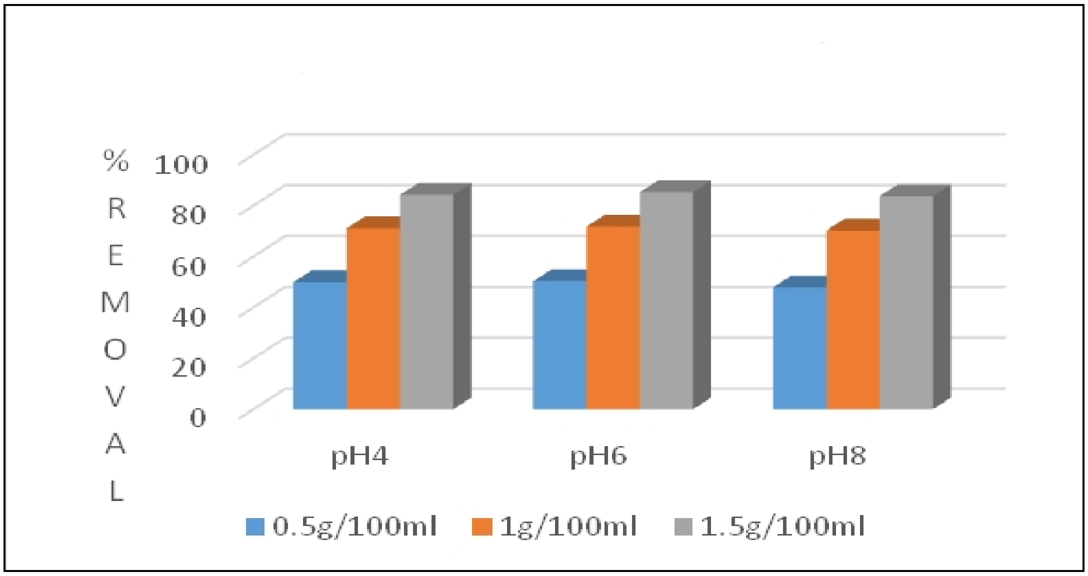

Fig. 3. Effect of pH on colour removal for initial concentration of 100 mg/l at contact time of 15 minutes and at different dosages of GAC

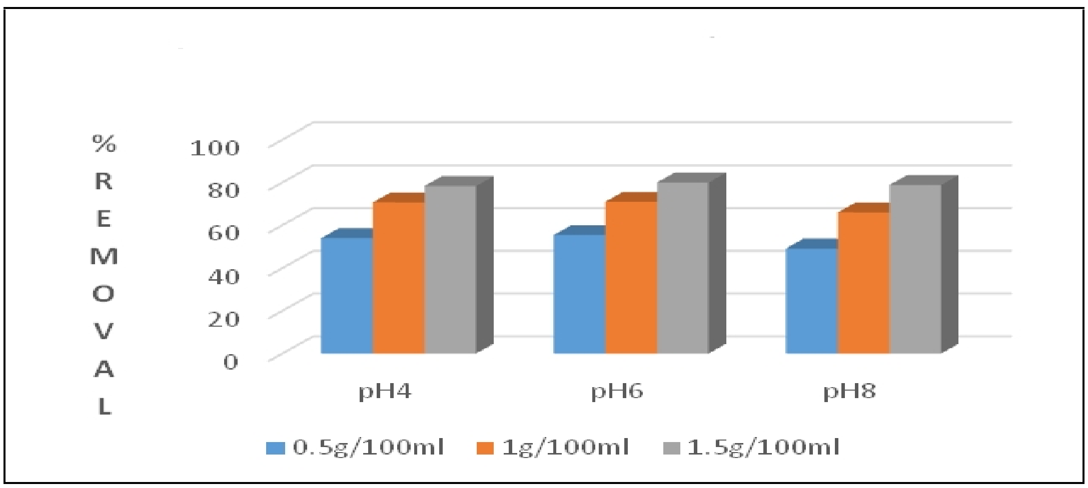

Fig. 4. Effect of pH on colour removal for initial concentration of 50 mg/l at contact time 15 minutes and at different dosages of coal ash

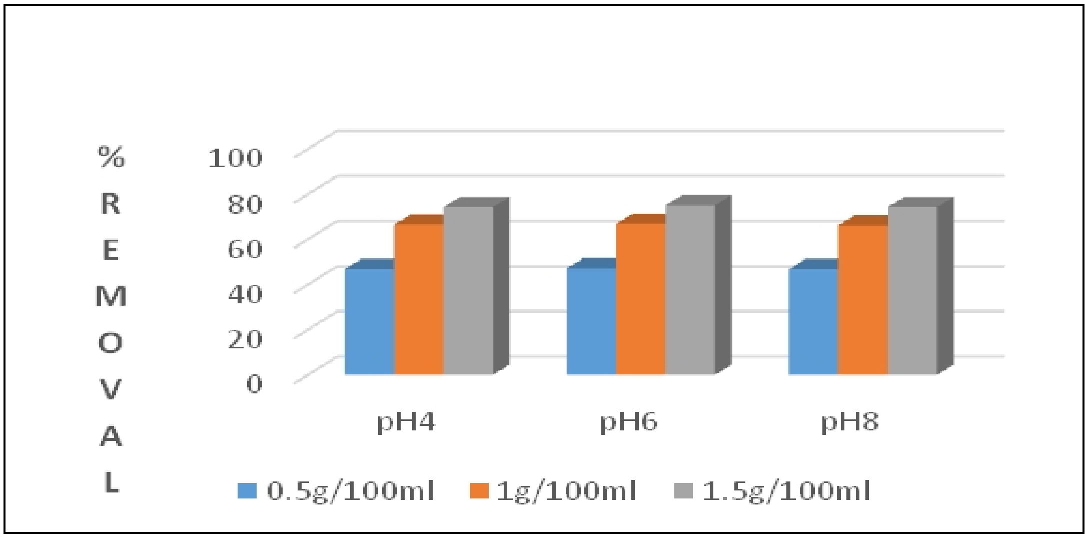

Fig. 5. Effect of pH on colour removal for initial concentration of 100 mg/l at contact time 15 minutes and at different dosages of coal ash

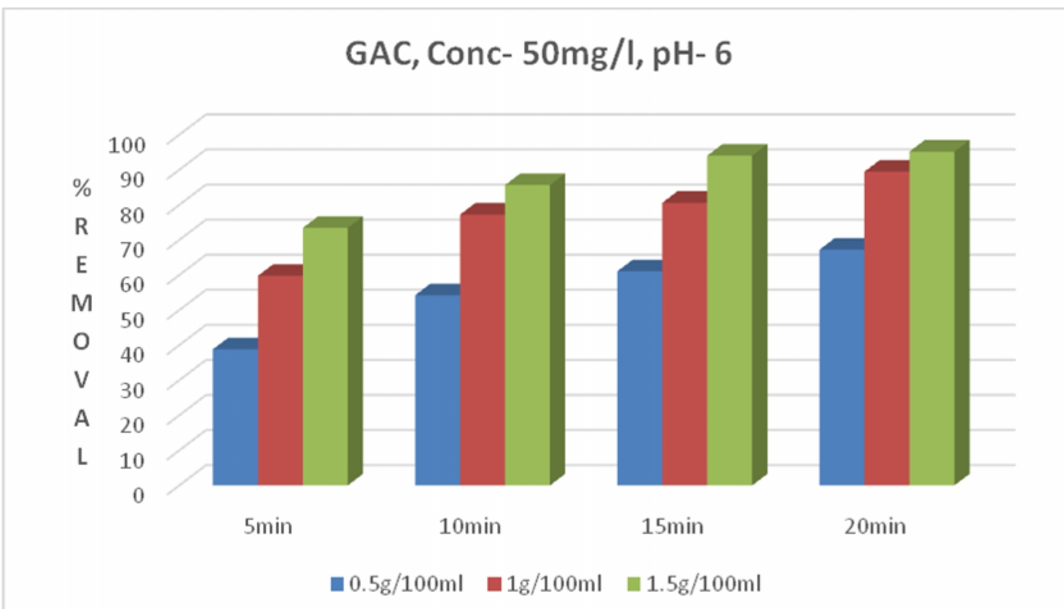

Fig. 6. Effect of Adsorbent dosage on colour removal for initial concentration of 50 mg/l at pH6 using GAC

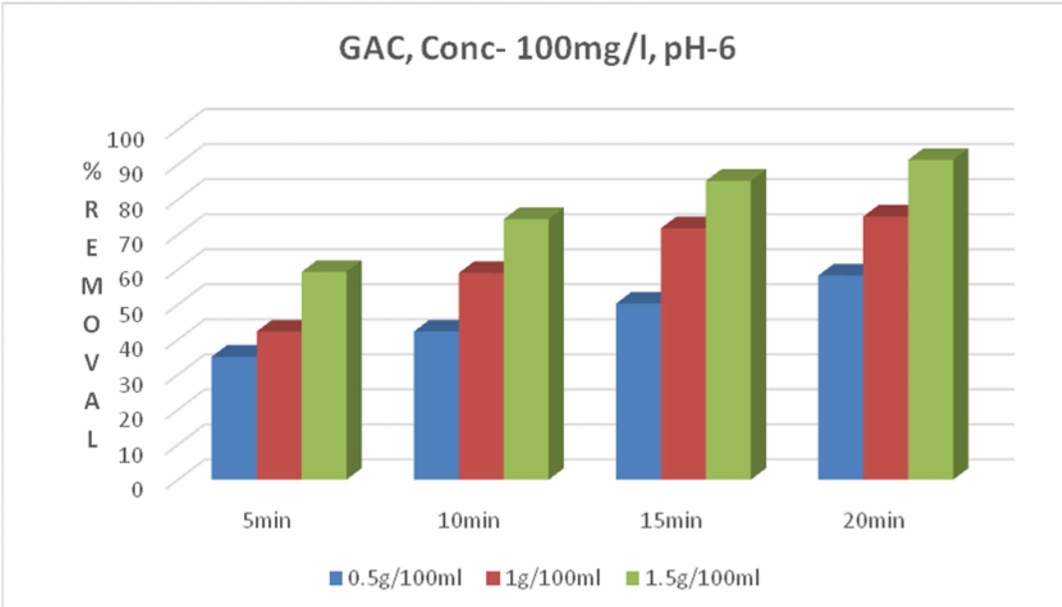

Fig. 7. Effect of Adsorbent dosage on colour removal for initial concentration of 100 mg/l at pH6 using GAC

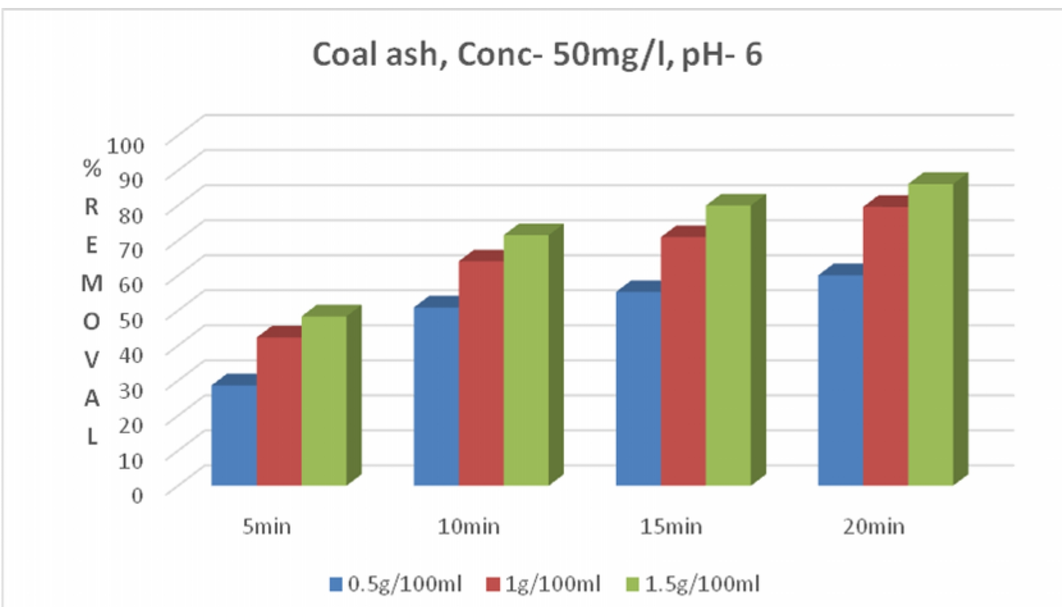

Fig. 8. Effect of Adsorbent dosage on colour removal for initial concentration of 50 mg/l at pH 6 using Coal ash

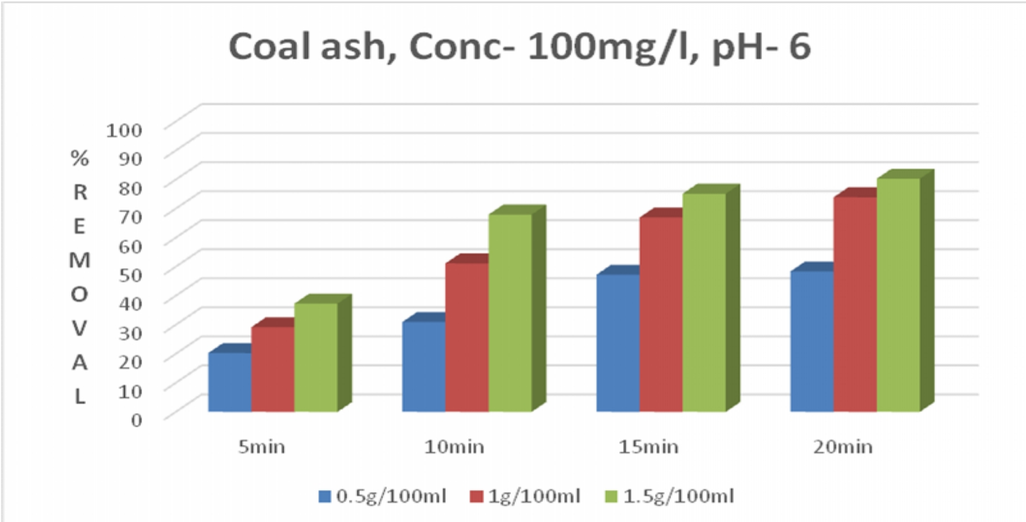

Fig. 9. Effect of Adsorbent dosage on colour removal for initial concentration of 100 mg/l at pH6 using Coal ash

3.2 Column Study

The ratio of effluent concentration to influent concentration was plotted against the column operation time with a constant flow rate of 7ml/min. From the column break-through curve, the saturation time for GAC for synthetic sample of initial concentration 100 mg/L was found to be 218 hours and the saturation time for Coal ash for synthetic sample of initial concentration d 100 mg/L was found to be 96 hours. Figs. 10 and 11 shows the break through curve for coal ash and GAC for initial concentration of 100mg/l respectively. Both freundlich and Langmuir isotherm were plotted. Langmuir isotherm was found to be best fit for both the adsorbents. The experiments were carried out on industrial wastewater for the removal of color with the optimum operating conditions which were obtained from batch studies. Results obtained on industrial wastewater showed the results were in par with the synthetic sample.

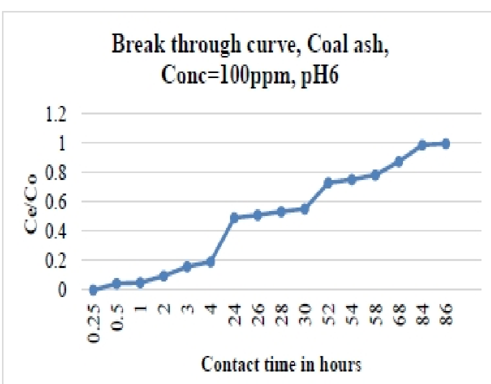

Fig. 10. Breakthrough curve for 15cm depth of Coal ash for industrial sample of Co= 100mg/l

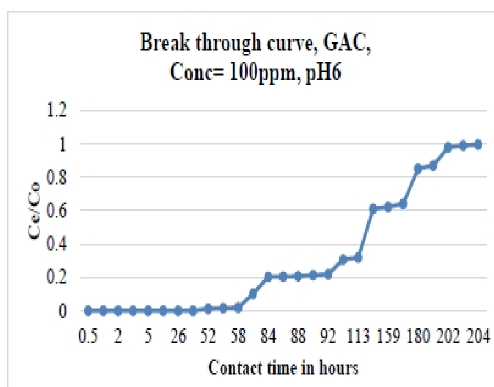

Fig. 11. Breakthrough curve for 15cm depth of GAC for industrial sample of Co= 100mg/l

4. CONCLUSION

In batch studies, the optimum pH, effective dosage and reaction time were optimized. As a result, pH of 6, dosage of 1.5 gm/100ml and contact time of 15 minutes were found to be optimized condition for the removal of acid dye by GAC of coconut shell and Coal ash. Increase in adsorbent dosage increased the percentage removal of dyes. Results from the column study showed that higher initial concentration resulted in shorter column saturation time. Adsorption isotherms were plotted for optimum conditions. Langmuir isotherm was found to be the best fit for both the adsorbents.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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