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Spectrophotometric Analysis and Removal of Fluorescein Sodium Dye from Aqueous Solution using Activated Charcoal & Bentonite

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Abstract

This work aims to study the adsorption of dyes on a adsorbent.Efficiency and performance of adsorbents like activated charcoal and bentonite clay for the removal of dye from aqueous effluents have been studied. The influence of variables including pH, initial dye concentration and contact time on dye removal have been investigated. It was found that more than 98 % removal efficiency was obtained within 15 minutes at adsorbent dose of 1g for higher initial dye concentration at pH 8 and pH 2. Intense sunlight degrades fluorescein quickly but samples are stable if kept in dark. Degradation slows down as dye concentration rises. The property of fluorescein sodium solution to change its color according to its concentration can be used to visualize the vapourization of plane and the adsorbent used is very effective for removal of dyes. Removal capacity of natural bentonite clay confirms the presence of montmorillonite unit and presence of electron donor functional groups in activated charcoal.

Keywords: Fluorescein Sodium,Degradation, Adsorbents, Bentonite, Charcoal.

1.Introduction

Disposal of wastewater containing toxic organic solutes, a serious threat to life. Waste reprocessing, contamination control and water treatment becomes fundamental questions for world. Synthetic dyes explored in numerous field such as textile, leather tanning, paper industry, food technology, agricultural research, hair coloring and cosmetics etc. All these contain critical amount of dyes. One of the commercially available textile dye and artificial coloring agent is fluorescein sodium. In the solid form fluorescein sodium dye exist in orange red to dark red powder tending to yellowish green on dilution under ultraviolet light. It explored from medicinal to forensics and cosmetics. The water contaminants like industrial waste, nuclear waste , domestic sewage and dye effluents are the cause of diseases like cancer, lungs diseases,allergic reactions, severe pain, Blurred vision, Abdominal discomfort, difficult to breath and urine discoloration. Around 60 percent release of dyes into waste water significantly increases the chemical oxygen demand and biological demand , which are not standard discharge as well as unacceptable for its toxicity, non- biodegradability ,mutagenic nature, causing destruction of kidneys, liver, Brain and Fertility.

Since, all these aqueous effluents and dyes causing environmental crisis and key problems for human beings, conventional biological treatment methods are incompatible to ecological deterioration of wastes, especially when the dyes are present in superabundance. However, the adsorption method is reckoned as universal approaches for organic dye removal and inorganic poisions due to its feasibility, sorption ability, cation exchange capability and high superficial area.

The present work aims to study a convenient and economic method for the fluorescein sodium dye removal by bentonite and activated charcoal. Bentonite as low cost and abundantly available adsorbents whereas Activated charcoal being a limited natural resource and difficulty of regeneration a search for cheap and effective adsorbents i.e the derivatives of bentonite clay plays a pivotal role. Due to the presence of electron donor functional groups of activated charcoal makes responsible for removing contaminants at peak level.

2.Materials and Methods

2.1. Instrumentation

UV-vis Spectrophotometer [Double Beam Spectrophotometer AU – 2703, Systronics(India) Limited] equipped with 1 cm quartz cuvette was used. To stir the solution, magnetic stirrer was used. The visible light source was normal w- filament bulb. For filter the solution Whatman filter paper, Cat No. 1001 125, 125 mm ø was used. Fluorescein powder is weighed by four digit analytical balance(BSM220.4).

2.2.Methods

Fluorescein sodium dye (Loba Chemie Pvt. Ltd) was bought from market with molecular weight 376.28 g/mol, C.I. No. 45350 and the stock solutions were prepared 100 ppm & 200 ppm by dissolving 0.1 g fluorescein sodium in 1000 ml of double distilled water in Borosilicate volumetric glass. The solutions were stored in dark place .This solution were diluted to prepare standard solutions when required. Different fluorescein sodium concentrations such as 10ppm,20ppm,30ppm,40ppm upto 200 ppm were prepared accordingly by diluting the stock solution with deionized water and by using formula $V_1N_1 = V_2N_2.$

100 ml of fluorescein sodium dye and 1g of bentonite (Barmer,Rajasthan) is added, then the electrodes were immersed in the solution and homogenized by continuous magnetic stirring with a rate of 220 rpm with defined temperature for pH 2 and pH 8 for bentonite and activated charcoal. Similarly, the batch method was conducted for charcoal at a fixed temperature and different time intervals at a gap of 15 minutes such as 15 minutes,30 minutes,45 minutes….while maintaining initial concentrations and pH dose . The suspension of bentonite and charcoal were filtered and the filtrate were analysed by double beam spectrophotometer AU-2703 . The degdration of dye removal was studied at different parameters and the absorbance of the degraded samples was noted at 490 nm. Removal percentage of fluorescein was calculated by formula

$$\% \text{ Removal} = \frac{\mathbf{Abs}_{o}^{m} - \mathbf{Abs}^{m}}{\boldsymbol{Abs}_{o}^{m}} \times \mathbf{100}$$

3.Results and Discussion

The color of a fluorescein water solution changes with decreasing concentration from red to orange to yellow and finally to light green. Fluorescein sodium dye has wavelength of 490 nm. It decomposes slowly. The concentration of fluorescein sodium ranges from 10ppm to 200ppm whereas the time ranges from 15 minutes to 60 minutes. The maximum absorbance at 45 minutes for 40 ppm shown in figure 1. The absorbance at 490 nm wavelength is 0.096. Table 1 shows the absorbance of fluorescein sodium at different concentrations at pH 2. At higher initial concentration of 150 ppm and 200 ppm absorbance is stable for 30 and 45 minutes.

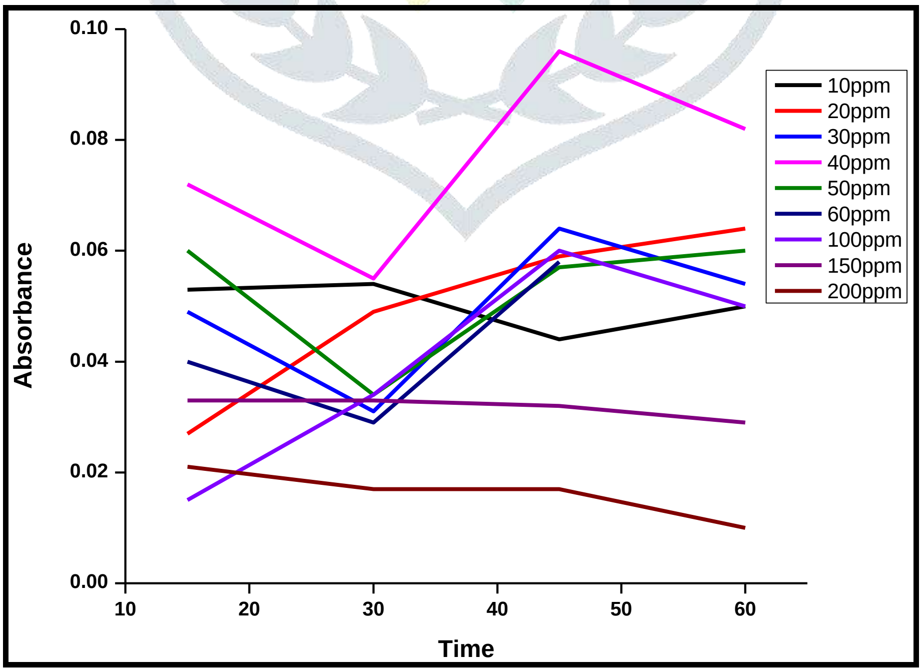

Figure.1.Absorbance at different time intervals at pH 2 using bentonite

Table 1. Absorbance of the fluorescein sodium dye with bentonite at different time intervals at pH 2.

Sample No.	Initial Concentration	Adsorbent Used	Time	Absorbance (490 nm)
F_1	10 ppm	Bentonite	15 minute	0.053
F_2	10 ppm	Bentonite	30 minute	0.054
F_3	10 ppm	Bentonite	45 minute	0.044
F_4	10 ppm	Bentonite	60 minute	0.050
F_5	20 ppm	Bentonite	15 minute	0.027
F_6	20 ppm	Bentonite	30 minute	0.049
F_7	20 ppm	Bentonite	45 minute	0.059
F_8	20 ppm	Bentonite	60 minute	0.064
F_9	30 ppm	Bentonite	15 minute	0.049
F_{10}	30 ppm	Bentonite	30 minute	0.031
F_{11}	30 ppm	Bentonite	45 minute	0.064
F_{12}	30 ppm	Bentonite	60 minute	0.054
F_{13}	40 ppm	Bentonite	15 minute	0.072
F_{14}	40 ppm	Bentonite	30 minute	0.055
F_{15}	40 ppm	Bentonite	45 minute	0.096
F_{16}	40 ppm	Bentonite	60 minute	0.082
F_{17}	50 ppm	Bentonite	15 minute	0.060
F_{18}	50 ppm	Bentonite	30 minute	0.034
F_{19}	50 ppm	Bentonite	45 minute	0.057
F_{20}	50 ppm	Bentonite	60 minute	0.060
F_{21}	60 ppm	Bentonite	15 minute	0.040
F_{22}	60 ppm	Bentonite	30 minute	0.029
F_{23}	60 ppm	Bentonite	45 minute	0.058
F_{24}	100 ppm	Bentonite	15 minute	0.015
F_{25}	100 ppm	Bentonite	30 minute	0.034
F_{26}	100 ppm	Bentonite	45 minute	0.060
F_{27}	100 ppm	Bentonite	60 minute	0.050
F_{28}	150 ppm	Bentonite	15 minute	0.033
F_{29}	150 ppm	Bentonite	30 minute	0.033
F_{30}	150 ppm	Bentonite	45 minute	0.032
F_{31}	150 ppm	Bentonite	60 minute	0.029
F_{32}	200 ppm	Bentonite	15 minute	0.021
F_{33}	200 ppm	Bentonite	30 minute	0.017
F_{34}	200 ppm	Bentonite	45 minute	0.017
F_{35}	200 ppm	Bentonite	60 minute	0.010

Figure-2 clearly shows the maximum absorbance graph at concentration of 200 ppm, 150 ppm ,100 ppm, 60 ppm, 50 ppm,40 ppm,30 ppm and also achieving the equilibrium condition with bentonite at pH 8. Figure-3 and Figure-4 at pH 2 and 8 respectively shows the absorbance at different time intervals of activated charcoal. Both the graph shows that maximum absorbance at higher initial concentration of 200pmm, 150ppm and also shows stability of maximum removal of dyes at this concentration. Table-2 illustrated removal percentage by charcoal at pH 8. Almost maximum absorbance and percentage removal of dyes is shown by charcoal at a concentration of 200 ppm, 150 ppm, 100 ppm at a time intervals of 45 and 60 minutes. Figure-5 shows the dye removal percentage at pH 8 with the help of bentonite. At concentration of 30ppm, 40 ppm, 50ppm, 60ppm, 100 ppm, 150 ppm and 200 ppm degraded the dye upto 98 % at pH 8.It confirms the presence of montmorillonite unit. Figure-6 shows that highly efficient and most effective capacity of charcoal combinedly for absorbance and for dye removal upto 99.9 % at pH 8. It is due to microporous nature, high specific area and pore volumes with electron donor functional groups such as hydroxyl, carboxyl, phenol, quinine and lactone on the surface. The decoloration of dye gradually increases when the dye concentration and time interval increases. The color removal goes on increasing with increase in dose.Figure-7. Clearly justify that at pH 2, the dye removal capacity of activated charcoal with respect to time at higher initial concentration is maximum.

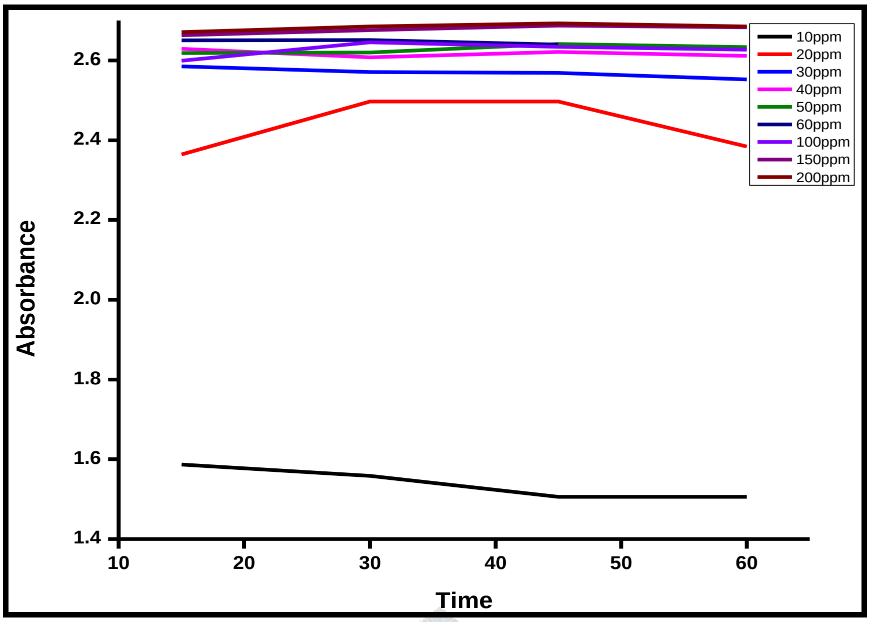

Figure.2: Absorbance at different time intervals at pH 8 using bentonite

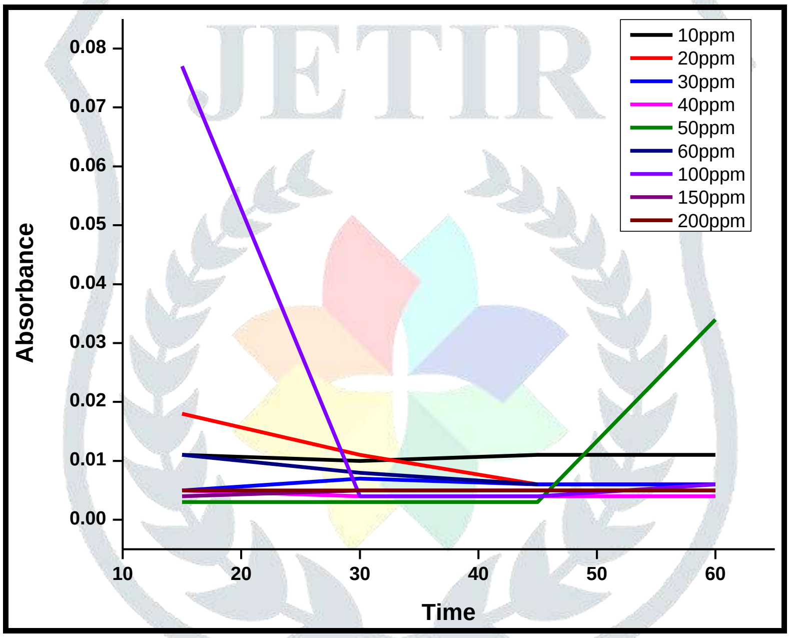

Figure. 3. Absorbance at different time intervals at pH 2 using charcoal

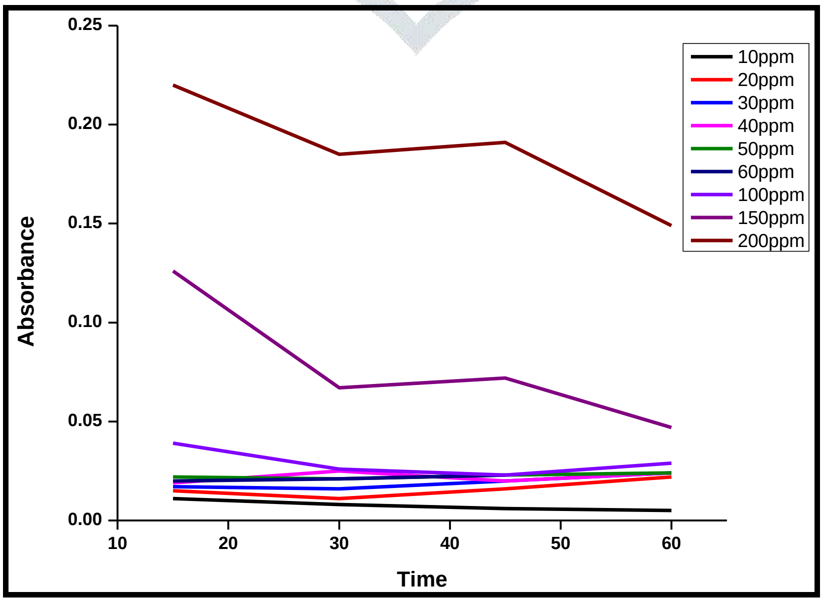

Figure.4. Absorbance at different time intervals at pH 8 using charcoal

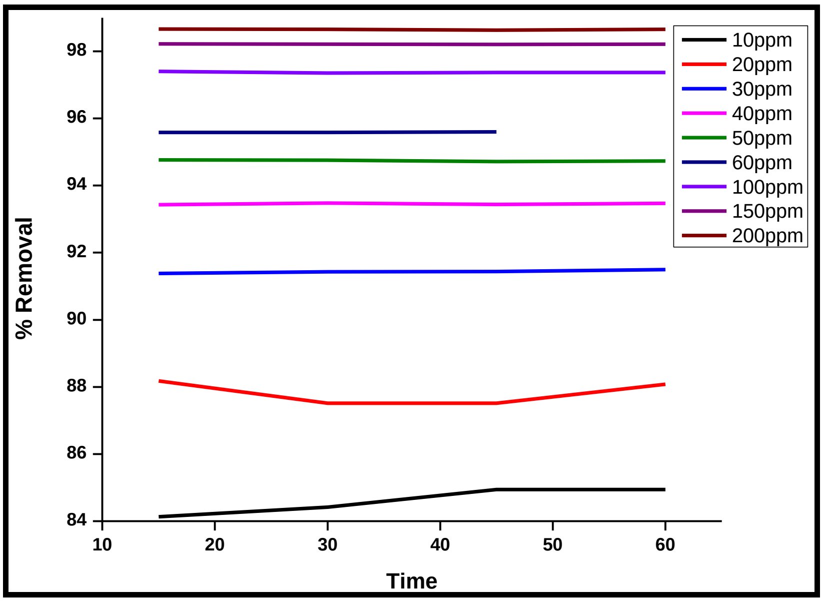

Figure.5. Percentage removal of Fluorescein sodium with bentonie vs time at pH 8

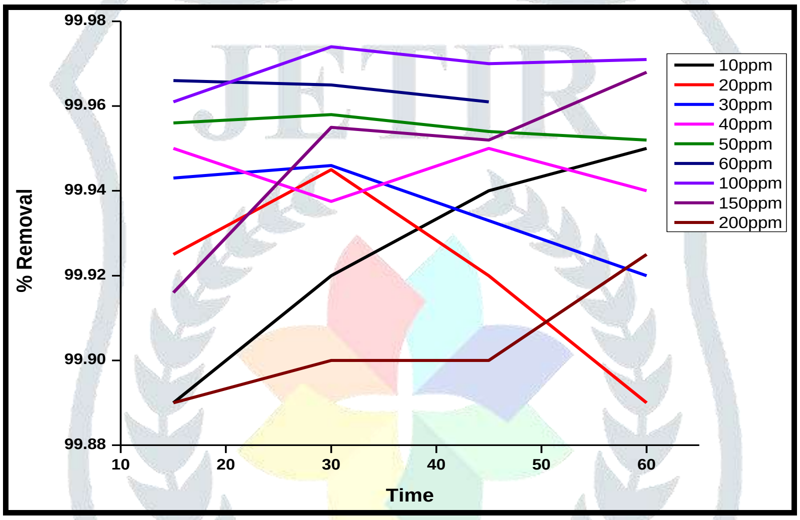

Figure.6. Percentage removal of Fluorescein sodium with charcoal Vs time at pH 8

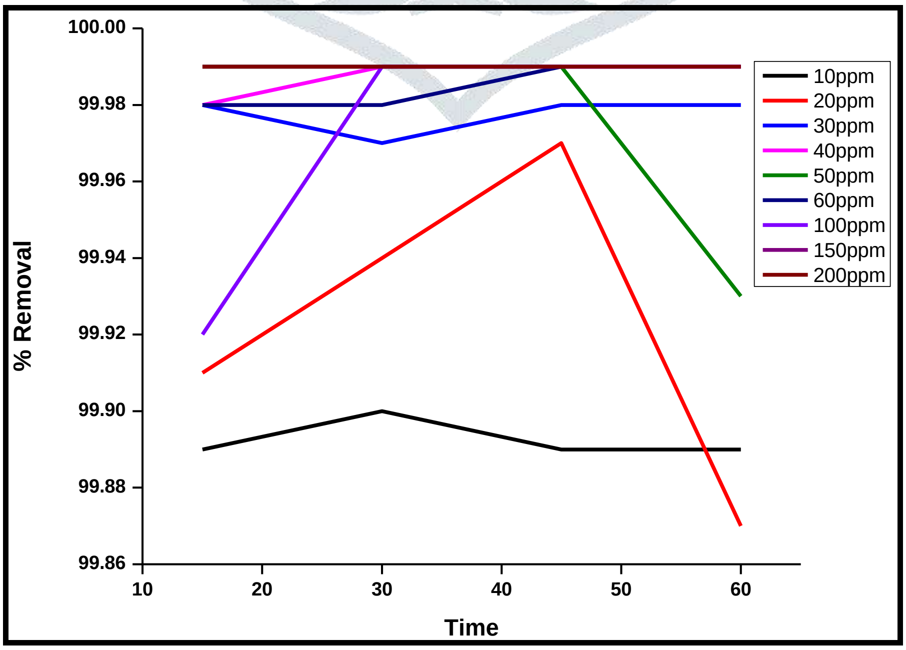

Figure.7. Percentage removal of Fluorescein sodium with charcoal Vs time at pH 2

Table 2. Percentage removal for different initial concentrations at different time intervals at pH 8

Sample No.	**Adsorbent Used**	**Concentration**	**Time**	**pH**	**% Removal**
F_1	Activated Carcoal	10 ppm	15 minute	8	99.89
F_2	Activated Charcoal	10 ppm	30 minute	8	99.92
F_3	Activated Charcoal	10 ppm	45 minute	8	99.94
F_4	Activated Charcoal	10 ppm	60 minute	8	99.95
F_5	Activated Charcoal	20 ppm	15 minute	8	99.92
F_6	Activated Charcoal	20 ppm	30 minute	8	99.94
F_7	Activated Charcoal	20 ppm	45 minute	8	99.92
F_8	Activated Charcoal	20 ppm	60 minute	8	99.89
F_9	Activated Charcoal	30 ppm	15 minute	8	99.943
F_{10}	Activated Charcoal	30 ppm	30 minute	8	99.946
F_{11}	Activated Charcoal	30 ppm	45 minute	8	99.933
F_{12}	Activated Charcoal	30 ppm	60 minute	8	99.92
F_{13}	Activated Charcoal	40 ppm	15 minute	8	99.95
F_{14}	Activated Charcoal	40 ppm	30 minute	8	99.93
F_{15}	Activated Charcoal	40 ppm	45 minute	8	99.95
F_{16}	Activated Charcoal	40 ppm	60 minute	8	99.94
F_{17}	Activated Charcoal	50 ppm	15 minute	8	99.956
F_{18}	Activated Charcoal	50 ppm	30 minute	8	99.958
F_{19}	Activated Charcoal	50 ppm	45 minute	8	99.954
F_{20}	Activated Charcoal	50 ppm	60 minute	8	99.952
F_{21}	Activated Charcoal	60 ppm	15 minute	8	99.966
F_{22}	Activated Charcoal	60 ppm	30 minute	8	99.965
F_{23}	Activated Charcoal	60 ppm	45 minute	8	99.961
F_{24}	Activated Charcoal	100 ppm	15 minute	8	99.961
F_{25}	Activated Charcoal	100 ppm	30 minute	8	99.974
F_{26}	Activated Charcoal	100 ppm	45 minute	8	99.97
F_{27}	Activated Charcoal	100 ppm	60 minute	8	99.971
F_{28}	Activated Charcoal	150 ppm	15 minute	8	99.916
F_{29}	Activated Charcoal	150 ppm	30 minute	8	99.955
F_{30}	Activated Charcoal	150 ppm	45 minute	8	99.952
F_{31}	Activated	150 ppm	60 minute	8	99.968

	Charcoal				
F_{32}	Activated Charcoal	200 ppm	15 minute	8	99.89
F_{33}	Activated Charcoal	200 ppm	30 minute	8	99.90
F_{34}	Activated Charcoal	200 ppm	45 minute	8	99.90
F_{35}	Activated Charcoal	200 ppm	60 minute	8	99.925

4.Conclusion

The optimal results of removal were the use of 1 g of adsorbents under standard conditions for a contact time of 60 minute at pH 8 and pH 2. The current approach supports the Sustainable Development Goals by lowering pollution and improving sustainable water management techniques in response to growing water scarcity.

5. Author Contributions

The authors contributed significantly to this manuscript, participated in experimental and data collection, and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:
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