International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/


(Research Article)

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# Removal of rhodamine dye from aqueous solution using white egg shell as low-cost adsorbent

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International Journal of Science and Research Archive, 2025, 14(01), 519–524

Publication history: Received on 05 December 2024; revised on 12 January 2025; accepted on 14 January 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.14.1.0133

## Abstract

The research of an inexpensive adsorbent for the adsorption of RD from its aqueous solution is the main goal of this work. Egg Shell Powdered (ESP), a cheap adsorbent, worked well for the sorption colors from its aqueous solution. This study investigates the possibility of using egg shell powder as an inexpensive adsorbent to remove rhodamine from aqueous solutions. For RD, the effects of primary concentration, sorption duration, and adsorbent quantity on dye removal were examined. An hour was allotted for equilibration. The equilibrium sorption isotherms have been studied using both the linear Freundlich and the Langmuir models.

**Keywords:** Rhodamine dye; Egg Shell Powdered; Adsorption processes; Dyes removal from aqueous solution

## 1. Introduction

Because of the harmful and irreversible consequences that these pollutants have on the environment and human health, the contamination of water by poisonous chemicals, heavy metal ions, and dyes causes ecological and public problems. Adsorption is a practical method of separation, and the adsorbent might be from a natural, mineral, or organic source [1].

Many different businesses have employed dyes to provide color. One of the major pollutants that releases highly concentrated effluent into the environment is the textile sector. Every year, more than 7x10' tons of dye and pigment of around 10,000 distinct varieties are produced globally, and the amount is continuously growing [ 2].

Carcinogens present in dyes can pose a significant risk to aquatic life and water users. Therefore, it is of utmost importance to eliminate these pollutants from wastewater before they are finally disposed of. [3,4] The processes of oxidation [5,6], coagulation [7,8], photodegradation [9], agglomeration [10], ion exchange, and filtering [11] are intricate and expensive, particularly because some of them need for extra chemicals or result in hazardous byproducts [12]. Adsorption has been demonstrated to be one of the most successful and economical strategies for eliminating color from aqueous solutions among [13,14].

Because of its high capacity to absorb organic molecules, the most popular adsorbent for this use is activated carbon. However, its application is restricted due to its expensive cost. Efforts have been undertaken to identify inexpensive substitute adsorbents in an effort to lower treatment costs. To extract colors from a range of starting materials from trash, several researchers have developed inexpensive and efficient adsorbents [ 3,15,16]. The goal of this project is to investigate egg shell powder's potential as an inexpensive color removal adsorbent.

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The current study investigated the adsorption potential of low-cost, locally available natural materials such as eggshell white using rhodamine (Rh) as a model contaminant. The paper, paint, and textile industries all make extensive use of rhodamine, a significant cationic dye. [17]. and as a biological dye in laboratories [18].

Additionally, Rh is commonly used as a tracer dye to determine the direction and rate of flow and transport in a range of aquatic settings. because of its intense fluorescence even at low concentrations and great solubility in water [19]. Like the majority of synthetic dyes, rhodamine is extremely harmful to a variety of organisms and may cause cancer [18, 19]. Because of its severely detrimental effects, it is crucial that it be removed from aquatic habitats and industrial waste.

## 2. Experimental

### 2.1. Materials

Materials used in this work is Rhodamine dye and egg shell powder.

### 2.2. Making powdered egg shell

After being gathered, egg shells were cleaned with distilled water and baked to dryness.It was then powdered and sieved to reduce the size of the particles. It was then kept in a closed bottle for use in adsorption research after being dried for four hours at 105 C °.

### 2.3. Adsorption studies

Consequently, RD (1g/L) was prepared as a stock solution and diluted to the required starting concentrations (25, 50, 75, and 125 parts per million). The adsorption tests were conducted at 20 ± 3C, or room temperature.25 mL of dye solution with the appropriate concentration was mixed with egg shell (0.03, 0.05, 0.1, and 0.2 g) and shaken at 75 rpm for 10 to 60 minutes. To separate the solid from liquid phases, the samples were immediately placed in a centrifuge. A UV-VIS spectrophotometer was then used for analysis. To get consistent findings, the trials were conducted three times.

## 3. Results and discussion

### 3.1. Effects of the First Concentration

Because it took 60 minutes to establish balance, the shaking period was determined to be appropriate for maximal adsorption and was adopted in all following trials. Figure 1 displays the results of adsorption experiments using RDon the (ESP) (0.1g of adsorbent weight) at different dye concentrations and contact times (25, 50, 75, and 125 ppm).

The equilibrium statistics show that when the dye concentration rises, the percentage clearance falls. Reduced surface area and saturated active sites result in a lower clearance %, as seen in the figure [20].

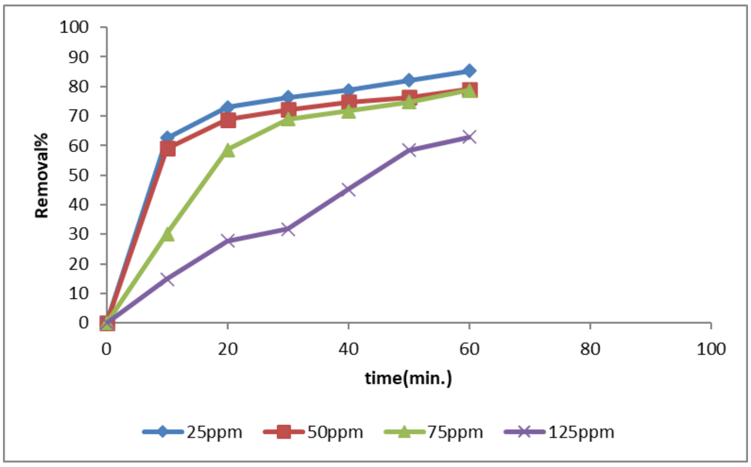


**Figure 1** Effect of initial concentration on removal %

### 3.2. Effect of adsorbent dosage

Depending on the amount of egg shell powder (ESP) taken (0.03, 0.05, 0.1, and 0.2 g), Figure (2) illustrates the elimination of RD dye (75 ppm). It is evident that the percentage of dye removal rises as the adsorbent dosage does. It goes without saying that as the adsorbent dosage is increased, the number of accessible adsorption sites also rises, which raises the dye removal percentage.

Due to the adsorption process's unsaturation of adsorption sites, the removal ratio decreases as the adsorbent dosage increases [ 21].

Particle interactions, like aggregation brought on by high adsorbent doses, could have a variety of causes. For example, aggregation could lead to a reduction in the number of surfaceactive sites by increasing the size of the particles and decreasing the adsorbent's overall surface area. [22 ,23]

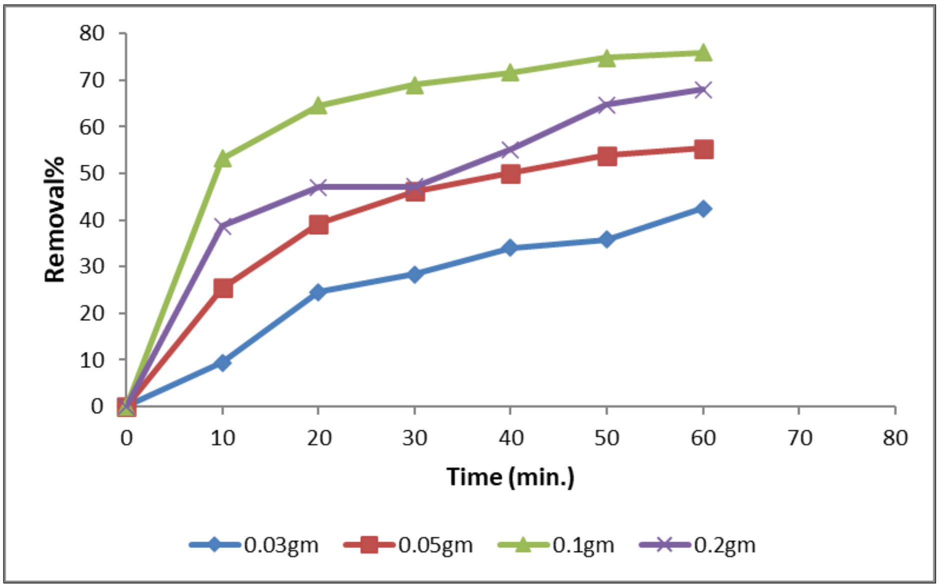


**Figure 2** The impact of adsorbent dose on removal percentage

**Table 1** The relationship between adsorbent dosage and removal %

| dosage of Egg Shell (gm) | Removal % |
|---|---|
| 0.03 | 42.45 |
| 0.05 | 55.38 |
| 0.10 | 75.99 |
| 0.20 | 68 |

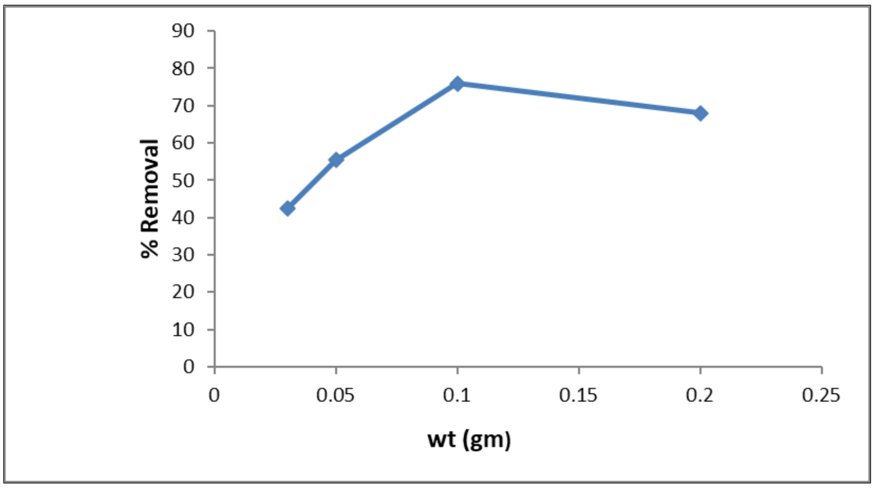


**Figure 3** The relationship between adsorbent dosage and removal %

The impact of egg shell weight on dye removal is shown in Table 1 and Figure 3. Since the optimum dye removal is achieved at a concentration of 75 ppm of the dye solution, it was discovered that the ideal weight for removal is 0.1 g.

### 3.3. Equilibrium studies

The linear freundlich adsorption isotherm was fitted to the equilibrium experiments carried out at various beginning concentrations and constant adsorbent dosage. This is the kind of

$$\frac{Log\ Kf + 1}{n \log ce} = \log\left(\frac{x}{m}\right)$$

$$\text{Log ( Q e )} = \frac{\text{log kf + 1}}{\text{n log } c_e}$$

where m is the adsorbent's weight employed (g) and X is the amount of dye extracted (mg). Kf and n are constants that include all variables influencing the adsorption process, such as adsorption capacity and intensity, whereas Ce represents the equilibrium concentration (ppm).

A Freundlich isotherm was followed by the adsorption. as demonstrated by the log (X/m) versus log Ce linear plot (figure 4). Kf and n, the Freundlich constants, were 0.349 and 1.213, respectively.

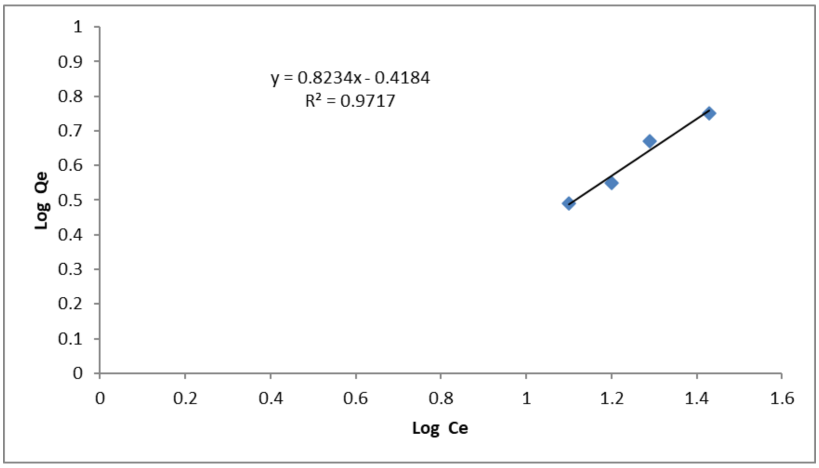


**Figure 4** Freundlich isotherm

The Langmuir isotherm's shape is

$$\frac{1}{\text{Qmb}} + \frac{\text{Ce}}{\text{Qm}} = \frac{\text{Ce}}{\text{Qe}}$$

It is employed in adsorption equilibrium, where Ce is the equilibrium concentration (ppm) and Qe is the amount of dye adsorbed (mg) per gram at equilibrium (mg/g). Langmuir constants Qm and b are associated with adsorption energy and efficiency, respectively.

It seems that the adsorption followed a Langmuir isotherm model according to Ce/Qe's linear plot vs Ce (figure 5). Plot slope and intercept were used to calculate Qm and b, which came out to be 20.7 mg/g and 0.0134 L/mg, correspondingly. Additionally, the adsorption results reveal monolayer adsorption with varied surface conditions, according to both Freundlich and Langmuir models [24].

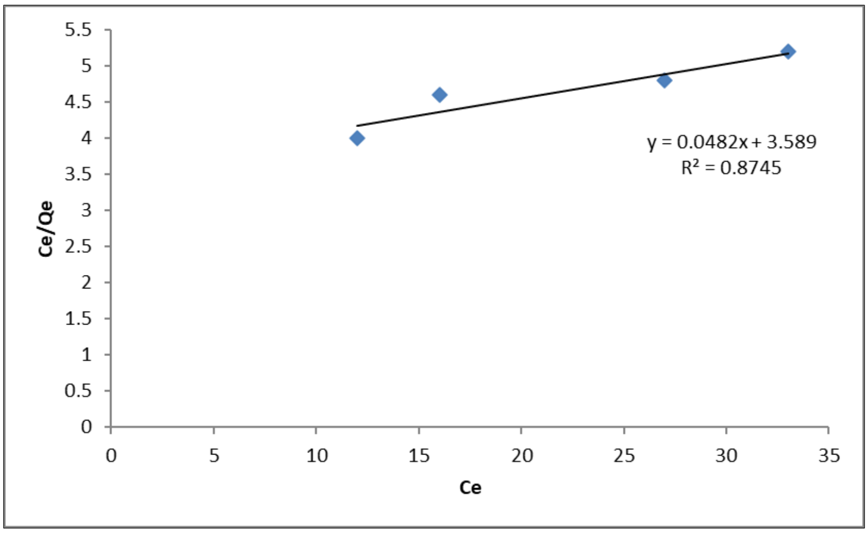


**Figure 5** The Langmuir isotherm

**Table 2** displays the Langmuir and Freundlich values

| Isotherms | Parameters | Values |
|---|---|---|
| Langmuir | $Q_m$ | 20.7 |
| | b | 0.0134 |
| | $R^2$ | 0.8745 |
| Freundlich | $K_F$ | 0.349 |
| | n | 1.213 |
| | $R^2$ | 0.9717 |

## 4. Conclusion

In addition to studying various measures, such as the best of mass for the ESP being 0.1gm and the best of concentration being 25ppm of dye, the study concluded that eggshell powder may be used as an inexpensive adsorbent for extracting dyes from its water-based mixture at lower concentrations. When compared to commercial activated carbon reported in literature, The effectiveness of removal and adsorption capacity of egg shell were shown to be greater. The Langmuir and Freundlich adsorption isotherms and the The experimental findings were in good agreement, and the corresponding isotherm parameters were computed.

## Compliance with ethical standards

*Disclosure of conflict of interest*

All authors declare that they have no conflicts of interest.

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