CHAPTER 1. INTRODUCTION

1.1 Background of The Problem

Dyes find extensive application in the textile and printing sector. The majority of these dyes consist of organic compounds, char- acterized by their toXicity, stability, and resistance to environmental degradation. Despite undergoing primary treatment, large-scale release of dye containing materials from industrial effluent like textile mills and printing company could pose a significant threat to aquatic ecosystems. The constituents commonly utilized in the dyeing industry encompass various organic substances, predominantly reactive dyes, disperse dyes, vat dyes, and direct dyes.

In 1884, Congo Red (CR) was discovered to have valuable functions as dye due to its great colouring qualities, simplicity and affordability which represented a significant achievement in the development of direct dyes. Typically, direct dyes are predominantly of the azo type (comprising mono-azo and poly-azo compounds). Majority of synthetic dyes available nowadays are azo based, primarily derived from aniline compounds. Hazardous pollutants like aniline compounds may pose severe environmental pollution and health risks. Since this notable di- rect dye of CR can exhibits carcinogenic properties and endanger the health of both human and animal; hence, removal of CR from effluents remains a critical concern.

Advanced physicochemical techniques such as ozonation, coagulation, membrane, electrocoagulation, chemical oXida- tion, biological, and etc, have been employed to remove CR dye. Nonetheless, these techniques are typically more costly and inefficient, need a regulated environment and significant amounts of chemicals, as well as produce hazardous by-products that can lead to waste management issues. For example, generating ozone requires significant energy input, often through ultraviolet (UV) light methods.The ion exchange approach is not appropriate for many types of dyes, whereas the membrane separation method typically generates sludge ina large amount. Additionally, only certain dyes can be mineralized by chemical oXidation, and this method is only practical economically to remove high concentration of dyes. The primary disadvantages of bio- logical treatment are the necessity for exact pH condition and tem- perature control, slow response rate, and disposal of sludge. Given these limitations, the adsorption process for removing CR dye appears to be the ideal option because of its relatively low operating expenses, excellent removal efficiency, ease of use, and reusable adsorbent.

Adsorbents such as banana peel powder, Citrus limetta peel powder, hydrochar, ZnO nanomaterial, FexCo3-XO4, and Fe(OH)3 @cellulose fibbers have been frequently utilized for the adsorption of CR. However, their preparation takes a long time and involves complicated purifying procedures. Alternatively, hy- drogel beads are polymeric materials that are easily prepared, afford- able, reusable, highly cross-linked, porous, and mechanically stable without the need for further purifying processes.

Hydrogel beads are three-dimensional, crosslinked polymer net- works capable of absorbing and retaining large volumes of water or aqueous solutions. Their tuneable properties, such as porosity, swelling behaviour, and surface chemistry, make them highly suitablefor various applications, including water purification. By in- tegrating specific functional groups or additives, hydrogel beads can be tailored to selectively adsorb target pollutants, such as CR dye. Among the materials used in hydrogel bead synthesis, sodium alginate (SA) derived from brown algae, stands out as a biocompatible, renewable, and economically viable option. Calcium (Ca) cations are fre- quently employed in crosslinking SA, leading to ion exchange and the formation of Ca alginate (CA) hydrogel. Furthermore, its molecular structure contains numerous hydroXyl (-OH) and carboXyl (-COOH) groups, making it an environmentally friendly choice for variety of dye molecules. Numerous studies have explored the adsorption of CR dye by SA; nevertheless, the key improvement highlighted by many studies is mostly connected to the weak stability of SA. SA may be generated into stable configuration of hydrogel beads through the cross-linking with synthetic polymer material. Various chemical modification techniques, such as cross-linking and the introduction of new functional groups, have been employed to improve stability and enhance SA's adsorption capacity.

Recently, surfactant-modified adsorbents, including biochar, iron oXide, and nanomaterial, have been utilized. Conse- quently, surfactant modification of SA for CR dye adsorption has been explored. Surfactants, characterized by their amphiphilic nature with hydrophilic and lipophilic components, are known to alter energy re- lationships at interfaces, typically by affecting surface or interfacial tension. Hence, surfactants have been widely employed in modifying various adsorbents. For instances, sodium dodecyl sul- fate (SDS), Poly (sodium styrene sulfonate) (PSS), sodium lauryl, and cetyltrimethylammonium ammonium bromide (CTAB). These surfactants serve as stabilizers for adsorbents, acting as surface modifiers and exhibiting an affinity for surface reactions.

However, CTAB stands out as the best choice for this study owing to itsstability in both alkaline and acidic conditions, robust surface activity, antibacterial characteristics, and cationic nature, facilitating the effective capture of CR dye through electrostatic attraction. Several reports have used CTAB as a surface modification of adsorbent and to enhance adsorption capacity of dyes such as activated biochar, chitosan-gelatin-CTAB composite, and organo-bentonite-CTAB. However, to the best of authors` knowledge, the incorporation of CTAB with SA for CR dye adsorption has not been properly docu- mented. Therefore, it was essential to assess their performance. In this present study, we would like to evaluate the feasibility of using SA- CTAB hydrogel bead composite with different CTAB ratio as an effective adsorbent to remove CR. It is expected that this research could address the lack of comprehensive studies on the properties, characterization, and ap- plication of SA-CTAB composite for CR dye adsorption. The effects of several factors including pH, initial CR concentration, and duration were examined. Isotherm and kinetic models were employed to comprehend the adsorption mechanisms. Additionally, regeneration of CR adsorption was also examined.

1.2 Research Question

Based on the background described in the Final Project above, the problem formulation is obtained, namely how the Composite Performance of Hydrogel

Beads Derived from Sodium Alginate Cetyltrimethyl Ammonium Bromide Respects the Adsorption of Congo Red Dye from Aqueous Solutions.

1.3 Objective

Based on the problem formulation that has been described in the title above, the aim is to be able to analyze and apply the Performance Of A Composite Of Hydrogel Beads Original From Sodium Alginate Cettyltrimetyl Ammonium Bromide On The Adsorption Of Congo Red Dyes From Aqueous Solutions.

1.4 Benefit

Based on the problem formulation and objectives that have been described regarding the Performance Of A Composite Of Hydrogel Beads Original From Sodium Alginate Cettyltrimetyl Ammonium Bromide On The Adsorption Of Congo Red Dyes From Aqueous Solutions, the following benefits can be taken:

a. Can be used as a reference for final assignments for students who want to complete their education at Jember State Polytechnic.
b. Can motivate readers in analyzing, and be able to test performance.
c. Can motivate students to try to analyze.