# COAGULATION/FLOCCULATION PROCESS FOR CATIONIC, ANIONIC DYE REMOVAL USING WATER TREATMENT RESIDUALS – A REVIEW

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**ABSTRACT**

*Due to rapid development of textile industries and the use of different synthetic dyes have resulted in severe water pollution. Considerable amount of colored effluent is generated from these industries due to consumption of large quantities of water at its different steps of dyeing and finishing among other processes. Coloration of water bodies due to disposal of untreated effluent from these industries is a major environmental problem especially in developing countries. Water treatment plants produce enormous amounts of sludge. Various intensive practices have been employed to reuse the alum sludge in an attempt to figure out how to fill the gap between successful drinking water treatment process and environmentally friendly alum sludge management for over the years. Therefore, in this research, an attempt is made to study the potential of aluminum-based water treatment residuals (WTR) discharged from water treatment plants as a coagulant for color removal from a cationic and anionic dye solution. This paper also attempts to study the cost effectiveness of reusing the sludge from water treatment plant as a coagulant for color removal.*

***Keywords: Catoinic dye, Anionic dye, Water Treatment Residuals, Coagulation/flocculation process, color removal***

## I. INTRODUCTION

The art of color application to enhance our self-appearance and the world around us has been known to man since time immemorial. Color is the main attraction of any fabric. No matter how excellent its constitution, if unsuitably colored it is bound to be a failure as a commercial product. Fabric was earlier being dyed with natural dyes. These however gave a limited and a dull range of colors. Besides, they show low color fastness when exposed to washing and sunlight. As a result they needed a mordant to form a dye complex to fix the fiber and dye together thus making the dyers' work tedious. Industries such as textile, leather, paper, plastics, etc., are some of the sources for dye effluents. The discharge of highly colored effluent is currently one of the world's major environmental problems as some of the dyes and their metabolites are either toxic or mutagenic and carcinogenic and pose a potential health hazard to all forms of life .

The presence of even very small amounts of dyes in water (less than 1 ppm for some dyes) is not only aesthetically displeasing, but also hinders light penetration, disturbing the biological processes in water bodies.

Over 100,000 commercially available dyes exist and more than $7 \times 10^5$ tonnes per year are produced annually. Further, some dyes cause allergy, dermatitis, skin irritation, and cancer to humans, in addition to being mutagenic. Various methodologies have been investigated for treating dye bearing effluents that can be classified in four categories: (i) physical (ii) chemical (iii) biological and (iv) acoustical, radiation, and electrical processes. Coagulation/flocculation is one of the most effective chemical treatment methods for dye removal from industrial wastewaters. Typical chemicals (coagulation reagents) used for water and wastewater treatment are predominantly inorganic salts of Al or Fe. Among these possible routes, the reuse of waterworks sludge as a coagulant in wastewater treatment can be considered as an attractive method that was studied by several research groups.

Dye removal by coagulation is the most commonly used method in industries, and is not based on the partial decomposition of dye compounds and thus no potentially harmful and toxic intermediates are produced. However, there is the inherent sludge formation and the need for disposal of the sludge produced. While the process has been widely employed, the operating conditions need to be carefully selected in order to maximize color/organic matter removal and to reduce chemicals consumption. Water treatment residuals are produced from the treatment of drinking and process water. Water treatment processes employ coagulants to remove inorganic and organic matter suspended in the untreated source water. The resulting product may be thickened liquid or a dewatered solid.

The present study focuses the potential and effectiveness aluminium-based WTR as an alternative coagulant for the removal of a cationic dye and anionic dye from water, which is widely used in textile industries in India. The effect of three parameters, namely, initial pH, WTR dosage, and initial dye concentration on color removal efficiency are studied.

### 1.1 Cationic and Anionic dyes

Textile dyes are classified under the categories of anionic, cationic and non-ionic dyes. Anionic dyes mostly include the direct, acid and reactive dyes. Acid dyes are water- soluble anionic dyes that are applied to fibers such as silk, wool, nylon and modified acrylic fibers using neutral to acid dye baths. Attachment to the fiber is attributed, at least partly, to salt formation between anionic groups in the dyes and cationic groups in the fiber. Acid dyes are not substantive to cellulosic fibers. Most synthetic food colors fall in this category.

Basic dyes are only the class of cationic dyes used in the textile industry. Basic dyes are water-soluble cationic dyes that are mainly applied to acrylic fibers, but find some use for wool and silk. Usually acetic acid is added to the dye bath to help the uptake of the dye onto the fiber. Basic dyes are also used in the coloration of paper.

Non-ionic dyes refer to disperse dyes, which do not ionize in aqueous medium. It is estimated that about 15% of the total world production of colorants are lost in the synthesis and processing of colorant. The wool and acrylic dyes tend to be in the best situation in this respect since high exhaustion is normal when applying anionic dyes to wool and cationic dyes to acrylic.

### 1.2 Water treatment residuals

Coagulation and flocculation are the essential pre-treatment practices employed by water industries around the world for water purification and conventionally aluminium and iron salts have been used for this purpose for many years. Many drinking water treatment facilities mix non-toxic aluminum-based or iron-based chemicals

into the water as part of the water cleaning process. After these coagulants have bound with a variety of trace contaminants (bacteria, salts, particles, etc.) in the water, they are removed by settling, taking the contaminants with them. Water treatment residuals are produced from the treatment of drinking and process water. Water treatment processes employ coagulants to remove inorganic and organic matter suspended in the untreated source water. The resulting product may be thickened liquid or a dewatered solid.

### 1.3 Coagulation/flocculation process

Coagulation is defined as a process that occurs when a coagulant is added to water to destabilize the colloidal suspensions, whereas flocculation process involves the addition of polymers that cluster the small, destabilized particles together into large sized particles so that they can easily be separated from the water. Coagulation is a chemical process that involves neutralization of charge whereas flocculation is a physical process and does not involve neutralization of charge. Jar test is most widely used to simulate the coagulation/flocculation process. The dose of the coagulant to be used can be determined by using the jar test. The jar test involves exposing same volume of sample to be treated to the different doses of the coagulant and then simultaneously mixing the samples at a constant rapid mixing followed my slow mixing time. The micro-flocs formed after the coagulation process further undergoes flocculation and is allowed to settle

## II. LITERATURE REVIEW

Various research papers have been published on the use of sludge from the water treatment plant as a coagulant on different types of dyes that are used in textile industry. Also different type of coagulants that are used for removal of color from textile industry wastewater have been published.

S. Sadri Moghaddam. et al, conducted a study to determine the performance of a waterworks sludge (FCS: ferric chloride sludge) for the removal of acid red 119 (AR119) dye from aqueous solutions were investigated. For this purpose, response surface methodology (RSM) was applied to optimize three operating variables of coagulation/flocculation process including initial pH, coagulant dosage and initial dye concentration. The results showed that the decrease of initial pH was always beneficial for enhancing dye removal and no re-stabilization phenomenon was occurred even at the used maximum FCS dosage. Dye removal of 96.53% is observed which confirmed close to RSM results.

Amir Talebi. et al, carried out a laboratory study on methyl violet removal from aqueous solutions by liquid–liquid extraction system, using crude palm oil and soy bean oil as solvent. The concentration of methyl violet has been studied in the range of 100 mg/L to 200 mg/L. The efficiency of dye extraction increased when two extractant di-2-ethylhexyl phosphoric acid and tributhyl phosphate were used as carrier. Under optimized conditions, 82% to 89% dye removal in 5 minutes rapid mix followed by 60 minutes slow mixing was achieved. The aqueous to organic phase volume ratio (A/O) was fixed at 1, pH varied from 1-6 and extraction study was carried out at [TBP]: 200mM and [D2EHPA]: 75mM.

Agata Szygu1a. et al, used Chitosan, an amino polysaccharide for the treatment of colored solutions by coagulation–flocculation. Acid Blue 92 (a sulfonic dye) was selected as a model dye for verifying chitosan's ability to treat textile wastewater. Dye removal efficiency at various pH levels and dye concentrations was evaluated. The efficiency of coagulation–flocculation with tap water was shown to be highly dependent on the pH control and coagulant dose. At higher pH levels, larger amounts of chitosan were required to reach the

maximum color removal of the treated solution. Chitosan can behave as a coagulant (charge neutralization) or as a flocculant (bridging), depending on the nature of the colloids, the pH of the suspension and the experimental conditions (i.e., concentrations). Dye removal reached up to 99% under optimum concentration.

Yen-Yie Lau. et al, demonstrated the Cationic dye (methylene blue) and anionic dye (methyl orange) degradation in the coagulation process. The key material was a natural coagulant–laterite soil dominated by a silica component, while aluminum-ferric ions acted as an auxiliary agent in the degradation process where charge neutralization, electrical double layer compression and sweeping flocculation were the mechanisms in the decolorization reaction.

Mahesh R. Gadekar et al, evaluated the potential of aluminum-based water treatment residuals (WTR) discharged from water treatment plants as a coagulant for color removal from a disperse dye solution. The results showed higher color removal at lower pH values. The usability of WTR as coagulant for the color removal of a synthetic disperse dye (Disperse Blue 79) solution was assessed in laboratory studies. The results of this study indicated that up to 88% color removal could be obtained with WTR dosage of 3,000 mg/L and at initial pH 3. Color removal was greatly affected by the pH of the system, with lower pH showing higher removal.

W. CHU et al, studied and optimized the removal of dyes from textile dying wastewater by recycled alum sludge (RAS) generated by the coagulation process itself. One hydrophobic and one hydrophilic dye were used as probes to examine the performance of this process. It was found that RAS is a good way of removing hydrophobic dye in wastewater, while simultaneously reducing the fresh alum dosage, of which one third of the fresh alum can be saved. However, the use of RAS is not recommended for the removal of hydrophilic dyes, since the high solubility characteristics ofsuch dyes can cause deterioration in the water quality during recycling.

## III. CONCLUSION

From above literature review it can be concluded that sludge has potential for utilization as a coagulant for dye removal from wastewater. The application of sludge can be considered as an alternative to the direct discharge of sludge to nearby resources as sludge has an immense potential to be utilized as a coagulant on dye removal due to presence of essential nutrients and bacteria that are essential for the dye removal from wastewater.

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