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Treatment of Laundry Wastewater Using Different Coagulants: Alum and HCA

Syadzadhiya Qothrunada Zakiyayasin Nisa'[1], Rizka Novembrianto[1]*, Firra Rosariawari[1], Muslikha Nourma Rhomadhoni[2], Maulayya Fatimah Azzahra[1]

[1]Department of Environmental Engineering, Universitas Pembangunan Nasional"Veteran" Jawa Timur, Surabaya 60294, Indonesia
[2]Department of Occupational Health and Safety, Nahdlatul Ulama University Surabaya, Indonesia

Corresponding author:
E-mail:
rizka.tl@upnjatim.ac.id

ABSTRACT

The wastewater from industrial laundries has a high quantity of contaminants from the washing process, as well as chemical additives. The current study assessed the efficacy of the coagulation/occultation/sedimentation (C/F/S) method to treat laundry wastewater in relation to physicochemical parameters of water quality with the goal of treating this type of wastewater. For this purpose, an experimental design was applied to the C/F/S step using the addition of coagulant Alum, coagulant Alum plus flocculant Superfloc, and coagulant HCA. Alum coagulant has removal efficiency of 52% for COD and 37% for phosphate. The use of alum coagulant and Superfloc flocculant produces COD removal efficiency of 60% and phosphate removal efficiency of 58%. The use of HCA coagulant shows a removal efficiency of 64% for COD and 78% for phosphate. This shows that using more HCA coagulant is more effective than using alum coagulant and Superfloc flocculant in laundry wastewater treatment.

Keywords: Laundry wastewater, alum, HCA, Superfloc, coagulant

Introduction

Persistent contamination of a body of water can cause water pollution, decline water quality, and disturb ecosystems. The problem of water pollution has become a global issue and is becoming a significant concern in handling water pollution. Wastewater management and treatment is one of the biggest challenges for a circular economy, as many industries depend on water. In addition, waste water is treated to prevent environmental pollution.

Industry washing commercial (laundry) plays a role in water pollution, to which laundry wastewater contributes about 10% of the total amount of waste water resulting in urban areas (Zoroufchi Benis et al., 2021). In general, one laundry can produce about 400 m^3 of waste water per day. Laundry wastewater contains organic dirt like surfactants, fats, and detergents, as well as inorganic elements like sand and particles. The main surfactants discovered in laundry detergents, namely linear alkylbenzene sulfonates (LAS) and nonylphenol ethoxylates (NPEOs), contribute to the degradation of the environment and health problems for both animals and humans (Braga & Varesche, 2014; Varbanov et al., 2022). This situation also significantly affects aquatic life. In addition, pollutants in this wastewater can cause genetic mutations in aquatic organisms. This reinforces the need for effective treatment of laundry wastewater.

Laundry wastewater treatment has been done in many ways, like electrocoagulation, filtration, adsorption, and processing combination biology (Varbanov et al., 2022; Vishali et al., 2023). The adsorption process was assessed as effective in reducing allowance pollutants in laundry wastewater; however, cost operations are very high because of the need for regeneration adsorbent. The application of laundry wastewater treatment requires more methods, so it can be applied. This is

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because laundry is an industry-scale home. Coagulation/flocculation/sedimentation processes are considered low-cost and friendly environments for treating laundry wastewater (Santiago et al., 2021).

Laundry uses water as one of the main inputs and releases large volumes of wastewater. Waste is loaded with pollution and is usually not processed well. Therefore, it's very important to process laundry wastewater to look after and maintain the quality of water bodies and ecosystems. This research was carried out on allowance pollutants in laundry wastewater through methods of coagulation/flocculation/sedimentation with comparable results using alum and HCA coagulants, as well as the use of alum with the addition of Superfloc flocculant

Material and Methods

Wastewater and analytical determination

Waste water originates from laundry located in the east of Surabaya, Indonesia. Waste water, as much as 6 liters, was taken from the channel disposal machine wash and stored in HDPE (High-Density Polyethylene) jerry cans. Waste water collection is done at one time and originates from the same machine wash.

The TSS, COD, and phosphate parameters of waste water were tested in this research. COD testing uses method titration and phosphate testing uses a spectrophotometer. Laundry waste water is treated with coagulation/flocculation/sedimentation methods in a scaled laboratory using jar tests. There are two types of coagulants used in this research, namely alum and HCA.

Wastewater treatment with alum and HCA Coagulants

In the coagulation process experiment, alum and HCA coagulants were tested separately. Waste water is prepared in a glass beaker with a sample volume of 1 liter. This was done with five different doses of coagulant: 0 mg/L, 20 mg/L, 40 mg/L, 60 mg/L, 80 mg/L, and 100 mg/L. Stirring fast was carried out at 120 rpm for 2 minutes, then the next stirring was carried out at 15 rpm for 15 minutes. The duration of floc deposition resulting from each variation of the experiment was 60 minutes.

Wastewater treatment with alum coagulant and the addition of superfloc

This test preceded the coagulation process using alum coagulant, where the variation of dosage, speed stirring, and time stirring were the same as in the test before. Furthermore, the flocculation process was carried out with the addition of Superfloc 1.5 mg/L of every variation dose coagulant. Slow stirring was set at a speed of 15 rpm for 15 minutes. The duration of the deposition of the resulting floc from each variation test was 60 minutes.

Results and Discussion

Characterization of the Wastewater

The laundry wastewater used in this experiment had a cloudy color and a pH > 8, which shows laundry wastewater is alkaline. Wastewater pH can influence the performance of the coagulation process. The results of the analysis of waste water parameters can be seen in Table 1. Wastewater parameters tested show that waste water quality exceeds the standard specified for disposal in a body of water.

Table 1. Characteristics of laundry wastewater

Parameters	Value of the parameters in the sample	Discharge Standards
COD (mg/L)	1305.6	250
Phosphate (mg/L)	12.6	10

The composition of laundry wastewater may be impacted by the type of detergent employed during the washing procedure and the particles present in the clothes (López Zavala & Estrada, 2016)

. Factors that influence the high COD value in laundry wastewater can be caused by surfactant ions and fabric materials from washed clothing fabrics. Clothing color can influence the COD value in wastewater, which results from washing clothes. Waste water from washing colored clothes will have higher COD levels than those from white clothes. High COD values can cause a decreasing rate of oxygen in water bodies due to the oxidation process of organic material (Adesoye et al., 2014).

The source of phosphate in laundry wastewater comes from the use of detergent. Phosphates are incorporated into detergents as builder compounds, typically in the form of sodium tripolyphosphate and sodium pyrophosphate (Agbazue & Romanus Ekere, 2015; Watiniasih et al., 2019). Phosphates can cause eutrophication in water bodies (Owodunni et al., 2023).

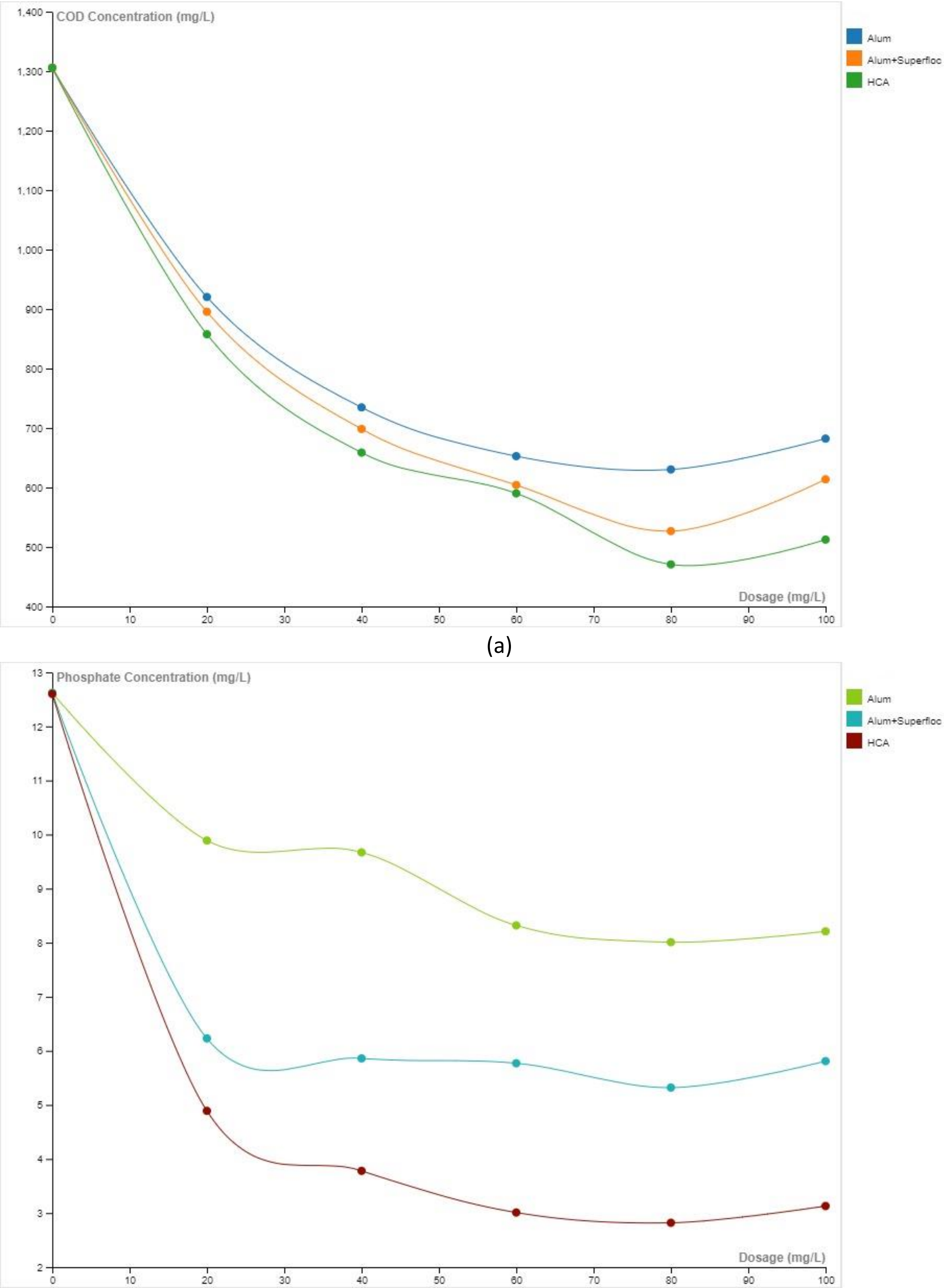
Determination of the Coagulant-Optimized Dosage

Laundry wastewater in this research was tested with the addition of two different types of coagulants, namely alum and HCA. The purpose of waste water treatment is to eliminate existing pollutant parameters in water. The process of removing organic matter and other contaminants involves introducing positively charged coagulants, which disrupt the stable negative charge surrounding the target particles by compressing the double layer. This disruption reduces the distance of repulsion between particles, leading to a decrease in the zeta potential. Consequently, the particles can approach each other closely due to Van der Waals forces. As a result, Van der Waals interactions become dominant, facilitating the aggregation of suspended fine particles and subsequent flocculation.

The results of COD and phosphate reduction from this research can be seen in Figure 1. In waste water testing with an alum coagulant, it can be seen that COD decreases show the highest results at a dose of 80 mg/L. This research shows that at a dose of 80 mg/L, the optimum dose for COD reduction was achieved, with a removal efficiency of 52%. A decrease in phosphate shows results highest at a dose of 80 mg/L, with a removal efficiency of 37%. The laundry wastewater coagulation process uses a general alum coagulant with its COD removal efficiency of 60–70% and phosphate of 90% (López Zavala & Estrada, 2016).

Tests were carried out again on laundry wastewater treatment using alum coagulant and the addition of superfloc. Dose Superfloc was used in the experiment, namely 1.5 mg/L. On testing, it was found that pollutant removal efficiency with the addition of alum coagulant in the coagulation and the addition of superfloc in the flocculation process was higher compared to processing with alum coagulant only. The highest COD removal efficiency reached 60%, and phosphate reached 58%. The combination of coagulant and flocculant is considered an effort to increase the effectiveness of the coagulation/flocculation/sedimentation processes. The enhancement of flocculation activity occurs when a metal coagulant and bio-flocculant are combined due to the simultaneous operation of three primary mechanisms: (i) charge neutralization, (ii) sweep coagulation, and (iii) floc bridging (Kumar et al., 2023) .

The use of HCA coagulant shows that the highest reduction in COD and phosphate was at a dose of 80 mg/L. Highest removal efficiency, namely 64% for COD and 78% for phosphate. This shows that HCA coagulant is more effective in reducing contaminants compared to alum coagulant. HCA's Al concentration in mg/L is higher compared to alum, where the Al strength in HCA is 12% while that in alum is 4%. Coagulants containing a significant portion of stable and strong positive electrical charges from Al are capable of efficiently eliminating contaminants. The specific gravity of coagulants also influences their performance. Where there are more heavy molecules, they will settle more easily. In other research, it is shown that the specific gravity of HCA is higher than that of alum (Zaman et al., 2021).



(a)

(b)

Figure 1. Results of laundry wastewater treatment with coagulation/flocculation/sedimentation processes: (a) COD reduction and (b) phosphate reduction

Conclusion

Laundry wastewater treatment can be done with the methods of coagulation/flocculation/sedimentation to reduce COD and phosphate parameters. Alum coagulant has a removal efficiency of 52% for COD and 37% for phosphate at an optimum dose of 80 mg/L. In research, this was also tested to influence the addition of Superfloc in the flocculation process after the coagulation process using an alum coagulant. The COD removal efficiency reached 60%, and phosphate reached 58% with a dose of Superfloc 1.5 mg/L. The coagulation process using HCA coagulant shows that the highest removal efficiency was 64% for COD and 78% for phosphate at the optimum coagulant dose of 80 mg/L. This thing shows that using more HCA coagulant is more effective compared to using alum in laundry wastewater treatment.

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