TREATMENT OF BATIK EFFLUENT THROUGH COAGULATION-FLOCCULATION PROCESS

A. O. FAMILUSI[1]*, B. E. ADEWUMI[1], J. O. OLUSAMI[1], D. A. OGUNDARE[1], M. O. ALAO[1], A. E. AKINDELE[1], B. A. ADEYEOLUWA[2]

[1]Department of Civil Engineering, Federal Polytechnic Ede
[2]Department of Civil Engineering, Osun State College of Technology Esa-Oke

***Corresponding Author: ayomacfamilson@gmail.com, Tel: +2348062060756**

ABSTRACT

The practice of industry and families disposing of untreated wastewater into the environment without selection has gained popularity, leading to the pollution of our water supplies. This study assesses the efficacy of the coagulation--flocculation technique in treating batik wastewater. Alum was utilized in the coagulation-flocculation treatment of the tie and dye batik effluent samples used in this investigation, which were obtained from a tie and dye fabric manufacturer in Ede at coordinates 7^0 45′ 30″ N and 4^0 26′ 19″ E. The effectiveness of the treatment method was ascertained by performing physico-chemical and bacteriological studies on the treated and untreated effluent. After treatment, the effluent was determined to be safe when the values from the physico-chemical and bacteriological studies were compared to the Federal Environmental Protection Agency's (FEPA) effluent standard. In the batik effluent, alum decreased the levels of colour, COD (chemical oxygen demand), and TDS (total dissolved solids) by 38.98, 24.46, and 73.91%, respectively. The coagulation--flocculation technique is a highly effective way to clean batik wastewater.

KEYWORDS: Batik Effluent, Coagulation, Contaminants, Wastewater, Treatment

1. INTRODUCTION

In recent times, concerns have arisen over the treatment and disposal of wastewater produced by families and enterprises. This is due to the disturbingly high rate of pollution that emerges from the careless release of untreated wastewater into the environment. Cadmium, Chromium, and Lead are heavy metals found in batik wastewater from batik business outlets, and these levels surpass the necessary environmental quality standards (Slamet et al., 2018). Textile mill wastewater is typically very alkaline, which has a negative impact on aquatic life (Wasif and Chinta, 2008). The process of coagulation-flocculation is a key component of many water and wastewater systems. Actually, because of its affordability and ease of use, the coagulation-flocculation process is one of the most crucial steps in the treatment of water and wastewater. The coagulation-flocculation process is typically incorporated, either as a pre-treatment or post-treatment step, depending on the kind of treated sample and the overall applicable treatment scheme (Tzoupanos and Zouboulis, 2008). In order to facilitate the formation of larger particles that are easier to remove from the raw water, the coagulant used in the coagulation-flocculation process is meant to neutralize that charge. Although $FeCl_3$, $FeSO_4$, and other coagulants, such as polyelectrolytes, can be employed, alum [$Al_2(SO_4)_3{\bullet}18H_2O$] is typically used. When alum is added to water, it hydrolyzes by consuming the alkalinity in the water through processes aided by the aluminum in this salt (Subramanian, 2017). To produce good coagulation, a high-energy, quick mix is required to distribute the coagulant properly and encourage particle collisions. Coagulation is unaffected by excessive mixing, however inadequate mixing will render this stage unfinished. Usually, the rapid-mix chamber has a contact time of one to three minutes (MRWA, 2018). Furthermore, the process of flocculation, a mild step of mixing, aids in the transformation of sub-microscopic micro-floc particles into visible suspended particles. Water or wastewater is prepared for sedimentation once floc reaches its ideal size and strength. The quantity of mix energy and mixing velocity must be carefully considered when designing contact times for flocculation, which can range from 15 to 20 minutes to an hour or longer (MRWA, 2018). Additionally, Badejo et al. (2022) assessed the efficacy of a batch-scale electrocoagulation (EC) technique for treating wastewater rich in indigo dyes and confirmed that the technology may be applied to reduce colour in wastewater rich in indigo dyes used in the textile sector. This study aims to assess the efficacy of the coagulation--flocculation technique in treating batik effluent.

2. MATERIALS AND METHODS

2.1 Materials and Equipment Required for the Study

Aluminum sulphate (Alum), Flocculating machine, Jar test apparatus, GPS, Samples of tie and dye (batik) effluent, Standard laboratory equipment for physico-chemical and bacteriological tests are among the supplies and tools used in this research project.

2.2 Methods

Preparation of alum (coagulant)

An alum solution was made by dissolving 200g of aluminum sulphate (alum) in 1000ml of distilled water. The alum was obtained from a store in Osogbo, Nigeria.

Collection of effluent samples

Batik effluent samples were collected from a tie and dye fabric manufacturer in Ede, Nigeria, located at coordinates 7^0 42’ 25’’ N and 4^0 23’ 38’’ E).

Jar test on the effluent sample

The effluent sample underwent a jar test in accordance with the protocol described by Familusi et al. (2021).

Coagulation of the batik effluent

The alum dose (found from the jar test) was added to $0.001m^3$ of the batik effluent in the flocculation bucket, which had a known volume of batik effluent delivered into the coagulation/flocculation bucket. After inserting the flocculation bucket into the flocculating machine, the samples were vigorously mixed for five minutes by the roller, and then slowly mixed for fifteen minutes. After an hour of settling, the sample was decanted.

Physico-chemical and bacteriological analyses

Osun State Water Corporation, Ede, Nigeria received three samples of each of the treated (coagulated) and untreated (batik) effluent for physico-chemical and bacteriological studies. The parameters were established in accordance with the American Public Health Association's recommended standard procedures for the examination of water and wastewater (APHA, 1998).

3. RESULTS AND DISCUSSION

3.1 Jar Examination

The findings of the jar test showed that 295 millilitres of coagulant (alum) were needed to treat 500 millilitres of batik effluent.

3.2 Physico-Chemical and Bacteriological Parameters

The following are the physico-chemical and bacteriological characteristics of the treated and ntreated wastewater samples.. Equation 1 was used to calculate the efficiency of the coagulation-flocculation process.

$$\eta = \frac{(C1 - C2)\ X\ 100}{C1} \quad (1)$$

where η is the efficiency of the treatment unit,

C_1 is the parameter value before treatment, and

C_2 is the parameter value after treatment.

pH

After the batik effluent was coagulated with alum, the pH value increased to 5.100±0.044 from 5.490±0.036. The pH increases somewhat throughout the coagulation process, however the result met the limit (6–9) set forth in the FEPA effluent regulations (1991). Alum often operates in an alkaline setting. According to Carrizales et al. (2021), effluent that is to be dumped into aquatic bodies should typically have a pH of 6.5 to 8.5. The treated sample somewhat failed to meet this criteria. It was discovered that the therapy effectively lowered the pH by 7.14%.

Turbidity

After coagulating with alum, the batik effluent's turbidity value, which was 500.000±1.136 FTU, increased to 484.000±1.732 FTU. The waxing procedure, which left behind leftover wax, and the leftover colouring water, which contained suspended dyes, are the causes of the high turbidity in batik wastewater (Soedjono et al., 2021). It was discovered that the treatment method was 3.2% effective in eliminating turbidity

Temperature

After coagulating with alum, the temperature of the batik effluent was measured at 25.420±0.171 ^{0}C, and it was found to be 26.000±0.361 ^{0}C. The results met the 40 ^{0}C limitations promulgated by the effluent standards of FEPA (1991). The temperature dropped by -2.282 percent, however the treated and untreated wastewater do not differ significantly in temperature.

Colour

The batik effluent's colour was measured at 2950.000±27.839 HU. After coagulating with alum, the colour value decreased to 1800.000±7.000 HU, indicating a 38.983 % coagulation effectiveness in the effluent's colour removal.

Conductivity

After coagulating with alum, the conductivity of the batik effluent was measured at 2500.000±5.196 µS/cm; this value was reduced to 2200.000±7.000 µS/cm. Since conductivity in a water or wastewater sample is a function of TDS, the decrease in conductivity level may be linked to the decrease in TDS observed during coagulation. Additionally, this aligns with the findings of Carrizales et al. (2021). It was discovered that the coagulation efficiency was 12 %.

Total Suspended Solids (TSS)

After coagulating with alum, the batik effluent's TSS value decreased to 1.900±0.046 mg/l from 4.688±0.013 mg/l. The readings obtained met the effluent regulations of the Federal Environmental Protection Agency (1991) limit of 30 mg/l. It was discovered that the treatment process had an efficiency of 59.571 %.

Total Dissolved Solids (TDS)

After coagulating with alum, the batik effluent's TDS value decreased to 274.000±1.732 mg/l from 1050.000±5.220 mg/l. The readings obtained met the effluent regulations of the Federal Environmental Protection Agency (1991) limit of 2000 mg/l. This aligns with the research conducted by Carrizales *et al.* (2021). It was discovered that the treatment method had an efficiency of 73.905 %.

Alkalinity

After coagulating with alum, the batik effluent's total alkalinity value—which was 126.000±3.279 mg/l—was reduced to 122.000±1.054 mg/l. The carbonates produced during the coagulation process may be the cause of the wastewater's increased alkalinity level. The treatment method was determined to have an efficiency of 3.175 %.

Hardness

After coagulating with alum, the batik effluent's total hardness value increased to 144.000±0.346 mg/l from 126.000±2.291 mg/l. It was discovered that the efficiency of the treatment process was -14.286 %.

Silica

After coagulating with alum, the batik effluent's silica content decreased to 24.000±0.265 mg/l from 27.290±0.185 mg/l. Because alum has a substantial silica concentration, the wastewater's greater silica level following alum coagulation may be explained by this. It was discovered that the treatment method had an efficiency of 12.056 %.

Sulphate

After coagulating with alum, the batik effluent's sulphate content decreased to 128.000±0.436 mg/l from 135.000±0.265 mg/l. Alum had a removal effectiveness of just 5.15 % for Sulphate, and the values obtained were in compliance with the FEPA (1991) effluent guidelines, which set a limit of 500 mg/l.

Chloride

After coagulating with alum, the batik effluent's chloride content decreased to 83.000±0.361 mg/l from 90.000±0.866 mg/l. The readings obtained satisfied the limit (600 mg/l) imposed by the effluent standards of FEPA (1991). It was discovered that the treatment method had a 7.778 % removal effectiveness for chloride.

Manganese

After coagulating with alum, the value of the manganese in the batik effluent was 3.104±0.007 mg/l, compared to the initial value of 3.461±0.010 mg/l. It was discovered that the treatment method removed manganese with an efficiency of 10.315 %.

Zinc

After coagulating with alum, the zinc value of the batik effluent was 12.463±0.033 mg/l, and it was 10.592±0.007 mg/l after that. The results meet the effluent guidelines of FEPA (1991) limit of less than one milligram per litre. It was discovered that the treatment method's zinc removal effectiveness was 15.012 %

Aluminium

After alum was added to the batik effluent, the aluminum content decreased to 6.314±0.013 mg/l from 8.591±0.037 mg/l. It was discovered that the treatment technique had a 2.277 % removal effectiveness for aluminium.

Chromium

After coagulating with alum, the value of the batik effluent's chromium decreased to 1.9470±0.003 mg/l from 2.169±0.002 mg/l. The results met the <1 mg/l criteria set forth in the effluent regulations of FEPA (1991). It was discovered that the treatment method had 10.25% removal effectiveness for chromium.

Iron

The iron content of the batik effluent was 54.360±0.314 mg/l; however, after alum was added, the value dropped to 38.000±0.529 mg/l. The value attained following treatment meets the <1 mg/l restrictions set forth in the effluent regulations of FEPA (1991). It was discovered that the treatment method had 30.096 % iron removal efficiency.

Nitrate

After coagulating with alum, the batik effluent's nitrate value decreased to 14.823±0.025 mg/l from 15.974±0.601 mg/l. The readings obtained meet the 20 mg/l maximum limitations set forth in the effluent regulations of FEPA (1991). It was discovered that the treatment method was 7.206 percent effective in eliminating nitrate.

Bio-Chemical Oxygen Demand (BOD)

The batik effluent's BOD value was 0.100±0.017 mg/l; however, after alum coagulation, the value increased to 0.200±0.017 mg/l. The results meet the 30 mg/l limit set forth in the effluent standard of FEPA (1991). It was discovered that the treatment method's BOD removal efficiency was -100 %.

Chemical Oxygen Demand (COD)

After the batik effluent was coagulated with alum, the COD value increased to 420.000±3.775 mg/l from 556.000±1.732 mg/l. The COD in the wastewater was reduced by 24.60% thanks to the coagulation process.

Coliform

After coagulating with alum, the value of the batik effluent's coliform dropped to 160 MPN/100 ml from 180+ MPN. Coliform indicates that harmful microorganisms may have been present in the wastewater sample. The levels attained met the 400 MPN/100 ml limit set forth in the effluent regulations of FEPA (1991).

4. CONCLUSION

The coagulation-flocculation method of treating batik effluent has shown to be effective in lowering the pollutant level of a variety of wastewater parameters. In the batik effluent, the method specifically decreased the levels of colour, chemical oxygen demand (COD), and total dissolved solids (TDS) by 38.98, 24.46, and 73.91 %, respectively. Nevertheless, the effluent's total hardness and BOD contaminant levels increased as a result of the coagulation-flocculation process. Although the procedure has not been very useful in treating wastewater, due to its efficiency, it is hereby suggested for treatment of wastewater in homes, businesses, and communities.

REFERENCES

APHA (1998). *Standard Methods for Examination of Water and Wastewater, 20th ed*. Washington DC, USA: A Publication of American Public Health Association.

Badejo, A. A., Nkeshita, F. C., Adelasoye, O. J. and Adeyanju, O. P. (2022). Reduction of Colour from Indigo Dye-Rich Wastewater by Electro-Coagulation Using Iron (Fe) and Aluminum (Al) Electrodes. Arid Zone Journal of Engineering, Technology & Environment, 18 (4), 659-668.

Carrizales, L. T., Ferro-Gonzales, P. F., Apaza-Panca, C. M., Sosa, E. G. P., Saico, C. R. Y. and Chokewanca, I. R. R. (2021). Evaluation of Environmental Parameters in the Espinar Puno Stabilization Lagoon. *Heliyon*, *7*, 1-5. https://doi.org/10.1016/j.heliyon.2021.e06959

Familusi, A. O., Adekunle, A. A., Badejo, A. A. and Adeosun, O. J. (2021). Efficiency of Coagulation-Flocculation Process in the Treatment of Abattoir Effluent. *Journal of Engineering Science*, *28* (1), 124 – 130. https://doi.org/10.52326/jes.utm.2021.28(1).1

FEPA (1991). National Environmental Protection (Effluent Limitation) Regulations. A Publication of Federal Environmental Protection Agency. Retrieved January 14, 2019 from http://extwprlegs1.fao.org/docs/pdf/nig120290.pdf

MRWA (2018). Coagulation and Flocculation Process Fundamentals. Retrieved July 3, 2018 from https://www.mrwa.com/WaterWorksMnl/Chapter%252012%2520Coagulation.pdf

Slamet, B., Anies, Hartuti P. and Henna, R. S. (2018). Environmental Analysis of the Impacts of Batik Wastewater Polution on The Quality of Dug Well Water in The Batik Industrial Center of Jenggot Pekalongan City. E3S Web of Conferences 31, 09008 (2018) https://doi.org/10.1051/e3sconf/20183109008

Soedjono, E. S., Slamet, A., Fitriani, N., Sumarlan, M. S., Supriyanto, A., Isnadina, D. R. M. and Othman, N. B. (2021). Residual Seawater from Salt Production (Bittern) as a Coagulant to Remove Lead (Pb^{2+}) and Turbidity from Batik Industry Wastewater. *Heliyon*, *7*, 1-9.

Subramanian, M. S. (2017). Advanced Wastewater Treatment. A Publication of Indian Institute of Technology, Madras. Retrieved 26th October 2017 from https://www.sswm.info/sites/default/files/reference_attachments/SUBRAMANIAN%2520Waste%2520Treatment.pdf

Tzoupanos, N. D. and Zouboulis, A. I. (2008). Coagulation-Flocculation Processes in Water/Wastewater Treatment: The Application of New Generation of Chemical Reagents. Proceedings of 6th IASME/WSEAS International Conference on Heat Transfer, Thermal Engineering and Environment (HTE'08), Rhodes, Greece. Retrieved November 25, 2019 from https://pdfs.semanticscholar.org/3446/54a735412c2110b947ccbe471e58621d65e1.pdf

Wasif, A. I. and Chinta, S. K (2008). Effluent Treatment in Textile Wet Processing: Technology Option and Effluent Treatment Plant. Retrieved January 31, 2020 from https://www.fibre2fashion.com/industry-article/3451/effluent-treatment- in-textile-wet-processing-technology-option-and-effluent-treatment-plant