



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

**PRODUCTION OF CRUDE BIOFLOCCULANT USING BANANA PEEL FOR
WASTEWATER TREATMENT**

**¹Santali, A. M., ³Karderam, B. D., ¹Mohammed, M., ¹Badegi U. M., ²Awaisu, A.
⁴Mohammed, Y., ¹Mahmud, J. ¹Kobo, A. M. and ⁵Ndace, A. S.**

¹Department of Chemistry Ibrahim Badamasi Babangida, Lapai. Nigeria.

²Department of Biological Science Ibrahim Badamasi Babangida, Lapai. Nigeria.

³Department of Biological Science, Nigeria Defense Academy, Kaduna. Nigeria.

⁴Department of Science and Tech, Waziri Umaru Federal Polytechnic, Birnin Kebbi,
Nigeria.

⁵Department of Science Laboratory Tech., Baiwa Educational Service Lapai, in affiliation
with Kaduna Polytechnic, Kaduna

***Corresponding email:** adamumuhammadsantali@gmail.com

ABSTRACT

Flocculation or coagulation technique is usually employed in wastewater treatment to eliminate debris, organic and inorganic compounds, colloids and other pollutants in an effective, efficient and easy way. For numerous centuries, organic and inorganic flocculants are used within the remedy of wastewater. Despite the fact that, using the flocculants have greatly been decreased, because of their non-biodegradability, restricted effectiveness, and associated health risks. This study describes the utilization of banana peel as a natural coagulant for the wastewater treatment. The natural coagulant extracted from banana peel was prepared by using simple extraction method of bio-flocculant, synthetic turbid water, jar test were used in this study to imitate the medium strength wastewater. The parameters investigated in this study were effect of pH, coagulant dosage, temperature and initial wastewater turbidity. The results obtained shows that the turbidity removal percentage increases with increase in temperature and the highest turbidity removal percentage of the bio-flocculant occurred at 40°C with a result of 75.18% while the lowest turbidity removal percentage was observed at 25°C with 71.67%. On the other hand, a different removal profile pattern was observed for alum, with the highest turbidity removal percentage was recorded at 30°C with 80.93% and the lowest turbidity removal percentage was achieved at 25° C with 65.93 %. It can be concluded that the efficacy of banana peels as bio-flocculant was compared to that of most frequently used conventional chemical coagulant (alum) the optimum turbidity removal percentage under pH effect was 93.44 % at pH 12. Additionally, it discovered that 150 ml of bio-flocculant was the best dosage for highest turbidity removal percentage of 71.34 %.



INTRODUCTION

Rapid increase in population growth and the corresponding economic expansion have led to increase in water pollution (Zurina *et al.*, 2014). The constant and unrelenting release of contaminants from various toxic sources into the environment and water bodies is hazardous to all forms of life (Ahmed *et al.*, 2020). Inevitably, there is a growing need for easily accessible, highly effective, low-cost techniques and procedures for treating contaminated water (Aljeboree *et al.*, 2017). Urbanization, industrialization and extensive agricultural activities are the major cause of environmental pollution in the world today, which result in tremendous increase in the volume of wastewater that must be treated to make it fit for human and animal consumption and use (Abdollahi *et al.*, 2018). Various toxic substances in different forms contaminate water bodies; Dyes are among the most common pollutant of water bodies (Agunbiade *et al.*, 2019). Most dyes are usually toxic to health, mutagenic, carcinogenic and teratogenic to microorganisms, marine organisms or animals, and humans, thus, dye-contaminated water is perceived as a major threat to the environment and the ecosystem at large (Al-Wasify *et al.*, 2017). Wastes from paper, textiles, coating and rubber industries all contains 'dyes', which are eventually released into the environments; even at exceedingly low concentrations, dyes can cause tremendous contamination, which result in damage to living things in the ecosystem (Allafchian *et al.*, 2019). Another major cause of environmental or water pollution is heavy metals, which have become a major environment issue and their remediation poses significant challenge (Maruti and Rao, 2013). Increased industrial activity has led to exponential increase in environmental issues caused by heavy metals (Vimala *et al.*, 2020). The presence of heavy metals in wastewater has necessitated the use of sustainable, low-cost and efficient treatment material (Zhang *et al.*, 2006). In step with Abdollahi *et al.* (2018), all wastewater remediation techniques should have little on environmental effect, excessive sustainability and value powerful. There are extensive forms of coagulants or flocculants for wastewater treatment, however the most often used in



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

remediation of wastewater are organic and inorganic flocculants (Zhang *et al.*, 2015). The principle components of inorganic flocculants are aluminum and iron, which changed into used because of their robust effectiveness on suspended solids and combined particles (Zhang, *et al.*, 2006). Then again, polyacrylamide and its byproducts also are the major ingredients in organic flocculants (Nourmoradi *et al.*, 2015). Natural flocculants are characterised through speedy flocculation, ease of separation and little dosage in line with use (Mu *et al.*, 2018). Banana peels had been located to be noticeably effective as a bio-flocculant in remediation of wastewater. This examine overview the efficacy and effectiveness of banana peels as a bio-coagulant in evaluation to different chemical and synthetic flocculants along with alum. The goal of this look at is to review literature and magazine of already current work on the efficacy and effectiveness of banana peels as a bio-coagulant in contrast to other generally used chemical coagulants consisting of alum. The goals of the research carried out by way of Zurina *et al.* (2014). To investigate the utility of banana peels as a prospective coagulant within the remediation of wastewater treatment with various pH of contaminated water, and dosage of flocculant. To examine the performance and effectiveness of banana peels as bio-flocculants with alum. The reason of this evaluation is to appraise banana peels as bio-flocculants inside the treatment of wastewater as a greater sustainable and green alternative to chemical coagulants in studies performed via Abdollahi *et al.* (2018).

MATERIALS AND METHODS

Collection of Banana Peel

Banana peels were screened for the potential to be utilized as bio-flocculant. Collected from a local fruit seller in kontagora new market. The preparation of bioflocculants was conducted based on the methods described by Zurina *et al.* (2014) with slight modifications. The samples were washed with distilled water several times to remove dirt and contaminants, followed by drying in a hot air oven at 80°C for at least 24 hours. The dried samples were



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

then grinded or crushed using pestle and mortar, sieved well in fraction of 150 μm . The powdered sample then was stored in an airtight container prior to bio-flocculant extraction processes.

Preparation of Bio-flocculant

The extraction of bio-flocculant from banana peels was according to the methods described by Zurina *et al.* (2014) with little alterations. The banana peels collected were thoroughly washed in distilled water, so as to remove dirt and other contaminants from the samples. The washed banana peels samples were then dried in a hot air oven at 80°C for 24 hours. The dried banana peel samples were ground using mortar and pestle, then seive. The powdered sample was kept in an airtight container before the extraction of bio-flocculant. To extract the bio-flocculant from the powdered sample, the powdered banana peels were soaked in distilled water at room temperature and were stirred for an hour on a hotplate magnetic stirrer. The resulting suspension was filtered with muslin to extract the coagulant proteins. The filtered extract was used in the subsequent experiments. Fresh bio-flocculant extract solutions were prepared daily and refrigerated to avoid ageing effect on the bio-flocculant. Extracted bio-flocculant solutions were shaken well before use.

Preparation of Synthetic Turbid Water

Clay was used in the preparation of model wastewater. The model wastewater was prepared by dissolving 30g of clay in tap water at room temperature. The suspension was moderately stirred for 10 minutes in a jar so as to obtain a uniform distribution of clay particles. The suspension was left 24 hour to settle and for total hydration of the particles. The turbidity of the suspension was maintained at 220 NTU (Zurina *et al.*, 2014).

Coagulation-Flocculation Properties of Bio-flocculants and Alum

The coagulation-flocculation testing of both bio-flocculant and alum was carried out using JAR test. This stage of the experiment involves rapid mixing, slow mixing and



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

sedimentation using a batch process. For the rapid mixing stage, Agitator was turned on to the speed of 200 rpm for 10 minutes after the addition of the bio-flocculant extracted from banana peels into a beaker containing 400 mL of synthetic turbid water (Zurina *et al.*, 2014). Various combinations of alum and bio-flocculant were used to investigate the best turbidity removal at varying range of temperatures of 25°C to 40 °C. (Zurina *et al.*, 2014).

Jar Test Operations

Basic jar test apparatus was used in the experiment to investigate the effects of coagulants extracted from banana peels and alum on samples of synthetic turbid water. The experiment was carried out as a batch test, which accommodated a total of six beakers with six-spindle steel paddles. The sample was thoroughly mixed to give a homogeneous mixture prior to operating the jar test. The samples were then measured for turbidity. Followed by the addition of varying concentration of coagulants into the beakers. Different rotating speed was used for whole processes in the jar test (Zurina *et al.*, 2014).

Construction of Filter

To remove the floc or sludge formed, a simple and cost-friendly filter was constructed using sand and charcoal. Clean and fresh charcoals were acquired and were crushed into tiny sizes. To save cost and materials, two 2L plastic bottles were used. A layer of gravel was placed at the bottom of the container to provide strength and underpin the overlying layers. And a well-compacted layer of gravel was placed on top of the mesh. Followed by a well-compacted thick layer of charcoal. The purpose of the charcoal is to act as absorbent that will eliminate odor and color. After the charcoal, a layer of well-compacted clean sand was put in place; the sand served as a mechanical screening, coagulation-flocculation and other biological activities. Also, coconut fiber was placed at the top of the constructed filter to act as antifungal agent. After constructing the filter, tap water was used to saturate the filter layer so as to remove dust and dirt.



Figure 1: Constructed Filter

RESULTS AND DISCUSSION

Effect of pH

The results in (figure 1) shows that the removal percentage of both bio-flocculant (banana peels) and Alum decrease substantially as the pH of the solution increased from 4 to 8, It revealed that the lowest activities of both coagulants and flocculant occurred when the pH of the solution was 8. Highest percent turbidity removal were 93.44% and 98.34% for banana peels and alum when the turbid solution is at the pH 12 respectively. But 81.42% and 86.68% of turbidity removal percentage were observed for bio-flocculant and alum at pH 4 respectively.

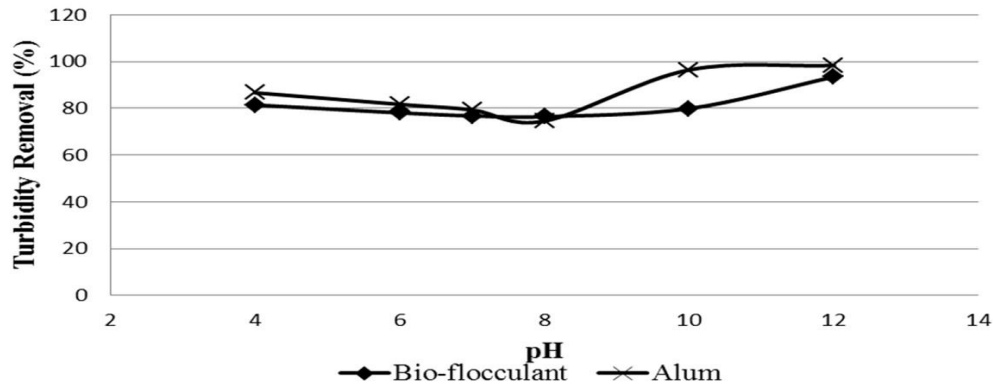


Figure 1: Effect of pH on turbidity removal percentage

The acidity or alkalinity (pH) of wastewater is one of the most significant elements that may affect the coagulation flocculation activities, which occur in waste water treatment (Zurina *et al.*, 2014).

Effect of Coagulants or Flocculants Dosage

Another vital variable that greatly affected the efficiency of turbidity removal from wastewater is the coagulant-flocculation dosage. From the results obtained in (figure 2), show that the turbidity of the synthetic wastewater decreased as the dosage of banana peels and alum increased from 50ml to 150 ml.

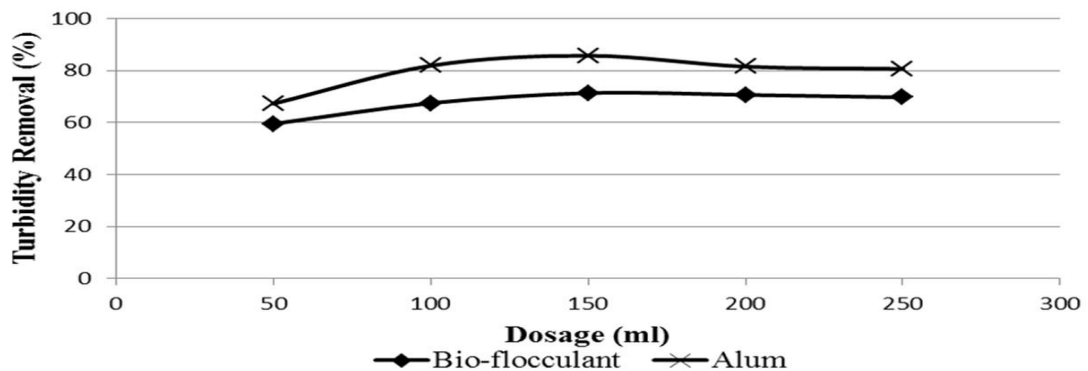


Figure 2: Effect of Coagulants or Flocculants Dosage on turbidity removal percentage



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

Nonetheless, dosage above 150 ml for both bio-flocculant and alum produced a reducing effects in the turbidity removal efficiency in the wastewater treatment. This is because acidity or alkalinity (pH) of wastewater are one of the most significant elements that may affect the coagulation-flocculation activities, therefore the optimum coagulation-flocculation for both banana peels and alum was observed to occur at 150 ml, with a turbidity removal percentage of 71.34 % and 85.69 %.

Effect of Temperature

In the experiment conducted by Lee *et al.* (2014), the effect of temperature on the turbidity removal percentage of both bio-flocculant (banana peels) and alum had been studied within the range of 25-40°C. Tolerance level of polymers (bio-flocculants) is a vital information when discussing the choice of coagulants and flocculants in wastewater treatment (Lee, *et al.*, 2014). From the result obtained, in (figure 3), show that the turbidity removal profile for both banana peel with increase in temperature from 25-40°C

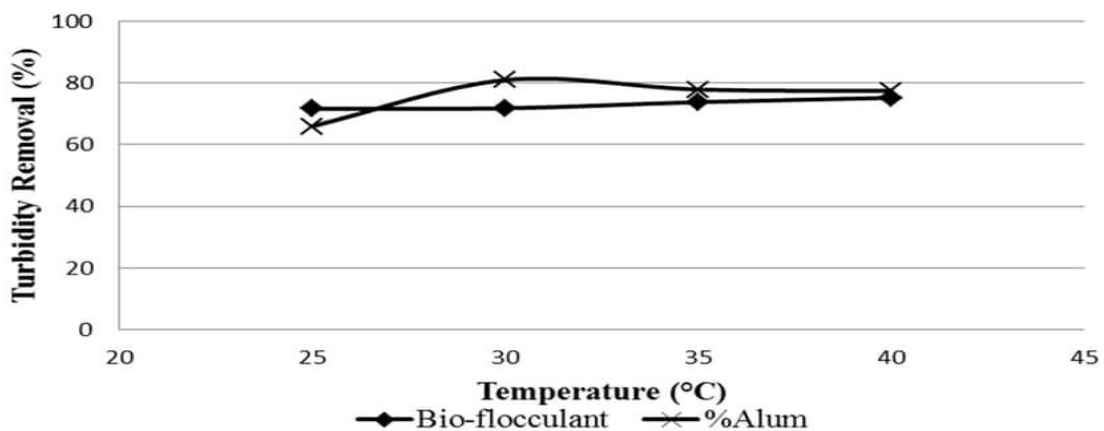


Figure 3: Effect of Temperature on turbidity removal percentage.

Figure 3 shows that the higher the temperature, the stronger the particle movement that is why the turbidity value increase with the increase in and the highest turbidity removal percentage of the bio-flocculant occurred at 40°C with a result of 75.18% while the lowest



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

turbidity removal percentage was observed at 25°C with 71.67%. On the other hand, a different removal profile pattern was observed for alum, with the highest turbidity removal percentage was recorded at 30°C with 80.93% and the lowest turbidity removal percentage was achieved at 25° C with 65.93%. This is because it can increase the cost of water treatment for drinking and food processing. While also harm fish and aquatic habitat by reducing the food supplies degrading spawning bed, and affecting gill fuction.

Effect of Initial Wastewater Turbidity

The results obtained from (figure 4), show that the turbidity removal using banana peels and alum at different initial turbidities of the synthetic wastewater indicate that the effectiveness of turbidity removal of coagulant-flocculant increased with increasing initial turbidity of wastewater, which ranges from low to very high level of turbidity.

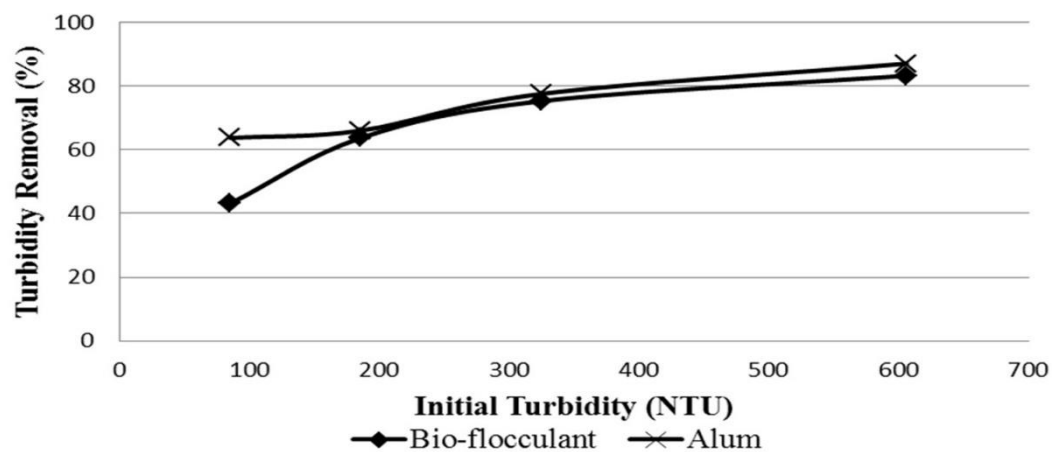


Figure 4: The effect of initial turbidity on turbidity removal percentage

This could be because high concentration of particles in wastewater with high turbidity level increases the rate of collisions between suspended particles with coagulants and hence, enhancing coagulation-flocculation process. Such increase in collisions between coagulants and suspended particles, larger and thicker flocs are formed, which promote high rate of



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

sedimentation in the wastewater treatment process. The highest turbidity removal percentage (83.33%) of bio-flocculant from banana peels was recorded when the initial turbidity of the synthetic wastewater was very high, while the lowest turbidity removal percentage (43.16%) was observed at low level of initial turbidity. The pattern profile obtained for alum was similar to that of banana peels profile. The turbidity removal percentage for alum increased from 63.75% to 87.14% as the initial turbidity level increased from low to very high.

The Potential of Bio-flocculants as Coagulant Aid

Optimization analysis on the ratio of banana peels extract as bio-flocculant to alum was performed under the treatment process conditions of pH 7, 210 to 260 NTU for turbidity, temperature at 25°C. The ratio of banana peels to alum became a 100% respectively to observe the top-quality mixture of alum and bio-flocculant for the highest turbidity elimination percentage. From the results, in (figure 5), show that turbidity removal percentage for alum and bio-flocculant (banana peels) alone.

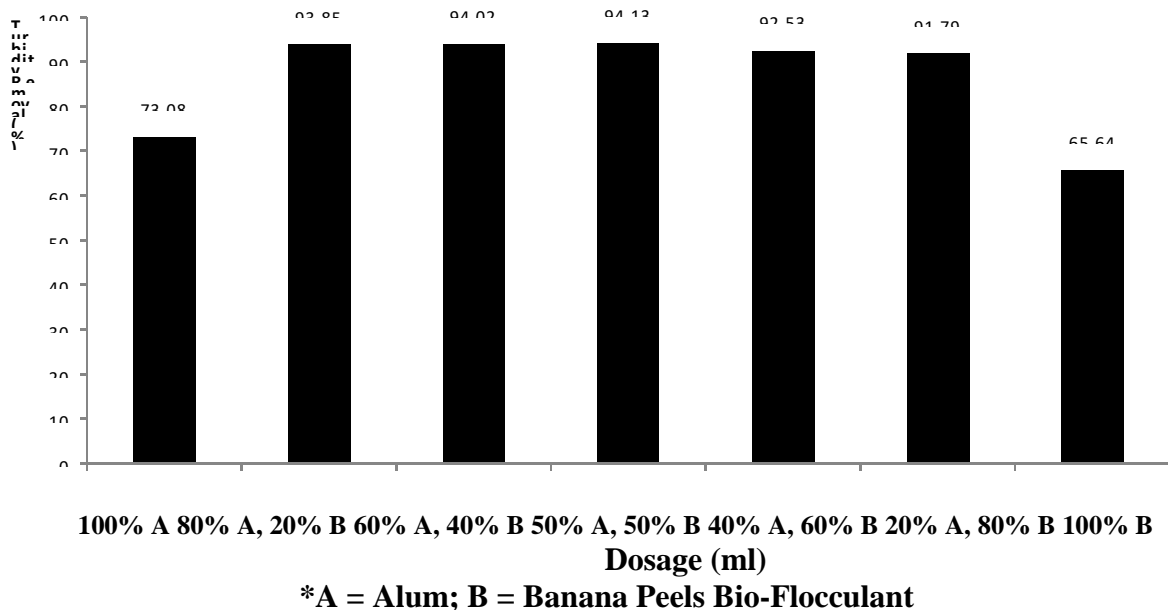


Figure 5: The effect of varying ratio of bio-flocculant to alum as coagulant aid



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

Figure 5 was 73.08% and 65.64%, respectively. The highest turbidity removal percentage of >94% was recorded at ratios 60 or 40 and 50 or 50 of alum to banana peels. No substantial variance was noticed between the performances of these two ratios, hence, the 50 or 50 ratio of banana peels and alum was considered as the optimum combination because it yielded the peak percentage of turbidity removal in all combinations. Therefore, the use of 50 % bio-flocculant could be considered as better, ecofriendly solution in wastewater treatment as it reduces the utilization of chemicalbased coagulants by 50%.

CONCLUSION

In this study the efficacy of banana peels as bio-flocculant was compared to that of most frequently used conventional chemical coagulant (alum) the optimum turbidity removal percentage under pH effect was 93.44 % at pH 12. Additionally, it discovered that 150 ml of bio-flocculant was the best dosage for highest turbidity removal percentage of 71.34 %. As for the effect of temperature, the peak temperature to achieve the optimum turbidity removal percentage for banana peels was at 40°C with 75.18 % percentage of turbidity removal. Besides, the turbidity level of ≥ 500 NTU produced an 83.33% turbidity removal percentage for banana peels extract. Lastly, it was derived from this experiment that the potential of extracted banana peels bio-flocculant was recorded at 94.13 % of turbidity removal for alum or bio-flocculant ratio of 50 or 50. Based on the above observation, it can be concluded that banana peels may be considered as healthier, cost effective, low production of biomass or sludge and environmentally friendly alternative to chemical coagulants in wastewater treatment.

REFERENCES

- Abdullahi, K., Yazdani, F., Panahi, R. and Mokhtarani, B. (2018). Biotransformation of phenol in synthetic wastewater using the functionalized magnetic nanobiocatalyst particles carrying tyrosinase. *Biotechnology*, 3(8), 419.



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

- Agunbiade, M. O., Pohl, C., Heerden, E. V., Oyekola, O. and Ashafa, A. (2019). Evaluation of fresh water actinomycete bioflocculant and its biotechnological applications in wastewaters treatment and removal of heavy metals. *International Journal of Environmental Research and Public Health*, 16(18), 3337.
- Ahmed, D. N., Naji, L. A., Faisal, A. A., Al-Ansari, N. and Naushad, M. (2020). Waste foundry sandorMgFe-layered double hydroxides composite material for efficient removal of Congo red dye from aqueous solution. *Scientific Reports* 10(1), 1–12.
- Aljeboree, A. M., Alshirifi, A. N. and Alkaim, A. F. (2017). Kinetics and equilibrium study for the adsorption of textile dyes on coconut shell activated carbon. *Arabian Journal of Chemistry*, (10), S3381–S3393.
- Allafchian, A., Mousavi, Z. S. and Hosseini, S. S. (2019). Application of cress seed mucilage magnetic nanocomposites for removal of methylene blue dye from water. *International Journal of Biological Macromolecules*, (136), 199–208.
- Al-Wasify, R. S., Ali, M. N. and Hamed, S. R. (2017). Biodegradation of dairy wastewater using bacterial and fungal local isolates. *Water Science and Technology*, 76 (11), 3094–3100.
- Maruti, P., and Rao, B.S. (2013). Environmental sciences a low cost water treatment by using a natural coagulant. *International Journal of Research in Engineering and Technology*, (2), 239-242.
- Mu, J., Zhou, H., Chen, Y., Yang, G. and Cui, X. (2018). Revealing a novel natural bioflocculant resource from *Ruditapes philippinarum*: effective polysaccharides and synergistic flocculation. *Carbohydrate Polymers*, (186), 17–24.
- Nourmoradi, H., Rahmati, Z., Javaheri, M., Moradnejadi, K., and Noorimotlagh, Z. (2015). Effect of praestol as a coagulant-aid to improve coagulationflocculation in dye containing wastewaters. *Global Network of Environmental Science and Technology (NEST) Journal*, (18), 38-
- Vimala, R. T. V., Escaline, J. L. and Sivaramakrishnan, S. (2020). Characterization of self-assembled bioflocculant from the microbial consortium and its applications. *Journal of Advanced Research*, 3(1), 515–518.



Lapai Journal of Science and Technology, Vol. 9, No. 1 (2023)

- Zhang, J., Zhang, F., Luo, Y., and Yang, H. (2006). A preliminary study on cactus as coagulant in water treatment. *Process. Biochemistry*, 41(3), 730-733.
- Zhang, Q., Zhang, F., Ni, Y. and Kokot, S. (2015). Effects of aluminium on amyloid-beta aggregation in the context of Alzheimer's disease. *Arabian Journal of Chemistry*, 12(8), 2897–2904.
- Zurina, Z. A., Fadzli, M. M., and Liew, A. G. (2014). Preliminary study of rambutan (*Nephelium Lappaceum*) seed as potential biocoagulant for turbidity removal. *Advanced Materials Research*, (917), 96-105.