International Journal of Infrastructure Research and Management
Vol. 11 (S), September 2023, pp. 50- 57

ENHANCEMENT OF ATTACHED GROWTH PROCESS USING BANANA PEELS AND ORANGE PEEL IN TREATING SECONDARY POME

Nik Nuraini Azhari, Angel We Chyi En, Khairunisah Kamaruzaman, Nadzifah Che Mat & Nurazim Ibrahim
[1]*Infrastructure University Kuala Lumpur, MALAYSIA*

ABSTRACT
Secondary palm oil mill effluent (POME) is a type of high organic strength wastewater that are produced from palm oil mill processing. It has been identified as a major contributor to water pollution issue due to its high COD, BOD, TSS and colour concentration. This study aims at enhancement of attached growth process using low-cost adsorbents in treating secondary POME. Attached growth system consists of immobile packing media so that microorganisms can grow as biofilm on the media and oxidize the pollutants in secondary POME. Meanwhile, carbonized orange peel powder and carbonized banana peel powder can be added into the attached growth system and be used as a bio-adsorbent to remove remaining pollutants from secondary POME. In this study, the highest COD, BOD, TSS and colour removal efficiency achieved by modified attached growth system with the addition of carbonized orange peel powder was 65.4%, 67.8%, 40% and 65.9% respectively. Whereas, the highest COD, BOD, TSS and colour removal efficiency achieved by modified attached growth system with the addition of carbonized banana peel powder was 88.5%, 71.0%, 40% and 88.6% respectively. This finding is probably beneficial to low cost and environmentally friendly adsorbents which can be used in wastewater treatment

Keywords:
Adsorbents, Secondary POME, Attached Growth System, Banana Peels, Orange Peels

INTRODUCTION

Palm oil industry has continuously played an important role towards Malaysian economic growth. The product produce from palm oils is used in food application and also in non-food application (Som and Yahya, 2021). In 2020, there was 5.87 million hectares of land area in Malaysia covered by oil palm (*Elaeis guineensis)*. Currently, Malaysia is one of the world's biggest palm oil exporters, contribute to 28% of global palm oil production. At the same time, Malaysia contributes about 33% in global palm oil products exports (Yi et.al., 2021). A huge amount of water is needed in the palm oil mill plant operation and therefore discharge an extent amount of wastewater, which is known as palm oil mill effluent (POME).

Palm oil mill effluent (POME) is a type of high organic strength wastewater. Although the palm oil industry is a major income earner for Malaysia, as it is also identified as a major contributor to the issue of water pollution. Massive treatment processes need to be done to POME before discharging to the environment due to its extremely high colour concentration, high chemical oxygen demand (COD) value, high biological oxygen demand (BOD), and high amount of total suspended solids (TSS). It is highlighted by the fact that there is no chemical added throughout the entire palm oil mill processing process (Zhang et., 2008 Zhen et al., 2021).

The palm oil industry is an indisputable source of water pollution in Malaysia. The concentration of chemical oxygen demand and soluble organics matter contains in the POME wastewater are in the range of 44-103 g/L (Emmanuel et al., 2022). Undoubtedly, the remaining of COD, BOD, TSS and colour concentration in treated POME is the main problem that causes the water pollution. Most of the millers in Malaysia are still adopting the traditional way to treat POME which is the conventional ponding system. However, the conventional ponding system is unable to treat the POME efficiently, especially to fully decolourise the effluent which is aesthetically important even before discharging to natural water bodies (Zahrim et al., 2014). Most of the pollutants are remained remarkably high and not meeting the required discharge standard even the conventional ponding system.

There is no doubt that banana and orange are the most popular fruits in the world. The main residue for both the fruits are their fruit peels. For instances, the banana peel accounts for 30-40% and orange peel accounts for 50-60% respectively of their total fruit weight (Rafie and Chong, 2014). Tones of orange peels and banana peels were discarded as useless daily wastes and it is essential to find applications and uses for these peels because waste management is becoming a concerning environmental issue nowadays. These waste peels are low cost, non-hazardous and environment friendly bio-materials which can be used as adsorbents in industrial wastewater (Thuraiya et al., 2015).

In this study, it is primary aimed to develop a system that is useful for further removal of the remaining COD, BOD, TSS and colour in the secondary POME. Thus, by adding in carbonized orange peel powder and carbonized banana peel powder into attached growth system, it is expected that the removal efficiency of COD, BOD, TSS and colour of secondary POME can be significantly enhanced.

METHODOLOGY

Preparation of Carbonized Banana Peel Powder and Carbonized Orange Peel Powder as Adsorbent

The mature fruit peels were collected as solid waste from fruit juice stalls. The collected fruit peels were processed by scrapping impurities that stay on the inner surface of the peels using a small knife and left the outer surface of the peels for the experiment. Then, the peels were washed three times with tap water and one time with distilled water to remove any external dirts and suspended impurities. The processed fruit peels were dried at 100ºC for 48 hours in Memmert oven to remove the moisture content from the peels. After the drying process, the peels were taken out from the oven and kept in the desiccators for 30 minutes for the purpose of cooling down to room temperature. Next, the banana peels were kept in Carbolite muffle furnace for 30 minutes at 200ºC whereas the orange peels were kept in Carbolite muffle furnace for 1 hour at 200ºC to convert them into carbon form. The peels were ready to be grounded into fine powder and sieved through 300 µm for particle size of equal or less than 300 µm (Yusoff & Nazri, 2022) Finally, the fine carbonized fruit peel powder was washed three times by using distilled water to remove the colour of the carbonized powder itself.

Figure 1: Carbonized Banana Peel Powder and Carbonized Orange Peel Powder

Lab Scale of System Set-up and Cultivation of Microorganisms Process

Cultivation of microorganisms is necessary as a part of preliminary preparation so that the useful microorganisms can be attached on the media. The cultivation of microorganisms is done for a period of one month so that a complete cultivation process can be assured. The cultivation of microorganisms is done by introducing 7 litre of secondary POME that collected from the final discharging aerobic pond influent, which is the same pond as the testing sample to the experimental setup. During the one-month cultivation period, 10% of the 7 litre of secondary POME, which is 700 ml should be discharged out of the system every 5 days so that 10% of 7 litre of fresh secondary POME can be introduced into the system. The reason for this step is to ensure there is sufficient food and nutrients for microorganisms and thus preventing the microorganisms from starving as well as dying. Aeration is also provided with a minimum DO at 3.5 mg/L to ensure sufficient oxygen for the growth microorganisms. For a successful cultivation, the colour of attached growth media should be changed from white colour to brown-yellowish colour.

Figure 2: Colour of Attached Growth Media Changed from White Colour to Brownish Colour

Treatment of Secondary POME

The raw of 7 litre of secondary POME was poured into the experiment set up, namely control system which represented as conventional attached growth system (CS), modified attached growth system with carbonized orange peel powder (OS) and modified attached growth system with carbonized banana peel powder (BS) respectively. The experiment setup as shown in Figure 3. During the experiment, the contact time for the system was fixed at 24 hours, 48 hours, and 72 hours. Aeration was then supplied to the system by using aquarium air blower and diffusers throughout the contact time periods. After the treatment for the required contact time, the treated secondary POME is allowed to settle down for 3 hours. Approximately 500 ml of supernatant after the settlement is taken out by using 1000 ml of beaker and used for analysing.

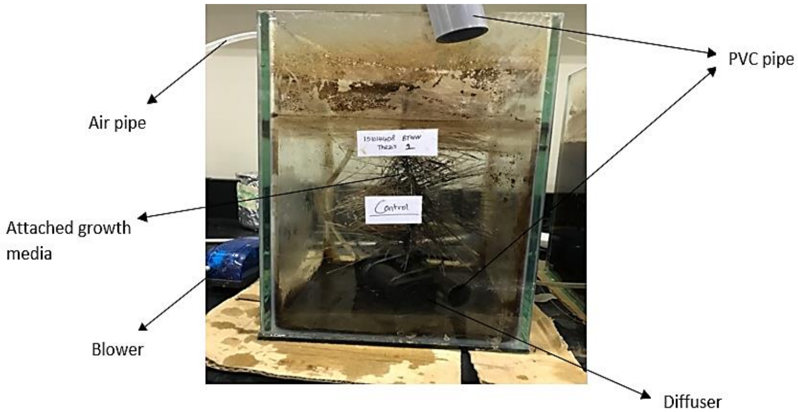

Figure 3: Lab Scale Set-up Represented as Conventional Attached Growth System

The measurement for initial colour concentration before experiment and final colour concentration after the experiment was tested by following platinum-cobalt standard method 8025. Moreover, COD measurement was conducted by using USEPA reactor digestion method 8000. BOD_5 test was carried out using standard procedure of APHA standard method 5210B with YSI 5000 dissolved oxygen (DO) probe. Lastly, TSS concentration was conducted using standard procedure of APHA standard method 2540D.

RESULT AND DISCUSSION

Removal Efficiency of COD, BOD, Colour and TSS of POME

The results obtained for the removal efficiency of selected parameters of secondary POME using CS, OS and BS system are tabulated as shown in Table 1. The finding indicated that BS system has the best treatment efficiency compared to CS and OS system. There are several chemical groups that can be found on the banana peel surface, for example, carboxyl, hydroxyl and amide groups which have been justified to play an essential role in bio-sorption process by increasing the bio-sorption capacity and shortening stable time (Cong et al., 2012). Moreover, banana peel has irregular and porous surface that makes the adsorption process possible. This statement is supported by the image of the banana peel surface that were observed by using electron microscopy (Ibrahim et al, 2012).

Table 1: Removal Efficiency (%) of COD, BOD, Colour and TSS Concentration of Secondary POME

*CT (h) / Parameters	24			48			72		
	CS	OS	BS	CS	OS	BS	CS	OS	BS
COD	26.9	32.7	53.8	32.7	59.6	84.6	38.7	65.4	88.5
BOD	7.1	29.9	41.2	13.7	54.6	64.9	31.5	67.8	71.0
Colour	4.5	40.0	52.3	10.2	59.1	85.2	20.5	65.9	88.6
TSS	20	20	20	60	20	40	80	40	40

*CT (h) – Contact time (hour)
Note: The unit removal efficiency of all the parameter are in the percentage (%).

Effect of Contact Time on Removal Efficiency

Based on the trend of graph that shown in Figure 4 and 5, COD and BOD concentration in CS, OS and BS systems decreased with the increased of contact time. All three systems achieved the highest COD and BOD removal efficiency after 72 hours of contact time. The highest COD removal efficiency that achieved by CS, OS and BS system are 38.7%, 65.4% and 88.5% respectively.

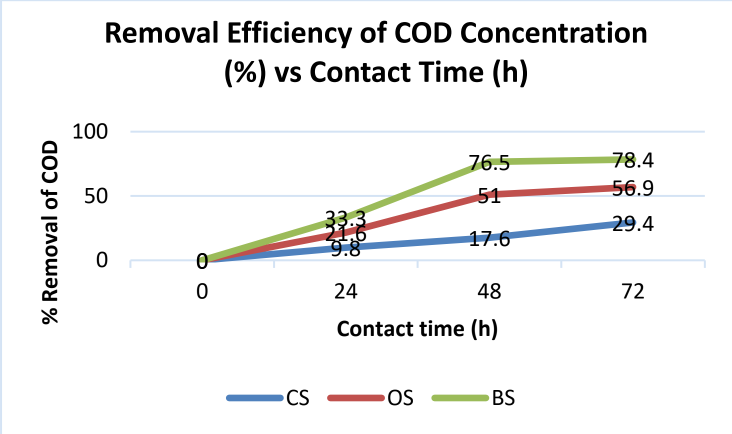

Figure 4: Removal Efficiency of COD Concentration (%) vs Contact Time (h)

Whereas, the highest BOD removal efficiency that achieved by CS, OS and BS system are 31.5%, 67.8% and 71.0% respectively. The highest COD and BOD removal efficiency achieved in BS system can be explained by the addition of carbonized banana peel powder as adsorbents. Besides the attached growth process, the adsorbent enabled the organic substances in secondary POME to stick with the adsorbent surface and thus resulting in a higher COD and BOD removal efficiency. Moreover, the packing media is in brush-like structure can ensure the high surface area to volume ratio for the microorganisms to grow (Ronser, 2017).

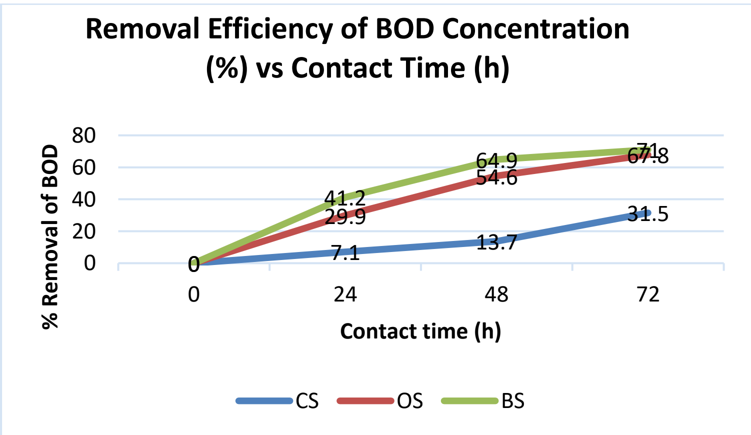

Figure 5: Removal Efficiency of BOD Concentration (%) vs Contact Time (h)

Based on the trend of graph in Figure 6, colour removal efficiency for all the three CS, OS and BS system increased with the increased of time. The highest colour removal efficiency which was 20.5%, 65.9% and 88.6% was occurred at contact time of 72 hours for CS, OS and BS system respectively. The highest colour removal efficiency in BS system can be explained by the adsorption process that carried out by the carbonized banana peel powder (Rafie and Chong, 2014;Yusof & Nazri, 2022).

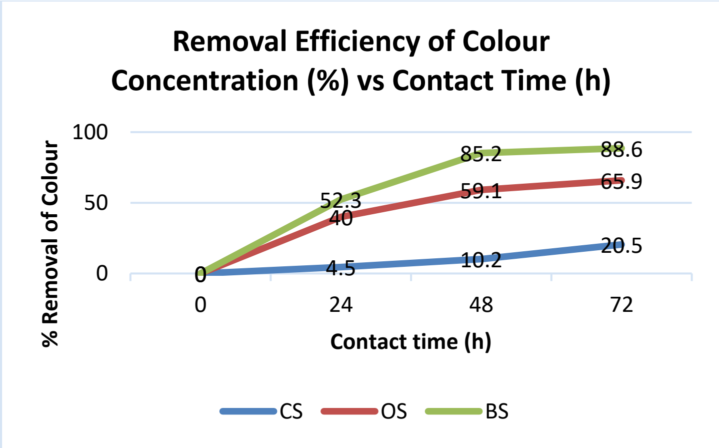

Figure 6: Removal Efficiency of Colour Concentration (%) vs Contact Time (h)

Based on the trend of graph in Figure 7, TSS removal efficiency for all the three CS, OS and BS system increased with the increased of time generally. The highest colour removal efficiency which was 80%, 40% and 40% achieved for CS, OS and BS system respectively throughout the contact time periods. It can be concluded that with the CS system itself, which represented the conventional attached growth system is capable for the TSS removal of secondary POME and with a higher removal efficiency compared to OS system and BS system. TSS removal in OS and BS systems were lower than CS system because the foreign substances, which were the adsorbents that added into the system in powder form did contribute as TSS concentration itself.

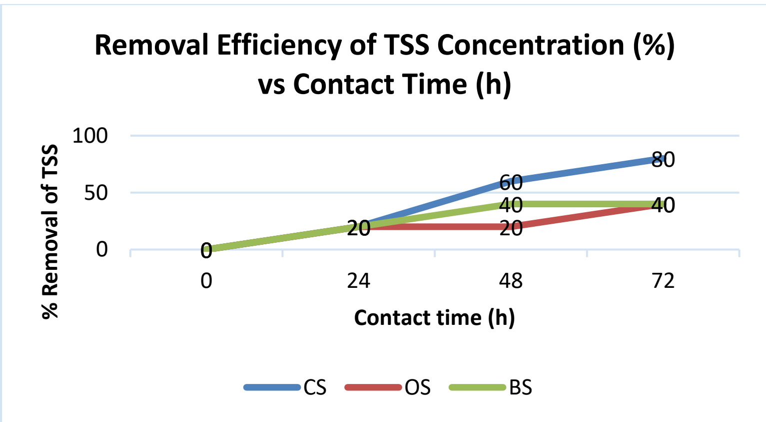

Figure 7: Removal Efficiency of TSS Concentration (%) vs Contact Time (h)

CONCLUSION

Based on the results of the highest COD, BOD, TSS and colour removal efficiency achieved by modified attached growth system, and it can be concluded that carbonized orange peel powder and carbonized banana peel powder can be used as additional adsorbent with longer contact time in improving attached growth process.

AUTHOR BIOGRAPHY

Nik Nuraini Azhari is a lecturer in the Civil Engineering & Construction Department of Infrastructure University Kuala Lumpur. She obtained her Master's Degree in Environmental Engineering from Universiti Teknologi Mara in 2012 and her interest focused on Water and Wastewater Treatment Technology. *Email: niknuraini@iukl.edu.my*

Angel We Chyi En is a final year student at Infrastructure University Kuala Lumpur. He is studying in Bachelor of Civil Engineering (Hons).

Khairunisah Kamaruzaman received her Master of Science in Environmental Engineering from Universiti Teknologi Mara in 2014**.** Her area of expertise is Environmental Engineering with a focus on Water & Wastewater Treatment. Her research project for bachelor degree focusing on Phytotoxicity of Seed Germination and accomplished research project for master degree in Geopolymer study. *Email: khairunisah@iukl.edu.my*

Nadzifah Che Mat is currently working as a lecturer in Infrastructure University Kuala Lumpur. She is an expert in construction materials and technologies. *Email: nadzifah@iukl.edu.my*

Nurazim Ibrahim, Ts. PhD is a lecturer in the Civil Engineering & Construction Department of Infrastructure University Kuala Lumpur. She research focused on alleviating problems associated with solid waste management and water pollution issues. *Email: nurazim@iukl.edu.my*

REFERENCES

Cong, L., Huu, H.N., Wenshan, G., & Kuo-Lun, T. (2012). Optimal conditions for preparation of banana peels, sugarcane bagasse and watermelon rind in removing copper from water. *Bioresources Technology*, Volume 119, 349-354.

Emmanuel, I.U., Juliana, H.P.A., Light, I.N., Vineet, K., Eberechukwu, L. I., & Egba, C.V. (2022). Optimization of parameter in biomethanization process with co-digested poultry wastes and palm oil mill effluents. *Journal of Cleaner Chemical Engineering.*

Ibrahim, S.I.M., Schmidt, T.C., & El-azeem, S.M.A. (2012). Banana peel as alternative bio-sorbent material for removal of 2-Chlorophenol from water. Holding Company for Potable Water & Sanitation (12.08.2017).

Rafie, R.M., & Chong, M.F. (2014). Treatment and decolorization of biologically treated palm oil mill effluent (POME) using banana peel as novel bioabsorbent, *Journal of Environmental Management,* Volume 132, 237-249.

Ronser Group (2017). Kuraray-Ronser POME BOD 20 treatment system (KRB20), Kuala Lumpur.

Som, A.M., & Yahya, A. (2021). Kinetics and performance study of ultrasonic-assisted membrane anaerobic system using Monod Model for Palm Oil Mill Effluent (POME) treatment. *Journal of Cleaner Engineering and Technology.*

Thuraiya, M.A.K., Joefel, J.D., Devi, M.G., Rao, L.N., & Feroz, S. (2015). Treatment of dairy wastewater using orange and banana peels. *Journal of Chemical and Pharmaceutical Research,* Volume 7(4), 1385-1391.

Yi, J.C., Hoong, W.L., & Selvarajoo, A. (2021). Comparative study of the synergistic effect of decanter cake (DC) and empty fruit bunch (EFB) as the co-substrates in the anaerobic co-digestion (ACD) of palm oil mill effluent (POME). *Journal of Environmental Challenges.*

Yusoff, N.A.S.M., & Nazri, M.A.A. (2022). The carbonization of pomelo and banana peels as adsorbent in heavy metal treatment of groundwater. *Recent Trends in Civil Engineering and Built Environment,* Volume 3, No.1, 1185-1191.

Zahrim, A.Y., Nasimah, A., & Hilal, N. (2014). Pollutants analysis during conventional palm oil mill effluent (POME) ponding system and decolourisation of anaerobically treated POME via calcium lactate-polyacrylamide. *Journal of Water Process Engineering*, Volume 4 (2014), 159–165.

Zhang, Y.J., Yan, L., Qiao, X.L., Chi, L.N., Niu, X.J., Mei, Z.J. & Zhang, Z.J. (2008). Integration of biological method and membrane technology in treating palm oil mill effluent. *Journal of Environmental Sciences,* Volume 20, 558-564.

Zhen, K.L., Yi, J.C., Zheng, T.H., Yew, H.Y., Ming, C.T., Ameer, I.T.A.A., Chong, S., Pau, L.S., & Chew, C.L. (2021). Biogas production enhancement by co-digestion of empty fruit bunch (EFB) with palm oil mill effluent (POME): Performance and kinetic evaluation. *Journal of Renewable Energy.*