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Integrated Anoxic-Oxic Sequencing Batch Reactor Combined with Coconut Fiber Waste as Biofilm and Adsorbent Media

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ABSTRACT

Coconut fiber waste has the potential to become a value-added product as a biofilm media and an adsorbent. The addition of biofilm media and adsorbent is important because it reduces the amount of sludge produced in wastewater. Furthermore, the quality of wastewater produced by the Integrated Anoxic-Oxic Sequencing Batch Reactor (IASBR)process with the addition of biofilm media and adsorbents can be used as clean water. The wastewater used comes from apartment wastewater. The Integrated Anoxic-Oxic Sequencing Batch Reactor was used to determine the optimal anoxic-aerobic processing time in a tropical climate. The study will further compare the efficiency of the two by using discarded coconut fiber as an additional adsorbent and biofilm media. The optimal adsorbent dose and weight of waste coconut fiber, as well as hydraulic retention time optimization, were all examined. As a result, clean water was discovered to be the primary product after the addition of adsorbent and biofilm media made from waste coconut fiber.

Keywords: anoxic-aerobic phase, activated carbon as adsorber, coconut fiber as fixed bed biofilm media, sequencing batch reactor.

INTRODUCTION

Organic materials and nutrients, which can harm and pollute the ecosystem as well as human health, are abundant in domestic wastewater. As a result, wastewater treatment should be carried out before discharge to the environment to reduce and eliminate pollutant levels in wastewater. One of the alternative wastewater treatment options is biological treatment. Biological treatment is a wastewater treatment technology that involves microorganisms that have been grown to attach to the media (Bakare et al., 2017; Li et al., 2008; Zhao et al., 2021). The anaerobic and aerobic procedures, respectively, are two biological treatment procedures that use oxygen. The Sequencing Batch Reactor (SBR) is one of the activated sludge technologies in which all phases, from loading to settling, are completed in one tank. Filling, reacting, settling, drawing, and idling are the five phases of an SBR process (Obaja et al., 2005; Wei et al., 2012, Wang et al., 2021). The operation of the SBR is based on two main principles: 1) the material in the tank should be partially removed during the discharging process, and 2) the amount of wastewater entering during the filling stage should be equivalent to the volume of wastewater released during the discharging phase (Cervantes, 2009; Dutta & Sarkar, 2015, Hendrasarie, 2021).

As previously stated by Fernandez et al., 2013, SBRs can be used to remove Chemical Oxygen Demand and Total Suspended Solid, as well as nitrification, denitrification, and biological phosphorus. These abilities are referenced in a lot of literature. One of these, i.e., Soluble Chemical Oxygen Demand, was removed at an average of 83% in urban wastewater. On days 22, 63, and 113, with values of 72%, 65%, and 66%, respectively, the removal efficiency was lower. Low oxygen concentrations influenced the average total nitrogen elimination, which was 50%.

The average clearance effectiveness of phosphorus concentration was found to be 50% with an organic loading rate of 0.6 g COD/L/day. In another study, (Muhammed and Kheria, 2020) for urban wastewater treatment, the performance of a sequencing batch reactor (SBR) on aerobic granular sludge was investigated. After 30 days of operation, the first granules observed had an average diameter of 0.1 mm and were injected with aerobic-activated sludge taken from a wastewater treatment plant. The biomass concentration reached approximately 4 g VSS/L. The applied Organic Loading Rate (OLR) ranged from 1.77 to 3.60 as COD/L/d, and the inlet Chemical Oxygen Demand concentration fluctuated between 422 and 817 mg COD/L. Nevertheless, the organic matter removal efficiency remained relatively steady from days 0 to 60, reaching a percentage for the remainder of the operational time. Denitrification was restricted, as measured by the average nitrogen removal of only 21%. Phosphate removal efficiency did not show a distinct pattern. Changes in intake phosphate concentrations were most likely to blame for this. Between 71 and 119 days, the maximum value of roughly 80% was reached.

Adsorbents have several advantages when it comes to removing organic and inorganic compounds. One of them can absorb organic contaminants through a method in which these are capable of binding to the surface of activated carbon, allowing pollutants to be removed from wastewater (Trilita et al., 2016; Hendrasarie et al, 2019). Previous studies utilizing adsorbents, such as Sekarani et al., 2020; Hendrasarie and Maria, 2021, have shown the utilization of adsorbents to decrease organic content. According to the findings of the study, the adsorbent can remove high levels of organic contaminants by more than 90%. As far as the author is known, the first-time coconut fiber that has been employed as a biofilm adhesive medium in SBR was by Wang et al., 2020. Using Hydraulic Retention Time of 7–8 hours and altering the stability time to 3–8 hours, in the investigated hospital wastewater. COD was reduced by 60.94%, N (Total Kjeldahl Nitrogen) was reduced by 73.03%, and PO_4 was reduced by 89.27%.

The hydraulic retention duration employed in SBR is in the range of 3–8 hours or 10–113 days, according to the various studies stated above. The results show that reducing COD by 60% to 85% was successful, although reducing nitrogen content by 50% to 73% TSS was still ineffective. Starting from this, it is believed that a shorter HRT will be able to reduce Biological Oxygen $Demand_5$, COD, Total Nitrogen, and TSS maximally in this study, utilizing a modification of the addition of adsorbents and biofilm media, HRT utilized 15–35 hours.

This research has three goals: Organic matter removal, optimization of hydraulic retention time, and aeration rate based on biofilm and adsorbent addition; identification of microbes in the biofilm; Fourier Transform Infra-Red (FTIR) test on the adsorbent.

RESEARCH METHODS

Wastewater properties

Wastewater samples were collected from the apartment wastewater treatment inlet. The initial characteristics of apartment wastewater are Chemical Oxygen Demand, Biological Oxygen Demand, Total Suspended Solid, and Total Nitrogen, in successive ranges of 365–490 mg/L, 165–200 mg/L, 250–300 mg/L, 26–40 mg/L, and 0.68–0.80 mg/L. With an organic loading rate of 1.89 g COD/L/day and an F/M ratio of 0.457–1.08 kg BOD_5/kg MLSS/day

Set up and operation of an IASBR

The IASBR was applied through the batch system. It also used the activated sludge released from apartment wastewater. The volume of SBR was set into 7 liters with a volume work of 5 liters. This study also performed a variety of Hydraulic Retention times namely: 16 hours, 25 hours, and 35 hours with an aeration rate of 7 L/minute. The recommended MLSS in SBR systems is within the range of 2000–5000 mg/L (Chiu et al., 2007; Sirianuntapiboon & Sansak, 2008; Sperling, 2007). Data is collected in five cycles, with each sample being performed in triplicate. At the feed point, samples were obtained. SBR operations are typically divided into the following five stages: filling, reaction, settling, drawing, and idle.

Meanwhile, the time distribution of each stage for one operational cycle is presented in Table 1 as follows.

The treatment was operated with HRT for 15 hours, 25 hours, and 35 hours and through three cycles at each HRT. The operation was performed as follows:

a) In reactors, A1 and A2, 1 and 3 g/L of adsorbents were added to the reactor at the beginning of the aerobic reaction stage, respectively. Adsorbent powder 1 gr/L and 3 gr/L were added into the reactor between the fill stage and aerobic stage with wastewater volume ± 5 L.
b) In reactors B1, and B2, 35 grams and 45 grams of coconut fiber were added, respectively. These coconut fibers had been acclimatized to grow the biofilm. For the use of coconut fiber as the biofilm media, this treatment used two variations of the media weight namely, 35 gram and 45 grams.
c) In reactor C, there are no adsorbent or biofilm media addiction

The temperature was set to 29–31°C while pH was set to 6–9, DO > 2 mg/L. Some variables must be controlled during the treatment, namely the volume of activated sludge, the volume of influent and effluent wastewater, Dissolved Oxygen (DO) in each stage of SBR operation, temperature, and pH.

The process of seeding and acclimatization

Before performing the main stage of the experiment, preliminary treatment was accomplished, namely seeding and acclimatization. The seeding technique was designed to help microorganisms develop and reproduce in wastewater. The seeding process was carried out organically in batches for 14 days. The wastewater was changed once a day during the seeding procedure. To expand and reproduce optimally, microorganisms require certain nutrients in the form of a C: N: P ratio. The C: N: P ratio for microorganisms was 100:5:1 (Artan et al., 2001; Gao et al., 2020; Keller et al., 1997; Liu et al., 2020; Wang et al., 2020). On the tenth day, the MLSS analysis was done, yielding a value of 2046.7 mg/L. At a concentration of 2000 to 5000 mg/L, MLSS was conditioned in sludge (Keller et al., 1997; Michalska et al., 2019; Ruan et al., 2020).

Acclimatization takes place in the SBR component. In this early treatment, three steps (the comparison of the percentages of clean water and wastewater) were completed: 1) wastewater 30%: clean water 70%, 2) wastewater 50%: clean water 50%, and 3) wastewater 70%: clean water 30%. Chemical Oxygen Demand was monitored and managed at each stage of the acclimation. The experiment might proceed to the next step if it attained a removal percentage of 50% and there was no fluctuation (Akin & Ugurlu, 2005; Kargi & Uygur, 2003; Schwarzenbeck et al., 2005; Wang et al., 2021).

Identification of isolated microorganisms

The identification of bacteria attached to coconut fiber as a biofilm media and also suspended in wastewater was conducted. The goal was to find out which bacteria are the most effective at reducing organic parameters in apartment wastewater, both suspended and attached to the biofilm media.

FTIR spectroscopy

Surface properties of activated carbon prepared from wastewater surface functional groups were determined by Fourier to transform infrared spectra (Perkin Elmer). FTIR analysis was used to determine the functional groups found in activated carbon in the form of cellulose ($C_6H_{10}O_5$), an organic compound on activated carbon that works as a pollutant absorbent component in the adsorption process. Analysis of spectra with wavelength ranges ranging from 4000 cm^{-1} to 450 cm^{-1} (Chen et al., 2017; Liu et al., 2011; Ruan et al., 2017).

Table 1. Time distribution of each stage for one operational cycle

Stage	Total 15 hours	Total 25 hours	Total 35 hours
	Time (minutes)	Time (minutes)	Time (minutes)
Fill	20	20	20
Anaerobic / anoxic react	360	480	600
Aerobic react	450	900	1350
Settle	90	90	90
Draw	15	15	15
Idle	20	20	20

Analytical methods

COD, BOD_5, total nitrogen, and TSS levels were determined in all samples. The analytical methods were carried out following the standard methods. The sludge volume index (SVI) was calculated after 30 minutes of mixed liquor settlement, as described in Standard Methods (2710-D). The probes of a WTW multi-parameter instrument were used to measure DO, pH, and temperature.

All of the analytical results were double-checked, and the average was taken. For treatment, the amount of biomass in the system is critical. TSS was used to determine the concentration of both attached and suspended biomass in each experiment. Detaching the biomass from the coconut fiber resulted in fixed biomass.

RESULTS

Organic matter removal

The ability of SBR to decrease or remove COD, TSS, and N-total is presented in the discussion section below. This study also examined SBR without modification that only relied on the cycles of the SBR, composing microorganisms that were suspended, and aeration rate.

The Ability to remove COD and BOD_5

Besides the aeration and decomposition of microorganisms, COD and BOD_5 removal are also affected by stabilization (*idle*) and aerobic reaction time in which the longer the HRT, the longer stabilization and aerobic reaction will be. An optimum COD and BOD_5 removal will be reached if the stabilization time and aeration are set at a long duration; however, COD and BOD_5 have been removed since the filling stage because in this stage microorganisms are in a condition in which they have a lot of organic substances. Before coming to the filling stage, a microorganism does not contain organic substances, starting from the aerobic reaction stage to the stabilization stage; therefore, when it comes to the filling stage, rapid removal of organic substances occurs.

As presented in Figure 1 (which can be seen in the support file**),** without additional biofilm media and adsorber, COD, and BOD_5 removal can be reached effectively at HRT 25 hours, with a percentage of removal of 72–75%. If HRT is increased, the ability of SBR to remove COD will decrease, and the lag phase will begin.

COD and BOD_5 levels are effectively reduced to 88.61% COD and 92.54% BOD_5 by bacteria which were assisted by adsorber with HRT set at 25 hours, and the addition of 3 gr/L activated carbon. When HRT was increased to 36 hours, the adsorber became saturated significantly. It shows that adding adsorbers was effective at an HRT of 25 hours.

Meanwhile, adding 35-gram coconut fiber as biofilm media could remove COD 95.11% and 97.65% BOD_5 with HRT set at 35 hours. This removal decreased significantly when the HRT was decreased. An optimum COD and BOD_5 removal will be reached if the stabilization time and aeration are set at a long duration; however, COD and BOD_5 have been removed since the filling stage because in this stage microorganisms are in a condition where they have a lot of organic substances. Before coming to the filling stage, a microorganism does not contain organic substances, starting from the aerobic reaction stage to the stabilization stage; therefore, when it comes to the filling stage, rapid removal of organic substances appears.

The ability to remove total nitrogen

As presented in Figure 2 (which can be seen in the support file), by adding an adsorber, the level of N-total can be removed effectively. It can be seen from the average value of removal efficiency of N-total reaching 94.54% at HRT 25 hours and with an aeration rate of 7 L/minute. This percentage is the highest removal efficiency of N-total. Based on this, it can be claimed that intermittent aeration or anaerobe and aerobe reaction, could remove the level of N-total in wastewater effectively. It is because anaerobic and aerobic reactions have affected the types of microorganisms that decompose nitrogen.

Meanwhile, by using coconut fiber as biofilm media, it could remove N-total effectively. It is proven by the value of removal efficiency of N-total reaching 96.21% at HRT 35 hours. This value is higher than the value reached by using an adsorber. The optimum removal of N-total was reached in the reactor using 35 grams of coconut fiber as biofilm media. Coconut fibers support the growing biofilm because of their rough surface. The rough surface helps the bacteria attach to the media. Meanwhile, the removal of N-total in the control reactor (without media) is not as optimal

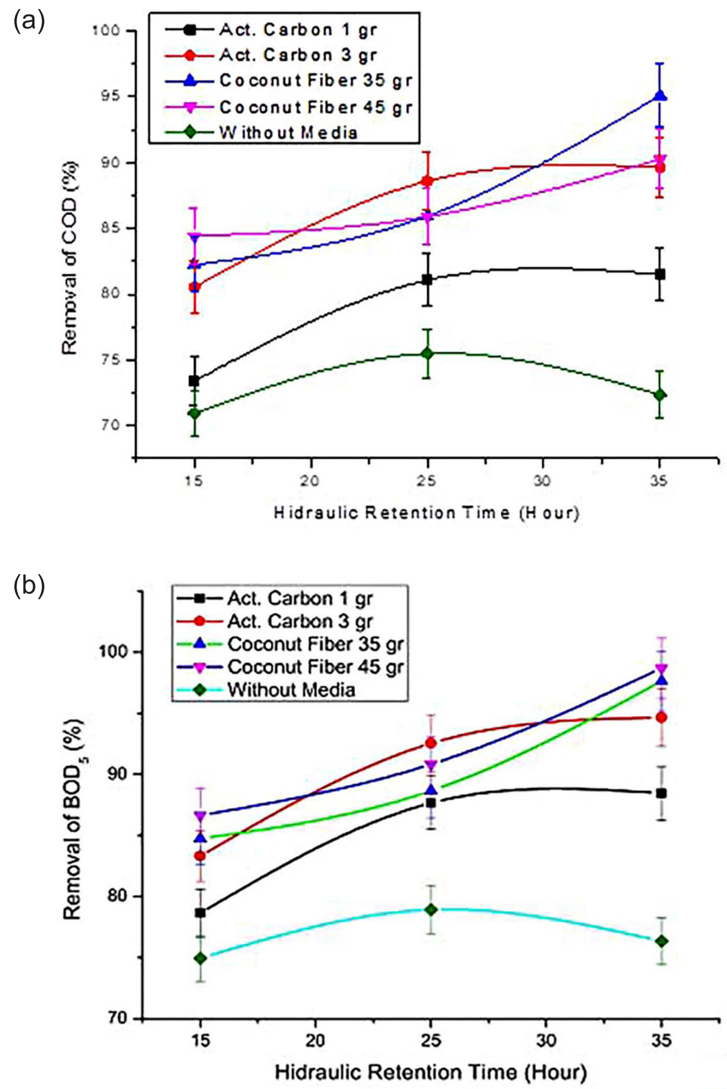

Fig. 1. Removal of (a) COD; (b) BOD_5 in one cycle based on variations in hydraulic retention time

as in the reactor with supporting media. Thus, it was revealed that using additional media could remove N-total more optimally than using a control reactor without media.

The ability to remove Total Suspended Solids

One of the stages that take place in the IASBR reactor is the settling stage. This stage aims to remove Total Suspended Solids (TSS), and like the sedimentation treatment unit, it can do so through the sedimentation process. The efficiency of TSS removal for each HRT generated during the SBR operation process described in Figure 3 is as follows.

Figure 3 (which can be seen in the support file) above presents the percentage of TSS removal that increased from one resident time to another resident. The optimum value of the TSS removal was reached at a residence time of 35 hours that appeared in all reactors. The highest value of the TSS removal with additional adsorbers was 61.41% which appeared at a residence time of 35 hours. However, there was also a reactor with a fluctuated value of TSS removal efficiency that was in the reactor without additional media and adsorber. The decreasing value of removal efficiency of TSS was due to a large amount of suspended solid carried during the effluent removal. The use of IASBR will be effective if it uses supporting biofilm media and activated adsorber carbon, for it could prevent SBR from bulking.

Hydraulic retention time optimization on 25 IASBR cycles

According to the previous discussion, the optimal HRT was with the addition of adsorbent and without any addition at 25 hours, while the

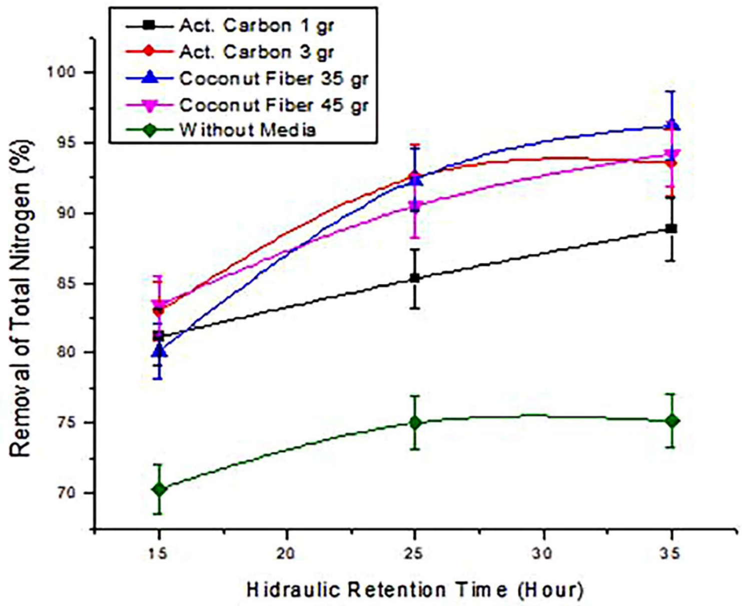

Fig. 2. Removal of total nitrogen in one cycle based on variations in hydraulic retention time

addition of biofilm was at 35 hours. The study was extended for more than one cycle, namely 25 cycles, based on the results of the optimal HRT. IASBR with the addition of biofilm required 1050 days in the twenty-five cycles, while SBR with the addition of adsorbent and without any addition required 750 days.

The ability to remove COD

This study was conducted at 35 h HRT for biofilm media addition, 25 h HRT for adsorbent addition, and no addition for COD reduction, as shown in Figure 7, COD reduction on IASBR at 25 cycles.

The influent COD concentration ranged between 365 and 490 mg/L in Figure 4 (can be seen in the support file). As a result, the final effluent concentrations in the three IASBR treatments differed. The concentration of COD effluent after adsorbent addition was 32.2–41.5 mg/L after biofilm addition was 10.5–18.2 mg/L, and without any addition was 75.6–128 mg/L. With the inclusion of adsorbent and biofilter media, the capacity to minimize COD in SBR is 88 percent to 97 percent. The main difference in HRT is that adding adsorbent took less time (25 hours) than using biofilm media (35 hours). However, the SBR was

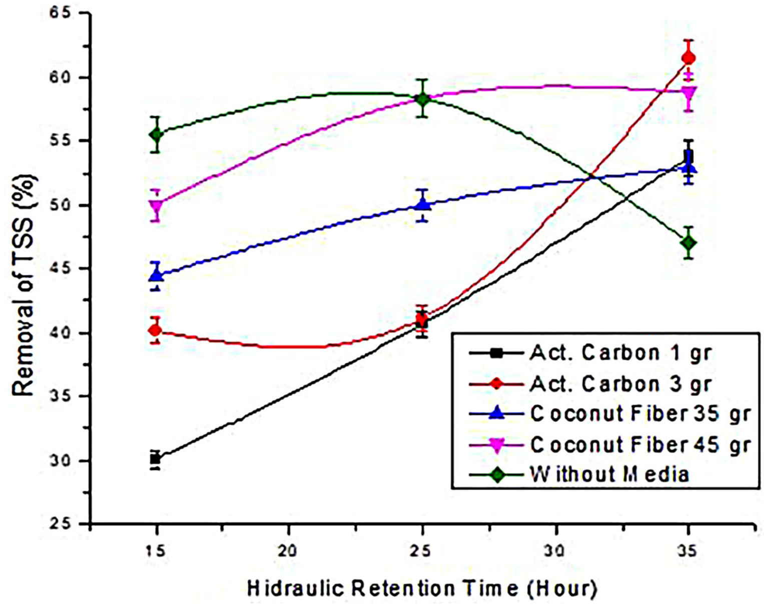

Fig. 3. Removal of total suspended solids in one cycle based on variations in hydraulic retention time

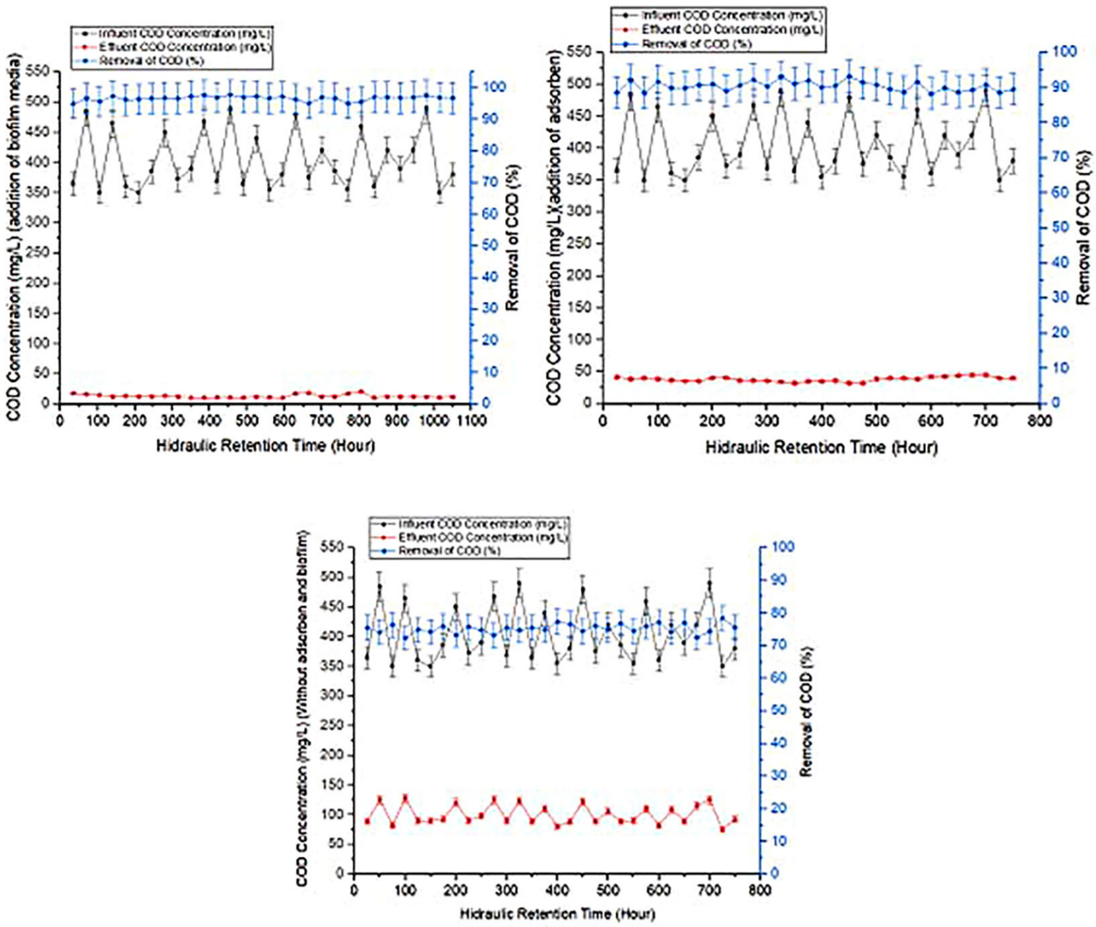

Fig. 4. COD removal in the IASBR 25 cycle. (a) With the addition of biofilm media; (b) with the addition of adsorbent; and (c) without any additions

able to remove COD by 75–77.3% without any additions to the 25-hour HRT. When the HRT was increased to 35 hours, the COD removal ability was reduced by 68–73%.

The ability to remove BOD_5

Figure 5 illustrates reduction in BOD_5. A total of 25 cycles were used to reduce BOD_5 in IASBR.

Figure 5 shows that the influent BOD_5 concentration fluctuated between 165 and 200 mg/L. As a result, the final effluent concentrations in the three SBR treatments differed. The concentration of effluent BOD_5 decreases with the addition of repeated cycles. The results showed that the concentration of BOD_5 effluent after adsorbent addition was 10.3–18 mg/L, biofilm addition was 2.5–8.5 mg/L, and no addition was 34.7–46.6 mg/L. When compared to the SBR without any additions, the effluent concentration of BOD_5 on IASBR with biofilm and adsorbent media was relatively stable.

The ability to remove total nitrogen

To assess changes in the decrease in total nitrogen concentration, 25 cycles of Total Nitrogen reduction were carried out. The timing of the anoxic-aerobic transition is known to affect total nitrogen removal.

Figure 6 (which can be seen in the support file) shows that the influent total nitrogen concentration fluctuated between 26 and 40 mg/L. As a result, the final effluent concentrations in the three IASBR treatments differed. With the addition of repeated cycles, the concentration of effluent Total Nitrogen removal increases. According to the research findings, the concentration of Total Nitrogen effluent after adsorbent addition was 2.0–4.0 mg/L, biofilm addition was 1.5–4.0 mg/L, and no addition was 6.5–10.6 mg/L. The reduction of total nitrogen pollutants in SBR after the addition of biofilm and adsorbent media was found to be optimal at 25 hours and 35 hours HRT, where the Anoxic-Aerobic time ratio was 1: 1.9–2.4.

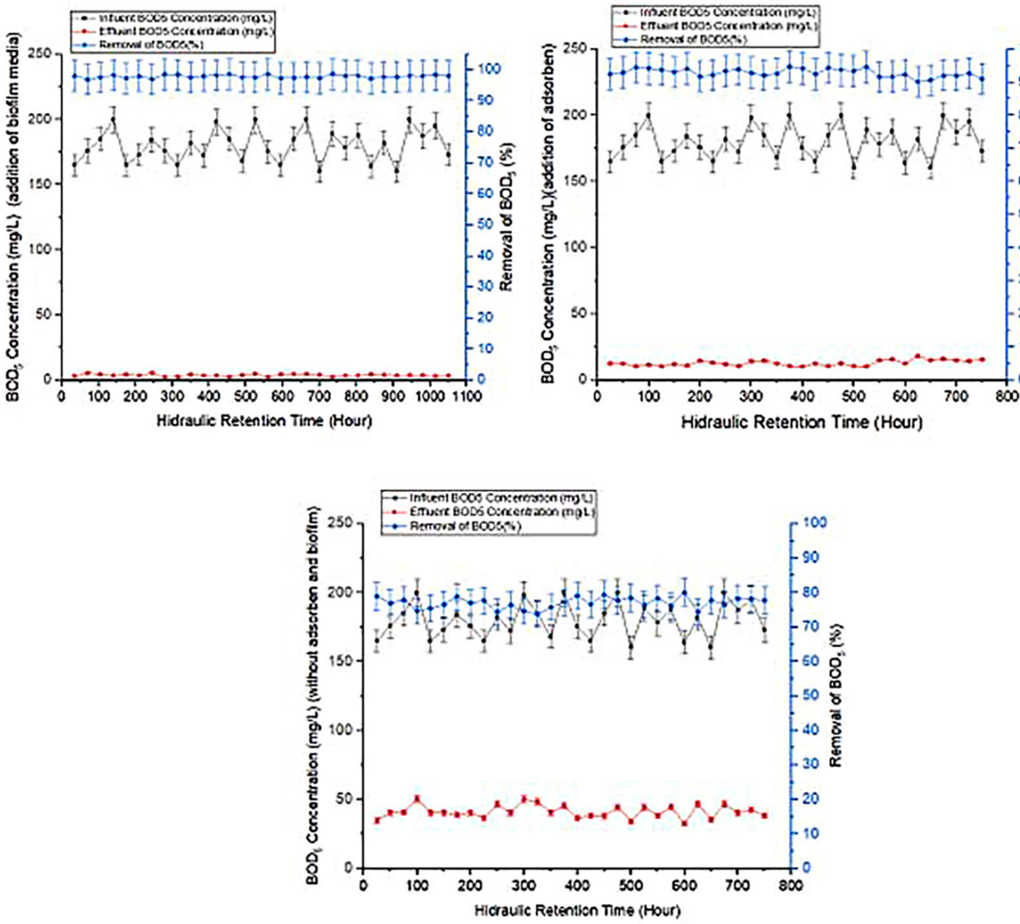

Fig. 5. BOD_5 removal in the IASBR 25 cycle. (a) With the addition of biofilm media; (b) with the addition of adsorbent; and (c) without any additions

The ability to remove total suspended solids

The ability of SBR to remove Total Suspended Solids is essentially insufficient. However, the purpose of this study was to compare the ability of IASBR with and without adsorbent and biofilm media to reduce total suspended solids.

Figure 7 shows that the influent Total Suspended Solid (TSS) concentration fluctuated between 165 and 200 mg/L. As a result, the final effluent concentrations in the three SBR treatments differed. The concentration of TSS effluent decreases with the addition of repeated cycles. The results showed that the concentration of TSS effluent after adsorbent addition was 140–180 mg/L, biofilm addition was 90–120 mg/L, and no addition was 100–130 mg/L. The concentration of TSS effluent without any addition was lower than with adsorbent. This is due to the addition of adsorbents, a variety of micrometer-sized adsorbents suspended in the wastewater.

Sludge volume index, sludge retention time, and characteristics of dissolved oxygen

The sludge volume index was used to assess the settling qualities (SVI). SVI is a critical metric that affects the system's performance. High SVI values (SVI >> 200 mL/g) reflect bulking sludge and low biomass concentration in the aeration tank, whereas low SVI values (SVI 50–150 mL/g) show good sedimentation characteristics of the sludge giving high biomass concentration in the aeration tank (Obaja and Alvarez, 2005). Before withdrawal, SVI was measured at the end of each cycle. The settling properties of SBR sludge were outstanding during the experiments. The SVI value for adsorbent addition is 101.45 mL/g, for biofilm media addition is 102 mL/g, and for no addition is 123 mL/g, indicating that the activated sludge properties in this study were in good condition. Because the SBR mechanism used is the Integrated Anoxic-Aerobic SBR, which is

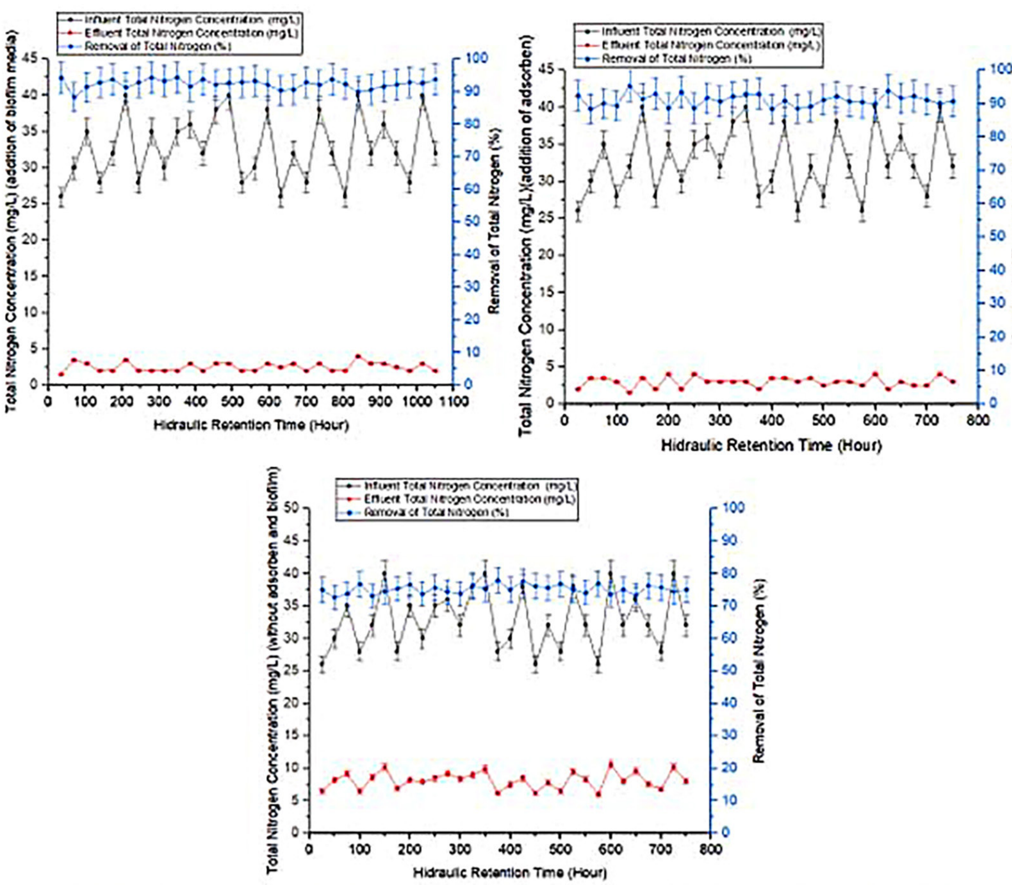

Fig. 6. Total nitrogen removal in the IASBR 25 cycle. (a) With the addition of biofilm media; (b) with the addition of adsorbent; and (c) without any additions

adjusted for the cycle time, this SBR produces little excess sludge.

The Sludge Retention Time (SRT) indicates how long activated sludge remains in the SBR system. In this study, the SRT value for adsorbent addition was 26 days, 21.9 days for biofilm media addition, and 15.6 days for no addition. IASBR without any addition has the lowest age in activated sludge, demonstrating that the addition of adsorbent and biofilm media can increase the life of activated sludge by 28.9% to 40%.

The result of the parameter test of Dissolved Oxygen (DO) at HRT and optimum aeration rate was 7 L/minutes, each stage is presented in Figure 8 Characteristics of dissolved oxygen.

In Figure 8, although 35 hours was the best HRT, the level of Dissolved Oxygen (DO) in the stage of *anaerobic reaction* was 1–2.45 mg/L. It can be stated that 1 mg/L is a fluctuating condition. This condition is extremely influential in the decrease of the N-total parameters. In turn, denitrification did not run effectively with Dissolved Oxygen (DO) 1 mg/L. Generally, to achieve anaerobic conditions and to perform denitrification maximally, the value of DO for denitrification should be < 0.5 mg/L. (Liu et al., 2018; Uygur, 2006; Wang et al., 2008).

Identification of microorganisms that attach coconut fiber biofilms to the IASBR

The identification of microorganisms in IASBR was carried out by adding media to identify the types of microorganisms playing an important role in removing pollutant organic substances during reactor operation. In this IASBR process, if it is without additional biofilm media, the most dominant bacteria are suspended bacteria. Figure 9 presents the appearance of the biofilm attached to the coconut fiber.

In this study, suspended microorganisms that play an important role in decomposing organic substances in domestic wastewater were bacteria from the *Bacillus* and *Micrococcus*.

Meanwhile, the microorganism that was dominantly attached to the biofilm media, coconut

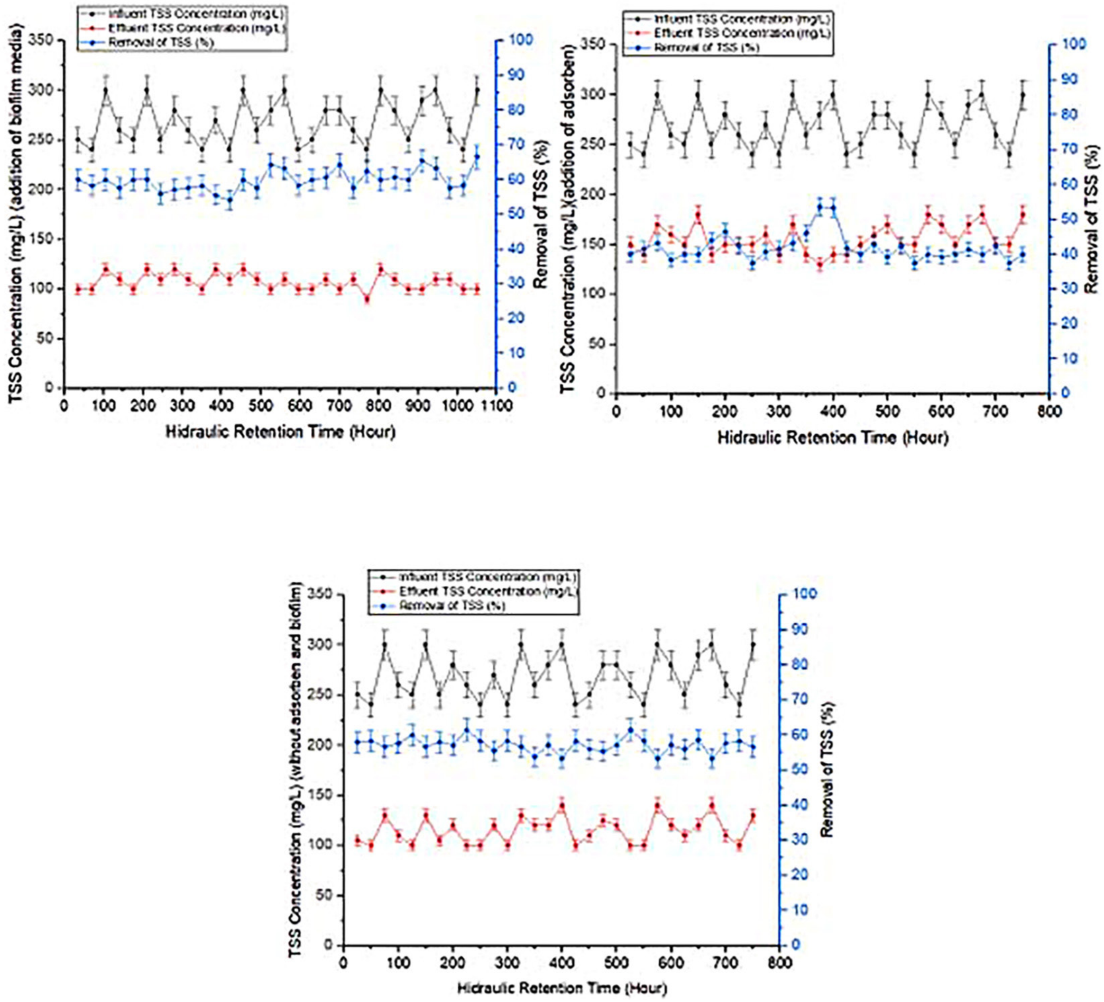

Fig. 7. Total suspended solids removal in the IASBR 25 cycle, (a) with the addition of biofilm media; (b) with the addition of adsorbent; and (c) without any additions.

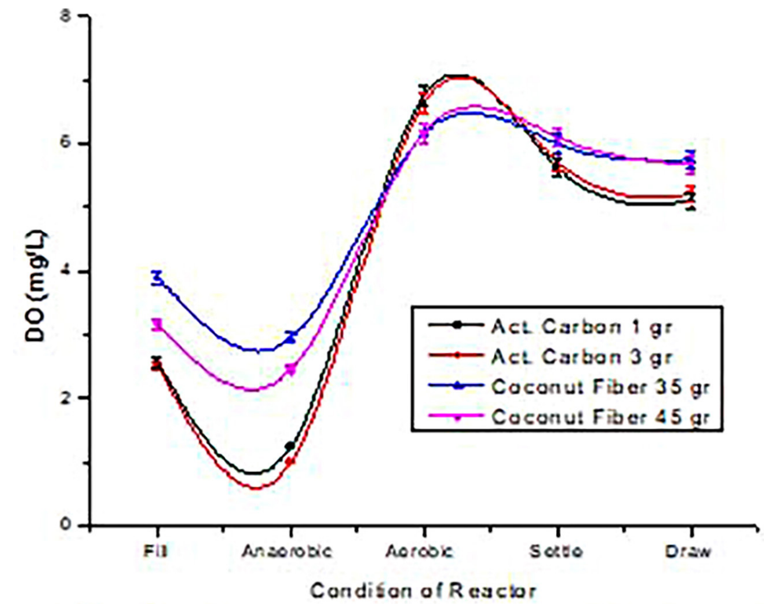

Fig. 8. Characteristics of dissolved oxygen at each stage of the Sequencing Batch Reactor

Fig. 9. Coconut fibers without biofilm (a); biofilm adheres to coconut fiber (b).

fiber, was the genus *Micrococcus* and followed by *Bacillus*. This microorganism identification was conducted in biofilm-attaching media. *Bacillus* and *micrococcus* play an important role in the denitrification process. Under anaerobic conditions with an organic substrate (carbon), denitrifying organisms such as *Bacillus, and Micrococcus*, could use nitrates as electron acceptors during respiration.

FTIR analysis of the coconut fiber adsorbent

One of the devices used to detect the vibrational spectra of molecules and predict the structure of chemical compounds by identifying the functional groups that make up the compound is the Fourier transform infrared (FTIR). Figure 10 shows the FTIR test results.

The addition of coconut fiber-activated carbon to the reactor affects the removal of organic materials as well as organic color, odor, and ammonia from wastewater. The organic matter with a chemical structure that is commonly found in wastewater, includes aliphatic, aromatic, and nitrogen organic pollutant compounds (Barros et al., 2020; Fang et al., 2020). According to Figure 10, the coconut fiber-activated carbon added to the reactor absorbs the organic matter present in the wastewater. Organic functional groups containing carbon and nitrogen are present.

Organic compounds such as proteins, carbohydrates, and oils, which contain elements of C, H, O, N, and S, are found in COD criteria (Lorini et al., 2020). These elements are present in all groups on the final activated carbon, including alkanes/alcohols (wavelength 538.23–512.29 cm^{-1}), and alkanes (wavelength 1384.58–1384.53 cm^{-1}), nitriles (wavelength 1638.26–1634.21 cm^{-1}), and amine (wavelength 3465.6–3444.4 cm^{-1}).

Ammonia, nitrite, nitrate, and organic nitrogen such as protein and urea are included in the Total N measure (Denisova et al., 2020). The existence of nitrile and amine groups, which are ammonia derivatives, proves that nitrogen molecules have been removed. Because TSS is an insoluble solid like mud, clay, and microbes, there is no indication of a supporting group for the TSS parameter. Furthermore, due to the development of heterogeneous chemical reactions, TSS might impede the formation of organic compounds in water.

The scattered light is measured in spectrophotometry by percent Transmission. The light that is absorbed is measured as absorbance if the wave crest is below or lower than the percent Transmission.

With an aeration rate of 3.5 L/min and 7 L/min, wave crests with a low transmission % on activated carbon after adsorption can be seen in Figure 10. This is because absorbance is defined as the number of organic materials absorbed. As a result, it has been established that the adsorbent used in SBR operations is effective and capable of absorbing organic materials.

CONCLUSIONS

The addition of adsorbents and biofilm media to the Integrated Anoxic-Aerobic Sequencing Batch Reactor (IASBR) can improve the ability thereof to reduce organic substances in apartment wastewater. COD levels can be reduced with the highest removal efficiency of 95.11% by using 35 grams of coco coir as a biofilm medium and 36 hours of HRT. After 25 hours of HRT, it was possible to remove 89.61% COD levels and 94% N-total levels using adsorbents. The concentrations of COD, BOD_5, total nitrogen, and

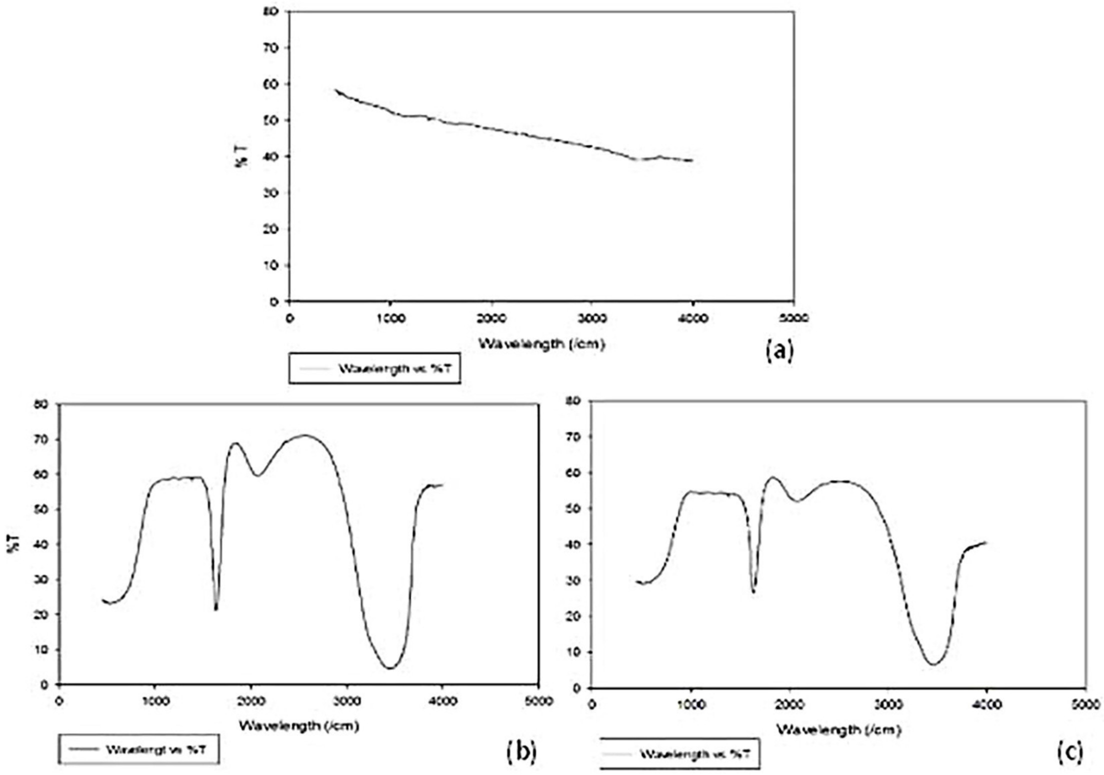

Fig. 10. FTIR research findings on (a) coconut fiber activated carbon before adsorption; (b) coconut fiber activated carbon after adsorption, with an aeration rate of 3.5 L/min (c) activated carbon after adsorption at a rate of 7 L/min of aeration

TSS in effluent wastewaters after the addition of biofilm and adsorbent media were in the range of 10.5 mg/L, 2.5 mg/L, 1.5 mg/L, and 100 mg/L, which were classified as clean water. Thus, the addition of adsorbent and biofilm media to IAS-BR can be a potential solution because it produces effluent clean water and excess sludge, as evidenced by the SVI value of 100 mL/g.

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