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Modification of sequencing batch reactor (SBR) using novel acryl-fiber (AFBC) for sanitary landfill leachate safe disposal

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ABSTRACT

A combined process of acrylic biomass carrier and activated sludge system (traditional system) was accomplished to treat sanitary landfill young leachate with a high concentration of ammoniacal nitrogen and organic material. Stable treatment performance of an acrylic biomass carrier reactor with activated sludge traditional reactor combined with bio-fringe loaded with microorganisms (CASBF) compared to activated sludge traditional reactor (CASR) was obtained under 10 L laboratory-scale reactor as 24 h sequencing batch reactor system and 2–5 mg/L dissolved oxygen, the temperature of (20°C–25°C), pH 7 ± 1, a volumetric organic load of 1,968 mg/L COD (chemical oxygen demand – COD), high ammoniacal nitrogen loading rates of 1,904.1 mg/L, food to microorganism ratio of 0.25, mixed liquor volatile suspended solid of 1,500 mg/L, sludge age of 2.7 d and hydraulic retention time of 1.7 d for 13 d duration of the experiment, respectively. The efficiency of both reactors was assessed based on the reduction in biochemical oxygen demand (BOD_5), COD, ammoniacal nitrogen (NH_3–N), total Kjeldahl nitrogen (TKN), phosphate (PO_4^{3-}), nitrite (NO_2^{-1}), nitrate (NO_3^{-1}), suspended solids and color. The results revealed that the reactor with CASBF efficiency removed NO_2^{-1}, NO_3^{-1} and PO_4^{3-} were 77.7% with effluent concentration 10 mg L^{-1}, 86.25% with effluent concentration 21.0 mg L^{-1}, and 63.2% with effluent concentration 18.1 mg L^{-1} respectively from young leachate in comparison to CASR which exhibited the efficiently removed of NO_2^{-1}, NO_3^{-1}, and PO_4^{3-} was 20.7% with effluent concentration 36.1 mg L^{-1}, 54.2% with effluent concentration 69.9 mg L^{-1}, and 45.6% with effluent concentration 26.5 mg L^{-1}, respectively. However, the reduction of NH_3–N also TKN was more within the CASR and achieved 68.7% with effluent concentration 538.90 mg L^{-1} for TKN and 92.5% with effluent concentration 134.2 mg L^{-1} for NH_3–N. This reduction is achieved via nitrification and denitrification processes. These findings indicated that CASBF has high efficiency of removal of COD, BOD, NO_3^{-1}, and PO_4^{3-} from sanitary landfill young leachate and have the applicability for sanitary landfill young leachate treatment.

Keywords: Landfill leachate; Reduction; Parameters; Efficiency; Comparison

1. Introduction

The high-strength sanitary landfill young leachate is one of the more completed wastes due to the high concentrations of non-degradable chemical substances. These wastes show biodegradable qualities (BOD/COD) > 0.4 (biochemical oxygen demand – BOD/chemical oxygen demand – COD). The COD/N/P ratio is optimum for biological treatment processing due to the high total phosphorus (TP) and total nitrogen (TN) contents ranging from 10–25 mg/L and 700–1,800 mg/L

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respectively in sanitary landfill young leachate and abnormal pH, organic compounds in addition hazardous heavy metals like total iron and zinc [1–3]. Therefore, the traditional processes system which is employed for reducing pollution of sewage has low efficiency to improve the sanitary landfill leachate quality. Besides, these methods require a large space and complicated system operations as well as produce a large quantity of sludge. The biological processes might provide an alternative method for removing selective pollutant components [4,5]. However, the biological method should be conducted with the augmentation process in which selected microorganisms are introduced into the sanitary landfill leachate with selective conditions. The biological methods which have been suggested by the authors in the literature depend on using selected microorganisms loading on bio-carrier materials [6]. In this context, the bio-fringe material is one of the most potent bio-carrier which allows users to attach large concentrations of the selected microorganisms on a flexible matrix in a fixed position. The source of the microorganisms loaded on the bio-fringe material represents the critical point in the treatment process. Many researchers used the microorganisms from the activated sludge [7]. However, the flexing of the loaded of bio-fringe (BF) with microorganisms brought on wastewater flow makes a motion (swimming) which enhances a nutrients mass-transfer to the attached microorganisms of attached growth [1].

The current study aimed to investigate the efficiency of activated sludge traditional reactor (CASR) combined with bio-fringe loaded with microorganisms (CASBF) compared to the traditional activated sludge reactor (CASR) to reduce pollutants in terms of COD, BOD_5, NO_2^{-1}, NO_3^{-1}, total Kjeldahl nitrogen (TKN), NH_3–N, PO_4^{-3}, color, and suspended solids (SS) from young leachate of the sanitary landfill.

By using the same technology (bio-fringe), this study examined the application of bio-fringe as a biomass carrier for sanitary landfill young leachate as semi-aerobic leachate treatment. Aziz et al. [1,15] applied bio-fringe fiber as a biomass carrier in the swim reactor of leachate wastewater. According to the authors, the reduction of sludge was accomplished in the bio-fringe reactor. The same reactor was efficiently removed nitrite, nitrate, and phosphorus from leachate; however, the removal efficiency for ammoniacal nitrogen as well COD was not significant in addition to the sludge volumetric index was around 50 mL g^{-1}. Qiao et al. [8] assessed the swim-bed + bio-fringe reactor performance and activated sludge reactor (ASR) for partly nitrification of anaerobic digester reactor for treating municipal wastewater. The authors revealed, that sequencing batch reactors with bio-fringe loaded with microorganisms (SBRBF) getting higher performed than the ASR in terms of BOD as well as ammonium nitrogen removals. Moreover, the sludge production for SBRBF has detected high protein levels indicating good settling capability of sludge [8].

2. Methods and materials section

2.1. Sampling and characterization of sanitary landfill young leachate

The samples of sanitary landfill young leachate were taking from an intermittent aeration pond from Tanjung Langsat, Pasir Gudang Landfill Site Malaysia. Prior to use in the experiment, the samples were stored in the laboratory in plastic containers at 4°C, to minimize both chemicals as well as biological reactions according to the APHA [9].

2.2. Sampling and characterization of activated sludge

In this study, used activated sludge (AS) was commercially collected from the wastewater treatment plant, Malaysia. The AS was collected from the sludge generated from the clarifier unit. The collected AS has pH 7.26, BOD_5 (160 mg L^{-1}), COD (7,327 mg L^{-1}), mixed liquor suspended solids (MLSS) ranging between 7,742 and 8,505 mg L^{-1}.

2.3. Experimental setup

The design of CASBF and CASR is presented in Fig. 1. Each reactor was made up of Plexiglas 10 L of the capacity. In order to avoid biomass demolition and to have a good liquid circulation, the design has two compartments [1]. An air pump (HAILEA – HAP-80/aquarium air pump – power 80 L/min) was employed to making the circular motion of wastewater as well as support aeration cycle inside the reactors.

Two laboratory-scaled batch reactors were constructed at the same dimensions and the same experimental setup and procedure with the only difference being the utilization of media that were fixed. In this system (biofilm system), the microbial biomass is static or immobilized to support material. Immobilization of microorganisms to the support material can be divided into two main immobilization processes [1] includes the self-attachment of microorganisms to the support material, which is defined as attached growth and the artificial immobilization. Prior to the experiment, the sample was mixed with activated sludge in reactors for 10 d.

The CASBF and CASR batch bioreactors were seeded with activated sludge and then loaded a collected sanitary landfill young leachate to maintain mixed liquor volatile suspended solid (MLVSS) between 1,200 to 1,500 mg L^{-1} [10]. In order to

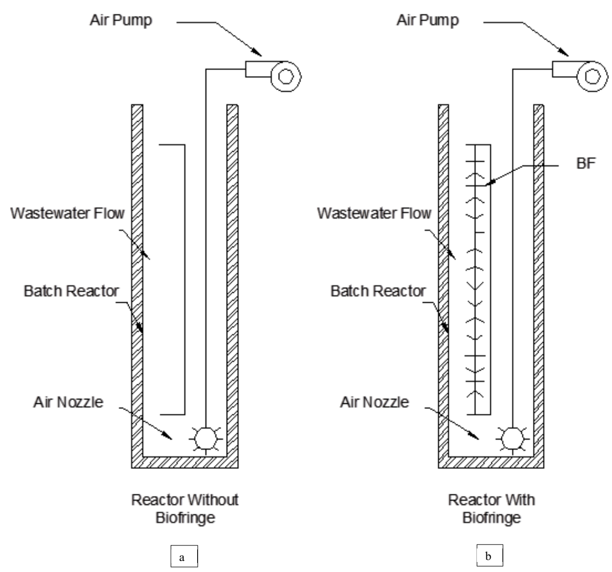


Fig. 1. Design of (a) CASR and (b) CASBF.

make a good condition for microorganisms as well as combine the sanitary landfill young leachate with AS in the reactors, the systems were provided with 21 h aerated. Thereafter, the air pump (for aeration purpose) was ended for settling purpose before decanting treated wastewater from the reactors, for examining purpose. The reactors were kept idle whenever the MLVSS was over the range. The reactors were loaded with sanitary landfill young leachate, then the air pump (for aeration purpose) was resumed to continue wastewater treatment for the second day. A solids residence time and hydraulic retention time for the experiment were 2.67 and 4.16 d, respectively. The BOD_5:TN:TP was 100:5:1. Also, to ensure good experimental conditions pH was adapted ± 7. The MLVSS should be calculated as below:

$$X_v = \frac{Y(S_O - S)}{1 + K_d f_b \theta_c}\left(\frac{\theta_c}{t}\right) \tag{1}$$

where X_v = MLVSS, S_0 is concentration of influent substrate, S is the concentration of effluent substrate, f_b = MLVSS bio-degradable, $f_b = \frac{f_{b'}}{1+(1-f_{b'})K_{d\theta_c}}$, Y is the yield coefficient (g VSS produced/g BOD_5), K_d is the coefficient of respiration (d^{-1}).

Environment Protection Act (EPA) [9] stated the MLVSS for conventional aeration activated sludge can be countable in the range from 1,500 to 3,500 mg L^{-1}. Besides that, the volatile suspended solids (VSS)/SS ratio has been discovered by EPA (1997) where AS was between 0.7 until 0.85. As for extended aeration, the VSS/SS ratio is stated between 0.6 and 0.75. The biomass growth of the microorganisms is dependable towards the BOD of the biomass. Therefore, these rates or feeding volumes can be obtained by using Eq. (2):

$$\frac{F}{M} = \frac{QS_O}{VX_V} \tag{2}$$

where Q is the feeding volume (m^3/d), F/M represents the ratio of food to microorganism, X_V is the MLVSS (biomass concentration) (g/m^3), S_0 is the influent concentration (BOD), V is the reactor volume (L).

In order to maintain MLVSS around 1,500 mg L^{-1} the sanitary landfill young leachate loaded was 2.4 L d^{-1}. In the both reactors the F/M ratio were set around 0.05 while the BOD was 247 mg L^{-1} for raw leachate [calculation: (F/M) food to microorganism = [(BOD × Q)/(MLSS × reactor volume)]; 0.05 = (247 × feeding volume)/(1,500 × 10); therefore, feeding volume = 3 L].

Considering [1] that the system was run in a long cycle (24 h cycle) operation, and the whole reactor was completely aerated as well as the sludge age is high rate 2.7 d, F/M ratio of 0.05 was selected. The concentration of MLVSS was checked during every aeration phase to maintained MLVSS between 1,500 and 3,500 mg L^{-1}. Activated sludge was added if the MLVSS dropped below 1,500 mg L^{-1}. In case if the MLVSS exceeded 3,500 mg L^{-1}, some sludge will be wasted until the MLVSS dropped to the desired level.

In this study, the optimization was performed to identify the optimum conditions of the sequencing batch reactor (SBR). In aerobic SBR, there are five levels including first level filling and follow by reaction level and then settling level and drawing level finally idle stage a working volume of 10 L and 24 h were used. The phases' time length was also widely differing used in this study.

2.4. Analytical methods

The sanitary landfill young leachate parameters were analyzed corresponding to APHA [9]. pH was determined by (Milwaukee SM101 pH meter, USA) and the temperature was determined by (Ger 21 temperature meter). COD, nitrite (NO_2^{-1}), ammoniacal nitrogen (NH_3–N), phosphate (PO_4^{3-}), nitrate (NO_3^{-1}) were determined using HACH DR/6000 spectrometer (USA). Reactor digestion method (Method 8000) was used for COD determination, Nessler method (Method 8038), ferrous sulfate method (Method 8153), cadmium reduction (Table 2) method (Method 8171), ascorbic acid method (Method 8048) and platinum-cobalt standard method (Method 8025) were used for NO_2^{-1}, NH_3–N, NO_3^{-1}, PO_4^{3-}, and color; respectively. However, BOD was determined using the 5th day BOD test with the 5210B method. The TKN and total suspended solids (TSS) were determined by method 4500 and method 2540D by the referred procedure of APHA [9]. The pollutant removal efficiency of a sanitary landfill young leachate was calculated by using Eq. (3).

$$\text{Removal Percentage}\,(\%) = \frac{(C_e - C_0)}{C_e} \times 100\% \tag{3}$$

where C_e is the initial concentration during sampling, C_0 is the final concentration at the end of the experimentation.

2.5. Biomass build up in BF reactors

The efficiency of the BF reactor for building up biomass (microorganism) produced during a treatment process of sanitary landfill young leachate was reliable in this study. The aeration rate and time employed as an operating reactor factor achieved a high recovery percentage of microorganism biomass. These elements evidently concluded the treatment efficiency contributing to building up biomass in the BF [1]. Therefore, the build of biomass can be calculated as below [1]:

$$\text{Biomass Bulid up} = a - b \tag{4}$$

where a is the fiber weight before treatment (g), b is the fiber weight after treatment (g).

2.6. Statistical analysis

The data collected from experiment were analysed employing MINITAB 14 CODE MES software. The descriptive statistics and significant test were carried our using F-test with 95% confidence level.

3. Results and discussion

3.1. Characteristics of sanitary landfill young leachate

A sanitary landfill young leachate characteristics samples were investigated in the current work are illustrated in

Table 1. Sampling was done twice per week, with approximately 150–200 L of wastewater collected from the sampling site. It was noted that the pH was 7.5, while the BOD_5/COD ratio was 0.11 which indicates the low biodegradation level of the organic compounds in the landfill age [2,11]. COD of leachate wastewater was 1,773–2,403.3 mg L^{-1}, indicate that it is more than that reported in the mature landfills (100–500 mg L^{-1}) [3,12,13]. Similar findings were reported by previous studies, indicating the need for an advanced treatment process for these wastes to improve the quality before the final disposal into the environment [1,2]. Moreover, NH_3–N average was 2,024.1 ± 252.42 mg L^{-1}, the height level of concentrations for NH_3–N is associated with eutrophication phenomenon in the freshwater systems [2]. In comparison the concentrations of TKN were 1,651.8 ± 95.2 mg L^{-1}, the value is less than that recorded for NH_3–N which was theoretically unacceptable. Due to the TKN is the sum of organic and ammoniacal nitrogen (NH_3–N) therefore, the value of TKN is usually higher than NH_3–N.

PO_4^{3-} concentrations were 50.7 mg L^{-1} indicate that it is viewing to be higher than discharge standard 0.4 mg L^{-1} [10] as there is a greater than fifty fold. The organic carbon decomposition by microorganisms has influences on many processes of the nitrogen cycle reaction in the reactor. With time, ammonium phosphate (one of nitrogen cycle) concentration increased due to microbial utilization. Which lead to an increase of PO_4^{3-} [14]. The organic matter decomposition (like humic acids, color) of sanitary landfill young leachate sample was high which strength intend wastewater to be black or brown, as also observed by Aziz et al. [1,15]. Besides, the SS contained in the sample was 443.5 mg/L (high) due to the decomposition of organic matter during the landfill life process (like humic acid). Humic acid chemical composition is preventing a biological treatment and formed non-biodegradable combines. Such results were agreed with Aziz et al. [15]. However, aeration had an effect on decreasing the SS [15].

Table 1
Characteristics of sampled leachate

Parameters	Mean ± St. Dev.*	Range (Min. – Max.)
pH	7.3 ± 0.25	7.52–7.99
COD, mg/L	1,968 ± 217.9	1,673–2,343.3
BOD, mg/L	257 ± 54.35	194–311
TKN, mg/L	1,721.8 ± 95.2	1,610.5–1,872.8
Ammoniacal nitrogen, mg/L	1,904.1 ± 252.42	1,789–2,127.5
Nitrite, mg/L	45.5 ± 4.01	37.7–42.7
Nitrate, mg/L	152.7 ± 0.77	134.4–171.8
Phosphate, mg/L	48.7 ± 2.8	45.87–51.77
Colour point, pt-co	4,176.8 ± 240.6	5,362.5–4,223
TSS, mg/L	458.7 ± 101.7	598.4–738.4
VSS, mg/L	364.7 ± 75.7	378.4–358.4

* Standard division

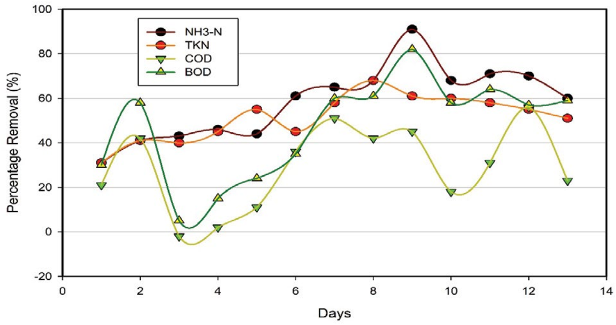
3.2. CASR performance

The removals efficiency of CASR was 52.1% COD and 78.2% BOD, and 68.7% TKN, and 92.5% NH_3–N, and 45.6% PO_4^{3-}, and –12.8% color and 31.6% SS in the raw high-strength sanitary landfill young leachate under 2–5 mg/L dissolved oxygen (DO), the temperature of (20°C–25°C), pH 7 ± 1 (Fig. 2). The maximum removal was recorded for NH_3–N (92%) followed by BOD_5 (78.2%) and TKN (68.7%). The concentration of NH_3–N dropped from 1,966 to 146.7 mg L^{-1}. However, NO_2–N and NO_3–N (Fig. 3) increased during the treatment process, which might be related to the nitrification process, since no chemical additives were used during the treatment process [1]. The results indicated that the level of organic degradation was accelerated when nitrite and nitrate, were present in the solution. In other words, the presence of nitrite and nitrate in the reactors increases the biodegradation of organic matter [1]. In addition, the same reactor

Table 2
Comparison between the performances of CASR and CASBF

		Removal (%) (day)				
		CASBF		CASR		
Parameters	*N*	Removals efficiency (%)	Concentrations (mg/L)	Removals efficiency (%)	Concentrations (mg/L)	*P*-value*
COD, mg/L	3	84.5% (9th day)	307.00	49.9% (13th day)	985.96	0.072
BOD, mg/L	3	89.9% (9th day)	25.95	79.2% (10th day)	53.45	0.557
TKN, mg/L	3	31.94% (12th day)	1,172.54	65.9 (9th day)	587.13	0
NH_4–N, mg/L	3	53.2% (9th day)	891.07	93.1% (9th day)	131.37	0.001
Nitrite, mg/L	3	52.4% (3rd day)	21.65	20.7% (3rd day)	36.08	0.008
Nitrate, mg/L	3	87.77% (4th day)	18.78	52.9% (3th day)	71.92	0.017
Phosphate, mg/L	3	62.2% (5th day)	18.40	47.6% (7th day)	25.51	0.008
Colour, pt-co	3	23.8% (11th day)	3,182.72	33.6% (11th day)	2,773.39	0.51
TSS, mg/L	3	2.9% (5th day)	445.39	–10.9% (5th day)	508.69	0
VSS, mg/L	3	3.9% (5th day)	349.80	–8.9% (5th day)	396.39	0

N: number of samples
* Significant



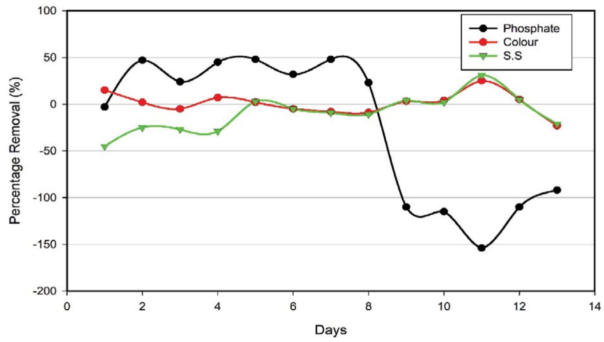


Fig. 2. The efficiency of CASR for pollution parameters selected in this study.

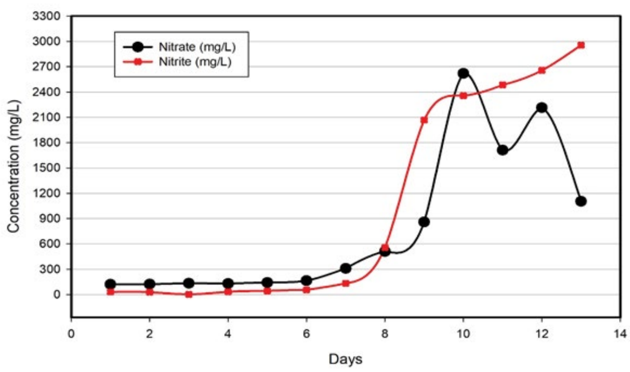


Fig. 3. Concentration of NO_2–N and NO_3–N.

have the possibility to achieve nitrification, denitrification and can also compromise phosphorus removal in a single reactor [1,2]. The concentrations of NO_2^{-1} raised from 45 to 2,875.3 mg L^{-1} on the other side the concentrations of NO_3^{-1} raised from 1.99 to 2,001 mg L^{-1}.

These findings are in agreement with that reported by Rosso et al. [16]. However, CASR was not provided anaerobic condition, hence the NO_2^- and NO_3^- decreased in considerably which might be related to the nitrification, denitrification process that achieves NO_2^- and NO_3^- removal in a single reactor. In the anaerobic zone the concentration of NO_2^- will be increased due to the air pump was not cut off after the concentration of NO_2^- and NO_3^- was reduced, finally resulting in increased concentration of NO_2^- and NO_3^- in the aerobic zone [16]. The removals efficiency was 52.1% COD and 78.2%

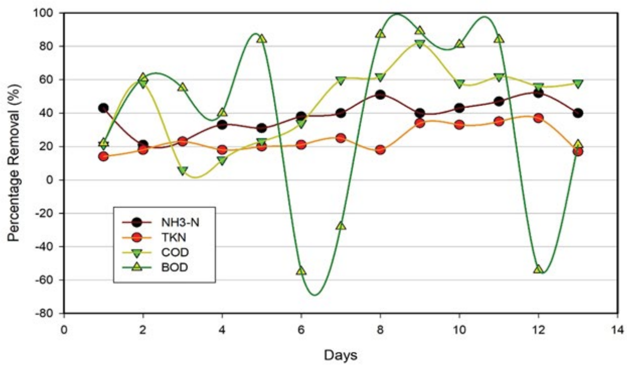


Fig. 4. The percentage removal of for pollution parameters selected in this study using CASBF.

BOD_5. On the other hand, BOD_5 concentrations reduced from 247.3 to 49.89 mg L^{-1} (on the 10th day). In contrast, the concentrations of COD decreased by approximately 2,200 mg L^{-1} in comparison with 1,046.7 mg L^{-1} (on 12th day). The bad removal efficiency of COD might be attributed to the presence of a refractory compound in the system [1,4,7]. In contrast, a result revealed that PO_4^{3-} was reduced by an approximately 49.86 mg L^{-1} in comparison with 30.01 mg L^{-1} (on 6th day). However, it has raised by approximately 134.7 mg L^{-1} (on the 10th day). According to the process called enhanced biological phosphorus removal, the aerobic bacteria during phosphorus removing were enriched in an anaerobic-anoxic or anaerobic-aerobic condition which happed during biological treatment to dissolve orthophosphate. However, if the aeration was prolonged the nitrification was carried out and result in decreased concentration of phosphorus in the aerobic zone. This phenomenon resulted in the incremental amount of the nitrate within the anaerobic zone, finally leading to phosphates enhanced within the aerobic zone [17]. The removal of color from raw high-strength sanitary landfill leachate was 31.6%, which indicate to the ability of humic substances to be resistant in the biological stage [7] and acted as non-degradation and/or refractory substances entering [18].

3.3. CASBF reactor performance

The individual removal efficiencies for BOD_5 and COD dropped significantly in contrary removal efficiencies for TKN and NH_3–N was not significantly dropped for raw high-strength sanitary landfill leachate using CASBF under 2–5 mg/L DO, the temperature of (20°C–25°C), pH 7 ± 1 is presented in (Fig. 4). In this context the maximum removal was recorded for BOD_5 (90.7%) on day 9, followed by COD (82.6%) on the 9th day. In contrast, the minimum removal was recorded for TKN (36.4%) and NH_3–N (53.2%). The high removal of BOD_5 indicated that organic matter oxidized by microorganisms loaded on the bio-fringe material. The COD removal in CASBF is more than 80% (it reduced from 2,185 to 401 mg L^{-1}). However, as a result of a presence of non-biodegradable organic matter in sanitary landfill young leachate as well as low BOD_5/COD ratio the performance was not satisfactory [17]. The NH_3–N removal was 53.2%, while it was 36.4% for TKN. The low removal of both parameters might be related to the increase of nutrient concentrations in the reactor which might inhibit the usage of NH_3–N and TKN by the microorganisms. Moreover, the anaerobic bioconversion of proteins in the landfill waste transport amino acid to ammonia [13,19]. Nevertheless, high evidence for nitrification occurred because of two-zone aerobic and anaerobic inside bio-fringe (BF) sponge (double zones within BF sponge the anaerobic inside the sludge and aerobic near the surface). Some researchers demonstrated that nitrification–denitrification processes occurred in a good condition in one single reactor when the intermittent aeration process was conformed to the system [20] which have been found to agree with the experimental results obtained with Chan et al. [17] who achieved BOD_5 ranging between 97% to 99%, COD removal ranging between 60% to 80%, and ammonium removal ranging between 60% to 80% in biological treatment. The PO_4^{3-} removal was 63.2% recorded on the 5th day of the treatment process (Fig. 5). The concentration was decreased by approximately 51.06 mg L^{-1} in comparison with 19.1 mg L^{-1}. Anaerobic and aerobic conditions because of the two-zone aerobic and anaerobic inside bio-fringe (inside the same system) were chemical reactions requirement occurring, to dissolve orthophosphate throughout the system of biological treatment [17,21].

The color during this process of raw high-strength sanitary landfill leachate was not stable, and it ranged between 3,012 to 4,567.7 pt-co. 21.8% was the highest removal which indicated poor decomposition of organic content acting for sanitary landfill leachate [18]. The concentration of NO_2^{-1}, as well as NO_3^{-1} in the raw high-strength sanitary landfill leachate during the treatment process using CASBF, are presented in Fig. 6. NO_2^{-1} was produced under oxic (containing DO > 0.8 mg O_2 L^{-1}) conditions and when containing DO < 0.8 mg O_2 L^{-1} (anoxic conditions) in this condition was continuously converted to nitric oxides (i.e. nitrogen gas). It was caused by NO_3^{-1} through biological reaction. A concentration of NO_2^{-1} was increased from 39.16 to 186.34 mg L^{-1}, while NO_3^{-1} concentration was also increased from 6.21 to 78.2 mg L^{-1} due to the aeration was not stopped then the nitrates element concentration increased in the anoxic zone (anaerobic), finally resulting in raised of NO_2^{-1} and NO_3^{-1} concentration in the aerobic zone [16].

3.4. Comparison performance of two treatment systems

The *P*-value of COD removal was 0.072 (>0.05), which statistical indicating a factor was not satisfactory because of the inefficiency of the biological treatment system to treat old leachates [22]. Further, the *P*-value of BOD was 0.557 (>0.05), implying that the factor was not significant. The *P*-value of NO_2^{-1} was 0.009 which less than 0.05 for two experiments comparison, which demonstrated that the CASBF system for NO_2^{-1} removal was satisfactory. Like findings were recorded regarding NO_3^{-1} (P = 0.021). Towards the CASR, NO_3^{-1} was raised because of the decreasing of NH_3–N and PO_4^{3-}, as well as the absence of anaerobic conditions [4]. The *P*-value of PO_4^{3-} in the comparison between CASBF and CASR was 0.008 (<0.05) which demonstrated that the swim-bed BF system for NO_3^{-1} removal was satisfactory. The CASBF showed positive removal while the CASR system had a negative removal percentage. PO_4^{3-} required both aerobic and anaerobic conditions for chemical reactions during biological treatment, to dissolve orthophosphate. The removal percentage of CASBF was higher than that of CASR, as both an aerobic and aerobic processes were involved in CASBF while CASR had only aerobic treatment. According to Amor et al. [18], both systems (anaerobic and aerobic) was proposed to simultaneously reduction of nitrogen compound as well as organic matter.

3.5. Biomass build up in CASBF treatment systems

Following the concept of an biofilm reactor, biomass was one of the main components that are expected to accumulate on the support media. Biomass on BF could be estimated in terms of weight. Fig. 7 shows the estimated amount of biomass attached to the BF in days of the experiment. A high amount of 512.7 g of biomass was accumulated on the bio-fringe fibers on day 9 with. Based on successful biomass build upon the BF, it can be concluded that BF is capable of providing a suitable environment for the growth of biomass which represents microorganisms that are responsible for pollutants removal from wastewater.

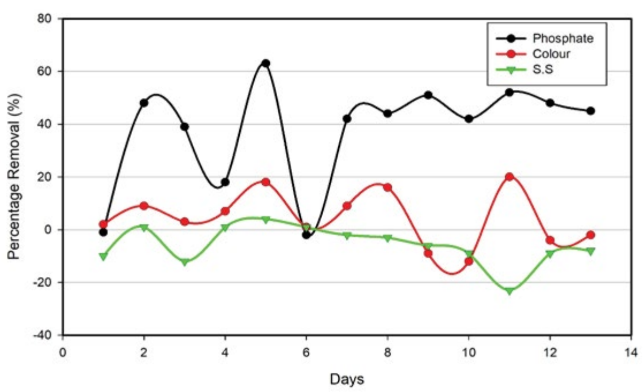


Fig. 5. Removal of PO_4^{3-}, color, and SS using CASBF.

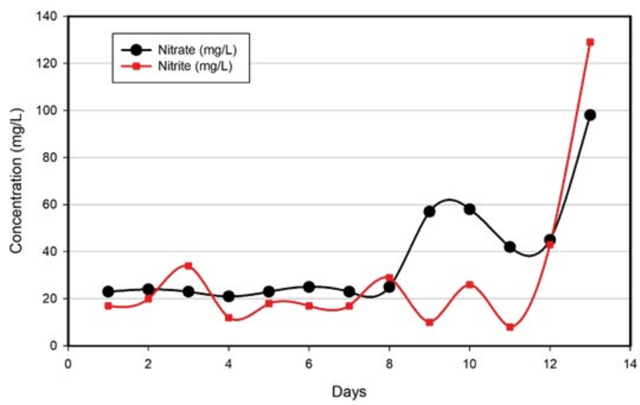


Fig. 6. The concentration of NO_2–N and NO_3–N using CASBF.

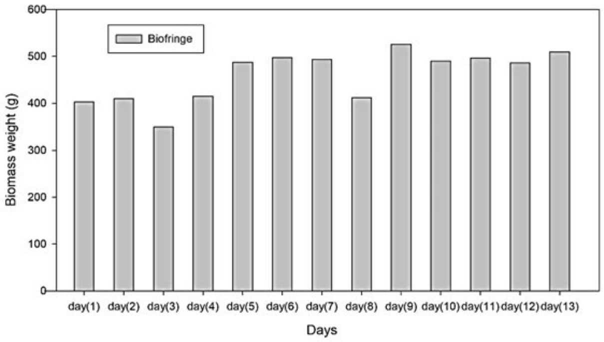


Fig. 7. Amount of biomass attached to the BF in CASBF.

4. Conclusion

The CASBF reactor showed better performance for NO_2^-, NO_3^- and PO_4^{3-} removal efficiency because of two phases inside the same system (aerobic and anaerobic). In order to enhance the removal efficiency (treatment process) through contact time extending with active microorganism in the system. This phenomenon used the attached growth concept and designed to minimize the effects of suspended growth processes. Also, these mechanisms show lower sensitivity to a condition exceeding regulatory limits (adverse environmental conditions). However, CASBF was unable to improve the conventional treatment plant in terms of COD, BOD_5 and NH_4–N removals for leachate treatment. The biological treatment application alone was not an effective option because of the complex nature characteristics of leachate but can use for moderate leachate (BOD/COD around 0.1), although anaerobic and aerobic processes have proved to be quite effective for young leachate treatment.

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