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Production of nutrients for non-edible plants using an anaerobic baffled horizontal wetland system

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Abstract

Typically, domestic wastewater has been collected and treated at a centralised treatment plant. Limitations and problem are progressively arising for centralised approaches. The construction and operation of centralised wastewater collection and treatment systems are expensive, particularly in areas where the population densities are low and the households are dispersed. On the other hand, growing attention is given to the decentralised system for wastewater treatment which implements a combination of onsite and/or cluster systems. This research focused on designing the anaerobic baffled horizontal wetland system and the feasibility of the system in producing nutrients for non-edible plants. The nutrients measured were ammonia, chemical oxygen demand (COD) and phosphorus. The design of the reactor is the integration of anaerobic baffled reactor, anaerobic filter and horizontal constructed wetland system with *Allamanda Cathartica* as the ornamental plants. Two similar reactors, known as Reactor A and Reactor B are constructed and evaluated for different scenarios respectively. Reactor A received wastewater influent directly from the oil and grease tank in the sewage treatment plant of Universiti Teknologi PETRONAS, while reactor B received wastewater effluent from a septic tank, which pre-treats the wastewater influent from the oil and grease tank. Both of the reactors are operated at flow rate of 225L/day. The effluents were collected from the anaerobic zones of both of the reactors via sampling points and tested to determine the amount nutrients produced. For reactor A, ammonia, COD and phosphorus has increased by 240%, 105% and 65% respectively; for reactor B, ammonia, COD and phosphorus has increased by 156%, 149% and 157% respectively. Reactor B displayed a higher production of

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nutrients. These results have shown that the reactors have the potential of producing nutrients for the plants.

Keywords: decentralised system, anaerobic baffled wetland system, ammonia, COD, phosphorus.

1 Introduction

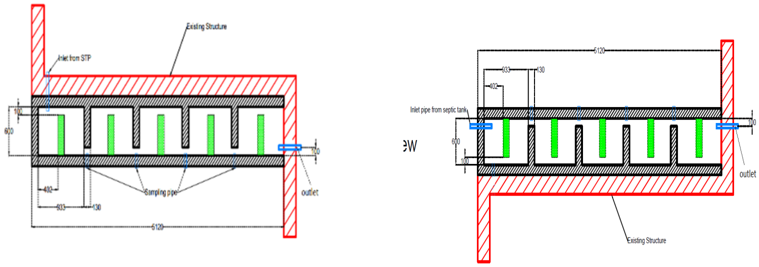
Conventionally, wastewater has been collected in comparatively large sewers and transported great distances to a centralised treatment plant. This requires capital investment for infrastructure, operation and maintenance requirements. Limited local budgets, shortage of local expertise and funding are the main factors for ineffective performance of wastewater treatment plants in developing countries [1]. Partially treated wastewater in developing countries would then be discharged into water bodies [2]. Unsanitary disposal of excreta, 1.8 million people die from diarrheal diseases annually [3]. In centralised systems, wastewater for the entire communities are collected and treated. Hence, large pipes, major excavations and manholes for access are required [1]. The construction of a centralised treatment system for small rural communities and peri-urban areas in poor countries will give rise to burden of debts for the general public [1, 4]. In fact, the collection process in a centralised system itself expends more than 60% of the total cost for wastewater management, especially in small communities that have low population densities [1]. Even though centralized facilities for wastewater have served society well, re-evaluation and re-engineering of conventional system for wastewater collection and treatment are needed in order to develop cheaper and more sustainable approaches for wastewater treatment [5]. Establishment of decentralised systems for areas with low population densities and integration of innovative decentralised treatment into the centralised wastewater treatment system may possibly play a part in the provision of a relatively cheap and sustainable solution to manage the wastewater problem [6]. Decentralised wastewater treatment system is applied to treat comparatively smaller volumes of wastewater, originating from individual or groups of houses and businesses that are situated nearby to each other [7]. Decentralised systems minimise the collection component of the wastewater management system and emphasis mostly on essential treatment and disposal of wastewater. Although sustainable development comprises an extensive range of criteria such as environmental, socio-cultural and technical factors, economics is the most significant gauge in decision making for most developing countries [1]. Therefore, a decentralised wastewater treatment system should be developed for the developing countries and to be integrated into the centralised wastewater treatment system of urban in order to lessen environmental and public health effects.

2 Experimental procedure

2.1 Reactor configuration

The design of the reactor is an integration of anaerobic baffled reactor, anaerobic filter and horizontal constructed wetland system. Two similar reactors, known as

Reactor A and Reactor B (as shown in Figure 1) were constructed and tested for different scenarios, respectively. Reactor A received wastewater influent directly from the oil and grease tank in the sewage treatment plant (STP) of Universiti Teknologi PETRONAS, while reactor B received wastewater effluent from a septic tank, which pre-treats the wastewater influent from the oil and grease tank. The system was designed for the wastewater treatment of one household (5 people per household). Baffles installed channel the wastewater flow throughout the reactor, as applied in anaerobic baffled reactor.



(a) Reactor A (b) Reactor B

Figure 1: Plan view of reactor A and B.

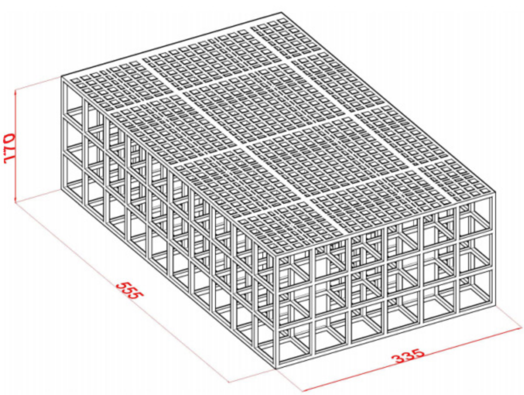


Figure 2: Schematic of anaerobic filter hive.

An anaerobic filter hive was constructed and placed in between the baffles, (Figure 2), which act as a medium to hold the biomass. In addition, the plastic hives also work to prevent short circuit of the wastewater by directing the wastewater to flow through the plastic hives. Biomass, the anaerobic sludge from the bottom of the clarifier was placed in the hive.

Then, a layer of soil, approximately 10–15 cm is placed on top of the plastic hives. Allamanda Cathartica, commonly known as Yellow Bell was then planted in the soil. Allamanda Cathartica is a shrub that is used in traditional medicine for treating jaundice and malaria [8]. The usage of plants to treat the wastewater and the horizontal flow of wastewater beneath the soil layer throughout the reactor originated from the horizontal subsurface flow constructed wetland.

2.2 Production of ammonia, chemical oxygen demand (COD) and phosphorus

Effluents were collected from at various sampling points throughout both of reactors every two days. The samples were tested to determine the amount nutrients produced specifically ammonia, COD and phosphorus. Tests were carried out according to EPA Standard Methods. The sampling and testing were carried out until steady state was achieved. The initial flow rate of both the reactors was set at 225L/day [9].

3 Results and discussions

3.1 Production of ammonia

Figure 3 shows the production of ammonia for reactor A. The average influent concentration is 10 mg/L, whereas the average effluent concentration is 34 mg/L. This average effluent ammonia concentration can be seen to increase along the reactor. Hence, the ammonia concentration in reactor A has increased about 240%. The increase in ammonia was due to the anaerobic digestion of substrates [10].

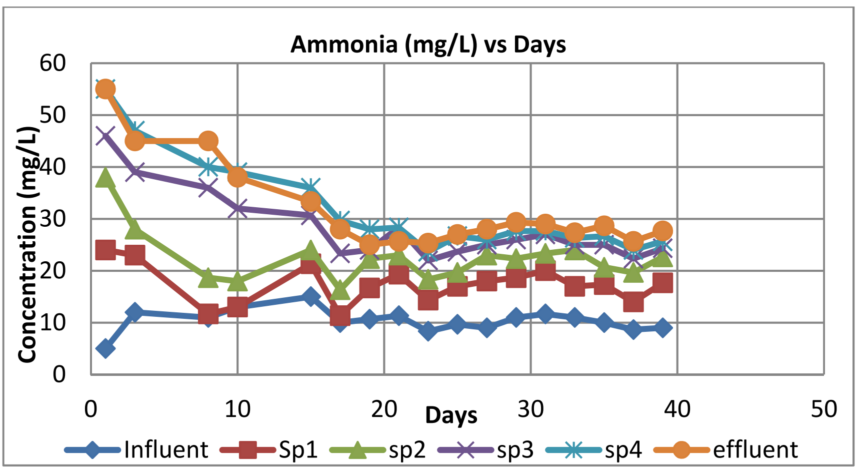


Figure 3: Ammonia concentration in reactor A.

Figure 4 depicts the production of ammonia for reactor B. The average ammonia concentration in the influent is similar to that of reactor A, which is approximately 9 mg/L. The average ammonia effluent concentration was found to be 23 mg/L. The increment observed is around 156%, which is lesser than reactor A. This may be due to the sewage was pre-treated using a septic tank. Therefore, there is less substrate in the wastewater compared to reactor A, which results in a lower ammonia production.

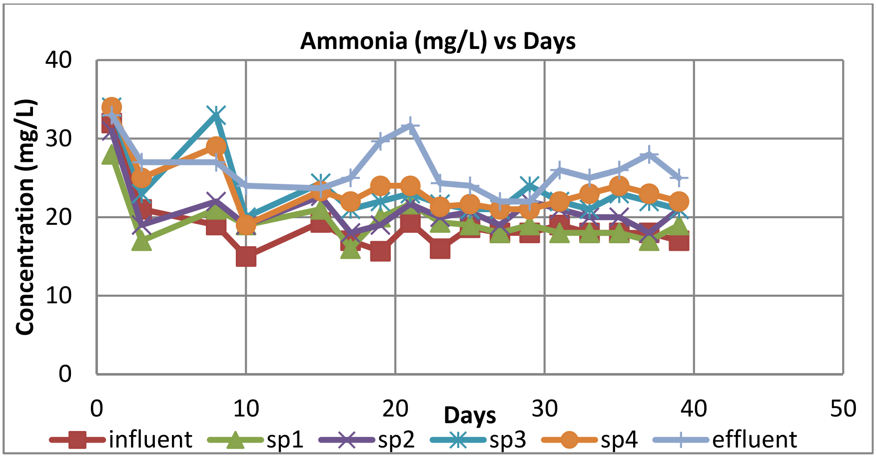


Figure 4: Ammonia concentration in reactor.

3.2 Production of COD

The production of COD for reactor A is displayed in Figure 5. The average influent concentration is 39 mg/L; the average effluent concentration is 80 mg/L. An increment of 105% was observed. The COD is produced from the anaerobic degradation of the biomass in the anaerobic chamber. Ammonia is also produced in the anaerobic degradation.

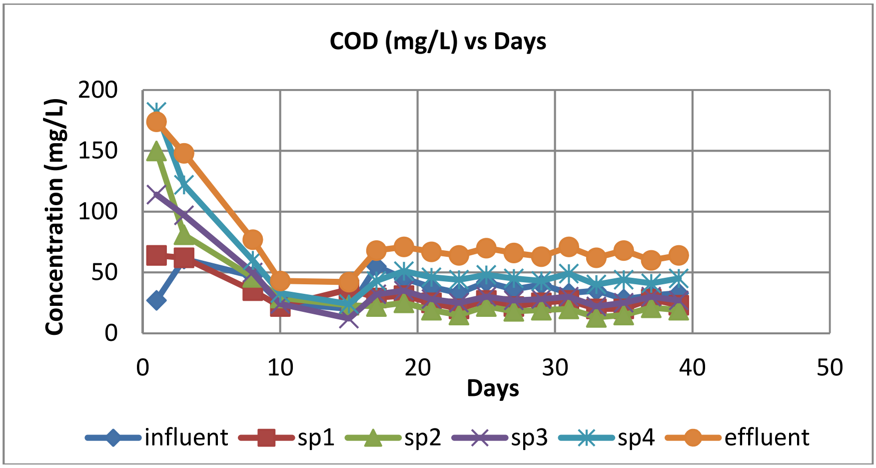


Figure 5: COD concentration in reactor.

The concentration of COD in reactor B is shown in Figure 6. The average influent concentration is 45 mg/L and the average effluent concentration is 112 mg/L. Hence, an increment of 149% was obtained. The increment was found to be greater than average effluent COD concentration from reactor A.

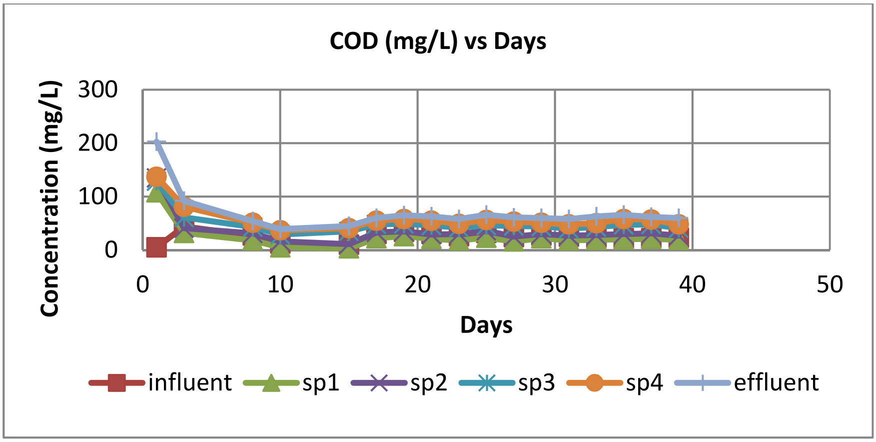


Figure 6: COD concentration in reactor B.

3.3 Production of phosphorus

Figure 7 depicts the phosphorus concentration for reactor A. For the influent, the average concentration is 17 mg/L. For the effluent, the average concentration is 28 mg/L. Therefore, the increment is about 65%. The phosphorus concentration in

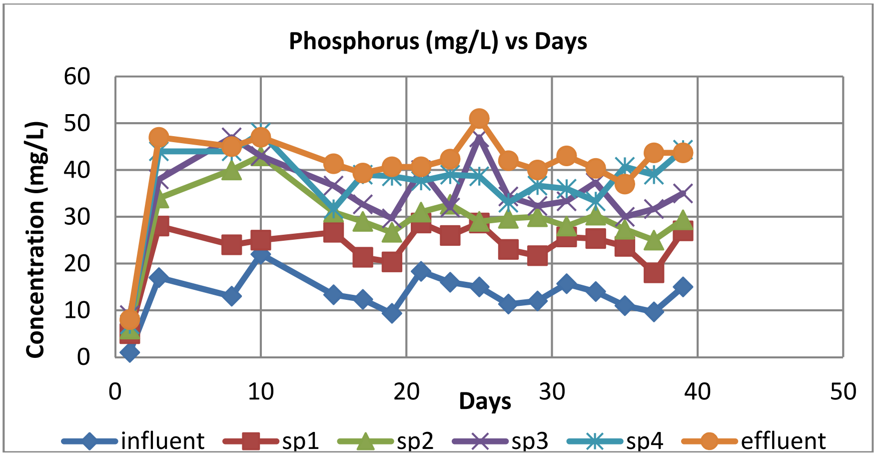


Figure 7: Phosphorus concentration in reactor A.

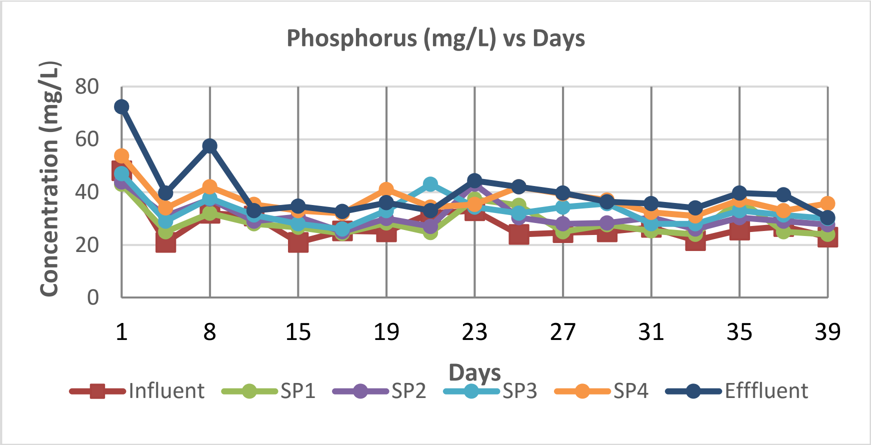


Figure 8: Phosphorus concentration in reactor B.

reactor B is presented in Figure 8. The average influent concentration is 20 mg/L; the average effluent concentration is 51 mg/L. The increment is 157%. Reactor B has higher increment compared to reactor A.

4 Conclusion

Anaerobic Baffled Horizontal Wetland System focused on the feasibility of the system in producing nutrients for non-edible plants. The average removal efficiency for reactor A, the concentration of ammonia, COD and phosphorus has increased by 240%, 105% and 65%, respectively. Whereas, for reactor B, ammonia, COD and phosphorus has increased by 156%, 149% and 157%, respectively. Reactor B displayed a higher production of nutrients. These results have shown that the reactors have the potential of producing nutrients for the plants.

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