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Landfill Leachate Treatment by Using Two Stage Anaerobic Aerobic Systems

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Abstract: In Sri Lanka, the Municipal Solid Waste is disposed in to sanitary landfills or dumping sites. The generated leachate at dumping sites causes many problems leading to various social, cultural, environmental impacts. Hence, it is decided to conduct this research to find out suitable solution for proper treatment for the leachate generated at waste disposal sites. In this research, two stage biological treatment processes were used to treat the leachate. At first stage up flow anaerobic sludge blanket (UASB) is used. The important of the UASB is it removes high amount of BOD_5 and COD in efficiently. However the UASB process is not capable for removing fair amount of nutrients. To overcome this problem an aerobic system sequence batch reactor (SBR) was used after the UASB. The specific task of this introducing this SBR system is to study the capabilities of removing nitrogen in leachate treatment. In the total system, the BOD_5 removal efficiency is around 92% and COD removal efficiency is reached to 54%. Therefore this system can be used as secondary treatment system, to treat leachate.

Keywords: Municipal Solid Waste, Leachate, Biological treatment processes, UASB, SBR, Nitrogen removal

1. INTRODUCTION

Along with the rapid growth of human population and their needs, the solid waste generation has increased dramatically all over the world. Hence, solid waste management is an inevitable term of sustainable development. “Landfill” is one of the most widely used, viable and economical method of solid waste management in the modern world.
When the degenerating waste of those solids in the landfills contact with moisture it generates a liquid called leachate, This is a serious environmental problem, which environmental mangers and engineers face today, because this leachate contains a substantial, amount of organic and inorganic substances and has the potential to pollute ground and surface water. Therefore, this leachate should be treated. Various methods have been used for leachate treatment. The biological method is a widespread method, which is adopted in many countries all over the world. The biological treatment method includes anaerobic process, anoxic process and aerobic process. At present pre-treatments such as mechanical or chemical-mechanical methods are used before these biological methods. Anyhow this kind of biological systems were not studied much for landfill leachate treatment. This system generally consists of an anaerobic system which can resist high loading capacity as the first stage of the combined system, followed by a low loaded aerobic bioreactor. In both systems activated sludge treatment process is used. In this research, this system was used to study the performance of two stages UASB (Upflow Anaerobic Sludge blanket)-SBR (Sequencing Batch Reactor) for landfill leachate treatment.

2. LITERATURE REVIEW

The municipal solid wastes is treated and disposed in different ways. Landfill is the most popular and widespread method in the modern era 1[4]. The types of landfills can be classified in different perspectives. However, in general it is not only limited to one perspective. A combination of requirements and criteria can be used in practical [4].

Landfill leachate is a liquid which is mainly produced by the physical mixing of garbage and chemical reactions with rain water which, falls on the landfill and infiltrates into the garbage [4]. The leachate usually contains larger number of pollutants and it can be divided into four groups. They are (a) Dissolved organic matter, (b) Inorganic macro components, (c) Heavy metals, (d) Xenobiotic organic compounds (XOCs) [3]. Landfill leachates can also be classified according to the landfill age. The three types are young leachate, intermediate leachate and stabilized leachate.

To treat this leachate biological system can be used due to its reliability, simplicity and high cost effectiveness. In biological treatment, there are different mechanisms such as aerobic treatment, anoxic treatment, anaerobic treatments and natural systems [1]. Microorganisms are the primary agent of this type of treatment.

Anaerobic bio treatment process is used primarily for the treatment of waste sludge and high strength organic waste. This process is advantageous because of the lower biomass yield. Furthermore energy can be recovered in the form of methane, from the biological conversion of organic substrates [2]. Up flow anaerobic sludge blanket reactor is a popular anaerobic reactor for both high and low temperature. This is a single tank process in an anaerobic bio treatment system achieving high removal of organic pollutants. Wastewater enters the reactor from the bottom, and flows upward. A suspended sludge blanket filters and treats the wastewater as the wastewater flows through it. Bacteria living in the sludge break down organic matter by anaerobic digestion, transforming it into biogas. Solids are also retained by a filtration effect of the blanket. The up flow regime and the motion of the gas bubbles allow mixing without mechanical assistance [6].

In the aerobic treatment process, the conversion of organic matter is carried out by mixed bacterial cultures in general accordance with the stoichiometry with the presence of oxygen. The SBR is one of an aerobic system which, complete mix activated sludge process is happened [2].The conventional SBR contains four steps: filling, reacting, settling and idling without a secondary clarifier.

To get the maximum performance of the biological systems, coupling can be done. In this research biological system coupling of UASB and SBR was established to treat landfill leachate in order to enhance organic and nitrogen removal. Combining anaerobic and aerobic biological treatments is effective and efficient because it can produce good quality effluent. Moreover, these systems are cost effective, simple and do not cause pollution. Therefore a biological approach that combines anaerobic and aerobic systems have been recommended as a feasible method for removing organic and nitrogen from landfill leachate [5].

3. Methodology and implementation

3.1. Experimental setup

An integrated treatment system was operated. The treatment train consists of a UASB followed by an equalization tank and then an SBR as shown in Figure 1.

The UASB has a working volume of 8.2*l* and HRT is 8hrs. The SBR had an effective volume of 10*l*. An equalization tank was designed to adjust the conflict between continuous effluent in the UASB and intermittent influent in the SBR.

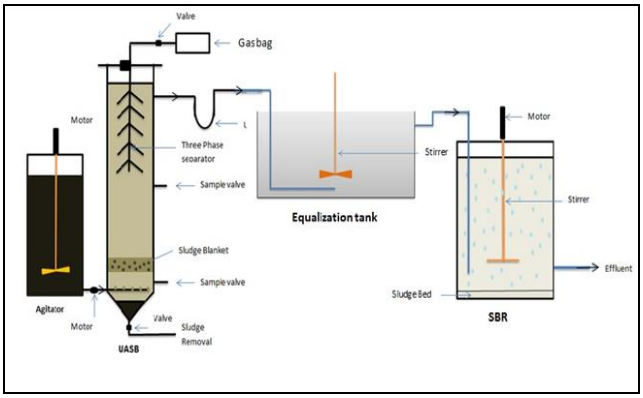

Figure1: Schematic diagram of the UASB-SBR biological system

3.2. Operating conditions

The system was run more than 4 months; this included the start-up of the system. The UASB was seeded with anaerobic sludge from UASB digester in the ice cream factory treatment plant (Ceylon Cold Stores Pvt Ltd plant at Ranala). The aerobic sludge was seeded to the SBR from the wastewater treatment plant at Temple of Tooth Relic. For the accumulation of the sludge the reactors were run with synthetic wastewater. After that, synthetic leachate was introduced to the system for 10 weeks. There onwards the UASB was operated with the avg. organic loading rate of (OLR) 84kg.COD/m^3.day. The SBR was fed with the UASB effluent, and it was operated under alternating aerobic and anoxic conditions. The cycle of the SBR consisted of 10-min filling, 90-min aerobic I, 205-min anoxic I, 60-min aerobic II, 150-min anoxic II, 120-min settling and 10-min decanting and idling period.

3.3. Sampling and analytical methods

The performance of the treatment system was evaluated by monitoring the quality of the influent and the effluent of each treatment unit. The physico-chemical analysis covered: pH, temperature. NH_4^+-N, NO_3^- -N, COD, BOD_5, TN.

For the UASB the MLVSS and gas yield was measured additionally. Inside the SBR, pH, temperature. NH_4^+-N, NO_3^- -N, COD, BOD_5, TN parameters were evaluated in each phase and the MLVSS also measured.

4. RESULTS AND ANALYSIS

4.1 BOD_5 removal of the UASB-SBR system

Figure 2 shows the system performance related to the BOD5 removal throughout the 10 weeks. In the system, the organic matter removal was around 92% which was in the expected efficiency range. The effluent BOD5 level of the system was below 30mg/l. These results have proven that, the combined system can be used to remove organic matter efficiently instead of using these two apparatus separately.

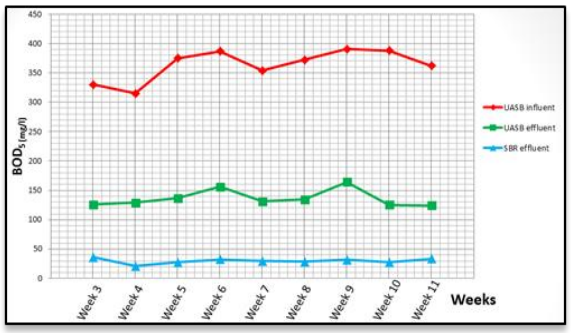

Figure 2: BOD_5 variation of the System

4.1 COD removal of the UASB-SBR system

The COD removal was measured during the experiment period. The figure 3 shows the variation of COD removal during the study period.

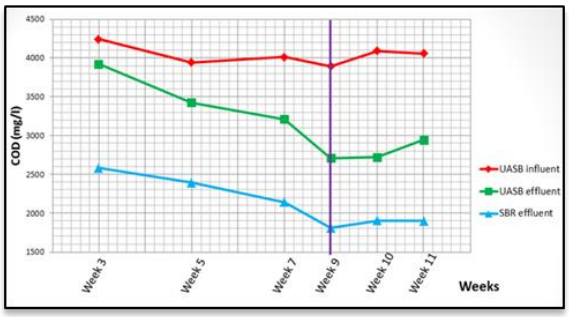

Figure 3: COD variation of the System

The COD removal efficiencies of the UASB, SBR and system were shown in Fig.4. And from the first week onwards, the COD was maintained around 4000 mg/l in the UASB influent. In the UASB, COD removal efficiency was not stabilized during the experimented period. In first eight weeks the gradual increment of removal efficiency was observed. Anyhow after fist six weeks, the increment gradient was slight. From the beginning, the SBR shows acceptable removal of the COD.

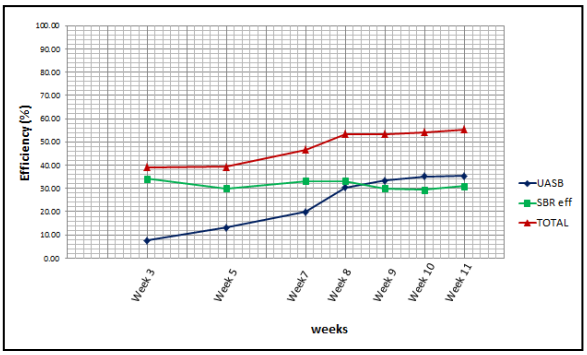

Fig.4. COD removal efficiencies of the UASB-SBR and the system

4.1 TN removal of the UASB-SBR system

The total nitrogen shows overall reduction in the effluent from the beginning in UASB and SBR effluents. The reason for the drastic drop of total nitrogen content at the influent from the seventh week in the UASB influent was the change of nitrogen source of the synthetic leachate. The total nitrogen removal was shown in figure 5. and it is clear that organic nitrogen was very high at the initial synthetic leachate composition which was not a significant feature of real landfill leachate. After the introduction of NH4Cl, the total nitrogen content was dropped but the NH3-N amount was almost equal with the previous leachate.

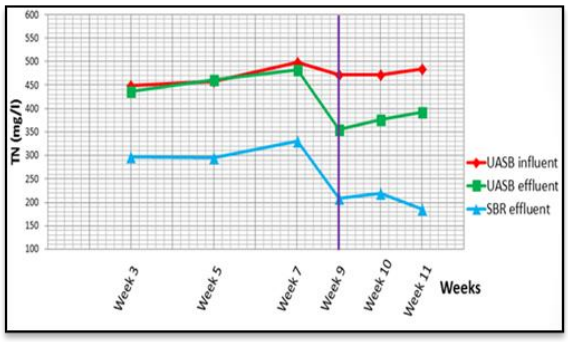

Figure 5: TN variation of the system

5. CONCLUSION

In this study, synthetic leachate was treated by using anaerobic and aerobic coupled system in laboratory scale model under tropical conditions in Sri Lanka for 10 weeks. BOD5/COD ratio of the synthetic leachate was between 0.09~0.14 throughout the study and this leachate had medium to low biodegradability. It was observed that the

combined system's organic matter removal efficiency was about 92%. Effluent BOD5 was below 30mg/l, which satisfy the standard to discharge into the inland surface water bodies. The organic matter removal was significant with this combined system. Considering all of these aspects, it is concluded that, the combined system was effective for treatment of leachate under tropical conditions.

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