Asian Journal of Water, Environment and Pollution, Vol. 5, No. 2, pp. 97-101.

Research Note

Combined Treatment of Landfill Leachate and Domestic Wastewater in Submerged Aerobic Fixed Film (SAFF) Reactor

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Received March 3, 2006; revised and accepted June 28, 2007

Abstract: A number of methods have been employed for the treatment of landfill leachate. In the present study attempts have been made to treat landfill leachate in a sewage treatment plant so that existing sewage treatment plants can be utilized for leachate treatment. A submerged aerobic fixed film reactor was employed for the study. The reactor consists of two compartments: the top one containing PVC media for the growth of biomass while the lower portion contains microorganisms under suspension. Diffused aeration was provided in the lower portion. The reactor was seeded with the digested sewage sludge obtained from Okhla sewage treatment plant, Delhi. A constant HRT of 24 hours was maintained throughout the reactor. Initially the reactor was fed with sewage and was operated for 30 days till steady state conditions were achieved, the COD removal efficiency being 90%. Thereafter leachate was introduced with the sewage at dilutions of 3%, 5% and 8%. With the addition of 3% leachate the COD removal efficiency decreased to 75%. Further leachate addition at 5% dilution shows a decrease in COD removal efficiency to an average of 67% and finally a higher dilution of 8% shows a COD removal efficiency of 49%. During the entire study the suspended solids removal was 100 %. The BOD removal efficiency was almost similar to that of COD removal efficiency.

Key words: Landfill, leachate, sewage, aerobic treatment, submerged aerobic fixed film (SAFF) reactor.

Introduction

The quantity of solid waste generation in New Delhi has been consistently rising over the years as a result of sharp increase in population, migration of people from rural to urban area and changed lifestyle of people. Landfill has been the least cost disposal option of solid waste. However, as water percolates through the solid waste in a landfill it dissolves inorganic and organic constituents and decomposition products thereby producing a potentially polluting liquid – Leachate. The main drawback with leachate treatment is that leachate changes in terms of strength, biodegradability, toxicity as the waste in the landfill ages with time. Leachate can be treated by a number of processes. However, high COD/BOD ratio and presence of toxic chemicals such as heavy metals present difficulties in biological treatment of landfill leachate (Zhao, 1999; Tchobanglous et al., 1993). The factors affecting leachate generations are climate, site topography, the final landfill cover material, the vegetative cover, site phasing and operation procedures, and type of waste material in the fill (O'Leary and Walsh, 1991).

Leachate contains a significant quantity of refractory organic matter that is not possible to biologically degrade by conventional methods. Traditional methods used include stabilization ponds, the activated sludge method, upper anaerobic sludge beds, sequencing biological

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reactors, land treatment etc. and their combinations (Zhao, 1999; Pohland, 1980; Ragle et al., 1995; Henry and Prasad, 2000). Furthermore, additional effluent processing was done using physico-chemical treatment e.g. coagulation-flocculation, adsorption, chemical or electro oxidation etc. (Marttinnen et al., 2001). Biological methods used for leachate treatment are mostly aerobic, anaerobic and anoxic processes, which are usually used in combination (Im et al., 2001). A combination of physico-chemical and biological methods has been used for leachate treatment. Pretreatment of leachate with ozone before biological treatment has also been practiced (Greenes et al., 2001). Park et al. have practiced combination of anaerobic, aerobic and rotating biological contractor (RBC) systems and approximately 98% of the organic material was removed when effluent of RBC was subjected to flocculation, adsorption and reverse osmosis. Co-treatment of landfill leachate with domestic wastewater is among the most important technique for leachate treatment. Some researchers have studied on a laboratory as well as pilot scale with emphasis on COD and nitrogen removal in different leachate/sewage ratios (Chang et al., 1995; Atkas and Cecan, 2001; Cecan and Atkas, 2001). However it was difficult to give general rules for an acceptable leachate proportion because each leachate and sewage has its own characteristics. Also different leachate discharge systems are employed at landfills as well as different treatment processes at the receiving wastewater treatment plant.

The present study was undertaken to assess the feasibility of submerged aerobic fixed film (SAFF) reactor for the co-treatment of leachate, with sewage, without any pretreatment. Different leachate/sewage ratios were tried.

Material and Methods

Leachate

The leachate was collected from Ghazipur landfill, one of the three existing landfills of the National Capital Territory of Delhi, India. The leachate was analyzed in the laboratory. Table 1 gives the characteristics of the leachate.

Experimental Set-up

The submerged aerobic fixed film (SAFF) reactor, shown in Figure 1, was used for the present study. The reactor consists of two identical compartments, in series, each containing the PVC media for the support of the biofilm. The lower portion of the reactor contains microorganisms under suspension and it acts as a suspended growth system. Diffused aeration is provided in the lower portion of the reactor. The reactor, thus, enjoys the advantages of both attached as well as suspended growth aerobic systems. The leachate, in dilution with sewage, was made to flow downward into the first compartment and then entered the second through baffle openings at the base of the reactor. Thus, the first compartment acts as a down-flow reactor whereas the second one as an upflow one. Two compartments are used in the reactor to increase the contact time of the wastewater with the biofilm. The reactor was seeded with aerobic sludge from the Okhla sewage treatment plant at New Delhi. During the course of the study the biofilm grew on the PVC media. The total volume of the reactor was 27.00 litre, the volume of each compartment being 13.5 litre. The media had 5 cm submergence. The media was supplied by M.M. Aqua Tech. Ltd. (India). FB 10.19 was selected for this study;

Table 1: Characterisitics of leachate

Parameter	*Concentration*
pH	8.1
TSS	1160
TDS	21,280
Hardness	3150
Alkalinity	3150
Chlorides	18447
Sulphates	1080
Lead	0.1
Copper	0.1
Arsenic	0.2
Chromium	0.1
Cadmium	0.05
Zinc	0.85
COD	9600
BOD	6720
MPN/100 ml	16800

*All values are in mg/l except pH and MPN.

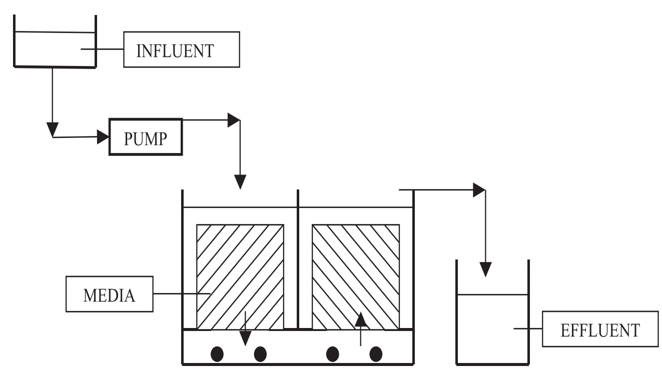

Figure 1: Experimental set up used in the study.

the media has openings of 19 mm. Technical data of the media is as given below:

(a) Material : PVC
(b) Void %age : more than 92% (20)
(c) Specific surface area : 157 m^3/m^2
(d) Dry weight : 4 kg/m^3

Small air pumps, which are usually used to supply air in fish aquariums, were used. Small-bubble diffusers were located 75 cm below the water surface and air was supplied by 5 mm PVC pipe. The oxygen transfer rate for the air pumps was calculated in the laboratory. The value of $K_L a$ (overall mass transfer coefficient) was found to be 2.4 h^{-1}.

The reactor was seeded with digested sewage sludge obtained from Okhla sewage treatment plant. The reactor was run initially for 30 days on sewage only to bring the working conditions of the biological reactor at par with a sewage treatment plant. Once optimum efficiency (~80%) was obtained leachate was introduced gradually at dilutions of 3%, 5% and 8% with sewage. The entire experiment was conducted at an HRT of 24 hrs. The flow rate was maintained with the help of a pump. The experiment was carried out as follows:

(a) Days 1 to 30 : sewage 100%
(b) Days 31 to 35 : sewage + 3% leachate
(c) Days 36 to 45 : sewage + 5% leachate
(d) Days 46 to 75 : sewage + 8% leachate

Analytical Methods

The COD, BOD, solids, pH and alkalinity tests were conducted in accordance with standard methods [American Public Health Association (APHA)].

Results and Discussion

The present study deals with the combined aerobic treatment of landfill leachate with domestic wastewater. The study was carried out in laboratory scale Submerged Aerobic Fixed Film (SAFF) reactor. As stated earlier the reactor was initially fed with domestic wastewater for one month so as to attain the working conditions of anaerobic sewage treatment plant. Figures 2 and 3 show the influent and effluent COD and BOD, for the first 30 days quite constant as it is fed with sewage only and the efficiency of around 80% was achieved as shown in Figure 4. As on 31st day, the 3% leachate was added with sewage, there is drop in efficiency of reactor to an average of 75%. Similar trend was shown as the leachate at ratio of 5% and 8% was added on days 36th and 46th respectively. BOD and COD removal efficiency remains at an average of 56% and 49% respectively at 8% leachate/sewage ratio. This forces us to conclude that the highly polluting nature of the leachate interferes with the efficiency of the sewage treatment system at a high

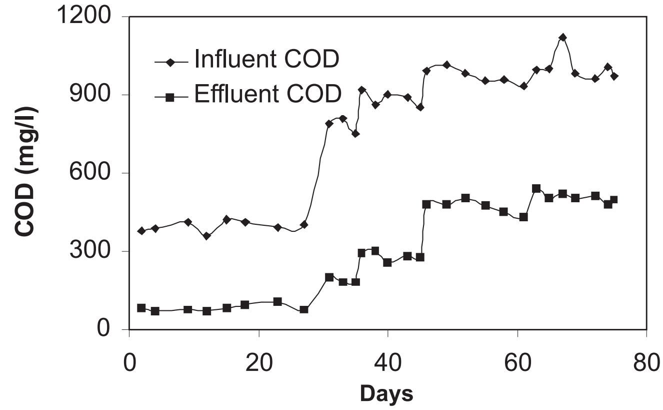

Figure 2: Variation of influent and effluent COD during period of study.

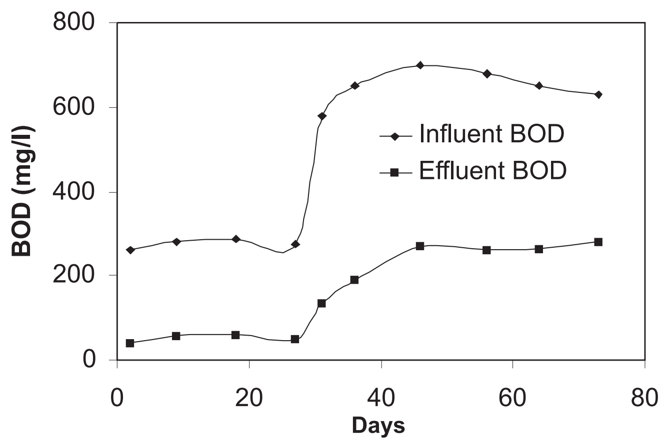

Figure 3: Variation of influent and effluent BOD_5 during period of study.

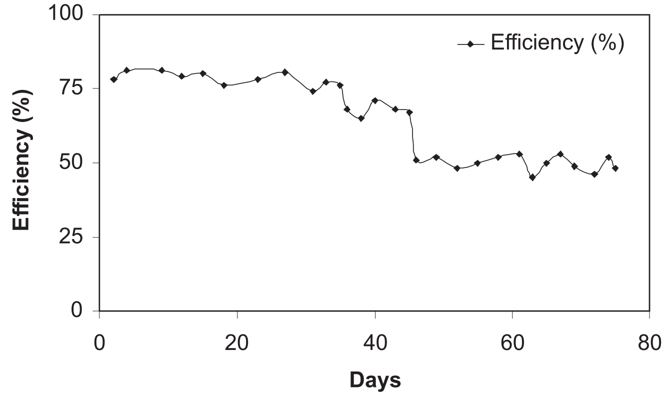

Figure 4: Variation of efficiency with time.

dilution. The apparent reduced efficiency is usual for a reactor that has to deal with a build-up of toxic and inhibitory chemicals that are inherent to leachate.

Figure 5 shows the variation of solids in the influent and effluent. The leachate introduction at 3% dilution shows an increase in total solids concentration. This pattern recurs twice when the leachate concentration is increased to 5% and 8%. The range of total solids concentration after leachate addition was found to be in the range of 1300 mg/l to 1650 mg/l. The biological treatment does not offer any removal of ions as sulphates, chlorides, etc. and therefore, these are found in the effluent also as dissolved solids. However, the suspended solid in the effluents were nil. The total solids concentration of the effluent was an average of 220 mg/l for sewage and 1300 mg/l after leachate addition.

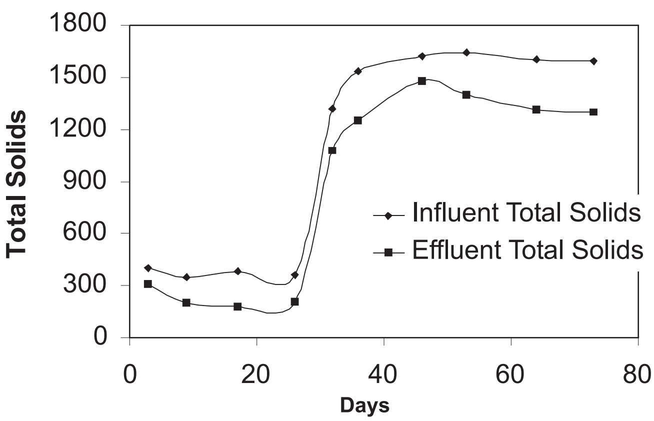

Figure 5: Variation of influent and effluent solids during period of study.

The influent alkalinity was adequate to counter the pH fluctuations of the wastewater going in for treatment. After the introduction of leachate at 3% leachate level, the influent alkalinity was found to be in the range of 1200-2000 mg/l as $CaCO_3$. As the concentration of leachate was increased to 5%, the alkalinity range increased to 1600-2000 mg/l as $CaCO_3$ and was found to be at an average of 1750 mg/l for the last 30 days of operation. The effluent alkalinity was lower than the influent values. However, it was not low enough to be a cause of concern towards the activity of the microorganisms and was found to be within the acceptable alkalinity requirement. The effluent alkalinity was in the range of 1000 to 2000 mg/l as $CaCO_3$ throughout the study period. The pH of the influent wastewater was around 8.0, whereas the pH of the effluent collected was measured in the range of 7.5 to 8.0.

Conclusions and Recommendations

The present study has been undertaken to assess the feasibility of the treatment of landfill leachate in a sewage treatment plant. Leachate, which is a necessary accompaniment of landfills, is a highly polluting liquid which requires treatment before it can be discharged to any water body or be disposed off. The results yielded by the experiment carried out for approximately 75 days have been described earlier in this article and each graph has been discussed separately. The final conclusions that can be drawn from the combined study of the graphs are as follows:

1. The pH and alkalinity of the effluent was under normal permissible limits.
2. The total solids concentration in the effluent reflects satisfactory solids capture within the biofilm and optimum efficiency of the reactor. No suspended solids were obtained from any of the samples. We can, therefore, record 100% removal efficiency for suspended solids.
3. The effluent BOD measured shows adequate results and reflects satisfactory reactor efficiency. Adequate BOD removal efficiency (~72%) is recorded at lower dilutions of leachate. For good effluent BOD values, the lower dilutions of leachate are recommended.
4. The efficiency of COD removal in the reactor is very good with sewage input and then decreases with the increase in leachate concentrations.

Considering all the conclusions made above, it is recommended that high concentrations of leachate are not advisable. It reduces the reactor efficiency, which points to the interference of leachate constituents with the sewage treatment system. It is also recommended to pre-treat the leachate using physico-chemical processes, prior to biological treatment, to reduce the polluting characteristics of the leachate and to increase its biodegradability and thus facilitate the co-treatability of leachate in a sewage treatment plant. It is also observed that a tertiary treatment is further required for the effluent and that a biological process alone does not make the effluent fit for discharge.

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