

Treatment of landfill leachate by using sequential batch reactor and sand bed filter followed by Granular Activated Carbon (GAC)

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ABSTRACT

This paper describes the treatment procedure of landfill leachate using sequential batch reactor. Leachate generation is a major problem for landfills and causes significant threat to surface water and groundwater. The leachate consists of different organic and inorganic compounds that may be either dissolved or suspended and this can be effectively treated by Sequential batch reactor (Biological treatment). Optimum obtained parameters like mixing ratio of 10%, Granular activated carbon (GAC) dosage of 10 g/L; alum dosage 2 g/L; reaction time and settling time of 1hr were applied on reactor. Removal efficiencies of colour – 95.42%, chemical oxygen demand (COD) – 89.41 %, total solids (TS) – 84.64%, ammonia (NH₃-N) – 81.24 %, Alkalinity - 82.68% , Turbidity – 78.82% and NH₃-N – 81.24% were measured. Better performance was obtained while sand bed filter used for pretreatment, Alum and GAC for tertiary treatment along with SBR were carried out in the treatment process.

Keywords: Leachate, SBR, HRT, Coagulation, Sand bed filter, carbon source, GAC.

1. INTRODUCTION

Disposal of municipal solid wastes (MSW) in sanitary landfills is usually associated with soil, surface water and groundwater contamination when the landfill is not properly constructed (Safaa, et al., 2013). The flow rate and composition of leachate vary from site to site, seasonally at each site and depending on the age of the landfill. Generally, leachate possesses high concentrations of ammonia and organic contaminants (measured in terms of chemical oxygen demand COD and biochemical oxygen demand BOD), halogenated hydrocarbons and heavy metals.

The effect of these substances on aquatic life of receiving waters is dependent extensively on specific cases. While developing a treatment sequence for leachate to be discharged into a river, Robinson et al. (2002) reported that COD levels of about 500 mg/L comprising humic and fulvic acids did not adversely affect aquatic life. Leachate varies from one landfill to another, and over space and time in a particular landfill with fluctuations that depend on short and long-term periods due to variations in climate, hydrogeology and waste composition (Keenan et al., 1984). Leachate varies widely in quantity and in composition from one place to another (Kennedy et al., 1988). Factors affecting the composition of landfill leachate are pH, temperature, Degree of on-going decomposition, moisture content, climate, landfill age.

2. MATERIALS AND METHODS

Sample collection: The Leachate was collected from 2 year old landfill site, which is located at “Perungudi Solid Waste Management Plant (SWMP)”, Chennai. Bulk volume of sample was collected for doing the entire work and it is stored under cold condition for avoiding further metabolism or degradation by any micro organisms.

Leachate characteristics: The freshly collected sample (leachate) were analyzed for evaluating the constituents present and characterized completely. The characterization will help us to work focused only on the treatment process whatever necessary.

Table.1.Leachate characteristics

Leachate Constituents	Concentration	S.No	Leachate Constituents	Concentration
pH	6.8	8	BOD	1740 mg/L
Temperature	27-29°C	9	TS	7560 mg/L
Colour	Black	10	TSS	1862 mg/L
Alkalinity	1132 mg/L	11	TDS	5698 mg/L
Absorbance	400 nm	12	NH ₃ -N	356 mg/L
DO	6.5 mg/L	13	NO ₃ -N	58 mg/L
COD	3120 mg/L	14	Total hardness	1240 mg/L

SBR Design: The Sequential batch reactor was made up of acrylic material with total volume of 4 L and working volume of 3 L. It has been designed with inlet and outlet valves for carry out the treatment process. The accessory components like stirrer for mixing provided with 1200 rpm and blower for aeration (bubble size of 2 mm). Storage tank for sample and effluent were provided along with SBR setup.



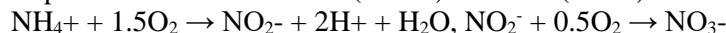
Figure.1.Sequential batch reactor set up



Figure.2.Laboratory setup

Biological nitrification/denitrification:

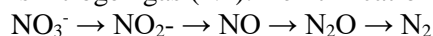
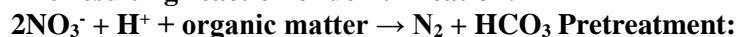
Nitrification is the process of biological ammonium oxidation with nitrate as the final product. It consists of two steps: oxidation of ammonia (NH_4^+) to nitrite (NO_2^-) and subsequent oxidation of nitrite to nitrate (NO_3^-):



The total reaction of nitrification is described by the following chemical equation:



Denitrification is the reduction of oxidized nitrogen compounds. The final product of complete denitrification process is nitrogen gas (N_2). Denitrification runs stepwise, from the most oxidized to the most reduced compound:

**The resulting reaction of denitrification:**

Sand Bed Filter bed was designed in the cylindrical shape with the dimensions of 7.5 cm diameter and 10 cm height. The micro porous sand particles were packed into the sand filter bed column and its sizes various from 0.3-0.5 mm.

Secondary treatment:

Sequential batch reactor, the operating parameters like time, temperature, pH, agitation speed and aeration rate have to be optimized for the efficient treatment.

Tertiary treatment:

For Coagulation and sedimentation, the supernatant from the SBR was collected in a buffer pool and the coagulant was mixed with leachate in the pipe before being pumped into the basin. Coagulation and sedimentation was performed in the basin. An overflow weir was fixed at the end of the basin for flocs separation. The hydraulic retention time (HRT) was controlled at approximately 5.5 hr. pH adjustment was not needed before coagulation. Three coagulants such as Alum (Aluminium sulphate), Ferric chloride, Ferrous sulphate were taken for coagulation process.

GAC Filter Bed is filled with granular activated carbon (Coconut shell) and it is used as the tertiary treatment process and thereby to enhance the ammonia-nitrogen and colour removal from the sample. Thus, the Removal of refractory organics can be obtained by adsorption on activated carbon.



Figure.3.Coagulation



Figure.4.GAC filter bed

3. RESULTS AND DISCUSSION

In the study, the sample has been characterized by analyzing their constituents. The operating conditions were optimized by carried out many treatment cycles in the sequential batch reactor. The chemical oxygen demand (COD), total solids (TS), and alkalinity were reduced to lesser amounts. The color of the sample was turned from black into yellow after the treatment. The removal efficiencies of COD, TS, color were improved while doing adsorption and flocculation.

Preliminary Treatment with sand bed filter removed the suspended solids, floating and colloidal matters and turbidity of the sample was also reduced. Total suspended solids were reduced from 1862 mg/L to 1456 mg/L.

Secondary Treatment which includes the SBR with nitrification and denitrification process. The microorganisms present in the sample were enhanced by aeration and agitation process and thereby the constituents like COD, TS and colour were reduced.

COD : 84.61 % (from 3120 to 480 mg/L)
 TS : 67.12 % (from 7560 to 2568 mg/L)
 NH₃-N : 55.50 % (from 356 to 162 mg/L)
 Alkalinity : 77.38 % (from 1132 to 256 mg/L)
 SVI : 37.10 % (from 1.864 to 2.963 ml/g)

Color of the sample has been changed from black into brown, orange and yellow. The various color changes depends on the different aeration (reaction) time. COD level of the sample has been reduced from 3120 mg/L into 480 mg/L at the optimum operating conditions. Efficiency of COD and total Solids reduction at optimum condition was obtained as 84.61 % and 67.12% respectively.

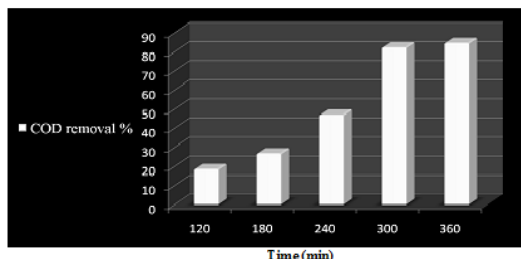


Figure.5.COD reduction with Time

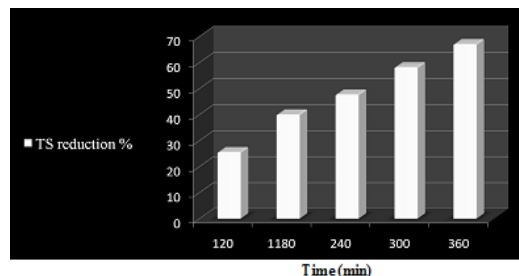


Figure.6.Total solids reduction with Time

Ammonia-Nitrogen (NH₃-N) and Alkalinity was reduced from 356 to 162 mg/L and 1132 to 256 mg/L at optimum operating conditions and its efficiency was upto 55.55 % and 77.38% respectively.

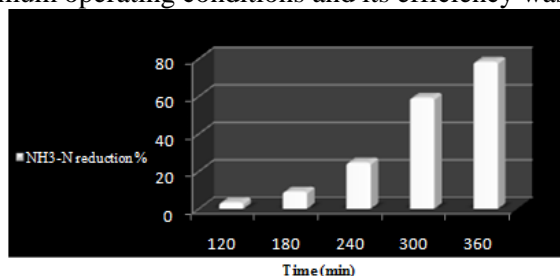


Figure.7.NH₃-N reduction with Time

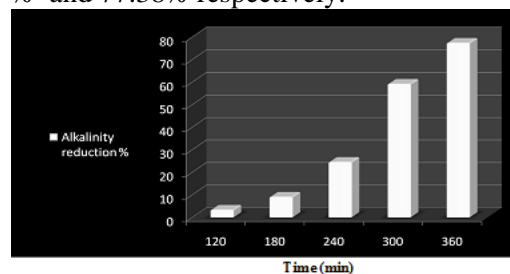


Figure.8.Alkalinity reduction with Time

With the effect of GAC Filter bed decolourization of yellow coloured sample (leachate) into colourless occurs. The various colour changes of the sample was analysed with spectroscopy and explained by fig.12. The heavy metal ions such as Cd²⁺, Cr³⁺ and Fe²⁺ were estimated from the sample by using Atomic absorption spectroscopy.

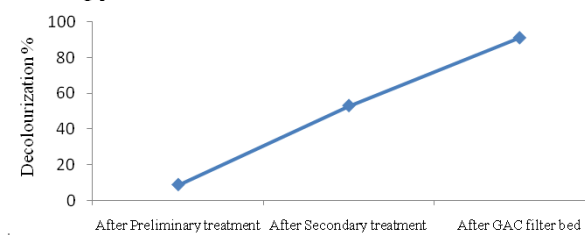


Figure.9.Decolourization by GAC

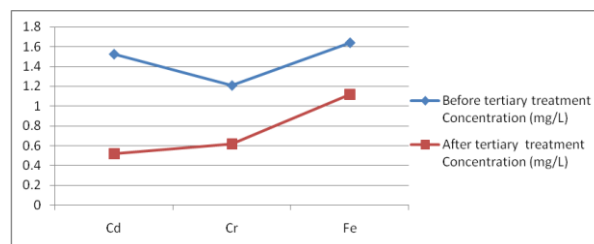


Figure.10.Removal of Heavy metal ions by GAC filter bed

4. CONCLUSION

The results of solids and organic & inorganic compounds removal in SBR system can be summarized as follows:

The floating materials present in the sample were removed completely through sand bed filter as pretreatment.

The removal efficiency of COD was obtained as 88.59 %.

The removal efficiency of ammonia nitrogen (NH₃-N) was obtained as 55.50 %.

The removal efficiency of TS and alkalinity were obtained as 81.17 % and 77.6 % respectively.

The color of the sample was turned from black into colourless, thus indicates the considerable amount of degradation takes place in the reactor.

The heavy metal ions like Cd²⁺, Cr³⁺ and Fe²⁺ were removed upto 80 % by GAC filter bed.

The sludge volume index (SVI) value increased up to 59.63 %.

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