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ScienceDirect

Procedia Technology 24 (2016) 224 – 231

Procedia Technology

Comparison of Photo ElectroFenton Process(PEF) and combination of PEF Process and Membrane Bioreactor in the treatment of Landfill Leachate

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Abstract

Landfill leachate treatment is an integral part of municipal solid waste management. The conventional biological treatment of landfill leachate is limited because of the presence of toxic contaminants and recalcitrant organics. Among Advanced Oxidation processes(AOPs), Photo Electro Fenton Process(PEF) can be used effectively for the treatment of highly contaminated water. In the treatment of leachate by biological methods, Membrane Bioreactor(MBR) is efficient while considering the effluent quality. So a combination of PEF followed by MBR treatment is adopted in this study.The percentage removal of pollutants -TSS, BOD,COD, Ammonia Nitrogen, Phosphate, Sulphate, Sulphide and Chloride from landfill leachate after PEF process is 89.3,71.9,83.6,100,58,92.3,65 and 65 respectively. The percentage removal of the same pollutant parameters after combined treatment of PEF followed by MBR is 95.5,90.2,96.2,100,82.7,93.3,88.2 and 88.3. The pollutant removal efficiency is increased by adopting combined treatment –PEF followed by MBR.

Peer-review under responsibility of the organizing committee of ICETEST – 2015

Keywords: *Landfill leachate ;Advanced Oxidation Processes; Photo Electro Fenton process,;Membrane Bio Reactor.*

1. Introduction

Municipal solid waste keeps growing as a result of increasingly wealthy lifestyles and continuing industrial and commercial development in many countries around the world. Landfilling method is the most frequently employed worldwide of all available dumping options under the solid waste management

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Peer-review under responsibility of the organizing committee of ICETEST – 2015

doi:10.1016/j.protcy.2016.05.030

system. Leachate gereration is a major problem for for municipal solid waste(MSW) landfills.

Treatment of landfill leachate has become a main concern in managing the environmental impact due to landfill. Leachate may contain large amounts of organic matter (Biodegradable and refractory to Bio-degradation). It also contains ammonia nitrogen, heavy metals, chlorinated organic and inorganic salts. The landfill leachate characteristics can be represented by parameters such as COD , BOD, the ratio of BOD / COD, pH, Suspended solids (SS) and ammonium nitrogen (NH3-N) [1,2]. The landfill leachate can be treated in two ways – Biological or Physicochemical methods . As age of leachate increases, it matures and non bio-degradable or recalcitrant substances become predominant. Conventional biological treatment methods are inadequate in the case of matured landfill leachates.. They cannot completely remove all pollutants in the leachate . After bio-degradation leachate contains pollutants such as heavy metals and some persistent organic compounds. Advanced Oxidation Processes (AOPs) are promising methods to treat effectively the recalcitrant substances present in landfill leachate [3].

1.1.Advanced OxidatioProcesses(AOPs)

Advanced Oxidation Processes (AOPs) are successfully used as pretreatment method for reducing concentration of toxic organic compounds in wastewater . In AOPs toxic organic contaminants oxidizes primarily by reacting with hydroxyl radicals. During AOPs oxidation occurs in two stages - (1) the formation of strong oxidants (hydroxyl radicals) which are highly reactive and (2) the reaction of these oxidants with organic contaminants in water. Hydroxyl radicals (•OH) are effective in destroying organic chemicals because they are reactive electrophiles (electron preferring) that react rapidly and non selectively with nearly all electron-rich organic compounds. Once generated, the hydroxyl radicals can attack organic chemicals by radical addition, hydrogen abstraction and electron transfer. Thus AOPs are effective in decomposing many toxic and bio-resistant organic pollutants without producing additional hazardous by-products or sludge which requires further handling. Many methods are classified under the broad definition of AOPs. Most of these methods utilize a combination of strong oxidizing agents (e.g H_2O_2, O_3) with catalysts (e.g. transition metal ions) and irradiation (e.g. ultraviolet, visible). Fenton's reactions are considered to be the most popular technologies for wastewater treatment.

Fenton's reagent is a mixture of ferrous iron $FeSO_4.7H_2O$ (Catalyst) & hydrogen peroxide (H_2O_2) (oxidising agent). The oxidation power of •OH radical (produced from hydrogen peroxide by adding Fe^{2+} as catalyst) is better on certain organic contaminants. When it is necessary to remove recalcitrant compounds , Fenton process is frequently used because of its simplicity. Fenton process can oxidize and mineralize almost all the organic carbons to CO_2 & H_2O. The reactions that takes place during Fenton process can be expressed as given below.

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH- + \bullet OH \quad (1)$$

$$Fe^{2+} + \bullet OH \rightarrow Fe^{3+} + \bullet OH \quad (2)$$

$$\bullet OH + RH \rightarrow H_2O + R\bullet \quad (3)$$

$$R\bullet + Fe^{3+} \rightarrow R^{+} + Fe^{2+} \quad (4)$$

Fenton reaction can be efficiently enhanced in photoelectro assisted Fenton process.The reason being Fe^{2+} may form complex with certain target compounds or byproducts, produced by UVA light and current. During photo-reduction and reduction in the cathode the ferric complexes reduce to ferrous ion .This assist in efficient Fenton chain reaction [4].Fenton pre treatment of landfill leachate will improve biological treatability [5].

1.2 Electro Fenton Process (EF)

Electrically assisted Fenton reaction is called Electro Fenton process The more OH• radicals produced will enhance the oxidation of the organics to CO_2 . There are two different methods in Electro-Fenton(EF) process – 1) the Fe^{2+} and H_2O_2 are added to the reactor from outside and inert electrodes having high catalytic activity are used as anode material. 2) H_2O_2 is added from outside and Fe^{2+} is provided from sacrificial cast iron anodes. EF method has the advantage of allowing a better control of hydroxyl radical production. In electro-fenton process, soluble Fe^{3+} can be cathodically reduced to Fe^{2+}. The fast generation of Fe^{2+} accelerates the production of •OH.The mechanism of EF process is represented in equations as below [6].

At anode: