TREATING LEACHATE USING ELECTROCOAGULATION TECHNIQUE: A REVIEW

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Abstract : Landfill is one of the most common and easiest way of treating solid waste. One of the biggest drawback is that the leachate production which is due composition and chemical reaction among different types of waste. An attempt is made by me to review treatment of leachate using electrocoagulation technique under various conditions. Various researchers had given variety of conditions for the removal of BOD, COD, dissolved metals, TDS, TSS etc. The biological treatment only helps is eliminating organic matter but leachate possess major contribution of inorganic matter which remains a problem. Electrocoagulation technique is now a days being used for removing inorganic material specifically COD and heavy metals like Cr, Hg etc. in order to meet the water quality standard for its safe dispose on the surface or in the river. This technique is popular now days due to its efficiency at cheaper rate.

Index Terms - Landfill leachate, Electrocoagulation, inorganic, efficiency

I. INTRODUCTION

Landfill leachate is highly polluted and complex in nature. It is the combination of all the physical, chemical and biological process that combines in the landfill with waste composition of different material and form such product that in thick and bad in odor. (*K.-U. Heyer and R. Stegmann 2014*) states that a litter possessing a very high complex structure formed from different types of waste dumped into the landfill. As the waste in the landfill goes under various stages of aerobic and anaerobic processes for the production of leachate.

Waste in the landfill is mainly solid waste generated from houses, hotels, schools, shops, industries etc. Major contribution is of MSW. (*United Nation ESCAP chapter 8*) at most about 1.5 million tons of solid waste in generated throughout the world and Asia remains at the top in the production of solid waste. Countries in Asia like China, Korea, Japan including Singapore produces almost 5 kg/person/day while other Asian countries such as India, Malaysia, Thailand etc. does produces between 0.5 to 1 kg/person/day. The waste generated from these countries is organic with at most 70% of their contribution.

1.1 USING ELECTROCOAGULATION TECHNIQUE

Electrocoagulation is the process in which anionic and cationic action takes place which ultimately results in the removal of contents like COD, BOD, TSS, TDS, Heavy metals and other inorganic and organic materials. (*Peter Kjeldsen , Morton A. Barlaz etc.* 2010) states that the leachate formation is similar in almost all the landfills due to dumping of different composite materials which undergoes certain chemical reactions and form leachate. Over all the waste in landfill is from municipal waste and mixed industrial waste.

Arash Dalvand, Mitra Gholami etc. (2011) in this the impacts of parameters such as voltage, time of response, initial dye concentration , electrolyte concentration, and electrode distance on color removal efficiencies were examined in accordance with energy consumption, electrode consumption, and operating cost at optimum condition . The outcomes demonstrated that 8color and COD removal efficiencies were 98.6% and 84%. Terminal utilization, vitality utilization and working expense were 0.052 kg/m^3, 1.303kWh/m^3 and 0.256 US$/$m^3$, individually. Color evacuation active took after first request energy. It can be inferred that electrocoagulation process by aluminum cathode is extremely proficient and clean process for receptive color expulsion from hued wastewater.

(Arseto Y. Bagastyo, Jelena Radjenovic etc. 2010) in this research work it has been illustrated that In this examination, electrochemical oxidation was explored for the treatment of ROC produced amid the recovery of metropolitan Wastewater profluent. Utilizing lab scale two-compartment electrochemical frameworks, five terminal materials were tried as anodes in group mode tests, utilizing ROC from a propelled water treatment plant. The best oxidation execution was watched for Ti/Pt_2/IrO_2 anodes, trailed by the Ti/SnO_2-Sb and Ti/PbO_2 anodes. The viability of the treatment seems to correspond with the arrangement of oxidants, for example, dynamic chlorine (i.e. Cl_2/HClO/ClO). Subsequently, electro-created chlorine prompted the copious development of

unsafe results, for example, tri halo-methanes (THMs) and haloacetic acids, especially at Ti/SnO_2/Sb and Ti/Pt-IrO_2 anodes. The most noteworthy convergence of aggregate HAAs i.e. 2.7 mg L^{-1} was measured for the Ti/SnO_2-Sb anode, after 0.55 Ah L^{-1} of provided particular electrical charge.

(C.B. Shivayogimath, Chandrakant Watawati 2013), observed the treatment of strong waste leachate by Electrocoagulation (EC) method utilizing aluminum electrodes. The specimen of leachate was gathered from Bagalkot Municipal strong waste (MSW) site. The impacts of process factors, for example, pH, voltage, and working time were researched on COD and turbidity evacuation. The EC procedure was done in a cluster reactor of 1 liter limit and tests of 750 ml were taken out for group at 5, 10, 15, 20, 25, 30, 35 and 40 minutes of operation. Results gotten from the analyses demonstrated that COD and turbidity removal was firmly impacted by the underlying pH. The most elevated COD what's more, turbidity removal of proficiency of 95.8% and 96.6% were gotten at a connected cell voltage of for 9V for 40 minutes of operation.

Fatih Ilhan, Ugur Kurt et al (2007) investigated treatment of leachate by electrocoagulation in a batch process. First comparison shows that EC process has higher treatment performance than Chemical Coagulation at current density of 348 A/m^2. Secondly, for EC process by changing the electrode material the variation in current density (from 348 to 631 A/m^2), COD and NH_4-N removal efficiencies were determined The electrode for EC process gave that aluminum electrodes exhibits more COD removal 56% than iron electrodes 35% toward the finish of the 30 min working time.

F. Bouhezila, M. Hariti et al.(2011) examined that factors such as electrode distance, magnetic stirring speed, current intensity and electrode material, sludge volume production, pH and temperature during EC procedure were studied. Also, vitality utilization and working expenses were ascertained with aluminum and iron nodes under the same test conditions. The discoveries, in this examination demonstrate that an expansion in current intensity (125– 500 A/m^2) increases the speed of whole process, the distance between the electrodes was 2.8 cm and the stirring speed was 150 rpm for leachate. The removal efficiencies of COD, oxides of nitrogen, colour and turbidity were 70%, 24%, 56%, and 60% with Al anodes and 68%, 15%, 28%, and 16% with Fe electrodes.

(Harun Akif Kabuk, Fatih İlhan etc. 2013) examined that leachate treatability with EC technique in response with surface methodology. A three-parameter optimization process and a 5-level, 6-replicate central composite design were included in the investigation on a set of 36 pieces. A second-order full polynomial approximation model was applied to evaluate the results of the optimization studies, which were performed for the removal of chemical oxygen demand, total suspended solids, total organic carbon, total Kjeldahl nitrogen, and NH3-N. When these parameters were compared, the appropriate working conditions obtained for current density and time were 20mA$cm^{-2}$and 60 min, respectively, at pH 8.

Ilona Heidmann, Wolfgang Calmano et al (2007) determined that parameters such as metal concentration, numbers of metals present, charge loading and current density and their impact on the electrocoagulation procedure. Concentration ranges from 50 to 5000 mg L^{-1} Zn, Cu, Ni and Ag did not impact the removal rates, though higher concentration caused higher removal rates of Cr. Increasing the current intr quickened the electrocoagulation procedure however made it less effective. Zn, Cu and Ni demonstrated comparative evacuation rates showing a uniform electrochemical conduct. The examination gave signs on the evacuation instruments of the explored metals. Zn, Cu, Ni and Ag particles are hydrolyzed and co-hastened as hydroxides. Cr(VI) was proposed to be lessened first to Cr(III) at the cathode before accelerating as hydroxide[5].

M. Poveda, S. Lozecznik, etc. (2015) the research focused on the four pre-treatment alternatives that were: air stripping, concoction coagulation, electrocoagulation also, propelled oxidation with sodium ferrate. Concoction coagulation detailed the best COD removal rate at 43%, contrasted with 18% for both air stripping and electro-coagulation, and 20% for oxidation with sodium ferrate. Then again, air stripping was far better than the other treatment alternatives regarding smelling salts removal of 86%. Oxidation with sodium ferrate achieved just 16%, while concoction coagulation and electro-coagulation evacuated less than 10%. Whenever consolidated, air stripping and compound coagulation evacuated up to half COD and 85% smelling salts.

O.T. Can, M. Kobya etc. (2006) investigated the initial addition of chemical coagulant such as Polyaluminum Chloride (PAC) or alum in a textile waste water which enhances in the removal of COD. The two material possess the same efficiency in chemical coagulation, but when combined with electrocoagulation technique the removal efficiency of COD content increases from textile waste water. PAC exhibits more effective in removal of COD and is also a cost effective method. The result obtained was that with combined Electro coagulation and CC the removal efficiency reached upto 80% with time interval of 5 minutes where as alone EC process was about 25% for same time interval.

ÖmerApaydin, Ertan Arslankaya, etc (2007) in this electrocoagulation (EC) and electro-oxidation (EO) processes were compared with each other based on organic pollutants with the COD and NH3-N removal rate. The results showed that NH3-N removal efficiency was obtained 9.8%, and COD removal efficiency was also obtained as 49.8% for 30 min of reaction time. After 30 min of operation, pH increased from 8.1 to 9.2 and the temperature increased from 24.2°C to 26.4° C. EO process with Ti/Pt electrodes, the results showed that NH3-N removal efficiency was determined as 83.9% and COD removal efficiency was also obtained as 52.9% for 360 minutes of reaction time. After 360 min of operation, pH increased from 7.7 to 8.3 and the temperature increased from 23.1° C to 51.7° C.

(RaffallaCosu, Annam Polcaro etc. 1988) the main objective of this research was to examine the impacts of current thickness, pH, and chloride focus on the evacuation of both COD and ammonium nitrogen. Titanium covered with lead dioxide (PbO_2) or, on the other hand tin dioxide (SnO_2) was utilized as the anode. A powerful process was accomplished in which the leachate was decolorized, COD was expelled up to an estimation of 100 mg L^{-1}, and alkali was completely disposed of. Normal current proficiency of around 30% was measured for a lessening of COD from 1200 to 150 mg L^{-1}, while proficiency of around 10% was measured for a close entire removal of ammonium nitrogen, beginning from an underlying estimation of 380 mg L^{-1}. Results showed that the natural load was expelled by both immediate and circuitous oxidation. Backhanded oxidation by chlorine or hypochlorite beginning from oxidation of chlorides is accepted to be principally in charge of the nitrogen removal.

(Rabahi Amel, Benchikh Elhocine Mossab etc. 2016) examined that using jar test experiment for Chemical coagulation, Aluminum sulfate ($Al_2(SO_4)_3$,10 H_2O) as a coagulant, Further more for the removal of phenol, nitrate and aggregate natural carbon efficiencies were compared. Test aftereffects of electrocoagulation utilizing an aluminum rods with a current intensity of 166.6 A/m^2furthermore, a time of 150 min have demonstrated its critical removal of limit as aggregate natural carbon and turbidity were 78.24% and 98 % sequentially and gives EC as a best treatment as compare to CC.

Selin Top, Elif Sekman etc. (October 2010) investigated that the average concentration of COD, TKN and alkali were determined to be 6200, 587.5, and 110 mg/L. Membrane also possess neutral pH, high conductivity and colour. After the treatment by electrocoagulation technique using aluminum plate anodes gives the outcomes that the most adequate current force for COD, colour, and phosphorus removal was resolved to be 15.9 mA/cm^2 and the most satisfactory treatment time was 30 min with the efficiencies as 45%, 60%, and 91.8%.

(Sonia Khoufi, Firas Feki et al.2006) observed that in olive mill waste water possess high Suspended solids, turbidity, Toxicity, COD. With the help of electrocoagulation technique all the impurities gets removed. The BOD5/COD proportion of the electrocoagulated OMW expanded from 0.33, starting worth, to 0.58. Moreover, the sedimentation step yielded removal of 76.2%, 75% and 71% of phenolic mixes, turbidity and suspended strong, individually, following 3 days of plain settling. The mix of electrocoagulation and sedimentation permitted a COD diminishment and decoloration of around 43% and 90%, individually. This pre-treatment diminishes the hindrance of Vibrio fishery iridescence by 66.4%. Constant anaerobic biomethanization tests led in parallel with crude OMW and electro coagulated OMW before and after sedimentation at a stacking rate of 6 g COD per day, demonstrated that the last pre-treated OMW was bio-converted into methane at high return while crude OMW was extremely dangerous to anaerobic microorganisms.

(*Tezcan Un U. and Oduncu E. 2014*) investigated that the removal of COD from landfill leachate utilizing aluminum anode by the electrocoagulation technique was examined. The examinations were keep running with the parallel plate monopolar aluminum anodes and the impact of pH and current thickness on evacuation productivity of COD and vitality utilization were resolved. The underlying COD fixation of 4100 mg/L was lessened to 1763 mg/L with the evacuation proficiency of 57% at the present thickness of 75 mA/cm^2 with pH 5.

V. Khandegar, Anil K. Saroha et al. (2012) states that the chemical coagulation procedure is moderate and produces huge sum of sludge. Electrocoagulation has as of late pulled in consideration as a potential procedure for treating modern profluent because of its adaptability and natural similarity. This method utilizes direct current source between metal cathodes submerged in the effluent, which causes the disintegration of anode plates into the effluent. The metal particles, at a suitable pH, can frame extensive variety of coagulated species also, metal hydroxides that destabilize and total particles or accelerate and adsorb the broke down contaminants.

(Xiangdong Li, Junke Song etc. 2011) presented a paper on leachate treatment using EC technology and observed the removal efficiency of ammonia nitrate (NH_3-N) and COD. The paper ponders the elements influencing the proficiency of expelling NH3-N and COD of leachate, for example, anode material, current intensity, electrolysis time, Cl concentration and pH. Treatment was completed in an irregular system and the outcomes demonstrate that the electrocoagulation can be connected to leachate pre-treatment. The working conditions were present with a current density of 4.96 mA/cm^2 with less pH, Cl concentration of 2319 mg/L, working time of 90 min with iron rods, the most astounding COD and NH3-N removal efficiencies were 49.8% and 38.6%.

1.2 USING NANO FILTRATION TECHNIQUE

Anissa Aouni, Cheïma Fersi etc. (March 2009) examines that the electrocoagulation procedure was examined under a few conditions of current densities and effect of experimental tense. Efficiencies of COD, turbidity and colour removal were examined for each experiment. The electrochemical treatment was indented essentially for colour removal, COD of wastewater while nano filtration was utilized to additionally enhance the removal effectiveness of the color, COD, conductivity, alkalinity and TDS.

(Fernandes, D. Santos etc. 2013) in this Ti/Pt/PbO_2, Ti/Pt/SnO_2 Sb_2O_4 and boron rods were utilized for the pretreatment of leachate with removal of COD at 6.2 g L^{-1} and ammonium nitrogen at 0.48 g L^{-1}. The test comes about three anode materials under examination, the COD evacuations were comparative in spite of the BOD anode all the more effortlessly advancing the entire burning of the natural issue. With respect to evacuation, metal oxide anodes were viable, though BDD was more productive in the

removal of natural nitrogen. For comparative exploratory conditions, Ti/Pt/PbO_2 showed the most astounding removal of 90%, trailed by Ti/Pt/SnO_2-Sb_2O_4 64% also, BOD removal of 56%. Recreated tests with similar to nitrogen content however without natural issue were likewise electrolyzed to better comprehend the disposal of the diverse types of nitrogen introduce in the tests.

(Mourad Taleb Ahmed, Toufik Chaabanea etc. 2012) observed that the water from landfill possess high heavy metals, fecal bacteria and high chemical pollution as measured by its chemical oxygen demand An electrocoagulation was connected as water pretreatment of a nano filtration procedure. The electrocoagulation was done in a group explore different avenues regarding two parallel aluminum plates of 15 cm^2.Water examination demonstrated a reduction of the COD from 60 to 5 mg L^{-1}, contingent on current thickness, current charge and arrangement pH. On account of electrocoagulation productivity, the most plausible number (MPN) of microscopic organisms diminished from 2500 to 2 MPN/100 ml. This sterilization permitted the performing of a ceaseless coupling treatment of electrocoagulation and nano filtration by utilizing a barrel shaped aluminum anode and a natural Nanomax50 film individually.

1.3 USING ELECTRO FENTON TECHNIQUE

Ahmet Altin et al. (2007) proposed that the proficiency of the procedure furthermore, settling attributes of waste muck delivered from the procedure were explored by changing some working parameters as, initial pH, H_2O_2 and current. The high evacuation efficiencies were seen at the underlying pH 3, introductory H_2O_2 concentration is 3000 mg L^{-1} with current 2.5A and treatment time was 20 min. Removal of COD, colour and phosphate under the revealed conditions were 94%, 97%, 96%.

(Hamidi Abdul Aziz, Osama Mohammed Othman, etc. 2012) examined that coliform bacteria is one of the major pollutant in semi aerobic leachate. They take two different samples from two different landfills having low and high coliform bacteria and optimal conditions for electro fenton was applied to both the sections and obtained a result of 100% removal from low coliform leachate sample and 99.9% bacterial removal from landfill leachate, which is very effective in both terms as in efficiency as well as in cost.

Hui Zhang, Xiaogang Wu etc. (April 2012) investigated that the impacts of working conditions such as H_2O_2 to Fe^{2+} mole proportion, Fenton's reagent measurement, initial pH, current intensity, between anode and hydrogen peroxide encouraging mode on COD removal was determined. The outcomes demonstrated that COD evacuation by oxidation is predominant because of the high H_2O_2/Fe^{2+} mole proportion utilized and the general COD removal shows the COD removal. The coagulation removal of COD increases with starting pH and ferrous iron measurements, yet it was autonomous of current intensity and the between terminal hole at a settled beginning pH esteem furthermore, ferrous iron measurement. Increasing Fenton's reagent dose or diminishing the underlying pH is probably going to advance COD expulsion by oxidation. There existed an ideal H_2O_2/Fe^{2+} mole proportion, current thickness or between anode hole to achieve the most elevated COD evacuation productivity by oxidation.
(Lee Mao Rui, ZawawiDaud, etc. 2012) examined that aluminum sulfate (alum) and ferric chloride in treating a balanced out leachate, and contrasted the outcomes in regard with the removal of suspended solids(SS), COD, colour and ammoniacal nitrogen. The ideal pH for the coagulants was 7. The ideal measurements were 9000 mg/L for alum and 3000 mg/L for ferric chloride. Among the two coagulants, ferric chloride demonstrated the most noteworthy SS removal of productivity (96%), shading evacuation effectiveness (84%), COD removal of proficiency (37%), ammoniacal nitrogen (26%) and with settling time for 30 minute.

II. RESULT AND DISCUSSION

Based on the review on treatment of leachate from different techniques under various conditions from different landfills it can be concluded that the leachate treatment is best suitable as:

For treating leachate with electrocoagulation technique using aluminum electrodes is best suited. As in this sample was treated with EC method at a temperature of 30º C at a current for 40 minutes at 9V.The samples was taken 1 liter with that after every five minutes parameters were calculated. After analyzing the data the result came out with 96.6% and 95.8% in the removal of COD and turbidity.

Treating leachate with Nano Filtration comes with the impurities removing from litter at nano level with the help of EC technique. The major dissolved impurities are removed by this process as the maximum efficiency is analyzed using Boron and tungsten rods simultaneously with percentage removal of 56% for BOD and 90% for COD.

Electro Fenton is the process in which Electrocoagulation technique is used with the addition of hydrogen peroxide for the maximum removal of pollutants from leachate. From the analysis the maximum of 94%, 97% and 95% removal of COD, color and phosphate with 100% removal of BOD. Overall it is clear from the review that the most effective treatment for leachate is electro fenton process with maximum efficiency.

III. ACKNOWLEDGEMENT

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