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Treatment of Leachate by Coagulation-Flocculation using different Coagulants and Polymer: A Review

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Abstract— **Leachate will be treated by using coagulation-flocculation. Coagulation and flocculation are essential processes in a number of diverse disciplines, including biochemistry, cheese manufacturing, rubber manufacturing, and in water and waste water treatment. It is effective for removing high concentration organic pollutant and heavy metals in wastewater. However, coagulation-flocculation examined the effectiveness of alum, ferric chloride and polyaluminum chloride (PAC1) as well as the use of synthetic polymers on the removal of suspended solid (SS), color, COD and ammoniacal nitrogen (NH_3N) from leachate. The coagulant dosage has typically been determined through jar test, which requires a long experiment time in a field water treatment plant.**

Keywords— **Leachate; Coagulation-flocculation; Coagulant; Polymer.**

I. Introduction

Leachates from MSW landfill sites are often defined as heavily polluted wastewater. Leachate is a liquid formed primarily by the percolation of precipitation water through the open landfill or through the cap of the completed site Leachates may contain large amounts of organic contaminants which can be measured as chemical oxygen demand (COD) and biological oxygen demand (BOD), ammonia, halogenated hydrocarbons suspended solid, significant concentration of heavy metals and inorganic salts. If not treated and safely disposed, landfill leachate could be a potential source of surface and ground water contamination, as it may percolate through soils and subsoils, causing pollution to receiving waters [1].

Landfill leachate has been shown to contain a wide variety of toxic and polluting components. A leachate management and treatment would be required to collect the leachate emanating from the mass of waste and treat it before discharge to a sewer. The generation rate of leachate is estimated based on such factors as the rainfall, the amount of the rainfall infiltrating to the waste through the cover, the absorptive capacity of the waste, the weight of absorptive waste and any removal of the leakage via seepage or discharge. Because of the uncertainties involved in the leachate generation process from real sites, the estimated leachate generation rate would include varied inputs to provide a worse-case scenario for sizing the leachate output and getting discharge consent to allow the leachate into the sewer [2].

The leachate generated from a landfill site will vary in volume and composition depending on the age of the site and stages biodegradation reached. Because of the changes in leachate composition with time, the leachate control systems should adapt to these changes. Leachate treatment is required to remove any contaminating components of the leachate and bring it to a standard whereby it can be released to a sewer, a water course, land or tidal water. Before release, a discharge consent or agreement is required from the local authorities or environmental agency. The consent or agreement may cover a range of potentially polluting components, for example, pH, concentration of organic material, ammonium and nitrate, suspended solids and metal content. Treatment processes for leachate are physico-chemical, attached growth processes, non- attached growth processes, anaerobic treatment, anaerobic/aerobic treatment, land treatment and leachate recirculation [3].

II. Material and Method

A. Coagulation-Flocculation

Coagulation-flocculation is widely used for wastewater treatment. This treatment is efficient and simple to operate. It have many factors can influence the efficiency, such as the type and dosage of coagulant/flocculant, pH, mixing speed and time, temperature and retention time. The optimization of these factors may influence the process efficiency [4]. Coagulation-flocculation treatments are done by adding coagulant and auxiliary coagulant. Ferum chloride, aluminium sulphate and polychlorinated aluminium are commonly used as coagulant. Furthermore, polymer coagulant is used as auxiliary coagulant. Coagulation-flocculation process is usually used for treating fresh leachate and it is applied as a pretreatment before biological treatment. It is used to remove heavy metal and non-biodegradable organic compounds from landfill leachate [10].

Coagulation-flocculation studies are carried out in usual jar test equipment. The jar test has been the typical technique used in wastewater and drinking water industry to improve the addition of coagulant and flocculants [5]. The speed and duration of mixing are significant factors in both the first and second steps. For example if the mixing strength is too high, it could be a reason to split up the aggregated floc. The other important factor is the duration of settlement.

B. Coagulation-Flocculation in Water and Wastewater Treatment

Coagulation-flocculation is essential processes in a number of diverse disciplines, including biochemistry, cheese manufacturing, rubber manufacturing, and in water and wastewater treatment. Coagulation-flocculation phenomena are extremely important in water and wastewater. In the area of potable water treatment, clarification of water with coagulating agents has been practiced from ancient times, using a variety of substances. The early Romans were also familiar with alum, although perhaps not for water treatment. Alum was used for coagulation in water treatment in England, and more formally for treatment of public water supplies in 1881 [6].

In modern water treatment, coagulation and flocculation are still essential components of the overall suite of treatment processes. From an engineering survey of the quality of water treatment at over 20 operating water treatment plants, reference [5] concluded that chemical pretreatment prior to filtration is more critical to success than the physical facilities at the plant. Coagulation and flocculation are useful because the flocculated particles can reduce fouling by producing more permeable deposits.

Reference [14] has been made to study the treatability of printing ink wastewater generated from an Indian currency printing press using coagulation-flocculation process. Polyaluminium chloride (PAC) was found to be the most efficient coagulant, achieving removals of colour, suspended solids (SS). Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of 95.9-96.5%, 96.5-97.0%, 61.3-65.8% and 54.8-61.8%, respectively at an optimum concentration of 1500 mg L-1. Other coagulants such as ferrous sulphate, ferric chloride and aluminium sulphate did not show substantial removals of colour, BOD and COD, except suspended solids in comparison to the performance of PAC.

Reference [15] has been done the viability of recycling waste plastic cups for synthesizing polystyrene sulfonate (PSS), which was used as an auxiliary agent of coagulation, flocculation and flotation in water and wastewater treatment plants. The study was carried out in the treatment plants of the Municipal Department of Water and Wastewater in Uberlandia, Brazil. The polystyrene sulfonate, when compared with commercial polymers, presented promising results for treating water with turbidity above 30 NTU, and presented the best results on the wastewater treatment.

C. Coagulation-Flocculation in Leachate Treatment

The coagulation process destabilizes colloidal particles by the addition of a coagulant. To increase the particles size, coagulation is usually followed by flocculation of the unstable particle into bulky floccules so that they can settle more easily. The general approach for this technique includes pH adjustment and involves the addition of ferric/alum salts as the coagulant to overcome the repulsive forces between the particles. According to reference [7] although the doses required were identical (0.035 mol/L of Fe or Al), with an initial COD concentration of 4100 mg/L, ferric chloride was found to give higher removal of organic compound (55%) than alum (42%). Furthermore, the previous study undertaken by Diamadopoulos in the Thessaloniki landfill. At an initial concentration of 5690 mg/L and at pH 4.8, the maximum COD removal of 56% was achieved with 0.8 g/L of $FeCl_3$, as compared to 39% with 0.4 g/L of $Al_2(SO_4)_3$. The results of both studies suggest that $FeCl_3$ is more effective than alum as a coagulant.

D. Synthetic Polymer

Although natural polyelectrolyte products have the advantages of being virtually toxic-free, the use of synthetic polyelectrolytes is more widespread. The use of anionic polymers with metal salts has been reported to results in a number of benefits and it will gives less sludge volumes. Bigger and compact flocs are achieved with greater settling rates, allowing use of higher surface overflow rates for primary settling tank. The sludge produced is low in moisture contents with good dewater ability. Floc strength is quite high and can be ascribed to the strong bonds of polymer chains due to bridging. The cationic polymer has been used successfully in some waters not only as a coagulant aid but also as the primary coagulant. In comparison with alum sludge that are gelatinous and voluminous, sludge produced by using cationic polyelectrolytes are dense and easy to dewater for subsequent treatment and disposal [8].

E. Inorganic Coagulant

Inorganic Coagulants such as Aluminium Sulfate (Alum) and Ferric Chloride are most commonly used. Inorganic Coagulants usually offer the lowest price and are quite effective in removing most suspended solids. They produce large volumes of floc which can entrap bacteria as they settle.

To treat the leachate in waste water engineering, the addition of electrolytes is of major significance to destruct the colloidal stability and they are called coagulant [9]. Alum (Al2(SO4)3 . 18H2O) was found to have relative higher coagulating power of a number of electrolytes because it is a trivalent salt. Their primacy as coagulants is due to their effectiveness in destabilizing the predominantly negatively charged colloids found in natural waters.

Ferric chloride (FeCl3) is available commercially in the liquid, crystal, or anhydrous forms, although the liquid form is by far the most common. The liquid and crystal forms are extremely corrosive and must be handled in a similar fashion to hydrochloric acid. Fe3+ and its hydrolyzed products can interact with negative colloids and neutralize their change when FeCl3 was added to the leachate, and it will make the colloids destabilization. The colloids can absorb the cations and become positively charged when the appropriate dosage is over [10].

In recent year, Polyaluminium chlorides (PAC) are a group of highly effective coagulants in water treatment that have replaced a large part of traditional aluminous coagulants. This is because of low dosage, high efficiency, low cost and convenient usage. The PAC to improve the coagulation efficiency and to suit different condition. The volume of the sludge generated in the coagulation process of PAC was much higher than Ferric Chloride and Alum [11].

III. Analysts

An analysis of leachate discharged or released onto or into any soil, or into any inlands waters or Malaysian waters shall be carried out in accordance with any of the methods contained in the publications as specified in the Environmental Quality Act 1974. This section exhibits and analyzes the results of the study performed on laboratory scale experiments. Landfill leachate composition varies widely among landfills. This variation makes a through characterization of leachate mandatory for each landfill before appropriate treatment schemes can be defined in table 1[12].

TABLE 1
Acceptable Conditions for Discharge of Leachate

Parameter	Unit	Standard
Temperature	ºC	40
pH value	-	6.0-9.0
BOD_5 at 20ºC	mg/L	20
COD	mg/L	400
Suspended solids	mg/L	50
Ammoniacal Nitrogen	mg/L	5
Mercury	mg/L	0.005
Cadmium	mg/L	0.01
Chromium, Hexavalent	mg/L	0.05
Chromium, Trivalent	mg/L	0.20
Arsenic	mg/L	0.05
Cyanide	mg/L	0.05
Lead	mg/L	0.10
Copper	mg/L	0.20
Manganese	mg/L	0.20
Nickel	mg/L	0.20
Tin	mg/L	0.20
Zinc	mg/L	2.0
Boron	mg/L	1.0
Iron	mg/L	5.0
Silver	mg/L	0.10
Selenium	mg/L	0.02
Barium	mg/L	1.0
Fluoride	mg/L	2.0
Formaldehyde	mg/L	1.0
Phenol	mg/L	0.001
Sulphide	mg/L	0.50
Oil and grease	mg/L	5.0
Colour	ADMI	100

ADMI-American Dye Manufacturers Institute

IV. Expected Outcomes

Coagulation-flocculation is one of the common methods for leachate treatment. There are many types of coagulants available to treat water and wastewater, opting the most effective coagulant for a particular wastewater still largely depends on the outcome of laboratory jar testing. PAC is a coagulant for water treatment.

According reference [13], at optimum conditions, 62.8% COD removal was achieved using alum, whereas removal using PAC was 43.1%. In contact, higher removal efficiencies for turbidity (94.0%), color (90.7%), and TSS (92.2%) were achieved using PAC than those using alum (88.4%, 86.4% and 90.1%).All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

V. Conclusions

It is important to note that the selection of the most suitable treatment technology for landfill leachate. The overall treatment performance compared to other technologies, age of a landfill, plant flexibility and reliability as well as environmental impact.finally, economic parameters such as investment and operational costs also play major roles in this decision making process. All the factors mentioned above should be considered to select the most effective and inexpensive treatment technology in order to protect the environment.

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