COMPARATIVE STUDY ON EFFICIENCY OF CALCIUM CHLORIDE AND BENTONITE FOR TREATMENT OF LEACHATE FROM SINGAPERUMAL KOIL DUMPSITE

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Abstract

Leachate from landfills is often made up of unwanted chemicals like organic and inorganic pollutants and is distinguished by having a high chemical and biological oxygen demand. Leachate from landfills can vary based on the volume and age of the contents, the rate of decomposition, the climate, and hydrological conditions. The major objective of this work was to use natural, inexpensive accelerator additives, such as, calcium chloride and bentonite to speed up the chemical treatment process using alum coagulant. Initial characteristics of leachate were tested and found out to be very high. With a steady dose of alum, the accelerator chemicals improved the effectiveness of the chemical treatment. The removal efficiencies were found out for conductivity, turbidity and COD and later comparison was made between the efficiencies of calcium chloride and bentonite. The best removal efficiency for alum was found at 90mg/l and this is taken as constant for further treatment with different doses of bentonite and calcium chloride. The removal efficiencies for turbidity, conductivity and COD at doses of 10, 20, 50, 90, and 100mg/l of bentonite for where found out be more than that of calcium chloride with same doses.

Keywords: leachate, alum coagulant, bentonite, calcium chloride

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INTRODUCTION

General

Recently, management of MSW have become a crucial issue due to the rapid population growth, changing lifestyles and industrial activities. Municipal solid waste has escalated in India during the past few decades. The amount of trash we produce has escalated due to our population's rapid growth and our growing consumption of consumer goods. Municipal solid waste includes all unwanted waste generated mainly due to human activities. These include waste from residential, industrial, institutional, commercial, and agricultural waste areas. They are biological and inorganic waste products that do not have any value to the original user[1]. The spectrum includes everything from the garbage we all make daily to the very poisonous industrial wastes generated during the manufacture of specialised goods like automobiles, electronics, computers, cell phones, and plastics.

Some of it is recycled and put back into the production process. Some of it is burned, which can be regarded as recycling or, more accurately, as the conversion of trash to energy when it produces electricity, useful steam, or heat. Sanitary landfills are currently the most practical and widely utilised way for getting rid of solid waste since they can help reclaim abandoned land[2]. Landfill site is a location where waste is discarded. It is oldest and most popular trash disposal method. MSW continues to decay after being dumped on a dump or placed in a sanitary landfill. Leachate and landfill gas are the major by-products of decomposition. The liquid level or leachate within the landfill area tend to rise if the rate of rainfall exceeds [3]. Environmental standards call for the leachate level to be managed, which necessitates the removal and disposal of extra leachate.

Trash means municipal solid wastes (MSW), which are a highly unstable mixture of materials from the residential, industrial and commercial areas [4]. The discipline of solid waste management can be described as the control of the generation, collection, storage, transfer, and disposal of solid wastes while upholding the highest standards of engineering, conservation, aesthetics, economics and other environmental considerations [5].

Due to the physical, chemical, and biological alterations of municipal solid waste, leachate, a by-product with a toxicity and high strength, is made up in transfer stations, incineration facilities and landfills [6]. Leachate is referred to as any contaminated liquid that comes from the water passing through a solid waste disposal site while accompanying contaminants and flowing into subsurface areas. Prior to being released into the water receivers or recycled, leachate must be appropriately treated utilising integrated leachate treatment methods[7]. Leachate pollution control is a worldwide concern and notable barrier to source reduction and pollutant elimination. It can move and contaminate subsurface areas if there is no restricting barrier below or around the waste dumping site. However, if gas and leachate generation is not well controlled, further effects could occur. The quantity of precipitation, stormwater runoff and infiltration groundwater volume entering the waste containing zone, moisture content and absorbency of the waste material affect the amount of leachate generated. The waste composition, water budget, and the biological, chemical, and physical conditions in the landfill body all have an impact on the quality of the leachate. The structure of waste, biological and chemical activities that take place during waste degradation, moisture content, rainfall, local climate, etc., all affect leachate quality, making it site-specific[8]. The prediction of leachate amount and quality is crucial for reducing environmental damage on the surrounding area while operating landfill sites because it is highly dependent on climatic conditions and landfilled waste materials.

Due to the great efficiency and efficacy in clearing, alum is the suggested coagulant for many wastewater treatment applications. The chemical provides very good turbidity removal and leaves no trace of colour behind. Accelerator is any substance that improves the rate of chemical reaction [9]. Perlite, bentonite, calcium chloride etc are few accelerators. The accelerators taken here is bentonite and calcium chloride. Cheaper clay minerals like bentonite and locally accessible resources offer cost-effective methods. Aluminium, iron, and clay are the main components of bentonite, a substance used to treat wastewater [10]. It is eco-friendly and cheaper. Calcium chloride is employed to filter out unwanted contaminants from wastewater treatment process.

MATERIALS AND METHODOLOGY

Study area

Chengalpattu is a city and the administrative centre of the Chengalpattu district in the Indian state of Tamil Nadu. The town is close to the IT and industrial centre. Appur kuppai in Singaperumal Koil in this district was selected as the study area [8]. Waste transported to Appur kuppai is the waste generated from Chengalpattu city which covers an area of 16sq.km. Chengalpattu has a population of

62,579. Quantity of garbage transported is 30MT per day in around 60 to 70 lorries with 12 tons of waste per lorry.

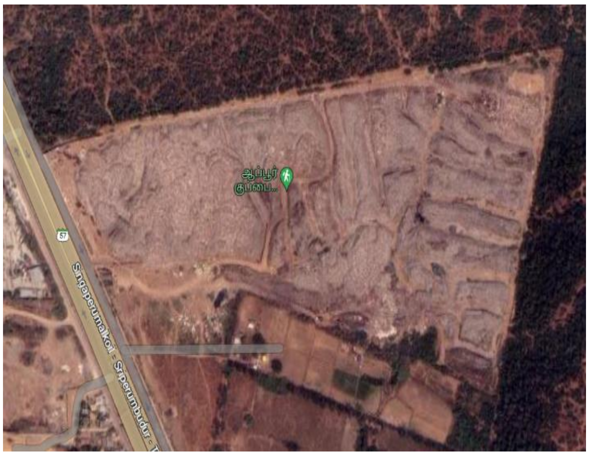

Fig 1. Satellite view of Appur Kuppai

Climate and rainfall

A tropical climate best describes the climatic conditions in this area. In Singaperumal Koil, the summers are much more rainy than the winters. This specific weather pattern is classified as an Aw by the Köppen-Geiger climate classification system. Singaperumal Koil experiences an average yearly temperature of 27.8 °C (82.0 °F). Rainfall totals 995 mm (39.2 inches) every year[3]. Due to its proximity to the equator, the Singaperumal Koil has a difficult time defining its summers.

Materials

Raw leachate samples were collected from Appur kuppai in Singaperumal Koil. 6 samples were collected from various points in and around the dumpsite during the post monsoon season. Six 5L cans were used for collecting leachate and they were stored in the laboratory for further study[11].

Fig 2. Solid waste dumped in Appur dumpyard

The coagulant used is alum and the accelerators used for treatment process are calcium chloride and bentonite[12]. Due to high efficiency, effectiveness in clarifying, and utility as a sludge dewatering agent, aluminium sulphate, also known as alum or $Al_2(SO_4)3$, is the preferred coagulant for many industrial and wastewater treatment applications[12]. The majority of suspended solids may be removed most efficiently and at the lowest cost using alum. Huge amounts of floc are produced, which can trap germs as they settle. The substance is quite effective at eliminating turbidity and leaves no aftertaste. Bentonite is usually a solid yellow powder with an average particle size of 14.124µm. Calcium and chlorine combine to form the ionic substance calcium chloride which is very water soluble and has a particle size of 10-100nm. Calcium chloride combines with impurities in waste water that includes fluorides, silicates, phosphates, sulphates, and heavy metals to create highly insoluble salts that precipitate, settle, and can subsequently be removed from the stream's bottom.

Methodology

Various characteristics of leachate sample are tested such as pH(p Hmeter), conductivity (conductivity meter), turbidity(2130 B APHA 23rd edition: 2017), BOD5(5210 B APHA 23rd Edition:2017), COD(5220 B APHA 23rd Edition: 2017), TDS(2540 C APHA 23rd Edition:2017), TSS, Sulphate(4500-SO_4 APHA 23rd Edition:2017), chloride(4500-Cl^- B APHA 23rd Edition:2017), copper(3500-Cu APHA 23rd Edition:2017), and zinc(3500-Zn APHA 23rd Edition:2017)[13].

Treatment method was carried out by coagulation flocculation process through jar test apparatus. The standard method for improving the addition of coagulants and flocculants in the wastewater and drinking water industries has been the jar test[14]. Significant variables include the mixing process's speed and duration. To separate up the aggregated floc, for instance, the mixing strength can be too high. The length of settlement is a further crucial aspect. Coagulation-flocculation is a conventional treatment method based on the addition of chemicals (coagulants and flocculants), which destabilise colloidal particles (organic and inorganic components, as well as diverse biological forms like algae, bacteria, and viruses) and cause aggregations (flocs)[15]. These bulkier, heavier flocs will settle and make removal easier. [16]. The process circumstances such as coagulant-flocculant dosage, pH, starting temperature and concentration, etc. and the type of coagulants/flocculants have a significant impact on the dominating mechanism and treatment effectiveness. The process effectiveness may be impacted by the optimisation of these aspects.

Alum was employed as the coagulant, and calcium chloride and bentonite were used as the accelerators. 100 rpm was used for the rapid mixing rate for 3 minutes, and then a flocculation basin was used for 30 minutes. 1 hours were spent in settlement[15]. Conductivity, turbidity, and chemical oxygen demand were the characteristics that were measured. The samples were given various Alum dosages of 10, 20, 50, 90, and 100 mg/l during the first run. These ranges of dosages are taken randomly so as to find out if there are major variations in removal efficiencies. The optimal alum dose is determined to be 90 mg/l and is considered in the next runs. The optimal alum dose (90 mg/l) from the first run was used in the second run along with various concentrations of calcium chloride[17]. The amounts calcium chloride is used in doses of 10, 20, 50, 90 and 100 mg/l. The ideal calcium chloride dosage is calculated. The best alum dose (90 mg/l) and various Bentonite doses were used in the third run. Bentonite is utilised in concentrations of 10, 20, 50, 90 and 100 mg/l[17]. The ideal Bentonite dosage is calculated. Comparative studies are done based on the efficiencies of these accelerators on turbidity, conductivity and COD[17].

Fig 2. Coagulation flocculation of leachate

RESULTS AND DISCUSSIONS

Initial characteristics

Characteristics test of 6 leachate samples were conducted and studied according to the Indian Standards. It vary according to the type of waste generated and over time[13], [18]. According to Municipal Solid Wastes (Management and Handling) Rules 2000, the obtained values for various parameters are out of the permissible limits[19]. Table below shows the various Characteristics of leachate.

Table 1: Characteristics of leachate samples

PARAMETERS	UNIT	S1	S2	S3	S4	S5	S6
pH	-	7.94	7.99	7.86	8.23	8.05	8.14
Conductivity	mS/cm	38.4	40.7	36.1	55.66	51.3	49.52
Turbidity	mg/l	277	294	245	356	340	328
BOD5	mg/l	335	365	371.9	626.3	614.4	583.15
COD	mg/l	2887.4	2956	2510.9	3561.2	3585.6	3490.1
TDS	mg/l	15700	15910	15480	17910	17637	17381
TSS	mg/l	138	279	141	106	114	108
Sulphate	mg/l	372.3	380	356.6	398.4	416.7	425.9
Chloride	mg/l	4282.2	4610.2	4019	5280.4	5184.9	4900
copper	mg/l	0.86	1.3	0.79	1.18	0.954	0.71
zinc	mg/l	0.93	1.09	0.88	1.201	1.060	1.4

Removal efficiencies for parameters such as turbidity, conductivity, and COD were done using alum and the optimum value out of it was used for further treatment using the accelerators respectively[20]. The characteristics of sample which is highly contaminated is used as the initial characteristics to find out the % removal and this sample is used for further treatment. Hence sample 4 is taken for further treatment.

$$\% \, removal = \frac{\text{initial characterestics} - \text{final characterestics}}{\text{initial characterestics}} * 100$$

Turbidity removal efficiency

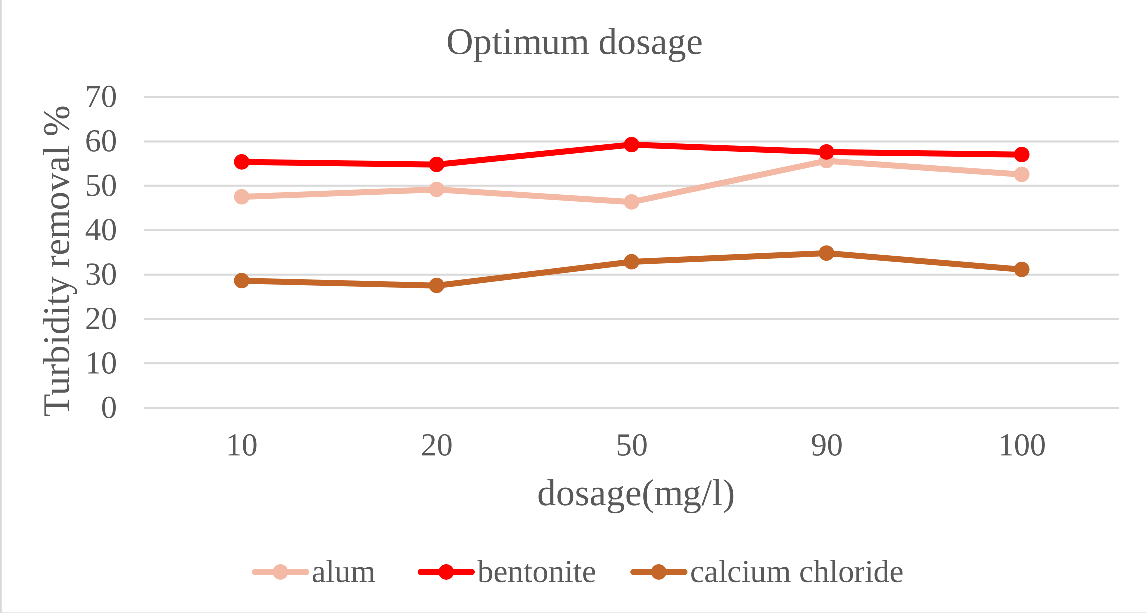

Fig 3. Removal efficiency for turbidity

The initial value of turbidity for the sample obtained was 356NTU. The settling of these particles following the equalisation of their ions is what caused the decrease in turbidity, which was referred to as the decrease in suspended solids. The best removal efficiency using alum was attained at a dosage of 90mg/l. This dosage limit of alum is taken for the further treatment with different doses of bentonite and calcium chloride. Various doses of bentonite were taken and found out that increasing weight of the substance is not enhancing removal efficiency. Best removal efficiency was given at 50mg/l with a value of 59.26% whereas removal efficiency using calcium chloride at 50 mg/l is 32.86%[9], [10]. The best removal efficiency using calcium chloride was shown at a dosage of 90mg/l which is less compared to bentonite[21]. The less solubility nature of calcium chloride makes it more turbid.

Conductivity removal efficiency

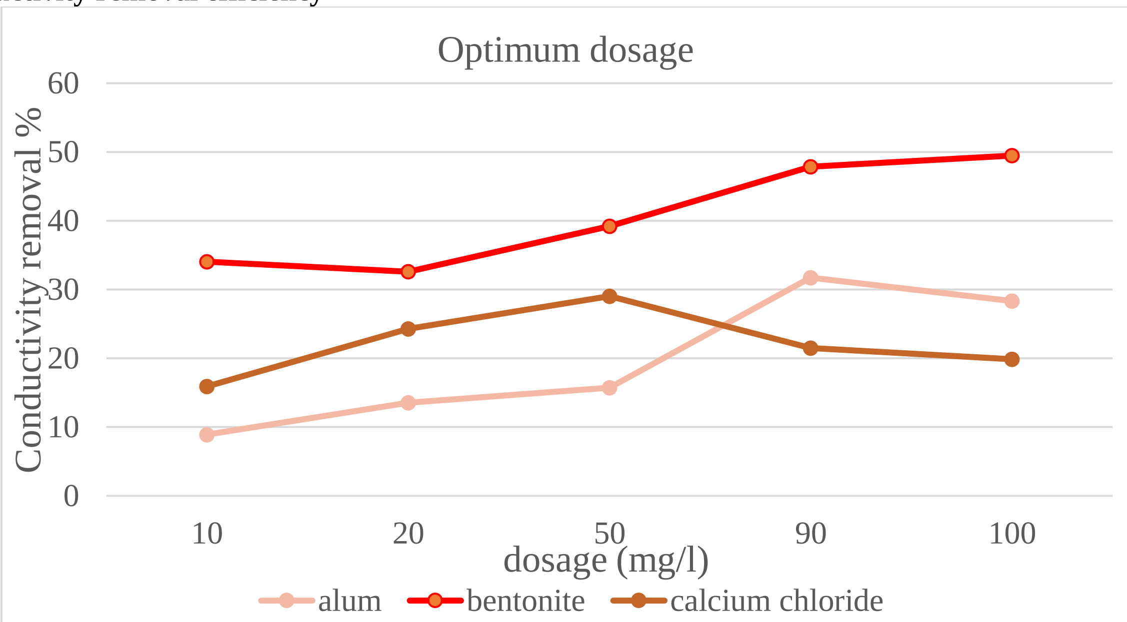

Fig 4. Removal efficiency for conductivity

The initial value of sample for conductivity was 55.66 mS/cm. The reason for change in conductivity is due the variations in dissolved salts present in it. The best removal efficiency using alum is at a dosage of 90mg/l. The adsorption behaviour of bentonite, which may adsorb various types of ions on its surface and reduces conductivity, is the cause of the conductivity decrease caused by bentonite[9]. Best removal efficiency of conductivity using bentonite is at 100mg/l and is 49.47% whereas for calcium chloride at 100mg/l is less. Conductivity in the presence of calcium chloride increases till 50mg/l which is having a high removal efficiency of 29.03% and then decreases. From the result , bentonite is more efficient than calcium chloride[21].

COD removal efficiency

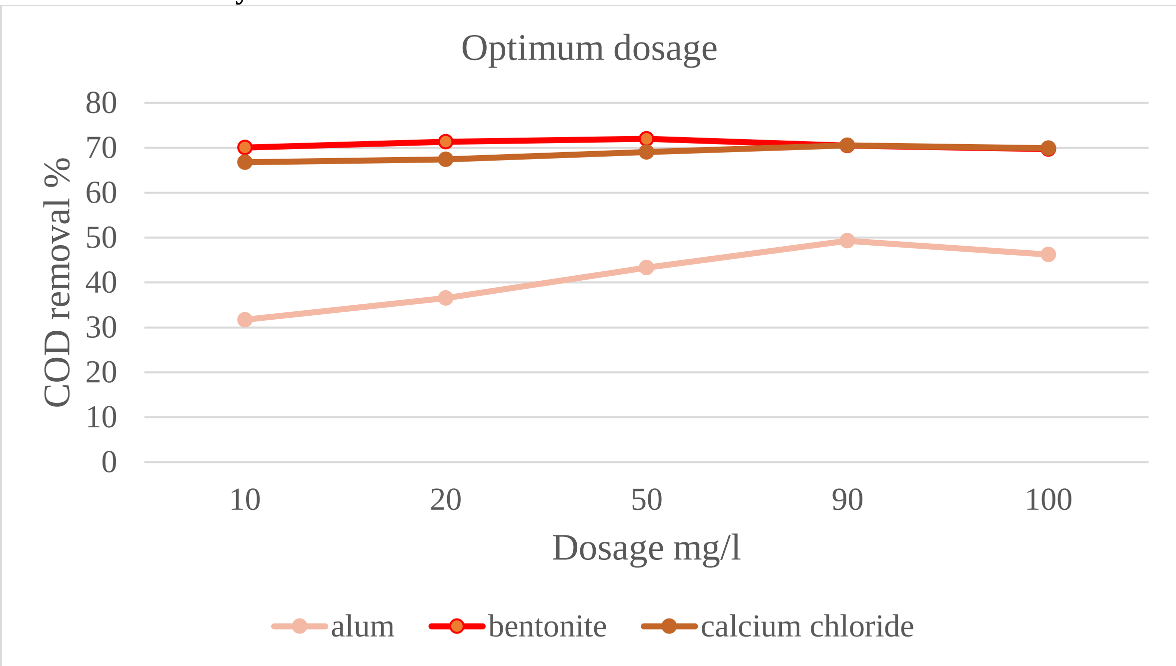

Fig 5. Removal efficiency for COD

Initial value of sample for COD was 3561.2mg/l. Removal efficiency using alum is best at 90mg/l[22]. Bentonite showed best removal efficiency at 50mg/l which is 72.01% and then it decreased as substance weight increased. Removal efficiencies using calcium chloride showed only slight variations as the dosages changes[21]. Performances of the accelerators are due to the change in numbers of microorganisms and the degradation of organic compounds[23].

CONCLUSION

Today's issue is to effectively handle leachate in order to minimise its detrimental effects on the environment[24]. Therefore, it is exceedingly challenging to offer broad recommendations due to the intricacy of the leachate composition[25]. Because leachates vary, especially over time and from site to site, the best treatment should be straightforward, all-encompassing, and flexible. Hence treatment is done using alum and accelerators. Removal efficiencies of pollutants done by comparing the characteristics of leachate after treatment with initial characteristics[26]. The removal efficiencies of using coagulant alum along with accelerators calcium chloride and bentonite were found out and the comparative study was done to propose the best treatment for leachate. From the results, treatment with bentonite is showing more removal efficiencies than that with calcium chloride. Further investigation is proposed in future with changing the substance weight to enhance the treatment[27].

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