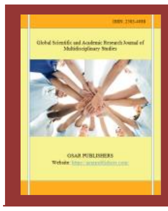

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Contaminated Landfill Leachate treatment through Synergistic Strategy of Chemical Coagulation

By

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Abstract

Soil, air and water contamination from heavy metals and metalloids is one of the most discussed and burning global issues due to its potential to cause the scarcity of healthy food and safe water. Pollution enter in to the soil from landfill activities contaminated the soil with heavy metals such as Lead, chromium, nikel and Cadium. Information regarding to pollution distribution, their reaction and their cleaning in ecosystems are vital. Environmental cleaning of the high concentration of heavy metals are important, due to its toxic effects. The efficiency of coagulation/flocculation of landfill leachate by using Aluminium sulphate,Calcium carbonate and Sodium Citrate as Immobilized Chemical Coagulant removal of heavy metals from landfill leachate was analyzed. Results of present study described thatAluminum sulphate and Calcium Carbonate efficient as Immobilized Chemical Coagulant removal of heavy metals from landfill leachate. Effect of chemical coagulants dose on the lechate wastewater treatment was studied by varying doses from as Coagulant 0.5 g/L, 1g/L, 2g/L, 5g/L at constant pH of 7-8 and found that total dissolved solids (TDS), sulphate$SO4^{-2}$ and choride percentage removal increased by increase the dose. But 0.5 g/L coagulants dose absorbed the maxium heavy metals contents. In comparison with different metals maximum Cadmium has removal efficiency with Aluminium Sulphate, maximum Lead removal efficiency with Calcium carbonate, maximum Nickle has removal efficiency with Calcium carbonate , maximum Chromium has removal efficiency with Sodium Citrate and Lead (Pb) has lowest removal efficiency with Sodium Citrate on different dose of coagulants of metal concentration in 50% leachate. In comparison maximum Chromium removal efficiency with Aluminium Sulphate ,maximum Lead removal efficiency with Calcium carbonate and maximum Chromium has removal efficiency with Sodium Citrate , maximum Nickle has removal efficiency with Calcium carbonate and lowest removal of Lead(Pb) on different dose of coagulants of metal concentration in 100% leachate found.

INTRODUCTION

Industrialization and technological advances are the main sources for high concentration of pollutants in environment. These higher levels of pollutants are badly affecting the self-sustaining capacity of ecosystems (Ahmad. et al., 2022). Anthropogenic activities are exploiting natural resources in a very unsustainable way resulting environmental degradation and pollution (Prasad and Freitas, 2016).Rapid growth of population is a major cause for variety of organic and inorganic pollutants (including heavy metals) which are persistent in nature (Yoon *et al.*,2019).

Environmental exposure of heavy metal Pollution

There are two types of sources for metal contamination in environment. **1) Natural sources** include erosion, weathering of rocks and volcanic eruption. **2) Anthropogenic sources** are industrial and manufacturing processes, mining and excessive use of agrochemicals i.e. fertilizers and pesticides (Jadia and Fulekar, 2008). Unregulated disposal of municipal solid waste is also increasing soil contamination load. Open dumping and land filling are the common practices worldwide due to low

cost and easy operation (Xu et al.,2016).Maintenance operations on roads
, corrosion and brake abrasion are some ways of metal contamination due to transportation (Sanchez Martin et al.2008).

Cadmium (Cd) enter into the environment from pigments, paints, electroplating, plastic stabilizers and incineration of cadmium plastic (Pulford and Watson, 2003).It is carcinogenic and teratogenic, causes renal failure, chronic anemia and also disrupts endocrine system(Awofolu, 2005). Steel industries and tanneries are sources for **Chromium (Cr)** in environment. Diseases related to exposure include depression, hair loss, anxiety, ulcers, fatigue, sleeplessness, loss of memory, irritability, vision disorder, outbreak, hypertension and poor functioning ofkidney,brain and lung (Ainza et al.,2010 and Gulati et al.,2010). Sources of **Nickel (Ni)** include kitchen appliances, industrial effluents, steel alloys, surgical instruments; car battery (Tariq et al., 2006).Its inhalation can cause cancer of lungs, stomach and throat. Fertilizers, pesticides, herbicides are the sources for **Copper (Cu)** (Khan et al., 2007). Its elevated level causes stomach irritation, kidney and brain damage (Wuana andOkieimen,2011).Manufacturing of batteries, combustion of leaded fuel, insecticides and pesticides are some important reasons for **Lead (Pb)**in environment (WuanaandOkieimen,2011).Leadpoisoningincreasesriskofcard iovasculardiseases.Learning disabilities, weakened development and shorter memory losses are effects of lead poisoning in children (Salem et al.2000;Padmavathiamma and Li , 2007; Wuana and Okieimen, 2011 and Iqbal, 2012).

Impacts of pollution due to heavy metals:
Heavy metals are important constituents of earth but anthropogenic activities have increased their concentration beyond the permissible limits, categorizing them as environmental pollutants. They pose serious threats for health and environment due to their non-biodegradable and persistent nature (Padmavathiamma and Loretta, 2007). Use of waste water for agricultural purposes is now very common throughout the world and it contains high concentration of heavy metals making their way in food chain(Athar and Ahmad, 2002).Their high concentration affects growth, reproduction and metabolism in plants(Xu and Shi, 2009).

Landfill Source of Heavy Metals Pollution
In developing world, land filling is economical choice for disposal of solid and municipal waste which results production of landfill leachate.This may infiltrate in soil , ground water and surrounding water bodies causing serious problems for living bodies and environment (Akinbile and Ajayi, 2011).So this special type of waste water (Leachate) requires immediate treatment before final disposal. Various pollutants are present in it like ammonia, heavy metals, chlorinated compounds, organic and inorganic compounds (Rai et al., 2019).

Coagulation/Flocculation of Leachate by Using Immobilized Chemical Coagulant option for Leachate treatment
A variety of techniques like chemical precipitation, ion exchange, adsorption, membrane, filtration, coagulation flocculation, flotation and electrochemical methods have been studied for removal of metal pollution from waste water (Vlyssides et al., 2002).Coagulation is a three step process. In first step electrical charges are neutralized and particles are separated. In second coagulant surrounds the separated particles and in third one, coagulant destabilizes the particles by adsorbing on their surface (VanLoon& Duffy, 2011). The objective of this study was to evaluate the efficiency of coagulation/flocculation for landfill leachate by using Aluminium sulphate, Calcium carbonate and Sodium Citrate as Immobilized Chemical Coagulant with varying doses.

METHODOLOGY

Sampling of Leachate
Solid waste in Lahore is managed by open at Lakhodair Landfill site which was selected for sampling of leachate water. Collected leachate samples were store and preserve in 1500 ml water bottles. Bottles were washed carefully with deionized water before collection. Temperature and pH was measure on site by using the portable pH meter. Sampling of leachate was done as described by (Arunbabu et al., 2017).

Chemical Coagulants
Chemical coagulants used were, Aluminium Sulphate, Calcium Carbonate and Sodium Citrate. These were purchased from market.

Immobilization procedure (beads formation)
Coagulant 5 g and 2.5 g sodium alginate were added to 250 mL deionized distilled water (DDW).This solution was mixed thoroughly and afterwards heated (at40^{o}C) on the hotplate until solution became homogeneous. Afterwards, the solution was introduced drop-wise using a burette into 0.1M $CaCl_2.2H_2O$ solution. The size of formed beads was 0.350mm. The immobilized chemical coagulants were preserved in 50mM CaCl2 solution until use. The dry weights of coagulant beads were determined after drying them at 60ºC for 48h. The doses of chemical coagulants were applied on their dry weight basis.

Leachate sample preparation and estimation of different parameters
50% and 100% Leachate concentrations were prepared in 1000 ml beakers and batch process was used for three coagulants. Effect of chemical coagulant dose on the leachate treatment was studied at different doses of 0.5 g/L , 1g/L , 2 g/L and 5g/L at constant pH of 8.2 methodology related to Imran et al., 2012. Samples of leachate were taken after every dose and values of Total Dissolved Solids (TDS), Sulphates (SO_4) and Chlorides (Cl^{-1}) were determined. Samples were also analyzed by Atomic Absorption Spectrophotometer (AAS) Z-8230 for Cadmium, Chromium, Nickel and Lead. Removal efficiency % was also calculated for each parameter.

Removal efficiency (%) = Ci – Ce/ Ci × 100 Where Ci and Ce are the influent and effluent concentrations.

RESULTS AND DISCUSSIONS

Removal of Total Dissolved Solids, Chlorides and Sulfates in Leachate by Coagulation

After experimental works removal efficiency of coagulation/flocculation for landfill leachate by using Aluminium sulphate, Calcium carbonate and Sodium Citrate as Immobilized Chemical Coagulant with varying doses evaluated.

Total Dissolved Solids (TDS)

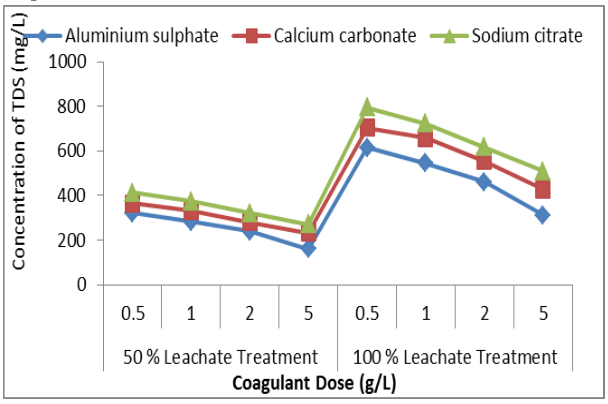
Total Dissolved Solids (TDS) mg/L of 50% and 100% leachate at different doses of coagulants and their efficiency removal found following trend 0.5 (g/L) Dose<1(g/L) Dose<2 (g/L) Dose<5 (g/L)Dose .Comparison of different doses of coagulants and their removal efficiency found following trend Aluminium sulphate>Calcium carbonate >Sodium.

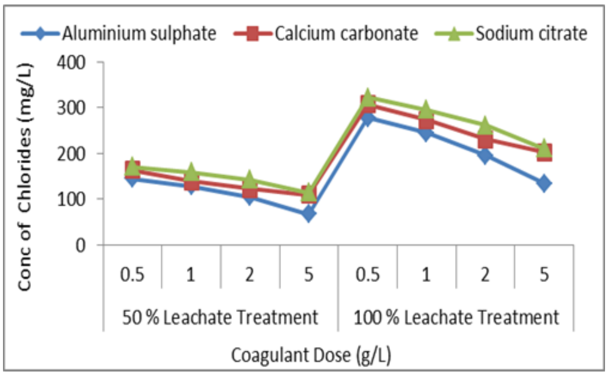
Chlorides (Cl^{-1})

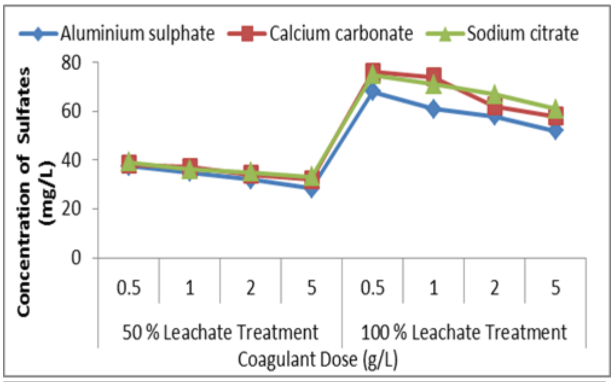
Chlorides (Cl^{-1}) mg/L of 50% and 100% leachate at different doses of coagulants and their efficiencyremoval found following trend 0.5 (g/L) Dose<1(g/L) Dose<2 (g/L) Dose<5(g/L)Dose. Comparison of different doses of coagulants and their removal efficiency found following trend Aluminium sulphate>Calcium carbonate >Sodium Citrate.

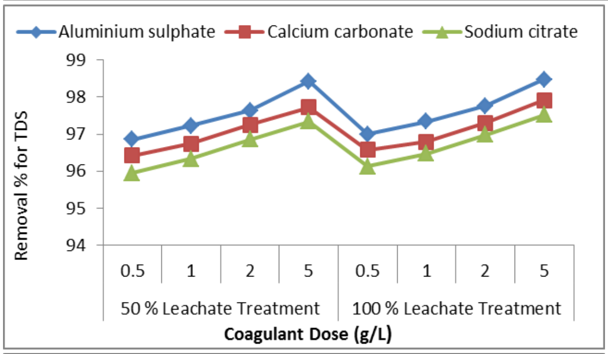
Sulphates (SO_4^{-2})

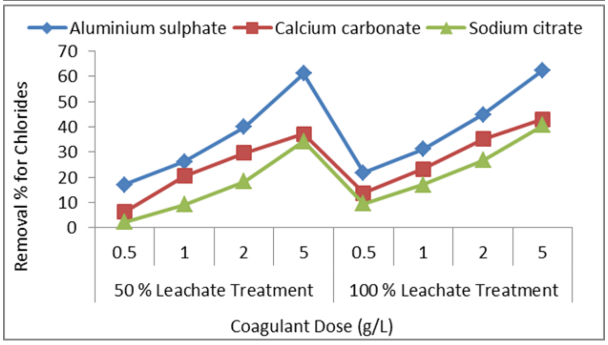
Sulphates(SO_4^{2})of50%and100%leachateatdifferentdosesofcoagulantsandtheirefficiencyremovalfoundfollowingtrend0.5(g/L)Dose<1(g/L)Dose<2(g/L)Dose<5 (g/L)Dose respectively. Comparison of different doses of coagulants and their removal efficiency found following trend Aluminium sulphate>Calcium carbonate >Sodium Citrate.

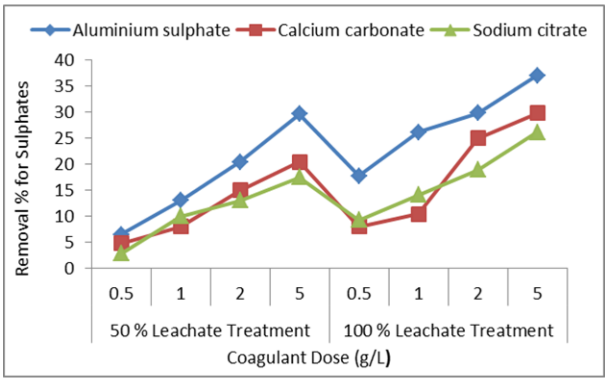










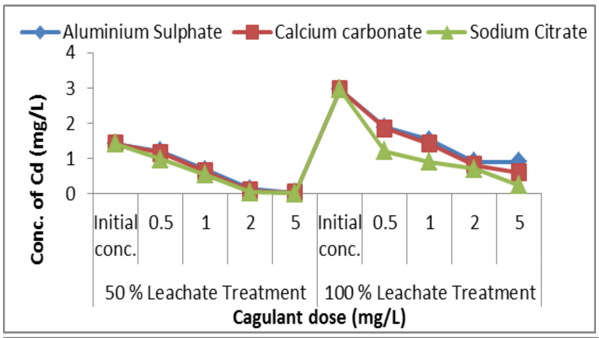


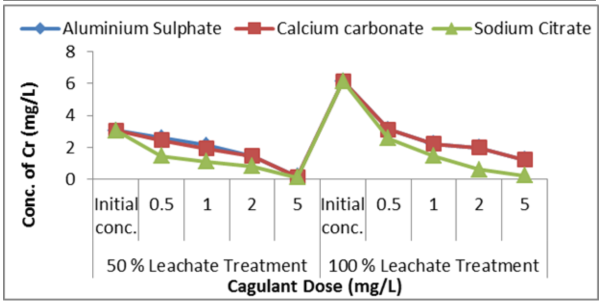
Removal of Metals from Leachate by Coagulation

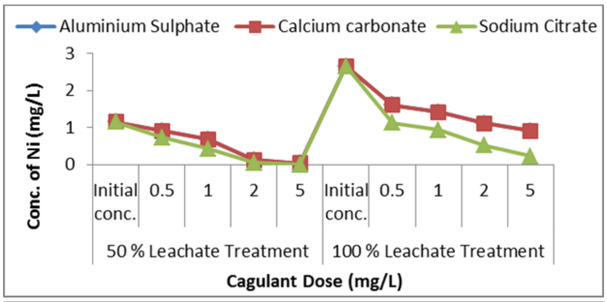
In comparison with different metals maximum Cadmium has removal efficiency with Aluminium Sulphate, maximum Lead removal efficiency with Calcium carbonate, maximum Nickle has removal efficiency with Calcium carbonate, maximum Chromium has removal efficiency with Sodium Citrate and Lead (Pb) has lowest removal efficiency with Sodium Citrate on different dose of coagulants of metal concentration in 50% leachate.

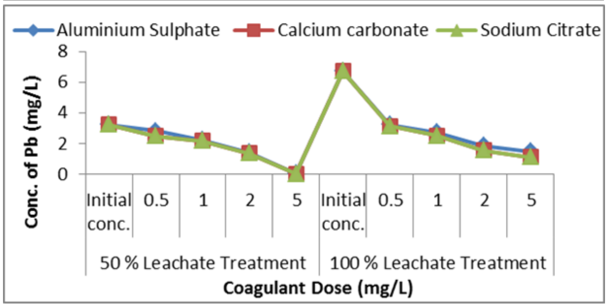
IncomparisonmaximumChromiumremovalefficiencywithAluminiumSulphate

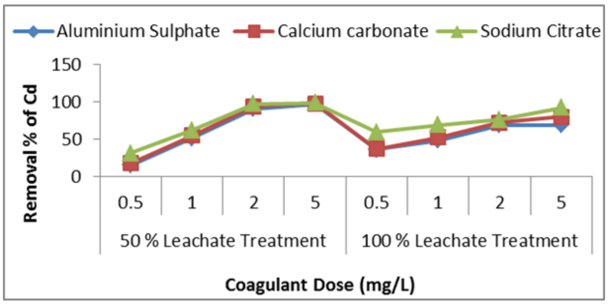
,maximum Lead removal efficiency with Calcium carbonate and maximum Chromium has removal efficiency with Sodium Citrate , maximum Nickle has removal efficiency with Calcium carbonate and lowest removal of Lead (Pb) on different dose of coagulants of metal concentration in 100% leachate found.

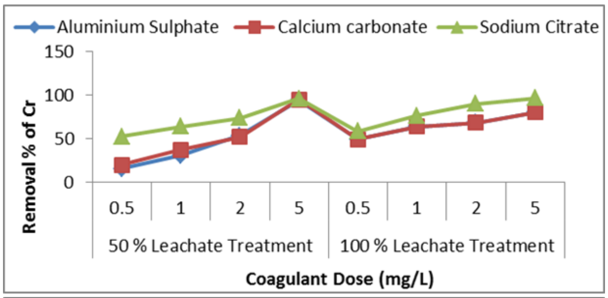


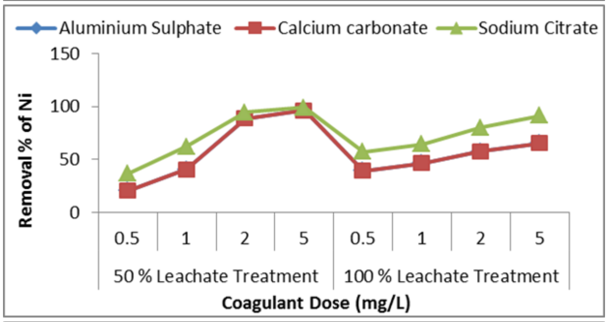


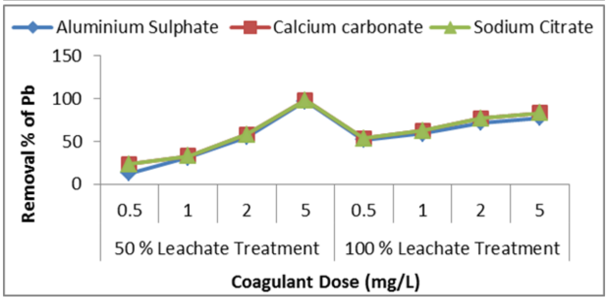












Discussion

Many countries are using the common practice of open dumping for municipal solid waste resulting in a number of environmental problems. Due to high variability in quantity and composition of leachate, its management is one of the important challenges of landfill sites. Leachate is actually the percolate of dumped wastes in landfill site which is produced due to rainfall, biological and chemical processes and moisture content of disposed solid wastes (Adeoluet al., 2011).

A number of factors like composition of wastes , moisture content ,density ,degree of compaction , age of landfill site , quality of liner , particle size , generation of gas and heat , rainfall, invasion of ground water , plantation ,cover, settlement ,irrigation,climatic factors like humidity , precipitation, seasonal variation and sunlight control the quality and quantity of leachate (Renou et al.,2008). Leachate has severe adverse impacrs to the environment if not properly treated and thus causing the pollution of water bodies and soil (Adeoluet al., 2011; Xie et al., 2016). Slow biological and chemical degradation processes in dumped wastes, help in the continuous formation of leachate even after final cover laid down and operational activities has seized on landfill site (Labanowski et al.,2016). Metal contaminated soil is a big environmental challenge and badly affects the animals, plant and human health. Physiochemical processes are not cost effective for reclamation of this type of polluted soil but these also damages the innate properties of soil.(Tandy et al., 2006;

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Sallah-Ud-Din et al., 2017). In contrary , using plant species to clean up the soil is a relatively new approach which is economically affordable and environmental friendly (He et al., 2005; Farid et al., 2017).

Coagulation of different concentrations of leachate by using different dosages of three coagulants was studied to evaluate the effective concentration and dosage (Çeçen & Çakiroglu 2001; Mojiriet al., 2006; Ranjanet al., 2016). Coagulation is a three step process. In first step electrical charges are neutralized and particles are separated. In second coagulant surrounds the separated particles and in third one, coagulant destabilizes the particles by adsorbing on their surface (Van Loon& Duffy, 2011).

Coagulation and subsequent flocculation is similar to chemical precipitation and leachate is treated to a basic pH and coagulating alum added to overcome the electrostatic repulsion of suspended colloidal particles. The heavy metals in the water act as a flocculating agent and cause colloidal particles to group together forming floccules that precipitate out of solution. Coagulation-flocculation methods for heavy metal removal are effective in removing high concentrations of heavy metals but many of the same disadvantages as chemical precipitation arise, namely large quantities of expensive chemical additives and large volumes of toxic sludge (Kurniawan et al., 2006).

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