

# Coagulation Study to Remove Heavy Metals from Leachate

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**ABSTRACT:** Leachate is a concentrated liquid that originates from solid waste dumping sites. Releasing of leachate to the environment without treatment pollutes the soil, surface and ground water. In this study leachate is treated with Alum and in conjunction with polyelectrolyte to remove heavy metals. The Alum with Polyelectrolyte has shown higher removal efficiency of heavy metals. Alum of dosage 1 g/l and combination with 0.3g/l of polyelectrolyte produced optimum results in removal of Cadmium, Chromium and Nickel removal efficiencies being 92.4%, 77.3% and 80.1% respectively at pH 7.

**KEYWORDS:** Leachate, coagulation, polyelectrolyte, pH, dosage.

## I. INTRODUCTION

Solid waste generation is growing rapidly due to change in life style and urbanization. Unscientific waste handling and management cause environment degradation and health hazards. In many cases the solid waste are either dumped in the open land or follow the sanitary landfill method for management of solid waste which is cost effective.

One of the greatest disadvantages of landfill method is leachate formation. Leachate is any liquid which is highly complex and polluted, produced due to the percolation of water through the body of landfill. In terms of pH, the leachate could be categorized as alkaline for old leachate and acidic for fresh leachate [1]. In India, the leachate is disposed of on open lands and it is fully exposed to water body thus leading to a drastic increase in pollution level of the surroundings [2].

A variety of waste is dumped in different landfill site of the city, which likely indicates the origin of Pb, Zn, Cu, Fe, Ni and Mn in leachate [3]. When leachate reaches the water by percolation or surface runoff, it causes water pollution. Heavy metals are drained regularly without proper treatment, then after some years the ground water will not be suitable for drinking purpose and it may cause diseases in the human being and animals.

There are several of methods to treat the leachate, in that coagulation is one of the treatments which is commonly used. Coagulation is generally achieved by adding different types of chemicals (like Alum, Ferric chloride, Ferric sulphate etc). These chemicals promote destabilization of colloidal dispersion and cause the agglomeration of colloidal particles. Once charge neutralisation takes place various particles come together which will result into coagulation [4]. The use of anionic polymers with metal salts has been reported to results in a number of benefits. Synthetic polymer will gives less sludge volumes, bigger and compact flock are achieved with greater settling rates [5].

Experimental study on removal of heavy metals from leachate was conducted by Afshin Maleki et al [4] using Alum and Ferric chloride. At pH 6.5 and Alum dosage 1400mg/l has been reported 18% removal of COD and 90 % removal of heavy metals (Cd, Ni, Cr, Cu and Zn). Lee Mao Rui et al. [5] conducted study on coagulation-flocculation in

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leachate treatment by using Ferric chloride and Alum as coagulant. Ferric chloride showed the highest removal efficiency of suspended solids (96%), COD (37%), ammonical nitrogen (26%) and colour (84%) at pH 7 compared to alum. Lee Mao Rui et al. [6] conducted study on coagulation-flocculation in leachate treatment using combination of PAC with Cationic and anionic polymers. Result from his study showed optimum removal by PAC with combination of cationic polymer was 99.2% of Suspended solid, 59% of COD, 89.8% of colour and 49% of ammonical nitrogen. The optimum removal by PAC with combination of anionic polymer was 99% of Suspended solid, 56% of COD, 89.4% of colour and 46% of ammonical nitrogen.

Adnan A. et al. [7] conducted study on treatment of raw leachate from fresh solid waste and the test was carried out for heavy metals. This study used conventional coagulants of alum, polymer and natural indigenous okra. The analysed results showed that the optimum pH values were 6.65, 7.00 and 9.00 for alum, okra and polymer respectively. In addition, the optimum dose of alum was 1400 mg/l and the removal efficiency of heavy metals was 45-80 %, while the optimum dose of polymer was 500 mg/L and the removal efficiency was of 70-95%. For okra, the optimum dose was 500 mg/L in which a removal efficiency of heavy metals was 20-100%. Polina Pilipenko [8] studied on cationic polyelectrolyte coagulant in municipal wastewater treatment. Polyelectrolyte dosage and treatment efficiency was predicted based on the raw water quality parameters, such as turbidity, suspended solids concentration and COD.

## II. METHODOLOGY

The grab leachate samples were collected as per sampling procedure from Avaragolla solid waste dumping place near Davangere and analysed for its characteristics. The TMS solution was prepared using three metal compounds containing chromium, cadmium and nickel. 5.7g of Cadmium sulphate, 5.65g of Potassium Chromate and 13.45g of Ammonium nickel sulphate were dissolved in 1000ml of distilled water. Thus 1ml of TMS solution was found to contain 5 mg of Cd, 1 mg of Cr and 2 mg of Ni.

To begin with experiments were conducted to optimize the Alum dosage at pH 3. Further the studies were carried out to optimize pH value (3 to 8) for the optimized Alum dosage obtained in the 1<sup>st</sup> set of experiment. The experiments were also conducted to evaluate the effect of polyelectrolyte in conjunction with Alum in removing metals selected for study. 0.3g/l of polyelectrolyte was used for experimentation and Alum dosage was varied from 0.5g/l to 2.5g/l. Jar tests were performed by maintaining the speed of 100 rpm for 5 min & 50 rpm for 30 min. After jar test, the contents of the Jar were allowed to settle for 1hour. Then the supernatant was analysed for metal concentrations, using Atomic Absorption Spectrometer.

## III. RESULT AND DISCUSSIONS

### A. Leachate Characterisation

The characteristic analysis was carried out for leachate collected at different timings as per experimental requirements which are tabulated in Table 1. The leachate pH value of 2.73-3.2 observed indicated that the leachate is acidic and the metal concentration in the leachate detect were form to be very low concentrations and hence TMS 1 ml/l of leachate.

Table 1. Characteristics analysis of leachate.

PARAMETERS	SAMPLE			
	1	2	3	4
pH	2.77	2.83	3.2	2.73
BOD (mg/l)	9400	9500	9542	9100
COD (mg/l)	46000	48540	59780	57850
Turbidity (NTU)	13875	9450	11175	16620
Conductivity (µs/cm)	10700	10010	13400	10920
Suspended Solids (mg/l)	5870	4930	6740	6990
TDS (mg/l)	9116	8300	9540	9240

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Colour (ptCo)	21525	21010	23530	21910
Chlorides(mg/l)	46000	42580	43000	44180
Acidity (mg/l as CaCO <sub>3</sub> )	1200	1350	1450	1340
Cadmium (mg/l)	0.1	0.13	0.06	0.09
Chromium (mg/l)	0.09	0.05	0.1	0.06
Nickel (mg/l)	0.3	0.26	0.23	0.1

Results after TMS addition was compared to the typical values quoted by different authors shown in Table 2.

Table 2. Heavy Metals present in leachate from different sources

Heavy metals	Leachate sample of present work (mg/l)	Value from Bagdad [7] (mg/l)	Value from Iran [4] (mg/l)
Nickel	2	5.97-6.42	0.65-3.8
Cadmium	2.5	1.02-3.7	0.07-0.34
Chromium	1	0.82-1.02	0.26-1.8

## B. Optimization Study

The coagulation study was carried out for dosage optimization using sample containing heavy metals. Alum dosage was varied from 0.5g/l to 2.5g/l with difference of 0.5 g/l, and pH 3 was maintained (by adding HCL/NaOH). The results of experimentation are shown in Fig 1. The removal metal sequence of Cadmium>Chromium>Nickel was observed. The optimum Alum dosage was found to be 1.5g/l. At this optimum dosage the removal efficiency of 48%, 50.8% and 17.75% respectively were recorded for Cadmium, Chromium and Nickel.

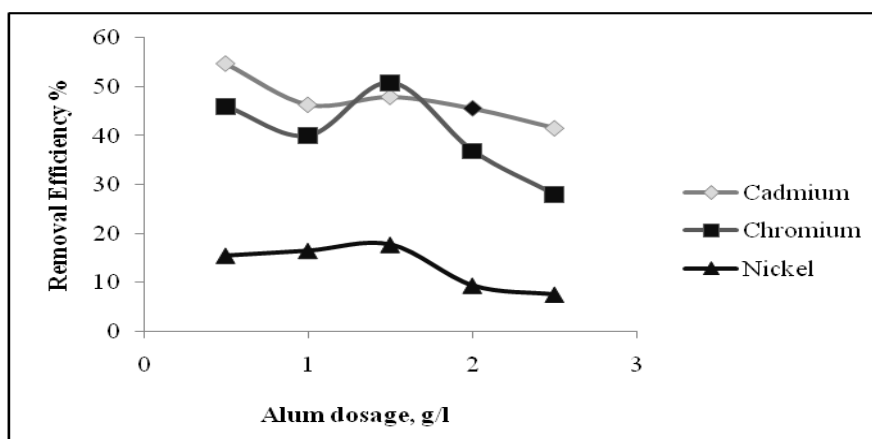


Fig. 1. Effect on removal efficiency of parameter using varying dosage of Alum at pH 3

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In the second set of experimentation pH was varied from 3 to 8 and optimized Alum concentration of 1.5g/l obtained in the 1<sup>st</sup> set was maintained. The result of experimentation was shown in Fig 2. Linear relationship between pH and removal efficiency was observed up to pH 7. And further increase in pH 7 to 8, at optimum pH 7 removal efficiency of 86.8% (Cd), 66.7% (Cr) and 78.9% (Ni) were recorded.

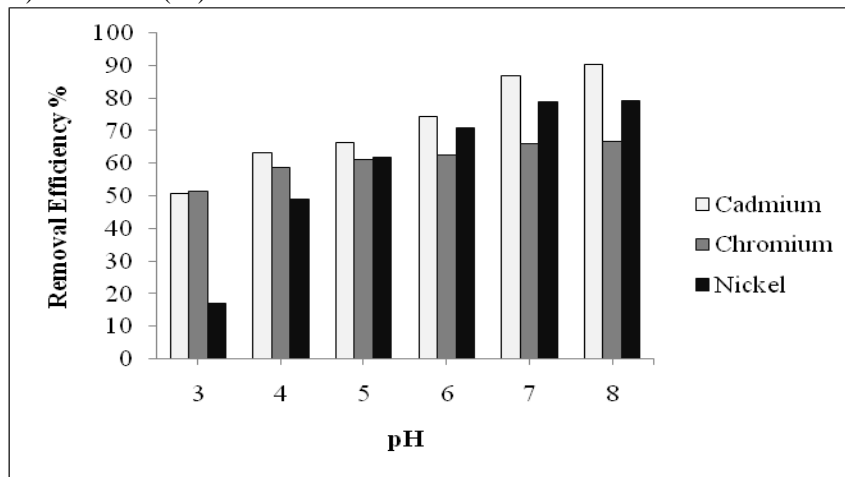


Fig. 2. Effect on removal efficiency of parameter using optimum dosage of Alum at varying pH

Further the experiment was carried out to evaluate the removal efficiency with the addition of polyelectrolyte along with Alum. Experiment was conducted at pH 3 and polyelectrolyte concentration of 0.3g/l (each beaker) and by varying alum dosage from 0.5g/l to 2.5g/l. The results are represented in Fig 3. Within the statistical limitations the removal efficiency were found to be better corresponding to Alum dosage of 1g/l and polyelectrolyte dosage of 0.3g/l, the correspond of removal efficiency were respectively Cadmium, Chromium and Nickel of 54.8%, 58.4% and 24.5%.

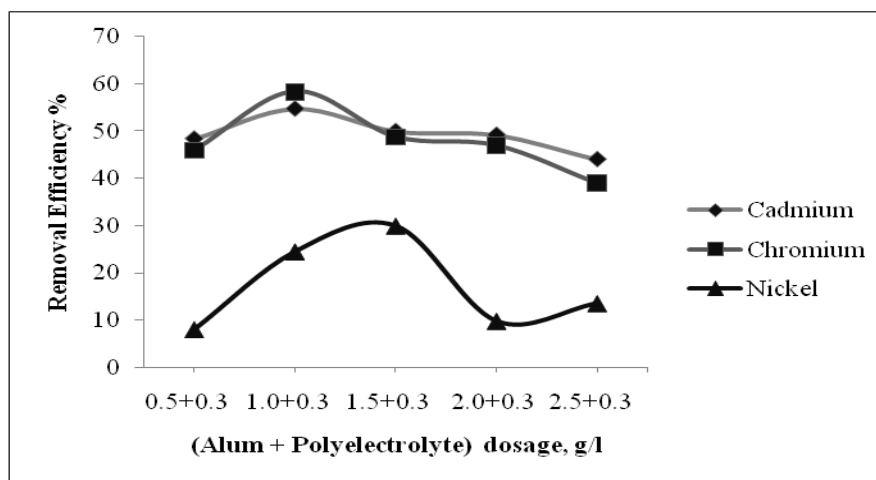


Fig. 3. Effect on removal efficiency of parameter using varying dosage of Alum with polyelectrolyte (0.3 g/l) at pH 3

The results obtained by conducting the experimentation to optimize the pH value in removing metals. At this optimized dosage of Alum and polyelectrolyte are presented in Fig 4. The trends of experimentation remain same at that of the pH studies using Alum without polyelectrolyte. Maximum removal efficiencies of 92.4%, 77.3% & 80.1% for metals Cadmium, Chromium and Nickel respectively were observed at pH 7.

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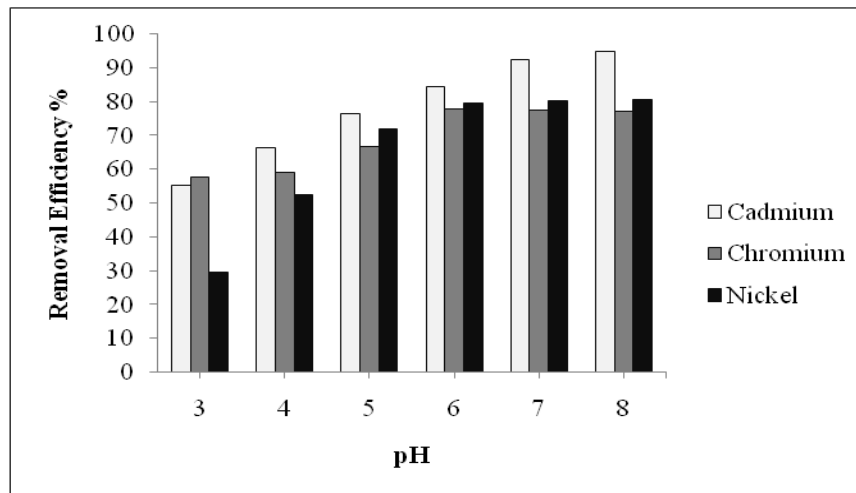


Fig. 4. Effect on removal efficiency of parameter using optimum dosage of Alum combination with polyelectrolyte at varying pH

## IV. CONCLUSION

The experimental result shows that Alum improved its removal efficiency of heavy metals after adding polyelectrolyte. The removal efficiency of the heavy metal increases with increasing pH until it reaches to optimum pH 7. Alum of dosage 1g/l and combination with 0.3g/l of polyelectrolyte has given optimum result in removal Cadmium, Chromium, Nickel showing removal efficiencies of 92.4%, 77.3% & 80.1% respectively at pH 7.

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