An Experimental Study on Purification of Leachate using Fly Ash and Analysis of Results

Chaitrali Sanjay Kulkarni[1], Dr. Saswati Datta[2]

[1]PG Student, Department of Civil Environmental Engineering, D.Y.Patil College of Engineering, Akurdi, Pune, Maharashtra, India.
[2]Associate Professor, Department of Civil Engineering, D.Y.Patil College of Engineering, Akurdi, Pune, Maharashtra, India.

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Abstract - *In most countries, sanitary land filling is nowadays the most common thanks to eliminate municipal solid wastes (MSW). In spite of the many advantages, generation of heavily polluted leachates, presenting significant variations in both volumetric flow and chemical composition, constitutes a major drawback. Year after year, the popularity of landfill leachate impact on environment has forced authorities to repair more and more stringent requirements for pollution control. This paper may be a study of landfill leachate treatments. Landfill leachate may be a significant polluting factor of the environment. The leachate generation may be a major problem of municipal landfill sites or dump yards. The leachate may be a toxic black liquid leached from the landfill containing dissolved and suspended matter in it. Leachate may be a product formed when precipitation or atmospheric moisture enters the landfill that's undergoing degradation. The leachate contains organic and inorganic compounds, heavy metals and pathogens, if not collected they will pollute both surface and groundwater.*

*Their low biodegradability, high nitrogen content and presence of other possible toxic components, the co-treatment of leachate together with the municipal waste water within the conventional municipal waste water treatment plants is undesirable. This paper presents a research of leachate treatment technologies, its fundamental background studies, and environmental implications. Also a literature review concerning particularly includes a filtration process that produces use of marine sand and ash filter beds followed by heavy metal removal using activated charcoal powder and therefore the finish may be a filtration method for treating landfill leachate. Because the filtrate from the leachate treatment process contains nutrients useful for plant growth mainly the nitrogen (N) content which plays an important role within the crop yield. So along with treatment process future scope of the project the suitability of leachate for irrigating plants, crop fields. Thus the use of fertilizer*s can be reduced and the soil fertility is enhanced.

Key Words: Leachate, Fly ash, Landfill leachate treatment, Adsorption, Filtration process, Marine sand, activated charcoal, toxic

1. INTRODUCTION

In India unscientific design of dump yards and indiscriminate disposal of waste is causing numerous threats to environment and mankind. Leachate is a dark-coloured liquid with strong smell that leaches or drains from landfill containing dissolved and suspended solids, percolating into the ground contaminating the ground water and the soil. Leachate composition is primarily a function of age of the landfill and the degree of water stabilization. The leachate consists of dissolved organic matter, inorganic macro components and heavy metals at higher concentration. Conventional methods of leachate purification include recycling and combined treatment with domestic sewage, chemical oxidation, adsorption, biological treatments, etc. Due to low biodegradability, high nitrogen content and presence of other possible toxic components, the co-treatment of leachate or conventional municipal waste water treatment plants is undesirable. Thus one should make sure that these components are removed or reduced according to the standards before discharge of the effluent. The depletion of water resources and the degradation of their quality is a major challenge. The richness of silica in marine sand allows higher reduction of COD and BOD and the pozzolanic reaction between fly ash and lime of sand stabilizes heavy metal. India the nearby wells were significantly contaminated due to leachate and 9% of the samples near to the disposal site were unsuitable for drinking purposes. Thus this paper focuses on the treatment of leachate with locally available materials. The filtration process makes use of marine sand and fly ash filter as filter beds forming the first stage of treatment followed by heavy metal removal using fly ash. The filtrate from the leachate treatment process is analysed for its physiochemical properties and its suitability for irrigation purpose is also studied. Thus reducing the use of fertilisers and enhancing the soil fertility.

1.1 Aim

- A physicochemical characterization of raw leachate.
- A Purification of leachate which contains toxic elements; it can pollute surface and groundwater also health risk.
- A use of waste by- product Fly ash.

1.2 Objectives

- To treat the leachate collected from Moshi landfill Site, PCMC, Pune, using a filtration process that makes use of Sand, gravel coarse base and Fly ash, a heavy metal removal and finally treatment through biological and chemical treatment.
- To design the model for experiment work.
- To compare test results with respect to raw leachate and after treatment collecting filtrate.
- To utilize the waste materials for project work.
- To optimize process for efficiency and cost.

2. Experimental Materials

2.1 Leachate

The leachate sample was collected from the solid waste management site at moshi, PCMC, Pune. The collected leachate's physical and chemical characteristics were found. The physical and chemical analysis involved temperature, pH, conductivity, turbidity, Total Kejaldal Nitrogen (TKN), chloride, COD, BOD and heavy metals.

Table 1 – Physicochemical characteristics of Raw Leachate

Parameters	Test Values	Standard Limits
pH	9	6.5-8.5
BOD	1375 mg/l	100 mg/l
COD	1200 mg/l	250 mg/l
TSS	4750 mg/l	200 mg/l
TDS	1568 mg/l	2100 mg/l
Turbidity	5 NTU	1 NTU

2.2 Fly Ash

Fly ash is a waste by product from thermal power plants, steel mills, etc. that is found in abundance in the world. In recent years, utilisation of fly ash has gained much attention in public and industry, which will help reduce the environmental burden and enhance economic benefit.
Fly ash is collected from sant tukaram sugar factory at kasarsai, Pimpri Chinchwad, pune. Fly ash is waste by product of sugar factory.

Understanding the physical, chemical and mineralogical properties of coal ash is vital, as these properties influence its succeeding use and disposal. the particular properties rely on the sort of coal used, the combustion conditions, and also the collector setup, among alternative factors. Physically, ash happens as fine particles with a mean size of twenty twenty and has low to medium bulk density. Most ash is alkalic, and its surface is charged at high pH scale. Hence, it are often expected to get rid of metal ions from solutions by precipitation or static surface assimilation. Besides, it contains a particular volume of unburnt carbon, that contains a high surface assimilation capability. Ash has been investigated for its direct use as an adsorbent in each volatilized and liquid applications.

2.3 Marine Sand

The marine sand was collected from nearby areas. As per locally available by near areas. Sieve analysis was carried out for these sand samples. Then it will be useful for project work.

When the aggregate is sieved through 4.75mm sieve, the aggregate passed through it called as fine aggregate. Natural sand is generally used as fine aggregate, silt and clay are also come under this category. This is sand will used in the experiment.

Table 2 – Sieve Analysis of Marine Sand

Sieve Size	Particle Diameter	Weight of Sample
4.75 mm	4.75	100
2.36 mm	2.36	100
1.18 mm	1.18	99
600 micron	0.6	78
425 micron	0.425	53
300 micron	0.3	42.5
150 micron	0.15	1
90 micron	0.09	0.5
Pan	-	0

Sand is a mixture of small grains of rock and granular materials which is mainly defined by size, being finer than gravel and coarser than silt. And ranging in size from 0.06 mm to 2 mm. Particles which are larger than 0.0078125 mm but smaller than 0.0625 mm are termed silt.

The fly ash used is a class C fly ash because it mainly consists of silica, alumina and calcium, Class C fly ash has more carbon content than a class F fly ash. Based on a trial and error method the suitable proportion for marine sand and fly ash (class C) was derived using a miniature prototype filter. The optimum amount of fly ash to be added is 2% of marine sand

2.4 Coarse Gravel

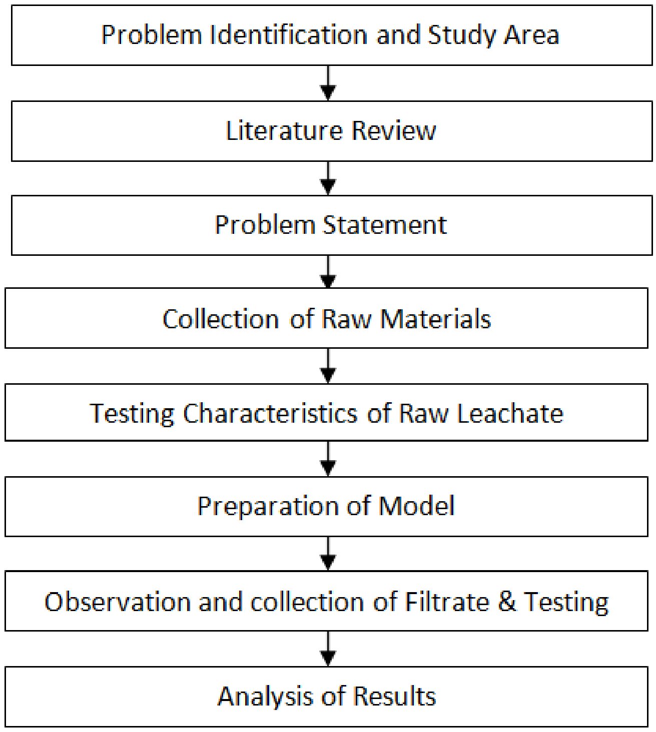
Aggregates can be classified in many ways. Classification of aggregates based on shape and size such as coarse and fine aggregates.

When the aggregate is sieved through 4.75mm sieve, the aggregate retained is called coarse aggregate. Gravel, cobble and boulders come under this category. The maximum size aggregate used may be dependent upon some conditions. In general, 40mm size aggregate used for normal strengths and 20mm size is used for high strength concrete. The size range of various coarse aggregates given below.

Table 3 – Coarse Gravel Size

Coarse Aggregate	Size
Fine Gravel	4mm – 8mm
Medium Gravel	8mm - 16mm
Coarse Gravel	16mm – 64mm
Cobbles	64mm – 256mm

3. METHODOLOGY



3.1 Collection of Materials

Various materials like raw leachate, fly ash, marine sand and coarse gravel required for purification process of leachate.

3.2 Tests on Materials

Following tests are required to tests the properties of raw leachate and for comparing the results to final results.
Tests on Raw Leachate

- ph
- Biological Oxygen Demand
- Chemical Oxygen Demand
- Total Dissoloved Solids
- Total Suspended Solids
- Turbidity
- Heavy Metal Concentrations – copper, manganese, nickel, arsenic, mercury, lead, chromium, cadmium, iron. Zinc.

3.3 Preparation of Model

To performing filtration technique and comparing the results for analysis of experimentation, the model is required so I will be doing experiment work on that model.

3.4 Observations and collection of Filtrate

After making model, filtration process was started with pouring leachate sample in it. Filtrate was collected in a container. Then it was taking for further testing. For analyasing the results, tests is required.

3.5 Analysis of Results

In the analysis, raw leachate tests observations and after treatment filtrate tests was compared and their toxicity performance was also analyzed. The comparison was shown with tests results.

4. STAGES OF TREATMENT

Based on the studies the following stage treatment process is proposed for the leachate treatment. This treatment ensures that the filtrate (effluent) has its physiochemical parameters within Indian Standard limits. The stages of treatment include a filtration process, a heavy metal removal process.

The filter model is a cylindrical unit of 25cm in diameter and 40cm in height. The height of filter bed is 36cm and 14cm for raw leachate. The filter bed consists of a coarse gravel layer at the bottom and over it a layer of marine sand and fly ash mixture. In order to protect the surface of filter bed coarse gravel are used. For filtration as a filter unit one filter mesh is used. All the materials used for experiment is waste materials.

At the bottom of this cylinder coarse gravel is used. Above that marine sand layer is filled. Then main part fly ash is filled over top most side of cylindrical unit. After that proceeding to filtration process.

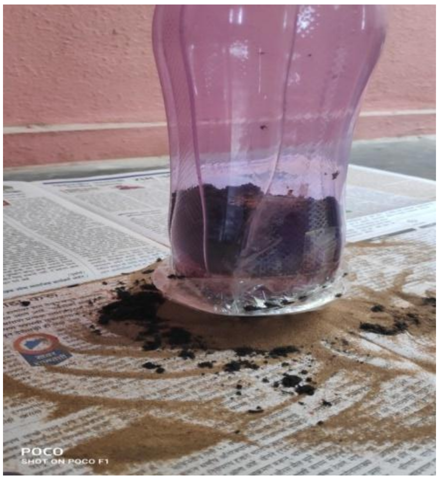


Fig. 1 Stages of Filtration – Pouring Materials

The method is based on the following principle: a slow filtration, the leachate passes under a constant load through the filter bed, the load is kept constant along the experiments.

Filtration Process: The filter model is a cylindrical unit of 25-30cm in diameter and 40cm in height. The height of filter bed is 36cm and 14cm for raw leachate. The filter bed consists of a coarse gravel layer at the bottom and over it a layer of marine sand and fly ash mixture. In order to protect the surface of filter bed gravels are used.

Fig. 2 Filtration Process

Heavy Metal Removal: The filtrate was collected from this arrangement of model. The filtrate (effluent) from the stage I filtration process is collected in container and it takes for further tests. The final effluent is thus tested for its physical and chemical properties.

5. RESULTS AND DISCUSSION

5.1 General

Comparison of tests results between raw leachate tests and after treatment of filtration.

The pre – treatment tests of raw leachate and after filtration filtrate (effluent) tests are done. The raw leachate tests like pH, BOD, COD, TSS, TDS, turbidity, and heavy metal concentration were treated continuously.

5.2 Analysis of Results

- The filtrate (effluent) from final stage of treatment is analyzed for its physicochemical properties and heavy metal concentrations.

Table 4 – Test Results

Parameters	**Test Values**		**Standard Limits**
	Raw Leachate	**Filtrate (effluent)**	
pH	9	8	6.5 – 8.5
BOD	1375mg/l	130 mg/l	100 mg/l
COD	1200 mg/l	648 mg/l	250 mg/l
TSS	4750 mg/l	104 mg/l	200 mg/l
TDS	1568 mg/l	950 mg/l	2100 mg/l
Turbidity	5 NTU	1 NTU	1 NTU

- The treatment has reduced the COD of leachate from 1200 mg/l to 648 mg/l, therefore the rate of reduction of COD using treatment process is 60%.
- The BOD reduction with the help of this treatment process is only 75%.
- After filtration process, it showed less temperature when compared with raw leachate temperature.
- The pH of aw leachate was 9 and for the filtrate is found to be 8. This shows that the leachate collected was alkaline in nature and after treatment it is under IS limits (6.5 – 8.5).
- The turbidity of raw leachate was 5 NTU and it is 1 NTU for filtrate (effluent).
- The turbidity of the filtrate (effluent) is within IS permissible limits.
- The TDS of raw leachate was 1568 mg/l whereas for the final filtrate it is found to be 950 mg/l. Therefore, the treatment process has provided a reduction rate of 70%.

Table 5 – Heavy Metal Concentration

Element	**Heavy Metal Concentration**		**Standard Limit**
	Raw Leachate	**Filtrate (Effluent)**	
Iron (Fe)	0.5	0.4	0.3
Zinc (Zn)	7.2	1.27	5.0
Manganese (Mn)	0.06	0.01	0.01
Arsenic (As)	0.1	0.01	0.01
Chromium (Cr)	0.021	0.03	0.05
Lead (Pb)	0.37	0.25	0.5
Cadmium (Cd)	0.004	0.01	0.005
Nickel (Ni)	0.032	0.1	0.1

- After filtration, the contents in heavy metals of leachate which revealed condsiderable concentration of iron, chromium, aluminium, arsenic and manganese.
- Cadmium level was negligible
- The lead concentration reached 0.25 mg/l, it is related to the industrial waste.
- The variability of removal rate of metals is due to the ionic form of each metal.
- Iron ions which recorded the highest concentration in raw leachate and persisted at the treatment and now strongly reduced with reduction rate 80%.
- The fly ash used to react with lime of sands, the reactions produces stable calcium silicate hydrates.
- After filtration, the contents in heavy metals of leachate with the richness of silica of sand, the surface hydroxyl groups are formed by hydration which allows the adsorption of metallic cations. It further allows the stabilization of heavy metals.
- Fly ash plays important role for the adsorption of heavy metals.
- Although rare, the manganese oxides of sands play also an important role because they have particular affinity for some heavy metals (Cu, Zn, Ni, Pb,..) which they can absorb in large amounts.

6. CONCLUSIONS

1. The leachate treatment process by these treatment stages has provided 60%, 75% and 70% reduction rates for COD, BOD and TDS respectively.
2. The turbidity and pH of the filtrate is under IS limits, thus the treatment process is effective on this aspect.
3. This treatment process makes use of locally available materials and thus its cost efficient.
4. The richness in silica of sands allows a higher reduction of COD and BOD and good absorption of metallic cations.
5. The pozzolanic reaction between fly ash and lime of sands promotes the stabilization of heavy metals of leachate with contents.
6. Sands filter allows an important reduction of contamination germs.
7. The filter substrate selected can be used for the landfill leachate treatment in big scale.

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