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Experimental Investigation of Leachate Treatment Using Low-Cost Adsorbents

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Abstract - The aim of the project work is to treat the landfill leachate before disposal. The necessity for landfill leachate treatment is a requisite to reduce the environmental related to impact related to municipal solid waste land fill. If leachate is directly disposed into environment it creates serious problems on the surrounding soil, ground water aquifers and nearby surface water. Therefore great attention has been directed towards new techniques based on physico- chemical process, and heavy metals removal using low cost materials as filter media with down flow reactor. Leachate generation is a major problem for municipal solid waste (MSW) landfills and causes significant threat to surface water and groundwater. Leachate can be defined as a liquid that passes through a landfill and has extracted dissolved and suspended matter from it. Leachate results from precipitation entering the landfill from moisture that exists in the waste when it is composed. Different consider while deciding for an appropriate treatment process. This paper presents the results of the analyses of leachate treatment from the solid waste land fill.

Key Words*: : *Leachate, physico-chemical process, landfill, precipitation, solid waste, Municipal Solid Waste (MSW).

I INTRODUCTION

Sanitary landfill is a process in the solid waste management system. It can be defined as "a method of disposing of refuse on land without creating nuisances or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation or at such more frequent intervals as may be necessary."

Solid waste landfills may cause severe environmental impacts if leachate and gas emissions are not controlled. Leachate generated in municipal land fill contains large amounts of organic and inorganic contaminants. Leachate may also have a high concentration of metals and contain some hazardous organic chemicals. The removal of organic material based on COD, BOD and ammonium from leachate is the usual prerequisite before discharging the leachate into natural waters.

A. OBJECTIVE

Our main objective is to treat the landfill leachate using low cost adsorbents.

- To utilize a natural low cost material for treating leachate concentration. To avoid potential risks and hazards to public health and ecosystem.
- On purpose of purifying leachate liquid for final discharge to natural Water body and land disposal.

To reduce the filtration of leachate through waste thus minimizing the migration of toxic pollutant.

B. COLLECTION OF SAMPLE

We have collected the leachate sample at the landfill site in Namakkal. The sample was collected using cans. The can were cleaned by rinsing them with acid initially and then with distilled water. They were dried and taken out to the sampling location. The cans were rinsed once again with the sample and then filled in cans. The sample were immediately brought to the laboratory &using grap sampling method, the sampling cans are 15 liter capacity which are cleaned several time with tap water, then with distilled water and rinsed fully with 1N HNO_3 for removal of living micro-organisms, pathogens and odor of the sample cans.

II METHODOLOGY

The method of systematical, theoretical analysis applied to a field of study is called methodology , it comprises the theoretical analysis of the body of method and principles associated with the branch of knowledge.

- Sample collection
- Sample testing
- Treatment by natural materials
- Testing after treatment
- Result & discussion

III MATERIALS USED

The following are the adsorbents used to treat leachate,

- Sugarcane bagasse
- Laterite soil
- Brick bats

A. SUGARCANE BAGASSE

Sugarcane bagasse is a lingo cellolusic fibre residue obtained from sugar cane culm , after the culm is milled and the juice is extracted. The average composition of sugar cane is 66–75% water, 12–18% sugars, 9–14% fibres and 13–23% soluble solids. The cane basically consists of juice and fibre (Santaella, 2007). The sugar cane bagasse has the following composition (by weight): cellulose, 41.8%; hemi cellulose (aspentosan), 29.0%; lignin, 21.6% Developing countries account for more than 68% of current global sugar consumption, particularly in Asia–and are expected to be the primary source of future demand growth. Brazil is the major player and the most competitive supplier in the world sugar market, with the lowest production costs both infield and factory Sugarcane bagasse presented a lower content of lignin than the other lingo cellulosic materials evaluated, and a high average content of extractives and holo cellulose.

Fig . 1 Sugarcane bagasse

B. LATERITE SOIL

Late rite is both a soil and a rock type rich in iron and aluminum and is commonly considered to have formed in hot and wet tropical areas. Nearly all laterites are of rusty- red coloration, because of high iron oxide content. They develop by intensive and prolonged weathering of the underlying parent rock. Tropical weathering (laterization) is a prolonged process of chemical weathering which produces a wide variety in the thickness, grade, chemistry and ore mineralogy of the resulting soils. Laterites are a source of aluminum ore; the ore exists largely in clay minerals and the hydroxides, gibbsite, boehmite, and diaspore, which resembles the composition of bauxite. In Northern Ireland they once provided a major source of iron and aluminum ores. Laterite ores also were the early major source of nickel.

Fig. 2 Laterite soil

A. BRICK BATS

Brick bats is defined as a cut portion of brick , generally the brick is cutted along the width and the length of brick piece is smaller then the original brick. brickwork, a bat (or, sometimes, bat) is a shorter and sometimes shaped section of a single brick to fit a specific need in the patter no bricklaying being performed he required quantity of brick bats is taken as filter media for treating landfill leachate. The following shows the image of brickbats, which removes heavy metals present in the leachate.

Fig. 3 Brick bats

IV TEST PROCEDURE

A. pH

In chemistry, pH is a measure of the activity of the (solvent) hydrogenion. pH, which measures the hydrogen ion concentration is closely related to and is often written as pH . Pure water has a pH very close to 7 @ 25ºC solution with a pH less than 7 are set to be acidic and solution with a pH greater than 7 are basic or alkaline. The pH scale is traceable to a set of standard solution whose pH is established by international agreement. Primary pH standard values are determined using a concentration cell with transference, by measuring the potential difference between a hydrogen electrode and a standard electrode such as the silver chloride electrode. Measurement of pH for aqueous solution can be done with a glass electrode and a pH meter or using indicators.

Fig. 4 pH Test apparatus

B.TURBIDITY

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Turbidity is considered as a good measure of the quality of water

Fig 5 Turbidity meter

B. BIOCHEMICAL OXYGEN DEMAND

Biochemical oxygen demand (BOD) represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic (oxygen is present) conditions at a specified temperature. The presence of a sufficient concentration of dissolved oxygen is critical to maintaining the aquatic life and aesthetic quality of streams and lakes. Determining how organic matter affects the concentration of dissolved oxygen (DO) in a stream or lake is integral to water- quality management. The decay of organic matter in water is measured as biochemical or chemical oxygen demand. Oxygen demand is a measure of the amount of oxidizable substances in a water sample that can lower DO concentrations. Certain environmental stresses (hot summer temperatures) and other human-induced factors (introduction of excess fertilizers to a water body) can lesser the amount of dissolved oxygen in a water body, resulting in stresses on the local aquatic life. One water analysis that is utilized in order to better understand the effect of bacteria and other microorganisms on the amount of oxygen they consume as they decompose organic matter under aerobic (oxygen is present) is the measure of biochemical oxygen demand (BOD). BOD analysis is similar in function to chemical oxygen demand (COD) analysis, in that both measure the amount of organic compounds in water. However, COD analysis is less specific, since it measures everything that can be chemically oxidized, rather than just levels of biologically oxidized organic matter.

Fig . 6 BOD Bottle

B. CHEMICAL OXYGEN DEMAND

The chemical oxygen demand (COD) is a measure of water and wastewater quality. The COD test is often used to monitor water treatment plant efficiency. This test is based on the fact that a strong oxidizing agent, under acidic conditions, can fully oxidize almost any organic compound to carbondioxide. The COD is the amount of oxygen consumed to chemically oxidize organic water contaminants to inorganic end products. The COD is often measured using a strong oxidant (e.g. potassium dichromate, potassium iodate, potassium permanganate) under acidic conditions. A known excess amount of the oxidant is added to the sample. Once oxidation is complete, the concentration of organics in the sample is calculated by measuring the amount of oxidant remaining in the solution. This is usually done by titration, using an indicator solution.

COD is expressed in mg/L, which indicates the mass of oxygen consumed per liter of solution.

C. TOTAL DISSOLVED SOLIDS

Total dissolved solids (TDS) is a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular (colloidal sol) suspended form. TDS concentrations are often reported in parts per million (ppm). Water TDS concentrations can be determined using a digital meter. Total dissolved solids are differentiated from total suspended solids (TSS), in that the latter cannot pass through a sieve of 2 micro meters and yet are indefinitely suspended in solution. The term settleable solids refers to material of any size that will not remain suspended or dissolved in a holding tank not subject to motion, and excludes both TDS and TSS. Settleable solids may include larger particulate matter or insoluble molecules. Total dissolved solids include both volatile and non-volatile solids. Volatile solids are ones that can easily go from a solid to a liquid state. Non-volatile solids must be heated to a high temperature, typically 550°C in order to Achieve this state change. Examples of non- volatile substances include salts and sugars.

D. CONCENTRATIONRANGESFORCOMPONENTS OF MUNICIPAL LANDFILL LEACHATE

It is estimated that each person contributes about 4 L/yr hazardous chemicals to their MSW stream. Lee and Jones (1991a) listed a wide variety of house hold products, which eventually reach MSW landfill, that contain Priority Pollutants; Brown and Nelson (1990) also discussed sources of hazardous chemicals in MSW leachate.

Parameter	**Concentration Range(Mg/L)**	**Average (Mg/L)**
BOD	1000-30000	10500
COD	1000-50000	15000
Total volatile acids	70-28000	NA
Nitrate	0.1-10	4
Ammonia	100-400	300
Phosphate	0.5-50	30
Ortho phosphate	1.0-60	22
pH	5-7.5	6.3
Chromium	0.05-1	0.9
Cadmium	0.001-0.1	0.05
Copper	0.02-1	0.5
Lead	0.1-1	0.5
Nickel	0.1-2	1.2
Iron	10-10000	430
Zinc	0.5-30	21

Table 1 Concentration Range of components in landfill leachate

E. EFFECT OF COMPONENTS

1) Copper

Copper is the third most used metal in the world. Copper is an essential micro nutrient required in the growth of both plants and animals. In humans, the production of blood haemoglobin. In plants, Cu is especially important in seed production, disease resistance, and regulation of water. Copper is indeed essential, but in high doses it can cause anaemia, liver and kidney damage, and stomach and intestinal irritation. Copper normally occurs in drinking water from Cu pipes, as well as from additives designed to control algal growth. While Cu' interaction with the environment is complex, research shows that most Cu introduced into the environment is, or rapidly becomes, stable and results in a form which does not pose a risk to the environment.

2) NICKEL

Nickel is an element that occurs in the environment only at very low levels and is essential in small doses, but it can be dangerous when the maximum tolerable amounts are exceeded. This can cause various kinds of cancer on different sites within the bodies of animals, mainly of those that live near refineries. The most common application of Ni is an ingredient of steel and other metal products. The major sources of nickel contamination in the soil are metal plating industries, combustion of fossil fuels, and nickel mining and electroplating.

3) ZINC

Zn concentrations are rising unnaturally, due to anthropogenic additions. Most Zn is added during industrial activities, such as mining, coal, and waste combustion and steel processing. Many foodstuffs contain certain concentrations of Zn. Drinking water also contains certain amounts of Zn, which may be higher when it is stored in metal tanks. Industrial sources or toxic waste sites may cause the concentrations of Zn in drinking water to reach levels that can cause health problems. Zinc is a trace element that is essential for human health. Zinc shortages can cause birth defects. The world's Zn production is still on the rise which means that more and more Zn ends up in the environment. Water is polluted with Zn, due to the presence of large quantities present in the waste water of industrial plants. A consequence is that Zn-polluted sludge is continually being deposited by rivers on their banks. Zinc may also increase the acidity of waters. Some fish can accumulate Zn in their bodies, when they live in Zn-contaminated water ways.

4) LEAD

Inhalation and ingestion are the two routes of exposure, and the effects from both are the same. Pb accumulates in the body organs (i.e., brain), which may lead to poisoning (plumbism) or even death. The gastrointestinal tract, kidneys, and central nervous system are also affected by the presence of lead. Children exposed to lead are at risk for impaired development, lower IQ, shortened attention span, hyperactivity, and mental deterioration, with children under the age of six being at a more substantial risk. Adults usually experience decreased reaction time, loss of memory, nausea, insomnia, anorexia, and weakness of the joints when exposed to lead . Lead is not an essential element. It is well known to be toxic and its effects have been more extensively reviewed than the effects of other trace metals. Lead can cause serious injury to the brain, nervous system, red blood cells, and kidneys . Exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure.

V TREATMENT METHOD

Landfill leachate is basically originated from infiltrated rainwater fraction in the cell of the landfill and water present in the mass grounded waste. Solid waste landfills may cause severe environmental impacts if leachate and gas emissions are not controlled. Leachate generated in municipal landfill contains large amounts of organic and inorganic contaminants. During treatment adsorbents will remove the heavy metals present in the leachate.

A. METHOD

- Land fill leachate is collected from municipal solid waste landfills NAMAKKAL Reactor body:- Prefabricated PVC pipe material: Laterite soil, brick bats and sugarcane bagasse
- PVC pipe having 57.15 mm internal diameter and 1067 mm height is used.
- Each reactor are provided with 100mm free board at the top; distance of 957 mm is maintained between in let and outlet port which were kept Constant in all reactors.
- Flow reactors R1, R2, R3 are used for study purpose.
- R1-consisting of laterite soil as filter media, R2- consisting of brick bats, R3-consisting of sugarcane bagasse, combination of all filter media in layers.
- Reactors are completely filled with filter media with light compaction.

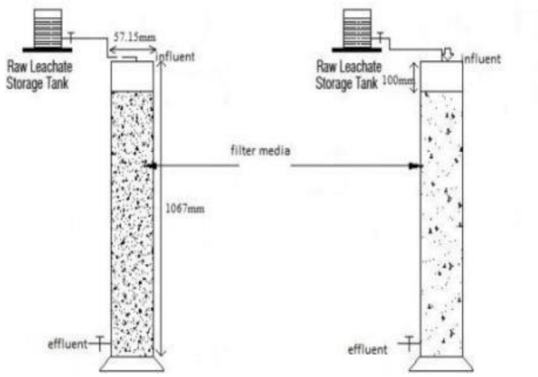

Fig 7 Filter media

VI TEST RESULTS

A. pH TEST RESULTS

Before treatment =4.6mg/l

After treatment using,

Sugarcane bagasse = 5.2

Late rite soil = 7.8

Brick bats = 6.3

B. TURBIDITY RESULTS

Before treatment = 0.57mg/l

After treatment using,

sugarcane bagasse = 2mg/l

laterite soil = 5.2.mg/l

brick bats = 2.54mg/l

C. TOTAL DISSOLVED SOLIDS

Before treatment,

Suspended solids = total solids – dissolved solids = 2.9-1.4

= 1.3mg/l

After treatment using,

sugarcane bagasse = 0.6mg/l

laterite soil = 0.4mg/l

brickbats = 0.9mg/l

D. BOD

BOD of leachate before treatrment = 10,000mg/l

After treatment using,

sugarcane bagasse = 623mg/l

laterite soil = 275mg/l

brickbats = 898mg/l

E. COD

COD of leachate before treatment = 30,127mg/l After treatment using,

Sugarcane bagasse = 6508mg/l

Laterite soil = 1502mg/l

Brick bats = 2598mg/l

F. HEAVY METALS REMOVAL FROM LEACHATE

The Atomic Absorption Spectrophotometer (AAS) (SHIMADZUAA-7000, Japan) was used for the determination of concentration of the metal ions present in the samples by reading their absorbance and comparing it on the respective standard calibration curve. Three replicate determinations were carried out on each sample and same analytical procedure was employed for the determination of elements in digested blank solutions and for the spiked samples.

The limit of detection for the heavy metals Cd, Cu, Pb, Zn and Cr was found to be 0.003, 0.01, 0.015, 0.002 and 1.01 mg /L respectively.

G . CONCENTRATION IN LEACHATE

Heavy metals	Limit in mg/l
Cadmium(Cd)	0.01
Zinc(Zn)	5.48
Lead(Pb)	5.00
Chromium(Cr)	0.10
Copper(Cu)	0.20

LTable 2 Leachate concentration

There were significant differences in the heavy metal concentrations of the leachates from the various waste dumpsites. The minimum and maximum mean concentrations of cadmium in leachates were 0.03 and 0.10 mg LG1from Kojokrom and Essipong waste dumpsites, respectively. Leachates from Effiakuma and Ntankoful waste dump sites recorded the same concentrations For cadmium (0.05mg LG1).The minimum and maximum mean concentrations of zinc in leachates were 0.20 and 5.48 mg/ L from Kojokrom and Essipong waste dump sites, respectively. Mean lead concentrations in the leachate samples from Kojokrom and Essipong waste dumpsites were the same. The minimum and maximum mean concentrations of chromium in leachates were 0.38 and 0.55 mg/L from Essipong and Effiakuma waste dumpsites, respectively. The minimum and maximum mean concentrations of copper in leachates were 0.17 and 0.90 mg/L from Effiakuma and Essipong waste dumpsites, respectively.

Metals	Sugarcane Bagasse (mg/l)	Laterite Soil(mg/l)	Brickbats (mg/l)
Copper	0.02	0.005	0.051
Lead	3.3	2.0	4.10
Zinc	4.0	3.4	4.2
Nickel	0.1	0.025	0.52

Table 3 Results of heavy metals after treatment

VII RESULTS AND DISCUSSION

The leachate sample was collected from landfill site using cans. we have used sugarcane bagasse, lateritesoil, brick bats as filter media for leachate treatment. The above results indicate that laterite soil removes the contaminants in the leachate when compared with other adsorbents. **After** treatment of landfill leachate using sugarcane bagasse, laterite soil, brick bats as filter media in PVC pipe, the effluent obtained from laterite soil as filter media contains less toxicity when compared with other adsorbents.

Laterite soil > Sugarcane bagasse > Brickbats.

Hence laterite soil, sugarcane bagasse are easily available, the process can be done for the treatment of landfill leachate which has been proven successfully.

VIII CONCLUSION

The reactor R1 which is filled with laterite as filter media is more efficient than compare to other reactors in removal of both heavy metals and physico-chemical parameters. Sugar cane bagasse and brick bats filter medias which contains high amount of dissolved organic matter which increases the dissolved solid content and Electrical conductivity. The removal of heavy metals is observed in both laterite and other filter media. The percentage of toxic content removed by laterite soil was 83%when compared to other filter medias. sugarcane bagasse can reduce the toxic content up to 62% which is higher when compared to brick bats 43%.Thus sugarcane bagasse, laterite soil are the best one to reduce toxic content in leachate. Leachate control is a very important step to receive the long-term functionality of the drainage system, to reduce treatment costs and to render possible high tech treatment systems. Now a days more than 100 leachete treatment plants are under operation in Germany, so there are many experiences concerning the technology, costs, the effluent quality and associated problems. In some cases the treatment of leachate resulted in increasing operation problems in opposite to the treatment of other wastewaters. The selection of the adaequate treatment process should not only include the compliance with the effluent limit values and maintenance but also the production of residuals which have to be further treated or disposed.

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