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Environmental Impact Analysis of Physico chemical Characterization of Landfill leachate from Municipal Solid Waste (MSW) dump yard in Dharapuram Town, Tamil Nadu, India

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Abstract

This paper discusses the physico chemical characteristics of leachate generated from municipal solid waste landfilling site of Dharapuram town, Tirupur district, Tamilnadu, India. Leachate samples were collected in and around the dump yard and analyzed for various physico-chemical parameters to estimate its pollution potential. The parameters were performed by following the standards of APHA, 2012. This research work aims to serve as a baseline data for the implementation of the most suitable technique and methods for reducing the negative environmental effects of discharging leachate in to soil. The present study on leachate analysis indicates that the quality of ground water was contaminated due to disposal of municipal solid waste at dumping yard. It was confirmed by the high Electrical conductivity, Total Dissolved Solids, COD and BOD values for both the seasons. The remaining parameters are also show the increase in concentration and the presence of heavy metal in the leachate samples are found at moderate concentration levels in all the leachate samples.

Keywords: Chemical Oxygen Demand, Leachate, Landfill, Heavy metals, Solids.

Introduction

Increasing human population levels, booming economy, fast urbanization and the increase in community living standards have greatly accelerated the generation of municipal solid waste in developing countries. Urban India generates 68.8 million tonnes per year of municipal solid waste (MSW) at a per capita waste generation rate of 500 grams/person/day. Generally in developing countries like India, MSW is disposed of in low-lying areas without taking proper precautions or operational controls in the municipality region. Municipalities should have responsible for waste management in all cities and towns to enhance the complete environmental quality for the sustainable development. However, the inhabitants often face problems beyond the capacity of the municipal power to tackle [1] mainly due to the poor organization structure, economic resources, complication and system multi dimensionality[2]

Landfill is the easy, inexpensive and most cost-effective method of disposing the municipal solid waste[3]. In the greater part of low to medium revenue developing nations, around 100% of generated wastes are disposed in unsanitary landfill areas. In most of the metropolitan cities, unrestrained dumping is commonly practiced, giving rise to serious environmental degradation. The leachate produced from the landfill sites contains concentrated toxic chemicals and it will affect the environmental quality[4]. The entry of rainwater through the dumped municipal solid waste in landfill area produce the liquid waste called leachate. Landfill leachate has contaminated the entire quality of surface and ground water systems in and around the dump site[5].

Leachate can be noxious, acidic, and affluent in organic acid groups and occurrence of heavy metals. They can contain sulphate and high proportion of familiar metal ions in leachate samples. It contains hazardous chemicals having a potential threat to human health. Also it changes the soil property and texture. Many authors undertaken the studies on ground and surface water contamination and project their results for the improvement of environmental quality[6-10].

The soil, surface water and groundwater were contaminated very seriously by the percolation of leachate. The system should be monitored very carefully in the aspect of continuous transportation of leachate to ground and surface water from the soil by evaporation, erosion and infiltration[11]. In this regard, some of the soil parameters such as soil characterization (organic matter, moisture content of the soil and pH of the soil, etc.) is very important for the continuous monitoring of environmental quality[12].

Materials and Methods

Leachate samples from the different locations within the radius 200m were collected during the month of May and December, 2013. Four leachate samples per week were collected for each

month to obtain the uniformity in the values. Leachate samples were collected from the base of solid waste lots in the dumped area where the leachate was drained out by gravity. The analyses of the physical and chemical parameters such as color, turbidity, pH, Electrical Conductivity (µmho/cm), Total Dissolved Solids(mg/l), Suspended Solids(mg/l), Total Solids(mg/l), Chemical Oxygen Demand(mg/l), Biological Oxygen Demand(mg/l), Nitrate(mg/l), Ammonia(mg/l), Total Kjeldhal Nitrogen(mg/l), Sulphate(mg/l), Chloride(mg/l), Alkalinity(mg/l), Total Phosphorus(mg/l), Calcium(mg/l), Magnesium(mg/l) and heavy metals such as Fe (mg/l), Ni (mg/l), Cd (mg/l), Pd (mg/l), Mn (mg/l), Cr (mg/l), Zn (mg/l), Cu (mg/l), were performed by the standard methods[13]. The concentration of heavy metals was estimated by direct air acetylene flame method using the Atomic Absorption Spectrophotometer Model: (SL 168 Elico, India).

Results and Discussion

Leachate samples of MSW landfilling site of Dharapuram were collected and estimate the pollution potential of various physico-chemical parameters. The high concentrations of organic and inorganic constituents were present in the leachate sample and some sample beyond the permissible limits. But the presence of heavy metals concentration in the leachate sample was in fewer amounts in municipal solid waste.

The dumping site at Dharapuram does not possess adequate channels for leachate collection and treatment. The present study conducted on leachate analysis indicates that the quality of ground water was contaminated due to disposal of solid waste at dumping yard.

The Physico – Chemical characteristics of leachate at May month and December month was given in Table 1 and 2 respectively. For all the four weeks in the May and December months, the chemical parameters and heavy metals concentration were not shown large deviations among the same months but shown some deviation between the different months.

Color and Turbidity: The physical parameters show that the color of the leachate was brownish color and the average of the four weeks turbidity was 82.5 NTU for May month and 86.75 NTU for December Month. The leachate color diverse from dark yellow to dark brown and it was mostly due to the oxidation reaction of ferrous ions in the leachate to ferric form and the development of ferric hydroxide colloids and the formation of complexes with fulvic / humic substances[14]. The turbidity values in the current study are reliable with those in earlier studies[15].

pH: The pH of the leachate at May and December months was 7.66 and 7.11 respectively. During second sampling, the pH value slightly decreased and this may be due to the acidification of organic compounds during the first phase of decomposition process. The pH of the leachate was found between 4.5 and 9[16]. The pH present in the young leachate is less than 6.5 while pH of the old landfill leachate has pH higher than 7.5 [17]. The pH at initial stage is due to excess concentration of volatile fatty acids in the leachate sample[18].

Electrical Conductivity: The Electrical Conductivity (EC) of the leachate was 37802.50 and 35014.5 (µmho/cm) for May and December month respectively. During the process of municipal waste decompositions, more soluble salts became prone to be leached out. This is reflected in increasing the EC values and the concentrations of soluble ions in leachate[19].

Total Solids (TS), Suspended Solids (SS) and Total Dissolved Solids (TDS): The total solids represent dissolved and suspended solids. The TS, SS and TDS of the leachate sample were 28499, 6429.75 and 22069.25 mg/l respectively at May month and 29741.25, 6978 and 22763.25 mg/l respectively at December month. The values are relatively high for the both seasons. TDS comprises in the leachate mainly of inorganic salts and dissolved organics substances[20].

Biochemical Oxygen Demand (BOD): BOD is the amount of oxygen required for the biodegradation of organic content present in the leachate and the value indicates the maturity of the landfill[21]. The BOD values for the leachate were 1049.25 and 1074.25 mg/l for May and December months respectively. There were no huge changes in the values, because the fresh leachate samples were collected at both seasons and also mature landfill leachate was not available during the period of sample collection. The BOD values were significantly higher than the prescribed standard limit. For new the landfills the presence of BOD values were ranged between 2000-30000 mg/l; for mature landfills it varies between 100-200 mg/l[22].

Chemical Oxygen Demand (COD): The COD values of leachate samples were 26472.75 and 24380.50 mg/l for May and December months respectively. High COD values were obtained in the samples indicating contamination of groundwater by oxidizable organic matter. The presence of COD is a measure of all oxidizable organic and inorganic matter in the leachate sample[23]. In the previous studies, it has been accomplished that high COD values recorded in young landfill but low COD concentration in old landfill[24].

Nitrate: The nitrate concentrations for leachate at landfilling sites were 18.05 and 21.49 mg/l for the month of May and December respectively. Nitrates are the principal pollutant that leaches into groundwater and cause underground water pollution. The nitrate values were higher than the standard limit. In many processes of the nitrogen cycle, the microbial decomposition of organic carbon influences and it create more changes.

Table-1
Physico – Chemical Characteristics of MSW leachate at May month

Parameter	May Month, 2013				Average
	1 week	2 week	3 week	4 week	
Physical Parameters					
Color	Brownish	Brownish	Brownish	Brownish	Brownish
Turbidity(NTU)	78	76	87	89	82.50
Chemical Parameters					
pH	7.55	7.65	7.89	7.54	7.66
EC (µmho/cm)	39,874	34567	37866	38903	37802.50
TDS (mg/l)	23,098	20653	21543	22983	22069.25
SS (mg/l)	6783	5627	6782	6527	6429.75
TS (mg/l)	29881	26280	28325	29510	28499.00
COD (mg/l)	27689	25873	26783	25546	26472.75
BOD (mg/l)	1098	983	1123	993	1049.25
Nitrate (mg/l)	15.3	14.6	23.4	18.9	18.05
Ammonia (mg/l)	983	783	893	976	908.75
TKN (mg/l)	1165	1342	1092	1162	1190.25
Sulphate (mg/l)	1256	1342	1243	1562	1350.75
Chloride (mg/l)	1876	1872	1982	1827	1889.25
Alkalinity (mg/l)	6785	7628	7828	7627	7467.00
Total Phosphorus (mg/l)	132	142	134	110	129.50
Ca (mg/l)	1245	1253	1435	1231	1291.00
Mg (mg/l)	1154	1178	1092	1053	1119.25
Heavy Metals					
Fe (mg/l)	1.23	1.62	2.65	2.98	2.12
Ni (mg/l)	0.98	0.98	1.12	0.82	0.98
Cd (mg/l)	1.234	BDL	BDL	0.9876	1.11
Pd (mg/l)	1.132	1.543	1.452	1.872	1.50
Mn (mg/l)	0.892	0.982	0.354	1.2	0.86
Cr (mg/l)	0.29	0.54	0.435	0.653	0.48
Zn (mg/l)	3.65	3.55	2.87	1.87	2.99
Cu (mg/l)	1.9	1.3	1.98	1.43	1.65

Table-2
Physico – Chemical Characteristics of MSW leachate at December month

Parameter	December Month, 2013				Average
	1 week	2 week	3 week	4 week	
Physical Parameters					
Color	Brownish	Brownish	Brownish	Brownish	Brownish
Turbidity	98	67	93	89	86.75
Chemical Parameters					
pH	7.89	7.45	6.7	6.4	7.11
EC (µmho/cm)	34876	32874	35765	36543	35014.5
TDS (mg/l)	23765	20952	22353	23983	22763.3
SS (mg/l)	7645	6548	6874	6845	6978
TS (mg/l)	31410	27500	29227	30828	29741.3
COD (mg/l)	24536	24657	25786	22543	24380.5
BOD (mg/l)	1065	896	1342	994	1074.25
Nitrate (mg/l)	23.6	17.9	24.7	19.76	21.49
Ammonia (mg/l)	876	876	986	956	923.5
TKN (mg/l)	1276	1254	1234	1098	1215.5
Sulphate (mg/l)	1546	1354	1324	1543	1441.75
Chloride (mg/l)	1874	1786	2134	1786	1895
Alkalinity (mg/l)	5786	7865	7456	6875	6995.5
Total Phosphorus (mg/l)	154	187	165	157	165.75
Ca (mg/l)	1124	1342	1298	1267	1257.75
Mg (mg/l)	1143	1134	1097	1435	1202.25
Heavy Metals					
Fe (mg/l)	1.34	1.54	1.98	2.65	1.8775
Ni (mg/l)	0.09	0.87	1.2	0.87	0.7575
Cd (mg/l)	BDL	BDL	BDL	0.879	0.879
Pd (mg/l)	1.43	1.34	1.87	1.12	1.44
Mn (mg/l)	0.786	0.987	0.567	1.1	0.86
Cr (mg/l)	0.67	0.56	0.65	0.76	0.66
Zn (mg/l)	3.65	3.78	2.98	1.87	3.07
Cu (mg/l)	1.78	1.43	1.78	1.2	1.5475

Ammonia and Total Kjeldhal Nitrogen (TKN): The concentration of Ammonia nitrogen in the leachate sample was 908.75 and 923.5 mg/l for May and December months respectively. The Total Kjeldhal Nitrogen in the Dharapuram dump yard leachate sample was 1190.25 at May month and 1215.5 at December Month. Ammonia nitrogen has chiefly been produced by the decomposition of nitrogenous organic substances in the refuse. Considering the nitrogenous compounds, ammonia nitrogen was present in high concentrations, probably owing to the deamination of amino acids during destruction of original organic compounds [25]. The greater part of total Kjeldahl nitrogen (TKN) content in the leachate sample was found to be in ammoniacal form. As the leachate percolates through the soil, its concentration decreases. It is retained in the soil by the Base Exchange process or under reducing conditions bacterial growth may also remove ammonia by bacterial assimilation.

Chloride and Sulphate: Chlorides and sulphates have relatively high solubilities and the occurrence of high concentrations in the leachate is due to the direct leaching of Na, Ca, Mg and K salts of these anions from the refuse. The concentrations of chlorides and sulphates for May month were 1889.25 and 1350.75 mg/l respectively and the values increased to 1895 and 1441.75 mg/l respectively during December Month.

The change in concentration of non-degradable chloride parameter is used to assess the variation of leachate dilution[26]. Since the presence of chlorides indicates inert, non-biodegradable compounds, it can also be used to assess the contamination of nearby water resources, provoked by contact with the untreated leachate. The concentration range between 200-3000 mg/l of chloride present in a 1-2 year old landfill and it decreases to 100-400 mg/l for a landfill greater than 5-10 years old[27].

Putrefaction of organic matter present in the municipal solid wastes takes responsibility for the concentration of sulphate in leachate sample. This decrease is caused by the reduction of sulphate to sulphide ion and due to the beginning of anaerobic conditions in the landfill[28]. Thus, the concentration of sulphate can also be used as a pointer of waste stabilization within dump yard[15].

Alkalinity: The alkalinity of the leachate sample was 7467 and 6995.5 mg/l for May and December Month respectively. The presence of alkalinity might have been due to bicarbonate ions and a large amount of mineral species in the leachate as the bicarbonate form[29].

Total Phosphorus: The total phosphorus of the Dharapuram Dump yard leachate samples were 129.5 and 165.75 mg/l for May and December months respectively. The measured total phosphorus values in the leachate samples were considerably higher than the prescribed standard limit. Phosphorus is one of the key elements and it is important for plant and animal growth. Phosphorus in surface water can promote the eutrophication process in lake and reservoirs.

Calcium and Magnesium: The calcium and Magnesium found in the leachate sample was 1291 and 1119.25 mg/l at May month and 1257.75 and 1202.25 at December Month. The concentration of the both the calcium and Magnesium present in the leachate was very high. The increase in cations Ca and Mg in the soil could be ascribed to the increase in amount of soluble inorganic species found in the refuse. The concentration of magnesium is due to the discarding of construction waste along with the disposed MSW[30]. The comparison of the results was shown in Figure-1.

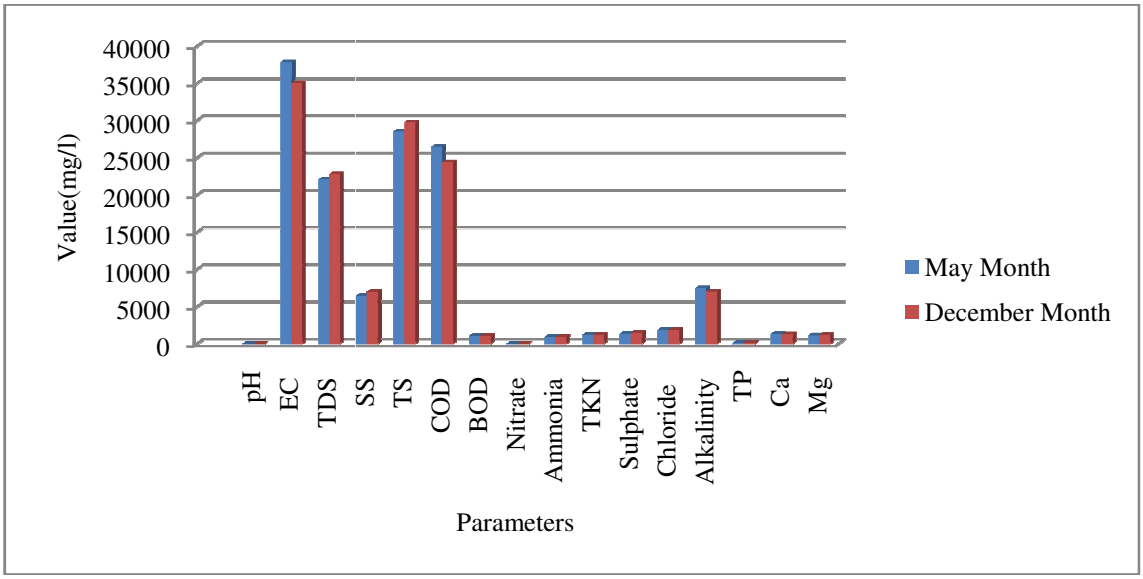

Figure-1
Chemical Parameters of leachate sample

Heavy Metals: Acidic pH condition will support the release of heavy metals. Usually these heavy metals concentration are found at moderate concentration levels in Dharapuram municipal landfill leachate. The results were shown in Figure-2. The same results were reported by the other researcher[31].

Iron concentration of the leachate sample was reported as 2.12 and 1.88 mg/l for May and December month respectively. Another researcher reported that concentration of Fe is associated with iron based waste material such as construction waste materials, paints, pigments, color compounds, polishing agents and electrical materials[32].

Heavy metals such as Ni, Cd, Mn and Cr are present in trace amounts like 0.98 and 0.76 mg/l of Ni at May and December months, 1.11 and 0.88 mg/l of Cd at May and December months, 0.86 mg/l of Mn was observed for both the seasons, 0.48 and 0.66 mg/l of Cr at May and December months.

The average value of the Zn present in the Dharapuram Dump yard leachate sample was 2.99 and 3.07 for summer and winter seasons. Among the heavy metals, Zn was observed in leachate samples because it was likely to remain active and more mobile in soils.

The concentration of the Pb in the leachate sample was 1.50 and 1.44 for May and December month respectively. The high concentration of Pb present in the leachate samples indicates the disposal of Pb based batteries, chemicals for photograph processing, Pb-based paints and pipes at the landfill site[33,34].

The amount of Copper present in the leachate sample was 1.65 and 1.55 mg/l at May and December months. The source of copper content in the leachate may be due to the disposal of copper wires, vessels in the municipal solid waste. Also most of the copper materials were picked by rag pickers.

Conclusion

The dumping site at Dharapuram does not possess adequate channels for leachate collection and treatment of leachate. The present study on leachate analysis indicates that the quality of ground water was contaminated due to disposal of municipal solid waste at dumping yard. It was confirmed by the high Electrical conductivity, Total Dissolved Solids, COD and BOD values for both the seasons. The remaining parameters are also show the increase in concentration and the heavy metals in the collected samples were found at moderate concentration levels. However, these pollutants constantly migrate and permeate into soil strata and after certain period of time, the entire ground water system is completely polluted. The appropriate treatment methods are used to reduce the pollutant concentration to a acceptable level earlier to discharge into receiving system. Indiscriminate dumping of municipal solid waste in the Dharapuram region without proper solid waste management practices should be blocked or some corrective measures were mandatory and it should be adopted to prevent pollution of the soil and ground water. The collected leachate should be treated properly and dispose the same in safe manner. The proper leachate management will develop the clean environment and support the sustainable development.

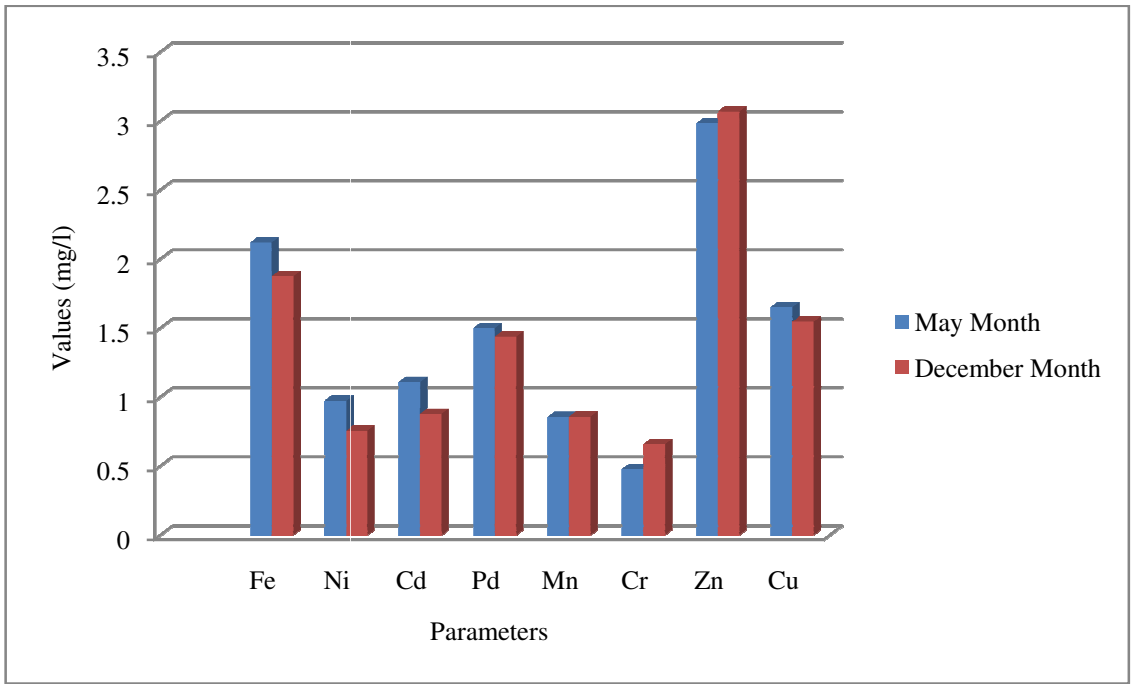

Figure-2
Heavy Metal analysis of leachate sample

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