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# To study the effect of leachate treated with scrap tire shreds and gravel on soil and groundwater

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## ABSTRACT

Laboratory studies were conducted to investigate the effect of leachate on soil and groundwater sample. Collected leachate sample was passed through Test Cell-1 consisting of scrap-tire-shreds (200 mm) and gravel layer (300 mm) with total thickness 500 mm of leachate collection layer. The treatment method which adopted consisted of a combined bed of a scrap-tire-shreds and gravel, that was quite effective in the reduction of various physico-chemical parameters of leachate of environmental concern. The percentage improvement in terms of reduction in various parameters of leachate sample was as high as 68.8 % and 79.6 % reduction in case of BOD and COD values respectively. Thus scrap-tire-shreds can be used as a potential alternative to conventional gravel in the leachate collection layer and for the treatment of leachate and would definitely reduce the magnitude of the current tire disposal problem by converting one waste into a beneficial material. Further, both leachate sample and treated leachate sample were passed through Test Cell-2 having beds of soil of thickness about 150 mm and then further passing diluted leachate and treated diluted leachate (50 % and 20 % by volume of water) through Test Cell-3 having groundwater sample. By comparing various physico-chemical parameters it was inferred that the leachate generated from the landfill site was affecting the soil and groundwater quality of the adjacent areas through percolation in the subsoil.

**Key words:** Groundwater, gravel, scrap-tire-shreds, leachate collection layer.

## INTRODUCTION

Municipal Solid Waste (MSW) Management in India has always been a low priority [1]. More than 90 % of the municipal solid waste is disposed off by landfilling [2]. According to an estimate 45 million tonnes/year of solid waste is generated from the urban centres of India which are collected inefficiently, transported inadequately and disposed unscientifically [3]. The solid waste is expected to rise to 125 million tonnes/ year in India by the year 2025 [4]. In Delhi, the capital of India, alone more than 5000 tonnes of Municipal Solid Waste (MSW) is generated everyday and is expected to rise to 12750 tonnes per day by 2015 [5]. The MSW generated per day in India's other major cities is Mumbai-6050 tonnes, Kolkata-3500 tonnes, Chennai-2500 tonnes, Bangalore-2000 tonnes, Hyderabad- 1800 to 2000 tonnes, Lucknow-1500 tonnes and Ahmedabad-1280 tonnes [6].

Realizing the need for proper and scientific management of solid waste, the Municipal Solid Waste (Management and Handling) Rules, 2000 were notified by the Ministry of Environment and Forests (MoEF), Govt of India[7]. The objective of these rules was to make every municipal authority responsible for the implementation of the various provisions of the rules within its territorial area and also to develop an effective infrastructure for collection, storage, segregation, transportation, processing and disposal of Municipal Solid Wastes (MSW). Solid Waste Management is an obligatory function of Urban Local Bodies (ULBs) in India.

However, this service is poorly performed, resulting in problems of health, sanitation and environmental degradation. The uncollected solid wastes remain in and around the locality or find its way to open drain, water bodies, etc. Human faecal matter is commonly found in municipal waste. Vector, insect and rodent are attracted to the waste and can transmit various pathogenic agents (like amoebic and bacillary dysentery, typhoid fever, salmonellosis, various parasites, cholera, yellow fever, plague etc.) and diseases, which are often difficult to trace the effects of such transmission to a specific population. Improper management of waste can therefore spread several diseases. Diseases like Cholera, Shigellosis, E. coli diarrhea, Poliomyelitis, Typhoid, and Hepatitis etc are generally occurring due to contaminated water [8].

Landfill leachate may be characterized as water based solution of four groups of pollutants dissolved organic matter, inorganic macro components, heavy metals and xenobiotic organic compounds [9]. Leachate is the liquid residue resulting from the various chemical, physical and biological processes taking place within the landfill. Landfill leachate is generated by excess rainwater percolating through the waste layers in a landfill [10]. The composition of landfill leachate, the amount generated and the extraction of potential pollutants from the waste depend upon several factors, including waste composition, degree of compaction, absorptive capacity of the waste and waste age, the climate, levels of precipitation, landfill temperature, size, geology, engineering and operational factors of the landfill [11, 12].

Scrap tires disposal remains a problematic issue in industrialized nations around the world. Economically and environmentally feasible alternatives have been investigated for recycling of scrap tires. Shredded tires obtained from scrap tires have been used as lightweight fill material for roadways, embankments and backfills behind retaining walls. Tire shreds can be used used as an alternative to crushed stones (gravel) as drainage media in landfill leachate collection systems.[13-17]. The recommended nominal tire shred size for use in leachate drainage layer is 50 mm with an acceptable range of 25-100 mm[18]. Further, the granular medium used in the construction of leachate drainage layer must posses a hydraulic conductivity equal to or greater than 1x $10^{-2}$ cm/s and minimum thickness of 300 mm and of 500 mm at the location of perforated leachate collection pipes[19].

In the present study, the experimental work was carried out to evaluate the affect of leachate generated from municipal solid waste dumping site on soil and groundwater sample so as to determine the extent of pollution caused from the leachate generated from the landfill site on the soil and groundwater quality of the adjacent areas through percolation in the subsoil. Further to determine the suitability of a treatment method of using scrap-tire-shreds bed as a part of leachate collection layer along with the gravel bed in the reduction of various leachate parameters of environmental concern was checked out. The present study will open a tremendous scope of using scrap-tire-shreds as potential medium for treating leachate and this would reduce the magnitude of the current tire disposal problem and convert one waste into a beneficial material.

## MATERIAL AND METHODS

### Leachate site

Leachate sample for present study is collected from municipal solid waste dumping site at Suchi Village; district Jalandhar near National Highway No.1 that spreads over 0.8 hectares of low lying land area. Jalandhar is a major city of India with a population of more than 8,00,000 lying at latitude 31.33° N and longitude 75.58° E with an average elevation of 229 m. This site is operational since 2004, receiving non-hazardous municipal waste. The site is non-engineered low lying open dump, looked like a huge heap of waste up to a height of 6–10 m. No cover, of any description, is placed over the spread waste to inhibit the ingress of surface water or to minimize litter blow and odors or to reduce the presence of vermin and insects. Since, there are no specific arrangements to prevent flow of water into and out of landfill site, the diffusion of contaminants released during degradation of landfill wastes, may proceed uninhibited.

### Field sampling and laboratory experimental setup

Leachate sample was collected during

rainy season. The landfill site was not equipped with leachate collectors. Leachate sample was collected from the base of solid waste heaps where the leachate was drained out by gravity. To have average composition of the representative leachate, integrated samples were collected from randomly selected locations as per guidelines of American Public Health Association (APHA). Further, to study the effect of leachate percolation on soil and groundwater, both the normal soil and groundwater sample was collected from National Institute of Technology (NIT), campus 5 km away from the disposal site. The samples were collected in well labeled clean bottles those were rinsed thrice prior to sample collection.

Leachate samples after passing through combined beds of scrap-tire-shreds and gravel gave better results as compared to conventional gravel bed. Improvement in various physico-chemical properties of leachate was found maximum with a combination having scrap-tire-shreds and gravel layer ratio 0.667 (thickness of scrap-tire-shreds layer 200 mm and thickness of gravel layer 300 mm), having scrap-tire-shreds size as length 25.4 mm to 76.1 mm and width 5 mm. Details of the tests were presented elsewhere.[20]

In laboratory, 3 experimental Test Cells - 1, 2 and 3 (PVC make) were constructed. Details of Test Cells were shown in Table 1. Collected leachate sample was passed through laboratory Test Cell-1 consisting of scrap-tire-shreds bed of 200 mm (size range length = 25.4 mm to 76.1 mm and width = 5 mm) and gravel bed of 300 mm (size range 10 mm to 20 mm) with total thickness 500 mm of leachate collection layer. Further, both untreated and treated leachate was passed through Test Cell-2 having bed of soil about 150 mm thickness and through Test Cell-3 having groundwater sample of volume 4.27 litre. Experimental setup of Test Cell- 1, 2 and 3 were shown in Figure 1.

**Analytical work**

Analytical methods as specified by American Public Health Association (APHA), 1998 have been used in the present investigation[21]. The pH was measured by electronic pH meter (4500-$H^+$.B of Standard Methods) whereas, Turbidity of samples was measured by Nephelometer by using optical properties of light (2130.B of Standard Methods). Properly shaken unfiltered sewage was used and estimated by gravimetric method (2540.B of Standard Methods). Filtered sewage through Whatman filter paper 44 enables to determine Total Dissolved Solids (2540.C of Standard Methods). Argentometric volumetric titration method in the presence of potassium chromate provides reliable results of chloride (4500-$Cl^-$.B of Standard Methods). Total Hardness- EDTA titration method with presence of Eriochrome Black T (EBT) indicator was adopted (2340.C of Standard Methods). Chemical Oxygen Demand (COD) refluxion of sample followed by titration with Ferrous Ammonium Sulphate (FAS) was adopted (5220-C of Standard methods). Dissolved Oxygen (DO) was determined by Azide modification of Winkler's method. Biological Oxygen Demand (BOD) was determined by estimating initial and final DO in the sample (5210-B of Standard methods). ammonical nitrogen, phosphate, iron, lead, chromium hexavalent and cadmium were estimated using UV-VIS Smart Spectrophotometer [22].

## RESULTS AND DISCUSSION

The results of leachate sample analyzed for fourteen physico-chemical parameters were shown in Table 2. The table also reflects the standards for the discharge of treated leachate on inland surface water, public sewers and land disposals. The results indicate that most of the parameters of leachate sample were beyond permissible limits.

Eight litre of collected leachate sample was passed through Test Cell-1 consisting of scrap-tire-shreds (200 mm) and gravel (300 mm) bed with total thickness 500 mm as leachate collection layer. Treated leachate collected from Test Cell-1 showed reduction in various parameters of environmental concern as indicated in Table 2. The mixture of scrap-tire-shreds and gravel bed has the combined effect of scrap-tire-shreds and gravel on hydraulic conductivity, compressibility, adsorption of chemicals and filterability. It was hypothesized that scrap-tire-shreds enhances the uniformity of the permeating leachate and thus increases both the amount of surface area and contact time available for sorption. Thus the study indicated that scrap-tire-shreds can be used as a potential alternative to conventional gravel in the drainage layer of leachate collection system thus by improving upon the reduction in the various leachate parameters of environmental concern.

Both soil and groundwater sample from the landfilling site were analyzed for various parameters, the results indicated that most of the parameters were beyond permissible limits due to the seepage of pollutants from the landfilling leachate through percolation in the subsoil of the adjacent area causing both soil and groundwater pollution. Further, to prove the above effect of pollution caused due to seeping of leachate generated from the landfill site on adjacent soil and groundwater both soil and groundwater sample of NIT campus were taken in laboratory. Four litres of both leachate and treated leachate (from Test Cell-1) samples were then passed through Test Cell- 2 having bed of soil sample of thickness about 150 mm and then passing both diluted leachate and treated diluted leachate (50 % and 20 % by volume) through Test Cell- 3 having groundwater sample of volume 4.27 litre. The results showed considerable increase in

**Table 1: Details of Test Cells 1, 2 and 3**

| Test Cells | Size of Test cells | | Scrap tire shreds | | Gravel size | Thickness of bed | |
|---|---|---|---|---|---|---|---|
| | Height | Diameter | Length | Width | Gravel | Scrap- tire -shreds | |
| 1 | 1219.2 | 152.4 | 25.4 -76.1 | 5 | 10 - 20 | 300 | 200 |
| 2 | 365.7 | 190.5 | | Soil bed | | 150 | |
| 3 | 365.7 | 190.5 | | Groundwater | | Volume = 4.27 | |

*All values in mm except for volume in litre.

**Table 2: Physico-chemical parameters of the leachate**

| Parameters* | Results | Standards ( Mode of Disposal )** | | | |
|---|---|---|---|---|---|
| | Leachate sample | Treated leachate sample from Test Cell-1 | Inland surface water | Public sewers | Land disposal |
| pH | 10.3 | 9.3 | 5.5 to 9.0 | 5.5 to 9.0 | 5.5 to 9.0 |
| SS | 1800 | 2046 | 100 | 600 | 200 |
| TDS | 6800 | 1332 | 2100 | 2100 | 2100 |
| Hardness | 638 | 342 | 300 | - | - |
| Turbidity (NTU) | 30 | 12 | 5 | 10 | 10 |
| BOD (3 days at $27^0$ C) max. | 809 | 253 | 30 | 350 | 100 |
| COD | 1690 | 345 | 250 | - | - |
| Chloride | 853 | 308 | 1000 | 1000 | 600 |
| AmmonicalNitrogen | 83 | 23 | 50 | 50 | - |
| Phosphate | 78 | 28 | - | - | - |
| Iron | 6.6 | 1.3 | 0.01 | 0.01 | - |
| Lead | 0.9 | 0.1 | 0.1 | 1.0 | - |
| Chromium hexavalent | 1.5 | 0.4 | 2.0 | 2.0 | - |
| Cadmium | 3.2 | 1.1 | 2.0 | 1.0 | - |

* All values in mg/l except for pH and turbidity.

**Municipal Solid Wastes (Management and Handling) Rules, 2000 values of various physico-chemical parameters due to leachate input in both the soil and groundwater sample as indicated in Table 3 and 4. It is clearly observed from the above study that the leachate generated from the landfill site is affecting the soil and groundwater quality of the adjacent areas through percolation in the subsoil. The treatment method adopted as in Test Cell-1 consisting of scrap-tire-shreds bed as a part of leachate collection layer along with the gravel bed was quite effective in the reduction of various leachate parameters of environmental concern. The percentage improvement in terms of reduction in various parameters of leachate was comparatively high as indicated in Table 3 and 4.

**The following conclusions were drawn from the present study;**

´ It has been concluded that leachate contains high concentration of organic and inorganic constituents and heavy metals and further on analyzing surrounding soil and groundwater sample of the landfilling site for various physico-chemical parameters, the results indicated that most of the parameters were beyond permissible limits that could be due to the seepage of pollutants from the landfilling site. Therefore, some remedial measures were required to prevent contamination.

´ The laboratory results of soil and groundwater sample analysis showed considerably increase in various physico-chemical parameters in both the soil and groundwater sample after passing leachate sample (both untreated and treated) through them. So concluded that the leachate generated from the landfill site was affecting the soil and groundwater quality of the adjacent areas through percolation in the subsoil.

´ More the dilution of leachate lesser would be the pollution potential. The present study indicated that the groundwater sample having leachate 50 % by volume of water causes more pollution as compared to groundwater sample having leachate 20 % by volume of water. So precipitation rate is a significant factor affecting the leachate quality.

´ The present study emphasized on using scrap-tire-shreds as potential alternative to conventional gravel in the drainage layer of leachate collection system for treating leachate and this would reduce the magnitude of the current tire disposal problem and convert one waste into a beneficial material.

**Table 3**: **Concentration of various physico-chemical parameters in soil samples after passing leachate sample**

| Parameters* | SS (L) | SS | SS (1) | SS (2) | Percentage reduction after passing treated leachate through soil sample |
|---|---|---|---|---|---|
| Ammonical Nitrogen | 95 | 14.6 | 20 | 16 | 20 |
| Phosphate | 88 | 5.8 | 18 | 12 | 33.3 |
| Iron | 6.9 | 1.9 | 3.1 | 1.8 | 41.93 |
| Lead | 1.0 | 0.1 | 0.4 | 0.15 | 62.5 |
| Chromiumhexavalent | 1.7 | 0.1 | 0.5 | 0.2 | 60 |
| Cadmium | 1.9 | 0.3 | 0.8 | 0.6 | 25 |

* All values in mg/l

SS (L) = Soil sample (Landfilling site)

SS = Soil sample (NIT, campus)

SS (1) = Soil sample after passing leachate from Test Cell-2.

SS (2) = Soil sample after passing treated leachate from Test Cell-1 to 2.

**Table 4: Concentration of various physico-chemical parameters in groundwater samples after passing leachate sample**

| Parameters* | GW (L) | GW | GW (1) | GW (2) | Percentage reduction after passing treated leachate (50 % by volume of water) | GW (3) | GW (4) | Percentage reduction after passing treated leachate (20 % by volume of water) |
|---|---|---|---|---|---|---|---|---|
| pH | 8.9 | 7.5 | 9.5 | 9.0 | 5.2 | 9.1 | 8.3 | 8.7 |
| TS | 857 | 468 | 3576 | 978 | 72.6 | 3016 | 686 | 77.2 |
| TDS | 683 | 289 | 2428 | 396 | 83.6 | 1812 | 288 | 84.1 |
| Hardness (as $CaCO_3$) | 468 | 284 | 489 | 308 | 37.01 | 395 | 293 | 25.8 |
| Turbidity (NTU) | 10 | 4 | 20 | 9 | 55 | 16 | 6 | 62.5 |
| BOD (3 days at $27^0$ C) | 95 | 20 | 385 | 162 | 57.9 | 302 | 115 | 61.9 |
| COD | 365 | 168 | 759 | 289 | 61.9 | 556 | 202 | 63.6 |
| Chloride | 504 | 214 | 582 | 275 | 52.7 | 433 | 219 | 49.4 |
| Ammonical Nitrogen | 8.9 | 0.9 | 36 | 18 | 50 | 30 | 10 | 66.6 |
| Phosphate | 4.7 | 0.6 | 30 | 15 | 50 | 21 | 9 | 57.1 |
| Iron | 1.5 | 0.1 | 3.2 | 0.8 | 75 | 2.2 | 0.5 | 77.2 |
| Lead | 0.5 | 0.03 | 0.4 | 0.3 | 25 | 0.3 | 0.1 | 66.6 |
| Chromium hexavalent | 0.8 | 0.05 | 0.9 | 0.5 | 44.4 | 0.6 | 0.3 | 50 |
| Cadmium | 1.6 | 0.09 | 2.0 | 1.2 | 40 | 1.8 | 0.9 | 50 |

* All values in mg/l except for pH and turbidity.
GW (L) = Groundwater sample (Landfilling site)
GW = Groundwater sample (NIT, campus
GW (1) = Groundwater sample + untreated leachate 50 % by volume of water after passing through Test Cell-3.
GW (2) = Groundwater sample + treated leachate 50 % by volume of water after passing through Test Cell-3.
GW (3) = Groundwater sample + untreated leachate 20 % by volume of water after passing through Test Cell-3.
GW (4) = Groundwater sample + treated leachate 20 % by volume of water after passing from Test Cell-3.

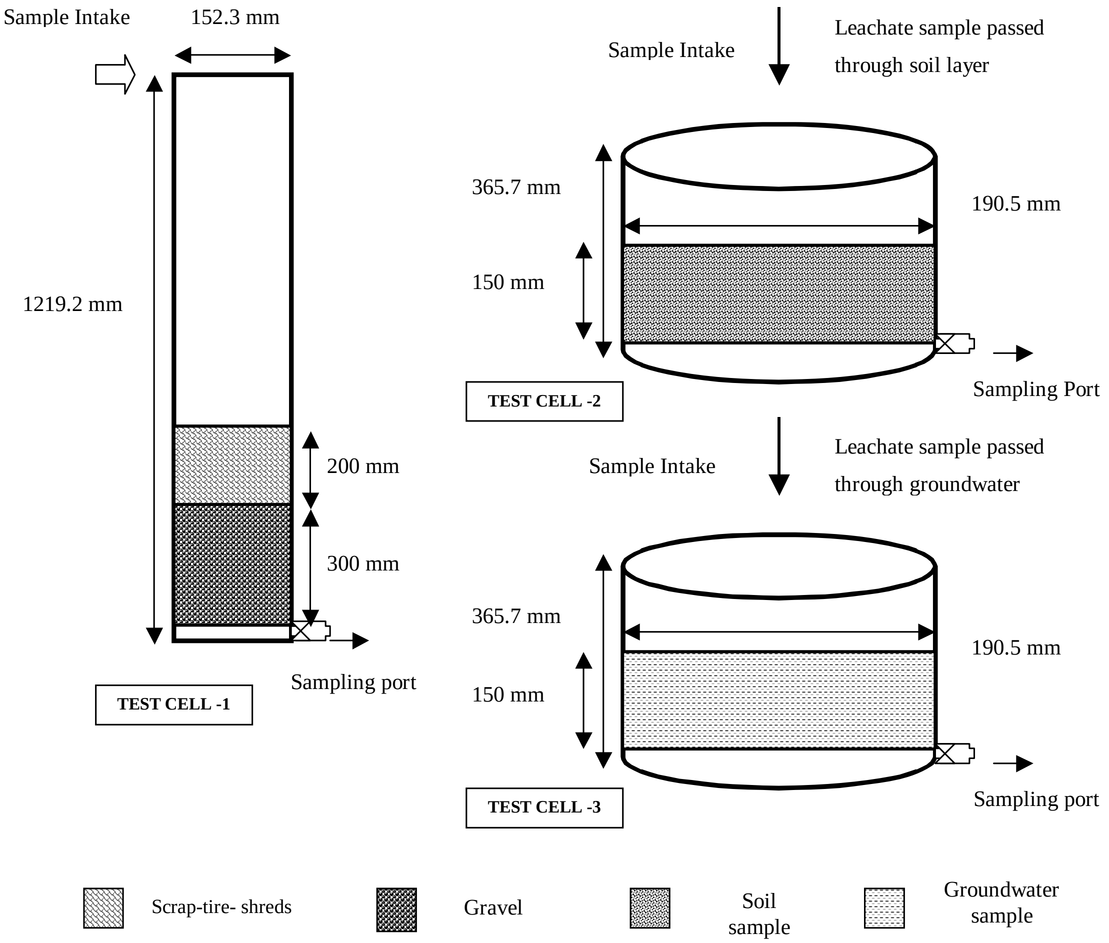


**Fig. 1: Schematic representation of the experimental setup, Test Cells- 1, 2 and 3**

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