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Impacts of landfill on the quality of local soils and groundwater with toxicity characteristics leaching procedure

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Abstract
To assess the level of contamination that has occurred or may occur, contaminant movement in soil and water media must be modeled. Additionally, these models aid in the selection of an appropriate remediation approach for the afflicted site. Leachate is a liquid that is created by the penetration of water into landfills and its percolation into waste, as well as by the compression of waste due to its own weight. Contamination causes abrupt changes in the water quality. As a result of natural and human activity, the quality of ground water is always changing. Water pollution is caused by a variety of factors. The main source of organic and inorganic contaminants in ground water is industrial water. Because of the rapid rise of industrialization, a large amount of sewage is disposed of, resulting in significant changes in ground water pollution. The experimental work was carried out according to the American Standard Testing Methods (ASTM, D3987-85 reapproved 200) standard procedures. The work entails sampling contaminated soils from the Shivakote dumpsite at several places and determining heavy metal background concentrations. A study of the level of groundwater contamination in and around the dumpsite would also be conducted. In order to treat them, multiple studies will be conducted by mixing them with various percentages of Fly ash (10-30%) and Bentonite (2-6%) as additives. We can say that the leaching phenomenon on soil and soil mixes spiked with heavy metals lead and nickel was studied using different load ratios of 50mg/kg and 100mg/kg. The leaching percentage for all MP soil and their blends was found to be higher when the load ratio was higher. The subsamples were obtained at 7-day, 28-day, and 45-day curing intervals, respectively. The ability of contaminants to be retained is mostly determined by the curing period, which is unaffected by the action of precipitation.

Keywords: leachate, solid waste, landfill, soil, ground water, TCLP, etc.

1. Introduction

In general, municipal solid waste landfills pollute the environment significantly due to landfill gas combustion, leachate leakage, and bad odours. Because leachate contains large concentrations of heavy metals, organic compounds, and hazardous substances, it has the greatest impact on the surrounding ecosystem, particularly surface and ground water bodies. Several examples of pollution of water bodies caused by municipal solid waste landfills have recently been documented around the world. Heavy metal production and use, such as copper, cadmium, and zinc, have risen dramatically in recent years. Because of their mobility, solubility, and capacity to transfer in water or plants, an excess amount of heavy metals disposed of on the ground can cause substantial damage to the environment and human health. Due to rainfall, MSW landfill leachate may leak into groundwater aquifers, spread into the nearby river system by groundwater flow, and contaminate the ecosystem. This process, however, continues even after landfill activities have ceased accepting solid waste. As a result, it is critical to continue studying and monitoring the environment around decommissioned landfill sites.

To assess the level of contamination that has occurred or may occur, contaminant movement in soil and water media must be modelled. Additionally, these models aid in the selection of an appropriate remediation approach for the afflicted site. Contaminant transport parameters can be determined through laboratory column experiments to obtain precise values, or they can be inferred using correlations from relevant data reported in the literature. Previous research has provided values for contaminant transport parameters for various metal ions. Various specialised computer software packages have been developed and are currently being utilised to solve pollution transport issues in the groundwater system. However, the flexible groundwater model-POLLUSOL, which is based on finite volume modelling hydraulic and concentration distribution, is the most powerful software package. Other software tools, such as the post-processing particle tracking model (MODPATH), the finite difference groundwater model (FEMWATER), two-dimensional finite element model (SPEED 2D), multi-phase transport model (UTCHEM), transport tools, and the transition probability geostatic software (T-PROGS), are used to model contamination transport in groundwater and predict interactions between water bodies such as surface and groundwater. The fuidyn POLLUSOL software application is used to simulate groundwater flows and estimate pollution dispersion across a porous media. For flow through porous media, flow equations are obtained using the conservation of total fluid mass principle and Darcy's law. The mass conservation equation for a single solute or several solute species that may decay or adsorb in the porous medium is used to create the solute transport equation.

1.1 Leachate

Leachate is a liquid that is created by the penetration of water into landfills and its percolation into waste, as well as by the compression of waste due to its own weight. The soluble elements from the trash are carried by the water that infiltrates into the landfill and may reach either surface water or groundwater, acting as a vehicle for delivering potentially harmful substances from the landfill to water bodies. Moisture, accessible oxygen, waste content, temperature, and elapsed time are the main determinants of leachate quality. In most cases, the quality of leachate from the same type of waste varies between landfills in different climate zones. The quality of leachate is also controlled by Dumpsite's working procedures. During the active phases of a landfill's operation during the monsoon season, a large amount of leachate is produced. Leachate from the dumpsite flows into the groundwater table.

1.2 The Impact of Landfill on the Quality of Soil and Groundwater

Contamination causes abrupt changes in the water quality. As a result of natural and human activity, the quality of ground water is always changing. Water pollution is caused by a variety of factors. The main source of organic and inorganic contaminants in ground water is industrial water. Because of the rapid rise of industrialisation, a large amount of sewage is disposed of, resulting in significant changes in ground water pollution. Ground water quality is determined by a variety of chemical elements and their concentrations, which are largely derived from geological data in the area. Ground water is found in the weathered portions of the rocks, around the joints and cracks. In fact, industrial waste and municipal solid waste have risen to the top of the list of pollutant sources for surface and ground water. Any chemical, solution mixture, or product that has no direct use but is carried for reprocessing, dumping, incineration, or other methods of disposal is considered waste. Rapid solid waste production is caused by urban industrialisation, social growth, and rising population, resulting in a major challenge. The environmental impact of these wastes can be severe if they are not properly disposed of and controlled.

1.2.1 Processes of Waste Degradation and the Production of Leachates and Gases

Knowledge the formation, content, and qualities of leachate and gas is crucial to a risk assessment framework's understanding and control of waste disposal landfill environmental concerns. As leachate, wastes that are either reactive or water-soluble sink down through the landfill. The amount of leachate produced by a landfill is greatly dependent on the amount of water penetration through the soil cover and hazardous waste layers. If the hazardous wastes have high moisture content, the amount of leachate produced could be raised even more.

2. Review of the Literature

Dr. BP & J. Naveen, Suma & R. Malik (2018) [1] The implications of a probable leachate leakage from a municipal solid waste dump in Mavallipura, Bangalore, India, on the surrounding water bodies are discussed in this study. The landfill, which covers around 100 acres and began taking waste in 2005, is spread out over a 100-acre area MSW was dumped in an unplanned manner, resulting in steep and unstable slopes, leachate collection inside the MSW mass, and leachate flow into neighbouring water bodies like ponds and open wells. The current research looks into the physicochemical characterization of landfill leachate and surrounding bodies of water. The heavy metal concentrations in the polluted soil were determined by batch leach testing. A number of column tests were also carried out to assess the rates of contamination migration through the soil. These transport parameters were also used as input for the fluidyn-POLLUSOL model, which was used to estimate leachate migration from the landfill to nearby water bodies.

Md. Hossain, Satyajit Das, and Mohammed Hossain. (2014) [2] To determine the degree of dumpsite pollution of surface and ground water throughout the rainy and winter seasons, physical, chemical, and bacteriological studies of leachates, surface, and ground water samples from the Rowfabad landfill in Chittagong, Bangladesh were conducted. Surface water samples were taken at distances of 100, 200, 300, 400, and 500 metres from the dump, respectively. Three places within a 0.30 km radius of the dump were sampled for groundwater. According to internationally approved processes and standard methodologies, all of the samples were evaluated for significant physico-chemical and biological parameters. DO concentrations in the leachate sample were found to be very low (0.8 mg L-1 in winter and 0.2 mg L-1 in rainy season), although BOD (550 mg L-1 in winter and 216 mg L-1 in rainy season) and COD (745 mg L-1 in winter and 430 mg L-1 in rainy season) were both high. The amount of faecal coliform in ground water was alarming (15/100 mL in winter and 71/100 mL in the rainy season). The increased levels of iron (3.26 mg L-1 in the winter and 2.61 mg L-1 in the rainy season) and arsenic (1.7 mg L-1 in the winter and 0.9 mg L-1 in the rainy season) in ground water were found to be concerning. The authority should take the necessary precautions to prevent further leachate contamination.

Muhammad Nawaz Chaudhry, Sidra Khan (2010) [3] the purpose of this study was to see how solid waste leachate affected groundwater and surface water quality at an unlined dumping site. COD and BOD averaged 2563 mg/L and 442 mg/L, respectively, in six leachate samples collected from various locations. Surface water samples were taken at two distinct times of the year (rainy and non- rainy). Non-rainy season samples were found to be more polluted than rainy season samples. Heavy metals (Cd, Cr, Fe, and Zn) and E.coli are found in soil samples taken at a depth of 1.5 metres. The presence of E.coli indicates that the groundwater quality has worsened due to leachate.

Odukoya, Abiodun & Abimbola, A. (2010) [4] geochemical investigations of groundwater and streams running around abandoned and active dumpsites in Lagos, Southwestern Nigeria were carried out by Abiodun Odukoya and Abiodun Abimbola. The results demonstrate that water samples from abandoned and active dumpsites had low total dissolved solids, with average values of 163.75 and 153.4, respectively. Total hardness varies from 10-220 mg/L calcium carbonate, and pH ranges from 3.96 to 8.34. (Soft to slightly hard). For abandoned and active dumpsites, average concentrations of the major ions were 57.8 and 25.86 mg/L (Na), representing 40.7 and 46.3 percent of total cations, respectively, and Nitrate (av. 96.89 and 61.51 mg/L), representing 49.1 percent and 40 percent of total anions, respectively The coliform count, pH, and The quantities of nitrate, iron, manganese, and sodium in majority of the water samples were higher than the US Environmental Protection Agency's proposed national drinking water criteria. Silver, arsenic, beryllium, bismuth, cerium, cobalt, chromium, lithium, selenium, tellurium, titanium, uranium, vanadium, tin, and yttrium were all below detection levels in all water samples, while tungsten, thallium, molybdenum, and lead were only found in surface and groundwater near dumpsites and had values higher than recommended standards, while copper, zinc, aluminium For abandoned and active dumpsites, the pollution index ranged from 0.009 to 1.26 and 0.106 to 6.25, respectively, while the water around most of the dumpsite regions surpassed the acute and chronic effect levels set by the US Environmental Protection Agency in 2007.

3. Objectives

- To examine impact of landfill on the quality of soil and groundwater.
- To analyze additives for leaching metal characteristics on local soils.

4. Research Methodology

The work entails sampling contaminated soils from the Shivakote dumpsite at several places and determining heavy metal background concentrations. A study of the level of groundwater contamination in and around the dumpsite would also be conducted. In order to treat them, multiple studies will be conducted by mixing them with various percentages of Fly ash (10-30%) and Bentonite (2-6%) as additives. These soils were also spiked with a known percentage weight of heavy metal as a contaminant in soil or a mixture of soil, and natural drying was recommended for 7 days, 28 days, and 45 days for curing. Lead and nickel are two pollutants that have been introduced. The American standard for testing materials procedures (ASTM) D3987 – 85 (Reapproved 2004), D4319 – (reapproved 2001), and D4646 – 87 have all been used to carry out these tests (Reapproved 2001).

The batch leaching experiment was carried out by knowing the weight of dried soil or its soil mixture, adding distilled water of known volume in the ratio of 1:20 solid-liquid ratio (S/L), and shaking it in a rotary shaker for 18 hours at a constant speed of 30 RPM (ASTM D 3987). The leach solution has been filtered and centrifuged. Chemical analysis has been requested for the filtered sample. The amount of pollutants leached has been calculated.

4.1 Soil and soil mixes leaching tests

The soil or soil mixture was mixed with a known weight of heavy metal as a contaminant and allowed to dry naturally for 7 days, 28 days, and an additional 45 days to cure. Batch leaching analysis was performed by knowing the weight of dried soil or its mixture, combining it with distilled water of a given volume in the ratio of 1:20 solid-liquid ratio (S/L), and shaking it for 18 hours on a rotary shaker at a constant speed of 30 RPM (ASTM D 3987). The leach solution has been filtered and centrifuged. Chemical analysis has been requested for the filtered sample. The amount of pollutant leached has been calculated.

4.2 Adsorption-Related Materials

- ✓ **Adsorbent:** The main soil was acquired from the Mavallipura dumpsite of Bruhat Bangalore Mahanagar Palike in Bangalore (the capital of Karnataka state), India; soil samples weighing roughly 10kg were excavated 0.15m beneath the land surface. The soil sample was dried in the open air and should have gone through a sieve up to 2mm. To ensure consistency of the material from the sieved soil, the samples were crushed to a powdered soil and aggregates of less than 0.1mm were obtained.
- ✓ **Fly ash's Function:** Flyash (grade-F) was obtained from a thermal power plant in Raichur(RTPS), Karnataka, India, and was used as a recycling material. Flyash is a waste product from the burning of coal to create electricity at thermal power plants. Alumina, silica, and iron oxide are the major ingredients of flyash, which is a finely split powder. It is a good adsorbent that is inexpensive and readily available in large numbers, as well as a strong binding substance. As a result, it can be utilised as a liner material additive.

4.3 Leaching Procedure for Toxicity Characteristics (TCLP)

According to the USEPA, two types of extraction solutions were utilised. Because shivakote has a higher alkalinity, it was used to extract S/S treated soil samples. A 0.1 M acetic acid solution with a pH of 2.88 was used to treat dumpsite soil with varied quantities of additions such as fly ash and bentonite. An extraction solution of 0.0643M NaOH and 0.1 M acetic acid with a pH of 4.93 was employed for untreated soils. On a rotating tumbler for 18 hours and 30 rpm, the closed polypropylene bottles were filled with drawn waste samples at a ratio of liquid to solid (L/S) of 20. After extraction, the final pH of the leachate was estimated, and the liquid was separated from the particles using a 0.45m glass fibre filter.

4.4 Research and Development Program

The experimental work was carried out according to the American Standard Testing Methods (ASTM, D3987-85 reapproved 200) standard procedures. The following is a brief description of the method. A load ratio of 50 mg/kg and 100 mg/kg was maintained at all times (100 mg/kg of load was derived from a 100 ppm concentration of contaminant solution diluted in 1000ml of distilled water and then added to a 1 kg of soil) and the mixture was allowed to dry before subsamples were collected and leaching tests were performed at regular intervals.

5. Discussion and Result

5.1 Additives for leaching metal characteristics on local soils

Long-term behaviour of residual pollutants on liner materials is critical in a landfill environment. These heavy metal ions may be expelled from liners due to a leaching event. The ecotoxicological importance of heavy metals in soils, as well as their potential risk in terms of mobility, is decided by the separation of soil-solution rather than the total heavy metal content. The release of heavy metal cations into the water phase ("leaching"), and thus their vulnerability to transport processes, is dependent on their solution identification and attraction to reactive surfaces in pore water and soil matrix, such as dissolved organic matter and particulate, metal (hydroxide-surfaces), or clays.

- **Lead leaching behaviour After 7, 28, and 45 days of curing, 50mg/kg and 100mg/kg of MP soil and soil mixtures in an aqueous media**

MP soil and its blends were subjected to leaching tests with load ratios of 50 mg/kg and 100 mg/kg. After adjusting the curing durations of 7 days, 28 days, and 45 days, the container was covered with a polythene sheet to ensure adequate curing and allowed to dry naturally at room temperature in the shade. The containers were not covered airtight; instead, a natural flow of air was maintained. Subsamples were taken at 7, 28, and 45-day intervals, and leaching tests were performed as described in the previous section. The percentage of pollutant leaching decreased after 7 days, but increased after 28 and 45 days. The data in figures 1 and 2 are for different curing durations.

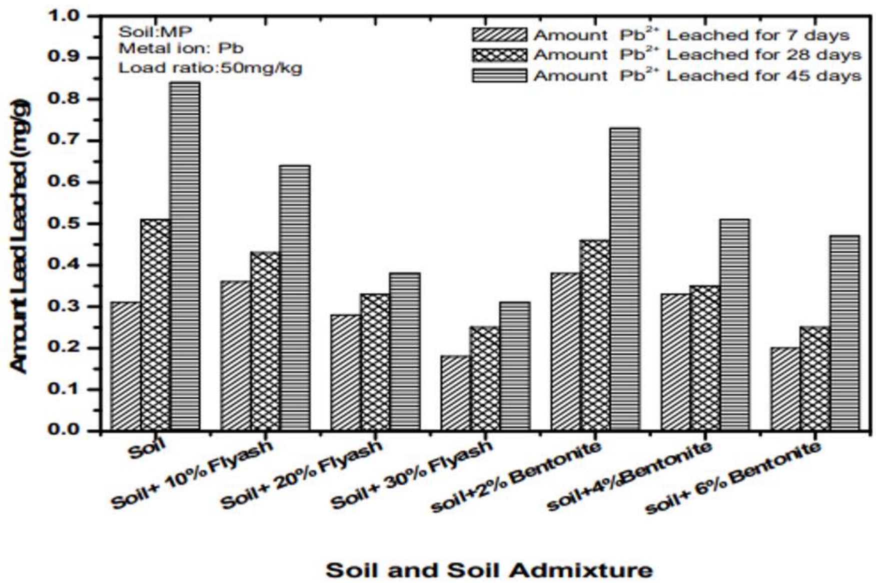

Fig 1: Leaching behavior of 50mg/kg Lead with MP soil and soil mixtures after 7, 28 & 45 days

Figures 1 and 2 demonstrate that MP soil alone leached the greatest quantity of lead at both loading ratios. It was discovered that the higher the load ratio, the more leached out of the soil and the higher the leached out of soil mixtures. For a load ratio of 100 mg/kg, MP soil leached to a maximum of 1.1 mg/g, but it has been drastically decreased to 30% bentonite and 10% fly Ash in addition to soil. However, with a 30 percent increase in fly ash concentration, leaching has been reduced even more. With a load ratio of 50 mg/kg, qualitatively identical behaviour is found. This was mostly due to metal ion precipitation at higher pH levels that result from the addition of fly ash.

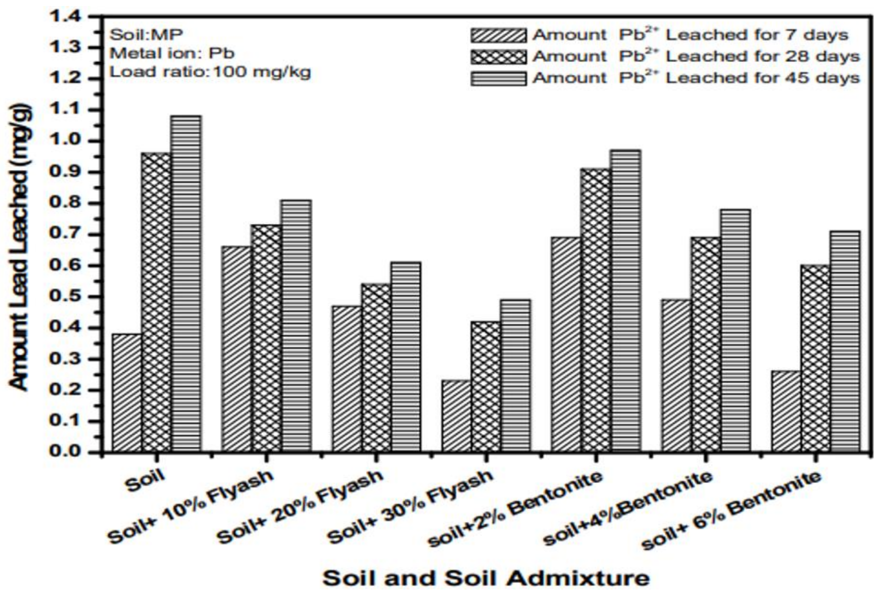

Fig 2: Leaching behavior of 100mg/kg Lead with MP soil and soil mixtures after 7, 28 & 45 days

Toxicity Characteristics Leaching Procedure (TCLP)

The method of toxicity characteristics leaching procedure (TCLP) were used to evaluate the experimental investigations on leaching behaviour of Pb2+ and Ni2+ on MP soil coupled with fly Ash and bentonite in a minor percentage. According to ASTM D3987, all of these two heavy metals were kept well in MP soil in the short term, but the metal ion was released back over a lengthy period of time.

Table 1: Leaching behavior of Nickel, Lead and as per TCLP test for MP soil

Sl. No.	Metal ion	Metal ion loaded (mg/kg)	Starting pH	Adjusted pH	closing	Leaching (mg/L)	Leaching (mg/g)
1	Nickel	3000	5.6	4.9	3.12	119.5	0.660
2	Nickel	3000	5.62	4.96	3.2	105.3	0.613
3	Lead	3015	5.56	4.9	2.98	99.03	0.797
4	Lead	3015	5.66	4.92	2.83	92	0.702

Table 2: Leaching behavior of Nickel and Lead as per TCLP test for MP soil and 10% FA

Sl. No.	Metal ion	Metal ion loaded (mg/kg)	Starting pH	Adjusted pH	Closing pH	Leaching (mg/L)	Leaching (mg/g)
1	Nickel	3000	7.8	2.93	5.54	53.7	0.259
2	Nickel	3000	7.84	2.9	5.62	52.56	0.265
3	Lead	3015	7.56	2.92	5.89	38.78	0.358
4	Lead	3015	7.61	2.9	5.91	39.72	0.350

Table 3: Leaching behavior of Ni2+, Pb2+ and as per TCLP test for MP soil and 2% Bentonite

Sl. No.	Heavy metal	Heavy Metal loaded (mg/kg)	Initial pH	Adjusted pH	Final pH	Leachate (mg/L)	Leachate (mg/g)
1	Nickel	3000	6.89	2.91	5.24	91	0.527
2	Nickel	3000	6.84	2.89	5.38	89.7	0.510
3	Lead	3015	6.56	2.78	5.28	79.03	0.606
4	Lead	3015	6.61	2.9	5.32	76.47	0.600

The wide-ranging further leaching tests were undertaken to validate these results, and it was established according to the TCLP experiment, as shown in tables 1–3. Heavy metal retention was found to be 55.08 percent, 23.96 percent, 43.53 percent, and 41.65 percent with MP soil and their additives such as 10% fly ash, 2% bentonite, 4% bentonite, and 6% bentonite, respectively, which was better than soil, and similarly, nickel retention was found to be 59.84 percent, 20.50 percent, 35.60 percent, and 37.12 percent with the same amended soil, which was better than soil. It was also demonstrated that in the pH range of 9 to 10, Extended TCLP test leaching is well controlled.

6. Conclusion

We can say that the leaching phenomenon on soil and soil mixes spiked with heavy metals lead and nickel was studied using different load ratios of 50mg/kg and 100mg/kg. The leaching percentage for all MP soil and their blends was found to be higher when the load ratio was higher. The subsamples were obtained at 7-day, 28-day, and 45-day curing intervals, respectively. The ability of contaminants to be retained is mostly determined by the curing period, which is unaffected by the action of precipitation. The development of complexes, on the other hand, appears to alter the cure period. In the case of lead, an increase in the curing time lowered the retaining capacity; nonspecific adsorption of lead was the main cause, and desorption of lead occurred as a result of the extended curing time; this proves lead is a highly unstable metal ion. The largest quantity of nickel was leached by MP soil, but with the addition of additives such fly ash to soils, the retention capacity was enhanced. Fly ash was shown to retain nickel by precipitation, and a higher percentage of fly ash dissolved some of the precipitated nickel, resulting in an increase in nickel content in solution.

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