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Amendment of landfill clay liner & decontamination of leachate.

Modificación del revestimiento de arcilla del vertedero y descontaminación de lixiviados

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ABSTRACT

The biodegradable wastes from the households collected have to be properly applied to municipal solid waste landfills. Landfills usually have liner systems and other safeguards to prevent contamination of the surroundings and the groundwater. There are various types of bottom liner systems, the simplest type being usually compacted clay. The clay has some unique characteristics of low permeability, which is the main reason to use clay as the liner. If the compacted clay liners kept for their function, are not properly executed, there can be chances of leachate movement through it, to percolate to underground water systems. In this work, the experimental study of the addition of biochar to proposed samples of the clay liner system & synthesized leachate was studied. From the literature review, it was found out that the minimum dosage of biochar was 3% and that the biochar was made by burning sunflower husks. Biochar treatment of leachate alters not only the turbidity but also the nitrogen, chloride, and phosphate content. Biochar is also used as a coagulant in many water treatment plants. The representative clay soil samples were collected from Manali river beds and laboratory permeability tests were conducted with a soil-biochar mixture for the varied dosages0.5, 1, 1.5, 2, 2.5 and 3. Similarly, municipal solid waste was laid with clay and thus synthesized leachate was amended with similar dosages of biochar 0.5, 1, 1.5, 2, and 2.5. The percentage of biochar addition corresponding to which soil biochar mix yielded minimum permeability was noted at 2% & the leachate- biochar dispersion showed the minimum level of turbidity was investigated also at 2%. Therefore, the paper is the outcome of an attempt to determine the optimum dosage of biochar to clay liner soil to improve the properties concerning permeability and to find out the range of biochar addition with leachate to lessen the anticipated level of contamination to subsurface water.

Keywords: Landfill, compacted clay, leachate, biochar, optimum dosage.

RESUMEN

Los residuos biodegradables de los hogares recogidos deben depositarse adecuadamente en los vertederos municipales de residuos sólidos. Los vertederos suelen tener sistemas de revestimiento y otras

salvaguardias para evitar la contaminación del entorno y del agua subterránea. Existen varios tipos de sistemas de revestimiento de fondo, siendo el más simple el de arcilla compactada. La arcilla tiene algunas características únicas de baja permeabilidad, que es la razón principal para utilizar arcilla como revestimiento. Si los revestimientos de arcilla compactada mantenidos para su función, no se ejecutan adecuadamente, puede haber posibilidades de que los lixiviados se desplacen a través de ellos, para filtrarse a los sistemas de agua subterránea. En este trabajo se estudió el estudio experimental de la adición de biocarbón a muestras propuestas del sistema de revestimiento de arcilla y lixiviado sintetizado. A partir de la revisión de la literatura, se descubrió que la dosis mínima de biocarbón era del 3% y que el biocarbón se elaboraba quemando cáscaras de girasol. El tratamiento de lixiviados con biocarbón altera no sólo la turbidez sino también el contenido de nitrógeno, cloruro y fosfato. El biocarbón también se utiliza como coagulante en muchas plantas de tratamiento de agua. Las muestras representativas de suelo arcilloso se recolectaron de los lechos del río Manali y se realizaron pruebas de permeabilidad de laboratorio con una mezcla de suelo y biocarbón para las dosis variadas 0,5, 1, 1,5, 2, 2,5 y 3. De manera similar, los desechos sólidos municipales se colocaron con arcilla y así El lixiviado sintetizado se modificó con dosis similares de biocarbón 0,5, 1, 1,5, 2 y 2,5. El porcentaje de adición de biocarbón correspondiente al cual la mezcla de biocarbón del suelo produjo una permeabilidad mínima se observó en 2% y la dispersión de lixiviado-biocarbón mostró que el nivel mínimo de turbidez también se investigó en 2%. Por lo tanto, el artículo es el resultado de un intento de determinar la dosis óptima de biocarbón al suelo con revestimiento arcilloso para mejorar las propiedades relativas a la permeabilidad y para determinar el rango de adición de biocarbón con lixiviados para disminuir el nivel previsto de contaminación del agua subterránea.

Palabras clave: Vertedero, arcilla compactada, lixiviados, biocarbón, dosificación óptima.

INTRODUCTION

All civil engineering structures are constructed on the soil. Many times, engineers encounter poor or problematic soil like soft soil, swelling soil, etc. In old times engineers generally avoid construction on such soil, but now a day due to the limitation of land, avoid such solution. Problematic soil can cause serious damage to the stability of structures. So generally, they are replaced by some strong soil or they are treated for better engineering properties. The use of biochar as a soil amendment is being widely studied. In this context, the stability of landfill by enhancing the quality of compacted clay at the bottom liner is studied. The optimum dosage of biochar addition to yield minimum permeability for the soil-biochar sample was the focus of the study. The clay used for the experiment is Manali river clay.

A practical case municipal solid waste disposal landfill was taken and, in that landfill, usually, the bottom and sides were provided with natural clay as a compacted layer. The design of the liner depends upon the characteristics of leachate and the rate of generation. It was also evident that biochar also served as a filtration medium to lessen the contaminant concentration of leachate, entering the subsurface water table.

MATERIALS AND METHODS

Landfills are sites or places set aside for waste materials disposal through burial. Landfills are the earliest forms of waste disposal and treatment. Traditionally, the waste would be left to decay or decompose by itself without being buried, but at present, the process involves burying the waste. Currently, these sites are also useful in the process of waste management, as they act as temporary waste consolidations and storage sites before recycling. Modern landfills are built with sections that we call cells. As the landfill grows individualcells are interlocked by exposing the perimeter of each adjacent cell, so that new cells and previous cells are connected leaving no gaps. This double composite liner system is comprised of many layers. Each layer is dedicated to upholding a specific aspect of a safe and effective liner system. Yet collectively all the layers interconnect and work together to contain waste and keep our environment stable and safe. The entire installation is overseen by a quality control engineer who assures continuity and confirms that all Massachusetts DEP construction standards are met. The first component of the liner system is under drain which includes a perforated plate, its sole purpose is to drain away groundwater from below the liner system. Between the under drain and the lowest plastic liner we place the compacted clay which is very dense and designed to impede water infiltration on top of that we place another layer of clay which has been screened toremove any stones greater than one inch in diameter.

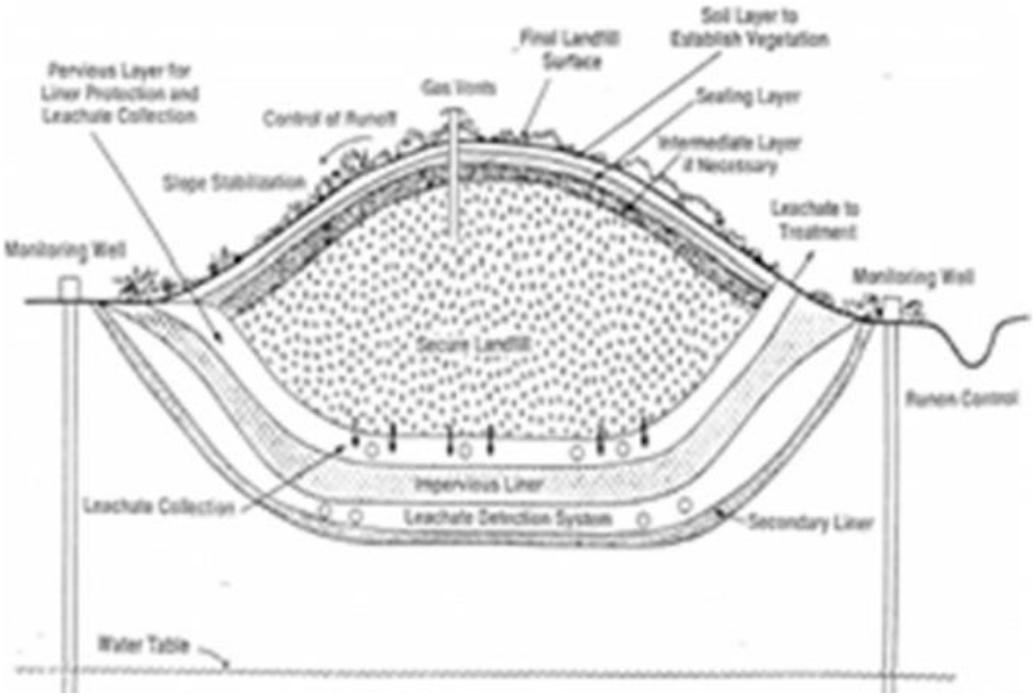
Biochar is a carbon-rich product of the thermal decomposition of organic matter oxygen. Used for soil amendment, waste management, and energy generation. The high carbon content of biochar (65-90%) and high surface areas due to micro-pores are the two primary properties that provide activated carbon with notable applications in chemical reactions, filtration/purification, and adsorption applications. Biochar with high surface area properties may be used directly as a low-yield activated carbon, but biochar with low surfaceareas is often used as a precursor for activated carbon. When a particular amount of biochar is added to the clay, it will reduce the permeability. Towards the experimental works, it was collected all parts of the medicinal plant such as Tulsi, Neem, and Aswaghandha. After three continuous days of sun-burning to ensure the removal of sap contents, the dry mass was burned in a kiln to prepare a biochar sample.

Clay comes from the ground, usually in areas where streams or rivers once flowed. It is made from minerals, plant life, and animals—all the ingredients of soil. Over time, water pressure breaks up the remains of flora, fauna, and minerals, pulverising them into fine particles. Larger particles are filtered out through rocks and sand, leaving silt to settle into beds of clay. How far silt travels from its source and how pure the silt is determines the type of clay it becomes. If, during its creation, the clay stayed put and picked up no impurities, it will be mostly white (kaolin clay), this is considered primary clay. It is simply made up of alumina and silica and chemical water, making the purest, whitest clay, also known as residual clay.

Leachate is a by-product derived from municipal solid wastes due to their physical, chemical, and biological changes and will be formed in landfills, incineration plants, composting plants, and transfer stations, with high strength and toxicity. Pollution control for leachate is a worldwide concern and still a big challenge in

source reduction and pollutant removals. Leachate must be treated properly before it is discharged into the water receivers or recycling using integrated leachate treatment processes. The leachate is prepared from a prototype and its turbidity and dissolved oxygen level is tested. Then it will be treated with different dosage of biochar and again its turbidity is tested.

FIG: Integrated leachate treatment processes.



RESULTS AND DISCUSSION

In the present study, Manali river clay was obtained from 1.5 m depth. The biochar was synthesized by burning medicinal plants and its properties were explained (Table 1). The characteristics of Manali river clay was explained (Table 2). The variation in permeability of clay (Table 3) and its graph is given (Fig 2). The variation of turbidity in leachate after the addition of biochar was well studied (Table 4).

Table 1: Properties of Biochar

Wood type	Medicinal
Production temperature(^{0}C)	600
pH	5
Density(g/cc)	1.8
Average % ash content	13.43

Table 2: Properties of Manali river clay

Properties	Values
Specific gravity	2.7
Liquid limit	53%
Plastic limit	33%
Shrinkage limit	19%
Free swell index	25%
Optimum moisture content	20%
Maximum dry density	1.42 g/cc
IS classification of soil	CL
UCC strength	72.62 kN/m^2
Permeability	4.5×10^{-9} m/s

With the varying percentage addition of biochar, the permeability of soil was significantly reduced as below.

Table 3: variation in permeability with different dosage of biochar

e of biochar(%)	Permeability (m/s)
0.5	2.36×10^{-9}
1	1.62×10^{-9}
1.5	1.04×10^{-9}
2	2×10^{-10}
2.5	1×10^{-9}
3	1×10^{-9}

In this work, the leachate was prepared from a prototype model and its turbidity and dissolved oxygen level is tested. Subsequently, synthesized leachate was passed with biochar added clay-liner, and its turbidity and dissolved oxygen level were again tested in different dosages of biochar.

Table 4: Properties of leachate

Properties	Values
Dissolved oxygen	22.82 mg/L
pH	12.32
Chloride content	209 mg/L
Turbidity	332.4 NTU

Table 5: change in turbidity

Biochar dosage (%)	Turbidity (NTU)
0.5	270
1	180
1.5	59.1
2	37.3
2.5	37.3

Turbidity is the measure of the relative clarity of a liquid. It is an optical characteristic of water and is a measurement of the amount of light that is scattered by material in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher will be the turbidity.

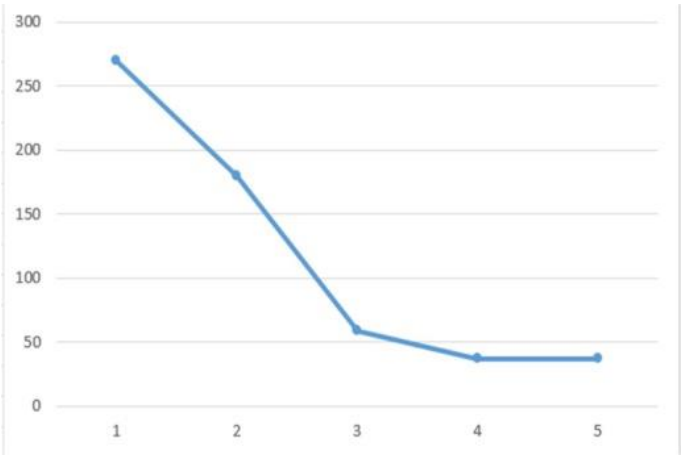


Fig: 2 Plot of biochar dosage v/s turbidity

The results obtained were satisfactory. Biochar was added at different dosages (0.5%, 1%, 1.5%, 2%, 2.5%, 3%) and permeability was obtained minimum of 2%. The turbidity of raw leachate obtained was 332.4 NTU and the same was conducted by adding different dosages of biochar, the minimum turbidity was also obtained at 2%. Hence, it was concluded that biochar can be used as a good soil amendment material, it also reduces the contamination in leachate.

REFERENCES

Maciej Gliniak et al. (2020) Impact of biochar on water permeability in soil, IOP Conference Series, Materials Science and Engineering, Volume 960, 1-4

Xuquin Pan et al. (2020) Effect of biochar addition on the removal of organic and nitrogen pollutants from leachate treated with a semi aerobic aged refuse bio filter, Waste Management & Research, 38(10):1176-

1184.

Clabiru Lindamulla et al. (2022) Municipal landfill leachate characteristics and their treatment options in tropical countries, Curr Pollution Rep 8, 273–287

Guo, Xiaoxia & Liu, Hongtao & Zhang, Jun (2019) The role of biochar in organic waste composting and soil improvement: A review, Waste management (New York, N.Y., 102. 884-899. 10.1016/j.wasman.2019.12.003.

Yuqing Sun et al. (2021) Roles of biochar-derived dissolved organic matter in soil amendment and environmental remediation: A critical review, Chemical Engineering Journal, Volume 424,130387, ISSN 1385-8947

Mohammadreza Kamali et al. (2022) Biochar for soil applications-sustainability aspects, challenges and future prospects, Chemical Engineering Journal, Volume 428,2022,131189, ISSN 1385-8947

Yuri Abner Rocha Lebron et al. (2021) A survey on experiences in leachate treatment: Common practices, differences worldwide and future perspectives, Journal of Environmental Management, Volume 288,112475,ISSN 0301-4797

Lingyue Zhang, Hao Bai, Yawei Zhang, Yang Wang and Dongbei Yue (2021)Life Cycle Assessment of Leachate Treatment Strategies, Environmental Science & Technology, 55 (19), 13264-13273, DOI: 10.1021/acs.est.1c02165

Camargo J A and Alonso A (2006) Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment, Environment international, 32:831- 849.

Chen X, Chen G, Chen L, Chen Y, Lehmann J, McBride M B and Hay A G (2011) Adsorption of copper and zinc by biochars produced from pyrolysis of hardwood and corn straw in aqueous solution, Bioresource technology, 102(19), 8877-8884.

Raksha Kishore Rai, Kelpie Wilson Wilson K (2014) How Biochar Works in Soil, Biochar Journal Arbaz, Switzerland, pp 25-33.

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