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Effect of amended Geosynthetic Clay Liners (GCLs) on chromium contaminated leachate

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Abstract— *Contamination of heavy metals has a detrimental effect on human health. Facilities for the disposal of municipal solid waste are among the possibilities that contaminate groundwater and the environment the most. Leachate is the term for the fluid that results from the anaerobic oxidation of solid waste in landfills. Depending on the type of waste, leachate comprises organic, inorganic, and heavy metals. The primary problem in developing countries is the leachate-related contamination of ground and surface water. Cr (Chromium), one of the heavy metals contained in the leachate, is one of the majority of heavy metals that are carcinogenic in nature. In the leachate sample, the concentration of Cr was determined to be 0.178 mg/l, more than double the allowed limit of 0.1 mg/l. Reducing the Cr concentration in leachate samples after passing through a modified geosynthetic clay liner is the goal of this study (GCL). The modified geosynthetic clay liner was created by mixing various amounts of Peanut Shell Ash (PSA) with encapsulated Sodium Bentonite (Na-B) in commercial GCL (0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, and 50%).*

Keywords— ***Contamination, Geosynthetic clay liner, Leachate, Peanut shell ash.***

I. INTRODUCTION

The explosive growth of municipal solid waste is especially worrying for everyone in the world. The average amount of waste produced daily per person worldwide is 0.74 kg, howeverindividual country waste output rates can range from 0.14 to 4.54 kg (Dixit et al., 2022). Unregulated and non-engineered waste disposal is one of the leading causes of groundwater contamination, air pollution, and land pollution, posing health risks to humans, organisms, and ecosystems (Dixit & Srivastava, 2015). In many nations, a substantial rise is observed in both municipal and industrial solid waste output along with improved standards of existing and sustained industrial and commercial development (Renou et al., 2008).Leachate is a type of contaminated liquid that develops when organic solid waste decomposes, gathers contaminants, and spreads into underground spaces (Renou et al., 2008). Heavy metals including chromium, nickel, copper, zinc, cadmium, lead, etc. are present in the leachate. Groundwater resources are significantly in danger from leachate from landfills. (Maiti et al., 2016). In some cases, identifying the exact nature of groundwater contaminant sources may be impossible (Datta & Singh, 2014). Groundwater is particularly vulnerable in areas with a high population density (Singh & Datta, 2021; Zahra et al., 2021). Unauthorized and uncontrolled pollutant injection into the aquifer is one of the most typical sources of groundwater contamination. (Datta & Singh, 2014).

Heavy metals are metallic chemical elements that have a comparatively high density and are hazardous or harmful even at low concentrations. The process of identifying possible threats to human health connected to environmental exposures is known as health risk assessment. Prolonged exposure to Cr may cause lung, liver, bladder, and kidney cancer. Additionally, it led to respiratory illness and skin damage. (Dixit & Roy, 2016).

The concentration of heavy metals has resulted in a significant increase in environmental danger on a worldwide scale in recent decades. Cr increases the incidence several of malignancies while causing extensive environmental harm and is now shown to be neurotoxic. A

wide range of plants and microorganisms play a significant role in the removal of dangerous metals from polluted settings. The individual eats Cr and its byproducts, particularly chromates. People have been exposed to Cr mostly by ingestion, cutaneous absorption, and inhalation. (Dixit et al., 2016; Sharma & Kumar, 2021)

In waste containment applications, geosynthetic clay liners (GCLs) are effective barrier materials for lining and covering systems (Scalia et al., 2018). Due to their low hydraulic conductivity, which helps to stop contamination from leaching into groundwater, and ease of installation, geosynthetic clay liners (GCLs) are being used frequently in landfill disposal facilities (Yu et al., 2021, De Camillus et al., 2016; Kong et al., 2017; Ozhan, 2018; Sari and Chai, 2013; Xie et al., 2018). The GCLs are created as hydraulic barriers, consisting of two geotextile fabrics and a layer of bentonite (Yu et al., 2021). Numerous research has examined how penetration with leachate from municipal solid waste landfills affects the hydraulic performance of GCLs (Wang et al., 2019).

II. MATERIALS & METHOD

2.1 SITE SELECTION

The study area Kanpur, which is situated on the north by the Ganga River and on the south by the Pandu River, is the 11th most populous city in India (Yamuna). The city is situated between latitudes 25°26′ and 26°58′ north and longitudes 79°31′ and 80°34′ east (Dixit et al., 2022). 33.3 °C and 3.7 °C are the highest and lowest recorded temperatures, respectively. The average relative humidity is 78.13%, there is 820 mm of rain on average per year, and the wind speed is 0.936 km/h (Mishra et al., 2021). A municipal solid waste disposal facility (26o27'12"N, 80o14'19"E) provided the leachate sample.

Fig.1 Leachate generation at the municipal solid waste dump site, Kanpur

2.2 PSA

Peanut shells were collected from small shops and the domestic waste disposal area. The shells that have been collected were cut into small pieces. The PSA was produced through pyrolysis with a controlled oxygen supply. The method is used as recommended by Murad et al., 2022.

2.3 GCL

The procured GCLs are made of needle-punched granular sodium bentonite sandwiched between a woven (carrier) and non-woven (Fig.2a). The woven geotextile with a density of 125 g/m^2 and a non-woven (cover) geotextile with a density of 200 g/m^2 is used in the study. The initial thickness of GCL is 6 mm. The peanut shell ash used in this study is presented in Fig.2b.

Fig.2a Procured GCL sample

Fig.2b PSA sample

2.4 EXPERIMENTAL SETUP USING PSA

Leachate contained heavy elements as Iron, Nickel, Zinc, Chromium, Arsenic, Cadmium, and Lead. The health of humans is seriously damaged by these poisonous metals. From GCL rolled sheet, 8x8 cm GCL specimens were cut. By mixing PSA with Na-B in GCL at room temperature (27°–30°), modified GCL specimens were created. PSA was added in various ratios to Na-B: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45%, and 50%. In order to create the synthetic leachate, distilled water was contaminated with 0.178 mg/l of Cr.

Fig. 2.4 Experimental Setup

III. RESULT AND DISCUSSION

The experimental results highlight that the lowest Chromium (Cr) content was found at 40% PSA in the effluent synthetic leachate from GCL (Geosynthetic Clay Liners) (Peanut Shell Ash). It is obvious that the synthetic leachate's Cr content decreased to 0.0520 mg/l and was the lowest of all the effluents collected from GCL. This demonstrates that the highest PSA absorption against Cr occurs at 40% Na-B addition in GCL.

IV. CONCLUSION

Based on the finding of the study, it can be concluded that peanut shell ash is an organic waste by-product and is available with low or no cost and it can be utilized as a better absorbent for total chromium-contaminated leachate. The application of PSA with GCL improves the reduction capacity of Cr concentration at 40% addition proportion. So, it is recommended that PSA canalso be used in GCL at the locations where leachate is contaminated by a high concentration of Cr. In case of failure, the self-healing property of GCL blended with PSA will reduce the chances of groundwater contamination with Cr.

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