Landfill Stability Research:

The new regulations control the future management of hazardous waste, but do not address the health and environmental problems from past disposal practices.
https://www.epa.gov/archive/epa/aboutepa/epas-hazardous-waste-regulations-effective-november-19-1980.html

"Landfill stability is closely related to the engineering behavior of municiple solid waste (MSW). For example, assessing the stability of landfill slopes requires an understanding of the shear strength of MSW [3–6]. In addition, the expansion of a landfill may lead to the settlement of the existing landfill and expanded landfill, which may cause problems with the linear system and slope stability [7]"
https://www.hindawi.com/journals/ace/2021/5574238/

"Instability phenomena in waste landfills are not rare and the consequences are more severe than ones for typical landslide, having also environmental impact. Old waste dumps are often located in dried (or partially dried) valleys, natural gulches or ravines, therefore waste is often placed on sloped ground. Their mechanical characteristics are often very poor and, due to lack of drainage systems, are in saturated state. Therefore, instability can appear at every stage of the operation, during the closure or post-closing. The paper presents some aspects related to specific instability phenomena in waste landfills and dumps and to stability analysis in saturated and unsaturated state using numerical methods. As well, it presents a case study of an old dumpsite in Romania where a landslide occurred during the closing works and for which a consolidation solution was proposed, based on drainage and mechanical consolidation. Numerical modeling has been used for simulating the effect of the drainage and for evaluating the gain in stability, considering the unsaturated final state of the drained waste."
https://www.researchgate.net/publication/315909450_Instability_Phenomena_in_Municipal_Waste_Landfill_Numerical_Modeling_in_Saturated_and_Unsaturated_Conditions

"A series of ecological indicators is used to evaluate and measure land quality: land soil quality, land soil stability, land landscape function, land infiltration, land infiltration rate, land runoff, land vegetative cover, land rills and gullies, land pedestals and terracettes, land bare ground, land litter, land soil surface loss, land plant mortality, and land integrity. The three attributes – soil stability, hydrologic function, and integrity of the biotic community – are also used as a common description of the quality of land."
https://www.sciencedirect.com/topics/earth-and-planetary-sciences/soil-stability

"Unregulated solid waste landfills are causing severe environmental impacts for environment and human health due to the formation of leachates and landfill gas during decomposition of organic wastes. Common problems that usually be faced with these sites are visual pollution, air pollution, water pollution, soil contamination, spreading of waste, spreading of diseases, subsidence and odor. Therefore the rehabilitation of waste dumping sites has become a matter of importance for controlling these adverse effects."
https://link.springer.com/chapter/10.1007/978-3-540-69313-0_101

- **Geotechnical Practice for Waste Disposal** pp 244–268

See attachment

https://link.springer.com/chapter/10.1007/978-1-4615-3070-1_11

- **Solid Waste Engineering and Management** pp 659–706

Abstract

Management of a landfill is a continuous process that proceeds long after the active landfill period, which is called landfill post-closure/after-care management. In most developed and developing countries, this after-care period is regulated for a minimum of 30 years after landfill closure. This ensures waste stabilization within the landfill layers, and there are minimal environmental threats to the surrounding area, especially from the leachate and landfill gas emissions. This chapter covers the legislation and requirements imposed by most countries related to the proper management of landfills during this passive phase, which involves the monitoring requirement and emission evaluation. The basic principles of landfill technology, its types, and operation will first be discussed as it influences after-care management. Emphasis will be made toward three methods/approaches (evaluation through target value, evaluation using impact/risk assessment, and evaluation through a performance-based system) in determining the completion or endpoint for the post-closure period. Both the advantages and disadvantages of each method will be further discussed and summarized.

https://link.springer.com/chapter/10.1007/978-3-030-89336-1_10

- **Stability of MSW Landfill Slopes Reinforced with Geogrids**

See attachment

https://www.mdpi.com/2076-3417/12/22/11866

- **Stability of slopes of municipal solid waste landfills with co-disposal of biosolids**

https://www.witpress.com/Secure/elibrary/papers/GEO06/GEO06022FU1.pdf

- **Geosynthetics in Civil and Environmental Engineering** pp 540–545

Abstract

Unregulated solid waste landfills are causing severe environmental impacts for environment and human health due to the formation of leachates and landfill gas during decomposition of organic wastes. Common problems that usually be faced with these sites are visual pollution, air pollution, water pollution, soil contamination, spreading of waste, spreading of diseases, subsidence and odor. Therefore the rehabilitation of waste dumping sites has become a matter of importance for controlling these adverse effects. In this study, it is aimed to promote the rehabilitation of unregulated solid waste landfills and to provide guidance on how to effectively rehabilitate these sites so that off-site emissions from leachate and landfill gases are minimized. This study focuses on the geotechnical solutions to the problems associated with open waste dump sites. Full rehabilitation process includes shaping the waste body, surface water control, leachate management, gas management, final cover system with HDPE liner, settlement analysis, slope stability analysis and monitoring after closure. As a case study, data belongs to the unregulated solid waste landfill called Silivri are used. For the rehabilitation of the unregulated landfill, USEPA and Turkish Regulations are taken as major guidelines.

https://link.springer.com/chapter/10.1007/978-3-540-69313-0_101

- **Characterization of an unregulated landfill using surface-based geophysics and geostatistics**

Abstract

This paper develops a geoelectrical and geostatistical-based methodology that can be used to screen unregulated landfills for the presence of leachate and obtain an approximation of the vertical/spatial extent of waste. The methodology uses a surface electromagnetic (EM) survey combined with indicator kriging. Indicator kriging allows for the use of EM data that have been collected over highly electrically conductive material such as that occurring within landfills. Indicator kriging maps were generated for several vertical sections cut through a landfill to establish the landfill strata. Similarly, horizontal sections were generated to evaluate the areas extent of waste and leachate in the vadose zone and saturated zones, respectively. The horizontal and vertical maps were combined to estimate the volume of solid waste and liquid within three zones: (1) waste, (2) waste and/or leachate, and (3) potential leachate. The methodology appears to hold promise in providing results that can be used as part of a hazard assessment, or to assist in the placement of monitoring wells at sites requiring additional study. A case study is used to demonstrate the methodology at an unregulated landfill in eastern Nebraska.

Authors:

Woldt, W E; Jones, D D [1]; Hagemeister, M E [2]

https://www.osti.gov/biblio/3022

- **Geoenvironmental approaches in an old municipal waste landfill reclamation process: Expectations vs reality**

Abstract

Nowadays, environmental geotechnics and engineering are facing several challenges to be addressed during landfill reclamation works. The purpose of the technical paper is to present examples of reclamation works designed to reduce the soil-water environment impact of an old municipal solid waste landfill and to ensure geotechnical safety. The authors tried to prove that even though the initially designed reclamation works could be difficult to implement and execute, they could bring the desired effect in real conditions. Several technical solutions to re-engineer shape the landfill body and reinforce the slope stability are discussed in the article. Commonly known pollution-reducing methods were also presented and discussed. For many years of operation, a landfill study area was located in difficult hydrogeological conditions, with no systems in place to prevent contamination. Using monitoring and numerical modelling, it has been shown that reclamation works increase the quality of groundwater and improve the conditions for landfill slope stability over time. The study also showed that both vertical barriers and leachate drainage systems can improve the condition of plant communities in landfill surroundings. Accordingly, reclamation works do not fundamentally change the function of a landfill but do limit its negative impacts on the environment, such as reducing the spread of pollutants into soil and water, protecting the slopes from erosion, reducing dust, allowing establishing of new vegetation cover, and improving the visual quality of the landscape. The research proved that expected reclamation results could only be reached if complex approaches and constant monitoring are provided when executing the reclamation works.

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https://ui.adsabs.harvard.edu/abs/2023SoFou..6301273K/abstract

- **Geoelectrical investigation of old/abandoned, covered landfill sites in urban areas: model development with a genetic diagnosis approach**

Geoelectrical methods have an important, albeit difficult role to play in landfill investigations. In the present economic conditions, with the environmentally sensitive regime, adequate desk-study and model development are essential ingredients for a successful site investigation of landfills. This paper attempts to develop a genetic investigative model for old/abandoned landfill sites where the records of operations are not available. The main elements of the model are the site boundaries, age and nature of anthropogenic deposits, depth and dip of the layers of refuse and sealing materials, the integrity and shape of the capping zones or separating walls and basal floor slopes, the position of concealed access roads in the site, the water table (or perched water bodies within the refuse) and the presence of leachate. The attendant geotechnical, hydrogeological, and bio-geochemical constraints at such sites are also incorporated in the model for consistency of practical solutions to landfill problems. The nature of anthropogenic deposits and the spatial-temporal characteristics of leachates are reviewed in a geoelectrical context. The analogy between waste degradation and leaching, and the well-known weathering processes of supergene mineral enrichment and saprolite formation in crystalline rocks is explored, and used to develop a conceptual resistivity-vs.-depth model for landfill sites. The main tenet of the model is that vertical conductivity profiles will attain maximum values in the zone of mineral enrichment near the water table and tail-off away from it. This conceptual resistivity model is shown to be consistent with non-invasive observations in landfill sites in different geographical environments. Power-law relationships are found to exist between some geoelectrically important hydrochemical parameters (fluid conductivity, chloride content and total dissolved solids) in leachates and leachate-contaminated groundwater from some landfill sites. Since some chemical parameters of fill are known to vary consistently with time, a plausible hydrochemical and age-deductive scheme for saturated fill is proposed for geoelectrical models of landfills without significant amounts of metal. Practical suggestions are made for a consistent approach in geoelectrical investigation and diagnosis of old landfill sites. A few field examples are used to illustrate the diagnosis approach.

https://ui.adsabs.harvard.edu/abs/2000JAG....44..115M/abstract

- **The Groundwater Geochemistry of Waste Disposal Facilities**

Abstract

Landfills of solid waste are abundant sources of groundwater pollution. The potential for generatingstrongly contaminated leachate from landfill waste is very substantial. Even for small landfills the timescale can be measured in decades or centuries. This indicates that waste dumps with no measures to control leachate entrance into the groundwater may constitute a source of groundwater contamination long after dumping has ceased. In addition to these dumps, engineered landfills with liners and leachate collection systems may also constitute a source of groundwater contamination due to inadequate design, construction, and maintenance, resulting in the leakage of leachate.Landfills may pose several environmental problems (explosion hazards, vegetation damage, dust and air emissions, etc.), but groundwater pollution by leachate is considered to be the most important one and the focus of this chapter. Landfills differ significantly depending on the waste they receive: mineral waste landfills for combustion ashes, hazardous waste landfills, specific industrial landfills serving a single industry, or municipal waste landfills receiving a mixture of municipal waste, construction, and demolition waste, waste from small industries and minor quantities of hazardous waste. The latter type of landfill (termed "old landfills" in this chapter) is very common all over the world. Municipal landfills are characterized by a high content of organic waste that affects the biogeochemical processes in the landfill body and the generation of strongly anaerobic leachate with a high content of dissolved organic carbon, salts, ammonium, and organic compounds and metals released from the waste.This chapter describes the biogeochemistry of a landfill leachate plume as it emerges from the bottom of a landfill and migrates in an aquifer. The landfill hydrology, source composition, and spreading of contaminants are described in introductory sections. The focus of this chapter is on investigating the biogeochemical processes associated with the natural attenuation of organic contaminants in a leachate plume. Studies have shown that microbial processes and geochemical conditions change over time and distance in contaminant plumes, resulting in different rates of degradation (biotic and abiotic). The availability of electron acceptors, such as iron oxides or dissolved sulfate, is an important factor for evaluating the efficacy and sustainability of natural attenuation as a remedy for leachate plumes. Understanding the complex environments developing in leachate plumes is important in assessing the risk to groundwater resources and for developing cost-effective remediation strategies.

https://ui.adsabs.harvard.edu/abs/2003TrGeo...9..579B/abstract