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Composition of Alternative Daily Cover Materials with a Perspective of Use of Latvian Local Resources

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***Abstract* — This paper focuses on alternative daily cover materials intended for use in solid municipal waste landfills. Currently available and proposed cover materials are described by type. The functional contribution of cover components was considered. Special attention was given to alternative daily cover materials in form of sprayable slurries or emulsions. Using the obtained data, conclusions were drawn concerning the most promising components and compositions of sprayable alternative daily covers. Particularly promising components of sprayable daily covers for the use in local environment (Latvia) are clays, which are found in abundance in local mineral deposits.**

***Keywords* — Daily landfill cover, sprayable cover materials.**

I. Introduction

Nowadays, environmental protection is widely recognized as a priority area and society expects that both companies and local municipal services will operate using new and existing environmentally friendly technologies. Environmental research is one of the steps to change the situation of the urban environment and agriculture [1].

In the last decade a large amount of research on biodegradable composite covers intended to be used for waste processing and for improving the situation in already degraded environments has been made.

The use of daily cover material is essential for landfilling operations and performs a number of important functions to minimize the impact of the landfill on the environment. Type, quantity and method of application of the cover material used at each landfill must be appropriated to achieve the overall objective of controlling potential nuisances that may arise [2].

Landfill daily cover is required to be placed on any area with exposed municipal solid waste at the end of each operating day.

The main objectives of daily cover at a landfill include the following: prevention of wind-blown litter (1), deterring scavenging by birds or any other animals such as rats (2), prevention of fly infestation (3), reduction of odour andmethane emissions (4), reduction of airborne dust nuisance (5), reduction of the risk of fire (6), and improvement of an overall visual appearance (7) [2]−[8]. The use of daily covers also minimizes moisture infiltration in the landfill site and thus the generation of leachate [9] and, furthermore, eases the flow of transport through the landfill site [8].

To achieve satisfactory results daily cover material must be applied on waste that has been sufficiently compacted to achieve an even surface without voids. Unsatisfactorily prepared waste layer can result in an inadequate coverage or excessive consumption of the cover material [10].

Traditional daily cover materials used in landfills are: soil, subsoil, rock and gravel, construction and demolition waste (for example, bricks or crushed concrete). However, it can often be difficult to obtain sufficient quantities of these 'traditional' daily cover materials. Thus alternative types of cover may have to be considered [2].

Soil is easy to obtain for the use as daily cover, but its use is controversial. A particular concern is the excessive consumption of valuable landfill space as waste in landfills is required to be covered daily with up to 15 cm of compacted soil. The use of soils as daily covers also contributes to instability of waste mass and its hydraulic heterogeneity reduces the efficiency of the drainage layer due to migration of fine soil particulates and clog formation [11].

The aim of this research is to give an overview on daily cover materials with a special focus on sprayable alternative daily cover compositions. The possible use of clays (which are found in abundance locally) in composition of sprayable daily covers is evaluated.

II. Classification of Alternative Daily Covers

Generally, alternative daily covers (ADCs) are mixtures of waste derived and non waste derived materials. Waste derived materials can include various types of locally available waste materials such as ash, automobile recycling fluff, fine particulates of construction and demolition waste, compost, shredded green waste (vegetation and leaves), contaminated sediment and soil, sludge, and shredded tires. Non waste derived materials can be generally classified into two groups: sprayable materials and geosynthetic materials or tarps [12]−[14].

A. Waste-Derived Alternative Daily Covers

Depending on the regulations the following materials may be used as a substitute for soil cover, either on their own or after being blended with soil, typically in 1:1 ratio [12], [15].

- Ash typically comes from the incineration of materials such as the combustion of coal in energy generation. Ash can be used as is or blended with soil or sludge.
- Automobile recycling fluff. Automobile shredder fluff is made in the process of shredding automobiles and recapturing metals and plastics for reuse. Typically fluff is less dense than soil and is blended with soil prior to use.
- Construction and demolition waste fines are a soil-like material that is left over after construction and demolition waste is processed for recycling. Normally these fines would be disposed of in a landfill.

- Composted materials can consist of decomposed wood, green waste or other solid waste. If this material has insufficient quality to produce revenue, then its use as an ADC is attractive.
- Shredded green waste. It is readily available at most landfills. Either ground or unground, this material can replace soil and also can be used as a substitute of gravel for maintaining roads and tipping pads.
- Contaminated sediment and soil. It is advantageous to replace clean soil, which has an associated cost to it, with contaminated soil. Leachate from contaminated sediment and soil may be a concern depending on the contamination and this material is not always available.
- Sludge can be used as an ADC as there is often no other use for it. The use of sludge can increase the overall waste density at a facility due to its high density and moisture content. Additionally, some sludge may be used to augment soil nutrients for growing vegetation and minimize erosion of the landfill cover.
- Shredded tires. By using shredded tires it is possible to dispose of tires without additional use of airspace as they would otherwise be landfilled like any other waste.

Suitability and acceptability are dependent on site-specific climatic and operation conditions and regulatory requirements. In most cases indigenous materials are spread with bulldozers as with traditional soil daily cover. As with soil they occupy a lot of landfill space. Also many unprocessed locally available materials generate dust [13].

B. Non-Waste Derived Alternative Daily Covers

These ADCs can be classified as sprayable covers and geosynthetic covers or tarps.

There are two major categories of sprayable ADCs: foams and slurries. To create foam soap, starches or resins are mixed with water. The foams form a thin layer over the waste. These are applied to the working face of the landfills using special equipment. They don′t occupy any landfill space, but last only a very short period of time and may be combustible. The foams do not harden like slurry ADCs do. Foam ADCs also tend to be very expensive [12], [13], [16]. Slurry ADCs are made by mixing solids with water and spraying the mixture on the working face of the landfill. Commercially available slurries utilize newspaper, mixed paper, wood fibre, cement kiln dust or fly ash, along with mixing agents and water [12], [16]. Specialized spray equipment is used to apply the slurry on the surface of the landfill. Special slurry ADCs can be sprayed on with hydroseeding machines. They do not occupy landfill space and can be used in inclement weather [13]. The sprayed slurry forms a thin layer over the waste. Several additional applications from different directions may be needed to ensure even coverage of the waste. The biggest advantage of sprayable covers is that they do not need to be removed. Instead the sprayable covers are pulverized as the next layer of waste is applied on top of them. It is also possible to include odour control agents or colorants in the composition of sprayable slurry ADCs.

Geosynthetic covers or tarps are large pieces of plastic sheets or fabric that are deployed using equipment (special equipment can be used to deploy geosynthetic covers) or small tarps can be put manually. Geosynthetic covers or tarps are placed over the working face at the end of the operating day. Geotextile covers can be reusable or non-reusable [13]. The reusable tarps are thick mats that can be unrolled or pulled over a working face at the end of the work day and removed again before the start of the next day. A non-reusable geosynthetic cover is simply left in the working face with the next day′s waste where it can degrade in an accelerated fashion due to the presence of a prodegradant additive. An advantage of a non-reusable geosynthetic is that it continues with barrier benefits through to the following waste fill sequence. It provides a continuous extended barrier between waste and environment. Reusable tarps provide good barrier action against fluid migration only while in place, but their time in actual coverage is limited to a partial day — being applied at the end of the day and taken from the working face before the start of operation the next day [17]. The disadvantages of geosynthetic covers are: a limited ability to control odours and rodents; the advantages are: no airspace consumption, minimal cost, quick deployment and removal and reusability. Unfortunately, geosynthetic covers are difficult to deploy in windy conditions or in low temperatures, employees are exposed to waste, and tearing often occurs upon dragging over the waste [12]. They can be used as rational complement in combination with other types of ADCs in the management of landfill.

One of technical advantages of using ADCs relates to the management of landfill gas and leachate. Use of non waste derived ADCs reduces the amount of soil used. This improves the flow of landfill gas and leachate by removing potential barriers within the waste. This may result in more intensive landfill gas generation, which in turn may also increase revenue. ADCs can also facilitate the flow of leachate through the waste mass to the collection layer, minimizing the potential for leachate seeps [12].

There is no one type of ADCs that works best at every solid municipal waste landfill, each technique has advantages and disadvantages and the choice of the best technique for a specific application depends on economic constraints, treatment efficiency and landfill operations. This does not mean that the landfills should not use these materials and should not stop the search for new materials. When it comes to ADC there are still many discoveries to be made.

From all the aforementioned materials, sprayable ADCs can be readily mixed and is easy to use in municipal solid waste landfills in Latvia and it is necessary to include the local subsoil resources. In this research the composition of sprayable materials was analysed in detail.

III. Composition and Methods of Deployment of Sprayable Daily Covers

Sprayable ADCs are intended to provide an effective landfill cover and to physically stabilize the waste [2]. Sprayable slurries are non-hazardous inert materials. Using the available literature data the composition of sprayable ADCs is analysed. The most often used components are various fibres and minerals.

Many ADCs utilize smectite group clay minerals. Research available so far has focused on natural fine grained soils such as clays and tills that are known to be capable of providing low permeability and/or high moisture retention capability in a constructed layer having a high level of saturation.

The long term effectiveness of clay covers has been questioned due to cracking and other deterioration caused by natural forces such as freeze/thaw cycles, burrowing, root penetration and erosion. Using natural soils as dry covers, moisture retention is enhanced by the fine grain size. As the elevation of a layer of fine grained, porous material increases above the water table so does the degree in interstitial suction, which in turn decreases the moisture retention capability of the layer and increases the proportion of air filled interstitial pore space. As the primary route of atmospheric oxygen through a fine grained, porous layer is the diffusion through air filled pore spaces, a significant decrease in pore water content is undesirable. Fortunately, research has demonstrated that a "capillary brake" can be established by placing a fine grained, porous material over a coarser layer. Using this approach a fine grained layer could be maintained in a near saturated state indefinitely provided it is protected from moisture loss due to evapotranspiration [18].

The biodegradability of the organic fibre content is dependent upon the pulp process used — either chemical or mechanical pulping. Chemical pulping is based on removing the lignin that glues the wood fibre together. Chemical pulp products include fine papers, wrapping paper and sack paper. The fibre content of chemical pulp is biodegradable. The fibre content of mechanical pulps is biodegradable under aerobic conditions, but not under anaerobic conditions due to its lignin content. Lignin is a complex natural polymer that provides support and protects plant cells in woody plants. Dry wood contains 30 % of lignin. Lignin is also a byproduct of pulp and paper industry.

Limestone and ash can also be applied to increase pH. Ash has considerable acid neutralization capacity and is also capable of moisture retention.

Gypsum and phosphate slag are also suitable materials for dry covers. Gypsum is acidic and unstable with a high permeability, while phosphate slag is highly pervious and essentially inert [4], [19], [20]−[22].

A sprayable ADC must also have suitable viscosity and must be able to form a layer. Therefore ADC must also contain cross-linking agents, tackifiers and viscosifiers. The cross-linking agent can be an inorganic salt. It has been found that sodium borate, sodium metaborate, sodium tetraborate, hydrated sodium borate, hydrated sodium metaborate, hydrated sodium tetraborate (Borax), magnesium sulfate, molybdenum sulfate, and sodium molybdate are sufficient in this regard. Other inorganic salts can also serve as cross-linking agents. The operative range of the cross-linking agent is 1−5 % of mass fraction [22].

Most often used polymers in ADC compositions are: guar gum, xanthan gum, psyllium and pregelatinized starch, starch derivatives, methyl cellulose, carboxymethyl cellulose and hydroxyethyl cellulose, polyacrylamide, polyacrylate.

Tackifiers (many polymers can be used as tackifiers) are used in hydroseeding slurries as well as on their own to provide temporary erosion and sediment control, to increase moisture retention and to control dust and wind scour [23].

Viscosity increasing polymers principally are: guar gum, xanthan gum and polyacrylamide. The polymer concentration to achieve the necessary viscosity is not sufficient to provide the required tack for the hydraulically applied slurries. More than one polymer may be used to provide necessary viscosity. Viscosifiers generally are not applied as tackifiers because not at high enough concentration. To function as tackifier, viscosifier has to have such a high loading that slurry cannot be mixed or pumped. The content of these materials must be less than 2 %.

The primary functions of a tackifier are: to assist in adhering mulch to the ground, to form a uniform seal or barrier from the elements, to rewet during rain and to hold the applied mulch together [24].

Tackifiers are used to provide temporary erosion and sediment control, to increase moisture retention and to control dust and wind scour.

By analysing the available scientific literature it is shown that the most often used sprayable ACD components are clays (10−90 %), fibres (20−60 %) and polymers (0.5−15 %) [19]−[22].

To evaluate the possible use of Latvian clay mineral deposits as component of sprayable ADC a thorough research of clay properties (including particle size distribution) and of interaction of clays and other components is needed.

IV. Conclusion

This paper presents early findings of an ongoing research.

The analysis of the available scientific literature allows to draw several conclusions about possible development and use of sprayable alternative daily cover material.

A sprayable cover material is the most convenient for daily use. The main materials used are clay (10−90 %), fibres (20−60 %) and polymers (0.5−15 %). It is possible to develop a sprayable alternative daily cover material by using polymer materials and fibres and locally available clays, which would allow greater use of the resources available in Latvia. In further research the desired composition of raw materials and the necessary properties of the composite will be specified − to obtain an aqueous suspension and to develop technology. The use of local subsoil resource for creation of biodegradable composite will have an important contribution to environmental protection.

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Olita Medne, Rita Seržāne, Līga Bērziņa-Cimdiņa. Alternatīvo ikdienas pārklājumu materiālu sastāva pētījumi ar perspektīvu Latvijas vietējo zemes dzīļu resursu izmantošanai.
Pēdējā desmitgadē aktualizējušies bionoārdāmu kompozītmateriālu pārklājumu izmantošanas pētījumi atkritumu apstrādes procesos, kā arī degradētas vides uzlabošanai. Pārklājuma materiāla izmantošana ir atkritumu apglabāšanas darbības būtisks elements un veic vairākas svarīgas funkcijas, lai samazinātu atkritumu poligona ietekmi uz vidi. Šajā rakstā apkopota informācija, kas īsi aplūko alternatīvos ikdienas seguma materiālus, kas paredzēti cieto sadzīves atkritumu poligoniem. Šī pētījuma mērķis ir dot ieskatu izmantojamo izsmidzināto pārklājumu materiālu raksturojumā, novērtējot to no resursu un izmantošanas viedokļa. Detalizētas zināšanas par iespējamo izejvielu izmantošanu tika iegūtas materiālu un produktu pētījumos. Analizējot literatūras datus apkopota informācija par izejvielu kopumu, kurus izmanto šādu materiālu izstrādē. Galvenās izmantotās izejvielas ir māli (10−90 %), šķiedras (20−60 %) un polimēri (0,5−15 %). Iespējams bionoārdāmu kompozītmateriālu izveidē smektīta grupas mālus aizstāt ar Latvijā pieejamajiem zemes dzīļu mālu minerāliem, kas ļautu plašāk izmantot Latvijā pieejamos resursus. Turpmāko pētījumu gaitā tiks precizēts vēlamais izejvielu sastāvs un nepieciešamās īpašības kompozītmateriāla — ūdens suspensijas iegūšanai, tehnoloģijas izstrādei un izmēģināšanai pilotprojekta režīmā. Vietējo zemes dzīļu resursu izmantošana bionoārdāmu kompozītmateriālu izveidē būs nozīmīgs pienesums vides aizsardzībā.