

Abstract

The presented dissertation is a study to focus on the subject of landfill gas collection layers as system-integrating component between the landfill cover system and the landfill venting system. The idea for this work was initiated by a research project whose goal was to study the durability of gas collection layer material containing calcium carbonate when exposed to landfill gas. Particularly this study was designed to answer the question whether the maximum level of 10 % in weight specified for calcium carbonate in gas collection layer material by the German Technical Manual for Municipal Waste (TA SIEDLUNGSABFALL 1993) is justified. Since it was revealed that knowledge regarding the material composition, positioning and dimensioning of the landfill gas collection layer is poor, this project was also conducted to study these issues essential to innovative landfill design.

Although it is known that grain size composition controls the gas permeability of porous media, there have previously been no requirements regarding the grain size composition of gas collection layer materials. For this reason a study was made using combined air-flow and CO gas tracer experiments to establish which grain size ranges enable optimum gas collection characteristics. The study showed that gas permeability is dependent not only on the composition in terms of grain size but also on the bulk density and water content which increase as the porous medium's fineness of grain increases. In relation to a sample of municipal solid waste only the grain grading 16 mm to 32 mm with its almost negligible compactability and water retention capacity is characterized by a clearly greater gas collection potential.

Largely uncertain was to what extent the arrangement and dimensioning of the gas collection layer impacts on the active landfill gas collection. For this reason, the project was supposed to show whether the landfill surface sealing in compliance with TA SIEDLUNGSABFALL (1993) was preferably suitable for the active landfill gas collection or whether changes in this design could lead to more favorable results. For this purpose a numeric flow simulation of the active gas collection for various landfill cover system layouts was performed. The results show that a highly gas permeable gas collection layer has the effect of laterally equalizing and reducing gas pressures beneath the mineral clay liner. Hence the gas collection layer plays an important role in the landfill's gas collection system. Beside the surface sealing system in compliance with TA SIEDLUNGSABFALL (1993) only one layout without a compensating layer beneath the gas collection layer was shown to be favorable in terms of landfill gas flow.

The CaCO_3 -tolerance value specified in the TA SIEDLUNGSABFALL (1993) is based on the assumption that calcium carbonate containing materials are not resistant to the landfill's gaseous atmosphere. A central point of this project was therefore to test experimentally, using eight different gas collection layer materials, whether this assumption is correct. Four materials selected, which were nearly free of any calcium carbonate, were quartz gravel, crushed granite and basalt stone, and electric furnace slag in the terms of industrial recycling. Further four materials, carbonate gravel, crushed dolomitic limestone, crushed Jurassic limestone and crushed Triassic limestone, by contrast, feature calcium carbonate concentrations far above 10 % in weight. To classify resistance according to a general approach, static leaching tests were applied. For classification according to a specific approach, i.e. simulation of conditions specific to a landfill gas collection layer, a landfill gas flow system was constructed which was placed at the Erbenschwang landfill site located in the district of Weilheim-Schongau. Both experimental approaches permitted an assessment of the material's physical and geochemical resistance. It was demonstrated that chemical decomposition of the drainage materials is primarily due to dissolving carbonate, but that this is far less than the existing carbonate dissolution models lead one to expect.

However, to verify the experimental results the physical conditions prevailing in a gas collection layer must be known. Investigations were carried out at the Erbenschwang landfill to determine these conditions. It was demonstrated that decomposition is promoted more under the experimental conditions than under the investigated landfill conditions. The results permitted a resistance forecast quantified in terms of time. Under the assumption of a maximum time period of landfill gas generation (100 yrs.) the extrapolation of the carbonate dissolution enables a worst-case estimate: less than 1 % in weight of carbonate is released, independent of the total carbonate content. Therefore the limitation on the calcium carbonate concentration for landfill gas collection layer material is no longer considered necessary.