Application of Protecting Layers to Existing Non-Insulated Fly-Ash Landfills for Reduction of Environmental Impact: Experimental Stage

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Non-utilized fly ashes from hard coal combustion processes are usually deposited in large ponds, which pose a threat to groundwater resources. Experiments were made to develop a technology, which would effectively protect groundwater against the negative impact of fly-ashes disposal sites. The studies were also aimed at defining technical and economic conditions for potential technology applications. The concept of raising pozzolana reactions in the floor of the ponds shows promising results as it causes cementation of loose structure of the deposited fly ash. Cemented structures show low infiltration factor. Also the penetration of chemical substances to the aquifer is inhibited. Investigated fly ashes show differentiated chemical composition depending on the geological conditions of hard coal layers. Diversified chemical parameters result in differences of pH in water solution of fly ashes and, consequently, in porous water. A reaction occurs between porous water and fly ashes solid phase during which intensive liberation of compounds rich in silica or aluminum takes place. The Al and Si ions strongly facilitate cementation of the landfill lump. The cementation process takes place in alkaline environment. At high natural content of CaO in fly ashes, the pozzolana reaction may take place spontaneously while in neutral or acid ash the reaction requires initiation.

There are three ways of transporting power wastes to their disposal sites: mechanical, pneumatic the most popular – hydraulic method. In Poland, two options of hydraulic method are most frequently used: high water content hydraulic transport and dense suspension method. In the first case the ratio of water to the dry weight of waste may be as high as 1:30. In the other method the optimum proportion of water to waste does not exceed 1:1.

Depending on the disposal method, fly-ashes landfills differ in geotechnical and geochemical structure. For ponds formed using high water content method the infiltration factor varies from 10^{-4} to 10^{-6} m/s due to irregular waste grain size distribution in the pond. This irregularity occurs as a result of sorting which fly ashes undergo on the way from the place of their discharge to the above-sediment water intake. In the case of the dense suspension method, the pond structure is rather homogenous with no above-sediment water intake. This type of fly-ashes landfills shows low infiltration factor ranging from 10^{-8} to 10^{-10} m/s. Such low infiltration results from the fact that elements responsible for cementing processes are retained in porous waters and their concentration facilitates the process.

On the contrary, in ponds formed by high water content method almost 90% of the components responsible for cementation undergo dissolution during fluming, finally to be discharged with above-sediment waters. In consequence, cementation processes in this type of landfills occur very rarely if ever.

Fly-ash ponds formed using high water content method pose a serious threat to groundwaters as the contaminated waters used for hydraulic transport easily penetrate the soil into the aquifer due to high infiltration factor. They are often enriched with chemical compounds contained in wastes but not leached in the hydraulic transport.

The goal of the conducted experiment was to analyze the mechanisms of cementation processes from the viewpoint of fly-ash pozzolanic properties and to investigate the possibility of tightening the pond floor by saturating it with calcium hydroxide with an addition of gypsum from flue gases wet desulfurization facility. The main objective was to cause cementation reaction of aluminum and silicon compounds, which in combination with calcium hydroxide and sulfate ions form sparingly soluble phases, i.e. hydrated aluminosilicates or ettryngite. Laboratory tests proved that saturating the landfill floor with an appropriate dose of a mixture of chemically active compounds allows reducing its infiltration factor to about 10^{-8} to 10^{-9}. Laboratory experiments additionally showed that the time required to achieve such low factor was about 1 month.

The investigated technology proved especially suitable for applications in fly-ash ponds in which wastes have already been disposed at least for several years. In such landfills, in the course of a long-term disposal process, relatively large amounts of colloidal silicon and aluminum compounds occur, especially in the bottom part of the pond. These forms not only react faster than the compounds contained in fresh fly ashes but they determine the intensity of the cementation process and its duration as well.

The presented technology shows potential for applications to the sites with the horizontal wells system developed. There are a number of technical problems that need addressing and field experiments, nevertheless the basic concept is under patenting procedure.

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