

**International Workshop on
Environmental Aspects of Coal Ash Utilization**

Tel Aviv, Israel
December 15th – 16th 2009

Discussion platform:

Environmental conditions for the application of coal ash in infrastructures and road paving

[Appendix – Discussion platform: maximum values for leachable trace elements](#)

Background

- Bottom ash belongs to the category of “inert” materials, based on the European landfill directive.¹
- Fly ash is categorized as “non-hazardous” in that directive.²
- Moistened and compacted coal ash used as structural filler in paving, is applied in road embankments as the nucleus, covered by a thick layer of natural cover material and its application is subject to the conditions of the construction specifications and quality control.³
- Contact of the ash with the environment in road paving is limited to the interface with the cover layer of the embankments.⁴
- As a result of aging, the exposure of fly ash in the embankment to the air lowers its pH level from its original alkaline level (in most coal sources) to a near neutral level within a relatively short period (a few months).⁵
- The rate of water permeability of a moistened and compacted fly-ash in an embankment decreases relatively quickly (within a few years) to effectively zero.⁶
- Due to the process of sealing, (water is prevented from seeping into the coal ash embankment), leaching of trace elements from the coal ash layer into the environment is prevented.⁷
- Moistened and compacted coal ash in an embankment behaves as a monolith.⁸

¹ 1. [Measured concentrations of leachate for bottom ash](#), report by Y. Nathan and Y. Deutsch on bottom ash; 2. Measured concentrations in [monitoring the Erez-Shikma wells in Zikim](#) near a bottom-ash site.

² Measured concentration of [trace elements in fly-ash leachate](#).

³ Israel National Roads Company [standard specification](#).

⁴ [Conclusions](#) drawn by Y. Deutsch and Y. Nathan regarding embankments in Jisr-el-Zarka.

⁵ Findings of study by R. Keren on the [behavior of ash in an aqueous environment](#).

⁶ Findings of monitoring by R. Keren of [Highway 6](#) and Jisr-el-Zarka.

⁷ Derived from findings of R. Keren's monitoring.

⁸ From findings of monitoring by M. Hoffman of paving with ash on Highway 57, monitoring of R. Keren of Highway 6 and monitoring of Y. Deutsch of Jisr-el-Zarka.

**International Workshop on
Environmental Aspects of Coal Ash Utilization**

Tel Aviv, Israel
December 15th – 16th 2009

Existing environmental conditions

- Fly ash:
 - In susceptibility zone C (in which there is no danger to the pollution of water sources) – use is unrestricted.
 - In susceptibility zones A and B – with the approval of the Water Authority, after it has been proven that there is no danger of pollution of water sources under local hydrological conditions. The criteria for testing sensitivity to groundwater pollution will include:
 - Soil depth permeability
 - Distance from water bodies and active wells
 - Direction of the groundwater flow
 - Dilution factor
- Bottom ash:
 - The use of bottom ash is unrestricted when the concentration of boron in groundwater is outside the 300-500 ppb range, except in close proximity to drinking-water wells (temporary requirement by the Health Ministry).
 - If boron concentration is within the concentration range of 300-500 ppb, permission of the Water Authority is required in consultation with the professional-scientific panel (pollutants). The authorization will be based on the following parameters:
 - Maximum amount of boron that can be leached from the ash
 - Boron release rate from the ash
 - Rate at which boron reaches the aquifer
 - The dynamics of water flow in the aquifer – addition from rain, subtraction by pumping
 - Degree of dilution in the aquifer
 - Ratio between the boron in the aquifer and the boron that can be expected to leach from the ash
 - Authorization by the Water Authority is not required for a total ash load of up to 5000 tons applied at a radius of five kilometers. Any amount of added ash will be subtracted from the total load calculation 5 years after its addition.⁹
 - Ash application within the radius C range from a drinking-water well, requires authorization by the regional health engineer in consultation with the Water Authority.

⁹ [Recommendation](#) of Y. Nathan and R. Keren.

**International Workshop on
Environmental Aspects of Coal Ash Utilization**

Tel Aviv, Israel
December 15th – 16th 2009

Subjects for discussion

- The impact of fly ash on the environment in road embankments.¹⁰
- Leaching of trace elements from the interface between the coal ash and the cover layer in road embankments.¹¹
- The leaching of trace elements from fly ash into the surrounding environment of the road embankment, with the fly ash body viewed as a monolith.¹²

Proposed environmental conditions derived from research findings

Paving of roads according to the specifications of the Israel National Roads Company or similar specifications

- Fly ash
 - In susceptibility zone C – unrestricted use will be permitted on the condition that it meets the ENH¹³ criterion, excepting up to 3 elements that can exceed these values by a factor of 3.
 - In susceptibility zone B:
 - Up to 70% of the upper limit for hazardous elements content defined for ENH, use will be permitted as a default.
 - In case of higher values, use will be permitted subject to authorization by the Water Authority as per zone A.
 - In susceptibility zone A – the existing conditions will remain in effect. To determine the sensitivity to pollution in susceptibility zone A, the following criteria will be added to the existing criteria:
 - The soil's adsorption characteristics (under the fly ash layer),
 - factors that influence the physical-chemical properties of the ash,
 - Climatic conditions (e.g., precipitation).
- Bottom ash: Unrestricted use will be permitted as long as it meets the compatibility requirements for useable ash.

Soil improvement for infrastructures

- Fly ash:
 - In susceptibility zone C – Unrestricted use will be permitted on the condition that it meets the compatibility requirements (rules of thumb) for useable ash.
 - In susceptibility zone B:

¹⁰ Summary of ten years of monitoring of Jisr-el-Zarka embankment by Y. Nathan (see footnote 4).

¹¹ [Summary](#) of findings of monitoring of Jisr-el-Zarka embankment by M. Ben-Hur.

¹² [Findings](#) of Deutsch's tests of monolithic fly ash compared to powder-like ash.

¹³ European nonhazardous criterion (see footnote 2).

**International Workshop on
Environmental Aspects of Coal Ash Utilization**

Tel Aviv, Israel
December 15th – 16th 2009

- Up to 0.19, 0.37 and 0.74% of the soil mass for soils with clay content <20%, 20-40% and > 40%, respectively¹⁴, where soil mass refers to a column extending from the mixed soil- fly ash layer down to the groundwater level at a given cross sectional area¹⁵, provided that it meets the compatibility requirements (rules of thumb) for useable ash.
- Higher loads of fly ash, subject to authorization by the Water Authority as per zone A.
- In susceptibility zone A – subject to authorization by the Water Authority based on the criteria defined for permitting ash use for road paving, in accordance with the concentrations in leachates measured in laboratory tests of soil-fly ash mixtures.

Other infrastructures

- The existing conditions will remain in effect.
- Upon completion of the monitoring period at the Zikim site (bottom-ash infrastructure close proximity to drinking-water wells) in 2011 (10 years after the ash was placed there), the radius restriction for placement of bottom ash near drinking-water well swill be reexamined in light of the findings of the monitoring.

¹⁴ [Keren competitive model](#) to simulate boron adsorption by soils, clays and Al and Fe oxides

¹⁵ The assumption is that the adsorption characteristic of the soil is uniform. When the soil is not uniform, the properties of the various soil types should be taken into consideration.