Proposed environmental conditions for coal ash application to soil

road construction

infrastructure

agriculture

- A set of environmental requirements which will serve as the basis for a body of regulations aimed at controlling the use of coal ash for land applications was formulated.
- Coal ash is defined for this purpose as any assemblage of particles that are formed as a result of burning coal.
- The proposed regulations, being specifically designed for coal ash and covering all aspects of its land use, will free one from the need to classify the ash as belonging to a broader category of substances, such as "waste" or "byproduct".

The original environmental guidelines for the use of fly ash in various soil applications –

in the paving of roads

as infrastructure fillers

as an additive to agricultural soil

were determined by the Ministry of Environmental Protection in 1998 in accordance with the recommendations of the National Coal Ash Board.

The guidelines were formulated based on the assumptions:

- maximum dissolution and leaching of pollutants from the ash
- instant passage through the soil
- accumulation in the groundwater of the total quantity of the leachable pollutants found in the ash applied for a given use.

The above assumptions are manifestly strict, but their adoption was inevitable, given the state of scientific knowledge regarding the processes occurring in the ash and its environment, at the time the guidelines were formulated.

The use of coal ash in infrastructures was restricted to areas of groundwater sensitivity C - absence of groundwater or existence of an impermeable protective layer.

Approval for use of fly ash in paving and infrastructures in areas of higher sensitivity required a specific local geo-hydrological assessment, and agricultural use also required an investigation of the interaction between the ash and soil.

The NCAB has initiated research with an eye to creating a knowledge-base for the formulation of guidelines that will better reflect the real risks and open up more room for flexibility in the approval of applications of the ash.

The findings of the studies and the environmental assessments derived from them regarding the uses of coal ash may be summarized as follows:

Very low concentrations of trace substances (except for boron) are leached into the runoff water from fly ash embankments

Compacted fly ash in road embankments is monolithic and chemically stable and inert to the environment -

leachability of pollutants in fly ash exposed to the environment is quickly decreasing due to their fixation within the coal lattice during its “aging” process

Fly ash worked into a road embankment becomes sealed to the passage of water relatively quickly, as a result of the sedimentation of lime due to exposure to CO_2 in the air.

- The adsorption and release mechanisms of oxyanions leached out of the ash **when mixed with soil** in agricultural and infrastructure applications can be expressed in a predictive equation that takes the type of soil into consideration.

No evidence pointing to any influence of fly ash on the concentration of available trace elements in the soil was found even at relatively high loads that exceed practical application levels

The concentrations of certain trace elements (molybdenum, strontium and chrome) rose to a certain degree in plants grown on soils containing coal ash at a high load; however, these levels pose no health risk.

Bottom Ash

All trace elements in bottom ash can be found in concentrations similar to or lower than the average concentrations in sedimentary rocks common in Israel

The concentrations of trace elements found in the drainage water of bottom-ash plant-growing beds is lower than the concentrations permitted by the drinking water standard.

No evidence of an effect of the application of bottom ash as filler in infrastructure works on the concentration of pollutants in groundwater was found.

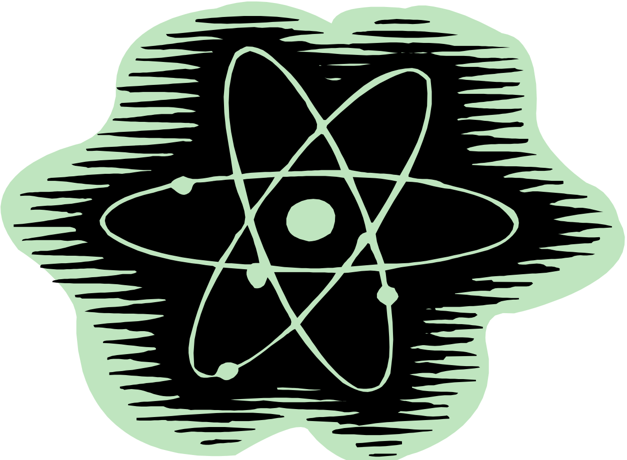
Additional environmental aspects of coal ash use in infrastructure and agriculture:

Exposure to dust

- Most of the quartz particles (crystalline silica) in respirable fly ash dust are coated with amorphous aluminosilicate and consequently pose no risk to health
- The respirable fraction in bottom ash is only 0.4%, and some never become airborne because they are trapped among very coarse particles
- The concentration of respirable free silica in **bottom ash** is very low (0.002%).

Exposure to radiation

- The additional radiation dose to which workers are exposed due to the use of **fly ash** as a soil additive at the accepted loads for agricultural applications (soil improvement, stabilization of sewage sludge) is at a trivial level, exempt from supervision and control.



- The additional radiation dose to which workers and the general public are exposed as a result of the use of **bottom ash** as a growth medium in agriculture and gardening is at a trivial level, exempt from supervision and control
- The rate of gamma radiation from coal ash used in infrastructure at a high volume and covered with a soil layer of one meter thickness is equal to the rate of environmental background radiation, and the radon emission rate is 4-5 times lower than the emission rate from the surrounding soil.

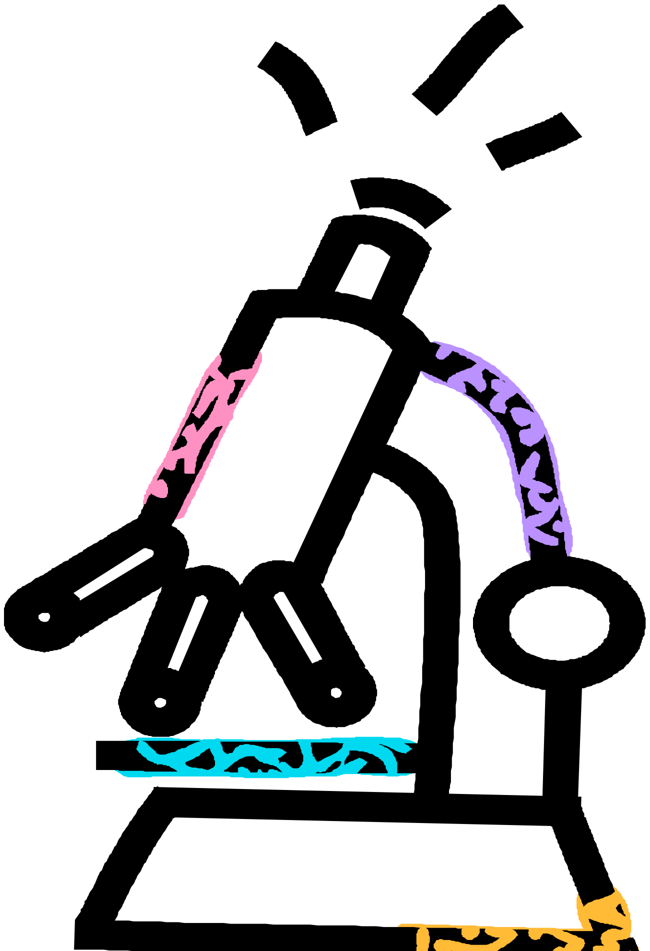
Uptake of trace elements by plants

Concentrations of heavy metals and radionuclides in fruits and vegetables grown on a bottom ash substrate or in soil amended by fly ash at 20 t/acre (and much more) were found to be lower than the permitted threshold and did not exceed the range of natural concentrations of these elements in plants.

Proposal for improved environmental requirements

The guidelines treat ash application according to the degree of groundwater, soil and vegetation sensitivity of the location of ash application and to the environmental effects of the **specific application**.

In addition to the relatively conservative default conditions, a local environmental assessment may be permitted using appropriate analytical tools and in accordance with the 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 <u>on the condition that the ash meets the ENH criteria, excepting up to 3 elements that can exceed the values defined by the above criteria by a factor of 3.</u>

<u>In susceptibility zone B - Up to 70% of the upper limit for hazardous elements content defined for ENH.</u>
<u>Higher values may be permitted subject to approval by the Water Authority as per zone A.</u>

In susceptibility zones A – ash application is allowed with the approval of the Water Authority, after it has been proven that there is no danger of pollution of water sources under the local hydrological conditions.

The criteria for testing sensitivity to groundwater pollution will include:

- Soil permeability
- Distance from water bodies and active wells
- Direction of groundwater flow
- Dilution factor
- The soil's adsorption properties
- Factors that affect the physical and chemical properties of the ash
- Climatic conditions (e.g., precipitation).

Bottom ash

Unrestricted use will be permitted as long as the ash meets the compatibility requirements for useable ash.

Soil improvement for infrastructures

Fly ash

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

In susceptibility zone B –

Up to 0.19, 0.37 and 0.74% of the soil mass for soils with clay content <20%, 20-40% and > 40%, respectively

(where soil mass refers to a column extending from the mixed soil-fly ash layer down to the water table at a given cross sectional area).

The assumption is that the adsorption characteristics of the soil are uniform. When the soil is not uniform, the properties of the various soil types along the profile should be taken into consideration*.

<u>Provided that the ash meets the compatibility requirements (rules of thumb) for useable ash.</u>

*Keren competitive model to simulate boron adsorption by soils, clays and Al and Fe oxides.

Higher loads of fly ash may be applied, 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 the use of ash for road paving and in accordance with the concentration of solutes in leachates obtained in laboratory tests of soil-fly ash mixtures.

Other infrastructures

Existing requirements will remain in effect, but

Environmental requirements will be subject to review as is necessary.

application of coal ash in agriculture

Bottom ash as a plant growth medium

The use of bottom ash in growth media for plants will be permitted if the ash meets the requirements of the compliance tests for usable ash and if the concentrations of trace elements in the agricultural products meet the requirements of the Food and Nutrition Services.

Authorization was granted by the Ministry of Health for annual plants.

The application of coal ash in animal litter will not be discussed here.

Fly ash as an additive to soil

In view of groundwater susceptibility, addition of fly ash will be permitted subject to criteria similar to those defined for the use of ash for soil improvement in infrastructure works.

Based on the assumption that the concentrations of trace elements in the ash do not exceed those defined as an upper limit for nonhazardous materials by the European Union criteria, the maximum quantity of fly ash that can be added to soil on which **crops sensitive to boron** are grown in the same year as the ash application is calculated by the Keren model.

For 10 cm incorporation depth the limits of application are:

∗ 0.25 T/dunam in soils with up to 20% clay content
∗ 0.5 T/dunam in soils with 20%-40% clay content
∗ 1.0 T/dunam in soils with a clay content of 40% and higher

The above values were calculated for the crops most sensitive to boron (such as citrus), where the fly ash is applied only to the upper 10 cm of the soil and the pH of the soil solution is 7.5.

The amount of fly ash per unit area of soil can be increased linearly with the depth of the soil layer to which the fly ash is applied.

The amount of the applied fly ash can also be increased for more boron tolerant crops as well as at higher pH values. At higher pH values, the adsorption capacity of the soil for boron increases and the boron dissolution rate from fly ash decreases.

The crop's root architecture should be taken in account as well. Higher fly ash application rates can be allowed in the upper 10 cm of the soil if the roots reach deeper.

In all cases the concentration of the trace elements in the agricultural products grown on soil-fly ash mixtures should meet the requirements of the Food and Nutrition Services.

And they did even in order of magnitude higher rates of fly ash applications.

The above conditions are related to one time application. Additional applications in the future will require a separate consideration.

Application in areas susceptible to floods and soil erosion requires site specific assessment.

Proposed monitoring requirements

- The compliance test of trace elements concentrations to the "useable ash" list will be performed in coal ash leachates in accordance with an Israeli version of elution method EN 12457-2. New leaching test procedures, currently in progress in US-EPA and CEN, will be considered as well.
- Continuation of the research for developing transfer coefficients for leachability from powdered ash to monolith , for the purpose of rationalizing compliance testing for the application of coal ash in infrastructure and paving.

For each ash (from a given source), a characterization curve of the elements released to the solution as a function of the pH will be built. The results will be used for checking the compliance of the given ash with the requirements for the defined application.

Values of elements in coal ash (ppm) vs. ENH values

Element	average values	EN*0.1	EN*0.5	EN*0.7	En	MAX VALUES*2 (for elements out of EN)
Ag	0.005					0.02
As	0.15	0.2		1.4	2	
B	76.3					892
Ba	12.89	10	50	70	100	
Cd	0.13	0.1	0.5	0.7	1	
Cr	2.50	1	5		10	
Cu	0.0921	5		35	50	
Hg	0.00035	0.02		0.14	0.2	
Mn	0.0248					0.18
Mo	6.024	1	5	7	10	
Ni	0.1444	1		7	10	
Pb	0.00692	1		7	10	
Sb	0.08242	0.07	0.35	0.49	0.7	
Se	1.4912	0.05	0.25	0.35	0.5	
V	0.9892					10.4
Zn	0.592	5		35	50	

Thank You

- Determination of expected concentrations of trace elements in coal ash from a new source will be performed, using ash formed by a test burning of the coal and a set of transformation coefficients for trace elements from laboratory ash (obtained from coal burnt in laboratory) to industrial ash (obtained from coal burnt in power station), based on historic statistical data.

Moreover, the analytical methods that were available and accepted at the time to estimate the dissolution of pollutants from industrial waste – TCLP of the USEPA – assumed an aggressive acidic environment that did not reflect the conditions to which the coal ash in its various uses was in fact exposed.

Over the years, a broad database on the dissolution of pollutants in ash from different sources has been built. Data based on different extraction procedures, specifically the European leaching system EN 12457-2 (leaching with distilled water)which was adopted by the IMEP.