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Upgrading of environmental guidelines for the uses of coal ash – paving, infrastructures and agriculture

Introduction

The environmental guidelines[1] for the use of fly ash in various soil applications – in the paving of roads, as infrastructure fillers and 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 (NCAB), based on the deliberations of the NCAB's professional-scientific committee on coal ash.[2]

The guidelines were formulated based on the strict assumption of a maximum dissolution and leaching of pollutants from the ash, instant passage through the soil and accumulation in the groundwater of the total quantity of the leachable pollutants found in the ash applied for a given use. The adoption of the above assumptions, which all experts agree are manifestly strict, 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. These processes inlude:

- Mechanisms of the dissolution the pollutants.
- The time-dependent profile of the dissolution of the pollutants.
- The extent of exposure of the ash in embankment to dissolution processes.
- The rate of leaching of pollutants from ash embankments.
- Mechanisms governing the transfer of pollutants in different soils.
- Processes of dilution of the pollutants reaching the groundwater, depending on the type of bedrock and characteristics of the aquifer.

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.

[1] Environmental guidelines for determining the use and handling of coal ash, May 1997
[2] A summary of recommendations of the scientific-professional committee on coal ash, May, 1997.

On the background of the above described strict assumptions and based on the findings of an initial investigation carried out under the guidance of the professional-scientific committee regarding the potential of leaching of pollutants from the ash in an artificial and extreme environment as defined in the TCLP test, the use of coal ash in infrastructures was restricted to areas of groundwater sensitivity 3 (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 requires an investigation of the interaction between the ash and soil.

At the recommendation of the committee, the NCAB has initiated in-depth research with an eye to creating a knowledge-base for the formulation of guidelines that will better reflect the real risks, on the one hand, and open up more room for flexibility in the approval of applications of the ash, on the other, clearly distinguishing between fly and bottom ash.

The findings of the studies and the environmental assessments derived from them regarding the uses of coal ash, were presented and debated at two international workshops held at the initiative of the NCAB, in 2005 and 2009. The main findings of the studies are as follows:

Fly ash

- **Very low concentrations of trace substances (except for boron) are leached into the runoff water from fly ash embankments** – "Monitoring of trace elements in runoff water, erosion and soil coverage in the Jisr el-Zarqa fly ash embankment, 1998-1999, 2008-2009," Dr. Meny Ben-Hur of the Soil, Water and Environmental Sciences Institute, Agricultural Research Organization, Volcani Research Center.
- **Compacted fly ash in road embankments is monolithic and chemically stable and inert to the environment** – "Follow-up of chemical and mineralogical changes in the Jasr-el-Zarka fly ash embankment," 1997, 2000, 2003, 2006, Yoetz Deutch, Dr. Yaacov Nathan, Geological Survey Israel.
- **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** – "The release of oxyanions from fly ash into an aqueous environment," Prof. Rami Keren, Soil, Water and Environmental Sciences Institute, Agricultural Research Organization, Volcani Research Center, 2008.
- **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 penetration of water in the fly ash in road embankments, Jasr-el-Zarka

(1999) and Highway 6 2005-2006," Prof. Rami Keren, Soil, Water and Environmental Sciences Institute, Agricultural Research Organization, Volcani Research Center.

- **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** – "The development of a method to assess the release of oxyanions from fly ash buried in the ground," Prof. Rami Keren, Soil, Water and Environmental Sciences Institute, Agricultural Research Organization, Volcani Research Center, 2005.
- **No evidence pointing to any influence of fly ash on the concentration of trace elements in the soil was found even at relatively high loads that exceed practical application levels** – "The use of fly ash to improve the features of agricultural soil," Dr. Pinhas Fine, Prof. Uri Mingelgrin, et al., Soil, Water and Environmental Sciences Institute, Agricultural Research Organization, Volcani Research Center, 2010.
- **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 danger of contamination** "The use of fly ash to improve the features of agricultural soil," Dr. Pinhas Fine, Prof. Uri Mingelgrin, et al., Soil, Water and Environmental Sciences Institute, Agricultural Research Organization, Volcani Research Center, 2010.

Over the years, a broad database on the dissolution of pollutants in fly ash from different sources has been built. Data based on different extraction procedures, – TCLP of the USEPA (leaching with acid) which was adopted in the early years as the regulatory method for the approval of the ash for uses in Israel; CALWET of the California EPA – which is stricter than TCLP; and the European leaching system EN 12457-2 (leaching with distilled water), using the Israeli version devised by the committee, which better reflects the conditions on the ground than the other procedures.

<u>Bottom Ash</u>

- **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 potential for pollution in the uses of bottom ash," Dr. Yaacov Nathan, Yoetz Deutsch, Geological Survey of Israel, 2004.
- **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 – Prof. Yona Chen, Tzila Aviad. Faculty of Agriculture, Food and Environment, Hebrew University, 1999.

- **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** – "Multi-year monitoring of trace element concentrations in ground water," Zikkim site, Dr. Yaacov Nathan, Geological Survey of Israel, 2001-2010.

Studies were carried out on additional environmental aspects of coal ash use in infrastructure and agriculture and the major findings are listed below :

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** – "Occupational hygiene aspects of fly ash," Dr. Yaacov Nathan, Geological Survey of Israel, Dr. Asher Pardo, Tel Aviv University, Dr. Ariel Metzger, Israel Electric Corporation, 2009.
- **The respirable fraction in bottom ash is only 0.4%, and some never become airborne because they are trapped among very coarse particles** – "Health and hygiene aspects in the use of coal ash," Dr. Asher Pardo, National Institute for Occupational and Environment, 2004.
- **The concentration of respirable free silica in bottom ash is very low (0.002%)** – "The pollution potential in the use of bottom ash," Dr. Yaacov Nathan, Yoetz Deutch, Geological Survey of Israel, 2004.

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** – "Assessment of radiological implications of adding sludge containing fly ash to the soil," Dr. Jean Koch, Radiation Safety Division, Soreq Nuclear Research Center, 2010.

- **The additional radiation dose to which workers and the general public are exposed as a result of the use of of bottom ash as a growth medium in agriculture and gardening is at a trivial level, exempt from supervision and control** – "Radiological aspects of the use of coal ash, Prof. Tovia shlezinger and Dr. Jean Koch, Radiation Safety Division, Soreq Nuclear Research Center, 2005.
- **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** – "Measurements of radiation in the bottom ash infrastructure at Kibbutz Zikkim," Dr. Victor Steiner, Ministry of Environmental Protection, 2001.

Uptake of trace elements by plants:

- **Concentrations of heavy metals and radionuclides in fruits and vegetables grown on a bottom ash substrate were found to be substantially lower than the permitted threshold and did not exceed the range of natural concentrations of these elements in plants** – "Examination of the concentrations of heavy metals and radionuclides in plants grown on a bottom ash substrate – Summary of multi-year experiments (1998-2006)," Prof. Yona Chen, Faculty of Agriculture, Food and Environment, Hebrew University, Jerusalem; Gustavo Haquin, Radiation Safety Area, Soreq Nuclear Research Institute.

Proposal for improved environmental conditions

The professional-scientific (pollutants) team of the NCAB has considered the conclusions of the above summarized research, and following the discussions of the 2009 workshop,[3] has consolidated recommendations for environmental guidelines for the application of coal ash in infrastructures and agriculture. These guidelines are presented in the following chapters:

A. Environmental requirements for coal ash applications in paving and infrastructures

B. Environmental requirements for coal ash applications in agriculture

[3] http://www.coal-ash.co.il/english/news_workshop.html

C. Procedures for monitoring pollutants in fly ash

D. Maximum values for trace elements allowed in the ash

Each chapter contains the following components:

- Details of the environmental requirements
  - Existing
  - Proposed
- Documentation of the relevant deliberations of the professional-scientific team in the 2009 workshop
  - Discussion platform
  - Minutes of the discussion
  - Links to relevant background material (abstracts and presentations)

As a rule, the guidelines treat ash application according to the degree of groundwater, soil and vegetation sensitivity of the location of the ash application, to the environmental effects of the application. In addition to relatively strict default conditions, a local environmental assessment may be permitted using analytical tools developed in the framework of the research and in accordance with the research findings.

For the convenience of the reader, the team's recommendations have been summed up in the "Chart of environmental requirements" document which summarizes the environmental guidelines according to application (infrastructures, soil improvement in infrastructures and agriculture).