Risk Assessments for Agricultural Applications of Fly Ash

Rami Keren

Institute of Soil, Water and Environmental Sciences, Volcani Center.

Abstract

The European Directive determines conditions for the burial of coal ash, assuming that it will be exposed to rain, either washing over the ash, percolation through it or there will be up and down capillary movement from the bottom. The behavior of coal ash in the characteristic environmental conditions found when it is applied to soil (structural filling in road banks; improvement of soil structure for agricultural and conservation purposes; stabilization of sewage sludge used as an additive for agricultural soils) is significantly different from the behavior expected when coal ash is used as land fill in accordance with the definitions in the Directive. Therefore, the findings when using the test method stipulated in the Directive do not reflect expectations when coal ash is applied to soil. The significant differences are expressed in the following criteria:

1. Application Method – The Directive assumes massive quantities of permanent fill exposed to the environment, while the application of coal ash to soils is typically, detached from the environment. For example: When used as structural fill for roads the environmental conditions differ from the environment determined by the Directive and the same is true for the spreading and incorporation of coal ash into the soil in agricultural applications. The Directive assumes permanent contact with the environment, but the exposure of the ash to the environment when used in road banks after compaction, causes the formation of a crust impermeable to the passage of water.

2. Changes with Time – The Directive assumes the extraction of elements under fixed conditions, while extraction of elements from coal ash varies (drops) with time due to the chemical processes occurring in coal ash exposed to the atmosphere (aging process). These processes are accelerated when the basic coal ash is in soil because of the moisture it contains and the high concentration of carbon dioxide found in soil air, reaching an order of magnitude higher than the concentration found in the atmosphere.

3. pH – The Directive assumes that the presence of coal ash causes the pH to rise, but when applied to soil, the soil serves as a buffer maintaining pH between 7 – 8.

4. Soil Response – The Directive assumes the movement of elements released from the coal ash into the ground water; but in the soil, there are element absorption and precipitation processes according to the type of soil.

Risk assessments for the agricultural application of fly ash are conducted for health reasons (the produce from crops grown in the presence of coal ash is eaten and the ground water is drunk in areas where coal ash has been incorporated into the soil) and to assess the damage caused by the element Boron (released from coal ash) to the plant and those assessments were carried out using the stringent assumptions explained below.

The assumptions for the assessment of risk to humans consuming agricultural produce from crops grown in soil with added stabilized sewage sludge used as a plant fertilizer (the addition of coal ash during the sewage treatment process) or alternatively, when coal ash is incorporated to improve the soil are as follows:

1. Stabilized sewage sludge spread at a rate of 20 tons per acre (equivalent to 8 tons of coal ash per acre).
2. The depth of the soil layer into which the sludge is incorporated: 20cm.
3. There is no absorption of elements by soil components.
4. There is no flushing of the elements to below the uppermost, 20cm deep layer of soil.
5. All the elements, which can be flushed out of coal ash are in the soil solution immediately after the stabilized sewage sludge is spread.
6. Soil water content is at field capacity.

It is important to mention that the concentrations found in the soil solution are the highest it is possible to achieve in view of the stringent assumptions and because of the use of the maximum element concentrations\ found during dissolution testing conducted between 2007 and 2012. Thus it arises that all the calculated data quoted below ensures a large safety coefficient.

Based on the aforementioned assumptions, it is possible to calculate the concentrations of elements released from coal ash into the soil solution and thereby, it is possible to estimate the quantity of coal ash, which can be added to the soil without any fear of harming the plants (boron poisoning); pollution of the soil solution and the ground water taking into account the Israeli standard for potable water.

<u>Boron</u> – Calculations for clay and loess soils (based on the stringent assumptions), show that it is possible to spread coal ash on to soil for 7 consecutive years at a rate of 8 tons per acre per year, without causing any harm to the most sensitive plants (citrus) and for longer when the crop is more resistant.

<u>Effects on Health (arsenic, cadmium, lead and mercury)</u> – Calculations based on the stringent assumptions show that it is possible to spread coal ash on to clay soil for 13 consecutive years at a rate of 8 tons per acre per year and only then does the concentration of arsenic in the soil solution reach the highest permissible concentration for drinking water in accordance with the Israeli Standard. Regarding the other three elements: Coal ash can be added for 18, 34 and 100 years continuously at a rate of 8 tons per acre per year before the concentrations of cadmium, lead and mercury respectively, reach the maximum permissible levels in potable water (50, 5, 10 and 1 micrograms per liter respectively). In loess soils it is possible to add coal ash continuously at a rate of eight tons per acre per year for far shorter periods: 7, 10, 19 and 100 years respectively, before reaching concentrations of the aforementioned elements in the soil solution similar to the concentrations permissible in accordance with the Israeli standard for potable water. In other words, If the quantity of coal ash added to the soil does rise above the aforementioned quantities; it is reasonable to consider the quality of the water taken up by the plants is equivalent to irrigation with potable water (assuming that the concentrations of those elements in the irrigation water is negligible, relative to the concentrations of sodium from coal ash. Therefore, under these conditions, there is no reason to suspect pollution of agricultural produce used for human consumption.