WEACAU-III: International Workshop on
Environmental Aspects of Coal Ash Utilization
Tel Aviv, Israel
December 11th – 12th 2012

Agricultural uses of coal fly ash

Fine, P[1], U. Mingelgrin[1], A. Bosak[2]

[1]Inst. Soils, Water and Environmental Sciences, Volcani Center, ARO, PO Box 6, Bet-Dagan 50250, Israel; [2]South Yehuda Growers, M.P. Shikmim 79813

Abstract

Approximately 1.5 million tons/year coal burning fly ash (FA) is currently produced in Israel. Coal sources and composition are very diverse and inevitably so are also the ashes. Generally, FA is composed of fine silt particles dominated by alumina and silica, and it possesses high pH and significant contents of oxyanions and other trace elements. FAs were used as soil amendments, either directly or via the application to soil of alkaline stabilized biosolids (ASB), a 'Class A' biosolids. The latter enhanced treated sludge

Direct FA application was tested as means to improve physical properties of problematic soils, and reducing the swelling and dispersivity of sodic soils. This exploited the cementing ability of the ash and its high calcium solubility. Rain simulation, wind tunnel runs, albedo measurements and field experiments were conducted. Hence, FA addition at up to 20% (w/w) increased water retention of sand by up to 8 folds, and increased 3 times its resistance to wind erosion. FA inhibited crust formation and improved water infiltration (by up to 2.5 fold) in loessial soil. This however increased the soil susceptibility to wind erosion. A clayey sodic soil in a field applied with 200 and 800 Mg ha^{-1} had reduced swelling, such that the soil ceased cracking upon drying and disking forms considerably smaller soil clumps. While in lab rain simulations the leachates contained oxyanions concentrations higher than allowed, the field grown crops displayed insignificant uptake even at 800 Mg ha^{-1}.

FA is the bulky alkaline admixture used for the stabilization of the untreated sludge produced at the Greater Tel-Aviv WWTF, comprising ≈80% (w/w dry) of the final product. The advantages of alkali sludge treatment are in the immediate pasteurization and vector attraction reduction gained, and the option to tackle untreated sludges as well, making the costly preceding digestion process unnecessary.

We believe that sludge disposal is an outcome not a purpose, and that it'll be successful only if it is done according to an agronomic logic and for a good purpose. Currently, ASBs are applied to field crop soils at rates of 20-150 Mg ha^{-1}, the implementing the environmental circumstances (e.g., soil and crop characteristics, irrigation, cultivation, weather), and the purpose sought. The purposes are as follows: (i) fertilizer (N, P, K and micro-nutrients) replacement, (ii) disinfection of soil-borne plant pathogens, and (iii) improve soil tilt and alleviate soil sodicity.

Extensive lab and greenhouse simulations and full scale field experiments revealed that (i) ASBs comprise a fertilizer value (per unit N applied) often as high as that of the original sludge itself, (ii) ASBs reduce soil-borne pathogens in calcareous, light-texture soils through the toxicity of gaseous NH_3. At any total NH_3 concentration, the gaseous form content depends on the pH following the Henderson–Hasselbalch relationships (log $[NH_{3(g)}] / NH_4^+{}_{(aq)}]$ = pH - 9.3, at 25°C). Hence, the application of

ASB for soil disinfection exploits both its high pH and its supply of NH_3 (via the ammonification process). Elevating soil temperature (by plastic cover) favors NH_3 generation (by reducing the constant in the above equation), thus reducing the NH_3 concentration and/or pH needed for efficient disinfection. So far, the disinfection of fungi, bacteria and nematodes was successful. Finally, (iii) in a field experiment, ASB application at 50 Mg ha^{-1} improved seed bed and cotton seed establishment, which significantly increased lint yield. Simulations revealed the ameliorating effect on soil aggregate stability (and resistance to crusting under rain) and hydraulic properties.

ASB performance was tested also in comparison to other sludge types, including untreated sludge (the ASB source sludge) and Class B sludge (both are prohibited in Israeli agriculture due to no/insufficient pathogen reduction), and sludge composts. ASB was usually equal to or superior over compost in all the above three aspects.