Agricultural uses of coal fly ash (FA) and FA-treated biosolids

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Coal burning fly ash (FA) was tested as soil amendment both directly and via the application to soil of biosolids that was pasteurized by treatment with FA and lime (N-Viro Soil©; NVS). Some 15-30% of the sludge of greater Tel-Aviv region ('Shafdan', undigested excess secondary aerated; 180 g solids kg^{-1}) is pasteurized by mixing with FA and burnt lime at approximately 50:45:5 (v/v) ratio. Inasmuch as windrow composting is by far the leading sludge pasteurizing method, the advantages of the alkali treatment are the instantaneous pasteurization and vector attraction reduction, and the ability to treat any sludge type. Thus the costly digestion pretreatment, the space and duration needed for windrowing are circumvented, and odors, air-drifting microorganisms and greenhouse gas emissions are avoided. In addition, ammonia volatilized (at ca. 40 kg N/sludge dry ton) is preserved, maintaining the high N mineralization potential of the raw sludge virtually intact. The main disadvantage of alkali treatments is the bulkiness of the final product. Health, agriculture and environment authorities are also concerned with the phytoavailability of FA-borne trace and heavy elements. The current work addressed this and other related environmental issues.

Israel use of NVS is mainly as fertilizer (N, P and micro-nutrients) replacement at 50 tons $ha^{-1}y^{-1}$, yet doses 10 times more are also examined. We also test NVS for ability to improve tilt of sodic soils and disinfect sandy soils diseased with plant pathogens. The three aspects were extensively studied in lab and greenhouse and field scale experiments. These revealed NVS to (i) comprise a fertilizer value (per unit N applied) often as high as that of the sludge it was made from, with ample P and trace elements phyto-availabilities, (ii) possibly improves seed bed (and cotton seed establishment), (iii) potentially reduces soil-borne pathogens in sandy soils through the activation of NH_3 toxicity. NVS performance is tested in comparison to other sludge types and it was equal to or better then compost in all the above three aspects.

Elemental composition of a wide range of crops (silage corn and wheat, chickpea, potato, carrot, clover, common vetch, and lettuce) was tested, some of which under heavy repeated applications. For example, lettuce was grown in 200-L barrels on 3 widely contrasting soils for 4 consecutive seasons with three yearly sludge applications (based on equal N doses; NVS, at up to 600 tons ha^{-1}, anaerobically digested class B sludge, and a compost from the latter; all sludges mixed into the upper 15-cm layer). Heavy metals and metalloids (As, Cd, Pb) contents were barely measurable and did not differ between treatments. Molybdenum and B (and sometimes also Se) concentrations in plants often significantly increased in

NVS treatments (especially in sand). Leaching of trace and heavy elements below the 80-cm soil layer was immeasurable except for boron.

Direct FA application was also tested as means to improve physical properties of problematic soils, exploiting FA pozzolanic property and high calcium solubility. At heavy dose applications (200 and 800 tons ha^{-1}) a swelling and dispersive sodic clayey soil ceased to crack upon drying, and when ploughed considerably smaller and more fragile soil clods were formed. Corn and chickpeas grown in the first years after FA addition displayed normal contents of trace and heavy metals.

Hence, our experience shows that application of NVS (FA and lime treated biosolids) in agriculture offers several concurrent benefits including: plant nutrition, improved soil tilth, and reduction of wide-range soil-borne plant diseases, and that this involves no real risk to crop and groundwater quality.