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Agricultural Use of Biosolids Stabilized with Lime and Coal Fly Ash

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Abstract

Coal burning fly ash (FA) was tested as soil amendment either directly or as the N-Viro Soil (NVS), product which is produced in Israel by mixing the Shafdan sludge (secondary aerated at 18% solids) with FA and lime at approximately 50:45:5 mixing ratio.

Extensive lab, greenhouse, lysimeter and full scale field experiments revealed that (i) NVS comprises a fertilizer value (per unit N applied) often as high as that of the original sludge itself ensuring high availability of N, P and trace elements that are essential to plant growth and human health; (ii) NVS can potentially reduce soil-borne pathogens in calcareous, light-texture soils through the activation of gaseous NH_3 toxicity. At any total ammoniacal N concentration, the content of the gaseous form depends on the pH (and temperature) following the Henderson–Hasselbalch relationships ($\log [NH_{3(g)}] / NH_4^+] = pH - 9.3$, at 25°C). Hence, the application of NVS for soil disinfection exploits both its high pH and its supply of NH_3 (via the ammonification process). Elevating the soil temperature (by short-duration solarization) favors NH_3 generation from NH_4^+ (by lowering the system's pKa). So far, the successful disinfection of fungi, bacteria and nematodes was demonstrated; Finally, (iii) NVS application at 50 Mg ha^{-1} improved seed bed and cotton seed establishment, which significantly increased lint yield. NVS performance was tested with a wide variety of crops including potatoe, carrot, lettuce, corn, wheat, chickpeas, fodder legumes etc. This was also done in comparison to other sludge types, including Class B sludge and sludge composts and NVS was found to be equal or superior to compost in all the above aspects.

Among other experiments, a 3 years long lysimeter study was conducted growing 4 lettuce crops on three soil (sand, loam and clay), undergoing 3 repeated applications of NVS at cumulative rates equivalent to 200 and 600 dry tons ha^{-1}. No significant differences in uptake by lettuce or leaching of priority metal pollutants occurred as compared with control treatments. Another extensive field trial is conducted now for the fourth consecutive year, where 16 treatments are tested, including 2 application rates of 4 manures (including NVS), with nitrogen application and without. Inasmuch as yields and crop composition were very similar, the farmers' revenue from NVS application is substantially higher than from application of composts (from either municipal solid waste or sludge) due to the significant difference between the cost of these additives. Moreover, the emissions to the environment of ammonia and GHGs involved with NVS use are minute compared with those involved with biosolids composting.

Direct FA application was also tested as means to improve physical properties of soils, especially for reducing swelling and dispersivity of sodic soils. This application exploits the cementing ability and high soluble calcium content of the ash. Ash (and NVS) effect on soil properties was tested with rain simulation, wind tunnel runs and in the field. FA addition at up to 20% (w/w) increased water retention of sand by up to 8 folds, and increased 3 times the sand's 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

loaded in the field with 200 and 800 Mg ha^{-1} FA showed reduced swelling such that the soil ceased to crack upon drying, and disking the moist soil formed considerably smaller clumps. While lab rain simulations revealed oxyanions leaching, field-grown crops displayed almost no increase of oxyanions uptake even at 800 Mg ha^{-1} FA.

We conclude that a long-term gradual application of NVS should cause no harm to soil or ground water quality, but rather to the contrary. The use of NVS in field cropping has advantages to all parties involved, the urban, by reducing (perhaps halving) sludge treatment costs; the environment, by reducing GHGs and ammonia emissions and odors and enhancing the recycling of by-products (FA and sludge); and the agricultural sector by reducing the need for synthetic fertilizers, improving soil till and directly enhancing profitability.