ADVANCED ALKALINE STABILIZATION OF SEWAGE SLUDGE

Jeffrey C. Burnham, Ph.D, Department of Microbiology, Medical College of Ohio, Toledo, OH 43699

These comments describe the use of cement or lime kiln dust in the N-Viro Soil Process which is a relatively new and exciting process for the alkaline stabilization and pasteurization of municipal sludge cake which results in a product we call N-Viro Soil.

When the name N-Viro soil was chosen for this product of the N-Viro pasteurization process for stabilizing municipal wastewater sludges, it was very fortuitous in view of the similarity of the two materials on a biological and physical basis. It has become increasingly clear to me, as I have worked with and tested N-Viro Soil made from wastewater sludge cakes from cities all over the United States, that this material is remarkably similar in many properties to a topsoil that all of us are familiar with.

With the alternatives for sludge processing changing because of the public awareness of the problems of sludge dumping into landfills or the oceans, the treatment of municipal sludges with cement kiln dust offers a technically solid solution to the current dilemma of how to process wastewater sludge so that it is safe, acceptable to the public and even converted into a useful, even saleable, commodity.

I have conducted a series of experiments which have provided data showing that treatment of municipal wastewater sludge cake with kiln dust (KD) alone, or with a small amount of quicklime with the KD, will reduce the pathogenic microbial population present in the sludge to below the USEPA's Process to Further Reduce Pathogens (PFRP) standard. This standard recognizes the problems that have been inherent with the older and less stringent standard that EPA set up for measuring sludge stabilization, ie., PSRP (Process to Significantly Reduce Pathogens). Instead of reducing pathogens on a percentage basis (99% or 90% depending upon the parameter) the PFRP standard requires that pathogens be reduced to a level defined as that which is just detectable by the best available microbiological technology. Both laboratory and large scale field tests have shown that indigenous and seeded populations of Salmonella, Poliovirus, and Ascaris ova could be reduced to below detectable levels within 24 hours if the treated sludge was contained at 52C for 12 hours.

Full scale mixing of the KD with the sludge cake (15%-35% solids) is best accomplished with a pug mill or screw blender. With proper mixing speeds the resultant product is a granular, easy to handle soil-like material that is then further treated in one of two methods, ie., Alternative 1 or Alternative #2 that a) allow the PFRP standard to be reached and b) stabilize the sludge so that it is deodorized to a level that should not be objectionable for community use. As a microbiologist I have to recommend Alternative #2 as far superior to the other alternative principally because of the added insurance it provides in achieving complete pathogen kills regardless of lump size or potential problems that might have occurred in admixture blending. Alternative #2 requires that a temperature of between 52C and 62C be reached throughout the sludge for a minimum of 12 hours. The heat for this part of the process is generated by the exothermic slaking reaction of the calcium oxide present in either the KD or the lime additive. This patented (N-Viro Soil) and EPA PFRP approved pasteurization process leaves approximately 10^6 indigenous microorganisms per 5 g dry wt sludge which help maintain the treated product so that the older the N-Viro Soil is, the better it is from a stabilization (soil-like odor and consistency) perspective. The specific chemical and physical effects of KD on municipal sludge cakes are presented below in order to explain the mechanisms of the pasteurization process.

MECHANISMS OF ACTION

1. pH above 12.0
2. accelerated drying
3. heat at 52C for 12 hours
4. ammonia release
5. salt
6. retention of an indigenous microflora

The raising of the pH in the sludge cake to over 12.0 causes most of the microorganisms in the treated sludge to be under a very severe stress. By itself this high pH will not kill enough of the pathogens to render the sludge pasteurized to the degree defined by the PFRP standards. Traditional lime stabilization relies on this kind of pH elevation in order to achieve the lower standard, PSRP, and to also achieve some degree of odor control.

The accelerated drying that is imposed by the alkaline additive on the N-Viro Soil treated sludge results in a soil-like consistency for the sludge product. This creates immediately a soil like ecology for the microorganisms present. This increased percent solids (at least 50%) increases the stress on the microorganisms present and makes it more difficult for the bacteria present to multiply at rapid rates and therefore provides increased stability on the sludge product. I like to use the analogy of mixing cement in a tub. It is remarkable how much water one must add to achieve the proper consistency to work the cement. A similar water absorption property is present with KD and this rapidly removes available water from access to the bacteria present in the sludge.

By using the CaO properties of the KD or lime additive we are able to introduce a heating stage in the N-Viro Soil Process. When CaO is converted to Ca(OH)(2 an exothermic reaction occurs which will heat the sludge to 52C to 62C and with remarkable insulating properties of the sludge cake, will retain that temperature easily for 12 hours when the mixed sludge is placed in the proper container environment. This temperature level by itself, like the pH described above, is not adequate to pasteurize the sludge. It will cause pasteurization when it is coupled to the properties of a high pH of 12 and the accelerated drying.

Ammonia release has been considered a negative by treatment plant operators using the traditional lime stabilization technology. From my point of view as a microbiologist, the ammonia release that occurs via percolation up through the sludge when the KD is mixed in is a real positive in terms of the disinfection capabilities of the N-Viro Soil Process. This, added to the above factors, is just additional insurance for the pasteurization process.

Finally, the factor that is the most unusual and completely separates the N-Viro Soil process from other PFRP processes that use heat to sterilize sludge cakes is this retention of a soil-like indigenous microflora. It is my opinion that the retention of this bacterial microflora provides increased stability tot he treated sludge cake by the very occupancy of a major ecological niche in the soil-like nutritive treated sludge. The situation is very analogous to that of administering antibiotics to humans and disrupting the normalcy of the gut flora. What often happens after broad spectrum antibiotics are taken is that yeast overgrowth will then occur in the human intestine causing a diarrhea. If the normal flora can be maintained or if a substitute normal flora can be established, eg., lactobacilli, then this unwanted yeast overgrowth can be prevented. I see the indigenous flora remaining in N-Viro Soil providing that kind of stability and helping to prevent the reestablishment of a pathogen population.

The total indigenous aerobic and facultatively anaerobic bacterial flora present in the sludge is reduced by KD treatment from an average 10^{10} to a stable 10^6 ($\pm 10^2$) per 5 g dry wt sludge, ie., to levels very similar to soil concentrations. This observation that N-Viro Soil is a pasteurized product containing a normal microflora is very important because it makes the N-Viro Soil product very different from sterilized sludge products and I believe contributes to the long term stability and soil-like odor of the N-Viro Soil product. The three dominant species in N-Viro Soil are Bacillus circulans, Bacillus pumilus, and Rhodococcus rhodochrous, all common soil microorganisms. In short, it is clear that there are many similarities between the microbiology of N-Viro Soil and that of agricultural soil from northwest Ohio It is our intent in the future to determine if the microbial activity of these organisms in degrading organic constituents is similar in the two materials as well. I predict that as the pH of NVS approaches pH 7.8 the NVS microbial activity will increase over that at the higher pH levels and approach that measured in AS.

The consistency of N-Viro Soil and soil from the Ohio State University Hoytville agricultural field station (AS in terms of its size and granularity, particularly for aged N-Viro soil, is very similar. When two materials were run through a USA Standard Testing Sieve #10 (ie., 2.0 mm openings) the percent of N-Viro Soil passing through was 32% while the AS was 40.7%. The mean granule size of N-Viro Soil that passed through the #10 sieve was measured to be 0.66 mm while that of a top soil used was 0.61 mm. The mean size of material larger than 2mm was 7.8mm for N-Viro Soil and 6.1mm for AS. In terms of percent solids, while this will differ depending upon the age of NVS and the degree of exposure of both soil and N-Viro Soil to the atmosphere, the measurements were 63.2 and 89.5 for N-Viro Soil and AS, respectively. Density is a better comparitor for the two materials with N-Viro Soil having a density of between 0.7 and 1.0 g/cc, while AS had a density of 1.1 g/cc. Volatile solids for the two materials were 9.3% for N-Viro Soil and 4.6% for AS.

The KD treatment renders most of the heavy metals present in sludge insoluble minimizing their ability to either a leachate. Dr. Gary Bennett, as part of our Edison Research, investigated Project the leachability of heavy metals from KD-treated sludge (N-Viro Soil). The standard test for determining meal leachability from solids is the USEPA's Extraction Procedure Test (EPTox). We found that all of the tested material and mixtures when exposed to acid will leach heavy metals--and the extent of the metals removed from them did increase as the pH of the extractant decreased. However, in no case did the resulting heavy metal concentration in the leachate exceed USEPA Extraction Procedure Toxicity limitations. Moreover, the leachate metal concentrations in the extraction conducted at a pH levels optimum for soil fertility (pH>5.5) even met drinking water quality standards in the tests we conducted with Toledo, OH and Monroe, MI sludges mixed with Dundee, MI, Medusa cement plant CKD.

There appear to be three major uses of the N-Viro Soil product to date. These are first, as a soil supplement for agriculture; second as a daily cover in landfill operations; and third, as a reclaimant additive for strip mines spoils. Agrinomic studies of N-Viro soil conducted by Dr. Terry Logan of Ohio State University, working in collaboration with the Edison Research Grant, have shown that application to corn and soybean crops have shown a positive value for this product. No adverse effect of N-Viro Soil application was observed on corn or soybean crops even at 20 dry tons per acre, ie., more than double the normal agrinomic application rate for this product. Some increase in productivity was observed for the higher application rates and this was at least partly attributed to the organic nature of the N-Viro Soil product protecting the crops against the difficult drought and heat conditions in the summer of 1988. The characteristics of the N-Viro Soil product include those of: a) a fertilizer with approximately a 1% N, P and K value; b) an ag-lime equivalency of between 35 and 45% and c) a soil conditioner with a high organic content.

It is exactly these same properties that make the product so useful for reclaiming the acid spoil lands of strip mines. The high calcium carbonate equivalency will raise the pH of the spoil and the nutrient and organic content of the N-Viro Soil will provide the base for revegetation. Finally the granularity and soil like consistency and stabilization, coupled with the alkaline KD properties of fixing and binding metals, make it very useful for daily landfill cover. In addition, recent testing by Hydropress Inc. showed the N-Viro Soil able to stand up to stresses of heavy landfill vehicle use when mixed 1:1 with traditional dirt used for cover.