12.6 Landfilling

The driving force of today's market is economics. What is the cheapest and most effective way to produce a safe and reliable product? In the case of biosolids disposal and utilization, the question may be "what is the cheapest and easiest way for me to get rid of my biosolids?" Many times the "ease" of which biosolids can be used or disposed plays a significant role in the decision process. For this reason, landfilling has become the default method of biosolids disposal for Georgia with over 40% of all biosolids going to landfill. In many cases, it is simply easiest to contract with a company to haul it to the landfill. Landfilling of biosolids carries no long term liability and no problems with permitting and regulations on the part of the generator. Tipping fees for landfilling biosolids at permitted landfills vary at each landfill but normally has a range between 25-35 $/ton. This does not include transportation cost which will vary with quantity and distance.

13.0 STRATEGIES FOR BIOSOLIDS UTILIZATION

Constructive opportunities for the beneficial reuse of biosolids have been the focus of many research projects. Several alternatives have been developed including the use of sludges in asphalt, sub-base road pavement, building block, concrete aggregate, mineral wool, and even telephone poles (Alleman, 1983). The feasibility of some of these projects is called into question when the economics of scale are applied. All too often "creative" alternatives can not be realistically performed at the municipal level but continual development designs will inevitably lead to economically beneficial opportunities.

13.1 Animal Feed Production

The use of protein from animal by-products for animal feed is not a new phenomenon. Poultry, swine, and beef are but a few examples of industries that have incorporated the practice of using by-products in feed production. They utilize protein-rich products that alone or in combination with other constituents provide a nutritional diet. Animal biosolids, like animal by-products, are an excellent source of protein and have been used in other parts of the world as a nutritional source for fish (Milstein, 1991). In conjunction with biosolids, other animal by-products such as poultry litter or poultry processing dissolved air floatation skimmings may be used in the feed mix. A satisfactory and palatable diet can be formulated from detailed nutritional information of all ingredients.

One breed of fish that is now farmed in Georgia that could be used in such an operation is the common channel catfish. Channel catfish is the choice of many commercial fish farmers due to the great growth potential and the taste of the flesh. Although fish raised on biosolids could not be used for human consumption, they can be used for high quality feed in other animal growth industries i.e. poultry, swine, aquaculture. Extensive research has been performed on the requirements for catfish production, making it relatively simple to construct a management plan that would address a wide variety of issues that may range from public acceptance to nutrient loading.

Although many types of by-products have been used in the formulation of feed used in animal production for human consumption, little is known about the potential effects on humans if biosolids are used in the process. There is a perceived danger about feeding biosolids to animals raised for slaughter. The key, some have suggested, may be to have an intermittent step in the food chain, using an animal to ingest the biosolids that is then eaten by yet another animal. One such animal that has been getting increased attention for this process is the earthworm. A possible use of earthworms grown in biosolids is as a protein meal substitute for animals. Studies by Stafford (1984) and Fisher (1988) have demonstrated the feasibility of using earthworms as a nutritional feed substitute for trout and poultry respectfully.

Fisher (1988) performed poultry feeding trials of worms processed in various manners. He concluded that the worm meals are excellent in chemical composition but the particular species of worms and the method of meal preparation may be important variables to consider in future investigations. Fisher developed diets with varying levels of worm meal and reported that at higher levels of inclusion (>72g/kg), there is a small but significant depression in growth and feed conversion efficiency. One possible explanation of this is that some worm meals may have physical or chemical characteristics that tend to make them relatively unpalatable for chickens.

Stafford (1984) reports that for a period of 70 days, the earthworm species *A. longa* and *L. terrestris* replaced the commercial trout pellet as a sole source of food for rainbow trout adequately. No adverse effects on health, growth rate or feed utilization efficiency of the fish was observed. In this project, Stafford concluded that *E. foetida* did not support good fish growth and determined that it might be due to large portions of noxious yellow coelomic fluid commonly used as a defense mechanism in this species that is unfavorable to fish. Later studies utilizing the blanching process, boiling worms for 5 minutes, showed no significant difference between the mean final body weight of fish fed blanched *E. foetida* and fish fed a control fish meal based pellet. Biosolids as a productive commodity is the direction of the future. Utilization of this continuous resource as a potential feedstock for intermediate species such as *E. foetida* that in turn can be used as a primary feed source for other high demand, high yield marketable products has enormous potential.   New advances in production methods, acceptance within local markets and a concern for natural resources all make the cultivation of fish a viable and profitable option for aquaculture producers in Georgia. Currently there has been a great interest in connecting the processes of biosolids recovery via vermicomposting and protein feed formulation for aquaculture. In order to promote this type of beneficial reuse in Georgia, a preliminary study needs to be performed to acquire data for more extensive future research.

13.2 Biobrick Production

A full scale study performed by Alleman in the Maryland-Washington D.C. area demonstrated that bricks can be made with utilizing municipal wastewater biosolids. Bench-scale experimentation indicated that conventional clay and shale ingredients for brick could be partially supplemented with sludge. These so called "biobrick" had the look, feel, and smell of regular brick. Compliance with appropriate ASTM criteria for severe weathering grade brick has been routinely maintained by specimens produced with volumetric sludge additions of less than 25 to 30%. Experimental progression to full-scale evaluation then yielded more than 500,000 bricks. These latter specimens are now being sold at standard commercial prices. Two recreational type structures have been constructed with "biobricks" (Alleman, 1984)

13.3 Fuel from Biosolids

13.3.1 Methane Production

One of the preferred stabilization processes for plants with average wastewater flows greater than approximately 5 MGD is that of anaerobic digestion. The wide use of anaerobic digestion compared to other stabilization processes stems from its potential advantages, including the following short list (American, 1998):

- The production of energy as methane, in excess of that required for process operation
- A reduction of 30 to 50% of volume required for disposal
- The production of solids generally free from objectionable odors when fully digested
- A high rate of pathogen destruction, particularly with the thermophilic process

R.M. Clayton in the city of Atlanta, located directly across the Chattahoochee River from R.L. Sutton, is Georgia’s largest wastewater treatment facility with the largest design capacity in Georgia of 100 MGD. R.M. Clayton anaerobically digests its sludge taking full advantage of the methane gas produced by this process. The methane in this facility is captured and used as the fuel for the incineration process. As a result, no fuel costs are associated with the operation of the incinerators, tremendously lowering the total operating costs. Actually, more methane gas is produced than can be used and is presently being flared. Some difficulties of economics in the cleansing process of the excess methane is present though investigation into a more beneficial use for the “extra” gas is in progress.

13.3.2 Synthetic Fuels

Thermochemical liquefaction of sewage sludge is a process that converts the sludge into various forms of liquid fuels. Project work on this subject was done under the direction of the EPA’s Municipal Environmental Research Laboratory located in Cincinnati, Ohio. This following section is included as a direct summary of the research project’s findings.

Direct thermochemical liquefaction of primary undigested municipal sewage sludge was carried out to produce a low molecular weight steam-volatile oil, a high molecular weight synthetic asphalt, and a residual char cake. The latter product is capable of supplying the thermal energy requirements of the conversion process. The steam volatile oil has immediate value as a synthetic fuel oil. The synthetic asphalt may prove to be a useful cement for paving with further research, or it can be used as a fuel or coking stock. It is outwardly similar to petroleum asphalt, but chemically different.

The thermochemical liquefaction process should be capable of operating in a technical and environmentally acceptable manner in conjunction with many existing wastewater treatment facilities. The overall feasibility of the process depends on the value of the oil and synthetic asphalt products as petroleum replacements and on the costs associated with disposal of sludge. Projected economics indicate that the process has considerable promise for many potential sites in the United States at the present time (EPA, 1981).

13.3.3 MixAlco Process

Dr. Mark Holtzapple of The Department of Chemical Engineering at Texas A&M University has developed a patented technology called the MixAlco Process that converts any biodegradable material (e.g., sorted municipal solid waste, sewage sludge, industrial biosludge, manure, agricultural residues, energy crops) into mixed alcohol fuels. These alcohol fuels contain predominantly 2-propanol, but also higher alcohols up to 7-tridecanol. The feedstock is treated with lime to increase its digestibility. Then, it is fed to a fermentor in which a mixed culture of acid-forming microorganisms produces carboxylic acids. Calcium carbonate is added to the fermentor to neutralize the acids to their corresponding carboxylate salt. The dilute (~3%) carboxylate salts are concentrated to 19% using an amine solvent that selectively extracts water. Drying is completed using multi-effect evaporators. Finally, the dry salts are thermally converted to ketones which subsequently are hydrogenated to alcohols.

All steps in the MixAlco process have been proven at the laboratory scale. A techno-economic model of the process indicates that with the tipping fees available in New York ($138.89/dry ton), mixed alcohol fuels may be sold for $0.04/L ($0.16/gal) with a 60% return on investment (ROI). With the average tipping fee in the United States rates ($64.45/dry ton), mixed alcohol fuels may be sold for $0.18/L ($0.69/gal) with a 15% ROI. A 50 dry ton/day pilot scale facility for the MixAlco Process is now in the construction stage.