internal protective mechanism to preclude problems with cadmium in the diet.

If the sludge did not meet these minimum conditions, then labelling might be required to indicate restrictions on use (e.g., lime in the sludge would not be desirable for some ornamental crops). If sludge were used as a filler in a high analysis fertilizer, appropriate ordinary state fertilizer regulations might apply, assuming applications of the high analysis fertilizer would be sufficiently low to minimize metal applications.

It is possible that the municipal wastewater treatment authority would be required to obtain a permit and implement certain necessary monitoring practices. One possibility of permitting would be under the National Pollution Discharge Elimination System. Monitoring would likely be geared to the potential degree of risk associated with individual projects. For example, there might be sludge quality, sludge application rate, and site monitoring requirements on high rate non-food chain land spreading sites. For programs involving the give-away, sale or home use of a "good sludge", only product monitoring might be required.

Obviously, scientific support for this guidance on the proper use of the different types of sludges for amending soils will be needed. This type of scientific support should come from studies in horticulture and in other agronomic fields.

Impacts of current guidance/regulations on sewage sludge utilization and disposal.

Weddle (9) recently discussed the impact of EPA rule making on sludge utilization and disposal and indicated that industrial pretreatment requirements should increase the amount of sludge suitable for land application. He also discussed, in more detail, the interrelationships of the "Criteria for Solid Waste Disposal Facilities" with the 405 sludge utilization/disposal regulations now being drafted. He recognized one of the most important aspects of sludge utilization – that of public perception, and how it is influenced by the Agency's rule making activities. He stated that EPA can minimize possible adverse impact on public perception by strongly encouraging beneficial utilization practices which comply with the regulatory standards that are developed.

Ettlich and Lewis (3) discussed user acceptance of sewage sludge compost. Composted sewage sludge is a form that will likely receive widespread utilization by horticulturists. Two recent publications by Gouin and Walker, and Hornik et al. (4, 5) indicate the usefulness of this form of material.

Chang and Page (1) have analyzed the impact of the sludge technical bulletin and the criteria upon land utilization of sludges in the United States. They show how these documents affect the rates of application of various types of sludges to agricultural land. Their analysis is of particular interest in that it represents an agriculturist view of the impacts from outside of EPA.

Walker (8) gave an overview of costs, benefits and problems in utilizing sludges. He noted that an estimated \$100-\$500 million could be saved in annual operating and capital costs by 1990 if the current level of sewage sludge utilization of about 30 percent is increased to 50 percent. He also pointed out that certain risks are inherent in sludge utilization as with any other sludge management practice.

EPA has the responsibility to both guide and regulate utilization practices to minimize risks while maximizing the benefits. If regulations are overly stringent, an increase in sludge utilization along with a realization of dollar savings and other benefits would not be possible.

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SEWAGE SLUDGE: PROCESSING AND MARKETING CONVERTS A PROBLEM INTO BENEFICIAL PRODUCTS

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In recent years a decided change has become evident throughout many areas of the United States: *sewage sludge is a valuable natural resource, not a problem to be disposed of!* Yet this knowledge is something Kellogg Supply in cooperation with the Los Angeles County Sanitation District, has been using to advantage for crops, lawns, gardens and landscaping for over 52 years (Fig. 1, 2).

Processing is what turns a potential detrimental product into one of beneficial uses. Most often, wet sludge from a digestor and/or after it has been air dried, has been detrimental to plants when used as a soil amendment. Even when centrifuged and stockpiled, the sludge often contains silicas and toxic substances.

Composting makes the difference!! It is this process that converts the organic waste into a biologically highly active, humus-type product. After undergoing 14 days of anaerobic digestion, the wet sludge undergoes double centrifuging. The centrifuging accelerates drying, but it also removes significant amounts of sands and silicas, along with other non-biodegradable objects and excess soluble salts.

There is a distinct difference between stockpiling and composting! The sterile residue is hauled to composting beds. First, dry, biologically active material, is blended with wet material from the centrifuge. The composting process begins. The mixture is thoroughly turned twice daily for the first 5 days with a Cobey Rotoshredder machine. Thereafter, turning is done once a day, 30 to 40 days.

After composting is complete, the product is trucked to Kellogg Supply yards for additional processing. However some is sold as is to grower nurseries as part of their planting medium. For many years, the product passed through a 3/8 inch (0.95 cm) screen and then was sold in bags or bulk. This product is known as "Nitrohumus" and is widely used as a soil amendment and for topdressing of turfgrasses, gardens, and landscape plantings. Sales demand over the past 6 years has nearly tripled, while the amount being produced has remained relatively the same. To extend the limited supply, nearly all of the "Nitrohumus" is now blended with other organic materials and is sold as speciality planting or topdressing mixes.

These special blends also receive additional composting to make them uniform. The "Nitrohumus" is mixed with shredded rice hulls, composted barks and/or wood shavings according to designated uses. For the many alkaline soils in California and other areas of the West, a product called "Gromulch" has acidifying agents and micronutrients added. Another product, "Topper", is composted with micronutrients and wetting agents and is sold as a seed cover. Still

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Fig. 1. Turning of sewage sludge by machine at Los Angeles County Sanitation District. Material is turned daily for 30 to 40 days to facilitate composting.

Fig. 2. Growth of 3 trees initially of same size, planted near Las Vegas, Nevada in 1977. The 2 smaller trees grew in unamended soil, the larger one in soil amended with 33% by volume of composted sewage sludge ("Nitrohumus") and milled fir bark in a ratio of 1:1.

another very popular material, "Amend", is a composted blend of "Nitrohumus", shredded rice hulls, and micronutrients; it is used widely as a soil amendment. "Nitrohumus" is also used in formulating indoor planter mix and potting soil. For this use the mix also contains vermiculite, perlite, horticultural charcoal, and urea-formaldehyde. A final product, "pH Acidall" has acidifying agents and micronutrients added to the "Nitrohumus" and is used as a soil acidifier and as a topdressing for existing turfgrasses, ground cover, and landscape plantings.

UTILIZATION OF MUNICIPAL WASTEWATER FOR THE CULTURE OF HORTICULTURAL CROPS

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The use of municipal wastewater for horticultural production on the surface appears to be a very simple concept (2, 10, 12). In its simplest form it is the use of a waste product of one process as the raw material for a second process. However, if the best use of the combination of the 2 systems is to be made, it will be necessary to maximize the sum of the 2 systems rather than of each individual system. These 2 systems, horticulture and municipal wastewater, are interfaced by a number of mutual components which are mineral nutrients, CO_2, water and heat. The heat and CO_2 can only be taken advantage of under controlled environmental conditions, with a bare minimum being greenhouse conditions, while all horticultural operations can utilize the nutrients and water (5).

Characteristics of municipal wastewater

In order to make the best use of this wastewater it is necessary to understand the characteristics that make it desirable for horticultural use and also the characteristics that could limit its use.

Probably cost is the first characteristic of wastewater that makes it an attractive management alternative to many other water sources. However, the total cost of reclaimed water is very high but the actual cost of the treated water for irrigation often depends on whether the local sanitation people view it as a disposal operation or as the marketing of a natural resource. Recent environmental considerations such as the banning of ocean discharges and requiring increased treatment before wastewater can be disposed anywhere in the environment are rapidly increasing the cost and degree of wastewater processing. Thus, the additional degree of processing required to make wastewater suitable for reuse is being reduced to the same degree, which makes the cost that can be attributed directly to reuse or irrigation relatively small.

The physical characteristic of a given effluent water is primarily dependent upon 3 major variables. These are: 1) the quality of the original water source; 2) the type of use; and 3) the renovation treatment. Because of this, the term "effluent water" by itself is not sufficient to describe the quality of an effluent water. The quality can range anywhere from almost pure water to water so grossly polluted that it is not a fit source of water for any use. However, most of the renovated water considered for reuse can be defined in terms of the above 3 variables. The original source of the water supply should be of good drinking quality. with less than 500 ppm of total dissolved solids (TDS). It should come from a primarily urban area without significant industrial input and the level of treatment should be at least secondary. There is presently still a lot of domestic effluent available for reuse, and the industrial effluent which is more difficult to clean up need not be considered until the demand is much greater. In California less than 10% of the wastewater is being reused.

The real question when considering the reuse of effluent water for irrigation of crops is how it differs from the original water supply; the original water being the standard for the area, any problems associated with it should already be understood. Again there are 3 major categories of characteristics that are modified during use: 1) biological composition; 2) organic composition; and 3) dissolved inorganic salts. Although the biological composition of the effluent water is of great concern because of pathogenic bacteria and viruses, renovated waters are not released for irrigation without prior approval of the public health officials, usually at a level acceptable for full body contact. Renovated water should cause no public health problem after secondary treatment and disinfection, provided that the approved handling procedures are followed. For irrigation purposes, the organic portion of the effluent water is generally of minimal consequence unless nitrogen is included in this fraction. However, after the initial treatment, the wastewater is often held in ponds where algae can grow, therefore, it is necessary to include sufficient filters to protect irrigation equipment. The characteristic that is going to have the most influence on the use of effluent water for irrigation purposes is the added salt load which it picks up in use. This will be the most important in the arid west where the use of recycled water is most attractive.

Salt load

The salt load is comprised of the soluble material found in the water as the result of having been used once. For example, the water used in the home for dishwashing has soap dissolved in it which, in turn, dissolves whatever is found on the dishes as they are washed. A general rule of thumb is that water going through 1 cycle of use picks up about 300 parts per million TDS of inorganic salt. This is the average amount of material that would be dissolved in the water when all uses of water in the home are considered and averaged.

Plants in general do not grow very well under saline conditions. Only a few varieties of plants can tolerate the high salt conditions found right along the ocean or in the saline areas of the desert. Some