

LAND APPLICATION OF DEWATERED WASTEWATER SLUDGE AS A BENEFICIAL UTILISATION.

A brief discussion of land application of dewatered wastewater sludge as a beneficial utilisation.

The application of wastewater sludge to land is directed by the Guide: Permissible Utilisation and Disposal of Sewage Sludge (known colloquially as PUDSS). This guide with the amendment gives details of a number of permitted land application usage together with restrictions. The total metal content of the soil that should not be exceeded and the total and available metal content of the sludge to be applied, are given,

The following procedure for application would be implemented. Suitable land would be identified taking the following factors into consideration.

1. Accessibility to suitable areas,
2. Distance and direction to nearest small holdings
3. Input from adjacent landowners and occupiers who would be consulted first,
4. Soil type - clay soils cannot be utilised in while wet. Very stony ground cannot be ploughed effectively to ensure adequate covering of the sludge,
5. Slope of the land and distance and direction to water resources - river, boreholes etc.
6. Crops grown - the dewatered waste activated sludge may not be used on crops that may be eaten raw, such as vegetables.

Sludge from the wastewater treatment works would be loaded into 15m³ ro-ro containers that would hold 12m³ of sludge. The containers have a raised back to prevent spillage while being loaded onto the transport vehicle. The vehicle would then drive to the land application area. The container would be offloaded at a suitable hardened area on the farm. As many of the farm internal roads are not suitable for the normal 6x4 chassis, a special off-road vehicle will load the container and transport it to the application area. The contents of the container will be offloaded into a temporary stockpile facility. This is effectively two containers bolted with the centre wall removed. A front end loader is used to load the tractor towed and powered land spreader from this unit. The land spreader is a unit specially designed and manufactured to handle mechanically dewatered waste activated sludge with a high polyelectrolyte content. The sludge in the 18m³ spreader is moved towards the rear of the unit through an adjustable vertical rising gate onto the two vertical spinning archimedes-type screws. These are fitted with specially profiled teeth that shear the sludge into small particles to ensure even spreading over the application area.

The rate of application is varied by adjusting the clearance under the vertical rising gate just upstream of the two screws and by varying the forward speed of the tractor towing the spreader.

In the annexure are photographs of the various stages in the spreading process and showing the various items of equipment used.

After spreading is complete, the sludge needs to be ploughed in. Ideally this should be done immediately, but experience has shown that sludge with a high polyelectrolyte content is highly thixotropic in nature and sticks to rubber tyres. Even on a land with a significant amount of stubble remaining from a previous crop, a 4 wheel drive tractor was not able to get sufficient grip to draw a plough to plough the sludge into the land. After about 12 hours, sufficient degradation of the polyelectrolyte has taken place to allow the sludge to be ploughed in. Dewatered sludge from lagoons or sand drying beds (not containing polyelectrolyte) may be ploughed in immediately.

The land application option has a number of advantages and a few disadvantages. These are detailed below.

1. ADVANTAGES.

1.1 RETURN OF NUTRIENTS TO THE SOIL.

Wastewater sludge contains the essential plant nutrients: carbon, nitrogen, phosphorus, potassium, calcium, magnesium and sulphur in predominately organic form. It also contains the micro-nutrients: iron, manganese, copper, zinc, molybdenum and boron. These minerals are taken up from the soil by crops and are removed by harvesting or by grazing and if not replenished, the soil will become deficient in these minerals. If not replaced, the soil will lose its fertility and will eventually become unsuitable for agricultural purposes.

The application of wastewater sludge to the soil returns these essential plant nutrients to the soil.

1.2 IMPROVEMENT IN SOIL MOISTURE RETAINING ABILITY.

Water is essential for the cultivation of crops. However, rainfall very rarely occurs at the same rate at which the crops require water. Thus the crops must make use of moisture retained in the soil. A large proportion of the agricultural land near Cape Town has either a very sandy soil or one with a high sand content. These soils have a poor moisture retaining ability that is aggravated by a low organic content.

Any material added to the soil that contains humus or other organic material will improve the moisture retaining ability of the soil. Wastewater sludge is such a material that contains a significant proportion of organic material. Many of the farm lands in the area near Cape Town are termed "dry land" farming as they rely entirely on rainfall over the winter to provide moisture for the crops to be grown in late winter and spring or spring to summer for grazing. In the latter case, the ability to retain soil moisture becomes even more critical.

1.3 REDUCTION IN WATER DEMAND OF THE CROP.

This is tied up to some extent to the point above. Even where irrigation is practised, any improvement in soil moisture retaining ability will result in a reduction in total irrigation demand of the crop.

1.4 IMPROVEMENT IN SOIL PHYSICAL PROPERTIES.

The majority of sandy soils in the Cape Town area have a small rounded particle size caused by wind action. These soils are easily eroded by wind and any organic material present in the upper layers of the soil can easily be blown away by the wind. The organic material in wastewater sludge improves the cohesion or binding ability of the soil and thus helps to reduce erosion by the strong winds found in summer in this area. In summer when the soils are the driest, the wind is at its strongest and thus the effect is most pronounced.

Another characteristic of the fine rounded particles making up the sandy soils, is the poor permeability of the soil. This reduces the rate at which rainfall can move into the soil. This means that during intense rainfall episodes, there is an increased likelihood of runoff. This runoff may be lost to the area that most needs the water. Again the addition of organic material through the medium of wastewater sludge improves the permeability of the soil.

This permeability improvement also occurs in clay soils that are also characterised by having a small particle size resulting in low infiltration rates.

1.5 IMPROVEMENT IN SOIL CHEMICAL PROPERTIES.

Crops absorb their nutrient and mineral requirements from the soil. Because the molecules are absorbed through the roots of the plant, they must be absorbed in a dissolved form. If all the nutrients and minerals were present in a soluble form, then they would be leached out by water passing down through the soil column. Therefore, a balance is required between the soluble form available to the plants and a "reserve" in an insoluble but readily available form.

The latter occurs when the nutrients and minerals are absorbed onto colloidal material such as humus in the soil. A measure of the soil's ability to hold the nutrients and minerals is through the Cation Exchange Capacity. This may be defined as "*the capacity of the soil or, more specifically, the colloids in the soil, to adsorb or exchange a certain quantity of cations, under specified conditions*". Poor sandy soils will have values as low as 2 cmol/kg whereas the average cultivated soil will generally have values in the 2-15 cmol/kg range. Humus such as that derived from wastewater sludge or compost will have values over 200 cmol/kg. Clearly, the addition of wastewater sludge to poor soils will improve the Cation Exchange Capacity of the soil.

The Cation Exchange Capacity influences the availability of essential plant nutrients and minerals and also has an important influence on other soil characteristics such as soil reaction (pH buffering) and the structural properties of the soil.

1.6 REDUCTION AND EVEN ELIMINATION OF THE USE OF CHEMICAL FERTILISERS.

Although wastewater sludge contains relatively low percentages of the 3 main nutrients (nitrogen about 3%, phosphorus about 1% and potassium about 0.1%), these elements are slowly released into the soil. In case of nitrogen, about 30% is released in the first year, about 15% in the second year and about 5% in the third year. By comparison, the nitrogen in Limestone Ammonium Nitrate is released in a matter of months. This slow nutrient release property of wastewater sludge is a major advantage of its use versus chemical fertilisers.

On most of the agricultural land upon which sludge has been applied over the past 2½ years in the Cape Town area, it was possible to eliminate the use of chemical fertilisers. This resulted in a significant reduction in input costs.

1.7 IMPROVEMENT IN MICROBIAL ACTIVITY OF THE SOIL.

As indicated above, plants can only absorb nutrients in a soluble form. In the case of nitrogen, this is in the form of nitrates. The complex nitrogen in nitrogen containing compounds must be broken down into simple nitrogen compounds such as ammonia and then converted into nitrate. These reactions are performed by bacteria. In poor soils, these bacteria are present in very limited numbers. Wastewater sludge by comparison contains large numbers of these "good" bacteria. Thus applying wastewater sludge to soils adds these "good" bacteria to the soil.

1.8 REDUCTION IN POTENTIAL OF GROUNDWATER POLLUTION.

As indicated above, the nutrients in wastewater sludge are present in a slow release form. In addition, the presence of humus type compounds in the wastewater sludge absorbs nutrients and minerals. These two processes combine to reduce the potential for the minerals and other organic compounds in the soil to move downwards into the groundwater. Chemical fertilisers by comparison, release their

nutrients quite quickly and indeed faster than the rate at which the plants can absorb and utilise them. This results in a far higher potential for the pollution of the groundwater.

1.9 IMPROVEMENT IN CROP YIELD AND QUALITY.

South African farmers using wastewater sludge as a soil conditioner amendment reported a 20% increase in the yield of cultivated maize. A crop grown as silage for cattle in a area north of Durbanville gave the following results.

CROP QUALITY AND QUANTITY IMPROVEMENT AFTER ONE APPLICATION OF SLUDGE AT * DRY TONS PER HECTARE.

	CONTROL AREA	SLUDGE APPLIED	IMPROVEMENT
Crop yield as silage – t/ha	13	24	85%
Protein content of leaf - %	9.8	17.0	73%
Phosphorus content of leaf - %	0.21	0.32	52%
Calcium content of leaf - %	0.15	0.35	133%
Zinc content of leaf – mg/kg	19	26	37%
Copper content of leaf – mg/kg	3	3	NIL

In the example shown in picture 1 in the annexure, only one watering of 10mm just after sowing of seed was the only irrigation applied to this land during the growing season.

1.10 RETURN OF ABANDONED LAND TO PRODUCTIVE USE.

There are several agricultural areas north of Cape Town where the soil is so poor and the rainfall so low, that hundreds of hectares have been abandoned as not financially not viable to farm. The value of the crop harvested often did not exceed the input costs. On one farm near the N7 National Road, some fields have not been tilled for 12 years.

An example of such a land is given in picture 2 in the annexure.

The return of land to productive use, reduces the need to import crops, grazing and other products such a milk from other areas of the country and even from abroad.

1.11 IMPROVEMENT IN FINANCIAL STATUS OF MARGINAL FARMS. With the generally poor soils in the area coupled with erratic rainfall, yields in terms of tons per hectare are low whereas input costs are high in the form of costs of seed, ploughing and chemical fertiliser. Where higher yields can be obtained with little or no increase in input costs, there will be an improvement in the financial status of many farms. This in turns improves the employment prospects for farm workers that will in turn reduce poverty in the rural areas and in a small way reduce the tendency to migrate to the cities.

1.12 SAVING OF VALUABLE LANDFILL VOLUME. Dewatered waste activated sludge is a listed material and accordingly may only be disposed of in a suitable licensed landfill. There is only one such landfill in the Cape Town that is operated by a sister company. It makes sound economic sense that were an alternative disposal option exists for a listed product that such alternative disposal option be utilised.

1.13 REDUCTION IN LEACHATE PRODUCTION AT A LANDFILL. Due to its high moisture content (about 85%), dewatered waste activated sludge adds a significant

moisture content to a landfill that may increase the rate of leachate. Hence diverting this sludge to an alternative disposal site will assist in reduction leachate production.

2. DISADVANTAGES.

- 2.1 FLYBREEDING. Because wastewater sludge is an active organic material and has a high moisture content it attracts flies, particularly in the drier and hotter months. Experience has shown that a pro-active fly spraying program especially at the sludge storage skips is essential. The use of fly traps on the downwind boundary of the application area assists in reducing the attraction of flies to the application area and those that are attracted to the area will be favourably attracted to the fly traps. Experience has shown that it is not possible to plough in the sludge immediately after ploughing due to the "plastic" nature of the sludge caused by the presence of polyelectrolyte. The sludge sticks to the tyres of the tractor drawing the plough and even 4 wheel drive tractors cannot get enough adhesion to draw the plough. After about 12 hours, sufficient degradation of the polyelectrolyte has occurred to permit ploughing.

The presence of primary sludge in the sludge to be land applied will dramatically increase the attractiveness of the sludge to flies. The City can play its part in limiting the potential for fly-breeding by ensuring that under no circumstances is primary sludge included in the sludge that would be land applied.

- 2.2 ODOUR PRODUCTION. Because wastewater sludge is an active organic material, the spreading on land can result in the release of odours. This would be more prevalent in the hotter months. During these times, the intention would be use lands that are remote as possible from small holdings. As indicated above, experience has shown that it is not possible to plough in the sludge immediately after ploughing due to the "plastic" nature of the sludge caused by the presence of polyelectrolyte. The sludge sticks to the tyres of the tractor drawing the plough and even 4 wheel drive tractors cannot get enough adhesion to draw the plough. After about 12 hours, sufficient degradation of the polyelectrolyte has occurred to permit ploughing.

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- 2.3 POSSIBLE BUILD UP OF HEAVY METALS IN THE SOIL. The organic fraction of the sludge will decompose with time. The metal content will not decompose and may be more readily available or less readily available to plants depending on a number of factors. Before application of sludge to land can commence, soil samples are taken and the various heavy metal contents determined. Usually only the total metal content would be determined as most samples to date have shown a low total metal content. Should the total metal content be more than 50% of the recommended maximum value, then the "available" metal content be determined. Using the soil metal content as a background value and knowing the metal content of the various sludges, one can calculate whether the norm of 8 dry tons per hectare would result in the metal content exceeding the guidelines.

Due to the success of the City in limiting the metal content of the wastewater sludges through effective industrial effluent control, it has not been necessary to reduce the sludge application rate during the past two years where land application has been undertaken by the company.

DETAILS OF EQUIPMENT THAT WOULD BE USED.

See photographs in the annexure.

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