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REACHING THE UNREACHED: CHALLENGES FOR THE 21ST CENTURY

Treated sewage effluent for agriculture

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SEVERAL TOWNS IN South Africa were created by the apartheid system that existed. This was to perpetuate separate development of black and white people. Black people were forcibly removed from areas identified for development for white people. Mothibistad was one such town.

When areas were chosen for resettlement, no care was taken to ensure that the land was suitable for settlement. Mothibistad was developed on dolomitic land, which was susceptible to the formation of sinkholes. Dolomite is a dense, non porous rock made up of alternate layers of $CaC0_3$ (Calcite) and $MgCO_3$ (Magnesite) with porosity of less than 0.3 per cent. Rain water dissolves atmospheric CO_2 and falls on the surface. This percolates through the soil dissolving more CO_2 becoming a weak carbonic acid solution. When this acidic water percolates through the tension fraction and faults in the rock, the dolomite reacts with the acidic water forming soluble bicarbonates, flowing away as solution creating a cavity or forming solution cavities which become larger with time. The overlaying sediment filters into these cavities, then the overburden collapses to form a sinkhole, which is a steep-sided opening that forms on the surface.

In 1993 a gravimetric survey was done in Mothibistad. It was only then realised that Mothibistad was on sinkhole material. This prompted a geological survey of the area to identify the high, medium and low risk areas. The investigation was to evaluate the thickness and the nature of the overburden overlaying the solid dolomite surface and the effect of the changing level of ground water. The investigation consisted of a gravity survey followed by a magnetic survey where necessary. The results thus obtained were cross-checked by drilling boreholes. The areas of high, medium and low risk were depicted by compiling a gravity map from the results of the surveys.

Mothibistad was also established to provide labour for an adjacent white mining and agricultural town. Mothibistad like all towns created by the apartheid system had no economic base nor a viable tax base. Thus the residents depended on the mining town for their living. The town councils were selected by the apartheid government until November 1995 when democratic local elections were held. It would be difficult to convince the residents to leave Mothibistad and resettle elsewhere. Resettlement would be expensive and tedious.

The Department of Local Government and Housing responsible for the municipal services of the town took precautions by surfacing the roads and installing a stormwater system. A waterborne sewer system was provided to replace the pit latrines that were poorly constructed and maintained, these increased the danger of sinkholes and polluted the underground water.

Sinkhole formation is also accelerated by artificial lowering of the water table. Therefore use of boreholes for water was not permitted.

The process of treating the effluent and discharging it safely, both in respect of quality and prevention of sinkhole conditions was carefully considered. In choosing the type of treatment works, consideration was given to, cost of construction, cost of maintenance and phase development. The sewage treatment works is planned to be constructed in four phases which would cater for increase in flow as the town develops.

- Phase 1: Construction of oxidation ponds and irrigation system.
- Phase 2: Provision of recirculation.
- Phase 3: Provision of aerators.
- Phase 4: Modified fully activated sludge system.

Initially five ponds in series were constructed without the planned irrigation system. This was due to lack of funds and as only a few houses were provided with waterborne sewer reticulation because of the delay in extending the reticulation and in the construction of 200 newly planned houses. The effluent was insufficient to fill the ponds and it had to be filled with potable water from the mains and kept full to prevent the lining from being damaged by the sun. The final effluent from the ponds collected in a shallow depression near the ponds and quickly evaporated. It was so diluted with potable water its pollution potential was very low. As more houses were connected to the sewer reticulation arrangements were made to install the irrigation system.

The ponds were constructed with selected material. Clay material with low permeability was used to provide a second moisture barrier in the ponds. On top of this, a layer, a highly permeable material was placed. This sand layer, free from sharp protrusions was used as base for the impermeable geo-membrane made of High Density Polyethylene (HDPE) of 1000μm thickness. Secondly the sand serves as a drainage layer for moisture that may leak through the geo-membrane. The membrane not only prevents pollution of the groundwater sources, it also prevents leaching of the soil which would cause sinkholes. The other alternatives included a soil modified with

Bentonite. Although this option was less expensive it could be damaged when the ponds are desludged. Another alternative was a rubber-bitumen lining on cement stabilized layer of soil. This could develop cracks through which the water would leak to the substrata. The second pond has a 100mm thick concrete slab on top of a geomembrane as at a latter stage, aerators will be provided to this pond.

Having effectively prevented pollution and creation of sinkholes by the effluent contained in the ponds, the next step was to handle the discharge from the ponds. The effluent from the ponds would not conform with the general standards of the water act, a drawback of oxidation ponds and therefore the out flow had to be irrigated. An area of 4 ha near the ponds was required for this purpose. When the works is in full operation the rate of irrigation will be 5mm / day. This low intensity ensures that it is a evapotranspiration system.

Effluent is analysed at regular intervals to check its quality and prevent pollution and health hazard. It was also necessary to analyse the effluent for its chemical quality before use in irrigation. It should not contain toxic compounds. Further its chemical suitability will depend on its electrical conductivity, sodium absorption ratioand boron content. The electrical conductivity measures the dissolved salts thereby the ' salinity hazard ' to the crop. Excessive salinity reduces the plants osmotic activity preventing absorption of water and nutrients from the soil. Sodium absorption ratio measures the alkali or 'sodium hazard ' to the crop. Sodium ions react with the soil displacing the magnesium and calcium ions resulting in poor internal drainage restricting the circulation of air and water when wet and becomes hard when dry. Boron at a concentration < 2mg / l is generally satisfactory for most crops. Bacteriological quality analysis is also essential. If the effluent is used for crops the faecal coliform (FC) density should be < 1000 cells / l00ml. If it is used for unrestricted irrigation a FC < 100 cells / l00ml is needed.

Soils used as a treatment facility require careful analysis of the relation between the water and the soil. A study was carried out by pedologists to characterise and map the soil and landform features and to determine its potential for irrigation, minimise the pollution of the underground water and also maintain the physical and chemical condition of the soil in order to protect the soil resource against degradation. Representative soil profiles, five in total, were sampled and three were chemically analysed . The study showed that there was ample irrigable soils in the area. Deep sand overlay the dolomitic formation. The broad soil pattern comprises of:

- Deep to very deep soils linked in a topo sequence occurring in a filled-in valley (Hutton Form).
- Shallow to litholic red finer sands with rock outcrops (Clovelly Form).

The irrigability of a soil depends on its depth . The Hutton soils of 150 to 200cm depth were the most suitable. The chemical properties of the soil, were such that, Nitrogen and Phosphorous content was low, fertilization being essential.

Potassium content being high to medium, avoid fertilization. Monitoring is necessary as Calcium & Magnesium content is high. Rise in ph would cause deficiency of micro nutrients

The discharge from the ponds were tested and analysed for its water quality for use in irrigation. The samples tested showed that salinity moderate, permeability none. Specific ion toxicity from root absorption; from sodium-none; from chloride- moderate; from boron-none. Specific ion toxicity from foliar absorption (for sprinkler use); from sodium-none, from chloride-moderate. HC03 hazard, moderate. Nitrogen hazard, moderate. "None" means no problems expected. "Moderate" means problems are expected with use over long periods. The calculated surface SAR of 1.66 and an average value of 4.66 with a leaching factor (LF) of 0,05 no significant reduction in infiltration and hydraulic conductivity rates are initially expected. If these properties deteriorate a mild acid dosing or low application of gypsum could be used. The increase of Ph value by the lime and magnesite precipitated during irrigation would reduce the micro nutrients. This is rectified by a small addition of gypsum. The calculated electrical conductivity indicates no crop yield reduction even with a low LF of 0,05.

The methods of irrigating proposed were by:

- Sub- surface; as used to discharge septic tank effluent.
- Surface; along furrows or by flood irrigation.
- Spray or trickle.

The first and second methods were unsuitable as it would causes ponding and pollute the underground water. The spray method was therefore selected as the most suitable. The prime object of this irrigation system was to dissipate water for environmental reasons, in particular to prevent the pollution of the underground water and prevent sinkholes. Any agricultural product from this scheme should be considered only as a by-product. After considering several options on what should be grown, the establishment of a vegetable garden to be managed by members of the community or by fledgling local entrepreneurs was investigated There were several disadvantages to this concept.

- The vegetables thus grown cannot be eaten raw. This limits the selection of vegetables.
- The perception of the purchasers of eating vegetable grown with the effluent.
- The managing and controlling of several small gardens in this large area of 3.0 ha.

The above has the following logistical problems; viability of each garden user; water rights and irrigation times; vegetable type selection; seedling purchases; insecticides and pesticides; marketing and crop sale; appointment of a permanent manager (and cost thereof); co-ordination of all the gardeners.

An alternate was the growing of lucerne. Lucerne is used as a dry animal fodder and it is the most important legumous forage in South Africa. It is also one of the most palatable forage and has a relatively high protein content, producing more protein per hectare than any other crop. It is also rich in calcium and vitamin A and D. Lucerne can improve milk production and growth rate of cattle. Lucerne has a high water demand. It has a deep root system with 60 per cent of the roots in the top 0.75m. The temperature range for growth is 10° to 30°C. The optimum temperature is 25°C. The ambient temperature in Mothibistad in winter is above 10°C. Lucerne seeding has to be done only once in five or six years. At the peak growing period harvesting is every three to four weeks. No pesticide is needed. The seed is readily available and sowing is inexpensive. Lucerne can be stored for long periods and be used during drought periods.

The irrigation equipment consists of a quick coupling sprinkler system with 9 sprinklers, each spraying a diameter of 18m. The length of the irrigation line is 225m, made up of 9 sprinkler pipes plus 29 blank pipes, each 6m. This single line is sufficient to spray the 3.3ha area currently planted with lucerne. A 15kw pump is installed, which could pump more than $50m^3/hr$, with a special float enabling suction footing to be adjusted to avoid excess algae being sucked into the system. The amount of water sprayed daily is measured with a rain gauge placed in the spray area. The cost of this system was R30,000.

An area of 150m x 225m (3.75ha.) was cleared of bush in six hours by grader at a cost of R2520, in March 1994 and irrigated immediately. This was to promote weed growth which was then removed by hand on a regular basis until the lucerne seed sowing time in March 1995. Between March and mid winter (June) the lucerne is able to germinate and grow faster than the weeds, and subdue the weeds, which prefer warmth, Out of the three lucerne cultivars, Topaz, CuF101 and SA standard, Topaz was chosen. Rhizobiurn bacteria are applied to the lucerne seed or soil, this process is called inoculation As the seedlings grow the rhizobia invade the root hairs and produce small growths called nodules. The ability of the lucerne to fix nitrogen in these nodules is one of the main reasons it was considered for irrigation with the treated effluent, which contains excessive nitrates. The nodules on the deep root system prevents the nitrates from leaching into the ground water by converting it to nitrogen. Superphosphate was spread at the rate of 200kg / ha to compensate for low phosphate as shown by the soil analysis.

Table 1

Harvest	*Date*	*Yield*
1st	11/10/1995	140 bags
2nd	01/12/1995	316 x 25kg bales
3rd	10/01/1996	355 x 25kg bales

Sowing was done by first mixing 500g (R17.25) of inoculate with 80g (R 1) of brown sugar, this encourages the inoculator to adhere to the seeds. This is then mixed with 25kg (R 492) seed. To this is added l00kg (R146) of fertiliser. This quantity is for a hectare. As even spreading cannot be achieved by hand sowing a hand operated lucerne sowing device was used. Prior to sowing the land is harrowed to create 20mm deep furrows and covered after sowing. The optimum water requirement of the crop is 6.5mm / day The spraying time is from 6 am to 6 pm with one hour to move the pipe to a new position. Spraying takes place seven days a week and pipes shifted in cycle by eight men at a labour cost of R39.11 per labour and transport cost of R10.10 per day.

The amount sprayed is more or less equal to the raw effluent inflow. Problems arise if the inflow exceeds the amount sprayed, when the excess effluent flow would result in ponding. This is overcome by extending the spraying time. This is not ideal as the water is not dissipated by evaporation and transpiration at night and the field becomes water logged. To avoid this, at present, the sprayers are moved out of the field and the adjacent bush is sprayed. This is also done three days prior to harvesting to dry the field and during the four days of harvesting. Shifting the sprayers is not the proper solution. The solution is to rotate harvesting by extending the fields. The extension of the present field is in progress.

The Department of Local Government and Housing was not willing to purchase specialised farming implements for harvesting as it was not viable. It was decided with the local council to call for tenders for harvesting. Unfortunately no tenders were received. Help was sought from the Agricultural department, who only cut the lucerne. The Department of Local Government had to rake and gather the crop at great expense and was only able to collect 140 bags, the remainder became mouldy. The second and third harvest was done by concluding an agreement with a farmer in the area. He cuts and bales the lurcene using his own implements in return he is entitled to 25 per cent of the harvest. The farmerrequested his share increased to 33 per cent. This agreement was very satisfactory as the harvesting was done professionally and expeditiously at no cost to the department. The remaining 67 per cent bales were sold to a local dealer in animal fodder and the money went to the council. The yields achieved are shown in Table 1. Statisticaly these yields are very good. The revenue earned during the 2nd and 3rd harvest were R2370 and R2660 respectively.

An additional 7 ha will be irrigated by the end of 1996. This will accommodate $650m^3$ treated effluent per day with potential annual revenue of R60,000 to R100,000 from lucerne cultivation. The project has made provision to plant citrus trees along the perimeter of the field, as the fruits are peeled before use.

Agriculture using treated effluent is not unique. It has been done in several countries successfully for many years. Lucerne is grown in many countries. The challenge of this project was to provide a sewer system with an oxidation pond treatment works and protect the underground water, prevent sinkholes and protect the environment. This has been done successfully and at the same time created a viable and income earining agricultural scheme.

The use of treated effluent profitably could now be used in other parts of the province, instead of discharging it into water courses or open spaces. The marginalised black people could now move into the next century happy in the knowledge that better, safe and effective sewer services are possible, under the *Reconstruction and Development Programme* of the present democratic government lUS$ = Rand 3.7.

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