CHAPTER 7

FATE OF THE ORGANIC COMPONENTS OF WINERY EFFLUENTS IN SOILS

7.1 GENERAL

The fate of the organic components of winery effluents in soils is discussed as a separate chapter here, because halfway through the study it became clear that the organic components of the effluents may constitute the most important pollutant in the effluents. Reference to the type of problem found in this study was found only in the publication of Levay (1995) and nowhere else in the literature that was available. It also became clear that management of problems caused by the organic fraction of winery effluents leaves a lot to be desired at the wineries studied.

7.2 ORGANIC SUBSTANCES FROM THE WINE MAKING PROCESS

According to Papini (2000) direct land application of stillage from brandy distilleries as irrigation water and as fertilizer has been cited as having the following effects on soil properties:

- Increase in soil pH.
- Increase in water and mineral salt retaining characteristics.
- Restoration and maintenance of soil fertility.
- Increase in soil microflora.

He further indicated that when organic matter is applied to soil, it could be respired as CO_2, converted into humic substances and/or incorporated into the soil biomass through the actions of soil microbes. He indicated that a potential big advantage of humic substances in soils is by means of improving soil structure and making the structure more stable. This will improve soil physical conditions and benefit root growth.

Chapman (1995b) shares the same sentiments as Papini, indicating that the soluble organic carbon in wastewaters produced by the wine industry would be extensively and rapidly removed from the soil solution by processes of adsorption and microbial

metabolism. Part of the soluble organic carbon is adsorbed to the surfaces of clay and organic colloids as the wastewater moves through the topsoil during irrigation.

The overall removal of soluble organic carbon during each irrigation with wastewater involves both the removal of the organic substrates added by the wastewater and, to a lesser extent, the removal of soluble organic compounds produced by microbial metabolism.

In the present study no indication was found that the organic matter from winery effluents remained in the soil after irrigation or had any positive effect on soil physical conditions. In the case of five wineries (Olifants River, Stellenbosch, Robertson 1, Paarl 2 and Orange River) results clearly indicate that all organic matter contained in the effluents leaches right through the soil until a water table, which forms on top of an impermeable layer (e.g. a dense clay layer), is reached or until it leaches out of the soil.

This was first identified at the Robertson 1 winery during May 2000 when the profile descriptions were made. The profile was dug to a depth of 1,0 m, where the soil became very wet. Augering was done from the bottom of the profile pit to establish the nature of the underlying limiting layer. At 1,2 m a water table was reached. From the top of the soil to that depth the soil was light gray, almost white, sand. The moment the water table was reached, it abruptly changed to pitch-black sand with a very bad odour. It was clear that **all** the organic matter in the effluent had moved right through into the water table, where it underwent anaerobic decomposition.

During November 2000, i.e. long after the end of the vintage season and shortly before the beginning of the next season, the thickness of this black layer in the soil of the disposal site of the Robertson 1 winery was determined. It was found to stretch from 1,2 m below the surface to 1,8 m below the surface, i.e. it was 60 cm thick. A sample of this black soil was washed in the laboratory by adding water, stirring it and decanting the supernatant liquid. After repeated washing the result was white sand, identical to the soil above the water table, and a black liquid (Plate 7.1)

Plate 7.1: Samples of black soil from the water table at Robertson 1 winery (left) and white sand remaining after washing of a similar sample with water (right)

This clearly indicate that the black substances is water-soluble organic matter from the effluent. Investigations in a drainage ditch at the bottom end of the area on which the effluent is disposed, revealed large amounts of black gel-like organic coagulates in the ditch (Plate 7.2). This indicates removal of the organic matter from the disposal site by lateral subsurface leaching. Since the ditch empties into a nearby stream, this poses a real organic matter pollution hazard to the stream.

Plate 7.2: Samples of black material from the drainage ditch at the disposal site at Robertson 1 winery (left) and normal white soil from the disposal site (right)

The results from the investigations at this site can be summarized as follows:

a. The organic matter in the effluent moved right through the soil into the water table, from where it leached laterally to open water (ditch/ stream), constituting a pollution hazard.

b. Under normal circumstances no bad odour from the anaerobic decomposition was evident. Some smell occured only when the polluted layer was exposed.

c. The thick black layer prevailing in November indicates that the anaerobic decomposition is very slow.

d. The problem was found only beyond 1,2 m depth and was thus not identified during the previous "normal" samplings to 90 cm depth.

At the Stellenbosch winery a similar situation to that at Robertson 1 was found during the May 2000 investigation, but with the water table starting already at 80 cm below the surface. In this case lateral seepage is directly into a stream and not via a drainage ditch. Thick layers of black organic coagulates, similar to that at Robertson 1, but in larger quantities, were found in the stream not only where the water from the disposal site seeped into it, but also some distance downstream from the seepage point. Upstream from the point at which seepage from the disposal site into the stream takes place, none of this material was found in the stream, clearly indicating that pollution was from the disposal site of this winery. This confirmed the off-site pollution potential of this type of situation.

There are various similarities between the Robertson 1 and Stellenbosch wineries:

a. At both the effluent has high COD for certain periods.
b. At both disposal is done by means of sprinkler irrigation on kikuyu grass.
c. At both disposal is done on a bleached sandy soil with low nutrient retention and water storage capacities and excessive permeability.
d. At both the disposal area is near a stream or ditch leading to a nearby stream.
e. At both there is a marked slope towards the stream, favouring lateral seepage to the stream.

It is important to relate various aspects of the situations at the above two wineries to statements in the literature. These can be summarized as follows:

a. According to Chapman (1994) land application systems are ideally suited for the treatment of organic carbon contained in winery effluents, because the water in the soil system transports the organic contaminants to the microbial populations that are supported on a stationary medium. Chapman (1994) also stated that sufficient contact time is allowed for microbial treatment and removal of organic contaminants from the soil solution before it is displaced by the next application of wastewater. Such situations clearly do not prevail in the bleached sandy soils of the disposal sites of these two wineries.

The warning of Levay (1995) should rather have been heeded that highly permeable soils are often unsuitable, except at low application rates, because contaminants may be leached rapidly into groundwater before uptake or breakdown has occurred. This is exactly the situation at these two wineries.

b. According to Chapman (1983) it is essential to allow sufficient time between irrigations for the soil to become aerobic. Most importantly waterlogging must be avoided. None of these conditions are met at these wineries. Apart from the fact that the soils are clearly unsuitable for disposal of this type of effluent, **disposal is done on very small areas of land**. To get rid of all the effluent, much more effluent is applied than can be handled by these soils with their low water holding capacities. Irrigations are clearly too frequent and too much water is applied per irrigation. Chapman (1994) indicated that irrigation of vineyards may be the only option available in many areas due to lack of available land for other forms of effluent disposal on land, such as irrigation of cultivated pastures or ponding.

c. According to EPA (1998) wastewater should not be irrigated onto waterlogged areas or land within 50 metres of streams or wetlands and according to the South African Standards it may not be nearer than 100 metres from a stream. In the case of the Stellenbosch winery the disposal area is right next to a stream. The disposal area of the Robertson 1 winery may be a bit more than 50 metres from the stream, but there is a drainage ditch running from the disposal area into the stream.

d. According to EPA (1998) increases in the median total organic carbon concentrations in a water course downstream of the winery waste water irrigation area should not exceed more than 50% of the concentrations at a site upstream from the irrigated area. No measurements have been made in the present study, but there is no doubt that this value will be exceeded far in the case of the Stellenbosch winery and probably also for the Robertson 1 winery.

At the Orange River winery, where disposal is done by means of ponding on a deep, well-drained sandy soil, there was no sign of organic matter accumulation to a depth of 2,0 metres. At 2,1 metres a black layer, similar to that found at Robertson 1 was found in a water table. Here the bad smell of the black material was even worse and more intense than at the other sites. The thickness of the layer could not be determined. Again, the odour was no problem as long as the black layer is not exposed. Here the site is not close to a stream, but the water table must be connected to other water bodies, e.g. streams further away or boreholes, that may be polluted by it. This will have to be investigated in future. It must be noted that the effluent from this winery had extremely high COD values at certain times of the year. It may also be somewhat of a misnomer to speak about ponding on this highly permeable soil. Most of the water probably moves right through the soil to where it is "ponded" in the water table at 2,0 metres depth. According to Shelef & Kanarek (1995) one of the disadvantages of ponding is the possibility of groundwater contamination by seepage from the ponds, especially in sandy and loamy soils.

At the Olifants River winery, where disposal is done by ponding on an impermeable soil, the black layer was found in a water table close to the soil surface, immediately below a white, washed out layer of diatomaceous earth. Again this winery had effluents with extremely high COD values.

At Paarl 2 an interesting situation was found: There was no indication of a water table at the disposal site and no black material was observed in the subsoil. In the drainage ditch below the disposal site only an accumulation of salt was observed (as discussed earlier), but no black coagulates. But when investigations were conducted some 50 metres downstream in the stream into which the ditch drains, accumulations of black organic coagulates were unexpectedly found in the stream, instead of the salt accumulations that were expected. The fact that the effluents from this winery do not have high COD's and that no black material was found in the subsoil at the disposal site or in the drainage ditch makes this finding somewhat of an inexplicable mystery at this stage. It will have to be followed up, however.

The results of this study clearly indicate that the organic component of winery effluents is of no benefit to the soil on which it is applied. It is, in fact, not retained by the soil and poses a serious pollution hazard to adjacent water bodies.

It was beyond the scope of this study to determine the composition of the organic fraction, the distance to which pollution takes place in streams from the point where it enters the streams, its influence on aquatic life and measures and technologies to remove the organic material from the effluent before it is applied to the soil.

Aerobic decomposition in aerated ponds may be required. Research on the treatment of winery effluents has been conducted in the Department of Food Science at the University of Stellenbosch, but efforts to obtain copies of the relevant dissertation and other reports on the research have been unsuccessful. Observations at the effluent disposal sites of five brandy distilleries, at which similar unreported studies were conducted together with the studies at the ten wineries, revealed that at those sites the organic matter accumulated on top of the soil surface. The soil surface looked hydrophobic. This is completely opposite to the situation with winery effluents.

7.3 OBSERVATIONS REGARDING DIATOMACEOUS EARTH

No information was found in the literature concerning the disposal of effluent containing diatomaceous earth on soils. Bentonite, which is used for protein stabilization and clarification of wine, and diatomaceous earth, which is used for filtering of wine, are important components of winery wastes and wastewater.

Most of the wineries that dispose their effluent through irrigation usually separate the diatomaceous earth from the liquid waste before the effluent is used for irrigation. The wineries that dispose their effluent through ponding for evaporation release their effluent with the diatomaceous earth still in it.

In the present study effluent containing diatomaceous earth was applied by means of ponding at the Orange River and Olifants River wineries.At both wineries the first observation was that the diatomaceous earth does not enter the soil, but remains on top of the soil and forms a thick white layer. As it always stays on top of the soil and being light, wind can spread it to other areas, resulting in environmental pollution. The second observation was that diatomaceous earth does not retain any of the organic matter originating from the winemaking process.

The most striking example was at the Olifants River winery, where the pure white diatomaceous earth was on top of the soil surface, with the black layer of effluent organic matter directly underneath it. The transition between the two layers was abrupt. At the Orange River winery the white layer of diatomaceous earth was on top of the soil and the black effluent organic matter in the water table at a depth of two metres.