CHAPTER 4

RESULTS AND DISCUSSION PER WINERY

4.1 GENERAL REMARK

Because of the sensitive nature of some of the data, names of wineries will not be given here. Wineries are indicated by area codes only. Readers must not confuse the regional/area names used here with the names of specific wineries that may have similar names. As was mentioned in the literature, wineries should comply with the legislation when they dispose of their wastewater. Wineries should comply with all criteria. If for example the pH of the wastewater is acceptable, but the COD is outside the legal norms, the winery may not dispose of the effluent by means of land application.

4.2 PAARL 1 WINERY

4.2.1 Main types of wines produced and chemicals used in the cellar

Both white and red wines are produced by this winery. Bulk filter and sheet filter with diatomaceous earth is used to filter the wines. Bentonite is also used for protein stabilization. The Q45 soaps and caustic soda are used to wash equipment in the cellar. Chlorine is also used to kill fungi.

4.2.2 Disposal method and soil description

This winery disposes of its effluent by means of irrigating kikuyu grass through conventional overhead sprinklers.

The soil of the disposal area was classified as belonging to the Hermon family of the Sterkspruit form (Soil Classification Working Group, 1991). This indicates that the soil is characterized by strongly structured subsoil with poor physical conditions. Most importantly its infiltration rate and hydraulic conductivity can be expected to be very low. This could cause a danger of ponding and eventually runoff and overflow of effluent into the adjacent channel. A description and particle size analyses for a modal profile from the disposal area are given in Appendix 4.1.

4.2.3 Effluent composition

Analytical data for the effluent samples taken at this winery on a monthly basis from December 1999 to June 2000 (except May 2000) are given in Tables 4.1 and 4.2.

Table 4.1: pH, COD, SAR, EC and Na data for effluent samples from Paarl 1 winery (From: Van Schoor & Mulidzi, 2001)

Month	**pH**	**COD (mg/l)**	**SAR**	**EC (mS/m)**	**Na (mg/l)**
December	6.4	2299	5.7	-	206
January	2.7	5296	1.8	-	61
February	5.1	2700	1.2	82	33
March	5.1	3373	4.4	109	152
April	5.0	7802	1.6	386	85
June	4.5	4458	1.8	170	66

At this winery the effluent **pH** of 6.4 for December 1999 is above the minimum acceptable pH of 6 specified in the General Authorizations in terms of Section 39 of the National Water Act, 1998 (Act No.36 of 1998) and should not pose a problem (Table 4.1).

The effluent pH dropped dramatically as soon as the wine making season started in January, however. The source of the low pH is probably citric acid (Van Schoor, 2000). According to the Department of Water Affairs and Forestry (1996) acidification of soil by applying water with a pH less than 6 may in the long-term lead to the availability of several micro or macronutrients in toxic concentrations. High availability of these nutrients has serious health and environmental implications.

The low pH also increases problems with corrosion of metal or concrete components of irrigation systems. The effluent pH of only 2.7 for January 2000 was the lowest recorded at any stage for any of the wineries studied. Thereafter it stabilized at a much higher, but still unacceptably low, level for the rest of the study period.

The effluent from this winery was characterized by moderate **COD** values of less than 5000 mg/l, which is the maximum acceptable to limited for irrigation of 50 m^3/d (Act

No.36 of 1998), for most of the study period. During January the COD of the effluent from this winery was just slightly above the maximum permissible level of 5000 mg/l, while in April it was significantly above this level. Thus, the disposal of the January and April effluents prior to treatment is not acceptable according to the South African environmental standards.

(Sodium adsorption ratio) **SAR** of the effluent for December was above 5, which is the maximum permissible value (Act No. 36 of 1998). In all other months the SAR values were acceptable according to the South African Water Act standards for irrigation. However it must be pointed out that the SAR value for March approaches the danger level, which indicates that if there is no improvement in the wastewater management sodicity problems may develop in the long term. Like SAR, **sodium** is higher in the December and March effluents.

Electrical conductivity (**EC**) was above the South African standard of 200mS/m for any disposal (Act No.36 of 1998) only for the April effluent.

Table 4.2: K, Ca, Fe, Mg, B and Cl contents of effluents from the Paarl 1 winery (From: Van Schoor & Mulidzi, 2001)

Month	K (mg/l)	Ca (mg/l)	Fe (mg/l)	Mg (mg/l)	B (mg/l)	Cl (mg/l)
December	-	57	-	1.07	0.11	-
January	32	60	5.30	0.63	-	98
February	125	39	3.13	0.44	0.10	173
March	65	64	1.85	0.66	0.11	130
April	336	185	7.25	1.00	0.37	132
June	211	75	6.27	0.64	0.27	116

None of the **nutrient elements** analysed had values that are unacceptably high at any stage, indicating that these do not pose toxicity hazards at this stage (Table 4.2). The April effluent showed elevated, but not unacceptable, K, Ca, Fe and B levels. Mg levels were very low throughout.

4.2.4 Soil analyses

The soil analyses showed some important differences between the control and the site irrigated with effluent (Table 4.3). Some of these are inconsistent and could perhaps be related to sampling/analytical problems (e.g. the very high Zn level in the March 2000 topsoil sample). Others may be cause for concern in regard to possible problems which may develop over the long term, especially when viewed in conjunction with similar trends at the other wineries studied.

Exchangeable sodium percentage **(ESP)** values of the effluent treated soil were low to moderate, but consistently higher than those for the control in the 0-30 cm and 30-60 cm layers. During December, when irrigation was done with effluent with a somewhat higher SAR, the ESP rose to between about 7.0 and 8.5% throughout the profile. Thereafter it dropped sharply, but started increasing again from March (when the effluent again had a slightly higher SAR) to May.

During May ESP values up to over 9.0% were found throughout the profile. Even though these values are not excessively high, and lower than those for most of the other wineries, problems may develop on the highly dispersive soil on which the effluent is disposed of at this winery. It must be pointed out that though the ESP does not seem to be a problem now, there are signs that it is building up such that in a long term it may become a problem. During soil classification in May, it was noted that there is a large amount of dispersed washed in clay in the B1 horizon, which may clog macro-pores. It is expected that continuous application of effluent on this soil will adversely affect the infiltration rate and hydraulic conductivity of the soil and aggravate the problem of runoff and overflow into the channel.

The topsoil **phosphorus** (P) levels in the December and January samples from the effluent treated site are a matter for concern since they are much higher than the levels that Eloff & Laker (1978) found to suppress crop yield (Table 4.3). Eloff & Laker (1978) found that for the Olsen method, which gives values similar to the Bray 1 method, any P values above 45 $mg.kg^{-1}$ suppress yields. The values for the other months were not in this grossly excessive range, but still very high. The sharp decrease in topsoil P levels after January is difficult to explain since subsoil P levels do not indicate P leaching. Unfortunately P data are not available for the effluents. Although indications are that in the long term excessive P levels may worsen to become a severe problem, the situation is better than at most of the other wineries studied.

During April and May the subsoil **potassium** (K) levels were very high compared to the control site (Table 4.3). During these months topsoil K levels were also higher than the control site. The high potassium values can be attributed to the K-H- bitartrate that occurs in both the must and the wine (Van Schoor, 2000).

The fact that the K levels were so high throughout the profile, even to deeper than 1 metre, and that topsoil K decreased from April to May while subsoil K increased during the same period, points to a high mobility of K in the soil. This is in contrast to the situation with P. The elevated K levels in the topsoil **and** the subsurface layer (30-60cm) during December and January (of which the source is not clear), followed by very low levels during February and March, further strengthen the idea of high K mobility. The apparent high K mobility may lead to leaching of K from the soil into water bodies, where it may become an eutrophication concern. At the moment this is speculation, but warrants follow-up work.

Topsoil **pH** values at the disposal site were acceptable, but subsoil pH levels were low to very low, especially in the deeper subsoils (60-90 cm). These values were not lower than those of the control site, however.

Table 4.3: Soil analyses for Paarl 1 Winery

Months	Depth	pH	Resistance	P	K	Na	K	Ca	Mg	S-value	Cu	Zn	Mn	B	ESP(%)
	(cm)	(KCl)	(ohm)	(mg/kg)	(mg/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
December	0 – 30	4.7	1880	104.00	199.00	0.73	0.51	3.95	1.20	8.57	2.35	3.30	12.40	0.36	8.52
December	30 - 60	4.2	1300	50.00	106.00	0.81	0.27	4.70	1.70	11.49	1.06	1.40	7.10	0.43	7.05
December	60 - 90	3.9	770	23.00	47.00	0.76	0.12	3.19	2.00	10.43	0.49	0.60	1.80	0.16	7.29
January	0 – 30	4.8	1880	131.00	289.00	0.33	0.74	4.84	1.62	9.53	2.92	3.20	14.60	0.34	3.46
January	30 - 60	4.6	2470	122.00	106.00	0.37	0.27	3.92	1.42	7.90	1.99	1.80	8.60	0.28	4.68
January	60 - 90	4.5	1360	66.00	70.00	0.59	0.18	4.46	2.45	10.73	0.56	2.00	6.40	0.25	5.50
February	0 – 30	5.0	1450	46.00	27.00	0.10	0.07	0.45	0.25	2.68	1.24	3.80	9.10	0.29	3.73
February	30 - 60	5.0	1310	22.00	8.00	0.11	0.02	0.39	0.28	3.47	0.50	1.00	4.30	0.24	3.17
February	60 - 90	4.6	640	8.00	4.00	0.10	0.01	0.28	0.28	2.40	0.31	1.00	2.20	0.19	4.17
March	0-30	5.9	1330	55.00	47.00	0.06	0.12	0.56	0.20	0.94	1.72	44.60	12.80	0.26	6.38
March	30-60	5.1	1510	28.00	20.00	0.09	0.05	0.40	0.18	2.76	1.41	13.50	7.10	0.21	3.26
March	60-90	4.6	650	6.00	8.00	0.09	0.02	0.32	0.26	3.91	0.30	7.50	2.20	0.07	2.30
April	0-30	5.0	1170	73.00	223.00	0.47	0.57	4.65	1.78	8.73	1.44	8.10	9.90	0.18	5.38
April	30-60	4.4	1500	33.00	215.00	0.62	0.55	4.36	1.80	9.85	0.66	2.30	4.40	0.13	6.29
April	60-90	4.0	1070	9.00	211.00	0.41	0.54	3.10	1.80	8.37	0.18	0.70	1.80	0.04	4.90
May	0-10	5.7	0	62.00	196.00	0.66	0.50	4.67	1.53	7.36	1.38	12.30	11.00	0.23	8.97
May	10-50	4.6	0	76.00	160.00	0.47	0.41	3.74	1.33	5.95	2.23	5.10	9.70	0.18	7.90
May	50-80	4.0	0	5.00	235.00	0.49	0.60	3.39	2.02	6.50	0.31	1.80	2.10	0.08	7.54
May	80-100+	4	0	2.00	239.00	0.52	0.61	2.44	2.06	5.63	0.14	0.40	0.70	0.05	9.24
Control	0-30	5	2560	62.00	145.00	0.22	0.37	5.64	1.28	8.69	1.73	1.20	16.70	0.42	2.53
Control	30-60	4.2	1830	26.00	66.00	0.17	0.17	4.07	1.13	7.66	0.59	0.40	4.30	0.27	2.22
Control	60-90	3.9	1090	7.00	35.00	0.25	0.09	2.42	1.02	5.04	0.14	0.10	0.10	0.12	4.96

The **bulk densities** of both the topsoil and subsoil of the effluent treated site were lower than those for the control site (Table 4.4). The value of 1 400kg/m^3 for the treated site is quite low and favourable. It seems as if the effluent applied on the soil did not bring about any problems as far as the soil structure is concerned. This is unexpected in view of the dispersed clay observed during the profile description.

Table 4.4: Bulk densities of the soils at Paarl 1 winery

Soil depth	**Treated plot**	**Control**
Topsoil	1400 kg/m^3	1600 kg/m^3
Subsoil	1400 kg/m^3	1700 kg/m^3

4.2.5 General evaluation

Overall the effluents from this winery are of a better quality than those from almost all the other wineries studied and seem to pose the least threat of negative environmental impacts. Some aspects are unacceptable and need attention, however. Most serious are the moderately high COD and EC values of the April effluent.

The extremely low pH and slightly higher than acceptable COD in the January effluent also needs attention and the general low pH values are unacceptable. Aspects that are acceptable according to the water quality standards but need attention with a view to long-term sustainability include the P, K and Na levels during some periods.

Disposal is done on a low potential soil, but it seems to be a much more suitable soil for effluent disposal than those used at by far the majority of other wineries studied.

4.3 PAARL 2 WINERY

4.3.1 Main types of wines produced and chemicals used in the cellar

This winery produces both red and white wines. The bulk filter, vacuum filter and drum filter with diatomaceous earth are used during the filtration of wine.

Bentonite is used for protein stabilization. Q5 special soaps are used to wash the tanks. Caustic soda is also used to remove the tartaric acid.

It was found that this winery uses water from a borehole that has high chloride content. From the results of this study, it appears that the water has high sodicity as well as salinity.

4.3.2 Disposal method and soil description

This winery disposes of its effluent through irrigating kikuyu grass by means of conventional overhead sprinklers.

The soil of the disposal area was classified as belonging to the Ermelo family of the Longlands form (Soil Classification Working Group, 1991). This soil is characterized by high chroma red and yellow mottles in a light gray matrix in the B-horizon, indicating alternating reducing and oxidizing conditions caused by a fluctuating water table. A description and particle size analyses for a modal profile from the disposal area are given in Appendix 4.2.

4.3.3 Effluent composition

Analytical data for the effluent samples taken at this winery on a monthly basis (except May 2000) from December 1999 to July 2000 are given in Tables 4.5 and 4.6.

Table 4.5: pH, COD, SAR, EC and Na data for effluent samples from Paarl 2 winery (From: Van Schoor & Mulidzi, 2001)

Month	pH	COD (mg/l)	SAR	EC (mSm)	Na (mg/l)
December	7.6	364	7.5	-	261
January	7.4	233	7.8	-	305
February	4.4	8520	6.3	269	269
March	4.6	6190	7.06	311	311
April	4.8	2257	10.04	448	448
June	5.3	3514	11.98	513	513
July	6.0	1968	11.2	313	446

At this winery the **pH** values of 7.6, 7.4 and 6.0 for December 1999, January 2000 and July 2000 are acceptable values for irrigation according to the General Authorisations in terms of Section 39 of the National Water Act, 1998 (Act No.36 of 1998) and is therefore not regarded as a problem (Table 4.5). The effluent pH decreased dramatically as soon as the wine making process started in February. Application of effluent with a pH of less than 6 may lead to the acidification of soil and also in the long term can lead to the availability of several micro and macro nutrients in toxic concentrations (Department of Water Affairs and Forestry, 1996). The low pH also increases problems with corrosion of metal or concrete components of irrigation systems.

The effluent from this winery was characterized by **COD** values slightly to moderately higher than the maximum permissible level of 5000 mg/l (when irrigating up to 50 m^3/d) in February and March (Act No.36 of 1998). In all other months the effluent from this winery was characterized by COD values that do not pose problems according to legislation. It is only the effluent in February and March that needs to be treated prior to any form of disposal.

SAR (sodium adsorption ratio) of the effluent is very high in all months. It is above the maximum permissible value of 5 for any disposal (Act No.36 of 1998). From the soil analyses and observations in the field (Section 4.3.4) it is evident that this effluent is causing sodicity problems in this area. The effective management of the effluent to eliminate the sodicity problem should be a priority to avoid any degradation of the soil. Similar to SAR, **sodium** values are high in all months. It is assumed that the high amount of sodium is due to the caustic soda used in the cellar and possibly the borehole water used.

Electrical conductivity **(EC)** was high and above the South African Standard of 200 mS/m for any disposal (Act No.36 of 1998) in all months. The use of water from the borehole could also be the reason for the high Na and EC of the effluent throughout all months at this cellar.

Table 4.6: K, Ca, Fe, Mg, B and Cl contents of effluents from Paarl 2 winery (From: Van Schoor & Mulidzi, 2001)

Month	K (mg/l)	Ca (mg/l)	Fe (mg/l)	Mg (mg/l)	B (mg/l)	Cl (mg/l)
December	-	39	-	32	-	-
January	163	46.2	0.08	41.9	0.2	285.99
February	267.7	64.5	14.1	62.5	0.49	869
March	313.7	65.7	11.96	67.6	0.48	760
April	113.7	32.3	0.13	46.7	0.25	470
June	244.8	63	6.94	52.2	0.31	704

Chloride shows unacceptably high values in February (869 mg/l), March (760 mg/l) and June (704 mg/l). The reason for the high chloride is that this winery uses chloride rich water from a borehole and they also use chlorine. None of the other **nutrient elements** analysed had values that were unacceptably high at any stage, indicating that these did not pose toxicity hazards (Table 4.6).

4.3.4 Soil analyses

The soil analyses showed some important differences between the control and the site irrigated with effluent (Table 4.7).

Exchangeable sodium percentage **(ESP)** values of the effluent treated soil were much higher than those for the control at all depths (Table 4.7). This reflects the influence of the high SAR and sodium levels of the effluent of this winery (Table 4.5). The degree to which this soil has already been affected by the sodic and saline effluent from this winery was evident when soil classification was done during the dry period of early May 2000. Extensive accumulation of sodium chloride precipitates was observed in the wall of the drainage ditch below the effluent application area, indicating leaching of salts from the area. These will subsequently be transported from the ditch to the streams into which it flows, with detrimental effects on the quality of the water downstream.

The **phosphorus** levels in all months' samples from the effluent treated site were not very high, although they were slightly excessive in December and April. Phosphorus levels follow the normal trend as for most cultivated soils, viz. decreasing P levels with depth. Only in February there was an anomalous situation where phosphorus was low in the top two layers and somewhat higher in the lower subsoil (60-90 cm). This may indicate slight mobility of P in this soil and may be related to the higher COD of the effluent in February. During December and May the subsoil **potassium** levels were very high compared to the control site (Table 4.7). Potassium showed similar trends at the other wineries.

Soil **pH** values at the disposal site were high to very high and fluctuated from significantly above the values for the control site at corresponding depths to significantly below it. A striking feature is the much higher subsoil pH levels (even in the deeper subsoil) at the disposal site than at the control site during February, March and April. This is in contrast with what would be expected in view of the low effluent pH during these months.

Bulk density of both the topsoil and subsoil of the effluent treated site and those for the control site are similar (Table 4.8). All the values are extremely high and should inhibit root development very severely. The organic fraction of the effluent did not improve the bulk density of the soil, as it did at Paarl 1 winery (Table 4.4). In literature (Chapman, 1995a) it is also postulated that the organic fraction of cellar effluents should be beneficial to the physical conditions of soils. The high sodium content of the effluents from this cellar however might have negated this.

Table 4.8 Bulk density analyses for the soils of Paarl 2 Winery

Soil depth	**Treated site**	**Control**
Topsoil	1800 kg/m^3	2000 kg/m^3
Subsoil	2000 kg/m^3	1800 kg/m^3

Table 4.7 Soil analyses for Paarl 2 winery

Months	Depth	pH	Resistance	P	K	Na	K	Ca	Mg	S-value	Cu	Zn	Mn	B	ESP(%)
	(cm)	(KCl)	(ohm)	(mg/kg)	(mg/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
December	0-30	6.7	1870	53.00	156.00	0.54	0.40	0.65	0.53	2.12	0.35	1.00	1.40	0.21	25.47
December	30-60	6.3	540	54.00	481.00	1.16	1.23	1.82	2.52	6.73	0.42	1.10	5.90	1.01	17.24
December	60-90	6.4	340	6.00	555.00	2.44	1.42	3.12	6.83	13.81	0.28	0.30	1.60	1.02	17.67
January	0-30	5.8	690	93.00	207.00	0.72	0.53	1.96	0.95	4.16	0.41	2.00	2.40	0.30	17.31
January	30-60	5.9	1410	31.00	82.00	0.21	0.21	0.84	0.42	1.68	0.23	0.30	0.60	0.12	12.50
February	0-30	7.5	810	14.00	23.00	0.11	0.06	0.20	0.20	0.57	0.57	1.90	4.60	0.32	19.30
February	30-60	7.2	1200	12.00	12.00	0.08	0.03	0.11	0.13	0.35	0.22	0.40	1.70	0.26	22.86
February	60-90	7	970	37.00	16.00	0.10	0.04	0.14	0.18	0.46	0.28	0.50	2.30	0.32	21.74
March	0-30	8.8	480	24.00	20.00	0.06	0.05	0.13	0.12	0.36	0.44	1.90	4.30	0.23	16.67
March	30-60	8.1	750	3.00	12.00	0.04	0.03	0.07	0.05	0.19	0.19	0.20	1.20	0.10	21.05
March	60-90	7.8	900	3.00	8.00	0.04	0.02	0.07	0.08	0.21	0.21	0.30	1.20	0.13	19.05
April	0-30	7.2	730	49.00	94.00	0.35	0.24	1.12	0.76	2.47	0.23	1.30	2.00	0.19	14.17
April	30-60	7.4	660	23.00	55.00	0.36	0.14	0.70	0.42	1.62	0.15	0.30	2.70	0.16	22.22
April	60-90	7.6	580	19.00	55.00	0.40	0.14	0.73	0.42	1.69	0.13	0.30	2.70	0.13	23.67
May	0-15	7.2	400	14.00	86.00	0.43	0.22	0.81	0.70	2.16	0.20	0.30	1.00	0.22	19.91
May	15-30	7.5	750	9.00	74.00	0.37	0.19	0.69	0.61	1.86	0.19	0.10	1.10	0.14	19.89
May	30-40	6.7	0	1.00	590.00	2.05	1.51	3.82	4.80	12.18	0.14	0.10	6.80	0.85	16.83
May	40-120+	6.9	0	1.00	895.00	2.51	2.29	3.85	7.57	16.22	0.11	0.30	2.00	0.64	15.47
Control	0-30	7.3	1040	5.00	129.00	0.32	0.33	6.00	0.98	7.63	1.29	1.40	4.30	0.53	4.19
Control	30-60	6.2	1920	2.00	90.00	0.18	0.23	1.82	0.55	2.78	0.16	0.10	0.00	0.38	6.47
Control	60-90	6.2	830	2.00	258.00	0.37	0.66	3.64	1.39	6.06	0.19	0.10	0.00	0.58	6.11

4.3.5 General evaluation

The effluent from this winery is of very poor quality, caused by its **very high** sodicity and salinity **throughout** all the months during which it was monitored. This is a unique feature for this winery, which was not found at any of the other wineries. Most of the other wineries had very limited or no sodicity and salinity problems, or had them for limited periods only. These aspects of the effluent from this winery are unacceptable and need serious attention. The effluent from this winery poses a threat of negative environmental impact, as evidenced by the salt accumulation observed in the drainage ditch below the disposal area. The moderately high COD values for February and March and the low pH values for some of the months are also of concern and require pretreatment of the effluent before disposal.

Changes to some of the practices at the winery may be required in order to eliminate the high sodicity and salinity of the effluent. ***Most importantly, continued use of the water from the present borehole will cause problems and it is imperative that an alternative water source will have to be found urgently.***

Development of a temporary water table during wet periods and strong lateral seepage above the water table are negative features of the soil on which disposal is done at this winery.

4.4 PAARL 3 WINERY

4.4.1 Main types of wine produced and chemicals used in the cellar

The types of wines produced by this winery are white, red, sparkling wine as well as fortified wines. Bulk filtering with diatomaceous earth is used for the filtration of wine. Sheet and membrane filtering with diatomaceous earth are also used in some processes. The types of detergents used to wash equipment in this winery include chlorine with caustic soda. Chlorine is preferred to kill fungi, as was the case with the wineries discussed previously.

4.4.2 Disposal method

This winery disposes of their effluent by means of ponding in a dam. No modal soil profile was studied.

4.4.2 Effluent composition

Analytical data for effluent samples taken at this winery on a monthly basis (except May 2000) from December 1999 to June 2000 are given in Tables 4.9 and 4.10.

Table 4.9: pH, COD, SAR, EC and Na data for effluent samples from Paarl 3 winery (From: Van Schoor & Mulidzi)

Months	pH	COD (mg/l)	SAR	EC (mS/m)	Na (mg/l)
December	5.6	582	0.58	-	8.8
January	4.4	3676	0.53	-	10.7
February	4.8	996	3.17	60	77.7
March	4.5	7262	0.79	137	29.6
April	5.3	7802	0.77	175	13.7
June	3.7	859	0.86	52	11.3

At this winery the effluent **pH** was below the minimum acceptable pH of 6 for irrigation specified in the South African General Authorization in terms of Section 39 of the National Water Act, 1998 (Act No.36 of 1998) during all months. According to Department of Water Affairs and Forestry (1996), acidification of soil by applying water with pH less than 6 may in the long-term lead to the availability of several micro and macronutrients in toxic concentrations.

The effluent from this winery was characterized by **COD** values of less than 5 000 mg/l, which is acceptable to any form of disposal provided not more than 50 m^3 is applied per day (Department of Water Affairs and Forestry, 1993), for most of the study period. During March and April, the COD of the effluent was somewhat above the maximum permissible level of 5 000mg/l (Table 4.9).
The disposal of the March and April effluents prior to treatment is not acceptable according to the South African environmental standards. It is however important to

realise that all parameters (pH, COD, SAR and EC) must be complied with and irrigation may only occur when all criteria fall within the legal limits.

Sodium adsorption ratio **(SAR)** of the effluent is very low. All values in all months are far below the maximum permissible value of 5 (Act No.36 of 1998) and will not pose any environmental risk. (Table 4.9). Like SAR, **sodium** is also low throughout.

The Electrical conductivity **(EC)** was below the South African Standard of 200 mS/m for irrigation (Act No.36 of 1998) in all months' effluents.

Table 4.10: K, Ca, Fe, Mg, B and Cl contents of effluents from Paarl 3 winery (From: Van Schoor & Mulidzi, 2001)

Months	**K (mg/l)**	**Ca (mg/l)**	**Fe (mg/l)**	**Mg (mg/l)**	**B (mg/l)**	**Cl (mg/l)**
December	-	15	-	1.6	-	-
January	40.3	25.7	8.2	3.3	0.08	98
February	15.3	30.5	0.16	9.1	0.06	96
March	334.1	90.4	1.29	8.8	0.29	54
April	290.6	14.3	2.6	6	0.45	58
June	85.4	10.9	0.6	1.3	0.02	27

None of the **nutrient elements** analysed had values that are unacceptably high at any stage, indicating that these do not pose toxicity hazards at this stage (Table 4.10). The March and April analyses, however showed slightly high amounts of potassium.

4.4.4 Soil analyses

The soil analyses showed some important differences between the control and the site irrigated with effluent (Table 4.11).

Exchangeable sodium percentage **(ESP)** values of the effluent treated soil were much higher than those of the control site. The subsoil ESP values of the effluent treated site were high to very high (Table 4.11). ESP is a real problem at this winery. This is very strange in view of the very low SAR and Na values of the effluents. At first it was speculated that a problem water source, similar to the borehole at Paarl 2, might have been used in the past, but the cellar manager did not give this as a possible explanation.

The **phosphorus** levels at the effluent treated site are lower than those of the control site and P is concentrated in the topsoil. **Potassium** is fairly high, but not excessive, in the top two soil layers (0-30 and 30-60cm) in both December and January. The high K level in the lower subsoil (60-90cm) in April (Table 4.11) indicates high mobility of K in the soil upon application of the March and April effluents with their high K contents (Table 4.10). This is a matter of concern as it points to the possibility that K could leach into streams and cause eutrophication of water bodies. High K mobility was also observed in soils at other wineries.

At this winery the exceptional situation is found that the **pH** values of the soil at the control site range from moderately acid in the topsoil to very strongly acid in the subsoil, but at the disposal site it is strongly alkaline in the topsoil in all months and during February, March and April also in the upper subsoil (30-60 cm depth). This is in sharp contrast to what would be expected upon application of the acid effluent, although the use of caustic soda may play a role. Quality of irrigation water depends on the collective water quality of the pond, which can be characterized by a combination of different cellar processes.

4.4.5 General evaluation

Overall the effluent from this winery is of better quality than the effluent from the other wineries studied. The slightly high COD in March and April necessitates treatment of these effluents before disposal, however. The elevated K levels in the March and April effluents, combined with the high K levels in the deeper subsoil in April also points to a situation that may need attention from an environmental point.

Table 4.11: Soil analyses for the soil at Paarl 3 winery

Months	Depth	pH	Resistance	H	Klip	P	K	Na	K	Ca	Mg	S-value	Cu	Zn	Mn	B	ESP(%)
	(cm)	(KCl)	(ohm)	(cmol/kg)	Vol%	(mg/kg)	(mg/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
December	0-30	8.1	1080	0.00	0.00	33.00	325.00	0.46	0.83	13.63	0.25	15.17	1.33	3.60	6.60	0.60	3.03
December	30-60	5.1	160	0.00	0.00	14.00	180.00	4.26	0.46	2.26	1.48	8.46	0.42	1.00	0.70	0.73	50.35
December	60-90	4.1	110	0.00	0.00	24.00	20.00	6.33	0.05	0.98	2.11	9.47	0.39	0.50	0.00	0.25	66.84
January	0-30	8.1	1150	0.00	22.00	25.00	168.00	0.12	0.43	7.08	0.50	8.13	2.11	4.90	10.00	0.53	1.48
January	30-60	5.3	180	0.52	31.00	6.00	164.00	2.30	0.42	2.67	1.96	7.87	0.54	1.20	1.40	0.74	29.22
January	60-90	3.7	100	3.05	2.00	4.00	35.00	5.51	0.09	1.47	4.21	14.33	0.32	0.90	0.00	0.72	38.45
February	0-30	8.1	1520	0.00	0.00	2.00	16.00	0.06	0.04	0.29	0.12	0.51	1.19	2.50	4.70	0.26	11.76
February	30-60	8.0	890	0.00	0.00	2.00	31.00	0.12	0.08	0.17	0.16	0.53	0.25	0.80	0.60	0.27	22.64
February	60-90	4.8	120	0.00	0.00	93.00	4.00	0.56	0.01	0.14	0.48	2.37	0.06	0.40	0.10	0.37	23.63
March	0-30	8.2	620	0.00	0.00	41.00	39.00	0.03	0.10	0.80	0.06	0.99	8.97	27.20	16.00	0.39	3.03
March	30-60	8.5	500	0.00	0.00	3.00	23.00	0.09	0.06	0.20	0.09	0.44	0.61	1.90	0.90	0.22	20.45
March	60-90	4.4	170	1.81	0.00	2.00	0.00	0.53	0.00	0.12	0.39	2.85	0.47	1.50	0.50	0.20	18.60
April	0-30	7.5	570	0.00	0.00	61.00	184.00	0.17	0.47	5.68	0.31	6.63	5.57	22.10	21.80	0.36	2.56
April	30-60	8.3	340	0.00	0.00	13.00	59.00	1.69	0.15	4.28	1.50	7.62	1.49	6.00	4.70	0.54	22.18
April	60-90	4.0	110	2.44	0.00	16.00	465.00	5.92	1.19	1.55	3.97	15.07	1.24	4.70	1.60	0.27	39.28
Control	0-30	4.5	980	0.94	14.00	94.00	199.00	0.08	0.51	2.03	0.64	4.20	0.71	4.00	6.40	0.40	1.90
Control	30-60	4.1	1240	0.94	17.00	74.00	109.00	0.07	0.28	1.55	0.54	3.38	0.45	7.00	2.80	0.33	2.07
Control	60-90	3.3	740	4.01	27.00	25.00	51.00	0.26	0.13	3.80	2.93	11.13	0.20	3.30	0.10	0.44	2.34

4.5 STELLENBOSCH WINERY

4.5.1 Main types of wines produced and chemicals used in the cellar

Both red, white and fortified wines are produced at this winery. Bulk filtering with diatomaceous earth is used for the filtration of wine. Filtration varies between different months and also on the availability of wine. Bentonite is also used for protein stabilization. The types of soaps used to wash equipment include PRO 41 for outside tanks. Caustic soda is also used.

4.5.2 Disposal method and soil description

This winery disposes of their effluent through irrigating kikuyu grass by means of conventional overhead sprinklers.

The soil of the disposal area was classified as belonging to the Waterton family of the Fernwood form (Soil Classification Working Group, 1991). It has a thick layer of undecomposed organic matter on the surface. A description and particle size analyses for a modal profile from the disposal area are given in Appendix 4.3.

4.5.3 Effluent composition

Analytical data for the effluent samples taken at this winery on a monthly basis (except May 2000) from December 1999 to June 2000 are given in Tables 4.12 and 4.13.

Table 4.12: pH, COD, SAR, EC and Na data for effluent samples from Stellenbosch winery (From: Van Schoor & Mulidzi 2001)

Months	**pH**	**COD (mg/l)**	**SAR**	**EC (mS/m)**	**Na (mg/l)**
December	5.3	3321	2.39	-	61
January	6.6	2372	4.9	-	86.3
February	4.3	14160	4.4	150	127.9
March	5	8175	9.1	170	251.5
April	3.1	12238	2.09	143	60.1
June	4.4	3394	3.59	74	58.8

At this winery the effluent **pH** of 6.6 for January is higher than the minimum acceptable pH of 6 specified in the South African General Authorisations in terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998). pH was moderately low to very low in other months and there is a sharp decrease in pH in April.

As discussed previously, acidification of soil by applying water with pH less than 6 may in the long-term lead to the availability of several micro or macronutrients in toxic concentrations. High availability of these nutrients as well as other heavy metals, also have serious health and environmental implications. The low pH also increases problems with corrosion of metal or concrete components of irrigation systems.

The effluent from this winery was characterized by moderate **COD** values of less than 5 000 mg/l, which is acceptable provided that application does not exceed 50 m^3/day (Act No.36 of 1998), for most of the study period (when excluding other parameters). During February, March and April the COD of the effluent from this winery was significantly above the maximum permissible level (for irrigation) of 5 000 mg/l (Table 4.12), with the values for February and April being particularly high. Thus, the disposal of the February, March and April effluent prior to treatment is not acceptable according to the South African environmental standards.

Sodium Adsorption Ratio **(SAR)** values of the effluent for five months were low to very low and falls within the South African environmental standards (Table 4.12).

Only in March the SAR value was above the maximum permissible level of 5 (Act No. 36 of 1998). Like SAR, **sodium** is high in the March effluent.

Electrical conductivity **(EC)** was below the South African Standard (for irrigating crops) of 200 mS/m for irrigation (Act No.36 of 1998) in all months.

Table 4.13: K, Ca, Fe, Mg, B and Cl contents of effluents from Stellenbosch winery (From: Van Schoor & Mulidzi, 2001)

Months	**K (mg/l)**	**Ca (mg/l)**	**Fe (mg/l)**	**Mg (mg/l)**	**B (mg/l)**	**Cl (mg/l)**
December	-	41	-	5	-	-
January	61.7	17.8	0.29	3.4	0.12	63.26
February	356.7	48.3	7.8	9.4	0.43	133
March	333.2	40.6	3.6	10.2	0.4	42
April	97	53.4	8.98	5.4	0.16	66
June	64.9	15.3	1.4	3	0.11	55

Of the **nutrient elements** analysed Mg, Ca, Fe and B were low throughout (Table 4.13). **Potassium** was very high in February and March. The high levels of potassium in the effluent for some months are a similar to the trend shown by other wineries during the study period. Chloride values were very high in February (Table 4.13).

4.5.4 Soil analyses

The soil analyses showed some important differences between the control and the site irrigated with effluent (Table 4.14).

Exchangeable sodium percentage **(ESP)** values of the effluent treated soil were in all months higher than those for the control site (Table 4.14). Some of the values are very high, exceeding 10 and even 15. The highest ESP values were found in the subsoils. During May a high value was also found in the thin surface layer sampled separately, probably due to capillary rise from the shallow water table. The high ESP is a matter of concern. Considering the fact that it is a soil and landscape with intensive lateral subsurface leaching, sodium can leach to the groundwater and streams.

The **topsoil phosphorus** levels in December and January were very high – far above the maximum acceptable limits for optimum crop growth (Eloff & Laker, 1978). They decreased to slightly higher than acceptable levels in February and March, but increased in April and May again. Subsoil P values are generally in the acceptable range. There are some indications of the possibility of limited P leaching, which may cause some concern in terms of possible eutrophication of water bodies. This can be seen from the following: P was very high in the 30– 60 cm layer during December, with elevated P levels in this layer also in January and February. During February and March there were also clearly elevated P levels in the deep subsoil (60-90 cm).

The topsoil and subsoil **potassium** levels of the effluent treated site were very high in December, January, April and May when compared to the control site. In contrast the K levels at all depths were exceptionally low in February and March, even much lower than at the control site. This is an anomaly, because these were the months with the very high effluent K levels. Although this winery showed the highest soil potassium values, other wineries also showed high potassium values. The high potassium levels in the subsoil may lead to the leaching of potassium from the soil into water bodies, causing eutrophication of the latter, as explained previously.

The very high **Cu** and **Zn** levels recorded at some periods, especially in topsoils, but also in some subsoils (Table 4.14), are reasons for major concern in terms of pollution.the source of these elements, however are not certain as these are not associated with any cellar activities.

Soil **pH** levels at the disposal site are generally acceptable. Topsoil pH levels are of the same order as those for the control site, except in April, when it is distinctly lower than the value for the control site. It is notable that this was the month with the high available Cu and Zn levels. Topsoil pH levels at this winery respond to effluent pH values, as indicated by the moderate drop in topsoil pH in February and the sharp drop in April. Subsoil pH values at the disposal site are throughout higher than at the control site.

Table 4.14: Soil analyses for the soil of Stellenbosch Winery

Months	Depth	pH	Resistance	P	K	Na	K	Ca	Mg	S-value	Cu	Zn	Mn	B	ESP(%)
	(cm)	(KCl)	(ohm)	(mg/kg)	(mg/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
December	0-30	5.6	550	185.00	387.00	0.64	0.99	4.14	0.40	6.17	6.91	27.90	1.50	1.14	10.37
December	30-60	5.8	1340	119.00	207.00	0.52	0.53	1.83	0.10	2.98	4.56	12.60	0.90	0.73	17.45
December	60-90	5.9	1000	25.00	422.00	0.87	1.08	2.93	0.26	5.14	1.59	3.80	0.40	1.27	16.93
January	0-30	6.0	780	143.00	524.00	0.53	1.34	7.45	0.82	10.14	8.28	45.00	4.00	1.64	5.23
January	30-60	5.9	1340	63.00	301.00	0.25	0.77	2.70	0.30	4.02	4.10	11.60	0.60	0.86	6.22
January	60-90	5.9	1170	53.00	348.00	0.30	0.89	2.53	0.25	3.97	2.84	7.90	0.60	1.00	7.56
February	0-30	5.4	1590	69.00	39.00	0.11	0.10	0.40	0.13	2.00	15.92	26.10	1.50	0.73	5.50
February	30-60	6.1	1510	53.00	27.00	0.09	0.07	0.43	0.13	0.72	10.16	53.80	3.10	0.44	12.50
February	60-90	6.0	1770	96.00	27.00	0.09	0.07	0.30	0.13	0.59	5.56	18.90	1.50	0.59	15.25
March	0-30	6.3	890	84.00	63.00	0.04	0.16	0.30	0.06	0.56	10.52	29.60	2.40	0.51	7.14
March	30-60	6.5	1460	18.00	47.00	0.04	0.12	0.16	0.03	0.35	1.69	6.60	0.80	0.34	11.43
March	60-90	5.8	620	62.00	59.00	0.06	0.15	0.51	0.06	0.78	16.22	40.40	2.10	0.67	7.69
April	0-30	4.6	120	275.00	551.00	1.05	1.41	6.46	1.10	12.77	81.01	129.60	10.80	1.54	8.22
April	30-60	5.4	540	41.00	239.00	0.46	0.61	3.07	0.39	5.08	12.93	24.50	2.20	0.78	9.06
April	60-90	5.6	950	22.00	141.00	0.30	0.36	1.50	0.22	2.38	4.64	7.30	0.80	0.63	12.61
May	0-10	0.0	0	259.00	156.00	1.80	0.40	8.78	3.08	14.06	18.74	89.30	17.80	0.20	12.80
May	10-40	5.6	680	97.00	242.00	0.38	0.62	5.88	0.48	7.36	9.90	42.80	4.90	0.70	5.16
May	40-75	6.2	810	28.00	109.00	0.25	0.28	1.74	0.13	2.40	2.26	10.90	0.20	0.32	10.42
May	75-100+	7.1	1660	24.00	66.00	0.19	0.17	1.37	0.13	1.86	1.35	6.10	0.80	0.17	10.22
Control	0-30	5.9	1370	50.00	78.00	0.08	0.20	8.87	1.11	10.26	1.44	4.60	10.80	1.01	0.78
Control	30-60	5.3	1690	27.00	74.00	0.06	0.19	3.79	1.32	6.30	0.23	0.80	1.20	0.88	0.95
Control	60-90	5.1	1740	14.00	125.00	0.09	0.32	2.88	1.50	6.05	0.28	0.60	1.00	0.92	1.49

The **bulk densities** of both the topsoil and subsoil of the effluent treated site were much higher than those for the control site (Table 4.15), especially in the subsoil. The values for the effluent treated soil are so high that root growth will be impeded. This indicates that the effluent has negatively impacted the structure of the soil, causing soil compaction.

Table 4.15: Bulk densities for the soil at Stellenbosch winery

Soil depth	**Treated site**	**Control**
Topsoil	1700 kg/m^3	1600 kg/m^3
Subsoil	1900 kg/m^3	1300 kg/m^3

4.5.5 General evaluation

Overall the effluents from this winery showed similarities with those from most other wineries. The main problem, that needs serious attention, is the high COD in February, March and April. This is not only an extended period, but also the February and April values are very high. The high SAR and Na in March also need to be addressed. If measures are not taken to correct the above-mentioned aspects, this effluent will pose a serious threat of negative environmental impacts.

The biggest problem at this winery is that effluent disposal is done on a soil that is totally unsuitable for the disposal of this type of effluent. The main issue is that this soil is unable to retain pollutants, thus causing a major potential for eutrophication of the adjacent stream. Leaching of organic pollutants into the stream has been clearly observed at this winery (Chapter 7). There are major similarities between the situation at this winery and that at Robertson 1 winery (Section 4.6).

4.6 ROBERTSON 1 WINERY

4.6.1 Main types of wines produced and chemicals used in the cellar

The types of wines produced by this winery include white, red, full sweet wines as well as grape juice. Bulk filter powder with diatomaceous earth is used for filtration. Bentonite is used for protein stabilization in the white wine, but sometimes also in red wines. Quatrammonium, Idofore, Bacteriax and iodine soaps are used to wash equipment. Caustic soda is also used to remove tartaric acid.

4.6.2 Disposal method and soil description

This winery disposes of their effluent through irrigating kikuyu grass by means of conventional overhead sprinklers.

The soil of the disposal area was classified as belonging to the Penicuik family of the Fernwood form (Soil Classification Working Group, 1991). This indicates that the soil is characterized by light gray, highly leached, structureless sandy subsoil. The infiltration rate and hydraulic conductivity of this soil are both excessive. A description and particle size analyses for a modal profile from the disposal area are given in Appendix 4.4.

4.6.2 Effluent composition

Analytical data for the effluent samples taken at this winery on a monthly basis from December 1999 to April 2000 are given in Tables 4.16 and 4.17.

Table 4.16: pH, COD, SAR, EC and Na data for effluent samples from Robertson 1 winery (From: Van Schoor & Mulidzi, 2001)

Months	pH	COD (mg/l)	SAR	EC (mSm)	Na (mg/l)
December	6.1	2241	29.03	-	692
January	7	3399	33.05	-	677.8
February	3.7	5788	1.94	60	35.1
March	3.7	11270	4.49	144	130.5
April	4.3	10614	1.74	90	38

At this winery the effluent **pH** of 6.1 and 7 for December 1999 and January 2000 are above the minimum acceptable pH of 6 specified in the General Authorisations in terms of Section 39 of the National Water Act, 1998 (Act No.36 of 1998) and should not pose problems (Table 4.16). The effluent pH decreased sharply to very low levels as soon as the winemaking season started in February.

As explained previously, acidification of soil by applying water with a pH less than 6 may in the long-term lead to the availability of several micro and macronutrients in toxic concentrations. High availability of these nutrients, as well as other heavy metals, also has serious health and environmental implications. The low pH also increases problems with corrosion of metal or concrete components of irrigation systems.

The effluent from this winery was characterized by low **COD** values of less than 5 000 mg/l, which is acceptable to irrigate crops provided, that not more than 50 m^3/day is applied (Act No.36 of 1998), during December 1999 and January 2000. During February the COD value increased to slightly over 5000 mg/l and it became higher than 10 000 mg/l in March and April. The disposal of the February, March and April effluents prior to treatment is not acceptable according to the South African environmental standards.

The sodium adsorption ratio **(SAR)** of the effluent was very high in December and January (Table 4.16). The SAR values in these two months are far above 5, which is the maximum value permissible for irrigating crops (Act No.36 of 1998). Irrigation of soil with effluent having a SAR value of above 5 can lead to sodicity problems. During February, March and April the SAR of the effluent was very low, posing no danger to the environment.

Table 4.17: K, Ca, Fe, Mg, B and Cl contents of effluents from Robertson 1 winery (From: Van Schoor & Mulidzi, 2001)

Month	**K (mg/l)**	**Ca (mg/l)**	**Fe (mg/l)**	**Mg (mg/l)**	**B (mg/l)**	**Cl (mg/l)**
December	-	25.0	-	6.7	-	-
January	107.1	22.2	1.8	5.8	0.31	55
February	93.1	16.8	1.4	8.1	0.17	86
March	298.5	30.3	1.2	18.3	0.46	166
April	79.6	17.8	1.9	11.1	0.31	141

Table 4.18: Soil analyses for soil from Robertson 1 Winery

Months	Depth	pH	Resistance	P	K	Na	K	Ca	Mg	S-value	Cu	Zn	Mn	B	ESP(%)
	(cm)	(KCl)	(ohm)	(mg/kg)	(mg/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
December	0-30	5.9	380	116.00	414.00	0.93	1.06	1.35	0.44	3.78	2.18	4.80	0.90	0.67	24.60
December	30-60	5.7	1680	46.00	168.00	0.46	0.43	0.48	0.14	1.51	1.57	1.30	1.00	0.26	30.46
December	60-90	8.3	830	81.00	145.00	0.50	0.37	5.13	0.41	6.41	1.50	0.60	3.70	0.28	7.80
January	0-30	7.4	470	39.00	469.00	1.25	1.20	1.87	0.65	4.97	2.89	4.60	1.00	0.56	25.15
January	30-60	7.0	570	25.00	364.00	0.87	0.93	1.14	0.51	3.45	2.79	4.30	1.00	0.46	25.22
January	60-90	7.5	1200	17.00	184.00	0.39	0.47	0.64	0.24	1.74	1.28	1.20	0.00	0.16	22.41
February	0-30	5.4	1870	27.00	20.00	0.07	0.05	0.26	0.16	1.09	8.46	8.80	3.20	0.35	6.42
February	30-60	5.7	2560	120.00	8.00	0.07	0.02	0.12	0.12	0.33	2.23	2.50	0.70	0.21	21.21
February	60-90	8.7	1200	81.00	16.00	0.07	0.04	0.31	0.16	0.58	2.97	1.20	9.20	0.26	12.07
March	0-30	5.4	610	16.00	35.00	0.04	0.09	0.43	0.15	1.97	19.13	17.70	3.80	0.15	2.03
March	30-60	6.1	1230	16.00	20.00	0.02	0.05	0.11	0.04	0.22	4.04	3.50	0.40	0.19	9.09
March	60-90	6.6	990	44.00	20.00	0.02	0.05	0.11	0.05	0.23	1.82	1.00	1.60	0.24	8.70
April	0-30	5.0	1310	36.00	66.00	0.11	0.17	1.29	0.49	2.69	1.79	4.00	2.30	0.20	4.09
April	30-60	6.5	1330	56.00	0.00	0.11	0.00	1.46	0.25	1.82	1.57	1.10	3.50	0.14	6.04
April	60-90	8.4	1260	170.00	86.00	0.11	0.22	5.34	0.69	6.36	1.28	0.40	24.40	0.18	1.73
May	0-25	6.0	1240	33.00	16.00	0.30	0.04	2.13	0.50	2.97	2.31	2.40	1.40	0.32	10.10
May	25-60	5.4	1160	21.00	70.00	0.17	0.18	0.79	0.24	1.62	2.66	0.80	0.60	0.14	10.49
May	60-100	5.5	1170	24.00	55.00	0.19	0.14	0.68	0.18	1.35	2.05	0.50	0.40	0.09	14.07
May	100-120+	5.3	340	105.00	90.00	0.17	0.23	1.06	0.74	2.51	0.46	0.20	8.10	0.11	6.77
Control	0-30	7.6	1430	43.00	86.00	0.16	0.22	5.18	1.48	7.04	5.35	10.60	1.50	0.36	
Control	30-60	8.0	1950	42.00	102.00	0.14	0.26	6.19	1.50	8.09	2.50	2.50	1.50	0.29	
Control	60-90	7.7	1670	68.00	86.00	0.12	0.22	4.80	1.26	6.40	5.41	3.90	1.30	0.25	
Control	90+	8	3030	37.00	51.00	0.10	0.13	2.37	0.69	3.29	2.51	2.30	0.70	0.19	

Electrical conductivity **(EC)** was below the South African Standard of 200 mS/m for irrigation (Act No.36 of 1998) in all months.

None of the **nutrient elements** analysed had values that pose toxicity hazards at this stage, but potassium was high in March (Table 4.17).

4.6.4 Soil analyses

The soil analyses showed some important differences between the control and the site irrigated with effluent (Table 4.18).

Exchangeable sodium percentage **(ESP)** values of the effluent treated soil were exceptionally high to a depth of 60 cm in December and moderately high in the 60-90 cm layer (Table 4.18). In January the ESP values were exceptionally high throughout the whole soil depth sampled (i.e. to 90 cm depth). The high ESP values in the soil during December and January are due to the extremely high SAR values and even more extreme Na levels in the effluent during these months (Table 4.16).

During February the ESP of the topsoil decreased sharply to a fairly low level, while that of the 30-60 cm layer remained extremely high. The value for the 60-90 cm layer was much lower than in January, although high. During March and April the ESP values were very low to moderate in all layers. During February, March and April the SAR values and Na levels of the effluents were low to very low (Table 4.16).

The ESP patterns show clearly that the high amounts of sodium, which accumulated in the soil in December and January, were leached from the soil during February, March and April. This ensures on-site sustainability, but the fact that the sodium is leached laterally to a nearby stream is a matter for concern. A study is needed to determine how much the leachate is diluted in the stream, especially since this leaching is at the end of the dry summer when the flow in the stream will probably be very low. In May the ESP values became high throughout the soil profile again, but unfortunately no effluent analyses are available for this month.

In December the topsoil **phosphorus** level at the effluent treated site was very high. A major concern is the high to very high subsoil phosphorus levels, especially in the deeper subsoils (Table 4.18). This was most noticable in April and May. Combined with the much lower P levels in layers higher in the soil profile, this points to massive leaching of P in this soil. This is not a normal phenomenon for P, but can be related to the sandy nature and lack of iron oxides in this soil. This has a major pollution potential through eutrophication of water bodies into which the P is leaching laterally from the soil. Algal growth is a prominent feature in the drainage ditch which drains the effluent treated site into the nearby stream, supporting the concern about eutrophication.

The **potassium** values at the effluent treated site were very high in the topsoil and high in the subsoil during December and January (Table 4.18). From February to May it dropped drastically, even to highly deficient values during February and March. This points to intensive leaching of K from this disposal site, posing an additional eutrophication danger to the nearby stream.

At this winery the soil at the control site showed an extremely high **pH** values at all depths. At the disposal site only the deeper subsoil (60-90 cm depth) had such high pH values throughout all months studied. The topsoil and upper subsoil at the disposal site had **much** lower pH values than those at the control site. These values are favourable and not too low at this stage. It is interesting to note how the topsoil pH levels fluctuate monthly according to the fluctuations in effluent pH levels, indicating the poor buffering capacity of this highly leached sandy soil.

The **bulk densities** of the topsoils of the effluent treated and control sites were equal (Table 4.19). The subsoil of the effluent treated site shows a very high bulk density, indicating a severe compaction problem.

Table 4.19: Bulk densities for soil at Robertson 1 winery

Soil depth	**Treated soil**	**Control**
Topsoil	1600 kg/m^3	1600 kg/m^3
Subsoil	1800 kg/m^3	1600 kg/m^3

4.6.5 General evaluation

The effluent from this winery was of poor quality and is posing a threat of serious negative environmental impacts. Problem aspects include high COD, low pH, high SAR and high sodium. Phosphorus and potassium pollution are additional problems. Improved and efficient effluent management is needed in this winery.

The biggest problem at this winery is that effluent disposal is done on a soil that is **totally** unsuitable for the disposal of this poor quality effluent. It is a sandy, bleached soil with no clay or iron oxides that can retain any of the pollutants in the soil. Apart from the observed subsoil compaction there is no long-term on-site land degradation, but major off-site degradation due to leaching of pollutants into adjacent streams. The latter also includes pollution by organic substances (Chapter 7).

In all respects the problems at this winery, from poor quality effluent to disposal on similar unsuitable soils and off-site pollution, are almost identical to the problems at the Stellenbosch winery (Section 4.5). They even have the same subsoil compaction trend.

4.7 ROBERTSON 2 WINERY

4.7.1 Main types of wine produced and chemicals used in the cellar

The types of wines produced by this winery include: white, red, sparkling as well as fortified wines. This winery uses bulk filtering with diatomaceous earth to filter the wines. Bentonite is also used for protein stabilization. They use caustic soda to wash equipment. Chlorine is also used to kill fungi.

4.7.2 Disposal method

This winery disposes of their effluent by means of ponding in a dam. No study of a modal profile was made.

4.7.3 Effluent composition

Analytical data for the effluent samples taken at this winery on a monthly basis from December to April 2000 are given in Tables 4.20 and 4.21.

Table 4.20: pH, COD, SAR, EC and Na data for effluent samples from Robertson 2 winery (From: Van Schoor & Mulidzi, 2001)

Month	pH	COD (mg/l)	SAR	EC (mS/m)	Na (mg/l)
December	4.4	1517	1.89	-	59
January	5.7	6561	1.80	-	61.12
February	4.9	1174	2.01	544	71.1
March	4.6	3770	2.06	92	66.4
April	6.1	448	2.36	177	80.2

At this winery the effluent **pH** is moderately lower than the minimum acceptable pH of 6 specified in the South African General Authorizations for crop irrigation in terms of Section 39 of the national Water Act (ACT NO.36 of 1998) in all months except April. As mentioned previously, acidification of soil by applying water with a pH less than 6 may in the long-term lead to the availability of several micro and macro nutrients.

The effluent from this winery was characterized by **COD** values of less than 5 000 mg/l, which is acceptable to crop irrigation, provided not more than 50 m^3/day is irrigated (ACT NO.36 of 1998), for most of the study period (Table 4.20). Only during January the COD of the effluent from this winery was slightly above the maximum permissible level of 5 000 mg/l.

Sodium adsorption ratio **(SAR)** of the effluent was low during all months, all values being below the maximum permissible level of 5 (ACT NO.36 of 1998). **Sodium** was also very low throughout the sampling period (Table 4.20).

Electrical conductivity **(EC)** was only for February above the South African Standard of 200 mS/m for crop irrigation (ACT NO.36 of 1998).

Table 4.21: K, Ca, Fe, Mg, B and Cl contents of effluents from Robertson 2 winery (From: Van Schoor & Mulidzi, 2001)

Month	K (mg/l)	Ca (mg/l)	Fe (mg/l)	Mg (mg/l)	B (mg/l)	Cl (mg/l)
December	-	34	-	12	-	-
January	137.5	39.7	4.02	15	0.38	76.62
February	95.1	31.9	0.15	14.3	0.1	66
March	89.9	32.8	0.99	13.5	0.12	87
April	48.7	27.3	0	12.2	0.02	45

None of the **nutrient elements** analysed had values that are unacceptably high at any stage, indicating that these do not pose toxicity hazards at this stage (Table 4.21)

4.7.4 Soil analyses

Soil analysis data for this winery are given in Table 4.22.

The exchangeable sodium percentage (**ESP**) was moderately low throughout. The low ESP values in the soil was not surprising as the effluent from this winery has very low SAR and sodium values. **Phosphorus** was very low and **potassium** was very high in April. **Manganese** was very high throughout the sampling period and cause negative environmental impacts (Table 4.22). Soil **pH** was extremely high throughout the sampling period.

4.7.5 General evaluation

Overall effluent from this winery was of a reasonable quality, (much better than those from almost all other wineries studied), and does not seem to pose a big threat to the environment. The only major concern is the high amount of manganese throughout. As it was sampled only in the topsoil due to rocks, it is difficult to say whether manganese is a problem in the sense that it is leaching to the groundwater. Its source is unknown because it could not be related to cellar processes. The effluent from this winery requires only little treatment prior to disposal, unlike the situation at the other wineries studied. From the effluent point of view, it is only high COD in January and high EC in February that are problems. Out of the 10 wineries studied, this winery seems to be the one that has the best effluent management.

Table 4.22: Soil analyses for Robertson 2 Winery

Months	Depth	pH	Resistance	P	K	Na	K	Ca	Mg	S-value	Cu	Zn	Mn	B	ESP(%)
	(cm)	(KCl)	(ohm)	(mg/kg)	(mg/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
February	0-30	8.5	340	38.00	70.00	0.14	0.18	1.41	0.40	2.13	1.46	1.60	131.60	0.43	6.57
March	0-30	8.6	300	25.00	82.00	0.13	0.21	1.47	0.44	2.25	1.22	1.40	127.10	0.49	5.78
April	0-30	8	350	31.00	555.00	1.22	1.42	13.01	4.51	20.16	1.34	1.70	143.70	0.69	6.05

4.8 WORCESTER WINERY

4.8.1 Main types of wine produced and chemicals used in the cellar

The types of wines produced by this winery include: white, semi-sweet white, red as well as sparkling wine. Bulk filtering method with diatomaceous earth is used for filtration of wine. Bentonite is also used for protein stabilization. Caustic soda is used to wash equipment.

4.8.2 Disposal method and soil description

This winery disposes of their effluent through irrigating kikuyu grass by means of conventional overhead sprinklers.

The soil of the disposal area was classified as belonging to the Mtamvuna family of the Dundee form (Soil Classification Working Group, 1991). The soil is characterized by black spots with high organic matter contents in the light coloured alluvial layered materials of the C2 horizon. A description and particle size analyses for a modal profile from the disposal area are given in Appendix 4.5.

4.8.3 Effluent composition

Analytical data for the effluent samples taken at this winery on a monthly basis from December 1999 to April 2000 are given in Tables 4.23 and 4.24.

Table 4.23: pH, COD, SAR, EC and Na data for effluent samples from Worcester winery (From: Van Schoor & Mulidzi, 2001)

Month	pH	COD (mg/l)	SAR	EC (mS/m)	Na (mg/l)
December	2.8	2595	0.71	-	5
January	4.7	4545	7.06	-	107.2
February	4.1	18044	3.46	65	59.2
March	3.6	6627	6.53	66	107.9
April	5.4	1117	2.33	44	24.9

At this winery the effluent **pH** of all months was very low. It was lowest in December month wherein winemaking processes have not yet started (Table 4.23). The pH trend in this winery is different from the other wineries studied, because in the other wineries effluent pH values were relative high in December (and in some cases even in January) and decreased when COD values increased when the winemaking period started.

Effluent from this winery was characterized by moderate **COD** values of less than 5 000 mg/l, which is acceptable for crop irrigation as disposal method, provided not more than 50 m^3/day is irrigated (ACT NO.36 of 1998). During February the COD of the effluent from this winery was very high, however, and far above the maximum permissible level of 5 000mg/l, while in March it was just slightly above this level. The disposal of the February and March effluent prior to treatment is not acceptable according to the South African environmental Standards.

Sodium adsorption ratio **(SAR)** of the effluent was high in January and March, when the SAR value was above 5 mg/l, which is the maximum permissible limit for irrigation (ACT NO.36 of 1998) provided that other criteria are also met. Although in all other months the SAR value was below the maximum permissible level, it must be pointed out that if there is no improvement in the wastewater management, sodicity problems may develop in the soil of the disposal site.

Electrical conductivity **(EC)** was low and below the South African Standard of 200 mS/m for irrigation (ACT NO.36 of 1998).

Table 4.24: K, Ca, Fe, Mg, B and Cl contents of effluents from Worcester winery (From: Van Schoor & Mulidzi, 2001)

Month	**K (mg/l)**	**Ca (mg/l)**	**Fe (mg/l)**	**Mg (mg/l)**	**B (mg/l)**	**Cl (mg/l)**
December	-	4.3	-	1.27	-	-
January	100.8	9.6	2.9	1.26	0.06	49.89
February	127.2	9.8	6.14	6.5	0.12	19
March	124.6	11.3	2.94	4.3	0.04	27
April	19.5	4.8	0.01	2.5	0	73

None of the **nutrient elements** analysed had values that are unacceptably high at any stage, indicating that these do not pose toxicity hazards at this stage (Table 4.24).

4.8.4 Soil analyses

The soil analyses showed some important differences between the control and the site irrigated with effluent (Table 4.25).

Exchangeable sodium percentage **(ESP)** values of this winery were high (in the 0-30 cm and 30-60 cm layers) to very high (in the 60-90 cm layer) in December and moderately high in February. When comparing the ESP of the effluent treated site with the control site, it is clear that the soil of the effluent treated site has higher ESP values than the control site. The very high ESP in the lower subsoil (60-90 cm) in December is a matter of great concern, especially in view of the increase in ESP from the topsoil to the upper subsoil (30-60 cm) and the sharp increase from the latter to the lower subsoil.

Such a sharp increase in ESP with depth and such a high ESP in the lower subsoil were not found at any of the other wineries, except Paarl 3 with extremely high ESP values at any stage of the sampling period. Since the effluent in December had low SAR and sodium levels, the high ESP levels must be due to sodium rich effluent from the preceding month(s). Such lag effect has been observed for various elements at various wineries during the study. The very low ESP in January, following the low SAR in the December effluent, and the relatively high ESP in February, following the high SAR of the January effluent further illustrate this. The ESP values at all depths of the soil the of disposal site were very low for all the other months. This shows that long term on-site sodification is not a real concern here. Combined with the ESP pattern found for December it does, however, indicate major leaching of sodium, applied in effluent, from this soil. Off-site sodification of water bodies or other areas into which leaching occurs from this site is, therefore, a major concern.

The topsoil **phosphorus** levels in the December and January samples of the effluent treated site were very high compared to the control site. It is also very high at the 30–60 cm depth during December, January and April. Phosphorus was extremely high in the 60–90 cm layer in April (Table 4.25).

These trends indicate that (a) large amounts of P are added to the disposal site and (b) leaching of large amounts of phosphorus through and from this soil occurs. The latter indicates that a major eutrophication danger for streams can be expected.

The winery does not show high amounts of **potassium** in the soil of the effluent treated site. The potassium values were even lower than those at the control site during January and February. The potassium values at this winery are different compared to the other wineries studied, because the other wineries showed high potassium values in the soils of the effluent treated sites.

At this winery there were no differences between the **pH** values of the soils at the control and disposal sites and all were in the optimum pH range.

The **bulk densities** of both the topsoil and subsoil of the effluent treated site were equal to those for the control site (Table 4.26). The effluent applied on the soil did not bring about any change in the soil structure.

Table 4.26 Bulk densities for soils at the Worcester winery

Soil depth	**Effluent treated site**	**Control**
Topsoil	1500 mg/m^3	1600 mg/m^3
Subsoil	1700 mg/m^3	1600 mg/m^3

Table 4.25 Soil analyses for Worcester Winery

Months	Depth (cm)	pH (KCl)	Resistance (ohm)	P (mg/kg)	K (mg/kg)	Na (cmol/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	S-value (cmol/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	B (mg/kg)	ESP(%)
December	0-30	5.1	2080	164.00	59.00	0.33	0.15	1.62	0.42	2.52	1.75	3.40	3.50	0.16	13.10
December	30-60	5.1	5190	142.00	55.00	0.31	0.14	0.95	0.19	1.59	0.98	1.10	1.10	0.06	19.50
December	60-90	5.1	11870	60.00	31.00	0.28	0.08	0.47	0.11	0.94	0.31	0.40	0.10	0.03	29.79
January	0-30	5.2	3060	121.00	63.00	0.05	0.16	1.99	0.63	3.35	1.44	3.00	4.30	0.12	1.49
January	30-60	5.0	4910	125.00	51.00	0.04	0.13	1.36	0.37	2.60	0.67	0.80	1.00	0.07	1.54
January	60-90	4.8	8600	68.00	27.00	0.03	0.07	0.83	0.24	1.69	0.22	0.20	0.00	0.02	1.78
February	0-30	5.7	3560	57.00	12.00	0.06	0.03	0.24	0.17	0.50	1.51	3.00	4.10	0.21	12.00
February	30-60	5.4	5320	30.00	20.00	0.07	0.05	0.13	0.14	1.02	0.41	0.70	0.60	0.13	6.86
February	60-90	5.4	4760	4.00	16.00	0.07	0.04	0.10	0.12	0.80	0.20	0.30	0.30	0.17	8.75
March	0-30	5.2	2620	39.00	4.00	0.01	0.01	0.16	0.06	1.03	1.76	2.90	5.20	0.03	0.97
March	30-60	5.5	4970	72.00	0.00	0.00	0.00	0.12	0.03	0.78	0.74	1.30	2.20	0.02	0.00
March	60-90	5.8	4960	76.00	12.00	0.00	0.03	0.10	0.03	0.16	0.35	0.40	0.80	0.03	0.00
April	0-30	5.0	3970	54.00	47.00	0.03	0.12	1.21	0.40	2.47	1.68	2.60	4.30	0.03	1.21
April	30-60	5.1	4600	101.00	31.00	0.02	0.08	1.01	0.22	1.88	0.76	1.50	1.50	0.03	1.06
April	60-90	5.4	3480	191.00	31.00	0.02	0.08	1.07	0.23	1.87	0.36	0.60	1.00	0.02	1.07
May	0-27	5.1	3220	35.00	70.00	0.07	0.18	1.85	0.59	3.40	1.72	3.80	7.10	0.04	2.06
May	27-55	5.0	7890	44.00	27.00	0.04	0.07	1.31	0.23	2.28	0.76	1.50	0.80	0.02	1.75
May	55-100+	5.0	19990	19.00	8.00	0.01	0.02	0.40	0.05	0.72	0.18	0.20	0.00	0.00	1.39
Control	0-30	5.4	4800	40.00	47.00	0.06	0.12	2.44	0.38	3.31	1.49	3.60	1.70	0.17	1.81
Control	30-60	5.2	9620	11.00	27.00	0.03	0.07	1.43	0.25	2.17	0.31	1.70	0.10	0.09	1.38
Control	60-90	5.4	9890	6.00	35.00	0.04	0.09	1.78	0.26	2.56	0.24	0.20	0.20	0.10	1.56

4.8.5 General evaluation

A number of problems were identified at this winery. The first important aspect that needs attention is the very high COD in February, the highest recorded in any month at any of the eight Western Cape wineries. This makes this effluent totally unfit for any form of disposal without pretreatment. The COD of the March effluent was also slightly high.

Secondly there seems to be a definite sodicity problem at this cellar. It is not an on-site problem, but an off-site problem due leaching of quite large amounts of sodium from the disposal site. The main source of sodium appears to be effluent that is applied in early summer (before December). This aspect will have to be studied in more detail in future. The SAR of the effluent was also above the South African environmentally acceptable standard in January and March.

The third worrying factor from this winery is the high amount of phosphorus that is added to the soil at the disposal site and the very clear indication that virtually all this phosphorus is leached from the soil. This poses a severe eutrophication hazard for the stream into which this phosphorus is leached. As was the case with the sodium, it seems that the P does not pose any on-site pollution hazard, but a severe off-site hazard.

Overall improved effluent management including cleaner production strategies in the cellar is needed so that an acceptable effluent quality should be achieved. The disposal is done on a soil that appears to be unable to retain important pollutants like sodium and phosphorus.

4.9 BERG RIVER WINERY

4.9.1 Main types of wine produced and chemicals used in the cellar

The types of wines produced by this winery include: white, red, dessert wine and grape juice. The bulk filter with diatomaceous earth material for filtration is used. Bentonite is used for protein stabilization and Q45 (biodegradable) and caustic soda are used for cleaning of equipment.

4.9.2 Disposal method and soil description

This winery disposes of their effluent through irrigating kikuyu grass by means of conventional overhead sprinklers.

The soil of the disposal area was classified as belonging to the Riebeeck family of the Swartland form (Soil Classification Working Group, 1991). This indicates that the soil is characterized by subsoil with strongly developed blocky structure. A description and particle size analyses for a modal profile from the disposal area are given in Appendix 4.6.

4.9.3 Effluent composition

Analytical data for the effluent samples taken at this winery on a monthly basis (except May 2000) from December 1999 to June 2000 are given in Tables 4.27 and 4.28

Table 4.27: pH, COD, SAR, EC and Na data for effluent from the Berg river winery (From Van Schoor & Mulidzi, 2001)

Month	pH	COD	SAR	EC (mS/m)	Na (mg/l)
December	5.6	1494	1.23	-	24
January	3.5	14229	0.53	-	15.7
February	4.3	10120	0.62	95	15.7
March	3.8	6389	0.48	76	10
April	5.1	2805	0.27	184	6.2
June	3.6	1205	0.35	110	8.3

At this winery the effluent **pH** was low to very low in all months and below the minimum acceptable pH of 6 specified in the South African General Authorizations in terms of Section 39 of the National Water Act, 1998 (ACT NO.36 of 1998) and should pose a problem. The effluent pH decreased as soon as the wine making season started in January. The low pH may in the long-term lead to the availability of several micro or macronutrients in toxic concentrations. High availability of these nutrients, as well as other heavy metals also have serious health and environmental implications. The low pH also increases problems with corrosion of metal or concrete components of irrigation systems.

The effluent from this winery was characterized by **COD** values of less than 5 000 mg/l in December, April and June, which are acceptable for irrigation, provided that not more than 50 m^3/day is irrigated (ACT NO.36 of 1998). During January the COD level was the second highest recorded at any of the Western Cape wineries in any month and far above the maximum permissible level of 5 000 mg/l (Table 4.27). The February effluent also had a high COD level, while the March effluent's COD also exceeded the permissible level. This winery was one of those with an extended (three month) peak period and its total COD for this peak period was second only to the very poor Stellenbosch winery. The disposal of the January, February and March effluent prior to treatment is not acceptable according to the South African environmental Standards.

Sodium adsorption ratio **(SAR)** of the effluent is very low in all months and far less than 5, which is the maximum value permissible for disposal (ACT NO.36 of 1998). Like SAR, **sodium** is also very low throughout (Table 4.27).

Electrical conductivity **(EC)** was low and below the South African standard of 200 mS/m for irrigation (ACT NO.36 of 1998) in all months, provided that the other criteria for irrigation are also met.

Table 4.28: K, Ca, Fe, Mg, B and Cl contents of effluents from the Berg river winery (From: Van Schoor & Mulidzi, 2001)

Month	K (mg/l)	Ca (mg/l)	Fe (mg/l)	Mg (mg/l)	B (mg/l)	Cl (mg/l)
December	-	25	-	1.85	-	-
January	264.96	48.6	4.93	10.6	0.5	126.5
February	279.9	36.2	2.84	7.3	0.3	63
March	242.5	24.9	0.84	5.2	0.2	43
April	311.6	34.6	0.22	3.3	0.16	28
June	279.7	35	6.1	4.4	0.15	27

Potassium remained high throughout the sampling period. It is a unique situation when compared to all the other "normal" wineries, excluding the totally abnormal Olifants River winery. The other **nutrient elements** are acceptably low throughout.

4.9.4 Soil analyses

The soil analyses showed some important differences between the control and the site irrigated with effluent (Table 4.29)

The exchangeable sodium percentage **(ESP)** values for the effluent treated soil were, with the exception of two months quite low during the sampling period (Table 4.29). The topsoil values were throughout the sampling period even lower than those for the control site. The low ESP values in the soil of the disposal area are in line with the very low sodium contents and SAR values of the effluents from this winery. This absence of indications of sodicity, even in the soil samples taken in December, is a unique feature of this winery amongst the wineries in this study.

The topsoil **phosphorus** levels in December, January and April samples of the effluent treated site were not only very high compared to the control site, but far above the acceptable maximum P level for optimum plant growth (Eloff & Laker, 1978). In the other months, P contents were low to moderate even in the subsoil, indicating that it is not leaching into the subsoil or through it to the groundwater or streams.

This site has structured subsoil, which could have low permeability, and the possibility of lateral leaching in the topsoil above this layer cannot be ruled out totally, because there are sharp decreases in topsoil P levels over short time periods. This will require more detailed study.

The **potassium** levels in the 0-30 cm and 30-60 cm layers of the soil at the effluent treated site of this winery were in all months much higher than those for any of the other normal wineries (excluding the Olifants River winery). During December and January the potassium levels were extremely high in the effluent treated soil. It was also very high in April and May. The high amount of potassium in the effluent treated soil was caused by high amount of K in the effluent, which is a unique feature of this winery, as indicated earlier. The high amount of potassium in the subsoil is a worrying factor as it indicates that the K can possibly leach out to the groundwater or streams, creating a eutrophication hazard.

This winery is one of only two at which high levels of all three trace elements/heavy metals, **copper, zinc** and **manganese**, were found at all depths in the soil at the disposal site. The other one is the Orange River winery. This is disconcerting because it indicates both on-site pollution and potential off-site pollution by these metals. The high availability of these above trace metals is unexpected in view of the fact that the **pH** levels of the soil at the disposal site were high to very high and availability of the trace elements would be expected to be low. A possible explanation is given in Section 6.5.

Bulk density of the topsoil of the effluent treated site was acceptable, unlike the abnormally high bulk density at the control site, indicating a severe compaction problem at that site (Table 4.30).

Table 4.30: Bulk densities for soils at the Berg River winery

Soil depth	**Effluent treated site**	**Control**
Topsoil	1600 kg/m^3	2100 kg/m^3

4.9.5 General evaluation

A number of serious problems are found at this winery. The first is the high COD values in the January, February and March effluents, which pose a worse situation than at most of the Western Cape wineries studied. Secondly there is the unique situation of the high potassium levels in the effluent in all months, leading to very high soil K levels. Thirdly very high soil P levels were found at the disposal site. Fourthly this winery is one of only two with high copper, zinc and manganese levels at all soil depths in all months at the disposal site. As indicated, some of these problems are more serious than at the vast majority of wineries studied.

On the positive side the low SAR of the effluent and low ESP of the effluent treated soil indicate that sodicity is not a problem at this winery. In this regard it is better than almost all the other wineries studied.

It seems as if that disposal of effluent is done on a more suitable soil than at most of the other wineries. During soil classification nothing unusual (e.g. black layers in the soil, lateral seepage, etc.) was observed. The higher clay content of this soil than at most of the other wineries is probably the most important advantage. The site is on a fairly steep slope and off-site investigations will have to be made to verify whether lateral seepage through the topsoil did not occur.

Table 4.29: Soil analyses for the Berg River winery

Months	Depth	pH	Resistance	P	K	Na	K	Ca	Mg	S-value	Cu	Zn	Mn	B	ESP(%)
	(cm)	(KCl)	(ohm)	(mg/kg)	(mg/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
December	0-30	5.7	830	137.00	1028.00	0.47	2.63	4.60	0.82	8.52	23.71	29.70	56.60	1.17	5.52
January	0-30	6.3	400	130.00	1685.00	0.42	4.31	10.45	2.40	17.58	38.63	65.50	75.30	2.08	2.39
January	30-60	6.8	750	62.00	981.00	0.17	2.51	4.99	1.13	8.80	14.22	18.00	63.80	0.87	1.93
February	0-30	7.2	590	22.00	129.00	0.09	0.33	0.91	0.27	1.60	19.25	27.90	97.40	1.01	5.63
February	30 60	8	680	47.00	109.00	0.07	0.28	0.47	0.18	1.00	6.28	8.00	82.60	0.53	7.00
March	0-30	8	840	27.00	117.00	0.02	0.30	0.51	0.11	0.94	25.07	32.90	52.00	0.88	2.13
March	30-60	8	810	3.00	176.00	0.02	0.45	0.42	0.21	1.10	5.29	4.00	73.90	0.40	1.82
March	60-90	5.1	560	2.00	94.00	0.10	0.24	0.32	0.78	1.60	2.13	1.70	51.40	0.37	6.25
April	0-30	6.4	570	85.00	598.00	0.29	1.53	5.46	1.16	8.44	19.59	31.40	50.90	0.69	3.44
April	30-60	7.5	820	8.00	520.00	0.21	1.33	2.76	1.22	5.52	3.28	1.60	61.30	0.31	3.80
May	0-15	6	0	16.00	301.00	0.14	0.77	3.28	0.76	4.95	7.84	10.40	57.70	0.41	2.83
May	15-50	6.7	0	32.00	348.00	0.16	0.89	3.16	0.63	4.84	5.12	2.70	64.40	0.50	3.31
Control	0-30	4.8	1590	1.00	160.00	0.41	0.41	2.36	1.97	5.46	1.15	0.40	13.50	0.36	7.51
Control	30-60	4.8	2000	0.00	102.00	0.25	0.26	2.20	4.64	7.90	0.88	0.20	4.50	0.46	3.16
Control	60-90	5	1470	4.00	59.00	0.26	0.15	1.75	8.70	11.10	0.42	0.30	7.60	0.33	2.34

4.10 OLIFANTS RIVER WINERY

4.10.1 Main types of wine produced and chemicals used in the cellar

The types of wines produced by this winery include: white, red, grape juice as well as fortified wines. Bulk filtering with diatomaceous earth is used for the filtering of wine. Bentonite is used for protein stabilization. Parsan soaps with caustic soda are used for the cleaning of equipment.

4.10.2 Disposal method and soil description

This winery disposes of their effluent by means of keeping it in a pond for evaporation. The pond is small, shallow and not lined. During soil classification, it was difficult to classify this type of soil. A description and analysis for a modal profile from the disposal area are given in Appendix 4.7.

4.10.3 Effluent composition

Analytical data for effluent samples taken at this winery on a monthly basis (except May 2000) from December 1999 to June 2000 are given in Tables 4.31 and 4.32.

Table 4.31: pH, COD, SAR, EC and Na data for effluents from the Olifants River winery (From: Van Schoor & Mulidzi, 2001)

Month	pH	COD (mg/l)	SAR	EC (mS/m)	Na (mg/l)
December	4.6	37739	5.8	-	252
January	7.1	1462	10.83	-	322.6
February	4	23872	1.5	524	51.6
March	4	47024	2.3	1008	97.1
April	4.5	58812	2.79	2340	109.7
June	4.8	70683	0.98	2570	90.4

At this winery the effluent **pH** was consistently low except in January, when it was acceptable (Table 4.31). The pH values of the effluent were lower than the minimum acceptable pH of 6 specified in the South African General Authorizations in terms of Section 39 of the national Water Act (ACT NO.36 of 1998), except in January.

The effluent from this winery was characterized by very high **COD** values of up to an order of magnitude higher than 5 000 mg/l, which is unacceptable for irrigation during all months except January (Table 4.31). The disposal of effluent from this winery prior to treatment is not legal.

Sodium adsorption ratio **(SAR)** for four months was low. The SAR value for December and January are the only values, which are above the maximum permissible value of 5 for irrigation (ACT NO.36 of 1998). **Sodium** is also very high in December and January. In other months sodium is at an acceptable level (Table 4.31).

Electrical conductivity **(EC)** was very high in all months and even up to an order of magnitude above the South African Standard of 200 mS/m for irrigation (ACT NO.36 of 1998).

Table 4.32: K, Ca, Fe, Mg, B and Cl contents of effluents from Olifants river winery (From: Van Schoor & Mulidzi, 2001)

Month	**K (mg/l)**	**Ca (mg/l)**	**Fe (mg/l)**	**Mg (mg/l)**	**B (mg/l)**	**Cl (mg/l)**
December	-	103	-	47	-	-
January	388.7	40.7	0.54	16.2	0.69	48.11
February	1448.6	103.7	8.72	124	7.59	158
March	4119	150.5	15.29	156.9	10.4	86
April	5577.6	155.9	23.32	166.7	11.7	134
June	6896	265.5	17.5	230.4	14	0

Potassium is high in January and very high from February to June, especially from March to June (Table 4.32). Boron is also very high from February to June and is pointing towards toxic levels. Magnesium and calcium were very high in the June sample. The sources for B are however, unknown at this stage because it cannot be related with cellar activities.

4.10.4 Soil analyses

The soil analyses showed some important differences between the control and the site irrigated with effluent (Table 4.33).

Exchangeable sodium percentage **(ESP)** values of the effluent treated soil were very high during December and January throughout the whole soil depth sampled. The high ESP values in the soil during December and January are due to the high SAR values and even more related to the extremely high sodium levels in the effluent during these months (Table 4.31). During February and March, the ESP of the topsoil and subsoil dropped to acceptable levels, in response to lower SAR values and Na levels in the effluent during these months.

During April ESP increased in both the topsoil and subsoil to very high levels, even higher than in December and January. In May the ESP was still relatively high in the topsoil, but it became low in the subsoil. An important question is where the sodium goes to during the periods when the ESP values drop. Plants cannot remove it because disposal is in a pond and not on an irrigated area. It cannot evaporate into the air, neither can it be fixed into non-extractable forms. The only possibility is leaching of this soluble cation to off-site areas. The answer may be found in the ESP data for the control site. The values for the control site were high, with the subsoil value being exceptionally high. Since the control site was only 50 metres **downslope** from the disposal pond, this may indicate massive downslope lateral seepage of sodium.

Table 4.33: Soil analyses for Olifants River Winery

Months	Depth	pH	Resistance	P	K	Na	K	Ca	Mg	S-value	Cu	Zn	Mn	B	ESP(%)
	(cm)	(KCl)	(ohm)	(mg/kg)	(mg/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
December	0-30	7.1	60	692.00	6100.00	6.18	5.60	6.85	4.94	33.57	6.99	15.70	264.50	9.75	18.41
December	30-60	8.8	60	872.00	6983.00	6.53	7.86	7.76	3.65	35.80	9.68	35.90	25.00	3.03	18.24
December	60-90	4.7	150	572.00	2057.00	1.29	5.26	3.69	1.85	13.92	6.02	14.30	24.60	4.05	9.27
January	0-30	6.9	70	227.00	3648.00	3.93	9.33	4.17	1.77	19.20	10.73	23.80	11.40	3.69	20.47
January	30-60	6.5	70	395.00	4145.00	3.09	10.60	5.56	2.47	21.72	8.14	14.00	43.00	2.62	14.23
February	0-30	9.4	50	457.00	716.00	0.17	1.83	0.64	0.51	3.15	4.39	9.20	100.20	8.47	5.40
February	30-60	9.2	90	3173.00	454.00	0.22	1.16	1.00	0.51	2.89	4.85	11.40	83.40	5.65	7.61
March	0-30	8.1	50	313.00	485.00	0.12	1.24	0.60	0.97	2.93	3.00	11.70	55.50	7.64	4.10
March	30-60	9.4	140	138.00	297.00	0.04	0.76	1.17	0.32	2.29	0.00	0.00	10.90	2.94	1.75
March	60-90	9.5	170	126.00	282.00	0.04	0.72	1.00	0.20	1.96	0.00	0.00	43.30	1.96	2.04
April	0-30	7.6	10	549.00	9548.00	15.60	24.42	6.91	6.52	53.45	1.50	15.80	55.90	7.51	29.19
April	30-60	8.7	20	858.00	5353.00	7.05	13.69	4.08	4.06	28.88	2.47	9.10	120.80	4.72	24.41
May	0-15	6.7	350	137.00	297.00	0.67	0.76	2.12	1.21	4.76	5.94	10.30	4.50	0.30	14.08
May	15-17.5	6.9	0	40.00	39.00	0.38	0.10	2.00	0.88	3.36	5.91	19.00	3.30	0.38	11.31
May	17.5-30	6.3	0	133.00	149.00	1.14	0.38	14.61	3.91	20.04	9.43	29.50	10.30	3.23	5.69
May	30-47	7.3	0	626.00	1310.00	0.88	3.35	12.39	2.06	18.68	2.15	3.00	103.00	1.53	4.71
May	47-100+	8.1	0	124.00	649.00	0.50	1.66	17.27	1.83	21.26	0.00	0.00	43.40	0.86	2.35
Control	0-30	8.7	160	23.00	821.00	3.92	2.10	14.89	1.62	22.53	0.26	0.60	27.70	2.48	17.40
Control	30-60	8.6	20	33.00	751.00	14.31	1.92	15.36	3.91	35.50	0.25	0.30	14.40	13.20	40.31

The **phosphorus** levels in the soil at the effluent treated site were very high to exceptionally high throughout the profile in all months. P is in most cases higher in the subsoil than in the topsoil. The P levels are high enough to be toxic to plants. Fortunately it does seem as if the P remains in the impounded area, since the control site does not have high P levels.

The **potassium** levels at both the effluent treated site and the control sites were very high throughout the profile. Some of the K levels in the soil at the effluent treated site are terribly high. This is not strange in view of the horribly high K levels in the effluent from this winery. The high levels of potassium in the subsoil of the disposal site, combined with the abnormally high K levels at the control site, is a worrying factor as it indicates lateral leaching of the K, which could end up in groundwater and cause environmental pollution.

Manganese and **zinc** are also high in the topsoil in some of the months. High manganese in the subsoil in April is a worrying factor as it may indicate the possibility of leaching to the groundwater or streams, resulting in environmental problems (Table 4.33).

The **bulk density** of the topsoil of the effluent treated site was lower than for the control site (Table 4.34). The value for the topsoil of the effluent treated site was abnormally low. This is not strange, since it was evident during soil classification that the topsoil layer was replaced by a man made layer of diatomaceous earth. The subsoil of the effluent treated site and that of the control site showed normal low bulk densities, indicating that effluent is not causing problems in terms of compaction.

Table 4.34: Bulk densities for soils at the Olifants River winery

Soil depth	**Effluent treated site**	**Control**
Topsoil	500 kg/m^3	1700 kg/m^3
Subsoil	1400 kg/m^3	1500 kg/m^3

4.10.5 General evaluation

The effluent from this winery is of **exceptionally** poor quality and is posing a threat of serious negative environmental impact if the evaporation pond should break or spill over. Compared with the other wineries studied, it is difficult to understand how this winery succeeds in producing such a bad quality effluent. Problem aspects include high COD and potassium levels for almost all months, low pH, high SAR and high sodium. Soil analyses indicated high phosphorus levels, while zinc and manganese pollution are additional problems. A special problem associated with the high COD will be discussed in Chapter 7.

Although not lined, an advantage at this winery is that the disposal pond was made in a soil with a dense clay and/or dorbank (duripan) subsoil, which limits seepage from the pond. (It was difficult to sample and classify it properly.) The sandy topsoil which overlies the clay and dorbank in the subsoil may lead to lateral leaching if the walls of the pond are not sealed properly with clay. Indications are that such seepage is occurring to some extent, not only in regard to the earlier mentioned results at the control site, but also in the form of observation of a wet patch in a depression downslope from the pond when the soil classification was done in May 2000.

In conclusion it can be said that big improvements in effluent management need to be done **very urgently** at this winery.

4.11 ORANGE RIVER WINERY

4.11.1 Main types of wine produced and chemicals used in the cellar

White, red, semi sweet, fortified, sparkling wines and grape juice are produced at this winery. Bulk filtering with diatomaceous earth is used to filter the wine. The SS cleaner and caustic soda soaps are used to clean the equipment. Bentonite is also used for protein stabilization. Chlorine is used to kill fungi.

4.11.2 Disposal method and soil description

This winery disposes of their effluent by means of ponding in shallow unlined ponds covering a much larger area than at the Olifants River winery.

The soil of the disposal area was classified as belonging to the Hopefield family of the Fernwood form (Soil Classification Working Group, 1991). A description and particle size analyses for a modal profile from the disposal area are given in Appendix 4.8. Augering immediately outside the pond area showed that the natural soil of the area has a typical sandy red apedal B horizon. The bleaching if the soil in the ponded area is ascribed to a "podzolization" effect in which the iron has been chelated by the organic matter in the winery effluent and transported deep into the profile together with it, thus stripping the red colour from the sand grains. (See also Chapter 7.)

4.11.3 Effluent composition

Analytical data for the effluent samples taken at this winery on a monthly basis (except May 2000) from December 1999 to July 2000 are given in Tables 4.35 and 4.36.

Table 4.35: pH, COD, SAR, EC and Na data for effluents from the Orange River winery (From: Van Schoor & Mulidzi, 2001).

Month	pH	COD (mg/l)	SAR	EC (mS/m)	Na (mg/l)
December	6.6	1176	1.22	-	40
January	4.1	3043	1.7	-	55.14
February	5.1	4000	1.65	88	53.2
March	4	23571	9.49	253	387
April	4.4	24752	0.94	125	28.7
June	5.8	574	0.99	67	29
July	5.7	980	1.4	62	41.5

At this winery the effluent **pH** of 6.6 for December 1999 is above the minimum acceptable pH of 6 specified in the South African General Authorizations in terms of Section 39 of the National Water Act, 1998 (ACT NO.36 of 1998) and should not pose a problem (Table 4.35). The effluent pH decreased when the wine making season started in January.

The effluent from this winery was characterized by low to moderate **COD** values of less than 5 000 mg/l, which is acceptable for irrigation (ACT NO.36 of 1998), for most of the study period. During March and April the COD of the effluent from this winery was extremely high and way above the maximum permissible level of 5 000 mg/l, however. These values were far higher than any obtained for any of the Western Cape wineries, but lower than the terrible values for the Olifants River winery.

The disposal of March and April effluent prior to treatment is not acceptable according to the South African environmental standards.

Sodium adsorption ratio **(SAR)** of the effluent is not very high, with the values for six months being very low (Table 4.35). It is only in March where the SAR value of 9.49 was above the maximum permissible level of 5 (ACT NO.36 of 1998). All values in all other months were still below the South African Water Act standards for disposal. Like SAR, **sodium** was only high in the March effluent.

Electrical conductivity **(EC)** was high and above the South African standard of 200mS/m acceptable for irrigation (ACT NO.36 of 1998) only for the March effluent.

Table 4.36: K, Ca, Fe, Mg, B and Cl contents of effluents from the Orange River winery (From: Van Schoor & Mulidzi, 2001)

Month	K (mg/l)	Ca (mg/l)	Fe (mg/l)	Mg (mg/l)	B (mg/l)	Cl (mg/l)
December	-	58	-	14	-	-
January	48.7	41.3	1.9	23.3	0.15	126.5
February	75.1	40.3	3.6	23.1	0.13	105
March	295.9	71.8	6.3	32.8	0.6	456
April	103.9	39	12.1	19	0.32	46
June	19.2	37.7	0.4	16.1	0.03	46

None of the **nutrient elements** analysed had values that are unacceptably high at any stage, indicating that these do not pose toxicity hazards at this stage (Table 4.36), except the March effluent, which had high levels of K and Cl.

4.11.4 Soil analyses

The soil analyses showed some important differences between the control and the site irrigated with effluent (Table 4.37).

The exchangeable sodium percentage **(ESP)** values of the effluent treated soil were high in December throughout the whole soil depth sampled (i.e. to 90 cm depth) and increased with increasing depth. In February the ESP values were also high, but decreasing with increasing depth. In April the ESP values were somewhat high throughout the whole soil depth.

The high ESP levels in April can be due to the high sodium and SAR values in the effluent in March. In May the subsoil ESP values were very low, being amongst the indications of intensive leaching of sodium from this highly permeable soil.

The topsoil **phosphorus** levels in the December, January and April samples from the effluent treated soil were high. Subsoil P levels were not very high, but generally higher than optimal. Subsoil P levels were much higher at the disposal site than in the control, indicating definite P leaching to lower soil layers. In December the P level in the deeper subsoil (60-90 cm) was very high.

The **potassium** levels were very high in January, April and May samples of the effluent treated soil and also on the control site (Table 4.37). The high amount of K in the subsoil is a matter of concern as it can leach into water bodies and cause eutrophication.

Zinc, copper and **manganese** levels were very high at all depths throughout the profile. This was one of only two wineries where levels of all three these elements were high at all depths, the other one being the Berg River winery.

At this winery there are clear indications of lowering of the **pH** of the soil pH in the 60-90 cm layer at the disposal site. In contrast the deep sampling in May indicated elevated pH levels of over 8 below 150 cm depth, just above the water table.

Table 4.37: Soil analyses for the Orange River winery

Months	Depth	pH	resistance	P	K	Na	K	Ca	Mg	S-value	Cu	Zn	Mn	B	ESP(%)
	(cm)	(KCl)	(ohm)	(mg/kg)	(mg/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(cmol/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
December	0-30	6.4	390	103.00	23.00	0.09	0.06	0.77	0.33	1.25	19.56	22.90	4.80	0.49	7.55
December	30-60	6.5	1220	84.00	23.00	0.08	0.06	0.29	0.20	0.63	9.58	6.00	2.90	0.24	10.99
December	60-90	6.4	1000	145.00	35.00	0.09	0.09	0.30	0.21	0.69	8.44	3.30	3.80	0.26	13.44
January	0-30	6.3	1080	136.00	266.00	0.22	0.68	5.28	1.52	7.70	13.04	28.10	24.70	0.74	2.86
January	30-60	6.1	1340	70.00	242.00	0.25	0.62	3.56	1.61	6.04	5.16	1.70	24.60	0.30	4.14
January	60-90	5.6	1560	49.00	192.00	0.21	0.49	2.97	1.59	5.26	1.53	0.80	35.40	0.18	3.99
February	0-30	6.1	360	64.00	47.00	0.08	0.12	0.33	0.17	0.70	3.01	1.80	13.20	1.85	11.43
February	30-60	7.7	490	64.00	66.00	0.08	0.17	0.51	0.18	0.94	5.68	1.60	35.60	2.49	8.51
February	60-90	4.9	210	42.00	63.00	0.11	0.16	0.28	0.18	1.91	17.51	4.90	6.10	1.68	5.76
March	0-30	7.0	1020	83.00	27.00	0.02	0.07	0.39	0.14	0.62	10.42	24.70	10.90	0.31	3.23
March	30-60	6.7	980	62.00	23.00	0.02	0.06	0.26	0.13	0.47	4.39	1.80	11.40	0.15	4.26
March	60-90	6.0	960	45.00	16.00	0.02	0.04	0.22	0.13	0.41	2.59	3.30	15.00	0.09	4.88
April	0-30	5.5	120	230.00	289.00	0.63	0.74	7.19	2.28	11.55	38.62	55.50	16.40	0.49	5.45
April	30-60	6.7	370	90.00	192.00	0.34	0.49	3.97	1.53	6.33	21.67	25.10	7.20	0.16	5.37
April	60-90	6.3	520	81.00	203.00	0.33	0.52	3.77	1.67	6.29	11.09	7.40	6.20	0.13	5.25
May	0-25	5.6	1080	49.00	184.00	0.14	0.47	1.38	0.60	2.59	0.00	0.00	0.00	0.20	5.41
May	25-50	5.1	1700	70.00	250.00	0.05	0.64	1.59	0.34	2.93	1.26	0.80	2.50	0.14	1.71
May	50-88	5.0	2540	55.00	192.00	0.05	0.49	1.61	0.35	2.74	1.37	0.60	2.90	0.13	1.82
May	88-120+	4.3	2910	61.00	227.00	0.06	0.58	0.91	0.34	2.52	1.16	0.50	4.80	0.11	2.38
May	150-175	8.3	460	23.00	391.00	0.05	1.00	10.16	0.31	11.52	1.31	0.50	29.20	0.20	0.43
May	175+	8.4	710	20.00	309.00	0.10	0.79	15.32	0.57	16.78	1.30	0.50	48.00	0.23	0.60
May	0-50	8.0	2430	7.00	133.00	0.15	0.34	4.52	1.15	6.16	0.33	0.30	9.60	0.09	2.44
Control	0-30	6.4	1260	45.00	364.00	0.11	0.93	2.97	1.19	5.20	0.38	0.60	6.80	0.54	2.12
Control	30-60	6.6	1270	31.00	266.00	0.16	0.68	3.14	1.35	5.33	0.30	0.10	3.30	0.65	3.00
Control	60-90	7.0	1500	10.00	141.00	0.17	0.36	3.11	1.31	4.95	0.28	0.30	14.10	0.41	3.43

The **bulk density** of the topsoil of the effluent treated site was very low (Table 4.38). It was, in fact, abnormally low, due to the presence of large quantities of diatomaceous earth. The topsoil of the control site had a very high bulk density. The subsoils of both the effluent treated and control sites had very high bulk densities, indicating compaction problems.

Table 4.38: Bulk densities for soils at the Orange River winery

Soil depths	Effluent treated site	Control
Topsoil	900 kg/m^3	1900 kg/m^3
Subsoil	1800 kg/m^3	1700 kg/m^3

4.11.5 General evaluation

The March effluent from this winery was of very poor quality in just about every possible respect, including exceptionally high COD and high K, Na, Cl, SAR and EC values, and is posing a threat of serious negative environmental impact when contained in an unlined pond system. The April effluent also had an extremely high COD. The very high COD is the main effluent problem at this winery, as will be discussed in more detail in Chapter 7. Soil analyses indicated P, Zn, Cu and Mn as potentially serious pollution problems.

The biggest problem at this winery is that effluent disposal is done on a soil that is unsuitable for the disposal of this effluent by means of ponding. It is a sandy soil with little clay that can retain pollutants in the soil. It also is a deep soil with high permeability. The effluent therefore leaches quickly through the soil until it reaches the water table at about two metres depth. The high pH levels, lower electrical resistance and high K levels found below 150 cm depth during the soil classification in May are indications of this. This aspect will also be elaborated further in Chapter 7.