Impact of Distillery and Winery Effluent on Soil Chemistry of Evaporation Ponds

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1. Background Information

EnviroAfrica was requested by DWAF to undertake a study to establish the effect of combined effluent from a distillery, winery and grape concentrate factory on the soil chemistry of evaporation ponds used to dispose of the effluent. The client intends to develop a reed-bed system on the area to improve the effluent with the intention of responsible irrigation of the water. The goal of the study was to establish whether the soil of the evaporation area is suitable for development of the reed-bed area without rehabilitation. The impact of the effluent on the chemistry of the soil in the potentially affected area is therefore compared to soil from an adjacent area. In addition, the heavy metal composition of coal ash from the distillery was established to evaluate it for possible soil contamination risk, if stored in the open.

2. Impact of Effluent on Soil Chemical Composition

Soil from eight locations was sampled at varying depths. The location of each sampling point is indicated in Figure 1. Sampling point one (1) is located at the closest point to the outlet, while the other sampling points (two to seven) were progressively further away from the outlet. Sampling point eight (8) was situated outside the affected area and serves as a control to which the impact of the effluent on the soil's chemical composition can be compared. Sampling points five (5) and seven (7) were also considered to be outside the affected area.

Bemlab conducted the chemical analyses that are presented in Table 1. The results indicate that the chemical composition of soil represented by sampling point one (closest to the effluent outlet) was detrimentally affected by the effluent. The soil's pH was reduced. It furthermore contains elevated levels of phosphorous (P), sodium (Na) and potassium (K). The last mentioned two elements are excessive which contribute to high salinity (indicated by a resistance value <300 Ω). Phosphorous contents in excess of 120 mg/kg and K higher than 290 mg/kg are considered to be excessive.

The 0-30 cm layers of sampling points four & six also have P and K concentrations that are higher than the other locations, but was not raised to the same extent as sampling point one. This is ascribed to a few incidents when effluent was discharged beyond the evaporation pond contours. Compared to the control (sampling point eight), the soil from the other sampling points (two, three, five & seven) was not affected. Soil layers deeper than 0-30 cm also remained unaffected in all cases. It therefore seems that when effluent was released, the volumes were small.

The chemistry of the soil from sampling point 1 can be remedied by application of one ton/ha gypsum and one ton calcitic lime per ha, with subsequent application of water to leach the Na & K from the soil. Mixing of layers of all the affected soils (sampling points one, four and six) to a depth of 60 cm during preparation of the area for establishment of the reed beds, must also be considered.

3. Composition and Pollution Potential of Coal Ash

The coal ash, that is waste material generated during steam production for both Orange River Cellars (OWK) concentrate plant and KWV distillery, was also analysed for its heavy metal content by Bemlab and the results are compared to published ranges in Table 2. The coal ash contains very low concentrations of only arsenic (As) & lead (Pb). Compared to ranges of heavy metal contents of coal ash, published by the American Coal Ash Association Educational Foundation (www.acaa-usa.org), as well as sludge analyses norms published by the Water Research Commission (Snyman & Herselman, 2006), the heavy metal content of the coal ash is very low. For every ton of coal ash deposited, only 2.74 g As and 2.31 g of Pb is applied.

4. Conclusions

- All the soils, including the control soil, have higher than expected K concentrations.
- Nevertheless, from the soil chemical analyses, it was found that only the soil represented by sampling point one was significantly contaminated by the effluent water. This is the area directly adjacent to the effluent outlet. The effect thereof can be remedied by lime and gypsum applications and the soil rehabilitated.
- The areas outside this heavily affected area show little or no contamination.
- It is advised that when the area is prepared for establishment of a reed bed system, the top 60 cm soil is properly mixed to lower the high P and K concentrations of the soil represented by sampling points four and six.
- The coal ash will pose no pollution threat when applied to soil or used in composting (if the volumes are less than 30% vol/vol).

Figure 1. Location of sampling points of soil in effluent evaporation ponds (courtesy of google.com).

Table 1: Chemical composition of soil in area where effluent evaporation ponds are located.

Sampling point	Soil depth (cm)	Soil texture	pH (KCl)	Resistance (ohm)	Stone Vol. %	P(Bray II) (mg/kg)	K (mg/kg)	Exchangeable Cations (cmol/kg)				Micro-elements (mg/kg)				Carbon (%)
								Na	K	Ca	Mg	Cu	Zn	Mn	B	
1	0 - 30	Sand	4.4	270	12	132	932	0.45	2.38	1.31	1.08	0.94	0.9	9.4	0.84	0.17
2	0 - 30	Sand	6.0	1470	43	4	150	0.05	0.38	3.16	2.56	0.59	0.2	89.9	0.33	0.12
	30 - 60	Sand	5.3	3470	7	7	187	0.04	0.48	1.83	1.60	0.58	0.3	95.5	0.35	0.10
3	0 - 30	Sand	6.2	2490	5	11	269	0.10	0.69	2.20	1.29	0.69	0.2	97.0	0.51	0.19
	30 - 60	Sand	5.9	1410	10	4	95	0.11	0.24	3.29	1.82	0.84	0.3	95.8	0.47	0.22
	60 - 90	Sand	6.1	1230	51	3	115	0.06	0.29	3.68	2.05	0.82	0.2	86.8	0.34	0.15
4	0 - 30	Sand	6.4	1860	13	50	441	0.02	1.13	2.73	1.09	0.90	0.7	62.6	0.39	0.29
	30 - 60	Sand	5.2	2440	8	13	204	0.03	0.52	1.99	1.79	0.96	0.6	114.5	0.31	0.15
5	0 - 30	Sand	6.7	2050	15	5	192	0.04	0.49	2.90	1.58	0.78	0.8	87.0	0.31	0.10
	30 - 60	Sand	6.5	1890	29	2	155	0.03	0.40	2.99	1.62	0.71	0.3	84.7	0.33	0.15
6	0 - 30	Sand	6.9	1450	49	52	331	0.03	0.85	8.74	1.11	1.72	1.2	91.7	0.36	0.15
	30 - 60	Loam	7.1	720	33	5	189	0.15	0.48	19.85	1.40	0.56	0.3	2.9	0.33	0.15
7	0 - 30	Sand	4.8	1850	14	17	211	0.04	0.54	2.16	1.98	0.88	0.5	122.5	0.31	0.22
	30 - 60	Sand	5.3	1980	12	27	203	0.04	0.52	2.48	1.27	0.88	1.0	62.8	0.32	0.17
8 (Control)	0 - 30	Loam	5.4	1190	53	10	217	0.03	0.56	4.34	2.48	1.38	0.4	116.8	0.45	0.17

Table 2. The pH and heavy metal content of coal ash produced by the KWV distillery.

Analysis	pH	Cd	Hg	As	Pb	Sb
		mg/kg				
Result	7.60	0.00	0.00	2.74	2.31	0.00
Published ranges of coal ash analyses*	-	0.01 - 76.0	0.013 – 49.5	0.00 – 391.0	0.02 - 273	-
Sludge norms**		< 40	< 15	< 40	< 300	-

* Source: American Coal Ash Association Educational Foundation, www.acaa-usa.org

** Source: Snyman, H.G. & Herselman, J.E., 2006. Guidelines for the utilization and disposal of wastewater sludge. Volume 2: Requirements for the agricultural use of wastewater sludge.