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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Agricultural waste management

Sustainable reuse of wineries waste

A completed, collaborative Water Research Commission (WRC) study successfully tested the reuse of augmented wineries wastewater for vineyard irrigation.

Background

Wine production is an important industry in the Western Cape and the Lower Orange region in the Northern Cape. Wineries produce large volumes of low quality wastewater, particularly during the harvest period.

Treated winery wastewater, in combination with other water, should be used for beneficial irrigation of agricultural crops, such as vineyards.

Furthermore, if winery wastewater could be used in a sustainable way, it would have the following benefits:

- Reducing the energy presently required for wastewater treatment, e.g. using pumps to aerate the water in ponds.
- The presence of plant nutrients in the wastewater, e.g. N, P and K, could also reduce cost of fertilization.
- Where irrigation water is limited, the reuse of wastewater will have a positive impact on grape yields if additional irrigation could be applied.
- If possible, the water saving and higher yields will contribute to the sustainability and economic viability of wine production.

Considering the foregoing, winery wastewater should be treated to specific quality standards, whereafter it could be stored in irrigation dams, and used for irrigation of crops. Until now, the impact of this practice has, however, not been studied comprehensively.

Thus, to know the impact of irrigating with winery wastewater the chemical composition and physical structure of the soil, grapevine performance, and wine quality, is indispensable.

As a result, the WRC, together with Winetech and the Agricultural Research Council, launched a research project to investigate the possible use of augmented winery wastewater for vineyard irrigation.

Experiment layout

The project was a multidisciplinary study which evaluated the impact of augmented winery wastewater on soils, vineyard performance and wine quality. The possibility of recycling winery wastewater for vineyard irrigation was investigated in a field trial near Rawsonville in the Breede River Valley.

Wastewater obtained from a cooperative winery was augmented to levels of 100 mg/ℓ, 250 mg/ℓ, 500 mg/ℓ, 1 000 mg/ℓ, 1 500 mg/ℓ, 2 000 mg/ℓ, 2 500 mg/ℓ, and 3 000 mg/ℓ chemical oxygen demand (COD), respectively, using raw water obtained from the Holsloot River.

The augmentation was carried out individually for each concentration in 15 m^3 tanks at the vineyard. Raw water from the river was used to irrigate the control grapevines. The irrigation treatments were applied to Cabernet Sauvignon grapevines planted in a sandy alluvial soil.

Each treatment was replicated three times in a randomized block experiment layout.

Determining the effect of augmented winery wastewater on the chemical properties of four different soils in a pot trial also formed part of the project and results are discussed in the final report.

Soil chemical status

Field trial

Soil samples were collected in the work rows of selected treatments after the application of wastewater irrigations in May, and again from all treatments at bud break, i.e. following winter.

Although there were no clear trends in soil pH, EC or acidity, EC was substantially higher after the seasonal wastewater irrigations compared to bud break. This was probably due to the higher salt content in the augmented wastewaters.

There was a close correlation between P applied via the irrigation water and the P levels in the 0 to 30 cm soil layer in the work row. Under the prevailing conditions soil K increased with a decrease in the dilution of the wastewater during all four seasons.

After four years, only the lowest level of augmentation, i.e. 3 000 mg/ℓ COD, maintained baseline K levels. Soil Ca and Mg did not show any consistent responses to the different levels of wastewater augmentation because there were no substantial different to amounts of these particular elements applied via the irrigation water.

Generally, soil Na increased with a decrease in the dilution of the wastewater. There were substantial differences in the amount of Na applied via the irrigation water. Although irrigation with winery wastewater had almost no other effects under the prevailing conditions, element accumulation, particularly with respect to K and Na, might be more prominent in heavier soils or in regions with low winter rainfall.

Element uptake and removal by cover crops

Cover crops, i.e. oats and pearl millet were established in the work rows during winter and summer, respectively. The dry matter production (DMP) and element content of the above-ground growth of these crops was determined over a period of four and three years, respectively.

Oats tended to produce more dry matter when irrigated with augmented winery wastewater compared to raw water irrigation, if not preceded by pearl millet as a summer interception crop. Oats continuously produced acceptable amounts of fibre.

The levels of Ca, Mg and K in the above-ground growth did not differ between treatments. Although differences occurred, no trends with respect to level of augmentation were observed for N and Na. However, the Na levels increased over time.

Being sown on 10 January allowed the growth of pearl millet to peak while 91% of the augmented winery wastewater was applied. The latter improved DMP of pearl millet.

The augmented winery wastewater did not affect the levels of N, P, Ca and Mg in the above-ground growth, but increased the level of Na slightly over time. Although the levels of K differed between treatments, no trends were observed. Using both species, too much N, K, P, Mg and Ca was intercepted. However, the amounts of Na removed remained insignificant.

The fertiliser added (about R2 800/ha/yr) to compensate for excess N and P intercepted by pearl millet, is much less than the R15 000 to be made by selling the harvested crop to fodder. Employing only pearl millet as an interception crop could, therefore, be a sustainable practice if the COD level of the winery wastewater is between 1 500 mg/ℓ and 2 500 mg/ℓ. The use of species normally planted for grazing as interception crops deserves investigation.

Soil microbial status

Soil microbial activity by enzyme analysis using a colorimetric assay was carried out in soils collected at different soil depth layers in grapevine rows over four seasons. This was supported by coarse-level comparisons of total heterotrophic and actinomycete populations by dilution plating on growth media, monitoring shifts in microbial communities as well as measuring soil glomalin.

It was found that soil microbial enzyme activity was most sensitive to changes triggered in the top soil layers where it was highest in the 0 to 10 cm layer, and gradually decreased with increasing depth.

Since this gradient in enzyme activity was observed, not only during pre- but also after-treatment assessments, it implies that irrigation with winery wastewater were of no negative consequence to organic matter breakdown processes in soil.

In fact, the findings suggest that when irrigation was applied, easily decomposable organic matter would have been added to the soil, which, when assessed, over the entire trial period, promoted soil enzyme activity, which coincided with an increase in organic loads, i.e. an increase in COD concentration.

Enzyme activity also seemed to have been stimulated over time as more irrigation was applied. When assessed over the entire trial period, microbial population sizes also decreased with depth, but the impact of irrigation with winery wastewater on general microbial counts was inconclusive.

Likewise, the shifts in soil microbial communities were inconclusive, primarily due to inconsistent results. Glomalin content also decreased with an increase in soil depth, but did not respond to level of COD in the augmented wastewater.

Given that both glomalin and soil microbial enzyme activity are considered good indicators of soil health, irrigation with winery wastewater should be of little to no consequence to general soil health. Furthermore, soil fertility may even be improved given the marked positive effects of winery wastewater on soil microbial enzyme activity under the prevailing conditions of the current study.

The foregoing findings should nevertheless be received with great caution as some of the findings should be substantiated with further research.

Grapevine responses

Vegetative growth and yield

Irrigation of grapevines using winery wastewater augmented up to a maximum COD level of 3 000 mg/ℓ did not affect vegetative growth or any of the yield components compared to the raw water control. Consequently, evapotranspiration and grapevine water status were not affected by the wastewater irrigation under the given conditions.

Juice and wine characteristics

Under the prevailing conditions, irrigation of grapevines using winery wastewater did not have any detrimental effects on juice ripeness parameters and ion content. Wine sensorial quality was also not affected.

Under the conditions of the study, the high irrigation volumes were generally detrimental to wine quality. Since wine quality is an important aspect, particularly if wine needs to be exported, the poor overall quality is of great concern.

However, there is ample evidence that less frequent irrigation, which allows higher levels of plant available water (PAW) depletion between irrigations, will enhance wine quality. This implies that the winery wastewater will probably have to be applied over large areas to allow sufficient PAW depletion between irrigations.

Distribution of winery wastewater over large areas will need additional infrastructure, which could be expensive. A pilot study carried out in the third season suggests that grapevine bunches exposed to direct contact with winery wastewater may decrease in spicy character, increase wine volatile acidity and cause a winery wastewater-like off-odour in wines.

Furthermore, as the quality of the water decreases, these off-odours may increase. Therefore, even though wine colour and common sensory wine descriptors were not affected by the various treatments, any further increase in wine volatile acidity or wastewater off-odour may reduce wine quality.

Although wastewater odours may differ from winery to winery, the risk for off-flavours cannot be excluded. The foregoing also clearly demonstrates that overhead sprinkler irrigation will not be suitable if winery wastewater is recycled for vineyard irrigation.

Recommendations

Several recommendations are included in the final report for this study, such as that the COD must be augmented to 3 000 mg/ℓ or less to avoid unpleasant odours while irrigations are applied and that it should preferably be a sandy soil with low CEC.

Further reading:
To order the report, *The impact of wastewater irrigation by wineries on soil, crop growth and product quality* (**Report No. 1881/1/14**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.