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THE EFFECT OF 40 YEARS OF EFFLUENT IRRIGATION ON SOIL AND PASTURE PROPERTIES OF THE LACTOSE NEW ZEALAND LAND TREATMENT SITE

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2000

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This thesis is dedicated to the memory of my grandfather,
B.J. Powell.

ABSTRACT

The Lactose New Zealand (LNZ) manufacturing plant, situated in South Taranaki, has an annual average daily effluent output of 1400-1600 m^3, over 11 months of the year. Total effluent loading rates are approximately 5 000 m^3 ha^{-1} yr^{-1}. Effluent composition is extremely variable and characterised by high levels of suspended solids, BOD_5, COD, K, total P and Na and low pH. Land treatment of effluent has been occurring for approximately forty years and currently effluent is irrigated onto three dairy farms in the vicinity of the manufacturing plant.

LNZ has experienced some difficulties in operating and managing both the land treatment system and the dairy farms. Problems have related to the degradation of soil, pasture, surface water and groundwater quality.

This study aims to describe the current status of the land treatment system through characterisation of the soil and pasture resource. Factors examined included soil physical, chemical and biological properties, the quality of pasture and the effect of a grazing event on some soil properties.

The soil type on the three land treatment farms is the Egmont brown loam, characterised by high P fixation and moisture retention, strongly developed soil structure and large microbial communities. Paddocks with varying years of effluent application (0, 9, 14, 30 and 40 years) were used in the characterisation of the soil and pasture resource. A range of soil physical, chemical and biological analyses were undertaken. Chemical soil samples were collected from 5 depths down the soil profile. A grazing trial studied the effect of grazing stock on some soil physical properties shortly after effluent irrigation.

Bulk density values in the topsoil of paddocks irrigated for 40 years are very low (0.52 g cm^{-3}) compared with non-irrigated soils (0.89 g cm^{-3}). Bare patches within paddocks irrigated for 40 years had extremely low bulk density values (0.42 g cm^{-3}). Penetration resistance is significantly lower ($P \leq 0.0001$) on irrigated paddocks compared to non-irrigated paddocks, however aggregate stability levels are similar. Soil water retention and moisture contents of the irrigated soils have increased compared to the non-irrigated soils. Effluent irrigation has had no consistent effect on the infiltration rate of the irrigated paddocks.

The effluent irrigation has resulted in a marked increase in the level of soil chemical fertility. Increases of some nutrient levels have not only occurred in the 0-7.5 cm soil depth, but at lower depths. Total carbon levels have increased slightly in all irrigated study paddocks. The largest increase in total carbon was measured at the 15-30 cm soil depth. This indicates that there was a movement of the soluble and fine particulate carbon added through effluent irrigation down the soil profile. Phosphorus adsorption isotherms demonstrated that effluent irrigation has increased the null point concentration of irrigated soils (30 and 40 years) from 1-2 $\mu g\ ml^{-1}$ to approximately 100 $\mu g\ ml^{-1}$, indicating phosphate desorption is likely to occur at shallow depths. Soil solution extract and suction cup solution analysed for P showed that up to an Olsen P level of 130 $\mu g\ cm^{-3}$ of soil, P was retained strongly in the soil and there were negligible concentrations of P in the soil solution. Above this, P concentrations in soil solution were significantly higher enhancing the potential for leaching losses. However, below 30 cm depth, effluent irrigation has had little effect on soil solution P, indicating these soils have the ability to adsorb additional phosphate at depth. Exchangeable sodium and potassium levels have increased significantly ($P \leq 0.05$) on irrigated soils compared with non-irrigated soils at 0-7.5 cm depth. This may lead to soil physical deterioration.

Effluent irrigation has had little influence on earthworm populations and soil respiration rates.

The extensive use of all three farms for effluent irrigation has impacted on shallow groundwater to varying degrees. Interpretation of Taranaki Regional Council data indicated that sodium, nitrate, conductivity and occasionally filtered COD levels in the groundwater of most of the impact bores had increased. However, the groundwater is not used for a potable supply and since the introduction of new management philosophies in 1995, groundwater nitrate levels have decreased.

Irrigated paddocks have similar values for most pasture quality parameters analysed. There is considerable difference between the dietary cation-anion difference (DCAD) of the irrigated and non-irrigated paddocks. Animal diets with high DCAD values tend to increase the incidence of milk fever mainly due to Ca deficiency. This suggests that there is a need to supplement the Ca levels in the forage. Nutrient status of the pasture on the irrigation farms is in the normal to high range recommended by AgResearch for adequate pasture nutrition.

The grazing trial showed grazing of pasture shortly after effluent irrigation had little effect on soil physical properties, however soil moisture levels were low during the trial.

The study has identified some trends that can be used to estimate the rate of change in soil properties due to the addition of effluent under the present conditions. There is the risk of a further decrease in soil bulk density, combined with increased soil moisture content, resulting in treading damage by grazing animals. The soil system still has a very large capacity to fix phosphate. However, of some concern is the likelihood of surface runoff containing high concentrations of P as a result of high levels of available P in the top 0-7.5 cm. The current policy of planting riparian strips should reduce this environmental threat.

The study suggests that forty years of effluent irrigation has had a considerable effect on soil, pasture and groundwater and surface water quality at the LNZ site. The system will require careful management to ensure the sustainable land treatment of LNZ effluent. Alternative management options are discussed.

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