STARCH MILL WASTEWATER AND THE SODIUM FACTOR

R A PATTERSON
Lanfax Laboratories
Old Inverell Road
ARMIDALE NSW 2350

INTRODUCTION

In late 1990, Goodman Fielder Mills disposed of all starch mill wastewater on their property at Scott's Road, along the Peel River floodplain. With the likelihood of relocation of the wastewater disposal area. GFM had been asked hy SPCC (now EPA) to quantify the effects of long term wastewater disposal on soil hydraulic conductivity and examine the potential for groundwater contamination prohlems.

Three paddocks were selected for the soil sampling program. Sun paddock was chosen as the control as it had not been used for effluent disposal. Holmwood had a short history of 3 to 5 years of effluent irrigation while No. 2 paddock (adjacent to house and sheds) had been used for 25 to 50 years as a wastewater disposal area.

lIndisturhed soil cores were taken from these three paddocks on the Scott's Road property in November 1990, and 270 sub-samples of the cores were subjected to saturated hydraulic conductivity (Ksat) measurements using 15 samples from each of two horizons for three paddocks. Ksat testing was undertaken to quantify soil percolation of rainfall, untreated effluent (wastewater) from the starch mill and effluent amended with lime in both the surface and sub-surface horizons. Analysis of the data was used to relate any changes in the two treated systems (Holmwood and No 2) to the control (Sun).

Implications for future disposal strategies could then he developed from the data and the methods repeated at other sites. "Werribee Park" was the proposed new disposal area and similar tests were conducted on surface and sub-surface red brown earths. The three treatments of rainwater, effluent and lime amended effluent were used.

UNDISTURBED SOIL TESTING

Undisturhed soil cores were subjected to saturated hydraulic conductivity measurements. These cores had the advantage that separate and identifiable horizons were selected for testing. Sub-samples were rejected prior to testing where the influence of root channels, microfaunal holes or other discontinuities were likely to influence saturated hydraulic conductivities. This is not possihle with permeameters until test results indicate a likely problem.

Soil samples were subjected to low constant head pressures over long periods until equilibrium was attained. In many cases saturation took up to 36 hours.

CHEMICAL TESTS

The water simulated rainwater while the effluent was supplied fresh from Goodman Fielders Mills. Tamworth and stored at 5°C until required. All soil core infiltration tests were carried out at room temperature (20-24°C).

The chemical tests performed on the three samples of infiltrate are given in Table 1 below.

TABLE 1

Chemistry of **Infiltrates**

Characteristic	Water	Effluent	Effluent + Lime
pH	6.94	3.00	10 67
EC (uS/cm)	62	1209	1560
Sodium (mg/L)	1	113	114
Potassium (mg/L)	1	75	77
Calcium (mg/L)	7	48	386
Magnesium (mg/L)	2	27	i5
Sodium Adsopnion Ratio	0	3.4	1.6
Hardness (mg/L CaC03)	20	204	1000
Acity (mg/L CaCO3)	2.5	1650	-
Alkalinity (mg/L CaCO3)	17.5		532

SATURATED HYDRAULIC CONDUCTMTY

The samples were approximately 40-60 mm in depth with a constant head of infiltrate of 40 mm maintained for the duration of the test. Fifteen samples for each of the water, effluent and lime amended effluent were tested for each of the six horizons (3 surface, 3 sub-surface) for Scotts Road and two surface and three sub-surface for Werribee Park. A period was allowed for the soil core to come to saturation before measurements were made. A time lapse of approximately 10 hours preceded the measurement of the volume of liquid flowing through the soil core. Measurements were made to the nearest millilitre.

Calculations of Ksat are based upon Darcy's equation, which relates the flow of water through the soil core to both the depth of soil and the constant head pressure of the water ponded over the soil.

RESULTS

SCOTTS ROAD

The comparisons of Ksat values within each soil are indicated in Figures I and 2. There is a significant decrease in Ksat for both the surface and sub-surface horizons from the rainwater across the untreated effluent with differing responses from the lime amended effluent. Although the sodium adsorption ratios for both effluents are low, the influence of the chemistry is significant. The lower SAR of the lime amended effluent (1.6 compared to 3.4) would be expected to increase the Ksat, but the reverse occurred. The possibility of a pH effect on soil dispersion was not pursued.

There was a significant difference in Ksat for the surface horizons Figure 1 for each location under both rainfall and unamended effluent. This difference is not repeated for lime amended effluent which shows little variation between the locations and is higher than the raw effluent. Holmwood has a higher surface Ksat than the control, while No.2 has a lower Ksat for both rainfall and effluent. In the subsoil (Figure 2), rainfall and effluent percolation repeats the surface response but amended effluent indicates a further loss of Ksat.

WERRIBEE PARK

None of the soils had been treated previously with effluent, each soil was used to simply compare responses with those of other samples. A repeat of the outcome from the Scotts Road analysis is obvious, Ksat was reduced significantly when effluent treatment was compared to rainwater. The increase in median Ksat values in the surface soils (Figures 3 and 4) with lime amended effluent suggest5 a similar hehaviour to that for the alluvial of Scotts Road.

The suh-surface soils responded differently with an increase in conductivity with effluent compared to rainwater in two of the three sites (Figure 3) with a further loss of Ksat with the lime amended effluent. This is similar to that experienced at Scotts Road (Figures 1 and 2).

MINIMISATION OF PERCOLATION TO GROUNDWATER

An interpretation of the Ksat in relation to the disposal of effluent on the Scott's Road property suggests *that* lime amended effluent has a very low Ksat (approximately 5 mm per day) for the surface soils (Table 5) and a lower value in the sub-surface soils. The limits of the 95% confidence interval give upper levels of approximately 10 mm per day while lower limits approach zero. For planning purposes the worst case of water percolating to the groundwater is at the rate of 10 mm per day. *A* water balance model would show evapotranspiration accounting for more than this over most of the year, given that irrigation scheduling does not keep the soil in a saturated state.

Figure 1. Surface horizons
Ksat (median) under three treatments

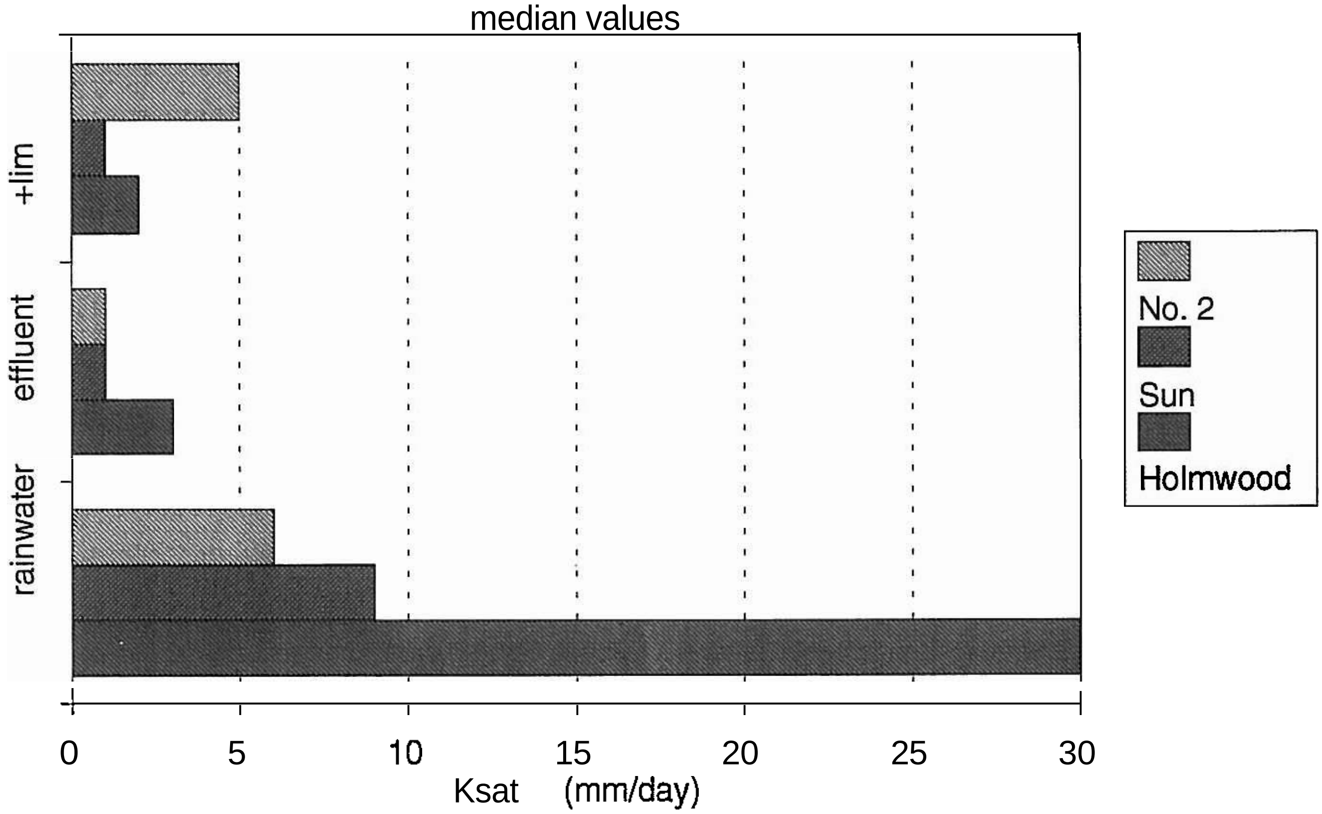


Figure 2. Sub-surface horizons
Ksat (median) under three treatments

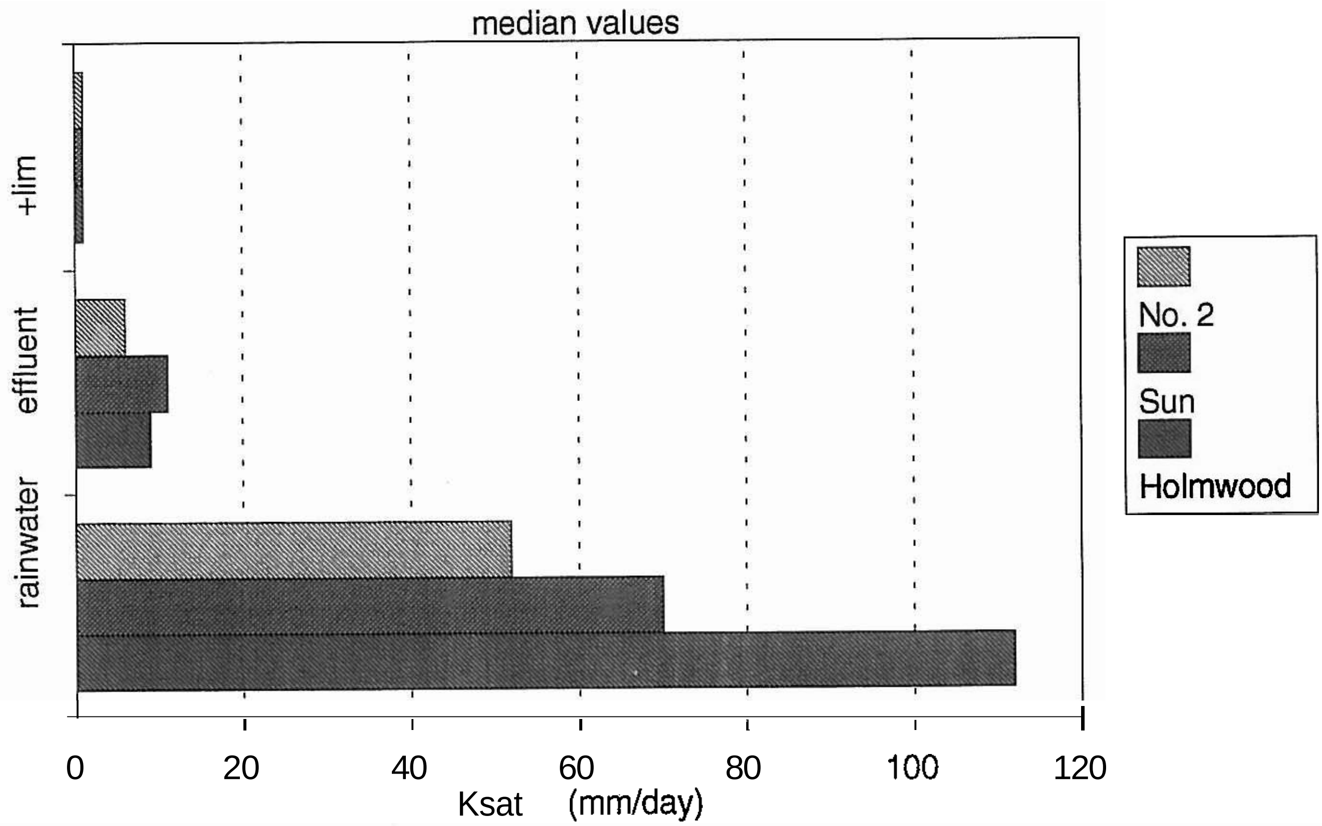


Figure 3. Ksat(median) Werribee Park
5 sites by 3 treatments A, B horizons

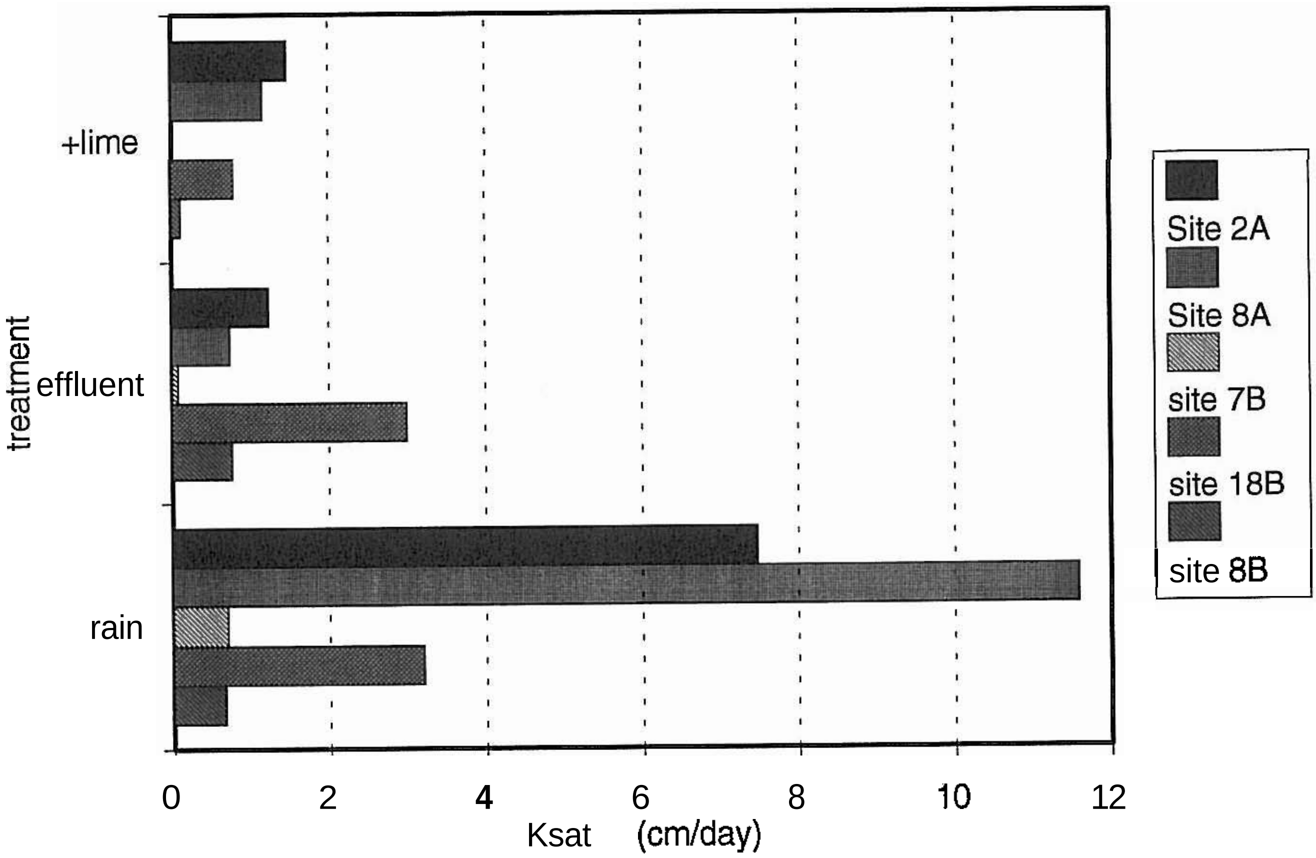
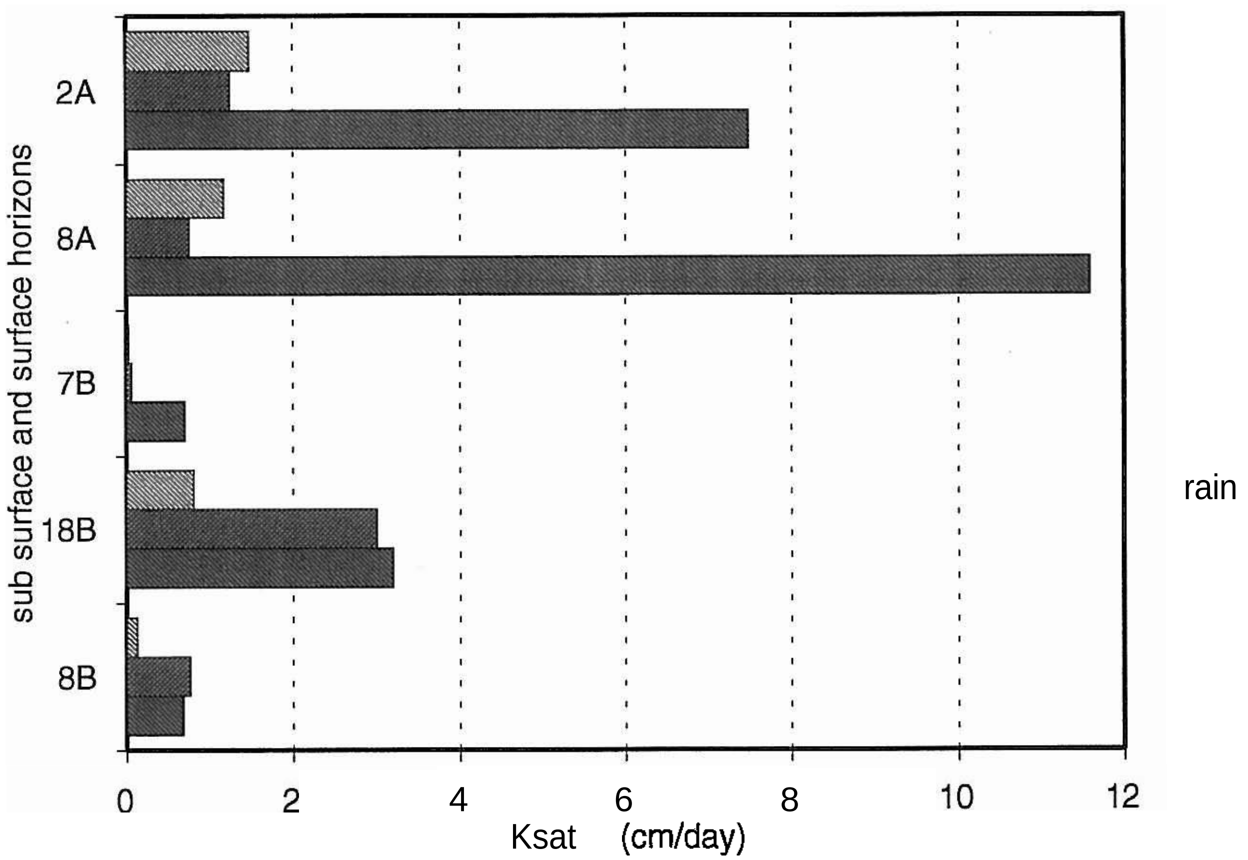


Figure 4.   Ksat(median) Werribee Park

3 treatments by 5 sites A, B horizons



The lime amendments should he beneficial in overcoming the effects of sodium in the raw effluent (SAR 3.4), however the effects of large dose of calcium (386 mg/L) may produce pH and other effects to reduce Ksat values.

The ability of the amended effluent to greatly reduce the Ksat of the effluent supports its continued use, not only on Holmwood and No.2 but also on Sun (control). The behaviour at Werribee Road suggests a similar outcome from the disposal of amended effluent. The graphical presentations from both sites indicate the greatly reduced Ksat under amended effluent across the sample sites. Under amended effluent there is less likelihood of organics leaching to depth than under normal rainfall conditions as the vertical cracking and drainage pathways are less likely to occur under near-saturated conditions.

CONCLUSION

The probability of effluent entering the groundwater can be greatly reduced by the maintenance of a moist profile, reducing the occurrence of cracking, and then irrigating with amended effluent. When soil moisture is naturally high through seasonal rainfall, the use of effluent, providing surface runoff is avoided, will move slowly through the profile, at rates estimated at less than 10 mm per day. Through management of the moisture content (evapotranspiration vs irrigation scheduling) effluent would be unlikely to reach depths beyond which organic residues would be consumed by the soil flora and fauna.

There is, therefore, a need to measure changes to soil hydraulic conductivities using effluent of a quality similar to that proposed for disposal. The rationale for amending effluent with lime to overcome the effects of sodium needs to be addressed in each case lo prevent contamination of groundwater either with increased sodium levels or through percolation of contaminated wastewater. Further examination needs to he conducted of the effects of the added calcium on the removal of other cations, including magnesium from the soil profile.

This project was limited to measurement of Ksat on the Scott's Road property and making a comparison with the Werribee Park proposal. The relocation of the starch mill wastewater disposal to Werrihee Park did not eventuate.