

DOES IRRIGATION WITH TREATED SEWAGE EFFLUENT AFFECT SOIL QUALITY IN A GREY CLAY?

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Introduction

As availability of irrigation water decreases due to a combination of drought and legislation, many cotton growers have considered using treated sewage effluent as an alternative source of water.

Treated sewage effluent contains large amounts of nitrogen and phosphorus. It can also contain moderate to high amounts of sodium salts. Consequently, if not managed carefully, salinity and sodicity may increase in fields irrigated with treated sewage effluent.

Options for controlling salinity and sodicity in irrigated cotton systems of Australia are commonly gypsum or lime. The objective of this research was to determine if gypsum application could minimise sodification and salinization of a grey clay irrigated with treated sewage effluent.

Trial site

The trial was located at "Federation Farm", near Narrabri, north-western NSW in a self-mulching grey cracking clay. Soil properties in the 0-1.8 m depth were: 49% clay, 14% silt, 37% sand; pH (in CaCl₂) was 7.5, EC_{1:5} 0.31 dS/m, soil organic C content 12.0 kg/ha, and exchangeable Ca, Mg Na and K contents 12.1, 6.5, 0.9 and 0.7 kg/ha, respectively. Mean exchangeable sodium percentage (ESP) was 3.9 in the 0-0.3 m depth and 6.9 in the 0.3-1.8 m depth.

Federation Farm is irrigated with stored rainfall runoff and treated sewage effluent produced at Narrabri Shire Council's sewage treatment plant (Fig. 1). The experimental treatments were: gypsum applied at a rate of 2.5 t/ha in June 2000 and an untreated control, replicated 3 times. Individual plot size was 24 m by 400 m. A cotton-wheat rotation was sown on 2-m permanent beds. N Fertiliser was not usually applied as nitrate concentration in irrigation water (Table 1) was sufficient to meet crop requirements. All crops were irrigated by furrow irrigation. Water sampled during the 2001-02 cotton season was analysed for salinity (EC_w), pH_w, nitrate-N, and Ca, Mg, K and Na.

Soil measurements

Soil cores were extracted from 2000 to 2003 to a depth of 1.8 m from each plot. The cores were divided into depths of 0-0.1m, 0.1-0.3 m, 0.3-0.6 m, 0.6-1.2 m and 1.2-1.8 m, weighed and soil water content determined on sub-samples to estimate oven-dried bulk density. Soil properties measured were: salinity (as electrolytic conductivity, EC_{1:5}),

exchangeable Ca, Mg, K and Na, nitrate-N and soil organic carbon (SOC). Soil chloride was measured in 2001 and 2002 and a steady state chloride mass balance model with anion exclusion was used to estimate deep drainage.

The cations in the 0-1.8 m depth were expressed in t/m^2 , SOC in kg/m^2 and nitrate-N in g/m^2 by multiplying the values for each depth interval by its bulk density and the depth increment, followed by summing up all the depth intervals.

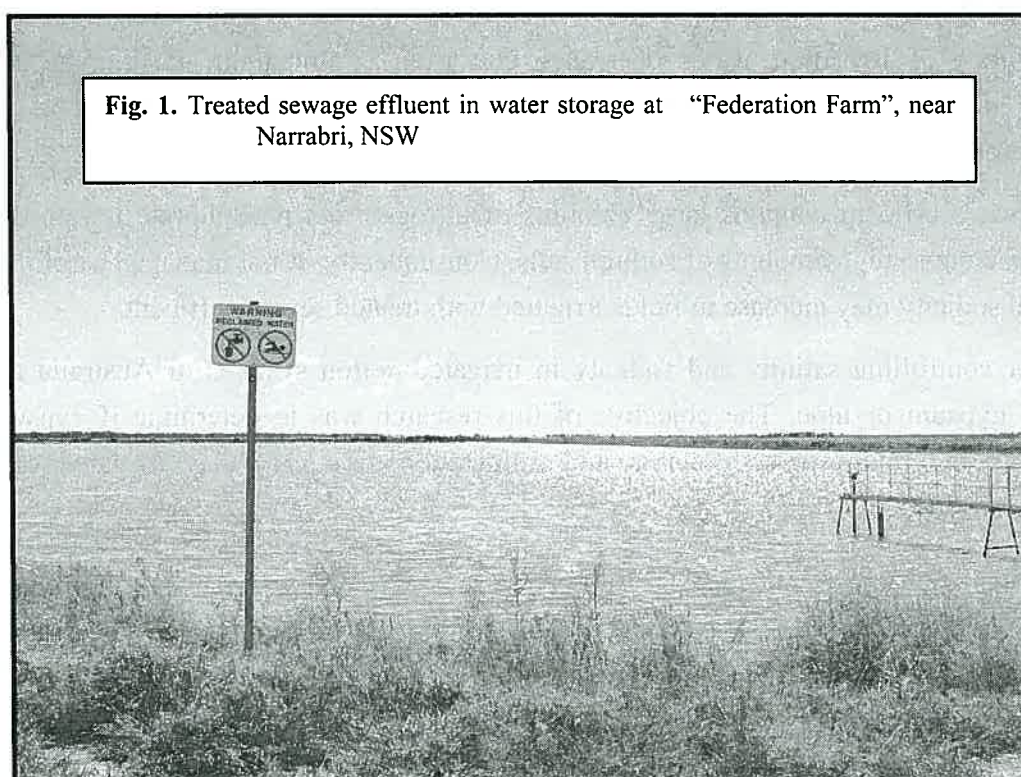


Fig. 1. Treated sewage effluent in water storage at “Federation Farm”, near Narrabri, NSW

Results and discussion

Water quality during the 2001-02 cotton season

Table 1. Quality of treated sewage effluent used for irrigation during the 2001-02 cotton season.

Irrigation date	pH _w	EC _w (dS/m)	K (kg/ha)	Ca (kg/ha)	Mg (kg/ha)	Na (kg/ha)	SAR [#]	NO ₃ -N* (kg/ha)
15 Oct. 2001	8.8	0.7	3.4	13.6	6.4	91.7	5.1	26.8
23 Dec. 2001	8.7	0.7	9.1	11.9	7.2	151.8	8.5	50.3
21 Jan. 2002	8.9	0.7	4.7	8.0	3.7	78.5	5.7	29.7
30 Jan 2002	8.7	0.7	15.5	13.0	7.7	172.2	9.3	46.2
18 Feb. 2002	9.2	1.1	8.9	11.2	6.1	119.3	7.1	56.6
8 March 2002	9.7	1.4	7.7	6.6	5.8	122.7	8.4	36.8
seasonal sum			49.2	64.3	36.9	736.2		246.5

[#] SAR = sodium adsorption ratio, a measure of water sodicity

*130 kg of N/ha was applied in the form of a dry application of urea on 15 December 2001.

Treated sewage irrigation water was alkaline, and initially, moderately saline and sodic. As the season progressed, however, alkalinity, salinity and sodicity increased markedly (Table 1). Concentrations of Ca and Mg were lower than those of bore and river water, whereas nitrate-N, Na and K were higher. Compared with traditional water sources, treated sewage effluent appears to be a good source of N and K but is more saline and sodic.

Deep drainage between September 2001 and February 2002

Deep drainage out of the 1.8 m depth was not affected by gypsum application. Average deep drainage was 32 mm in gypsum-treated plots and 27 mm in the control plots.

Changes in soil properties between June 2000 and September 2003

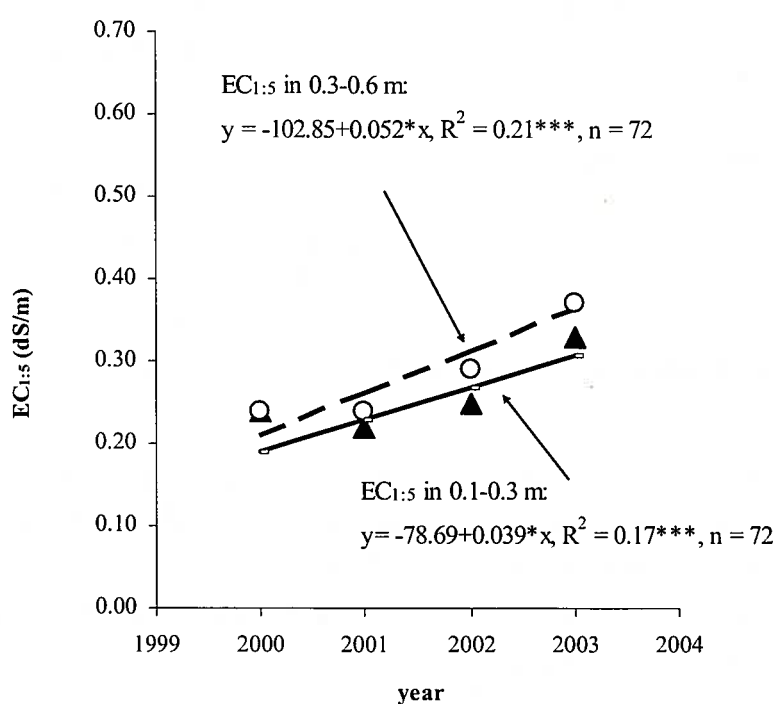


Fig. 2. Changes in EC_{1:5} in the 0.1-0.3 m (▲) and 0.3-0.6 m (◻) depths between June 2000 and September 2003

Salinity (EC_{1:5}) in the 0.1-0.3 m and 0.3-0.6 m depths increased with time by about 0.1-0.15 dS/m, but not with gypsum application (Fig. 2). The small regression coefficients (R² values) indicate that these changes are minor. EC_{1:5} in the other depths did not change with either time or gypsum application. Average EC_{1:5} was 0.23 dS/m in the 0-0.1 m depth, 0.32 dS/m in the 0.6-1.2 m depth and 0.37 dS/m in the 1.2-

1.8 m depth.

There were no changes in exchangeable Ca. While there were statistically significant increases in exchangeable Mg, K and Na, and decreases in soil organic C in the 0-1.8 m depths, these were quite small. With respect to Na it is also because a major part of the increase occurred in the surface 0.1 m and far less so in the subsoil.

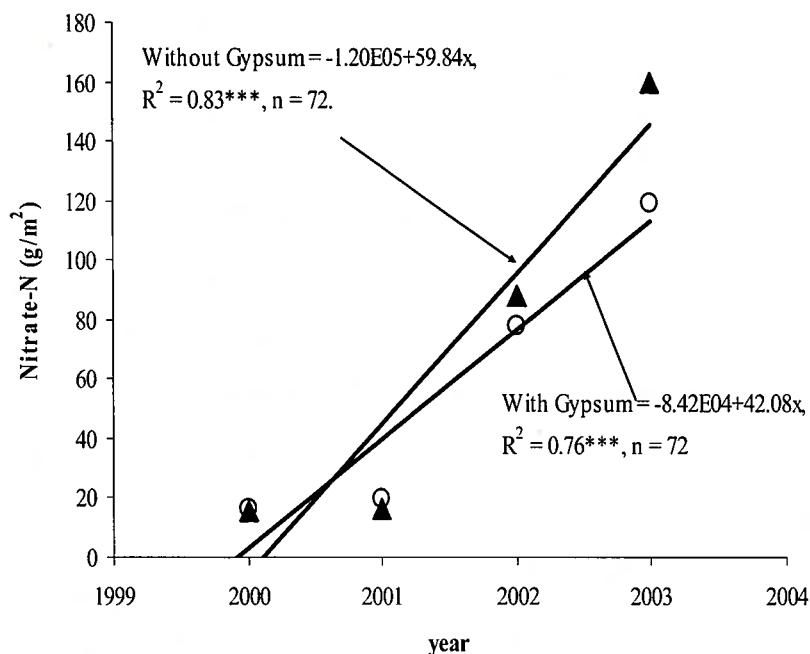


Fig. 3. Changes in nitrate-N in the 0-1.8 m depth between June 2000 and September 2003 with (□) and without (▲) gypsum application

Nitrate-N in the soil profile increased markedly with time, although gypsum application resulted in a slower rate of accumulation (Fig. 3). Whilst gypsum had no significant effect on deep drainage between September 2001 and January 2002, the slower nitrate-N accumulation in gypsum-treated plots suggests that it may have had some

beneficial effects on subsoil structure and, consequently increased drainage and nitrate leaching by 2003.

The increase in profile nitrate-N with time in all plots also suggests that the cotton-wheat rotation may not be using all the N supplied in the treated sewage effluent. N accumulation in the soil could be reduced by including a cereal forage crop such as forage sorghum in addition to the wheat or a grass pasture phase in the rotation to increase N extraction. The extracted N could then be exported off-farm as hay or silage.

Conclusions

Effluent water was moderately saline, and compared with river water, had higher concentrations of Na, nitrate-N and K, and lower concentrations of Ca and Mg. Irrigation with treated sewage effluent caused large increases in nitrate-N, small increases in EC_{1:5}, exchangeable Mg, Na and K, and small decreases in SOC. Gypsum application resulted in lower nitrate-N accumulation by 2003 but did not affect any other soil property or deep drainage.

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