Shallow groundwater quality for irrgation

Harnam S Gill
Research Agronomist (Soils), NSW Department of Primary Industries, Yanco Agricultural Institute

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- A considerable volume of marginal quality shallow groundwater is used for irrigation in the Murray Irrigation Districts (MIDs) after its dilution or shandying with surface water
- Available analytical data on shallow groundwater quality of MIDs indicate that most samples are either poor or marginal in quality as a result of salinity and/or sodicity
- Before safe practices of use of poor quality shallow groundwater in combination with surface water can be developed, research is needed to evaluate the impact of poor water quality on the sustainable use of soil and water resources in the MIDs

Use of shallow groundwater to reduce potential waterlogging and salinisation problems, as a result of rising watertables, has been emphasised in the Land and Water Management Plans (LWMPs) of all the Murray Irrigation Districts. Use of this water would primarily control watertable depths in high watertable areas, reduce mobilisation of salts, check downstream impact of groundwater rise, achieve water balance, and provide additional irrigation water supplies.

Direct use or reuse of marginal quality shallow groundwater is generally favoured for agricultural production assuming adjustments are made to salinity levels in the groundwater by irrigators. However, salinity alone may not be a sound criterion in many situations as sodicity, either alone or in combination with salinity, may also be a significant problem. Systematic research information on these issues is however unavailable. This article is prepared for awareness of related soil and water problems using available information (MIL, 1998) on important groundwater quality aspects.

History of shallow groundwater use

Due to the impact of 1982–83 droughts, a large number of private spear point pumps were installed by farmers of the MIDs to extract shallow groundwater for agricultural use. This was well before the development of LWMPs in the MIDs. Many of the pumps were not used regularly after 1982, as the cost of surface water supplies were less than the operational expenses of the pumps. However, most spear point pumps were put to use again in the 1990s due to the reduced allocations of surface water supplies as a result of environmental and economic regulations (such as MDBC cap and NSW water reforms) and frequent occurrence of drought. It is estimated that there are now a few hundred such pumps in the MIDs. Most of these pumps are used for extracting shallow groundwater to shandy with good quality surface water. Shandying basically aims to increase the volume of irrigation water supply to an electrical conductivity (EC) of 1.0 dS/m or less. The ability to maintain the desired EC of shandied water is difficult. Sophisticated equipment is required to mix ground and surface water in an appropriate ratio, which takes into consideration the salinities of both the supplies.

Figure 1 shows a notable variation in the dilution required for groundwater of 1, 2, 3, 4 and 5 dS/m EC, being shandied with surface water of 0.2 dS/m EC, to achieve desired EC irrigation water. For example, groundwater of 5 dS/m EC needs to be diluted 25 times (25:1) compared to 5 times (5:1) with 1.0 dS/m groundwater, to produce 0.2 dS/m EC water supply.

Assessing water quality solely on the basis of salinity lacks scientific credibility. Other water chemistry parameters are equally important and should not be ignored when assessing water quality. See IREC *Farmers' Newsletter* No. 169, pages 34–37. The quality of shallow groundwater can vary significantly both in space and time. In addition, it can change with intensity of aquifer extraction, size of an aquifer, and intrusion of variable quality water surrounding an aquifer.

Reuse of shallow groundwater with EC 5.0 dS/m or less forirrigation is considered economical and environmentally attractive, provided watertables are high. However, it can potentially cause serious problems to the sustainable use of soils. Therefore, an understanding of the shallow groundwater quality and its potential suitability for irrigation use across the MIDs is important. To this end, analytical results of groundwater investigations conducted by Murray Irrigation Ltd (MIL), NSW Department of Infrastructure, Planning and Natural Resources (DIPNR), and Australian Geological Survey Organisation (Watkins *et al.*, 1998) were consulted for this purpose.

This article aims to assess shallow groundwater quality for irrigation in the MIDs and consider the potential problems due to its use, either alone or shandied with good quality surface water.

Important features

The MIDs are situated in eastern and central eastern region of the Murray geological basin. This is believed to be filled in early tertiary geological period. There are mainly three hydro-geological formations in the MIDs – the Shepparton, Calivil and Olney (part of Renmark group) formations.

Shallow groundwater in the MIDs occurs within the Shepparton formation, which extends from ground surface to 80–90 m depth. Use of this groundwater is important for regulating watertable depths in high watertable areas of the MIDs.

Bore wells which extract groundwater from the Shepparton formation are generally low in yield due to the impermeable geological strata and small sized aquifers. Investigations in the MIDs outlined two criteria for locating suitable areas for shallow groundwater pumping. These were (a) existence of an extractable aquifer within 20 m depth of the surface usually confined to the prior stream country) and, (b) the presence of high watertable. In general, groundwater quality deteriorates from the east to west of MIDs which is also the usual direction of groundwater flow.

Potential problems

Systematic research on the evaluation of shallow groundwater quality for irrigation in the MIDs is limited. The analytical results reported by MIL (1998) and Watkins *et al.*, (1998) are used to illustrate water quality constraints for irrigation purposes.

Considering the emphasis in the LWMPs of the MIDs for lowering watertable depths through irrigation using shallow groundwater, systematic research must be done to evaluate the impact of different groundwater qualities on the sustainable use of soils for agricultural productivity on a long-term basis.

Available analytical data focus on salinity, sodicity (or constrained water infiltration) and specific-ion toxicities, as the three important potential problems associated with continuous use of shallow groundwater for irrigation. Each of these parameters is explained in the following discussion. For improved understanding of the effects of irrigating with this water, any interactions of water chemistry with physical and chemical characteristics of soils, climatic conditions, crops and their water requirements, soil and water management practices, watertable depth and quality of shallow groundwater, are important and need further research.

Salinity

Salinity readings, as determined by EC, of 1167 shallow groundwater samples (Figure 2) indicated limited prospects for extensive use of this resource for irrigation.

Berriquin was the only district where 33.7% of samples tested had an EC less than 3.0 dS/m. The corresponding values for Denimein, Wakool, and Deniboota districts were 20.2%, 14.1%, and 11.9% respectively. Similar was the trend for samples with EC of 3–10 dS/m. These numbers show that most shallow groundwater in the MIDs, except Berriquin, is highly saline and unsuitable for sustained irrigation, regardless of other quality characteristics.

The LWMPs of the MIDs promote the shandying of shallow groundwater with EC less than 5.0 dS/m with good quality surface water. It must be noted that shandying or dilution of marginally saline water may lessen the salinity risk only by incurring a corresponding decrease in the quality of the surface water it is to be mixed with. The benefit of mixing of

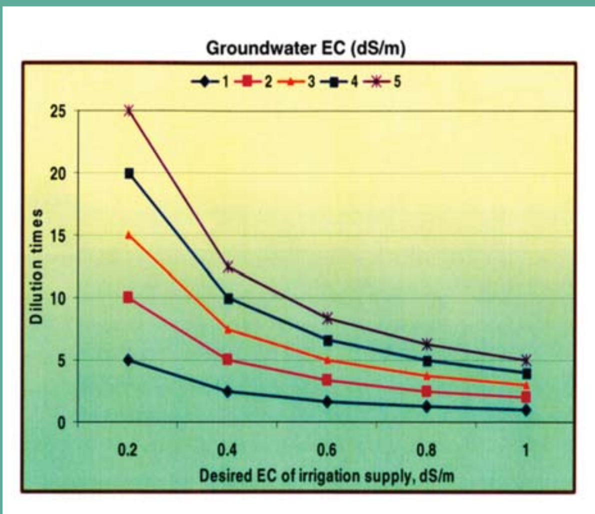

Figure 1 *Relationships showing number of dilutions (dilution times) needed to shandy groundwater of 1, 2, 3, 4, and 5 dS/m to produce irrigation supply with desired EC of 0.2–1.0 dS/m, assuming 0.2 dS/m EC of surface water supply*

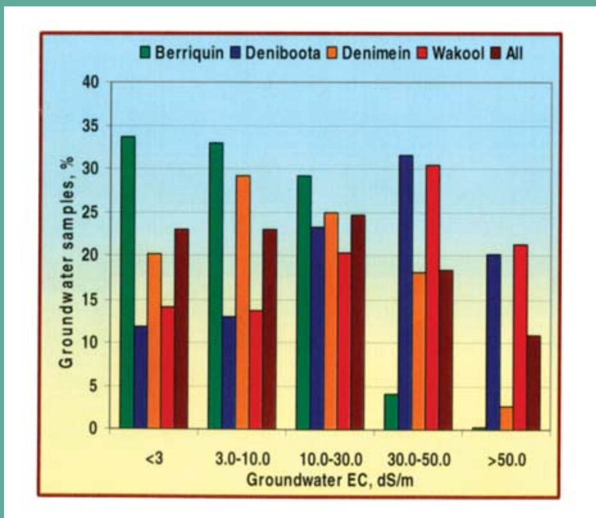

Figure 2 *Distribution of the shallow groundwater samples of the MIDs into different EC categories*
Source: MIL (1998)

good and marginal quality water for irrigation is debatable, as the increase in the EC of irrigation supply produced by shandying may override the benefits of pumping shallow groundwater.

The salinity of groundwater must be monitored regularly to ensure that periodic changes in water quality are detected and managed appropriately. Equipment used for mixing saline shallow groundwater with surface water should have suitable adjustments to change dilution rates in response to variation in EC (Figure 1).

Lowering salinity may not improve water quality if other chemical parameters are problematic, eg sodicity. Salinity and sodicity are related to each other and must be considered together when assessing the suitability of groundwater for irrigation use either alone or in combination with surface water.

Sodicity

Sodicity of water is due to high sodium ion relative to the sum of both calcium and magnesium. This is reported as SAR (sodium absorption ratio) and its calculation is possible by knowing the concentrations of sodium, calcium and magnesium of water.

Analytical results of 1089 shallow groundwater samples indicated potential sodicity problems as measured by SAR (Figure 3). International standards set a SAR level of 3 or less, as safe for continuous irrigation use. More than 50% of shallow groundwater samples in Berriquin had SAR greater than 15 (regarded as highly sodic), whereas Denimein, Deniboota and Wakool had 61%, 84%, and 81% of samples as highly sodic.

Variation and distribution of sodicity readings for given SAR categories for Berriquin and Denimein were almost similar. Water of SAR less than 5 is regarded as low sodicity. It may be used for sustainable irrigation in coarse textured soils. However, continuous use of such water in heavy textured soils can cause moderate to high soil sodicity problems. About 12–13% of shallow groundwater samples had SAR less than 5. But groundwater in Deniboota and Wakool has less than 5% of sampled locations with SAR less than 5. Almost similar was the trend for 5–10 and 10–15 SAR categories. Figure 3 also indicates that shallow groundwater of the eastern districts is comparatively less sodic than the western districts. Thus, commercial potential for use of shallow groundwater in western districts is less promising.

The relationship between salinity and sodicity of the samples was examined (Figure 4). Of the 314 samples that had an EC of 5.0 dS/m or less, the level at which the LWMPs deem suitable for possible irrigation use, only 30% had a SAR of 5 or less. The number of samples with EC less than 5.0 dS/m and relatively high SAR was higher in Denimein than other districts. In view of these facts, shandying groundwater to improve its quality must address sodicity as well as salinity.

Most shallow groundwater samples had bicarbonate alkalinity (Figure 5) and alkaline pH (Figure 6). Continuous uses of such water for irrigation will favour the build up of sodicity in soils unless SAR is sufficiently improved by appropriate shandying to amend either water supply or addition of gypsum to soils. Accumulation of alkalinity can cause precipitation of soluble calcium and/or magnesium in the root zone. Relative differences in solubilities of sodium, magnesium and calcium in the presence of sufficient bicarbonates can also affect the soils adversely by resulting in an unfavourable imbalance of these nutrients with adverse effects on crop growth.

Specific ion toxicities

Relatively high concentrations of specific ions such as chloride and sodium in most samples restrict the use of shallow groundwater for surface and sprinkler irrigation, unless diluted or with good quality surface water. Concentrations of chloride and sodium in water for safe sprinkler irrigation must not exceed 3.0 me/L. For avoiding ionic toxicity of sodium and chloride due to continuous flood

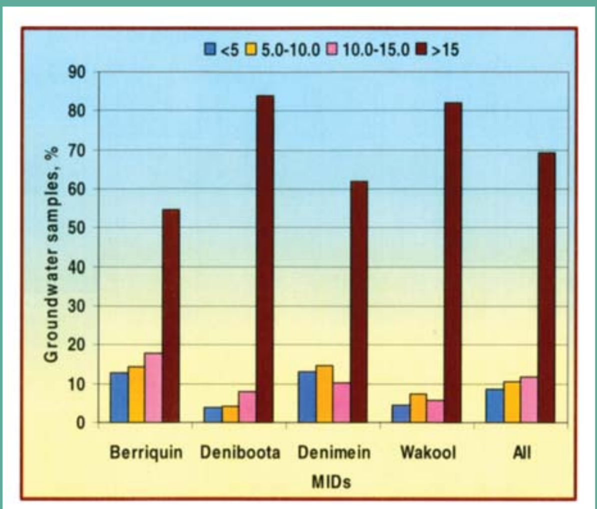

Figure 3 *Distribution of the shallow groundwater samples of the MIDs into different SAR categories*
Source: MIL (1998)

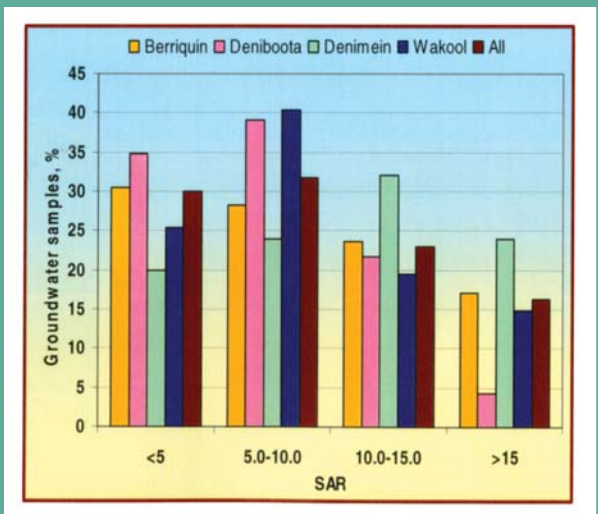

Figure 4 *Distribution of the shallow groundwater samples of the MIDs with EC 5.0 dS/m or less into different SAR categories*
Source: MIL (1998)

irrigation, critical SAR is 3 and chloride concentration 4.0 me/L.

Specific ion toxicities may occur more in chloride or salinity sensitive crops. Therefore, choice of crops to be grown using saline-sodic water is also important. Accumulation of chloride and sodium may occur more in heavy than light textured soils. Absorption of bicarbonates by plants or their accumulation in the root zone is also toxic for plants. Other investigations into water quality focussed on important trace metals that can be toxic if present in very low or micro concentrations in irrigation supplies. No serious problem was reported to occur. High concentration of bicarbonates may reduce availability of important micronutrients to crops by converting their soluble forms to relatively insoluble ones.

Future irrigation use

The current procedure for shandying shallow groundwater relies only on EC to determine suitable water quality for irrigation. This has potential risks for sustainable use of soils for agricultural productivity. Available facts indicate that most shallow groundwaters of the MIDs are saline-sodic. Their long-term irrigation use without paying attention to water chemistry or quality parameters other than EC will cause sodification of the soils.

Heavy or clayey soils may face sodification earlier than coarse textured soils. Similarly, for crops grown in summer, especially rice, if irrigated continuously with suspect quality water will develop such problems earlier than irrigation use of such water for crops with low water requirements or winter crops. Therefore, frequent irrigations with marginal quality water should be avoided.

Efforts need to be made to have complete control in ameliorating water quality for safe use. If needed, amendments like gypsum should be used to limit degradation of soils due to sodicity. This can be done by regular monitoring of water quality and the soils irrigated with shallow groundwater.

A general lack of research on the use of shallow groundwater by its shandying necessitates investigations aimed at developing strategies for its safe use, as LWMPs of the MIDs clearly emphasise direct use of shallow groundwater with EC 5.0 dS/m or less for controlling watertable depths in high watertable areas.

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Further information

Harnam S Gill
NSW Department of Primary Industries
T: 02 6951 2717
E: harnam.gill@dpi.nsw.gov.au

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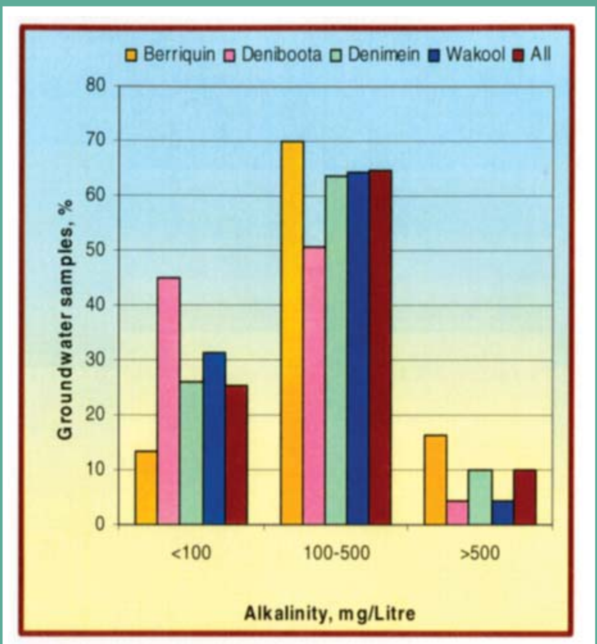

Figure 5 *Distribution of shallow groundwater samples of the MIDs into different alkalinity categories*
Source: MIL (1998)

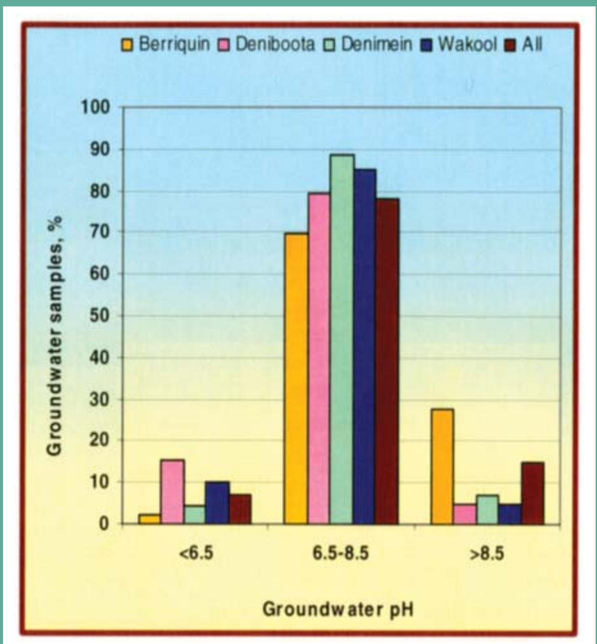

Figure 6 *Distribution of shallow groundwater samples of the MIDs into different pH categories*
Source: MIL (1998)