TRITIUM CONTENT OF SHALLOW GROUNDWATERS IN THELIVERPOOL PLAINS CATCHMENT

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Summary. Hydrogeologic studies indicate that up to 195,000 ha of the Liverpool Plains are at risk from rising groundwater. Long fallow farming systems have been held partly responsible for rising water tables through being more leaky than the original natural grassland. Analysis of shallow groundwater in the Mooki sub-catchment for bomb pulse tritium indicates recharge rates of 20-30 mm per year where significant levels of tritium were present. However, more than half the shallow groundwaters sampled contained low levels of tritium indicating the presence of water older than these farming systems.

INTRODUCTION

The Liverpool Plains, one of the most fertile and productive agricultural areas in Australia is at risk from rising water tables and dryland salinity. The catchment covers 11,728 km^2, half of which is arable, highly productive self mulching clay soils. The average annual rainfall is around 650 mm with a distribution which permits year round cropping and perennial pasture growth. Probably around 1,000 ha are severely salted with production losses greater than 80%, around 30,000 suffer lesser losses (2) and ultimately 195,000 ha are at risk with water tables within 5 m of the ground surface (3). These problems have been attributed to the clearing of native vegetation, an increase in rainfall since the late 1940's and long fallow cropping systems. Trees were cleared from much of the outcropping hills from the 1890's to the 1930's and the light textured soils were extensively cultivated until the 1950's when the technology became available to crop the heavy textured soils of the plains and the foothills of the Liverpool Ranges. The plains, dominated by dryland cropping since the 1960's, were originally grasslands dominated by plains grass (*Stipa aristiglumis*) of which only isolated areas remain (1). Dryland cropping consisted largely of paddocks of continuous winter cereal until the early 1970's; high yields were maintained by high levels of native fertility in the self mulching clay soils. With wheat quotas and demonstrable control of wild oats (4) long fallow wheat-sorghum rotations became popular and are a widely practised farming system on the alluvial plains. To reduce erosion in long fallows, strip cropping (crops grown in a systematic arrangement of strips across the slope), was promoted by the Soil Conservation Service. The contribution of long fallows to ground water `on site' is not known. However, `first cut' analysis (5) (K. Abbs pers. comm) with the hydrologic simulation model PERFECT (6) suggests high levels of recharge in long fallows (39 mm per year) compared to opportunity cropping (12 mm per year) or perennial pastures (0.5 mm per year).

Environmental isotopes have been used to investigate mechanisms of groundwater flow processes (7). For example, the natural background level of tritium changed significantly in 1952 due to the explosion of the first thermonuclear weapons at testing ranges in the northern Equatorial Pacific. Because of greatly contrasting tritium concentrations in pre-1952 precipitation (pre-bomb) compared to post 1952 precipitation (post-bomb), and because a distinct peak in atmospheric levels occurred world-wide during 1962-1965, tritium has been used as an environmental tracer for groundwater recharge, age and flow rate studies.

In this paper, we report a survey of bomb pulse tritium levels (7) in shallow groundwaters in the Mooki sub-catchment of the Liverpool Plains. Our hypothesis was that if leakage into groundwater by long fallow cropping systems has made a major contribution to recharge since the 1960's then most groundwaters will be relatively recent with high levels of tritium.

MATERIALS AND METHODS

Thirty shallow (<14 m) piezometers (Fig. 1) installed by the NSW Department of Conservation and Land Management (3) were sampled for groundwater between 15/12/92 and 28/8/93. Piezometers were measured for standing water level and pumped out 3 times before samples were taken, electrical conductivity (EC) was measured and a 2 l sample was taken for tritium analysis (7). Water was collected from the Mooki River at Breeza (15/12/92), Warrah Creek (near piezometer 13, 16/12/92), a rain water tank (near piezometer 157, 15/12/92) and rain water from a single event near Pine Ridge (9/9/92).

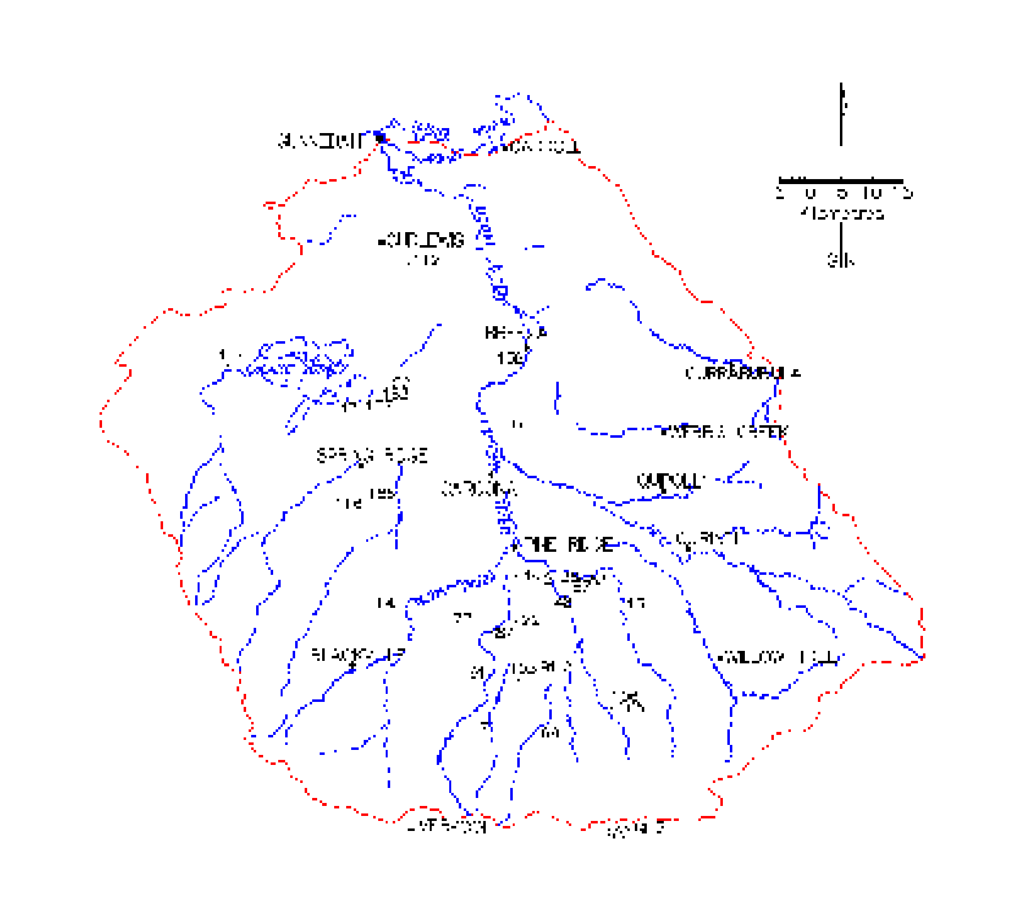

Figure 1. The Mooki subcatchment of the Liverpool Plains showing piezometer locations (after Broughton, reference 3).

RESULTS AND DISCUSSION

Tritium activity in rainwater was 2.7 ? 0.3 T.U. (tritium units, 7). Water from the rainwater tank, Mooki River and Warrah Creek yielded 5.5 ? 0.5 T.U., 4.4 ? 0.5 T.U. and 4.3 ? 0.2 T.U. respectively.

Shallow piezometers yielded a wide range of values (Fig. 2). Tritium activity in water sampled from 10 of 19 piezometers located in the alluvium was ≤1.0 T.U., indicating pre-bomb recharge or old water (numbers 1, 13, 14, 27, 73, 92, 114, 143, 152, 153 in Fig. 1). Two (48, 157) yielded values between 1 and 2 with high EC levels (>20,000 ?S/cm) suggesting mixing of recent and old water; the remaining 7 of the 19 in the alluvium yielded higher values indicating post-bomb recharge. Of four piezometers (7, 68, B_1, B_2) located in alluvium but near basalt hills, only one (B_2) yielded old water suggesting recent flushing of the fractured basalt aquifer; of five in the alluvium near outcropping hills of Triassic or Jurassic sediments, four (42, 116, 138, 166) yielded old water and one (119) recent water. Two piezometers (44, 57) located in Triassic sediments yielded old water.

Negligible tritium yields (≤ 0.7 T.U.) were obtained from all five piezometers screened deeper than 8 m (including the two in Triassic sediments). However, negligible activity was also detected in samples from four very shallow (1-3 m) piezometers (42, 73, 138, 153) in the alluvium (Fig 2).

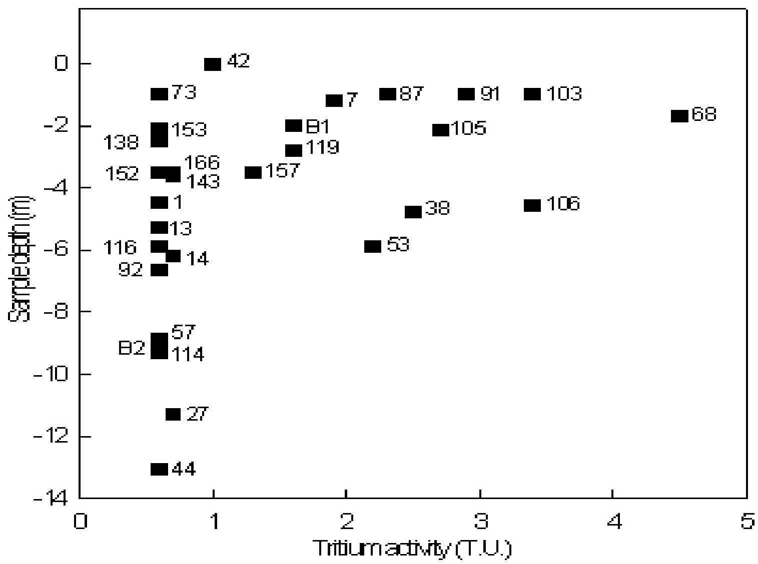

Figure 2. The relationship between tritium activity (T.U.) and depth of sampling of groundwater (ie. depth to the top of the screen or slotted part, usually 1 m long). Tritium activity ≤1 T.U. indicates age of groundwater is at least 35 years. Piezometer 48 yielded 1.3 T.U. Depth to screen not known.

Electrical conductivity varied from <1500 ?S/cm (Mooki River, Warrah Creek, 7, 105, 138, 143, 132) to >30,000 ?S/cm (48, 114, 166). The relationship between tritium activity and EC was such that waters with high tritium activity (>2 T.U.) generally had low EC (<5,000 ?S/cm) whereas waters with high EC (>20,000 ?S/cm) had low tritium activity (<2 T.U.), i.e. all salty groundwaters were old water. However there were samples with negligible tritium activity (<1 T.U.) and low EC (<5,000 ?S/cm). There were no samples with both high EC values and high Tritium activity, i.e. no recent waters were salty.

There is a clear depth (5-6 m, Fig 2) below which no samples had tritium activity >1 T.U. This tritium interface, together with an assumed bulk porosity of ≤0.2 (3), yields recharge rates (6) of post-bomb water of around 20-30 mm per year. These values are similar to the PERFECT estimations (5) and to target interception rates (0-34 mm per year) needed to halt rising groundwater in the Mooki sub-catchment (3). However this method (6) of estimating recharge assumes wetting fronts move downwards by piston flow which is unlikely in landscapes such as the Liverpool Plains. This is illustrated by the high proportion of shallow piezometers yielding pre-bomb water which suggests that the recent problems of rising water tables is not simply due to fallows overfilling and leaking into groundwater. The presence of pre-bomb water near the ground surface is probably due to low rates of recharge since 1952 and dilution of recent recharge by larger volumes of old water. Upward pressure on alluvial groundwaters from deeper aquifers recharged from the Liverpool Ranges and outcropping Jurassic and Triassic sediments (3, 8) may contribute to the presence of old water at shallow depths. The complexity of the hydrogeology is further illustrated by the high frequency of occurrence of old waters in the upper catchment south of Pine Ridge. This contrasts with a higher proportion of more recent groundwaters sampled from deep bores (9-69 m) in the upper catchment suggesting that these aquifers below the alluvium are well flushed with recent recharge from the Liverpool Ranges (8).

This initial study together with subsequent hydrogeologic studies (3, 8), suggests that the relationships between recharge and discharge are complex. Further hydrogeologic studies, together with experiments, which we are now conducting, on the water balance of major farming systems, are required to quantify the spatial and temporal relationships between recharge and discharge in the Liverpool Plains catchment.

ACKNOWLEDGMENTS

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