XXXVIII IAH Congress

Groundwater Quality Sustainability

Krakow, 12–17 September 2010

Extended Abstracts

Editors:
Andrzej Zuber
Jarosław Kania
Ewa Kmiecik

University of Silesia Press 2010

abstract id: **341**

topic: **3**
Aquifer management

3.4
Environmental and artificial tracers in hydrogeology

title: **Investigation of recharge pathways and recharge rates using environmental isotopes (2H, 18O, 14C and 3H) in the Maules Creek Catchment, NSW, Australia**

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keywords: isotopes, groundwater, recharge, surface water groundwater interactions

INTRODUCTION

Groundwater resources are increasingly being relied upon for irrigation in arid and semi-arid regions especially in periods of drought. The often large volumes abstracted for irrigation purposes have the potential to deplete groundwater resources that are relied upon for stock and domestic water uses, and to reduce surface water flows in streams and rivers. The processes and timescales at which these impacts operate and the mechanisms of replenishment (or recharge) are generally not well understood. In addition, quantifying these processes in the field is expensive and time consuming. Consequently, groundwater management decisions are often based on numerical models of an aquifer system where the recharge rates are evenly distributed and represent a constant fraction of the average rainfall. Furthermore, the connection to surface water is often poorly conceptualised due to a lack of data. This has implications for the usefulness of such models as predictive tools. In part, this difficulty has arisen due to a scarcity of field based studies identifying zones of recharge, and surface water groundwater exchange, and estimating the rate at which this occurs and its temporal variability. Groundwater dating using environmental isotopes, in addition to traditional hydrogeologic methods, can aid in the understanding of recharge mechanisms and rates, as well as the surface water groundwater interaction processes.

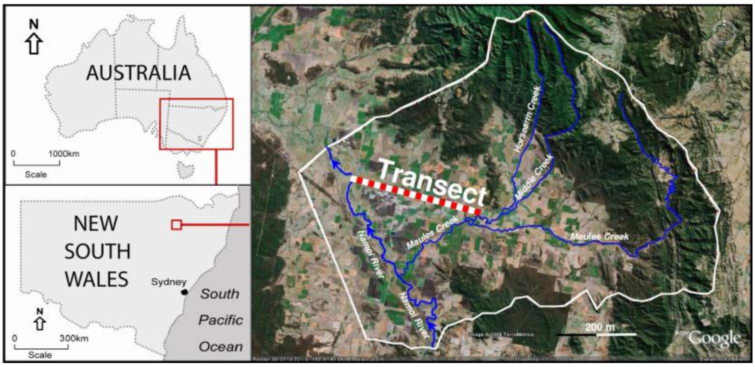

Figure 1. Location of study catchment and aquifer transect.

AIM & STUDY SITE

The objectives of this study were to assess recharge pathways and rates for the Maules Creek Catchment (NSW), a sub-catchment of the Murray-Darling Basin (Fig. 1). Surface water and groundwater were sampled for environmental isotopes ^{2}H, ^{18}O, ^{14}C and ^{3}H. Within the catchment, groundwater abstraction used mainly for the irrigation of cotton, has been carried out since the mid 1980s. As a result of these abstractions, an average decline of groundwater levels of about 4–5 m has been observed (McCallum et al., 2009). Flow in the main river, the Namoi River, also appears to have become more intermittent over the same period.

STABLE ISOTOPE DATA

The ^{2}H and ^{18}O data from the catchment shows that there is a large contrast between the regional groundwater and the river water, with the river water having a distinct evaporative signature. Shallow groundwater (<20 m) in proximity of the river (0.1–1 km) generally shows a mixed stable isotope signature indicating river water recharging the aquifer and mixing with the regional groundwater (Andersen et al., 2008). Although this data is useful in identifying end-member sources, it does not provide an indication of the groundwater residence time or rate of river recharge.

RADIOISOTOPES

The recharge rates of the aquifer were investigated using ^{3}H and ^{14}C data. Whilst ^{14}C mainly provides information on average groundwater residence times prior to the commencement of groundwater abstraction, ^{3}H can give information on groundwater recharge over the past 4 to 5 decades as illustrated by groundwater samples from the transect in Fig. 2. The uncorrected ^{14}C (Fig. 2a) and the ^{3}H (Fig. 2b) results generally indicate increasing apparent groundwater ages with depth beneath the ground surface. However, noticeable differences to this pattern are observed. Near the Namoi River, older groundwater is generally found at much shallower depths than anticipated (red circles in Fig. 3). This indicates up-welling of deeper groundwater eventually discharging into the river (gaining river conditions).

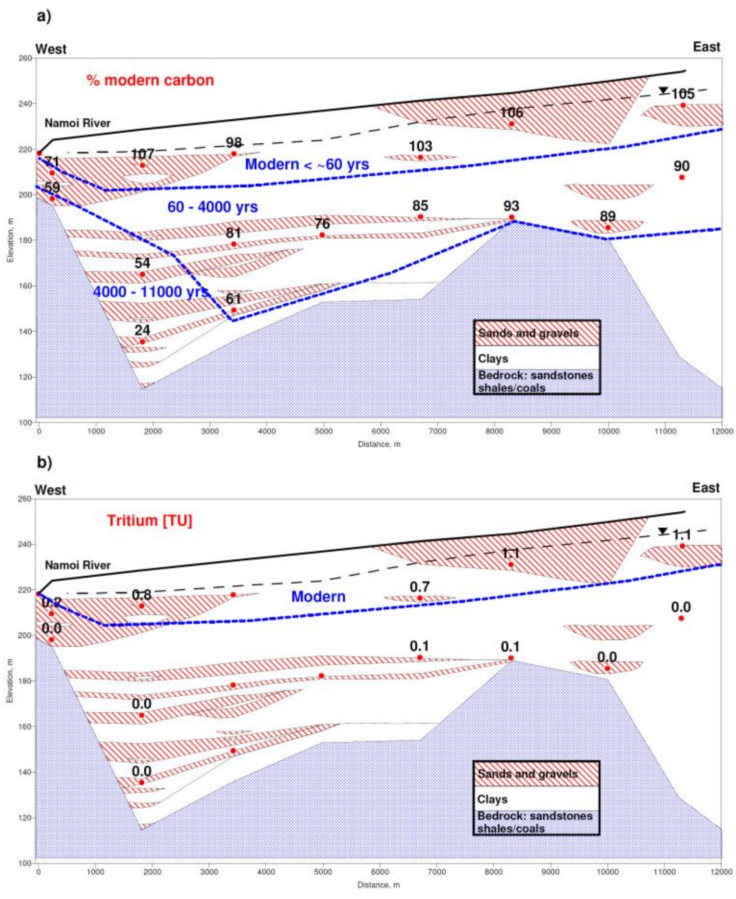

Figure 2. Transect through the Maules Creek aquifer (location shown in Fig. 1): a) Percent modern carbon and; b) 3H in tritium units (TU).

It is possible that this is a relict of past discharge patterns since presently there appears to be little or no discharge of groundwater to the river based on evidence from river level and groundwater head data (McCallum et al. in prep). In other wells, the opposite pattern is observed with modern water found at depths of up to 60 m (yellow squares in Fig. 3). These wells are located in areas near the river, where groundwater abstraction is causing large seasonal drawdowns. It appears that the origin of this modern groundwater is recently infiltrated river water (losing river conditions) entering the aquifer due to the lowered groundwater levels caused by groundwater abstractions.

RECHARGE ESTIMATES

The diffuse (rain-fed) recharge to the aquifer has been estimated in this study by ignoring the samples close to the river which are considered to be either recharge or discharge zones. A simple exponential age-depth relationship was obtained by assuming a homogeneous isotropic box-shaped aquifer with uniform depth (95 m) and porosity (0.3). Based on this, a long term diffuse recharge of 4-10 mm/yr was estimated (Fig. 3). This is an initial estimate of recharge conditions for the system and is subject to changes in the age distribution caused by deviations from the assumptions of homogeneity and isotropy. The scatter observed in the data shows that the aquifer is most likely not homogeneous and isotropic.

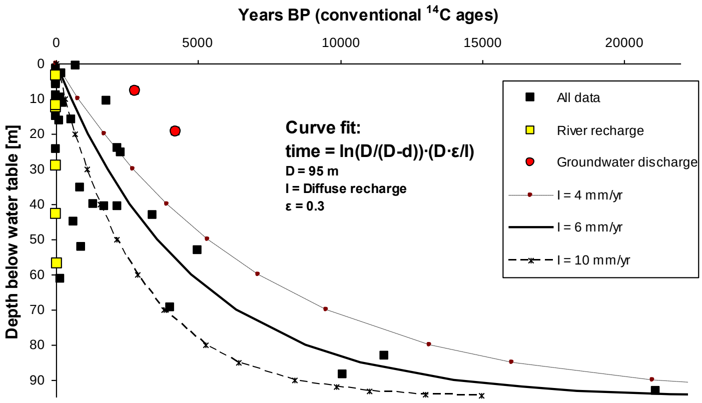

Figure 3. 14C ages vs. sampling depths in the saturated part of the aquifer. The curves represent the age-depth distribution given a diffuse recharge of 4, 6 and 10 mm/yr, respectively. They are fitted assuming exponentially increasing ages with depth in a 95 m deep, rectangular shaped homogeneous aquifer with a porosity of 0.3 (see Appelo and Postma, 2005).

CONCLUSION

This study shows that the changes in the surface water/groundwater interactions impact on the catchment water balance and especially on the fluxes entering the river from the aquifer. This data suggests the aquifer in the Maules Creek catchment is experiencing unexpectedly low recharge rates, which will have further implications for sustainable groundwater management in this part of the Murray-Darling Basin.

REFERENCES

Andersen M.S., Meredith K., Timms W., Acworth R I., 2008: *Investigation of δ18O and δ2H in the Namoi River catchment — elucidating recharge sources and the extent of surface water/groundwater interaction.* XXXVI IAH Congress Toyama, Japan 26th of October, 1st of November 2008.

Appelo C.A.J., Postma D., 2005: *Geochemistry Groundwater and Pollution.* second ed. Balkema Publ.

McCallum A.M., Andersen M.S., Kelly B.F.J., Giambastiani B., Acworth R.I., (in prep.): *Impacts of groundwater abstraction on surface water groundwater interactions in a semi arid catchment.*

McCallum A.M., Andersen M.S., Kelly B.F.J., Giambastiani B., Acworth R.I., 2009: *Hydrological investigations of surface water–groundwater interactions in a sub-catchment in the Namoi Valley, NSW, Australia.* In: Trends and Sustainability of Groundwater in Highly Stressed Aquifers eds.: Taniguchi M. et al. Proc. of the Joint IAHS & IAH Congress, Hyderabad, India, 6^{th}–12^{th} of September 2009. IAHS Publ. 329, 2009, pp. 157–166.

International Association of Hydrogeologists

AGH University of Science and Technology

2-vol. set + CD
ISSN 0208-6336
ISBN 978-83-226-1979-0