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# Dual isotopic approach for determining groundwater origin and water-rock interactions in over exploited watershed in India

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Groundwater flow and storage in hard rock areas is becoming a matter of great interest and importance to researchers and water managers either with regards to the quantity, quality of water as well as delimitation of resources and aquifers. Degradation of groundwater resources by abstraction, contamination, ... has been increasing in many areas and is of growing concern for few decades. In terms of hydrogeology, hard rocks represent a quite heterogeneous and anisotropic media with irregular distribution of pathways of groundwater flow, typically consisting of three vertical zones, upper weathered, middle fractured and lower massive bedrock.

Aim of this work is dual and the Maheshwaram watershed (53 $km^2$, Andhra Pradesh, India) representative of watersheds in southern India in terms of geology, overpumping of its hard-rock aquifer (more than 700 classical open end wells in use), its cropping pattern (rice dominating), and its rural socio-economy mainly based on traditional agriculture is investigated through stable isotopes of the water molecule and lead isotopes in groundwater. The overall objective is to incorporate isotopic- and chemical-tracing data and constraints into methods for evaluating groundwater circulation. It divides into fingerprinting the groundwater recharge processes (e.g. the input by the monsoon) and the water use in such agricultural watershed, which is of primary importance in such semi-arid context and investigating the processes of water-rock interactions (e.g. granite-water interaction).

In the frame of delimitation of resources and aquifers and long-term sustainability, we monitored the input from monsoon-precipitation over 2 years, and measured spatial and temporal variations in $\delta^{18}O$ and $\delta^{2}H$ in the groundwater and in precipitation. Individual recharge from the two monsoon periods was identified. This led to identification of periods during which evaporation affects groundwater quality through a higher concentration of salts and stable isotopes in the return flow. In addition, such evaporation is further affected by land use, rice paddies having the strongest evapotranspiration.

Lead concentrations span over one or two orders of magnitude up to approximately 20 $\mu$g. $L^{-1}$. Pb-isotopes, measured in water by MC-ICPMS using an improved new procedure, fluctuate largely as exemplified by the $^{206}Pb/^{204}Pb$ ratio, reaching values up to 25. Most of the lead in the groundwaters is of geogenic origin, and through the lead isotopic signature in groundwater we have traced and fingerprinted the processes of water-rock interactions considering the granite matrix. Combining a weathering model and field observations, we have defined a two step weathering process that includes a control on the Pb-isotopes ratios by accessory phases and by the main mineral from the granite in a second step of weathering.

For future studies, multi-isotope approach will be necessary for the identification of possible flowpaths, in conjunction with the larger exploitation of the groundwater resources. This is also challenging for generalising the use of isotope tools (such as Nd, Sr, Pb and newly developed isotope systematics like Ca, Si...) in many other catchments that may face structural problems of groundwater overdraft.