

Characteristics of local groundwater recharge cycles in South African semi-arid hard rock terrains – rainwater input

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Abstract

Rainfall events in semi-arid regions of South Africa are characteristically erratic in terms of depths and recurrence rates. Chemical assessment of cyclic rainwater has recognised 3 intervals, spaced over the hydrological cycle, reporting diverse hydrochemical compositions of rainwater in winter and summer rainfall regions. Winter rainwater is generated over the south Atlantic maritime waters. This rainwater contains noticeably higher concentrations of oceanic aerosols (NaCl) than the summer rainwater generated in the Intertropical Convergence Zone/equatorial western Indian Ocean. Sporadic addition of terrigenous dust generated over the continent substantially elevates concentrations of non-oceanic nitrogenous and sulphurous aerosols in the summer rainwater. Prominent seasonal variations in the rainwater hydrochemistry signature coincide with cyclic rainfall depths, characteristic of the semi-arid climate. Macro-element concentrations during the summer dry period, April to September, are relatively high in relation to those recorded for the wet cycle, October to March. However, the latter period reports a noticeably depleted hydrochemical rainwater input into the local groundwater budget during the peak rainfall period (January to March). The October-December (early) period represents a phase between a dusty, dry winter atmosphere and a relatively flushed atmosphere in December, after the first regional rainfall manifests around middle September. Individual early rainfalls contain even higher hydrochemical concentrations than the previous dry period, which subsequently diffuses as the airborne moisture content increases towards the peak rainfall period starting in January. Continuous rainfall event monitoring in the summer semi-arid regions identified short-term wet cycles containing extraordinary high rainfall events, referred to as episodic events. These wet cycles are highly erratic in time and may last from 3 to 8 consecutive days with a recurrence rate of 1 in 5 years. The rainwater hydrochemistry signature differs significantly from the normal rainfall composition and represents a unique opportunity for tracing the infiltrating rainwater. For example, chloride concentrations from individual, high rainfall events (40 to 150 mm) may be as low as $0.4 \text{ mg} \cdot \text{L}^{-1}$, whereas the background value varies around $0.8 \text{ mg} \cdot \text{L}^{-1}$. Environmental chloride represents a conservative tracer for estimating the migration between rainwater and groundwater recharge. The concentration levels are not constant throughout the year and may lead to erroneous assumptions when performing groundwater recharge estimations using accumulated rainwater samples and uncontrolled groundwater sampling techniques.

Keywords: monitoring programme, rainfall patterns, rain-week event, rainwater hydrochemical composition, episodic groundwater recharge, water table rebound, rainwater-groundwater interaction