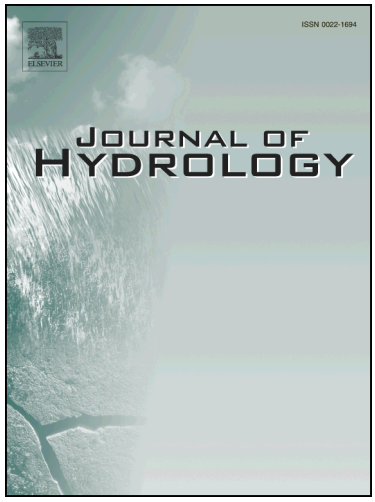

Evaporation and abstraction determined from stable isotopes during normal flow on the Gariep River, South Africa

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PII: S0022-1694(18)30141-0
DOI: https://doi.org/10.1016/j.jhydrol.2018.02.059
Reference: HYDROL 22608

To appear in: *Journal of Hydrology*

Please cite this article as: Diamond, R.E., Jack, S., Evaporation and abstraction determined from stable isotopes during normal flow on the Gariep River, South Africa, *Journal of Hydrology* (2018), doi: https://doi.org/10.1016/j.jhydrol.2018.02.059

Evaporation and abstraction determined from stable isotopes during normal flow on the Gariep River, South Africa

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Keypoints

- The first full length stable isotope survey of the Gariep River is presented.
- Evaporation on the Gariep River was calculated at about 20% of flow, or 40 m^3/s.
- Abstraction on the middle reaches of the Gariep River was calculated at 175 L/s/km.
- The application of stable isotopes to the hydrology of major water resources is demonstrated.

Keywords: hydrology; stable istopes; evaporation.

Abstract

Changes in the stable isotope composition of water can, with the aid of climatic parameters, be used to calculate the quantity of evaporation from a water body. Previous workers have mostly focused on small, research catchments, with abundant data, but of limited scope. This study aimed to expand such work to a regional or sub-continental scale. The first full length isotope survey of the Gariep River quantifies evaporation on the river and the man-made reservoirs for the first time, and proposes a technique to calculate abstraction from the river. The theoretically determined final isotope composition for an evaporating water body in the given climate lies on the empirically determined local evaporation line, validating the assumptions and inputs to the Craig-Gordon evaporation model that was used. Evaporation from the Gariep River amounts to around 20% of flow, or 40m^3/s, of which about half is due to evaporation from the surface of the Gariep and Vanderkloof Reservoirs, showing the wastefulness of large surface water impoundments. This compares well with previous estimates based on evapotranspiration calculations, and equates to around 1300 GL/a of water, or about the annual water consumption of Johannesburg and Pretoria, where over 10 million people reside. Using similar evaporation calculations and applying existing transpiration estimates to a gauged length of river, the remaining quantity can be attributed to abstraction, amounting to 175 L/s/km in the lower middle reaches of the river. Given that high water demand and climate change are global problems, and with the challenges of maintaining water monitoring networks, stable isotopes are shown to be applicable over regional to national scales for modelling hydrological flows. Stable isotopes provide a complementary method to conventional flow gauging for understanding hydrology and management of large water resources, particularly in arid areas subject to significant evaporation.