Application of isotope hydrology and other supporting tracers in subterranean flow studies.

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Abstract

Isotope hydrology have been applied in several water studies in southern Africa over the last ~40 decades to support investigations of large groundwater flow systems regarding groundwater recharge, tracking surface water from lakes/river systems, in the groundwater flow domain, and simply, understanding groundwater flow regimes in general. South African researchers such as Balt Verhagen†(Schonland Isotope Research Unit-WITS), Chris Harris (UCT), Siep Talma†(CSIR) and Dr. Mannie Levin (AEC) contributed significantly to building a significant baseline of isotope research studies of complex surface water and groundwater systems such as (i) the Stampriet Artesian Basin, (ii) the Gordonia Kalahari Aquifer Systems, (iii) interaction of the Central Botswana Kalahari/Karoo Aquifers', (iv) the Table Mountain Group Aquifer, (v) the Tshipise Deep Aquifer System in Limpopo] and many other smaller studies and supporting global research programs of the International Atomic Energy Agency. The level of South Africa's contribution to international isotope hydrology research programs [in Africa] is in no other words, momentous. Continuation of isotope hydrology in southern Africa is, therefore, a [real] concern – especially the post-2000 water scientists.

The above-mentioned studies focused on the application of isotopes [in water, or H_2O] using the well-known hydrogen-oxygen pair – "stable isotopes", and the radiogenic isotope of hydrogen, or Tritium (^3H). Application of radiogenic "Carbon-14 analyses have been used extensively in large hydrological basin studies, i.e. Stampriet and the Gordonia–Central Botswana Kalahari Basin in the 1980-2000's, however, recently ^{14}C-related research has been questioned as a reliable "aquifer-resident water timing" indicator. Tritium, on the other hand, as a conservative tracer has been "dropped" due to depleting TU counts after the thermo-nuclear period came to an end in the 1970's.

Application of the environmental stable isotope suite, i.e. ^2H (also referenced as Deuterium) and ^{18}O, for short-term applications became a potential hydrochemical supporting tool – specifically, investigating surface water and groundwater flow characteristics on much smaller terrains with a strong differentiated water cycling pattern such as mines, industrial sites and surface water-groundwater interactions.

ESI analyses are done by the National Research Foundation's iThemba Laboratory at WITS University – the same premises as the former [and well-known] Schonland Isotope Research Laboratory. The latest analytical methods for ESI analyses are based on modern laser technology, which renders the analyses relatively cheap and quickly.

ESI's have been applied on several mining and industrial sites all over Africa and tracking of water sources (i.e. rivers, storm water, shallow/deep groundwater, and far-field aquifer domains) were possible and extended to results hydrochemical patterns observed in the same water sources using elementary applications such as Schoeller and Piper Diagram analyses. Due to specific fractionation of the ESI ratio's in H_2O during surface evaporation from pans, lakes, tailings facilities, pollution control dams, and alike, the development of evaporated ESI signatures allows a good subterranean tracking in the case of different water sources based on the "evaporation-line" principle. A few case studies will be discussed where ESI's as well as nitrate (NO_3) isotopes and SF_6 (part of the CFC application) have been applied.