Changes in groundwater dynamics along a dryland alluvial aquifer system

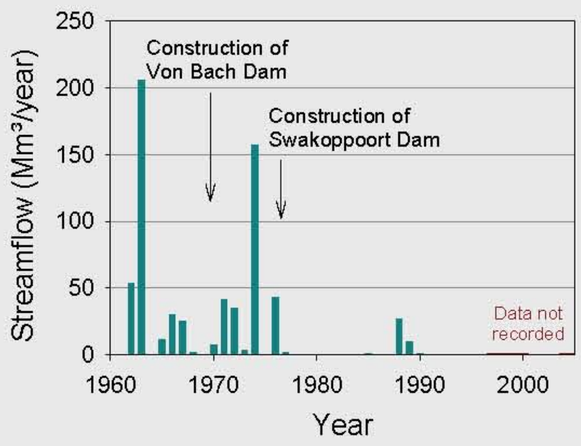
Vera Marx [1], Christoph Külls [1], Arnold Bittner [2], Rainer Ellmies [3]

HYDROLOGY

INTRODUCTION

In Namibia water resources are commonly scarce and their annual replenishment is highly variable challenging local authorities to provide for safe water supply. Rural areas largely depend on groundwater from alluvial aquifers.

In the Swakop River Basin the construction of two surface water dams in the 1970s significantly altered the hydrological regime of the ephemeral river.



The objectives are to characterise the system properties along the alluvial aquifer and to investigate potential impacts of the dam construction.

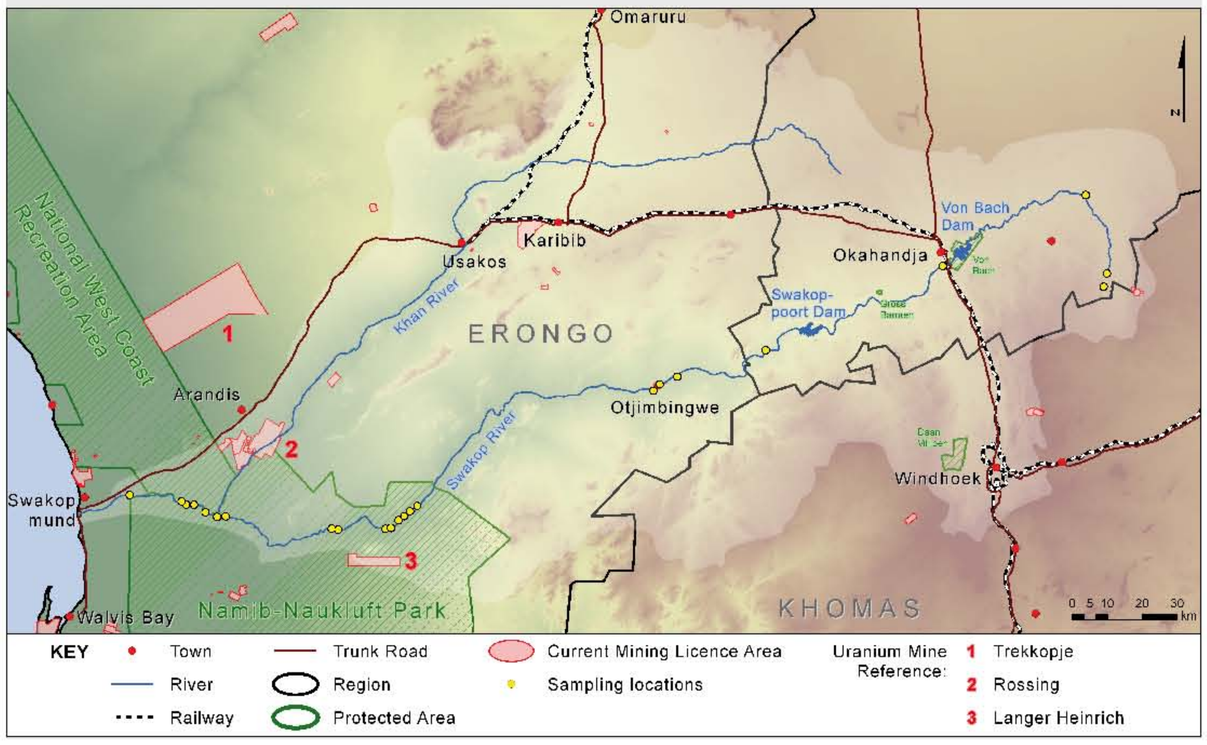
METHODOLOGY

For the assessment a combined approach was applied using hydrochemical, stable isotope and residence time analysis. In total 24 samples were taken in the dry season 2008 from the alluvial aquifer along a longitudinal profile and analysed for CFCs, major ions, trace elements and stable isotopes (^{18}O and ^{2}H).

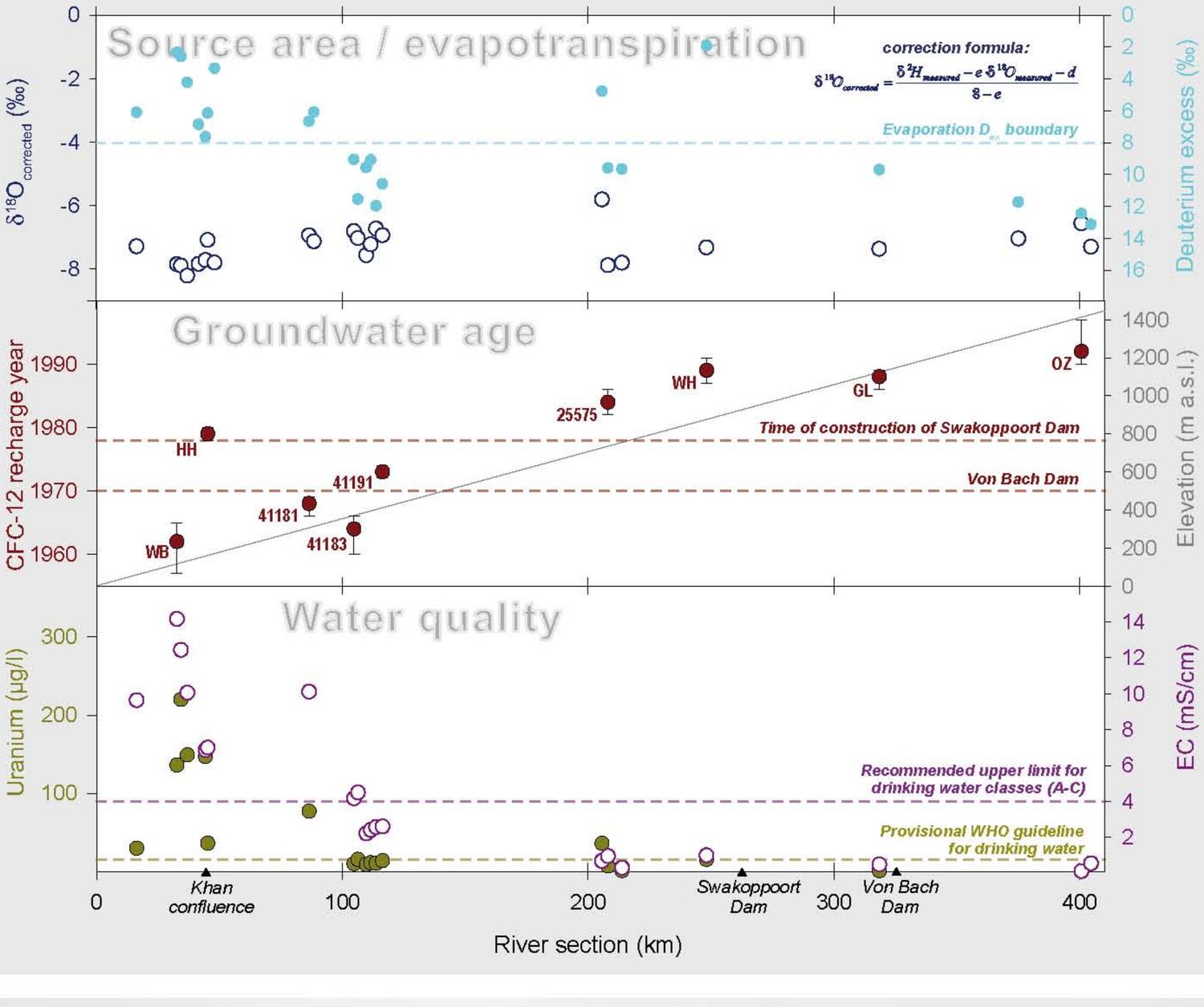
STUDY AREA

The Swakop River Basin (area: 30.000 km²) is characterized by a strong climatic gradient from east to west with a range in rainfall from 450 - 0 mm. The basin is currently undergoing major changes due to the expanding uranium mining sector leading to a strong competition of water related ecosystem services.

The alluvial aquifer (length: 420 km) of the ephemeral Swakop river is not continuous, but instead it is divided into compartments by natural barriers.



LONGITUDINAL SAMPLING RESULTS



Evaporative enrichment in 2 zones

- deuterium excess < 8 ‰ indicates evaporative enriched water in lower and middle parts

No altitude effect in groundwater

- correction for evaporative enrichment
- characterization of source area: isotopic composition in the lower aquifer is similar to headwaters

Groundwater age increases towards the coast

- recharge years vary between 1962 and 1992
- CFC age must be regarded as 'apparent age'
- piston flow model (minimum ages) and inflow of very old (CFC free) water from the basement (maximum ages)

Substandard water quality in lower and middle parts

- electric conductivity (EC: measure of salinity) ranges from 0.12 - 14.16, mean of 4.64 mS/cm
- mean concentration of dissolved uranium (U) is 48.71 µg/l (min: 0.06, max: 220 µg/l)
- no investigation whether U concentrations are of natural or anthropogenic origin

CONCLUSIONS

A unique dataset was obtained from the sampling campaign and the method has proven to be an effective tool to characterise alluvial aquifers in large-scale semi-arid basins.

Isotope analyses: evaporative enrichment in the middle and lower aquifer may result from ponding after floods or irrigated agriculture. The lower aquifer largely depends on recharge from floods generated in the more rainy headwaters.
CFCs: longitudinal age pattern depicts the hydrological situation in the basin: large floods recharging the lower alluvium are of reduced volume and less frequent due to transmission losses, climatic conditions and surface dam construction in the less arid headwaters.
Uranium/EC: water quality is affected by lateral inflow from the surrounding bedrock especially towards the coast.

The findings serve further investigations as a basis for a detailed modelling of the alluvial groundwater resources and thus for the determination of water requirements for both people and nature.

ACKNOWLEDGEMENTS

AN INITIATIVE OF THE Federal Ministry of Education and Research

IPSWaT

The IPSWaT scholarship of the BMBF is gratefully acknowledged.
I am also cordially thankful for the support during the fieldwork from BIWAC, DWAF and BGR-GSN as well as from my supervisors Prof. M. Weiler and Dr. Ch. Külls.

(1) Institute of Hydrology, Albert-Ludwigs-University of Freiburg
Vera.Marx@hydrology.uni-freiburg.de, Christoph.Kuells@hydrology.uni-freiburg.de

(2) Bittner Water Consult (BIWAC), Windhoek
arnold@biwac.com

(3) Bundesanstalt für Geowissenschaften und Rohstoffe, BGR-Project in Geological Survey of Namibia
rellmies@mme.gov.na