Investigation of Groundwater Discharge processes in GDEs in the Khakea Bray Transboundary Aquifer.

Thandeka Ngobe

Msc Geohydrology

University of Free State

Supervisor: Professor Modreck Gomo

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Presentation Outline

- Background of the study
- study aim and objectives
- methods and materials
- conclusion

Background of the study

- Groundwater dependant ecosystems (GDEs) can be defined as a naturally occurring environmental system that requires access to groundwater for it survival.

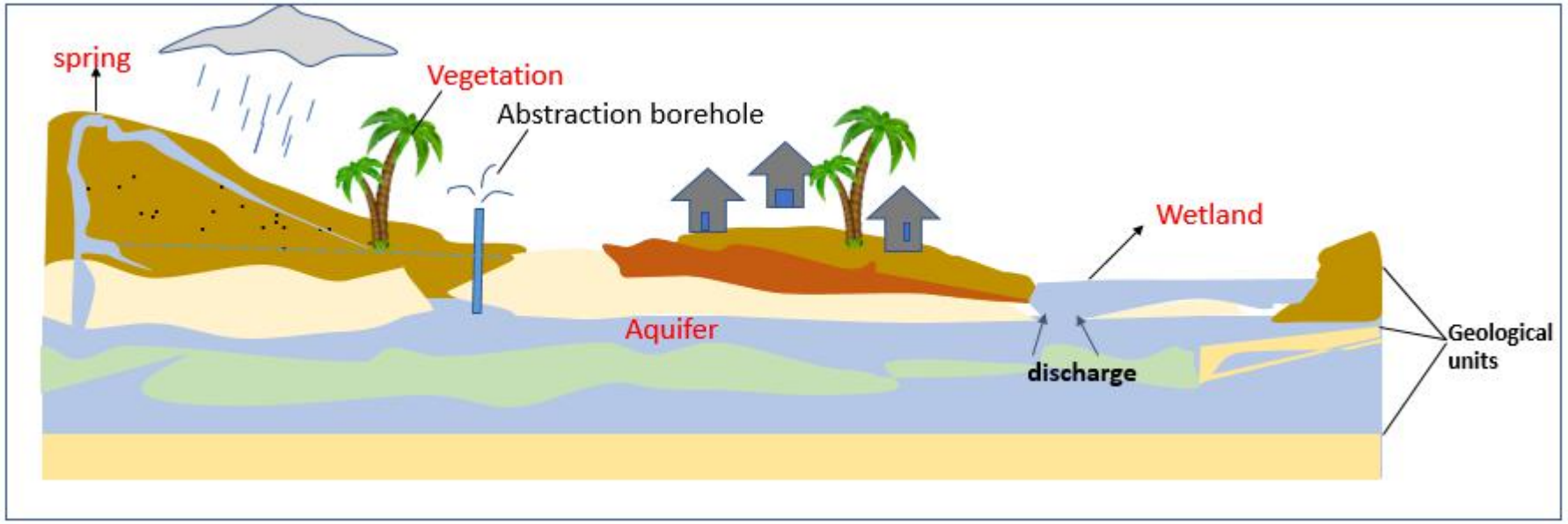

Figure 1: illustrations of the GDEs

Background of the study

Why groundwater discharge ?

- plays a role towards the sustainability of the GDEs.
- Important parameter for modelling of aquifers.
- Sustainable management of groundwater in relation to abstraction.

Study aim and objectives

- The aim of this study is to understand the groundwater discharge processes in GDEs.
- Objectives:
  - Understanding and evaluation of the different approaches that can be applied to quantify groundwater discharge into GDEs.
  - characterization of the geology of the area.
  - Quantify groundwater discharge into the GDEs.

Methods and materials

Understanding the different approached of estimating groundwater discharge

Literature review

The scientific publications on the following:

- Groundwater and surface water interaction,
- Approaches of estimating the groundwater discharge
- Guidelines on field data collection for the different approaches.

Methods and materials

Geological Investigations

- Identify linkages between the geology and the groundwater discharge processes.
- Understanding the potential influence of the geology to groundwater discharge processes.
- Two approaches will be used to characterize the geology of the area:
  - Reconnaissance survey
  - Geophysical assessment

Reconnaissance survey

Geological outcrops and visible geological structures will be used to characterize the surface geology of the area.

Methods and materials

Geophysical assessments

To understand the subsurface geology and subsurface geological structures that may contribute towards the groundwater discharge. Two geophysical methods will be applied:

a) Magnetotelluric method: this method measures vertical subsurface apparent resistivity through the use electromagnetic waves. The apparent resistivity data will be used to model the Earth subsurface up to 300 meters.

b) Magnetic method: proton magnetometer will be used to delineate subsurface geological features such as dykes, sills, contact between geological units of different magnetic properties .

Methods and materials

Hydraulic Test

To estimate the in-situ hydraulic properties of the geological materials, a single well slug test will be conducted. This test will conducted on the piezometers.

Slug test

- Involves the lowering or raising of the static water level and monitoring the rates at which the water level recovers or drop to the static level.
- For this study the static water level in the piezometers will be raised using a solid slug and the recession of the water levels versus time will be recorded to allow the determination of hydraulic conductivity (K).

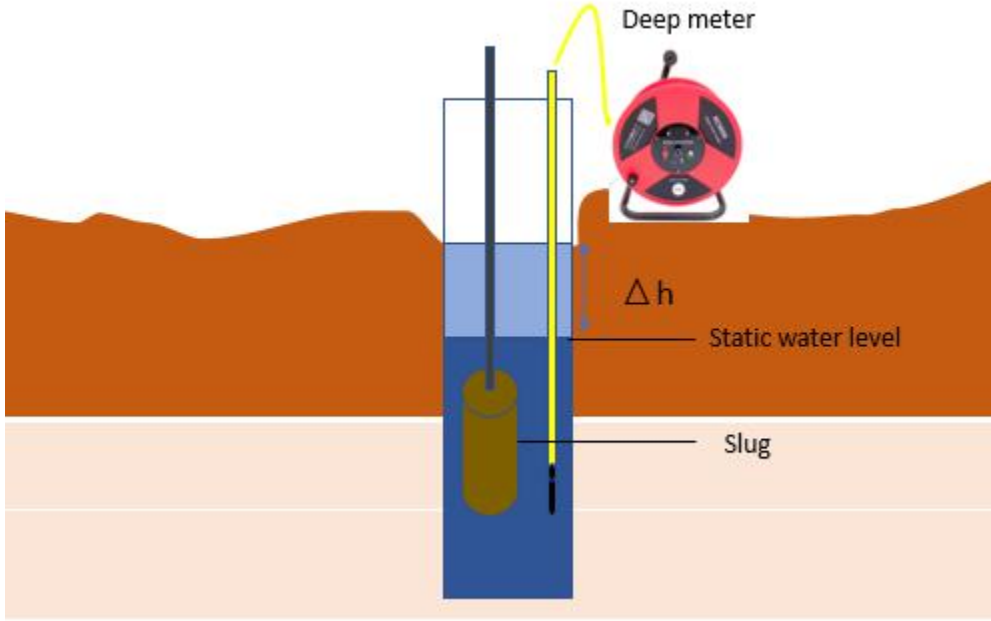

Figure 2: schematic of a slug test

Methods and materials

- *Data analysis*

Analytical methods such as Bouwer and Rice (1976) will be used to estimate the hydraulic conductivity

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

Equation 1 (Bouwer 1989)

Methods and Materials

Quantification of groundwater discharge

Three different approaches will be used to estimate the groundwater discharge into the GDEs.

1. Darcy's Approach

- This method allow the estimation of discharge (Q) using the Darcy's equation:

$$Q = KiA \quad \textit{Equation 2}$$

Where K: is the hydraulic conductivity from slug test

A: (m_2) is the surface area perpendicular to the groundwater flux

i: is the average hydraulic gradient (dh/dl)

Materials and methods

2. Point dilution Tracer Test Approach

- This test uses a single well to estimate the Darcy velocity.
- A salt tracer (NaCl, Br) is injected manually and mixed uniformly in the testing zone of the piezometer.
- The testing zone can be determined using an EC profiling technique, targeting mainly the preferential groundwater flow zones.
- The dilution of the tracer in relation to time will be monitored by measuring the EC.

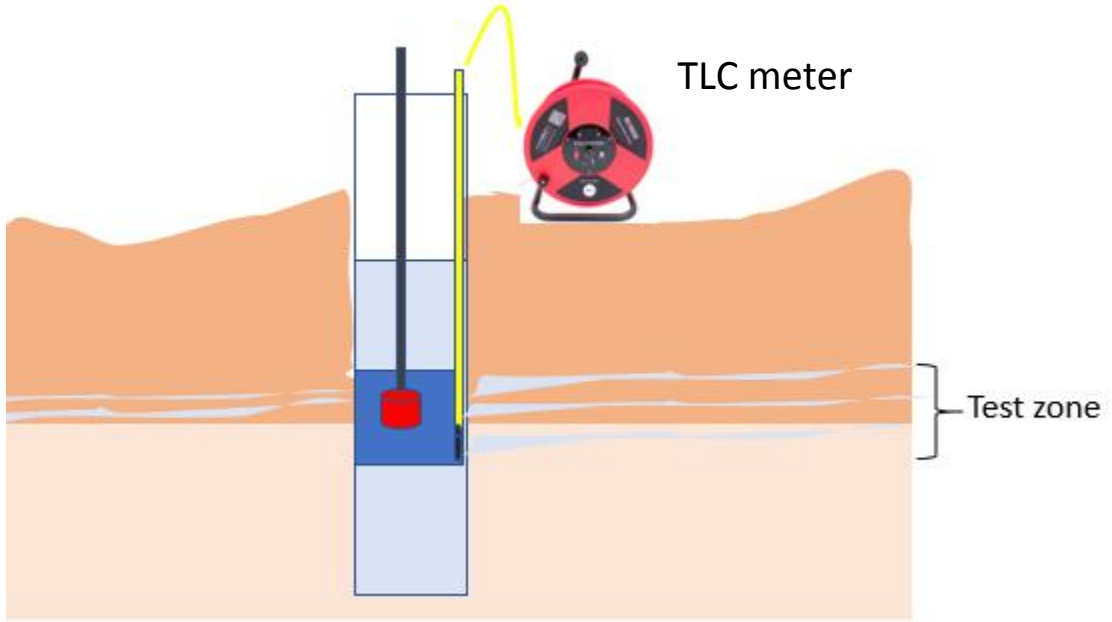

Figure 3: PDTT schematic diagram

Materials and methods

2. Point dilution Tracer Test approach

- ***Data Analysis***
  - Equation 3 can be used to standardize the EC measured during the monitoring of the dilution of the tracer.

$$C_t^* = \frac{C_t - C_b}{C_o - C_b}$$ Equation 3

  - Equation 4 can be applied to estimate the Darcy velocity (m/d)

$$q = \frac{W}{\alpha A t} \ln \frac{C_0}{C}$$ Equation 4

  - To estimate the discharge the following equation will be applied

$$Q = q/A$$ Equation 5

Materials and methods

3. Isotopes and Tracers Approach

- Water samples will be collected from the piezometers and the GDEs for chemical analysis (major cations and anions) at the laboratory.
- This method will help in understanding the processes of recharge.
- Used to understand the origin of both the groundwater and surface water through the analysis of stable isotopes (Oxygen -18 and deuterium).

Conclusion

- Detailed field investigation test will be carried out on two sites (one in South Africa and one in Botswana).
- data will have to be collected before and after the rainy season.

References

- Ardenas, M. & Zlotnik, V., 2003. A simple constant injection test for streambed hydraulic conductivity estimation. Groundwater, p. 869.
- Bennie, H., 2018. ORANGE-SENQ WATER INFORMATION SYSTEM. [Online]
- Available at: http://wis.orasecom.org/khakheabrayaquifer/
- [Accessed 05 June 2021].
- Butler, J., 2020. The design, performance, and analysis of slug tests. 2nd ed. London,New York: CRC Press.
- Dippinaar, M. et al., 2014. Vadose zone hydrology; concept and technics, Pretoria: Water Research Commission .
- Dresel, P. E. et al., 2010. Mapping Terrestrial Groundwater Dependent Ecosystems: Method Development and Example Output.. Future farming systems research, p. 66.
- Freeze, A. & Cherry, J., 1979. Groundwater. United States of America: Prentice-Hal.
- Hattons, T. & Evans, R., 1998. Dependence of ecosystems on groundwater its significance to Australia.. Land water resources research and development Cooperation.
- Piccinini, L., Fabbri, P. & Pola, M., 2016. Point dilution tests to calculate groundwater velocity: an example in a porous aquifer in northeast Italy. Hydrological Sciences, 61(8), pp. 1512-152.
- Tobias, C., Harvey, J. & Anderson, I., 2001. Quantifying groundwater discharge through fringing wetlands to estuaries: Seasonal variability, methods comparison, and implications for wetland–estuary exchange. Groundwater input to fringing wetlands, pp. 604-615.
- Woessner, W., 2017. Chapter 8 - Hyporheic Zones. In: A. Press, ed. Methods in Stream Ecology, Volume 1 (Third Edition). s.l.:Department of Geology, University of Montana, pp. 129-157.