Analysis of the hydrological processes of a semi-arid region lake, the case of Lake Ngami, Botswana


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Background

• Accurate information on the condition and trends of a country’s water resources – quantity and quality – is required as a basis for both economic and social development, and for maintenance of environmental quality (WMO/UNESCO, 1990).
• Quantitative assessment of water resources is underpinned by the water balance concept, which is fundamental to the study of hydrological processes.
• Water balance analysis provides a foundation for effective water-resource and environmental planning and management (Healey et al., 2007).
• It aims at quantifying the hydrological fluxes into and out of a defined hydrological system, together with the related changes in storage.
• In general, the water balance of a given system can be summarized as:

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\Delta V = P + I_E + I_O - E_o - G_o - G_s
\]

+ \Delta V is change in storage with time, P is precipitation, I_E and I_O are surface and groundwater inflow respectively, E_o is evapotranspiration, G_o and G_s are surface and groundwater outflows respectively.
+ Change in water levels can be used as a proxy for change in volume.

Lake Ngami, located at the southwest corner of the Okavango swamp in north-western Botswana, is characterized by episodes of being inundated and subsequently being desiccated. This, together with its remote location, has rendered hydrological and meteorological monitoring around the lake almost non-existent.

Objectives

The main objective of this study is to assess the hydrological fluxes of Lake Ngami on a monthly and annual time scales using the water balance concept.

Methods

Study area

• Lake Ngami, an endorheic, shallow depression lake at the distal end of the Okavango Delta in the Okavango Basin Ramsar Site in northwest Botswana.
• The limits of the lake are marked by a series of concentric ridges raised about 2 metres above the surrounding flat land (Akanyang, 1997).
• Main flux into the lake are the Kunyere and Nhabe Rivers, which join to form Mogapelwa river just upstream of the inlet into the lake at Toteng. The two rivers are some of the rivers that drain the Okavango Delta, which gets most of its water from the Angolan highlands.
• Direct precipitation on the lake surface is another source of input into the lake.
• Main flux out of the lake is direct evaporation and seepage to groundwater.
• Total surface area of the lake was estimated from a 2012 bathymetric survey.
• Average depth was estimated to be 3.99 m, while surface area was 287 km², giving an average storage of 1.14 km³ at the time.

Discussion

• Data limitations restricted the depth of analysis that could be carried out.
• The data used in the analysis shows that annually, direct precipitation on the lake is highly variable over the analysis period.
• However, this is a reflection of general precipitation patterns in the semi-arid regions.
• As was to be expected, the monthly evaporation rates mirrors the net radiation balance, highest during the summer period (October to March) and going down during the winter and summer transition period (April to August).
• It is notable that the period of lowest evaporation rates coincides with the largest areal extent of the lake, which is also the dry period in Botswana. Any management interventions put in place on the water resources of Lake Ngami must factor in this.
• At the annual time scale, evaporation rates vary within a narrow range. The possible implication of this is that were the inflows into the lake to somehow diminish, evaporative losses will accelerate the desiccation of the lake, which has happened in the past.

Recommendations

• Monitoring, both hydrological and meteorological, around the lake must be enhanced.
• Ideally a weather station in the lake or on the shore of the lake must be installed.
• Frequency of discharge measurements at Mogapelwa must be increased considerably, particularly during periods of high inflows. This will also enable estimation of residence time of water in the lake.
• Continuous water level monitoring in the lake must be implemented.
• Groundwater level monitoring around the lake to enable surface water groundwater interaction assessment must also be implemented.

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References