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Impacts of extreme floods on groundwater recharge and contamination in arid regions: lessons learned from the major 2017 flood event in Botswana

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It is recognized that floods resulting from high rainfall events are crucial to groundwater recharge in arid and semi-arid regions. While climate change is expected to result in increase in frequency and magnitude of high rainfall and flood events, it is not well established whether these ‘extreme’ events are equally contributing to groundwater recharge. Furthermore, it is not well known how they facilitate contaminant infiltration and sub-surface transport, particularly in urban/peri-urban areas, and how temporal processes and effects of increased concentration versus dilution take place. A better understanding of these processes is crucial to the sustainable management of groundwater resources in arid regions subject to changing climate patterns.

This project aims to address these questions through monitoring of the impact on groundwater quantity and quality of the extreme, destructive decadal flood event that took place in Jan-Feb 2017 in the Gaborone catchment, upper Limpopo Basin, Botswana, a region underlain by contrasted aquifer types of Precambrian age, from productive, karstified dolomite to poorly productive fractured crystalline basement. A suite of multidisciplinary investigations has been deployed involving high spatiotemporal resolution monitoring of ground and surface water level and quality, time-lapse geophysical surveys in floodplains and in the vicinity of landfills, and flood sediments records in dams.

Preliminary monitoring results show that: (1) groundwater levels have rapidly risen following floods, by up to 20 metres, and are remaining at high levels months after the event; (2) the water table rise is higher and more spatially ubiquitous than following previous ‘normal’ flood events; (3) downstream major dams, which reached full capacity within a couple of weeks for the first time in a decade, the water table rise continues months after the event, whereas other areas (upstream dams) show decline at a normal rate for dry season; (4) groundwater mineralization has temporarily increased in rural areas upstream dams, while mineralization increase continues in peri-urban areas downstream dams; (5) at local scale, geophysics revealed dilution of leachate plumes downstream the major landfills; (5) chemical contaminant indicators (metals) show a minor increase post floods.

These initial findings provide valuable conceptual insights on the understanding of extreme flood impacts on groundwater in arid regions under complex hydrogeological and landuse settings. They overall suggest that the 2017 event in Botswana triggered both a major, rapid recharge event over the catchment and delayed, slower recharge downstream major dams (probably from the dams themselves), this along with possible contaminant migration in groundwater in peri-urban areas, yet concurrently diluted by recharge water volumes resulting in near-steady concentrations. Subsequent modelling activities will provide further quantitative, spatiotemporal knowledge of groundwater-flood interactions, recharge and contaminant migration processes required to assist effective groundwater management, including managed aquifer recharge approaches.