

Estimating Natural Groundwater Recharge in the White Volta River Basin using Multiple Techniques

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Background and Objective

The White Volta River basin has enough water resource to meet current demands. However, the basin faces many challenges including high spatio-temporal variability in rainfall, global and regional climate change and high population growth rate (2.5%). Exploitation of groundwater in the basin has increased substantially and can lead to depletion of the resource if abstraction exceeds recharge. This study estimated the groundwater recharge amount and mapped the spatial distribution of the recharge at two areas in the basin: the Upper East Region and the Lower White Volta River basin.

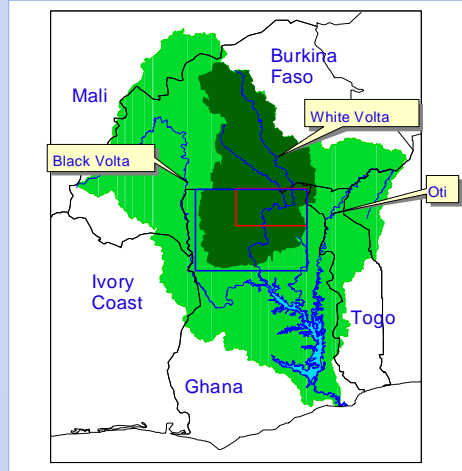


Figure 1: Map of the Volta basin showing the Upper East Region (marked red) and the Lower White Volta basin (marked blue)

Methods

Two recharge estimation techniques were used: the chloride mass balance (CMB) in the Upper East Region in 2006; and the water table fluctuation (WTF) in the Lower White Volta River basin in 2006/2007.

- The CMB is widely used in semi-arid areas. It provides long-term recharge values by analyzing the increase in chloride concentration due to evaporation.
- The WTF requires data of specific yield and changes in water level over time. It is best suited for areas with distinct period of recharge.

Results and discussions

CMB recharge estimates and distribution

Well location	UTM Coordinate		Altitude of land surface (m)	Monthly chloride concentration (milligram per liter)			
	XPR	YPR		Mar	Jun	Aug	Dec
Kpasenkpe	712994	1155700	122	6.3	6.8	7.0	6.7
Sumbungu	726544	1199243	114	11.2	10.9	10.9	11.0
Yorougo	734764	1196872	191	10.1	9.8	10.3	9.6
Zongoire	782889	1180367	230	18.5	18.0	18.6	18.6
Pwalugu	735237	1172564	221	22.1	23.8	23.7	23.5
Doninga	674960	1177106	164	5.9	5.7	5.8	6.2
Naga	717775	1172774	159	11.4	11.0	10.9	12.1
Navrongo	704408	1202456	179	13.9	-	12.9	12.9
Gowrie	734709	1201218	181	6.0	-	6.0	7.0
Bawku	799594	1223879	224	9.9	-	11.9	11.9
Datuku	757915	1184680	194	4.0	-	4.0	5.0
Bongo	739687	1207007	224	39.7	-	28.8	39.7

Table 1: Monthly chloride concentrations in groundwater in selected wells in the Upper East Region, Ghana, in 2006

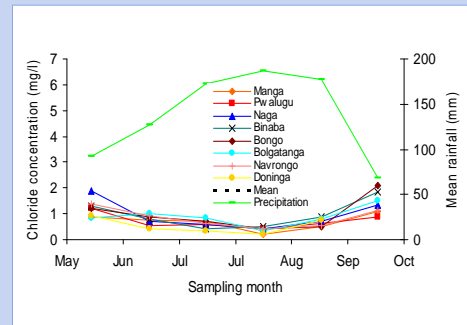


Figure 2: Monthly rainfall amount and chloride concentrations in rainfall in the Upper East Region, Ghana, in 2006. Mean chloride value (0.84 mg/l)

- Dry atmospheric depositions and direct runoff amount were not considered due to lack of data. The recharge results could have been improved if such data were included.

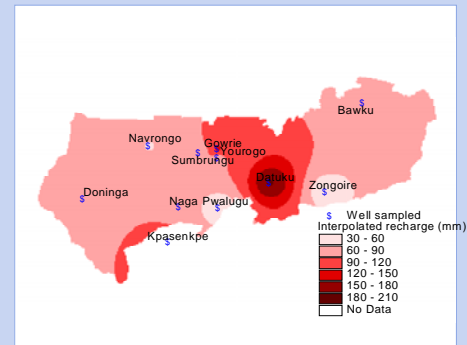


Figure 3: Spatial distribution of groundwater recharge in the Upper East Region, Ghana. Area weighted mean (82.4 mm; 8.3 % of long-term mean annual rainfall)

- The estimated recharge values are long-term because they were derived in part from long-term data of annual rainfall and chloride in groundwater.

WTF recharge estimates and distribution

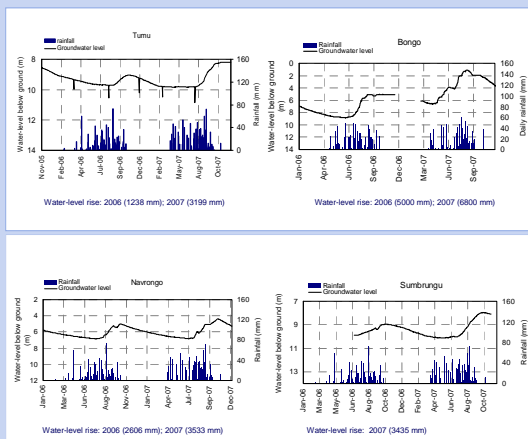


Figure 4: Groundwater hydrographs for selected observed wells in the Lower White Volta basin, Ghana, in 2006/2007.

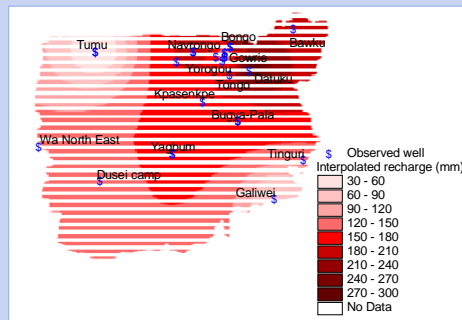


Figure 5: Spatial distribution of groundwater recharge in the Lower White Volta basin, Ghana, in 2006. Mean recharge (145.7 mm; 16.7 % of the annual rainfall)

- Wide variation in annual recharge was due to wide range in specific yield values in literature. Results could have been improved if the exact specific yield values would have been determined.

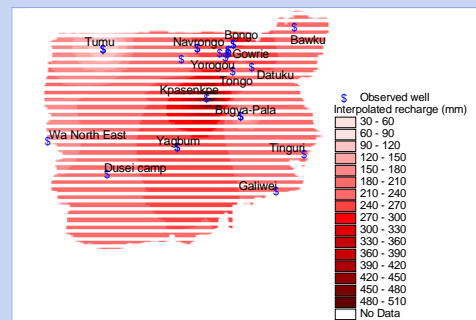


Figure 6: Spatial distribution of groundwater recharge in the Lower White Volta basin, Ghana, in 2007. Mean recharge (209.0; 17.2 % of the mean annual rainfall)

- Differences in recharge values between 2006 and 2007 can be attributed mainly to differences in annual rainfall amount and seasonal pattern.

Conclusions and recommendations

- The CMB recharge values are less uncertain and more reliable compared to the WTF. Recharge values estimated with the two techniques differ for the same year, but the pattern of high and low recharge areas are similar. Reducing uncertainties, increasing the number of observed wells and using long-term data can improve the reliability of the results.