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Groundwater recharge in the Bekaa : insights for enhanced water management

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The Bekaa Valley : context and objectives

Despite the extensive efforts of the international community and local authorities to address water scarcity, millions of people are subject to insufficient access to safe drinking water and sanitation services in Lebanon. This study attempts to understand the dynamics and the role of groundwater recharge due to precipitation in different water level behaviour, using a soil moisture water balance and water table fluctuation model with field data. It also strives to identify eventual water over extraction zones. The study focuses on three zones of the Bekaa valley, that are represented on Fig.1, in which lies two to three wells in distinctive aquifers.

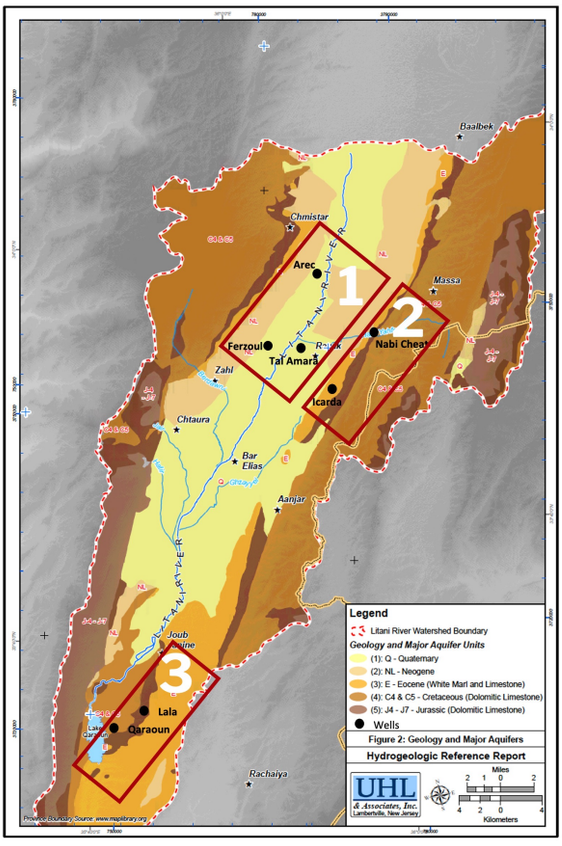

Fig. 1. The three studied zones on the aquifer map and their respective wells.

Materials and Methods

In this study, two ”one dimensional” methods were used to describe, assess and quantify the groundwater recharge and the water level fluctuation in specific regions of the Bekaa. The suggested methodology strives to validate previous recharge estimates using a more local scale, and a higher temporal resolution. The first method is a soil moisture water balance, with its soil parameters calibrated on actual evapotranspiration data, which allows to compute recharge due to precipitation. The second method is the water table fluctuation method allowing to compute net recharge with water table level. Confronting those two methods to previous estimates allows the methodology to be validated and gives some insights on the different recharge mechanisms in the studied zones, and identify over-extraction rates. Fig.2 illustrates the three steps of the developed workflow.

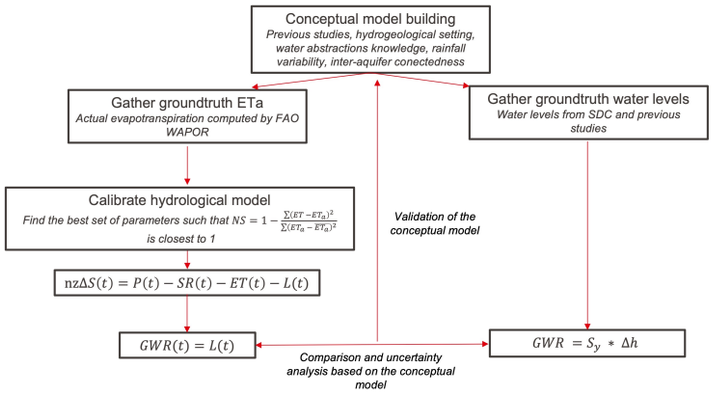

Fig. 2. Schematic representation of the workflow developed for the study

Results and Discussions

The obtained results allowed to validate previous estimates. The calibration process of the soil moisture water balance led to a Nash-Sutcliffe coefficient of over 0.89. The water table fluctuation method computes the total recharge on a specific site, and also allowed to validate previous estimates. According to the results we obtained, Bekaa’s recharge due to precipitation ranges from 15 to 30% of the total recharge, depending on the aquifer. Comparing the results of the two methods, it is possible to : validate the conceptual model developed for each zone; eventually identify abnormal recession periods associated with high extraction rates, and give food for thought in the development of an integrated water management at each individual wells given their recharge process. Combining methods of computation of recharge allows to better assess the accuracy of the conceptual model of specific regions of the Bekaa. The results obtained for each wells are compiled and summarized in table 1. The wells highlighted in red are those for which over abstraction rates were identified with the developed workflow.

	Zone 1			Zone2		Zone 3	
	Arec	Ferzol	Tal Amara	Icarda	Nabi Cheat	Lala	Qaraoun
Mean annual value							
Precip. Recharge [mm] (Soil Wat. Bal.)	35.8	50.3	26.3	215.2	339	602	592
Net Recharge [mm] (WTF)	201	279	32.7	707	1238	3971	2714
Precipitation [mm]	466	466	466	466	702	1095	1144

Table 1. - Final results of the methodology developed. In red, the suspected wells exposed to abnormal water abstractions

Conclusions

Recharge is probably the less understood component of the water cycle in the Bekaa. This is due to numerous and large uncertainties related to data scarcity and unavailability. And yet, the knowledge of the behaviour of this component is crucial to implement a sustainable management of the water resource.
The methodology we suggest allows to identify the processes, driving forces and parameters that have to be considered in the modelling of the recharge. Indeed, it was possible to validate previous estimates and quantify the part of recharge due to rainfall and the part of recharge due to inter-aquifer flows and localised recharge.