Abstract n°2469

Assessment of vulnerability in karst aquifers using a quantitative integrated numerical model: catchment characterization and high resolution monitoring – Application to semi-arid regions- Lebanon.

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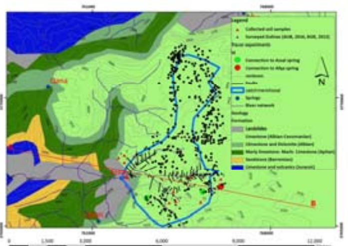
Abstract

Karst aquifers are highly heterogeneous and characterized by a duality of recharge (concentrated; fast versus diffuse; slow) and a duality of flow which directly influences groundwater flow and spring responses. Studies have shown that vulnerability of aquifers is highly governed by recharge to groundwater. On the other hand specific parameters appear to play a major role in the spatial and temporal distribution of infiltration on a karst system, thus greatly influencing the discharge rates observed at a karst spring, and consequently the vulnerability of a spring. This heterogeneity can only be depicted using an integrated numerical model to quantify recharge spatially and assess the spatial and temporal vulnerability of a catchment for contamination.

In the framework of a three-year PEER NSF/USAID funded project, the vulnerability of a karst catchment in Lebanon is assessed quantitatively using a numerical approach. The aim of the project is also to refine actual evapotranspiration rates and spatial recharge distribution in a semi arid environment. For this purpose, a monitoring network was installed since July 2014 on two different pilot karst catchments (drained by Qachqouch Spring; 90m asl, and Assal Spring; 1500 m asl) to collect high resolution data to be used in an integrated catchment equivalent porous numerical model with MIKE SHE (DHI, 2014) including a bypass component including climate, unsaturated zone, and saturated zone. Catchment characterization essential for the model included geological mapping and karst features (e.g., dolines) survey as they contribute to fast flow. Tracer experiments were performed under different flow conditions (snow melt and low flow) to delineate the catchment area, reveal groundwater velocities and response to a snowmelt event. An assessment of spring response after precipitation events allowed the estimation of the fast infiltration component. A series of laboratory tests were performed to acquire physical values to be used as a benchmark for model parameterization, such as laboratory tests on soils for conductivity at saturation and grain size analysis. Time series used for input or calibration were collected and computed from continuous high resolution monitoring of climatic data, moisture variation in the soil, and discharge at the investigated spring. The model is currently being validated based previous years (Assal catchment). A preliminary sensitivity analysis revealed the most sensitive parameters to be further investigated. This similar model approach used on a catchment site in Germany is being validated on one pilot karst catchments in Lebanon governed by semi-arid climatic conditions.

I) Field Site and Characterization

El Assal spring is an important karst spring located at 1552 m (above sea level) in Kfardebbiane area that provides downstream villages in the Kesrouane district with about 24,000 m^3 of water daily for domestic use. It originates from the Cenomanian fissured karst aquifer located at altitudes varying between 1600 till 2100 m asl



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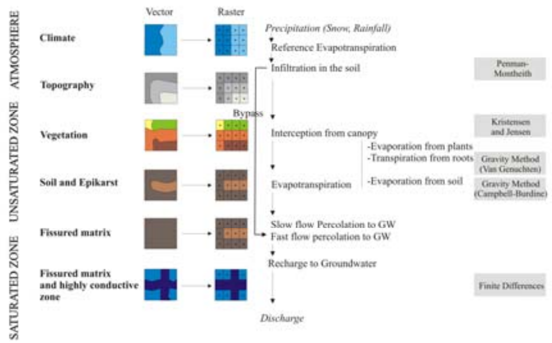
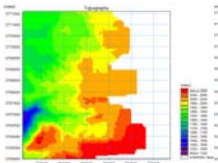
II) Numerical Approach

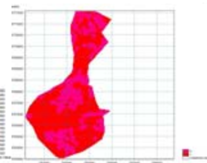


Integrated Model (Doummar et.al., 2012, Mike She, 2014)

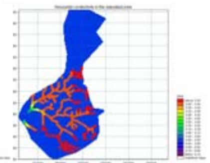
III) Parametrization and Model Geometry



Topography (based on 10- m contour)



Dolines and fast infiltration distribution

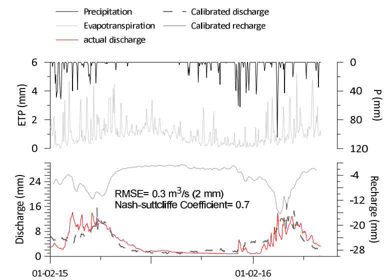


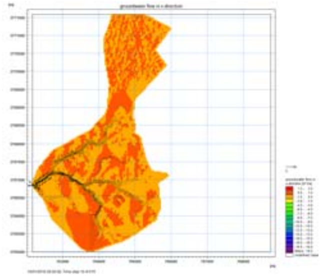
Highly conductive lens (Dry Valley)

Parameterization of the karst system compartments using fixed or time series (Physical, literature and calibration values)

Component		Highly and Medium Sensitive Parameters	Unit	Allowed Calibration Range	Type of Parameter	Type of component affected	Initial Calibrated Estimate
Atmosphere and Surface	Vegetation (Kristensen and Jensen)	**C_1**	-	0.1-0.3	Measured	Ratio Evaporation/Transpiration	
		C_2/C_3	-	0.1-0.3		Infiltration to UZ Canopy Interception	
		Type of vegetation (LAI, Kc, RD)				Plant Transpiration	
		Degree-Day Coefficient	mm/C/d	2 or Varying with time	Physical Fixed Parameter	Discharge	2 mm/°C/d
Unsaturated Zone	**Soil**	**Hydraulic Conductivity at saturation (K_s)**	m/s	2. $10E^{-5}$	**Measured +literature**	Evaporation from Soil Root Transpiration Recharge to SZ	2. $10E^{-5}$
		Type of soil (θ_s, θ_r, K_s)	-	Loamy-Sand	**Measured**		
		α (Van Genuchten)		0.124	**Literature**		0.124
		Soil thickness	m	0-5			5
	Epikarst	**Saturated moisture content (θuz_s)**	-	0.2-0.5	**Fitting**	Recharge to SZ	0.2
		Particle Index (λ)	-	0.1-0.3	**Fitting**		0.1
		Bubbling Pressure	m	0.1-1.4			0.464
	Bypass	**Bypass portion of net rainfall (BYP)**	-	0.1-0.3	**Fitting**	Fast Recharge to SZ	0.2 (doline)
Saturated Zone	**Matrix**	Hydraulic conductivity (vertical and horizontal) (K_x, K_z)	m/s	$10E^{-5}$-$10E^{-3}$	**Fitting**	Discharge	$10E^{-4}$
	Highly conductive zone	**Hydraulic conductivity (vertical and horizontal) (K_x, K_z)**	m/s	0.1-0.5	**Fitting**		0.5

IV) Preliminary Results





V) Significance and Future Work

A- Quantitative assessment of local water resources through physically based processes

Real distributed real evapotranspiration rates and recharge spatial distribution over a semi arid karst catchment, and thereby identifying quantitatively scale parameters affecting it (e.g., soil thickness, etc…).

B- Identification of high vulnerability areas in relation to areas of recharge

Tailoring a conceptual quantitative vulnerability approach based on recharge distribution.

C- Numerical Model= Tool for predictions (forecast) for future climatic scenarios

prediction of the variation of karst spring responses for different future scenarios of climate change in semi -arid environments.

Future work

- Calibration of the model
- Sensitivity analysis of model parameters
- Quantification of model input on a zonal basis
- Transport modelling of a tracer test
- Forward simulation to test the model under different climatic constraints (based on future climatic scenarios)

References

- Doummar J., Sauter M., Geyer T., 2012. Simulation of flow processes in a large scale karst system with an integrated catchment model (Mike She) - Identification of relevant parameters influencing spring discharge. Journal of Hydrology, v. 426-427- p 112-123.
- Jukić, D., and Denić-Jukić, V., 2009. Groundwater balance estimation in karst by using a conceptual rainfall-runoff model. Journal of Hydrology, v. 373- p 302-315

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