Numerical exploration of the dynamics of infiltration in hill reservoir

Maroua Bouteffeha, Cécile Dagès, Rachida Bouhlila, Jérôme Molenat

Numerical exploration of the dynamics of nfiltration in hill-resevoir

Maroua BOUTEFFEHA[1], Cécile DAGES[2,], Jérôme MOLENAT[2] and Rachida BOUHLILA[1]

[1] Tunis El Manar University, National School of Engineering of Tunis, LMHE, 1002 Tunis Belvédère, Tunisia, [2] UMR LISAH, Université de Montpellier, INRAE, IRD, Institut Agro, AgroParisTech, Montpellier, France

contact : maroua.bouteffeha@enit.utm.tn

Introduction

Hill reservoirs are rain water-harvesting structures adopted in arid and semi-arid regions, such as North Africa, to capture and conserve runoff water and for use as alternative water resources in agricultural development. The inflows for a hill reservoir are direct rainfall and runoff (*Fig. 1*). Loses are evaporation and infiltration through the dam and the reservoir bed.

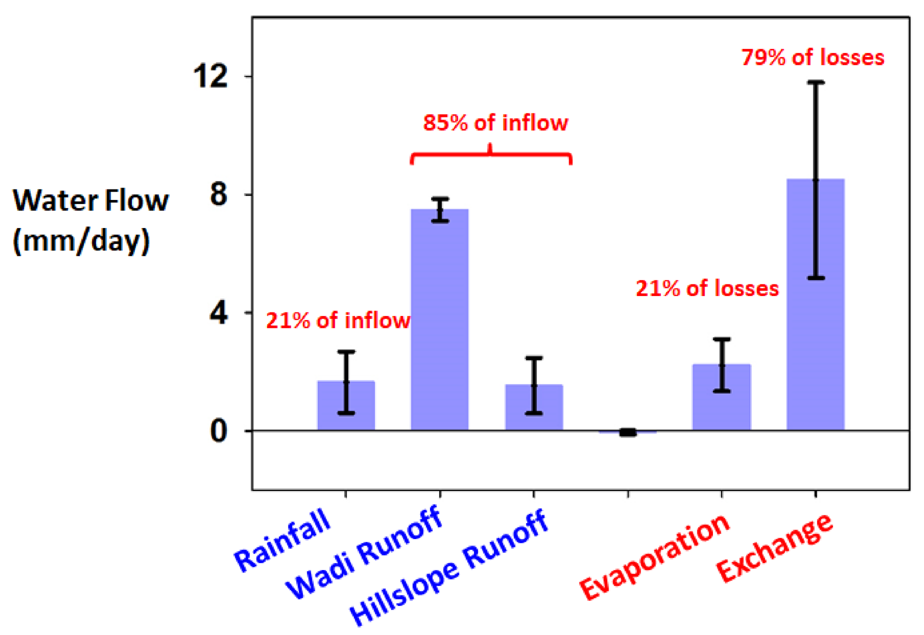

Fig.1 : Water balance of the kamech hill resevoir for 2010-2011 (Bouteffeha et al., 2015)

Evaporation was generally considered as a major reservoir loss for surface water storage structure. However, as shown by Bouteffeha et al. (2015), infiltration as a loss greatly exceeds evaporation. Knowledge of the predominant hydrological flows and their dynamics is essential in order to project for new reservoir design and also to facilitate the management of water resources, which is critical in the Mediterranean region due to the increasing scarcity of and demand for water. Knowledge of hydrological flows controlling stored volumes, especially of the surface-subsurface exchange volume remains poorly studied and insufficiently known

Aim of the study

Analyzing by a numerical exploration the dynamics of the infiltration through a hill reservoir bed according to the hydraulic conductivity and the reservoir water level variations.

Method

Data are from the Kamech catchment (Cap Bon region, Tunisia) -OMERE- (***Fig.2***). Main data are the bed

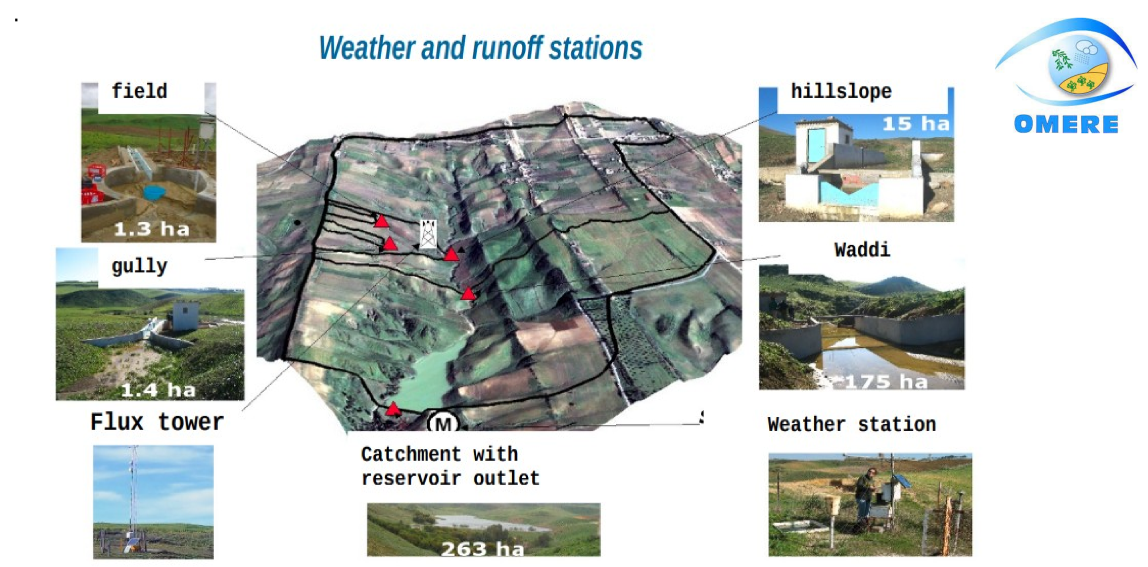

Fig. 2 : Monitoring station of the Kamech catchment (Cap Bon region, Tunisia)

Numerical exploration considers a 2D-domain representing a longitudinal cross-section of the reservoir with the underlying groundwater and uses the Hydrus 2D code (resolving Richards equation) ***(Fig. 3)***.

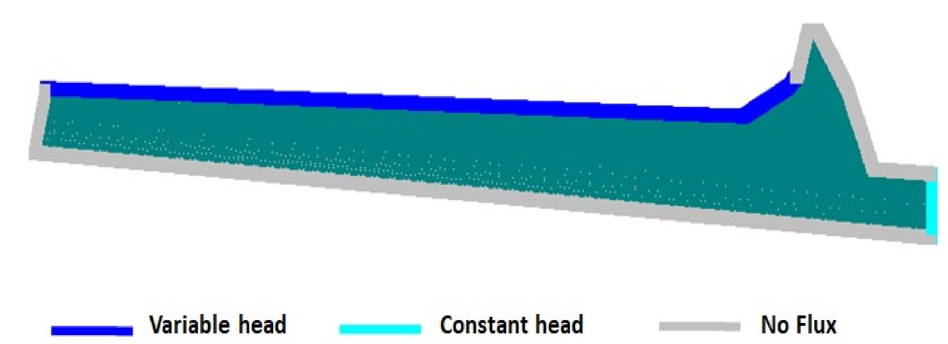

Fig. 3 : Modeled longitudinal cross-section of the reservoir with the types of boundary conditions

3 different types of water level (h) variations in the reservoir, as well as 3 values of hydraulic conductivity (Ks) of the underlying aquifer, are considered leading to 9 scenarios ***(Fig.4)***. So every one combines one value of Ks with one type of h variations.

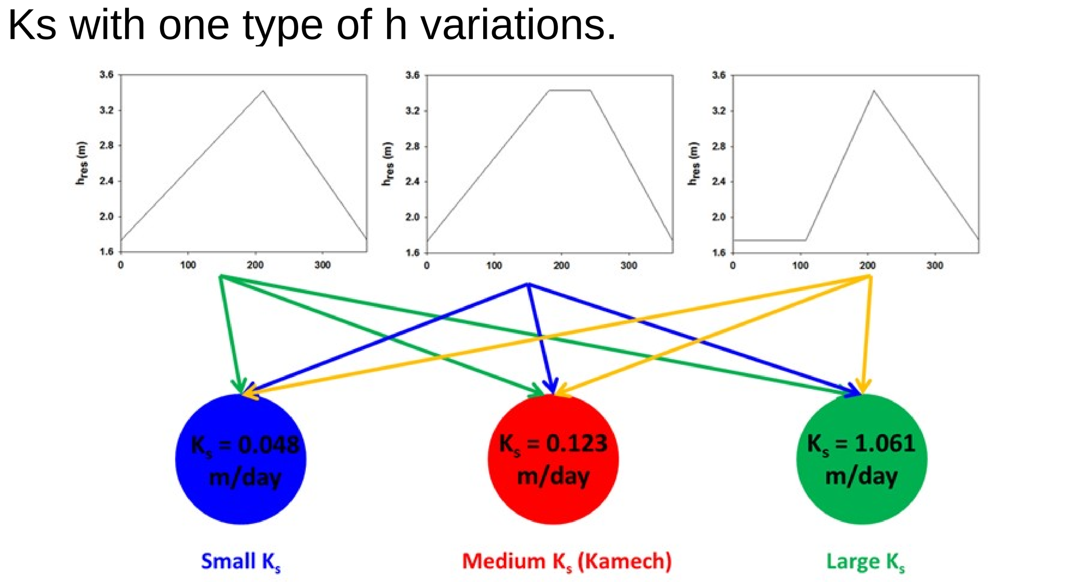

Fig. 4 : The reservoir water level variations and saturated hydraulic conductivity considered in the modelling

Results

As a validation step, the simulated monthly infiltration was compared to the estimated one (Bouteffeha et al., 2015). The fit is good for the autumn period ***(Fig.5)***.Simulation overestimates the infiltrated volume for the period from March to May, even though the simulated infiltration reproduces the large infiltration rate in March and the slow decrease from March to May.

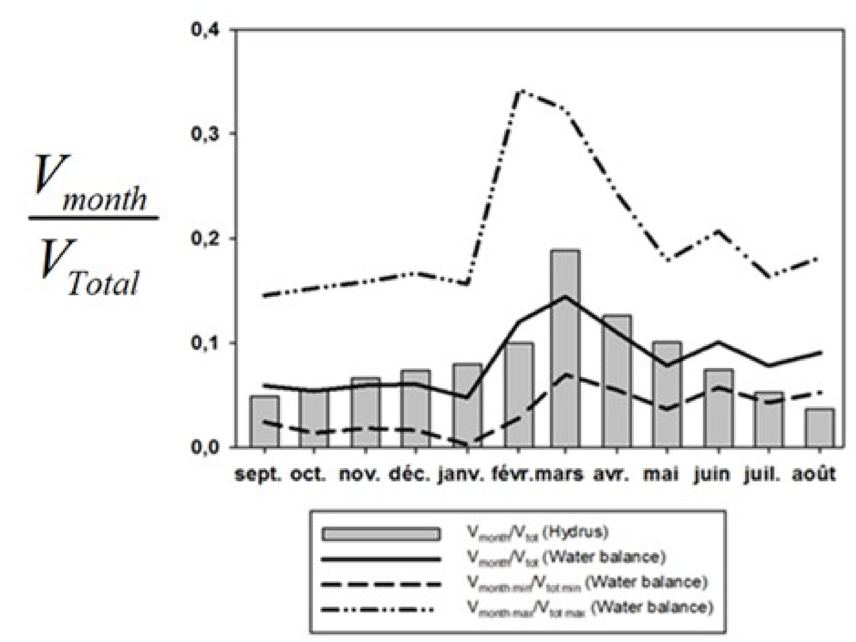

Fig. 5 : Monthly infiltration rates -simulated by Hydrus and estimated via a water balance (2010-2011)

The relationship between infiltration and the water level was hysteretic indicating different amounts of infiltration for the rising and the recession phases **(Fig. 6)**. Ks has an impact not only on the infiltration flow rate, but also on the width of the hysteresis. The width of hysteresis seems to increase with the decrease of Ks **(Fig. 7)**.

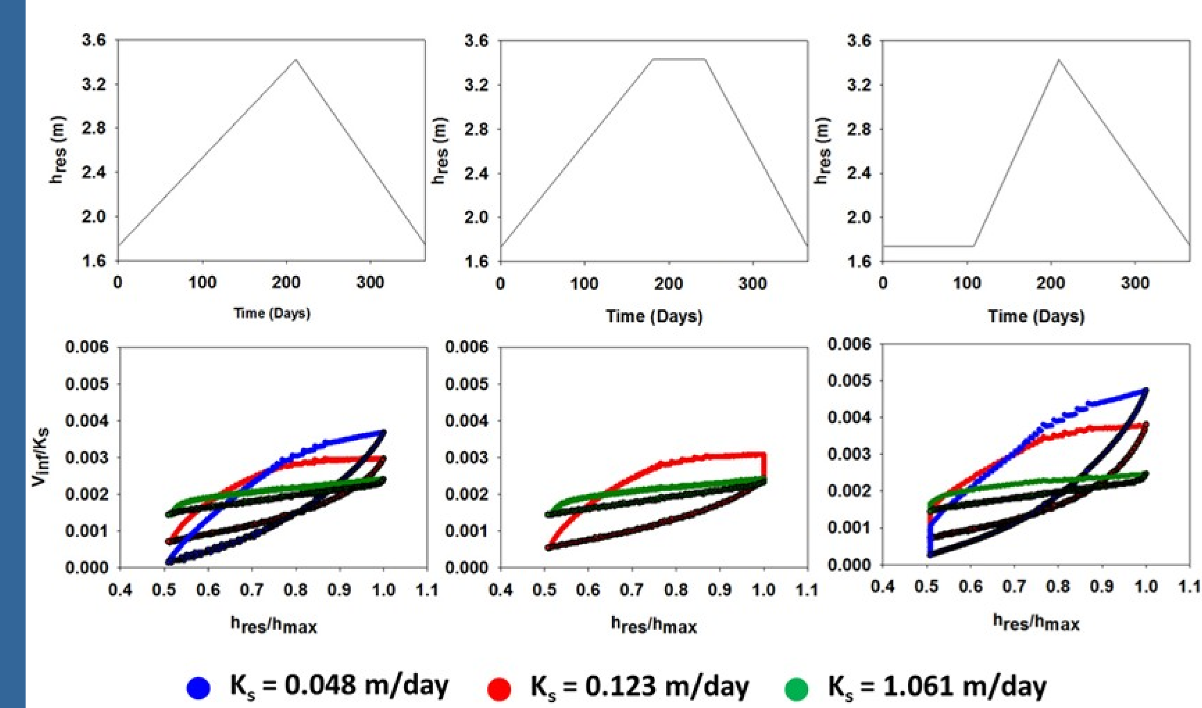

Fig. 6 : Ratio of the daily infiltration through the dam and the hydraulic conductivity

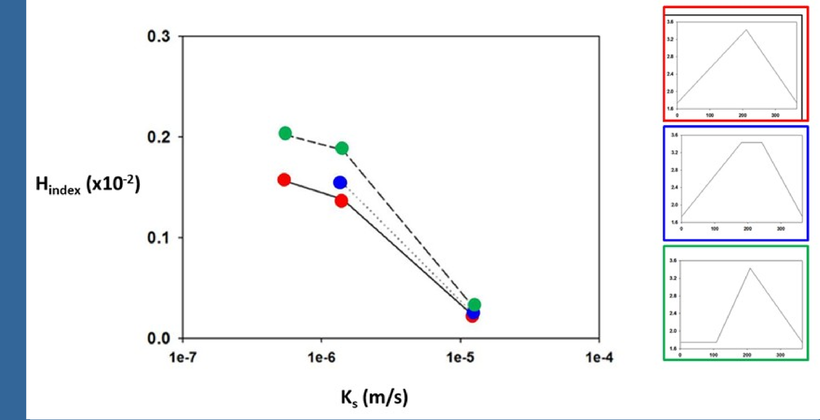

Fig. 7 : Calculated Hindex for the different scenarios

Discussion

The relationship between the infiltration and the water level in the reservoir is non unequivocal: there is an ***hysteretic pattern***. The classical linear relationship for infiltration and water level should be "revised".

The calculated Hindex emphasizes the influence of Ks on the infiltration rate from the dam and particularly on the difference of the infiltration rate for the rising and the recession phases of the water level in the reservoir. This point should be investigated in order to determine the characteristic gap between the two branches of the hysteresis based on the value of Ks.

Conclusion

- Infiltration through the dam is governed by water level variation and hydraulic conductivity of the reservoir bed
- The infiltration.vs.water level relation exhibits a hysteretic pattern
- Hysteretic pattern should further analyzed to be able to derive a priori relation between water level variations and infiltration rate

Reference

Bouteffeha M, Dagès C, Bouhlila, R and Molénat J., 2015, Hydrological Processes, DOI: 10.1002/hyp.10308

Acknowledgements

OMERE team is acknowledged for providing the data and maintaining the Kamech infrastructure. This wok is partly derived from the M. Bouteffeha PhD granted by IRD.

INRGREF International Scientific Days 2023. 10 and 11 October, 2023 - Sciences City of Tunis, Tunisia.