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Assessment of check-dam groundwater recharge with water-balance calculations

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Studies on the enhancement of groundwater recharge by check-dams in arid and semi-arid environments mainly focus on deriving water infiltration rates from the check-dam ponding areas. This is usually achieved by applying simple water balance models, more advanced models (e.g., two dimensional groundwater models) and field tests (e.g., infiltrometer test or soil pit tests). Recharge behind the check-dam can be affected by the built-up of sediment as a result of erosion in the upstream watershed area. This natural process can increase the uncertainty in the estimates of the recharged water volume, especially for water balance calculations. Few water balance field studies of individual check-dams have been presented in the literature and none of them presented associated uncertainties of their estimates. The objectives of this study are i) to assess the effect of a check-dam on groundwater recharge from an ephemeral river; and ii) to assess annual sedimentation at the check-dam during a 4-year period. The study was conducted on a check-dam in the semi-arid island of Cyprus. Field campaigns were carried out to measure water flow, water depth and check-dam topography in order to establish check-dam water height, volume, evaporation, outflow and recharge relations. Topographic surveys were repeated at the end of consecutive hydrological years to estimate the sediment built up in the reservoir area of the check dam. Also, sediment samples were collected from the check-dam reservoir area for bulk-density analyses. To quantify the groundwater recharge, a water balance model was applied at two locations: at the check-dam and corresponding reservoir area, and at a 4-km stretch of the river bed without check-dam. Results showed that a check-dam with a storage capacity of 25,000 m3 was able to recharge to the aquifer, in four years, a total of 12 million m3 out of the 42 million m3 of measured (or modelled) streamflow. Recharge from the analyzed 4-km long river section without check-dam was estimated to be 1 million m3. Upper and lower limits of prediction intervals were computed to assess the uncertainties of the results. The model was rerun with these values and resulted in recharge values of 0.4 m3 as lower and 38 million m3 as upper limit. The sediment survey in the check-dam reservoir area showed that the reservoir area was filled with 2,000 to 3,000 tons of sediment after one rainfall season. This amount of sediment corresponds to 0.2 to 2 t h-1 y-1 sediment yield at the watershed level and reduces the check-dam storage capacity by approximately 10%. Results indicate that check-dams are valuable structures for increasing groundwater resources, but special attention should be given to soil erosion occurring in the upstream area and the resulting sediment built-up in the check-dam reservoir area. This study has received funding from the EU FP7 RECARE Project (GA 603498)