



## **Limited runoff response in Mountainous Middle Eastern cities**

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The Mediterranean climate together with the type of urban setting found in mountainous Middle Eastern cities generate much lower runoff yields than previously reported and than usually estimated for urban design. In fact, a close analysis shows that most of the rainwater remains within the cities as a possible source for urban groundwater recharge. The present study examined two locales – Ramallah, an old traditional Palestinian Arab town, and Modiin, a new township in Israel – both situated on the karstic Yarkon Taninim aquifer. This aquifer supplies the only high-quality drinking water in the region (one quarter of the Israeli-Palestinian water demand), which is characterized by dense populations and limited water resources.

This paper provides the first measured information on the hydrological effects of urbanization in the area. It was found that the shift of the mountainous natural steep slopes into a series of closed-terraced homes and gardens created areas that are disconnected from the urban runoff response. Roofs drained into the attached gardens and created favorable recharge units. Mainly low-gradient roads became the principal source for urban runoff already following  $\sim 1\text{-}4$  mm of rainfall. Parallel roads converted single peak hydrographs towards multi-peak runoff responses, increasing flow duration and reducing peak discharges. The remaining urban area (public parks, natural areas, etc.) generated runoff only as a result of high-magnitude rainstorms. All of the above conditions limited urban runoff coefficients to an upper boundary of only 35%. During extreme rainstorms ( $>100\text{mm}$ ) similar runoff coefficients were measured in urban and natural catchments as a result of the limited areas contributing to runoff in the urban areas, while natural terrain does not have these artificial limits. Hence, it was found, the effects of urbanization decrease with event magnitude and there is significant potential for urban groundwater recharge. However, frequent low-magnitude rainstorms often generate highly polluted stormwater in urban sewer systems and this water should only be used with great caution.

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