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# Extended Abstracts

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title: **Estimation groundwater recharge in arid, data scarce regions; an approach as applied in the Hawashyia basins and Ghazal sub-basin (Gulf of Suez, Egypt)**

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## INTRODUCTION

Estimating groundwater recharge in arid regions is an extremely important but difficult matter, one reason for the latter being definitely the scarcity of data in arid regions. This is also true for the East Egyptian desert where along the Red Sea coast line groundwater is used for irrigation purposes in agricultural reclamation.

This paper summarizes an approach that was applied in the area of the East Egyptian desert for the estimation of runoff and ultimately groundwater recharge, despite the described scarcity of data. It is based on a rainfall–runoff relation that itself was developed on the basis of geomorphologic and hydrogeologic catchment data and uses flood marks in the catchments for the calibration of the hydrograph. For this purpose, two models, "Gerinne (=channel model)" and "Stormwater Management and Design Aid (SMADA6)" were coupled. The method was so far applied in two basins, the El Hawashia basin and the Ghazala sub-basin.

## HYDROGEOLOGICAL CHARACTERISTICS

The El Hawashia basin can be divided into three geomorphological entities, (1) the mountainous area composed essentially of Pre-Cambrian basement rock, a maximum altitude of 1019 m and steep slopes, (2) the hilly area and (3) the piedmont plain with a shallow slope. Geologically, the El Hawashyia basin is located in the West Bakr sedimentary basin that is primarily used for petroleum abstraction. It has a total catchment area of 976 km$^2$, consists of basement rock (51.2% surface outcrops), cretaceous rock (24%) and quaternary deposits. Two aquifers, one Post-Miocene and one Miocene aquifer are present in the area. The Post-Miocene deposits, which are composed of gravels and sands are represented by large thicknesses in the El Hawashyia basin ranging from 100 m in the west to 450 m in the east, i.e. at the Wadi outlet to the Red Sea. From the available, scanty data, it is known that the water table actually reflects the topography and that the aquifer is unconfined. From geoelectrical investigations it is known that the thickness of the alluvial in the main channel of El Hawashyia ranges from 80 m to 200 m. The groundwater level lies as deep as 120 m below surface towards the inner catchment and close to 20 m below surface towards the Gulf of Suez. It is assumed that rains in the upper catchment tend to result in flood hydrographs in the El Hawashyia Wadi, which recharge the Post-Miocene aquifer if the flood reaches the lower parts of the catchment, i.e. the piedmont plain with its the less slopy main channel and in succession the active alluvial fan of the catchment.

The Ghazala sub-basin contributes with 155 km$^2$ to the El Hawashiya basin and lacks the presence of cretaceous rocks. Basement rock contributes to 81% of the surface are of the sub-basin.

## RESULTS

Using the model "Gerinne", it was calculated from the flood marks at the edges of the main channels in the catchments, that a total rainfall of 25 mm must have fallen for the observed events at Ghazala sub-basin and 18 mm in the Hawashyia basin. This corresponds to a discharge of 635 m$^3$/s at El Hawashyia basin and 290 m$^3$/at Gazala sub-catchment at their outlet towards the quaternary plain. These rainfall amounts have a return period of 20 years and a probability of 5% as compared to the Hurghada climate station. For El Hawashyia basin the corresponding discharge volume that is transferred to the delta corresponds to $10.2\times10^6$ m$^3$. The infiltration

corresponds in total to 4.7 mm, i.e. 26% of the rainfall. In Ghazala sub-basin, a total runoff volume of $3.16 \times 10^6$ m$^3$ is calculated to reach the delta while 3.2 mm (13%) of the rainfall infiltrate. The difference in the infiltration percentage between El Hawashyia and Ghazal sub-basin can be matched to the difference in Geology in the two catchments, with the Ghazala sub-basin consisting with 84% of a much higher proportion of basement rocks. For an estimation of groundwater recharge, the evaporation loss should be considered which accounts on daily mean to approximately 10.4 mm/day. From archival data and from oral information from inhabitants, the time of concentration in El Hawashyia basin ranges from 12–20 hours. This matches with the calculated times of concentration of 15 hours for El Hawashyia basin and 10 hours for Ghazala sub-basin. For the studied flood events the modelling resulted in calculated evaporation losses of about 3.3 mm and 2.1 mm, i.e. with percentages of 18% of total rainfall and 8% for El Hawashyia basin and Ghazala sub-basin, respectively.


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