	Artificial Recharge of Groundwater with Stormwater as a New Water Resource
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Abstract:

Due to the existing deficit in the water resources budget in the Gaza Strip, the groundwater quality was deteriorated and salinity reached more than 1500 mg/l as chloride ion. Moreover the groundwater level declined continuously until it reached few meters below sea levels in most areas. The average annual rainfall amounts to 350 mm giving a bulk volume of rainfall fallen on the Gaza Strip amounting to 114 Mm3 every year, from which only 45 Mm3 /year is infiltrated naturally to groundwater, and the rest either evaporates or flows to the sea. Non-conventional water resources such as desalination, wastewater reuse and storm water harvesting are needed to bridge the gab in water resources budget. Desalination is faced by financial constraints in addition to problems of available power. Wastewater reuse and artificial recharge with effluent is still at early stages since the quality of the effluent does not meet the local nor international standards for either direct reuse for irrigation and artificial recharge of the aquifer. According to a pilot project operated for five years in Gaza City for recharging treated effluent to aquifer, it was found that there was negative impact on the local groundwater quality. However, storm water utilization has less potential quantities than those from desalination and effluent reuse, but it has the advantage that it is cleaner and suitable for artificial recharge of the aquifer. Urban stormwater harvesting became an important water resource that plays a significant role in enhancement of water resources management. It has a potential input of about 28 Mm3 per year as runoff, from which 22 Mm3 come from urban areas in cities only based on the existing landuse. Some large scale storm water harvesting projects were constructed in north, central and south of Gaza Strip, but there was no perfect control which hindered the function of these projects. Collection of storm water running from rooftops and yards of buildings and diverting it into local onsite artificial infiltration systems will decrease the road flooding and water quantities reached the central rainwater collection lagoons. XI Most of the scarce water countries promote rainwater harvesting system (RWH) as one of the strategic water resources due to growing demand of water. RWH is practised commonly in remote areas especially in the villages, where connecting water pipes is not economically feasible. RWH was a must for their survival and enters its efficient practice after legal regulations are set. This will need to change the procedures of issuing licences of new constructions to have RWH system in each building such as playgrounds, parks and yards. The system could be implemented as initiative behaviour of the people, since they are aware of the scarce water problem in their country. This approach should be incorporated into bye-laws for all new constructions including all residential, institutional and commercial utilities. From the socioeconomic study made in Gaza, it was noted that there has been an increasing awareness for the need of RWH and could be adopted as a new water resource. Since the people are well aware of the severe water problem, they are willing to adopt this technique in the form of onsite rooftop rainwater infiltration at their houses. However, financial incentives are needed from the local authorities to make this option successful. The onsite rooftop rainwater infiltration system is encouraged in individual houses in urban areas, where free land is available around the house. Using GIS, it was estimated that the total rainwater harvested from house roofs and open yards belong to buildings was 5.2 Mm3 , which forms 24% of the whole urban storm water in the Gaza Strip. This quantity could be artificially recharged to the aquifer through infiltration pits around the houses themselves or in the yards of schools and other public buildings. Onsite RWH was tested at one pilot concrete house located at the middle of the Gaza Strip, and the collected water quantity and quality were monitored in the rainy season 2007/2008. Quantitatively, it was found that rain runoff coefficient from roofs and yards increases with the increase of rainfall intensity and rainstorm duration. The runoff coefficient reached more than 0.9 for high intensity rain events and 0.4 for low intensity ones. Unlike the value of runoff coefficient of buildings listed in hydrology literatures for building, the runoff coefficient at the pilot concrete roof house has been weighted to have an average value of 0.74 in the monitored rainy season. To harvest XII 90% of rainwater fallen on the roofs, it is enough to construct one infiltration pit with 1.0 m diameter for every 100 m2 of the roof area without the need of storage facility. Qualitatively, the harvested rooftop stormwater runoff in Gaza has proved to be suitable for artificial recharge and close to WHO drinking water standards, where low concentrations of chloride and nitrate were found. The measured concentrations of lead, cadmium, iron, zinc, chromium, aluminum and copper were in the acceptable limits set by WHO for drinking purposes. However, relatively high concentrations of total organic carbon (TOC) were found in urban road runoff water. This can be explained by minor mixing with wastewater when sewage manholes flood to roads. The results of heavy metal analyses were also acceptable for both rooftop and road storm water. The concentrations of poisonous metals, such as cadmium and lead, were found to be close to the international, regional and local standards for artificial recharge purposes. There is no danger from the mobility of these metals in the infiltrating water, since the pH values of all the measured storm water samples were close to 7.0, under which most of the heavy metals will be either absorbed, precipitated or co-precipitated in the soil aquifer matrix through its infiltration to the groundwater.