The potential and actual urban aquifer recharge and site selection for artificial recharge using GIS and AHP methods (Case Study: Urmia urban aquifer)

Nosrat Aghazadeh[1*], Manochehr Chitsazan[2], Yahya Mirzaee[2]

1-Department of Civil Engineering-Water Resource Management, Urmia Branch, Islamic Azad University, Urmia, Iran
2-Department of Geology, Faculty of Earth Sciences, Shahid Chamran University of Ahvaz, Ahvaz, Iran

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1-Introduction

Urban aquifers are of considerable importance to the long-term viability of many cities across the world. Development of urban areas has a significant impact on the natural water cycle. Expansion of impermeable surfaces caused reduce infiltration, increase runoff volume and changes in the amount and source of aquifer recharge. On a quantitative basis, two urbanization-related processes affect groundwater recharge: i) the increase of impervious surfaces, leading to evapotranspiration reduction and runoff increase (Lerner, 1990; Paulachok, 1991) and ii) the building of water supply and sewer networks, which increase groundwater recharge rates due to leakages (del Campo et al., 2014). With the growing urbanization, land-use change is continuously influencing on the runoff and recharge parameters. Groundwater recharge is one of the most highly modified components of the hydrological cycle in urban areas.
A few studies indicate that recharge decreases in urban areas as surface sealing prevents infiltration and increases surface water runoff compared to natural landscapes (Grischek et al., 1996; Hardison et al., 2009; Rose and Peters, 2001). The methods used to estimate the groundwater recharge in urban aquifers are different. The commend methods includes, using hydrodynamic methods and groundwater flow models (Thomas and et al., 2006; Tubau and et al., 2017; Tama and et al., 2018), water budget (Kruse and et al., 2013; Minnig and et al., 2018), mass balance (Vazquez and et al., 2010; Kumar, 2011) and using experimental methods.
The purpose of this research is to estimate the aquifer recharge, to determine the suitable areas for the spread of urban flood for artificial recharge of the aquifer in Urmia. For this purpose, we construct aquifer recharge model and potential and actual recharge maps were prepared and then, based on sufficient criteria, the final map of suitable areas for urban flood spreading prepared for aquifer recharge.

2-Methodology

In this study, in order to estimate the aquifer's recharge from direct rainfall, based on the conceptual hydrogeological model of the study area, the first step was to provide the necessary information layers for the various components of the model in GIS. Then, based on the relationships between the components, the parameters of recharge were calculated, and the recharge maps prepared.
For to determine the importance of factors useful in identifying the suitable areas for urban storm water spreading, infiltration of storm water and artificial recharge of groundwater resources in Urmia city, factors in groundwater recharge such as land use, impact of aeration zone media, drainage net, depth to water table, slope, electrical conductivity, and transmissibility were determined. The AHP model was used to determine the weight coefficients of each layer. The overlap techniques were used to provide and produce the map of the suitable area for urban storm water spreading and groundwater recharge of the study areas considering weight coefficients of each layer.

3-Results and discussion

The lowest percentage of runoff formation from rainfall related to green space and agriculture land with a runoff coefficient of 0.2. The highest amount of runoff generated from industrial-commercial and roads - streets land use with 0.9 runoff coefficient. The results show that, from the total volume of 26.851 m3 of precipitation in 1995, about 21.01 m3 has been converted to runoff. The most significant amount of runoff associated with residential land use with 9.648 m3. Interflow depends mainly on the slope, porosity, storage capacity, average moisture

* nosrataghazadeh@yahoo.com

content, effective permeability, permeability anisotropy, and lateral continuity of a perching horizon. The actual recharge has changed according to different land use, and it was between 0-28 mm/y. The highest potential recharge was related to, bare land, open spaces, parks, and agricultural land and various between 4-262 mm/y. According to the calculation of recharge, total indirect recharge from drinking water network leakage, wastewater reclamation wells and agricultural return water, was about 18.92 million cubic meters.

The study of the land use change trends in the last 25 years shows that the urban area reached 52.15 km2 in 1370, with an area of about 100 km2 in 95 years.

The results show that the aquifer's recharge rate from direct infiltration of precipitation in 1370 reached 3.1 million cubic meters to 2.15 million cubic meters in 1395. Accordingly, during this time interval, due to an increase in impregnable surfaces, direct penetration has decreased by more than 40 percent .

In more than 60% of the study area, there is no possibility of flood spreading for groundwater recharge, and only in the western part of the study area can be performed artificial recharge projects. Barren and agricultural land with a slop of less than 5%, areas with high thickness of aeration zone, coarse sediment and high permeable in the suburban area are a suitable site for artificial groundwater recharge.

4-Conclusion

The result shows that due to the expansion of urban areas and the increment of impermeable surfaces, the potential of direct aquifer recharge has decreased. The most aquifer recharge is through leakage from public drinking water network, sewage wells, and irrigated water returns.

In the study area, land use, the impact of the aeration zone and drainage net are the most critical factors that affects site selection for flood spreading. Finally, the model of recharge has highlighted the need for more information about runoff estimation, interflow, unsaturated zone flow below paved areas and the role of the pipe network. The urban recharge model presented in this research can be suggestive for other urban aquifers in Iran.

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