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Prediction and estimation of Qeshm urban runoff and flood with SWMM hydrological model

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Introduction

Qeshm city is located at the end of the eastern part of Qeshm Island, which is the largest urban human settlement of Qeshm Island. Part of the neighborhoods of this city, especially the eastern areas which are also towards the coast, due to the topographic slope of the ground and also the way of human constructions, are water catchers, and after the flood rains that occur mainly in the cold half of the year, the generated runoff does not leave the surface of the neighborhood. This causes accumulation of surface water and creates a source of pollution. In order to carry out civil and structural operations to remove water from the neighborhood, the volume and flow rate of the runoff at the neighborhood level must be predicted first. Then, based on the hydrological characteristics of the neighborhood, the surface topology of the neighborhood, the slope of the bed and the surface of the streets, the direction of the slope of the neighborhood and other hydrological-physiological characteristics and land use of the neighborhood, solutions based on the disposal of surface water from the neighborhood are made; Therefore, in this research, SWMM hydrological model has been used for modeling, forecasting and disposal of surface water in Qeshm city after floods.

The movement of surface water and canals in the city is a function of the slope and the main direction of the land slope and west to east, center to north and center to south towards the sea. In low-lying coastal areas, due to the small height difference and in some cases the land surface is negative compared to the sea, surface water disposal is difficult. This problem is doubled in open sea coasts that have semi-tides, and the height of the sea water during the tides creates significant disturbances in the disposal of surface waters. The main direction of surface water disposal is from the highlands to the plains and finally it flows towards the sea in the direction of the general slope. The method of surface water disposal in Qeshm city and its roads is based on the general slope of the land. Among the areas that face the problem of surface water disposal in the city, we can mention Chabahar neighborhood and Old Bazaar. According to the findings of flood management in advanced and leading countries in the face of environmental crises, in this research, due to the flooding of the neighborhoods of Qeshm city, the main goal is to simulate the hydrological flow of Qeshm urban basins during urban floods.

Methodology

The present research has been conducted in the direction of modeling, forecasting and disposal of surface water in Qeshm city after floods by using SWMM hydrological

model. Thus, this research is considered to be an applied research in terms of its purpose and a descriptive-analytical research in terms of its nature. In this research, in order to estimate the volume of surface water in Qeshm urban sub-basins, canals and manholes when heavy rainfall of more than 50 mm occurs, it has been simulated and estimated with SWMM hydrological model. Using this model, the rate of conversion of precipitation into runoff has been calculated at the level of the neighborhoods of Qeshm city. Also, in times of flood, what is the response of the surface runoff collection network against the flood and the amount of discharge depth and water flow in urban canals and manholes are predicted.

Thus, in the current research, in order to estimate and simulate Qeshm urban flood and runoff using the SWMM model, the following steps have been performed:

1) Dividing the city of Qeshm into sub-districts based on the slope and exit route of urban runoff;

2) Drawing a map of drainage channels, manholes and the final outlet of flowing water;

3) Preparing and entering meteorological and hydrological information into the model;

4) Determining the unsustainable flow of Qeshm urban runoff;

5) Solving Horton's equation to calculate water penetration in Qeshm urban sub-areas.

Also, in this study, to determine the boundary of the Qeshm urban area, the boundaries of the basin and sub-basins were determined from the land use map and field surveys regarding the method of surface water collection, the slope of streets and alleys, as well as the use of a topographic map. In order to calculate the characteristics of the canals, field visits and note its characteristics such as the length of the pipe, the roughness coefficient, the shape of the cross-section, the width of the floor and the cross-sectional area are required. The specifications of the connections and the location of the flow of water of each sub-basin into the drainage network channels have been calculated through field visits and determination of their physiographic characteristics using ArcGIS software.

Results and Discussion

In this study, two events (2019/6/17) and (2020/1/9) were used for the SWMM model interface. In order to analyze the results from the NASH criterion, the third event (2020/4/5) was used to evaluate the model as well as to analyze the results of the error coefficient and the average square squares. The results of calibrating the model with the observed values of discharge, depth and runoff velocity with the NS and RMSE criteria indicate their appropriate compliance and the ability of the model to simulate the hydraulic behavior of floods. The output of the model showed that in the event of 70 mm of rain, 47.8 mm of it turned into runoff. This issue has created 355 million liters of water in Qeshm city, which manholes and drainage channels in residential and dense sub-areas with a reverse or very low slope, where the ground is flat and located in the eastern part of Qeshm city near the coast, do not have enough capacity to transfer the runoff. This caused the flooding of urban sub-districts. The depth of water rises from the surface of

canals and manholes in Chabahar and Old Bazar neighborhoods and spreads over the neighborhood. These neighborhoods are water catchers and water enters the neighborhood with an intensity of 9 to 10 meters per second and suddenly the water stagnates as the slope of the bed decreases. In general, the largest volume of flooding in the neighborhoods of the old texture of Qeshm city in the eastern areas has occurred in the neighborhoods of Old Market and Chabahar, where between 100 and 200 million liters of water exited the canal and entered the neighborhood; Therefore, the results of this model show that the surface water disposal system of Qeshm city, especially in the eastern areas and near the coast, needs to be improved and designed to transfer runoff caused by floods.

Conclusion

Understanding the hydraulic behavior of runoff caused by urban floods plays an important role in planning and formulating management strategies for flood control. Researchers have also used computer models such as SWMM, HEC-HMS and HEC-RAS along with geographic information system to simulate and estimate flood flow in different uses.

In the present study, the amount of urban runoff was estimated using the SWMM model, and the observed and simulated values were used in the evaluation of the model, and the results of the validation criteria indicated the acceptability of the model simulation results. The result of urban flood modeling in Qeshm indicated that dense areas and the old structure of Qeshm city, including Bazar Qadim and Chabahar neighborhoods, due to the very low slope and flat surface and even the reverse slope of the land bed, are waterlogged during floods and surface water does not leave these neighborhoods. This problem causes that manholes and drainage channels in these neighborhoods do not have enough capacity to transfer runoff during floods. With these conditions, the results of this research can be available to planners and designers of surface water management systems and urban drainage network of Qeshm.

Keyword: Runoff, Urban Flood, SWMM Hydrological Model, Qeshm City.

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References:

Persian References:

1. Akbarpour, M., Mousavi Eraghi, Sh., & Azimi, S. (2020). The role of human creativity in the sustainable development of tourism in Qeshm Island, Iranian Urbanism, 3 (4), 159-167.
2. Babaei, S., Ghazavi, R., & Erfanian, M. (2018). Urban flood simulation and prioritization of critical urban sub-catchments using SWMM model and PROMETHEE II approach. Physics and Chemistry of the Earth, Parts A/B/C, 105, 3-11.
3. Badieizadeh, S., Bahremand, A.R., Dehghani, A.A. & Nora, N. (2015). Urban flood management through surface runoff simulation using SWMM model in Gorgan city, Golestan province. Journal of Water and Soil Protection Research, Volume 22, Number 4, pp. 155-170.

4. Daliran Firouz, H., Mokhtari Khozani, F., Soltani, S., & Mousavi, S.A. (2015). Assessment of flood damage in Qamsar and Gharoud watersheds using HEC-FIA software, Science Journal Water and soil (agricultural sciences and techniques and natural resources), year 19, number 74, pp. 63-75.
5. Hataminejad, H., Asiai, M., & Goharkhah, F. (2022). Evaluation and measurement of dimensions and components of resilience of Golbahar new city against natural hazards, Iranian Urbanism, 5 (8), 150-170.
6. Heydarzadeh, M., Nohegar, A., Malekian, A., & Khurani, A. (2017). Evaluation and sensitivity analysis of the amount of runoff and drainage system in a coastal urban basin (case study: Bandar Abbas coastal city). Journal of Water and Soil Conservation Research, Volume 24, Number 3, pp. 203-218.
7. Jahan Dedeh, A., Asadi-Nilvan, A., Faraji, N., & Valion Kioj, M. (2019). Identifying types of floods as an environmental crisis and factors influencing its occurrence, 14th National Conference on Watershed Science and Engineering of Iran, 25 and 26 July 2018, Urmia University.
8. Jahanbakhsh Asal, S., Rezaei Banafsheh, M., Rostamzadeh, H., & Alinezhad, M.H. (2018). Continuous simulation of runoff precipitation in Shahrchai basin of Urmia using HEC-HMS model. Journal of Hydrogeomorphology, No. 16, pp. 101-118.
9. karimi, V., Soleimani, K., Habibnezhad Roshan, M., & Shahidi, K. (2015). Flow simulation in underground and surface sewers with EPA-SWMM model (Case study: Babolsar urban area), Watershed Management Journal, Year 6, Number 11, pp. 162-170.
10. Khalighi Sigardavi, S., Rostami Khalej, M., Mahdavi, M., and Salajegheh, A. (2015). Calibration and evaluation of the SWMM model in order to simulate urban runoff (case study: Imam Ali township, Mashhad city), Iranian Journal of Natural Resources, Volume 68, Number 3, pp. 487-498.
11. Moayeri, M., & Entezari, M. (2008). Floods and a review of floods in Isfahan Province, Geographical Landscape Quarterly, Year 3, Number 6, pp. 110-124.
12. Rahimzadeh, Z., & Habibi, M. (2018). Simulation of flood hydrograph with HEC-HMS hydrologic model and prediction of return period in Ravansar basin of Kermanshah, Geography and Development, No. 53, pp. 175-194.
13. Rashidpour, M., Soleimani, K., Shahedi, K., & Karimi, V.A. (2017). Flood simulation in the surface runoff drainage network (case study: Prince Babolsar River-Mazandaran urban watershed). Watershed Management Journal, Year 8, Number 15, pp. 213-224.
14. Taatpour, F., Khorsandi Kohanestani, Z., & Armin, M. (2019). Evaluation of the efficiency of the surface water collection and disposal network using the SWMM model (case study: Likk city, Kohgiluyeh and Boyer Ahmad provinces), Journal of Irrigation Science and Engineering, Volume 42, pp. 33-48.

Latin References:

1. Cowles, A., Willson, C., & Twilley, R. (2019). Effects of Land-Use Change (1938–2018) on Surface Runoff and Flooding in the Amite River Basin, Louisiana, USA Using Coupled 1D/2D HEC-RAS–HEC-HMS Hydrological Modeling.
2. Elliott, E., Bain, D., Shelef, E., Thomas, B., River, M., & Guy, M. (2020). Flooding in Southwestern Pennsylvania: Knowledge Gaps and Approaches.
3. EM-DAT, The international Disaster Database. (2019).
4. Garner, M., Sebastian, A., Hakkenberg, C. R., Juan, A., Gori, A., & Bedient, P. B. (2019). Integrating Annual Landsat Imagery in a Hydrologic Impact Analysis of Localized Land Use Change for a Rapidly Developing Watershed in Houston, Texas. AGUFM, H53L-1943.

5. Hua, P., Yang, W., Qi, X., Jiang, S., Xie, J., Gu, X., & Krebs, P. (2020). Evaluating the effect of urban flooding reduction strategies in response to design rainfall and low impact development. Journal of Cleaner Production, 242, 118515.
6. Jiang, L. E. I., Chen, Y., & Wang, H. (2015). Urban flood simulation based on the SWMM model. IAHS-AISH Proceedings and Reports, 368(1), pp.186-191.
7. Kabeja, C., Li, R., Guo, J., Rwabuhungu, D., Manyifika, M., Gao, Z., & Zhang, Y. (2019). The Impact of Reforestation Induced Land Cover Change (1990-2017) on Flash Flood Peak Discharge Using HEC-HMS Hydrological Model and Satellite Observations: A study in Data Scarce Tributary of Sichuan Basin, China. AGUFM, H13K-1868.
8. Kilavi, M., MacLeod, D., Ambani, M., Robbins, J., Dankers, R., Graham, R., & Todd, M. C. (2018). Extreme rainfall and flooding over central Kenya including Nairobi city during the long-rains season 2018: causes, predictability, and potential for early warning and actions. Atmosphere, 9(12), pp. 472.
9. Mohammed, M. H., Zwain, H. M., & Hassan, W. H. (2021). Modeling the impacts of climate change and flooding on sanitary sewage system using SWMM simulation: a case study. Results in Engineering, 12, 100307.
10. Schilling, K. E., Gassman, P. W., Kling, C. L., Campbell, T., Jha, M. K., Wolter, C. F., & Arnold, J. G. (2014). The potential for agricultural land use change to reduce flood risk in a large watershed. Hydrological processes, 28(8), pp. 3314-3325.
11. Shen, Y., Morsy, M. M., Huxley, C., Tahvildari, N., & Goodall, J. L. (2019). Flood risk assessment and increased resilience for coastal urban watersheds under the combined impact of storm tide and heavy rainfall. Journal of Hydrology, 579, 124159.
12. Stoleriu, C. C., Urzica, A., & Mihu-Pintilie, A. (2020). Improving flood risk map accuracy using high-density LiDAR data and the HEC-RAS river analysis system: A case study from north-eastern Romania. Journal of Flood Risk Management, 13, e12572.
13. Tang, Z., Engel, B. A., Pijanowski, B. C., & Lim, K. J. (2005). Forecasting land use change and its environmental impact at a watershed scale. Journal of environmental management, 76(1), pp. 35-45.
14. Wu, S., Jang, J., Wu, T., Lin, J., & Li, B. (2019). An evaluation of the flood diversion project d Junaidi ue to extreme rainfall event in Taipei City. In IOP Conference Series: Materials Science and Engineering (Vol. 615, No. 1, p. 012061). IOP Publishing.
15. Zeng, Z., Lai, C., Wang, Z., Chen, J., Chen, P., He, S., & Li, S. (2019). Rapid Simulation of Urban Rainstorm Flood Based on WCA2D and SWMM Model. AGUFM, H13J-1811.

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