IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A FRAMEWORK FOR STORM WATER QUANTITY AND QUALITY MODELING IN AN URBAN ENVIRONMENT

D. Allwin[1], R. Muthu Uthayan[2], S. Mathan Kumar[3]

[1, 2, 3] Department of Civil Engineering, Noorul Islam Centre for Higher Education, Kumaracoil, India

Abstract: As the predominant land use of a catchment area changes from rural to urban, the alterations to the natural surface cover are frequently radical that the provision for stormwater quantity and quality control becomes indispensable for the protection of lives and property. Hence the stormwater runoff quantity and quality modeling were carried out. The volume of stormwater runoff generated in the urbanised area for various return period was estimated using StormNET model. StormNET is a package comprising of hydrology, design of drainage network and graphic displays etc. The stormwater quantity modeling involves the computation of peak runoff, surface runoff volume and detention pond design to reduce the peak runoff. The stormwater quality modeling involves the quality characteristics of urban runoff, pollutant buildup, washoff rates and evaluating the effectiveness of Best Management Practices (BMPs) for reducing the pollutant loadings.

***Index Terms*: Urban runoff, stormNET, stormwater quantity, stormwater quality.**

I. Introduction

Urbanization and the surge in impervious surfaces typically associated with urban development have steadily been shown to result in degraded aquatic ecosystems. These effects are a function of increased stormwater runoff volumes across a watershed due to the efficient routing of stormwater of impervious surfaces and into a storm sewer system that ultimately discharges into a receiving water body. Stormwater runoff is the precipitation that has not been absorbed by the ground. Rather, it rinses over the surface of the land picking up pollutants as it travels. Stormwater runoff may gather soil particles, petroleum products, residues from industrial activities, litter, and pet waste. All of these pollutants are carried with the runoff into surface waters where they adversely impact water quality. The volume of stormwater runoff rises as natural forests and fields are traded with hard surfaces such as buildings, parking lots, driveways, and roads. Also, without any plants to interrupt the flow, stormwater moves across the land more quickly than it did under predevelopment environments. This greater, faster flow of stormwater can severely degrade receiving water bodies by accelerating erosion which primes to flooding, demolition of plant and animal life, and loss of habitat. Also, pollutants carried by stormwater impair water quality by increasing levels of nitrogen, phosphorous, suspended solids, biological oxygen demand, and chemical oxygen demand.

II. StormNET Builder

StormNET Builder is the most innovative powerful and inclusive stormwater and wastewater modeling package available for investigating and designing urban drainage systems, stormwater sewers and sanitary sewers. StormNET builder is the only model that combines complex hydrology, hydraulics and water quality in a completely graphical, easy to use interface. It is also one of the computer programs used for generating the hydrograph for single or multiple land use catchments.

III. Modeling

The stormwater quantity and quality modeling should be capable of simulating the flows and the transport of pollutants over impervious and pervious areas, through channel, pipe networks and storage. Modeling studies were done to better evaluate management options for solving the pollution problems. The modeling requires adequate representation of both the hydrologic and hydraulic behaviour of drainage systems in order to size and configure system control elements in a cost-effective manner. The modeling results should summarize the behaviour of the catchment response as a function of time and at several locations throughout the catchment. From a hydrological perspective, the estimation of runoff derived from precipitation is required. From a hydraulic perspective, the transport or routing of these flows through various drainage system elements such as conveyance devices and storage facilities is necessary. The simulation of flash flooding and stormwater infrastructure failure, which are increasing problems in urban areas can be modeled with such algorithms.

3.1 Creation of DEM

The term DEM refers to Digital Elevation Model. DEM represents the three-dimensional representation of the earth's surface. It was created to delineate the urban area into zones of overland flow, discharge and recharge. To create the DEM the data required are the study area map, reduced level and contour map. The DEM was created by using the Map Info Package.

3.2 Stormwater Quantity Modeling

Stormwater quantity modeling involves the computation of peak runoff, surface runoff volume, hydrograph generation and detention pond design.The sub-basin diagrams, flow units, sub-basin hydrograph method, time of concentration method, return period, link routing method and IDF curves are given as input for each sub basin to the StormNET. The required inputs are listed in the table 3.1.

Table 3.1 Inputs given to StormNET

Sub basin hydrograph method	Rational
Time of Concentration method	Kirpich Equation
Return Period considered	2 & 5 Years
Routing method	Hydrodynamic Routing

IV. Steps Involved in StormNET Model

The following steps are typically used in constructing a StormNET Builder model:

- Define the default options and element properties to use in the analysis model
- Draw a network representation that represents the physical elements of the study area
- Edit the properties of the elements that make up the system
- Define the analysis options
- Run the analysis
- View the analysis results.

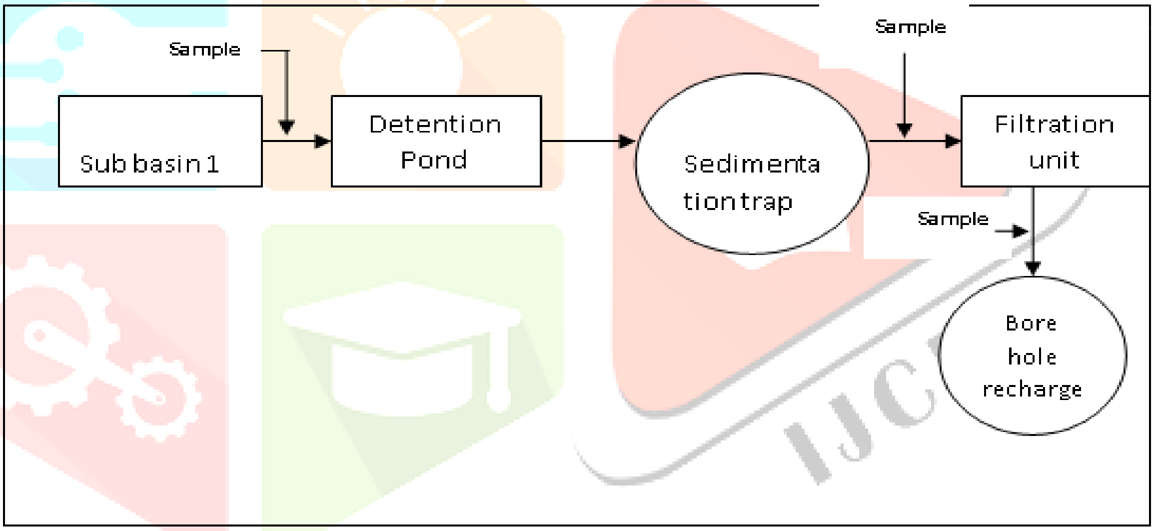

Figure 4.1: Flow Diagram for Rain Water Harvesting Structure

To characterize the urban storm water quality, the physical and chemical analysis were carried out. At sub-basin one rain water harvesting structure exists which consists of detention pond followed by sedimentation trap and filtration unit. Storm water sample was collected before sedimentation trap after sedimentation trap and after the filtration unit which is shown in figure4.1. The runoff water from the sub basin1 flows through an outlet that discharges into a detention pond then directed into sedimentation trap, filtration unit and finally into the ground through borehole recharge. The quality parameters considered were pH, Turbidity, Chloride, Sulphate, Nitrite, Phosphorus, Sodium, Potassium and Bicarbonates. Then the analyzed water quality parameters were compares with the standards. Table 4.1 shows the comparison of the physio-chemical characteristics of the stormwater samples with Indian standards.

Table 4.1: Physio-Chemical Characteristics of the Storm Water Samples with Drinking Water Standards.

S.No	Parameter	Range in samples	Mean	IS Standard	
				Desirable limit	Max. Permissible limit
1	p H	6.6 – 8.4	7.5	6.5 – 8	9.2
2	Chloride (mg/l)	10 to 15	12.5	250	1000
3	Turbidity (NTU)	21 – 93.1	57.05	5-10	25
4	Sulphate (mg/l)	16 – 28.8	22.4	200	400
5	Phosphorus (mg/l)	0.08 – 0.26	0.17	5-15	-
6	Nitrite (mg/l)	0.08 – 1.72	0.9	-	-
7	Sodium (mg/l)	34 – 42	38	40-70	-
8	Potassium (mg/l)	25 – 42	33.5	-	-
9	Bi carbonate (mg/l)	73.2 – 36.6	54.9	120	-

V. Conclusion

Historically, the management of stormwater has focused on runoff quantity primarily through control of peak runoff rates during land development to limit susceptibility to flood related damage. Recently, however considerable emphasis has also been placed on managing stormwater quality i.e., pollutant removal from stormwater prior to discharge to receiving waters. The stormwater quantity modeling involves the computation of peak runoff and surface runoff volume for 2 year and 5-year return period. StormNET model gives the good estimate of runoff magnitude and distribution in the urban area. Dealing with quantity, increase in the return period there was increase in the peak runoff and surface runoff volume. As far as quality is concerned the pollutant washoff rate gets increased when there is a increase in the return period. Increase in the percentage of BMP efficiency the pollutant there was increase in the pollutant removal. The stormwater quality modeling involves the quality characteristics of urban runoff, pollutant buildup and wash-off curves and evaluating the effectiveness of Best management practices for reducing the pollutant loadings.

References

1. Mignot, E.; Li, X.; Dewals, B. Experimental modelling of urban flooding: A review. J. Hydrol. 2019, 568, 334–342.
2. Petit-Boix, A.; Sevigné-Itoiz, E.; Rojas-Gutierrez, L.A.; Barbassa, A.P.; Josa, A.; Rieradevall, J.; Gabarrell, X.Floods and consequential life cycle assessment: Integrating flood damage into the environmental assessmentof stormwater Best Management Practices. J. Clean. Prod. 2017, 162, 601–608.
3. Burns, M.J.; Schubert, J.E.; Fletcher, T.D.; Sanders, B.F. Testing the impact of at-source stormwater managementon urban flooding through a coupling of network and overland flow models. Wires Water 2015, 2, 291–300.
4. Beaudry, M. From Nuisance to Resource: Understanding Microbial Sources of Contamination in UrbanStormwater-Impacted Bodies of Water Intended for Water Reuse Activities; University of Alberta: Edmonton, AB,Canada, 2019.
5. Hamel, P.; Daly, E.; Fletcher, T.D. Source-control stormwater management for mitigating the impacts ofurbanisation on baseflow: A review. J. Hydrol. 2013, 485, 201–211.