A Review on Surface Hydrologic Modeling

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Abstract- The purpose of this study is to estimate the rain fall – runoff process of an urban catchment by using soil water assessment tool (SWAT). If the correlation between the Mannings roughness coefficient of urban surface runoff using model developed though objective 1 to develop a distributed parameter hydrologic model capable of simulating the rainfall – runoff process of an urban catchment. In this study the work flow for developing a Green –Ampt infiltration equation based on distributed parameter hydrologic model for urban catchments.

Keywords : Rainfall-runoff, Manning roughness coefficient, soil water assessment Tools.

Index terms: Alkali – activated slag cement, Compressive strength test, Red mud, split tensile test, ultra pulse velocity.

I. INTRODUCTION

The study of water fluxes in urban watersheds has gained importance in recent years because of growing concerns about water sustainability and droughts in urban areas with subsequent economic, public-health and flooding impacts. Flooding in urban areas is a serious and growing problem. Hydrologic models are increasingly used to simulate hydrologic processes and study floods in complex watersheds. In urban areas, they are commonly used as a management tool and for designing storm water drainage infrastructure. Hydrologic models are simplified representations of hydrology, primarily used for understanding underlying processes and simulate potential scenarios. Hydrologic processes include precipitation, interception, depression storage, surface runoff, subsurface runoff, evapotranspiration, channel flow, and groundwater flow [1].

Hydrologic models are classified based on the aspect of the hydrological cycle they address e.g. rainfall-runoff models. Runoff models are the mathematical models that describe the rainfall-runoff relations of a rainfall catchment area. Runoff models can be used to predict increment in the surface runoff from an urban area due to change in factors governing the surface water flux [2].

The conceptualization of the water fluxes is essential for understanding the hydrological behavior of an urbanized catchment. Hydrologic models can simulate various fluxes (runoff) from watershed for different real and hypothetical scenarios of rainfall events. This information is vitamin understanding and devising plans to reduce floods. Further, they can also be used to analyze the capacity of the existing storm water drainage infrastructure in an urban area. Modeling of storm water runoff in urban areas is complex because of heterogeneous land cover and changing overland flow paths due to newer constructions. However, recent advances in remote sensing and computing power have resulted in increased use of distributed numerical models to understand and study floods typically, two types of hydrologic models - lumped models and distributed models, are used to model a flood. Distributed models allow the simulation of flood in 'as realistic as possible' manner Such models coupled with a long time-series of historical data that relates stream flows to measure past rainfall events are used to produce the discharge hydrographs from catchments. For example, a distributed model based on Green-Amptinfiltration equation and Continuity equation could be applied to estimate runoff from some selected attachments within the Back River watershed. Lumped models, however, are limited in their capacity to map the spatio-temporal behavior of floods in urban watersheds. They lack the capability to incorporate a variety of spatially varying data from different datasets on higher solution precipitation, soil characteristics, land use etc. A universal model applicable in all types of catchment would be difficult to create as hydrologic process varies with region and even within the same region at different times. This research aims to study urban hydrology by estimating surface runoff using an event-based distributed parameter hydrologic model. The hydrologic model is developed using combination of Green-Ampt infiltration equation, Manning's equation for shallow flows, and Continuity equation. It is used to produce discharge hydrograph at the outlet of small catchments in Baltimore. The developed model is also used to analyze the change in surface runoff volume due to land cover change [3].

II. LITERATURE REVIEW

Urban hydrologic modeling [4]

Hydrologic models are the watershed models that are used to study the rainfall-runoff relation of a watershed in connection to geography and geology. Watershed models have been extensively used from early times for flood control and drainage of storm water. Recent advances in the field of satellite technology and remote sensing, GIS and database management systems have significantly improved the ability of urban watershed models to predict urban hydrology. These improvements in urban watershed models have made them an increasingly attractive tool to manage urban water systems for public health and sanitation, flood protection and more recently, for environmental protection. Despite the advances, many important challenges in urban watershed modeling still remain unresolved. The global trend of urbanization has meant that water management paradigms have evolved from the simple objective of just securing the water supply and flood protection, to a combined management strategy of the various urban water system components i.e. water treatment, distribution, recycling, sewerage and storm drainage etc. Thus, there is a need for the newer urban watershed models to be able to address these management strategies while also ensuring that the models are reliable, usable, affordable, resilient, and, adoptable to address the uncertainties of climate change and urbanization Modern urban hydrologic models act a tool for providing an integrated water management solution.

Integrated water management strategies use a multi-dimensional approach centered on the need for water, the policy to meet the needs and management strategies. The first dimension may consist of water elements encompassing various aspects of water quantity and quality. The second dimension may consist of water uses which include agriculture, water supply, energy generation, industry etc. Other dimensions may consist of policy to balance the supply of water amongst different users. Usable water is limited in its availability and depends on the environmental systems such as atmosphere, hydrosphere, ecosphere etc. of a particular area The practice of managing environmental systems as a cohesive whole is a recent phenomenon and needs further research. Traditionally, water management strategies have lacked an integrated approach and considered all components independent of each other in a fragmented manner Development of watershed models has progressed along the same path as management.

Various models are available for different parts of the urban water system, each capable of addressing some water system components to a great detail, but lacking the capability to interact with the surrounding environment. Therefore, the focus in recent times has been more towards the development of integrated watershed models that are capable of addressing issues related to integrated water resources management.

Historical and Current practices [5]

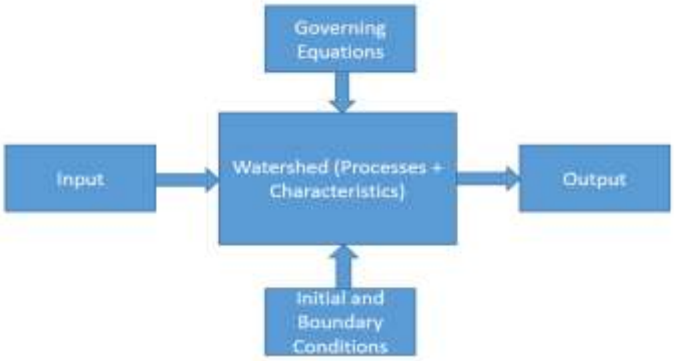
The main idea behind the development of urban watershed models was to come up with a tool that can help understand the hydrological behavior of urbanized catchments. The primary hydrological needs of urban population are availability of clean water and management of waste-water/sewage. The initial development of hydrologic models was mainly guided to address these two particular issues – drainage of excess storm water and proper evacuation of waste. As that technology related to hydrologic models grew, so did the capabilities of the models. Issues related to safety i.e. flood prediction, pollution risk assessment etc. were also addressed by the hydraulic and transport models The need for proper drainage of storm water and wastewater was felt by the people from the earliest civilizations of the Mediterranean and the Middle East. The current urban drainage practices are based on the concepts of urban drainage developed in European and American cities in the early 1800s (Delleur,2003). As urban population centers started growing in sizes, the need for more sophisticated means.

Classification of contemporary hydrologic models [6]

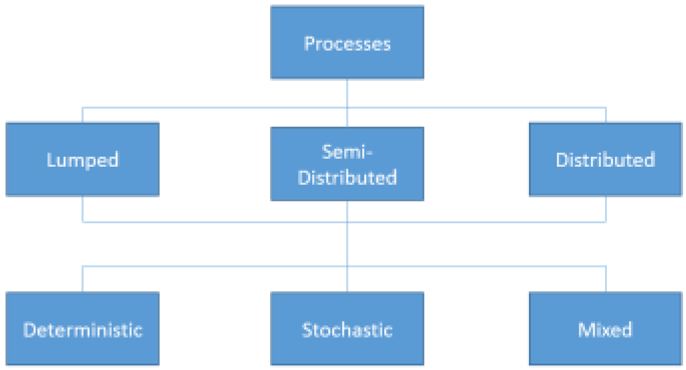
Recent hydrologic models are grouped into various categories based on the modeling approach used. Stated that watershed-scale modeling approaches are distinguished based on - the algorithm employed (empirical, conceptual, or physically-based) to develop the model, the approach used for model input or parameter specification (stochastic or deterministic), and, the spatial representation (lumped or distributed). Ever since the development of the Stanford Watershed model (1966), a number of hydrologic models have been developed (Singh, 1989). Different types of models were developed for different purposes. While many models share structural similarity, some are different. Classified the hydrologic models into different groups as follows:

Process based classification [7]

A hydrologic model has five components – 1) system (watershed) geometry, 2) input, 3)initial& boundary conditions, 4) governing equations, and 5) output as shown in figure.



Different combinations of model components are done to produce different types of models. The fifth component (output) is affected by the watershed processes and characteristics. Watershed processes include all the hydrologic process that affects the output. Based on the watershed processes and characteristics, the models are described as lumped or distributed, deterministic or stochastic, or mixed as shown in figure.



In lumped models, the watershed is delineated as a single entity and the spatial variability of the processes within it aren't taken into account. Some examples of lumped models are HYMO.

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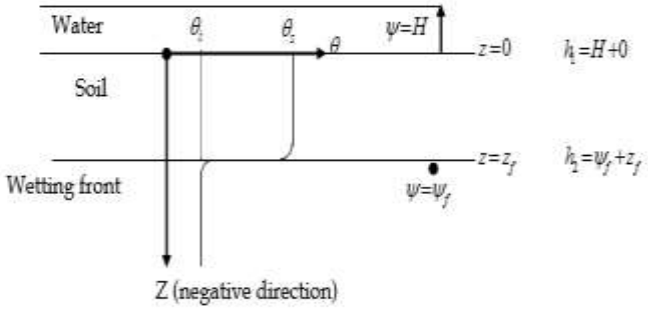

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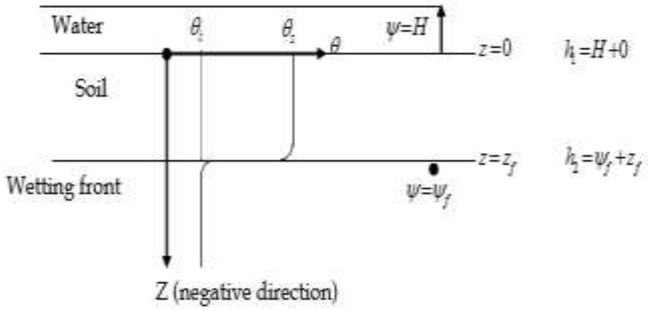

In Green Ampt method of infiltration estimation, instantaneous infiltration rate is defined as a function of hydraulic conductivity of the given soil (K) , soil suction head (ψ), and the initial amount of infiltrated water already present in the soil (ΔΘ) as given in equation (1).

$$F_t = K\left(\frac{\psi . \Delta\Theta}{Ic} + 1\right) \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where F_t is the rate of infiltration in cm/hr. at time t, Kis the effective hydraulic conductivity of the transmission zone in cm/hr., ψ is the wetting front suction head in cm, ΔΘ is the available soil moisture content and Ic is the cumulative infiltration in cm.

The advantages of the Green-Ampt infiltration model are:

1. Wetting front location can be computed because of the availability of analytical solution.
2. Soil properties can be characterized by using less numbers of parameters i.e. only two.
3. It is a widely tested infiltration model. Further, it is simple and self-sufficient to handle various field conditions.
4. "The model is sufficient to represent the soil spatial heterogeneity in a lumped manner."

Conclusion

The identification of climate change signals in Wainganga basin through statistical analysis of historical climate viriables, modeling the watershed hydrology int eh Wainganga basin physical based large scale hydrological model. The best results shall be evaluated in used SWAT. The model uses a typical structure as hydrological model (HYMO) Willian and hann 1978 for runoff-measurement. Further research will even include justification of using SWAT for land cover change.

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