OPTIMIZATION MODELING OF STORMWATER FOR URBAN AND RURAL AREAS: A CRITICAL REVIEW

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ABSTRACT-
The continuous increase in global urbanization, deforestation, and population affects the stormwater. The available water and its demand are getting imbalanced due to hasty population and climate change. Although a lot of research and development work is going on the water area, still we have a scarcity of good quality and quantity of water. The purpose of this study is to overview the work-related stormwater management and comes with findings which could be helpful to stakeholders. The methodology adopted in this work is past papers on the stormwater management is reviewed and grouped into specific categories. The groups are divided into Stormwater modeling, Best management practices (BMPs), and Challenges in Stormwater Management. It is observed that the universal degradation of water resources is due to improper stormwater management, climate change and population. Also, lack of consideration in environmental issue, institutional co-ordination problems and less percentage of research implementation. The modeling approach is not up to that mark because of insufficient hydrological data. This paper summarizes work related to stormwater, conclusions are provided based on this review, which could be useful for the researcher and society.

Keywords: Stormwater management, Sustainable development, Optimization modeling, Groundwater recharge, water pollution.

1. INTRODUCTION
The surface water flow resulting from heavy rainfall or from snow melting is called stormwater. The Stormwater management (SWM) is an Endeavour to reduce runoff volume of rainwater and other forms of precipitation. Previously, the stormwater management was mainly intended for flood control and less for water quality improvement, but now days it has to be modify for sustainable water management. The objectives of stormwater management are to prevent the runoff from mixing to landfill waste material and hence to reduce groundwater contamination and prevent erosion.
Stormwater management includes the use of berms, retention basins, grading, catch basins, and storm drainage system. The advantages of stormwater management are protection of wetlands & aquatic ecosystems, conservation of water resources and flood control. Fig. 1 Shows Hydrological cycle and runoff from land area that before and after the construction. Conventionally, stormwater was considered as unwanted water in developed areas and which is drained out. But the current global scenario is that due to huge population and climate change there is shortage of water. Also to fulfill food demands of forecasted 9.5 billion people in 2050, 60% more food will require as compares to current demand [1]. The global agriculture land which is under irrigation is affected by waterlogging and secondary salination by more than 33% [2]. So such circumstances emphasize the need of stormwater management.

Stormwater management model (SWMM) was used for urban watershed hydrology by [3]. Also, it was used as simulation model for water-quality in the world [4].

**1.1 HISTORY & OVERVIEW OF SWM**

The SWMM was developed by U.S. Environmental Protection Agency (USEPA) in 1971. The aim of SWMM software was to provide data in terms of quality and quantity of water for simulation. Since, 1971 there are six versions have been published by USEPA. The first version i.e. SWMM-I, was developed by USEPA, The university of Florida & Metcalf Eddy, it was a combine project [5]. The table no. 1 gives the details about SWMM.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Model Version</th>
<th>Year</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SWMM-I</td>
<td>1971</td>
<td>It can execute Runoff, Transportation, Storage and Discharge.</td>
</tr>
<tr>
<td>2</td>
<td>SWMM-2</td>
<td>1975</td>
<td>Applicable to Large area.</td>
</tr>
<tr>
<td>3</td>
<td>SWMM-3</td>
<td>1981</td>
<td>Used for Design &amp; Planning.</td>
</tr>
<tr>
<td>4</td>
<td>SWMM-4</td>
<td>1988</td>
<td>Improvement in Rainfall &amp; Temp. measurement.</td>
</tr>
<tr>
<td>5</td>
<td>SWMM-5</td>
<td>2005</td>
<td>Available in C language, separate graphical interface</td>
</tr>
<tr>
<td>6</td>
<td>SWMM-2.1.013</td>
<td>2018</td>
<td>Easy, available in C, Run with Windows XP.</td>
</tr>
</tbody>
</table>

![Fig 1. Hydrological cycle & Runoff (The Pocono Northeast Resource Conservation & Development, RC&D)](image)

![Fig 2. Stormwater Management Discourses (Brown, R.R. 2005).[6]](image)

Also from Fig. 2 & Fig. 3 it is clearly seen that the awareness about SWM are increasing over a decades. Now the people are very much interesting and having research work in water management.

**1.2 KNOWLEDGE GAPS & RESEARCH NEEDS**

Though the stormwater management operates in rapidly evolving advancement but still core research area will remain unanswered or needs to improve.
because of knowledge gaps and some limitations, so current SWM is needs to focus on research area like,
1) Public policies and public awareness about the environment.
2) Stormwater source reduction and pollution prevention.
4) Maintenance, levy and Cost Analysis.
5) Analysis of stormwater runoff in quality and quantity wise.
6) Stormwater impact on groundwater and surface water.
7) Education regarding water use & its treatment.

2. CURRENT SCENARIO OF STORMWATER MANAGEMENT

As we know, stormwater is the runoff of water over surface due to some reasons like impervious ground, plain topography, and saturated condition of ground. After reviewing a lot of literature it is seen that the stormwater have a negative impact on natural ecosystems. Because it carry mostly polluted water and contaminates surfaces as well groundwater sources. The rapid industrialization and urbanization are main parameters which are responsible for pollution. Also erosion, addition of hazardous waste, air pollution and land pollution are increasing day by day. So, many of researcher have recognized this problem and developed new ideas and solutions to minimize imperviousness and to increase the infiltration with some tools like rain barrel, rain gardens etc. are called Low impact Development (LID).

2.1 BEST MANAGEMENT PRACTICES (BMPS)

The Rain Barrels and Rain Gardens are the two BMPs were used [8] for stormwater management, the EPA SWMM-5 version was used to analyze performance of BMPs and the result reveals that Rain garden is better option for stormwater management. Ma et al. (2011) [9] used filtration process to treat the stormwater. In this work authors used filtration media to adsorb orthophosphate and removed the total phosphates from stormwater. The optimization of aquifers for stormwater storage studied [10]; this system helps to store as well as to recover the water with reference to climate change.

Frauke Hoss et al. 2016 [11] studied the effectiveness of best management practices for stormwater treatment as a function of runoff volume. Authors studied BMPs such that Bioretention, dry and wet ponds, porous pavement, which shows effectiveness, decreases with increases in size of storms. So authors have conclusion that BMPs are used to reduce the runoff volume.

2.2 STORMWATER MANAGEMENT MODELING

Chen and Adams (2006), [12] developed analytical urban storm water quality models based on pollutant buildup and washoff processes. For this study authors used two different types of rainfall-runoff transformations to improve model performance. The results shows that appropriately formulated rainfall-runoff transformations along with pollutant buildup and washoff processes, will able to serve as efficient tool for stormwater quality control. Predictive model for stormwater analysis was used [13] model was based on GIS platform, unit area loading method and Browne’s empirical equation. The major findings of model are in terms of estimation of quantity of runoff and contaminant load. For permeable pavement system [14 a] developed simulation model. The Low impact development (LID) module was coupled with SWMM. Shuster and Pappas (2011)[15] studied the laboratory scale simulation of urban runoff and runoff hydrograph, for this study authors made lab-scale basin setup, with artificial rainfall authors have compared the observed curve numbers with SWMM5 curve numbers. The SWMM used to analyses water quality at site, using rainfall and runoff values the model is calibrated and used to compare infiltration values with previous research values [16]. A pervious pavement system is a low impact development practice which store water in subsurface strata; an analytical equation is formulated [14b] to estimate efficiency of pavement systems. The linear programming (LP) based Integrated water resource management (IWRM) developed by [17] to upper Ipswich river basin Massachusetts. The success of any stormwater management system is depends on the drainage system and pipe networks. The quality of pipe networks is mostly depends on funds available [18] developed performance index using fuzzy to rate and analyze the system. Soil and Water Assessment Tool (SWAT) model was used by [19] to parameter uncertainty analysis; the model was used to simulate streamflow of river at Vietnam.
3. CHALLENGES IN STORMWATER MANAGEMENT

Conventionally the stormwater is considered as the cause of urban flooding but from past few decades it is observed by different water policymakers and researchers that stormwater can be an important source of water. It can be used as recharging for groundwater storage. So for current era the challenges are to reduce, reuse and recycle the stormwater with the help of different methods.

The effective implementation of stormwater management is basically depends on adaptation of urban drainage systems to that area. The problems faced during stormwater management implementation are institutional, legal, social, financial, and Cultural.

3.1 INSTITUTIONAL AND FINANCIAL BARRIERS

From the literature, it is observed that there is not a dictum in public organization with environmental issues. In most of developing country people are less aware about environmental issues. The decisions taken by competent authority are not support the sustainability and environment e.g. the use of public garden, open space for water retaining structures like detention basin are not permitted. The main reasons are lack of funds and also possibility of sewage contamination.

Also in addition to the institutional issues some issue are arise due to water policy makers, due to population, and from social activist. If we consider the detention basin as BMP, but if it is not properly maintain then it will creates unhealthy environment and that’s why the above stakeholders can oppose this practices.

So, to overcome such problems some solutions are made which are as follows,

1) By providing technical information to designers to allow collaboration of aquatic project.
2) By giving environmental education to public through social or technical events.
3) By providing such syllabus in academic will have remedial measures for such issues.

4. DISCUSSION

This study aims to have the review of stormwater management work. As we know global population is increasing day by day, and good quality water is decreasing quantity wise so there is scarcity of water. So we have to use water in optimal way to fulfill water demands. It is observed globally that water pollution is due to runoff from urban as well as rural area. The rapid urbanization results in to increase in impervious surface which cause more runoff and hence it will washout all pollutants which are present on surface. So such reasons lead to water pollution. Also due to deforestation soil erosion take place and water detention is reduced so there is less ground recharge. So on short note we can say that rapid urbanization and hasty population have made water management very challenging. To overcome such problems we can use different tools or optimization simulation methods which are described in below table no. 2.

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Tools Used</th>
<th>Use/Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SWMM</td>
<td>It can execute Runoff, Transportation, Storage and Discharge. Used for Design &amp; Planning. Applicable to Large area. Easy, available in C, Run with Windows XP.</td>
</tr>
<tr>
<td>2</td>
<td>Rain Gardens</td>
<td>Collect and slow stormwater Runoff and increase the infiltration in soil.</td>
</tr>
<tr>
<td>3</td>
<td>Grassed Swales</td>
<td>This is vegetated channels used to filter stormwater flow.</td>
</tr>
<tr>
<td>4</td>
<td>Pervious pavements</td>
<td>Used to allow and increase percolation of water in soil.</td>
</tr>
<tr>
<td>5</td>
<td>Parking lot filter strips</td>
<td>Used to remove sediments, filtration and Percolation.</td>
</tr>
<tr>
<td>6</td>
<td>Retention Basin</td>
<td>Used to slow and treat on site stormwater runoff.</td>
</tr>
<tr>
<td>7</td>
<td>Underground storage</td>
<td>Treated water is stored in underground tanks or in aquifers for future use.</td>
</tr>
<tr>
<td>8</td>
<td>Green Roofs</td>
<td>Roof with thin layer of living plants growing on its top. Used to slow, treat and store the stormwater.</td>
</tr>
<tr>
<td>9</td>
<td>Rain Barrels</td>
<td>This are sometimes called cisterns, it is surface water storage device which stores water from roof area.</td>
</tr>
</tbody>
</table>

Future research in stormwater area will be-

1) Quantifying ecosystem services with stormwater- it will help to understand the extent to which stormwater may enhance or reduce the ecosystem service or environment.
2) The integration of Engineering, Environmental and social criteria into stormwater management- This is required to identify the most appropriate and effective stormwater management infrastructure to be used for holistic development of area. Also to evaluate the coordination between this discipline to enhance the stormwater management.

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Mr. Khendad Ashish, Ms. Barure Rupali
3) The integration of stormwater management and water policy- To encourage the researcher in water area to find out social, environmental, cultural, economic, and policy benefits of stormwater management will enhance environmental related policy.

5. CONCLUSIONS
The conclusions for this study are provided on reviewing the literature in stormwater management. The major reasons which are responsible for poor and unsatisfactory stormwater management are given below:

1) The research outcomes are not completely implemented to mitigate the problems.
2) There is lack of consideration of complex problems in environmental field.
3) The co-ordination of Govt. with research institute is poor i.e. institutional issues.
4) Models like SWMM, SWOT, IWRM and programming method can improve the stormwater management, but raw data is less available for such models.
5) Best management Practices (BMPs) is best tool to improve the stormwater in quality and quantity.

6. NOMENCLATURE
BMPs - Best management Practices
SWMM- Stormwater Management model
SWOT- Soil and Water Assessment Tool
IWRM- Integrated water resource management
USEPA- United States Environmental Protection Agency
LID- Low impact development
GIS- Geographic information system

REFERENCES


