# Water Logging Menace in Metro Cities Needs a Conceptual Change in Approach for its Permanent Solution

*Mahesh Prasad* [1]

**Abstract**

**Cities in India have witnessed a colossal growth in area as well as population in last few decades. As a result, the civic facilities in cities have come under great stress. The drainage of storm water, water supply system, roads, electric supply system, waste disposal systems generally need a major augmentation. Storm water drainage due to encroachment of water bodies, abnormal increase in built up area in cities, loss of green areas, construction of flyovers and under passes has become a great area of concern. Even with a small intensity of rainfall the cities suffer water logging problems in major parts of cities causing complete disruption of normal life and functioning of utility services. The existing system needs a major revamp. Gravity flow of storm water through generally choked and silted surface drains has become a question mark. In this situation, catching the storm water in collection sumps and pumping out the storm water to nearby natural water bodies is the viable answer but this needs planning and design of entire pressure pipeline network. This paper highlights the need and certain salient issues in design of such a system.**

***Keywords :*** **Metro cities, underground reservoirs, water logging**

## I. INTRODUCTION

Onset of monsoon used to be a welcome time and a sign of happiness, and normally was being celebrated by a variety of folk songs and dances all over India, but since quite some time it is proving to be a curse due to floods in rural areas and water logging lasting for weeks, particularly in metro cities like Mumbai, Delhi, and other capital cities like Patna, Bhopal, etc.

Drainage in metro cities is generally dependent on a network of surface drains which take the run off to major nallahs, which further leads the rain water to rivers. The problem with the drain networks is that they are not only inadequately designed but are also inadequately maintained by local bodies. They get easily blocked by plastic waste, vegetation, and other waste materials thrown by citizens. Despite all efforts and expenses incurred, the conditions are found quite bad and things get exposed every time in the early spell of monsoon itself. There is political hue and cry each time but ultimately the alacrity dies down and things go into background till the next monsoon.

The second issue with the network of drains is that they have very mild and sober gradient. The flow takes place under gravity and discharge capacity of drains is low and the fail to take the peak discharge resulting in water logging here and there. The situation further gets aggravated due to local choking of drains by plastic waste and other types of waste openly disposed by public.

So it is quite clear that drainage concept of metro cities has a technical snag. Gravity flow of water through surface drain is quite slow as the available gradients of surface drains is lesser than required to ensure a self cleansing velocity in the drains and sectional area of drains are inadequate for peak period. Choking of drains further adds to the technical snag of under design in dense areas where larger size of drains is not feasible due to space constraints.

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## II. NETWORK OF PRESSURE PIPELINE AND SUMPS

The effective solution is to boost the capacity of drainage system by laying pressure pipes which don't suffer from low gradient problem and can follow the shortest routes. The discharge capacity of pressure pipes and pumping installations can be well designed to meet the peak load. The system is not affected by choking as in the case of surface drains.

The laying of pressure pipeline will need a well designed network of local collection sumps in all vulnerable localities which will be provided with a set of non-clog submersible pumps of adequate discharge capacity at required pumping head. The local sumps are required to collect rain water through feeder open drains or even through pressure pipes from nearby smaller sumps in the designed network. The network of collection sumps must be widely spread to cover the entire catchment area of the affected locality. Ideally, the location of sumps must be in low level patches in the catchment. The aggregate collection capacity of all the sumps in the zone should be equal to or more than the expected runoff caused by highest rainfall figure recorded in 24 hours in the past 5 to 10 years of metrological data. Ideally, the collective storage capacity of sumps should be designed to ensure 6 to 8 hours storage of runoff caused by highest rainfall taking place in the catchment module for which pressure pipe network is planned. The period of 6 to 8 hours is considered adequate to put the pumping system in the entire catchment in action.

The sumps catered for in the network are to be served by well designed non-clog submersible pumps, atleast two in number to serve as standby for each other. The planning and design of entire network of sumps, pipes and fittings, non-return valves, and non-clog submersible pumps is essentially required to be done in modular concept to ensure easy substitution/replacement of pumps and fitting during process of repair and maintenance of the system. The size of inventory of spares, fittings, pump sets, electrical kiosks, and switches can be kept small in case the system is designed based on the modular concept. Use of level sensors for auto operation of pumps installed can be well associated in the design of the system.

## III. SCADA SYSTEM OF CONTROL

A Supervision Control and Data Acquisition (SCADA) system is made up of both hardware devices and SCADA software that allow a user to control and monitor the operations of any network widely scattered in a large area [4].

A SCADA system can collect, monitor, and analyze data coming from the series of water collection sumps in real-time, allowing supervisors to monitor and control operations with greater visibility from a central control room without loss of time [4]. This system will ensure a hi-tech control of entire network of pressure pipeline, sumps, pumps, level sensors, electrical kiosks etc. Physical running around and communication by supervisors may be minimized as during peak rain and flooded conditions, traffic system get paralyzed. There is a possibility of power failure during water logging, therefore, standby power source provisioning needs to be well catered to in design, so that uninterrupted pumping operations could continue even in the event of power breakdown. Specialist agencies in the field of automaton are available in India to undertake design and installation of such a system on a turnkey basis.

## IV. MODULAR CONCEPT OF PLANNING

The storm water discharge network for the major cities essentially needs to be planned in a modular way in all respects to keep maintenance and operation easy and cost effective. The entire city area is to be divided in modules of 8 to 10 acres keeping in view the topography and the contour map of the city. Every module may have atleast two collection sumps located preferably at low patches. The sumps are to get storm water from individual households through laid pressure pipe network which shall be 40 to 50 mm dia GI pipes. Household booster pumps will discharge directly in the network and storm water from houses reach directly to the collection sumps from where the storm water get pumped to nearby natural water bodies or to still larger sumps in nearby location so that the water gets ultimately pumped to the river. For this purpose, adequate numbers of suitable capacity non clog submersible pumps need to be installed in the sumps. The starting and switching off of submersible pumps is to be controlled by level sensors installed in the sumps so that dry running of pumps is avoided and pumps remain submerged all the times. The entire operation of sumps and pumps and status of water level in sumps can be monitored from a central control room through an installed SCADA system. The capacities and sizes of sumps, capacity and type of submersible motors, size and type of pipes, valves and fittings, cable sizes and start up switches must be planned in a modular way to have minimum inventory of required spare parts and easy substitution and quick replacement of defective/damaged parts during operation of the system. Where gradients are available, the surface drains along roadsides need to be modified so that they discharge fully/partially into nearby sumps of the storm water network.

The so designed pressure pipe network shall exclusively be aimed to cope up with storm water during monsoon and supplement the gravity flow network of surface drains already existing in most of the old cities. The sewerage system of the city meant to carry domestic waste only must be kept separate and in no case it should be combined with the storm water drainage system.

## V. PREVAILING SCENARIO IN MAJOR CITIES

During monsoon, waterlogged roads, traffic jams, open potholes, open manhole etc. are now becoming features of cities, even metropolis like Mumbai, Delhi, Kolkata where well resourced local bodies exist and are suffering from the same syndrome. Major parts of urban area are built up, concreted or paved, which results in quick collection of entire storm water low level area on roads and the drainage system is unable to cope up with the peak load. The result is chaos due to water logging on roads, water entering into houses, shops and traffic flow getting completely paralyzed. In cities on coastline there is another factor, that is, high tide situation due to which drainage system becomes ineffective and water enters back into cities through drains. Earlier, people used to blame India's poor rain forecasting system for the lapses but now with updated weather technology, the blame now lies on the shoulders of the municipal corporations for drainage system failure. There is a common belief that 30% of problems are happening due to heavy rain. The rest 70% blame goes to human negligence. Usually, no question is raised on the tactical concepts applied in planning of storm water drainage system which is generally based on concept of gravity flow through empirically/arbitrarily designed surface drains. While the current response to urban flooding is limited to the construction of roadside drains, design standards recommended by the Central Public Health and Environmental Engineering Organisation (CPHEEO) are outdated. While CPHEEO standards recommend a design according to one or two-year flood data, drains so designed are not able to accommodate increased run-offs because of more frequent high-intensity rain and adverse affects of climate change [1].

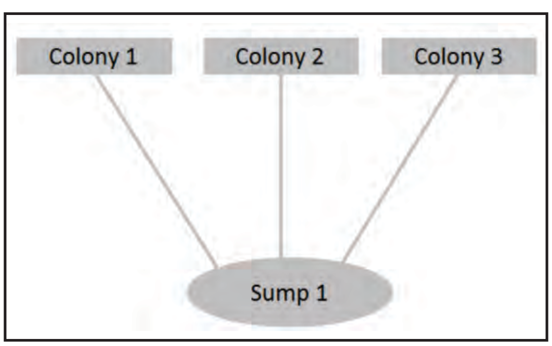


**Fig. 1. Network of collection sumps**

Urban infrastructure development missions including the Smart Cities Mission, the Swachh Bharat Mission and Atal Mission for Rejuvenation and Urban Transformation fail to provide a comprehensive vision and strategy to address issues of urban flooding [1].

## VI. CERTAIN POSITIVE ACTIONS BY STATES

Urban flooding has been taken as a serious concern across India and certain welcome steps have been taken by different state governments that are likely to have a positive impact on the scenario regarding urban storm water management.

- Mumbai launched a state-of-the-art Integrated Flood Warning System (IFLOWS) recently. The warning system helps identifying imminent floods due to high rainfall or cyclones.
- The Chennai Flood Warning System that provides spatial flood warnings for the city was launched in October 2019. These systems help build resilience and can inform the public and authorities regarding risks.
- The India Meteorological Department launched the Mausam mobile application that provides rain forecasts including warnings.

- The Karnataka government launched the Meghasandesha mobile application which provides real-time rainfall measurements, along with forecasts for rain, flooding and thunderstorms for the capital city Bengaluru.
- Delhi has prepared several multi-dimensional strategies to address the issues of urban flooding. The city was the first to have a drainage master plan, prepared by the Indian Institute of Technology, Delhi.
- The Delhi Jal Board also took up the revival of 159 water bodies in the city along with floodwater harvesting projects in the floodplains of Yamuna.
- Both Chennai and Delhi also recommended properties to implement rainwater harvesting structures as run-off control measures.
- Odisha government's housing and urban development department issued an advisory for implementing rainwater harvesting in public parks and open spaces in urban areas across the state.

While these measures look good on paper, they must be followed through by effective implementation, taking operation and maintenance and coordination with stakeholders including architects, planners, hydrologists, and groundwater experts.

## VII. SCENARIO IN MUMBAI

On July 16, 2021, a 253mm rain was recorded in 24 hours at the Santacruz observatory, which is the third-highest 24-hour rainfall in a decade. This led to 27 roads being inundated, 85 bus routes being diverted and 250 people evacuated from the Mithi river bank as the river started swelling [3]. Hind Mata area, Kurla-Matunga area were badly waterlogged. Certain areas have been identified as chronic flooding spots and low lying areas like Nana Chowk, Mumbai Central, Hindmata, Parel, and Gandhi Market remain flooded for a long time. The list is now enlarged to include areas like Lamington Road, Nair hospital, Agripada, Chinchpokli, Lalbaug, Worli Seaface, and Worli BDD Chawl were among the new water logging spots. As per BMC report, there were 115 water logging spots in the city.

Flood situation is getting aggravated due to poor co-ordination in operation of floodgates, opening and closing during high tide and low tide are not done in a coordinated manner. The drains network is 100 years old and need total redesign. Certain widening of drain was partially done, hence it is not effective.

## VIII. SCENARIO IN DELHI

According to the India Meteorological Department (IMD), the national capital recorded 139 mm rainfall, the highest one-day rain for August in the last 13 years [2]. This led to extensive water logging in several road stretches across Delhi, including near Pragati Maidan in the central part of the city and Dhaula Kuan in the southern part. Water logging and traffic jams were also seen at key road stretches, including Dhaula Kuan, Moti Bagh, ITO, Vikas Marg, Mathura Road, Pul Prahladpur, near Pragati Maidan, Mehrauli-Badarpur Road, Sarai Kale Khan, and Rohtak Road. The Delhi Metro Rail Corporation (DMRC) had to shut the entry of commuters to Saket Metro station in the afternoon due to waterlogging in the underground station.

- **Flawed Design :** The IIT Delhi report had pointed out major problems with the “dilapidated” design of the drains in the 1976 Master Plan. For example, the storm water drains in all the three major drainage basins in the city—Trans Yamuna, Barapullah, and Najafgarh basins—have the wrong slope, which takes the water away from its natural downstream flow, that is, the excess rainwater doesn't flow into the main sewage drains naturally. Therefore, it is required to be pumped back [5].

Pumps have been installed at most major water logging junctions but it is common for them to fail when most needed. A 2019 PWD report admits that many pumps in areas prone to water logging such as the Moolchand underpass, Nizamuddin subway, and Badarpur have been defective or out of order.

Another issue with Delhi Metro is that as back in 1976, Delhi's population was around 41 lakh. Forty-four years later, it is 1.7 crore (2011 census), but the drainage plan remains the same with unplanned construction further encroaching on the drains. Further, the capital's sewerage infrastructure is grossly inadequate. Excess sewage flows into the storm water drains, choking them and leading to water logging due to siltation.

As per figures given out by the state government, Delhi has 2,846 drains spread over 3,692 km managed by 11 different agencies, PWD, three (East, North, and South) municipal corporations, NDMC and Delhi Development

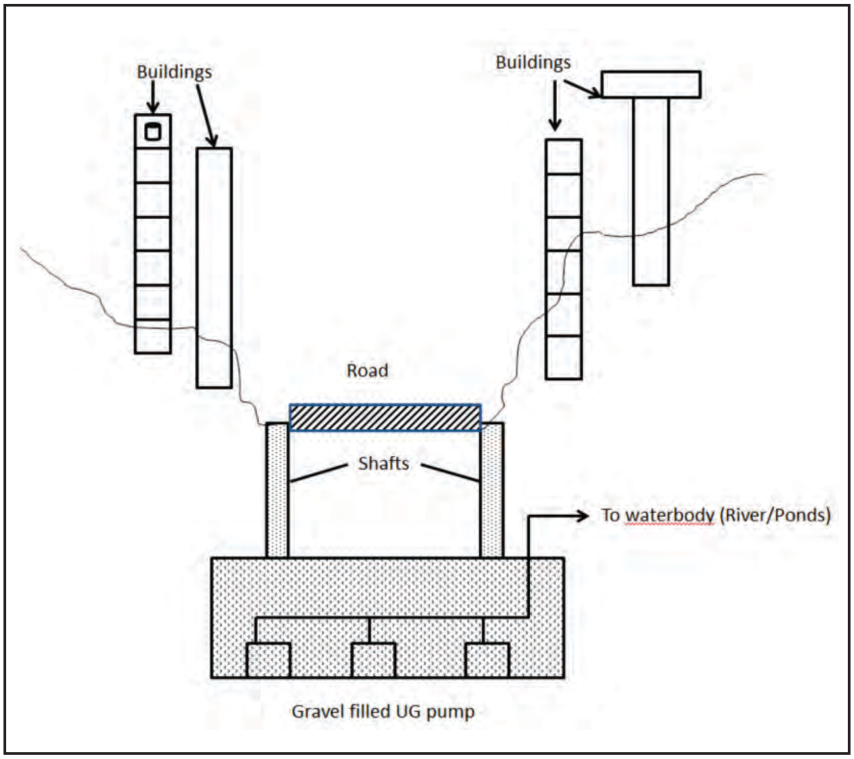


**Fig. 2. Sand Filled Storage for Rain Water**

Authority (DDA). Thus, there is also lack of coordination and fund/resource constraints with various agencies, a real hindrance.

## IX. DEEP UNDERGROUND SAND FILLED RESERVOIRS

With advancement of tunneling technology and this being getting cost effective day by day, creation of underground reservoirs with its inside surface reasonably lined with waterproof layer, located at depths to the extent of 20 to 30 meters from earth surface so that structures on ground are not structurally affected, can be a viable solution, particularly in thickly populated city centers where land is costly and not available to have surface collection sumps.

These underground reservoirs after construction need to be filled up with coarse sand and debris/gravel entirely as the construction proceeds so that it receives the storm water accumulation and retains it for atleast 24 hours in usual course. In the mean time, the storm water so accumulated inside the reservoir gets pumped out with help of a series of non-clog submersible pumps installed in porous chambers located at bottom of reservoirs. The wall of these chambers were designed in a manner that is able to stop coarse sand and gravels from having entry and getting pumped out by the installed pumps.

Such underground sand filled reservoirs are likely to prevent storm water accumulation in thickly populated posh areas in metro cities, densely built up areas having no open spaces.

It is desirable to locate the gravel/sand filled reservoirs in low level grounds in city so that water flow automatically takes place and water percolates into reservoirs easily and quickly.

## AUTHOR'S CONTRIBUTION

Mahesh Prasad worked alone on this research and preparation of the manuscript.

## CONFLICT OF INTEREST

The author certifies that he has no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter, or materials discussed in this manuscript.

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**Mahesh Prasad** completed B.E. Civil engineering in 1972, M.E. (Civil Engineering) in 1993, and MBA in 1997. He started his career as Assistant Professor (Civil Engineering) in 1972 with Department of Technical Education, Bihar. He got associated with the erstwhile Central Water and Power Commission and Flood Forecasting Division at Patna in 1975. This was the time when Patna City witnessed a historical flood due to peak flows in river Sone and the river Ganga. He worked to develop an empirical formula to forecast water levels in river Burhi Gandak, Bihar based on the rainfall data in catchment area of this river which proved to be quite effective. Thereafter served in Military Engineer Service, Min of Defence from 1976 to 2010, and retired from the post of Chief Engineer in 2010. Thereafter, he served with Military Engineer Service, Ministry of Defense from 1976 to 2010, and retired from the post of Chief Engineer in 2010. Thereafter, he remained associated with an Australian MNC firm, SMEC International as Senior Consultant, where he got associated with prestigious projects such as AIIMS in Rishikesh, ESIC Hospital in Lucknow, and Tourism Infra-Projects in Sikkim in 2016. He was empanelled in the role of National Quality Monitor (NQM) with the Ministry of Rural Development, National Rural Road Development Agency, Pradhan Mantri Gram Sadak Yojna (2017 to 2020).