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STORMWATER MANAGEMENT – A BASIC CONCEPTS

A complete well-functioning urban drainage (sewerage) is the most effective solution to the sewage and urban runoff problem. Such systems allow utilization of the most modern methods for household and commercial wastewater disposal (flushing toilets and in-sink garbage grinders), as well as rainwater. The need for cesspools, septic tanks and other on-site sewage disposal systems is therefore eliminated. A complete urban storm drainage and waste collection system can be optimally and economically developed when protection of receiving waters and their ability to assimilate wastewaters are included in the design. This paper provides background information and summary data on wastewater management in generally.

1. Introduction

Drainage systems are needed in developed urban areas because of the interaction between human activity and the natural water cycle. This interaction has two main forms: the abstraction of water from the natural cycle to provide a water supply for human life, and the covering of land with impermeable surfaces that divert rainwater away from the local natural system of drainage [1].

Urbanization and growth of megacities are not new phenomena. However, the trend of current urbanization in developing countries differs greatly from that in developed world. Gradual growth rates also enabled these cities to progressively and effectively develop the necessary infrastructure and the capacities to manage their water supply and sewerage services. The current concept of wastewater collection, treatment and discharge is based on centralized sewer systems, which were installed in municipal areas to remove all kinds of mixing polluted liquid streams from the household. In order to limit environmental pollution and to reduce the public health risks in waste and wastewater, wastewater and other waste from household are conveyed far away from residential sites as quickly as possible. To a large degree, conventional centralized sewage system could solve the problems of sanitation very efficiently [2]. This is now regarded as the standard approach in industrial wastewater treatment. Decentralized wastewater systems treat wastewater close to the source, typically providing treatment on the property of individual homes or businesses [3]. Decentralized management can be regarded as an alternative, the sustainable strategy and redevelopment of rural and urban human settlement, practically considering ecological, economical and social criteria.

2. Wastewater

Wastewater, or sewage, is one of the two major urban water-based flows that form the basis of concern for the drainage engineer. Wastewater is the main liquid waste of the community. Safe and efficient drainage of wastewater is particularly important to maintain public health (because of the high levels of potentially disease-forming micro-organisms in wastewater) and to protect the receiving water environment (due to large amounts of oxygenconsuming organic material and other pollutants in wastewater) [1].

The basic sources of wastewater are summarised in Fig. 1 and consist of [1]:

- domestic,
- non-domestic (commercial and industrial),
- infiltration/inflow.

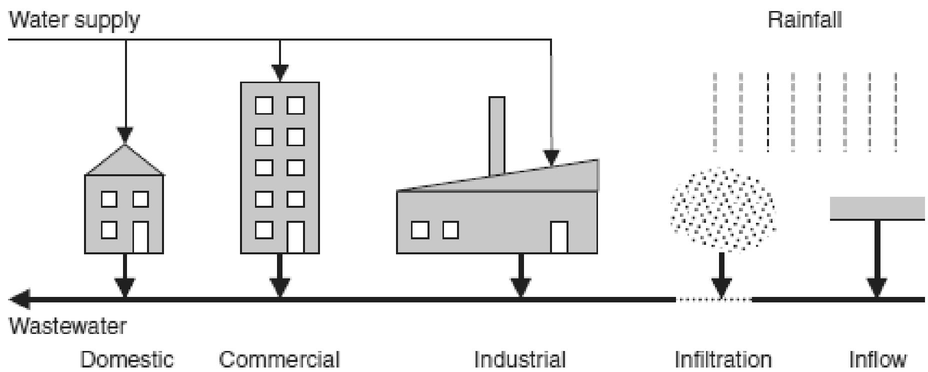

Fig. 1 Sources of wastewater

In practice, the relative importance of the components will vary with a number of factors, including [1]:

- location (climatic conditions, the availability of water and its characteristics, and individual domestic water consumption),
- diet of the population,
- presence of industrial and trade effluents,
- the type of collection system (i.e. separate or combined),
- condition of the collection system.

The following is concerned with the generation and characteristics of wastewater. It collates quantity and quality information on the various sources of wastewater and discusses their relative importance.

3. Domestic

In many networks, the domestic component of wastewater is the most important. Domestic wastewater is generated primarily from residential properties but also includes contributions from institutions (for example, schools, hospitals) and recreational facilities (such as leisure centres). In terms of flow quantity, the defining variable is domestic water consumption, which is linked to human behaviour and habits. In fact, very little water is actually consumed, or lost from the system. Instead, it is used intermittently (degrading its quality) and then discharged as wastewater [1].

Important factors affecting the magnitude of per capita water demand include the following [1]:

- Climate - climatic effects such as temperature and rainfall can significantly affect water demand. Water use tends to be greatest when it is hot and dry, due largely to increased garden watering/sprinkling and landscape irrigation.
- Demography - it has been demonstrated that household occupancy levels are important, with larger families tending to have lower per capita demand. While, at the other end of the scale, retired people have been shown to use more water than the rest of the population.
- Socio-economic factors - the greater the affluence or economic capabilities of a community, the greater the water use tends to be. There is link between water demand and economic indicators such as dwelling type or dwelling rateable value. This is due to greater ownership such as washing machines, dishwashers and power showers.
- Development type - dwelling type is important. In particular, dwellings with gardens may use more water than flats or apartments.
- Extent of metering and water conservation measures - water undertakers with metered supplies usually charge their customers based on the quantity of water used in a given period. In theory at least, metered supplies should prevent waste of water by users, reduce actual water use and therefore reduce wastewater flows.
- Quantification - water consumption per head of population is extremely varied. Approximately one third of the water in the home is used for WC flushing, one third for personal washing via the wash basin, bath and shower, and the final third for other uses such as washing-up, laundry and food/drink preparation. It is notable that only a very small percentage of this potable standard water is actually drunk.

4. Non-domestic

There are two categories [1]:

- Commercial - this category includes businesses such as shops, offices and light industrial units, and commercial establishments such as restaurants, laundries, public houses and hotels. Demand is generated by drinking, washing and sanitary facilities, but patterns of use are inevitably different to those generated by domestic usage. The toilet/urinal usage is an even more dominant component of water use (50%) than in the domestic environment. Much less detailed information is available on commercial usage than on domestic usage.
- Industrial - the component of wastewater generated by industrial processes can be important in specific situations, but is more difficult to characterise in general because of the large variety of industries. In most cases, effluents result from the following water uses: sanitary (e.g. washing, drinking, personal hygiene); processing (e.g. manufacture, waste and by-product removal, transportation); cleaning; cooling.

5. Infiltration and inflow

Unlike the other sources of wastewater, infiltration and inflow are not deliberate discharges, but occur as a consequence of the existence of a piped network. Infiltration and inflow have are defined as water that enters the sewer system through indirect and direct means respectively. Infiltration is extraneous groundwater or water from other leaking pipes that enters the sewer system through defective drains and sewers (cracks and fissures), pipe joints, couplings and manholes. Inflow is stormwater that enters separate foul sewers from illegal or misconnected yard gullies, roof downpipes or through manhole covers [1].

6. Rainwater

Rainwater is generated by rainfall, and consists of that proportion of rainfall that runs off from urban surfaces.

Concerning the proportion of evaporation, infiltration and runoff, rain water infiltration can contribute essential benefits to the harmonization of natural water balance, and also positive influence for soil, weather, fauna and vegetation. Hence, they can not only significantly reduce the peak runoff in sewers, but also reduce the size of the sewage pipes required to handle the waste stream, which is important when aging systems have to be rebuilt. In addition, the construction of retention and infiltration systems is usually more economic than the construction of technical rain water utilization system and the related construction work generally does not limit the use of space above ground, since the systems can be also installed underground [4].

Systems for rainwater collection, storage and utilization are commonly used in many countries as sources of reduced quality water to be used in a sanitary network system of buildings and for watering, among others [5].

7. Rainwater harvesting

The reasons for collecting and using rainwater for domestic use are plentiful and varied [6]:

- Increasing water needs/demands - the increased need for water results in lower groundwater tables and depleted reservoirs. Many piped water supply systems fail. The use of rainwater is a useful alternative.
- Variations in water availability - the availability of water from sources such as lakes, rivers and shallow groundwater can fluctuate strongly. Collecting and storing rainwater can provide water for domestic use in periods of water shortage. Rainwater may also provide a solution when the water quality is low or varies during the rainy season in rivers and other surface water resources (for example in Bangladesh).
- Advantage of collection and storage near the place of use - traditional sources are located at some distance from the community. Collecting and storing water close to households improves the accessibility and convenience of water supplies and has a positive impact on health. It can also strengthen a sence of ownership.
- Quality of water supplies - water supplies can become polluted either through industrial or human waste or by intrusion of minerals such as arsenic, salt or fluoride. Rainwater is generally of good quality.

When considering the possibility of using rainwater catchment systems for domestic supply, it is important to consider both the advantages and disadvantages and to compare these with other available options. Rainwater harvesting (RWH) is a popular household option as the water source is close by convenient and requires a minimum of energy to collect. Some advantages and disadvatnages are given in Table 1 [6].

An advantage for household systems is that users themselves maintain and control their systems without the need to rely on other members of the community. Since almost all roofing material is acceptable for collecting water for household purposes, worldwide many RWH systems have been implemented successfully [6].

However, RWH has some disadvantages. The main disadvantage of RWH is that one can never be sure how much rain will fall. Other disadvantages, like the relatively high investment costs and the importance of maintenance, can largely be overcome through poper design, ownership and by using as much locally available material as possible to ensure sustainability (and cost recovery). The involvement of the local private sector and local authorities can facilitate upscaling of RWH.

Tab. 1 Advantages and disadvantages of rainwater harvesting

Advantages	**Disadvantages**
Simple construction: Construction of RWH systems is simple and local people can easily be trained to build these themselves. This reduces costs and encourages more participation, ownership and sustainability at community level.	**High investment costs:** The cost of rain-water catchment systems is almost fully incurred during initial construction. Costs can be reduced by simple construction and the use of local materials.
Good Maintenance: Operation and maintenance of a household catchment system are controlled solely by the tank owner´s family. As such, this is a good alternative to poor maintenance and monitoring of a centralised piped water supply.	**Usage and maintenance:** Proper operation and regular maintenance is a very important factor that is often neglected. Regular inspection cleaning, and occasional repairs are essential for the success of a system.
Relatively good water quality: Rainwater is better than other available or traditional sources (groundwater may be unusable due to fluoride, salinity or arsenic).	**Water quality is vulnerable:** Rainwater quality may be affected by air pollution, animal or bird droppings, insects, dirt and organic matter.
Low environmental impact: Rainwater is a renewable resource and no damage is done to the environment.	**Supply is sensitive to droughts:** Occurrence of long dry spells and droughts can cause water supply problems.
Convenience at household level: It provides water at the point of consumption.	**Limited supply:** The supply is limited by the amount of rainfall and the size of the catchment area and storage reservoir.
Not affected by local geology or topography: Rainwater collection always provides an alternative wherever rain falls.	
Flexibility and adaptability of systems to suit local circumstances and budgets, including the increased availability of low-cost tanks (e.g. made of Ferro cement, plastics or stone/bricks).	

8. Collecting and storing rainwater

There are basically two types of conventional (centralized) sewerage system: a combined system in which wastewater and rainwater/stormwater flow together in the same pipe, and a separate system in which wastewater and rainwater/stormwater are kept in separate pipes [1].

In the following some of the modern methods of rainwater harvesting (decentralized) for individual houses are [7]:

- Percolation pits methods (Fig.2) - in this method of rainwater harvesting, a long bore hole is dug into the ground. When it rains water seeps into the pit.

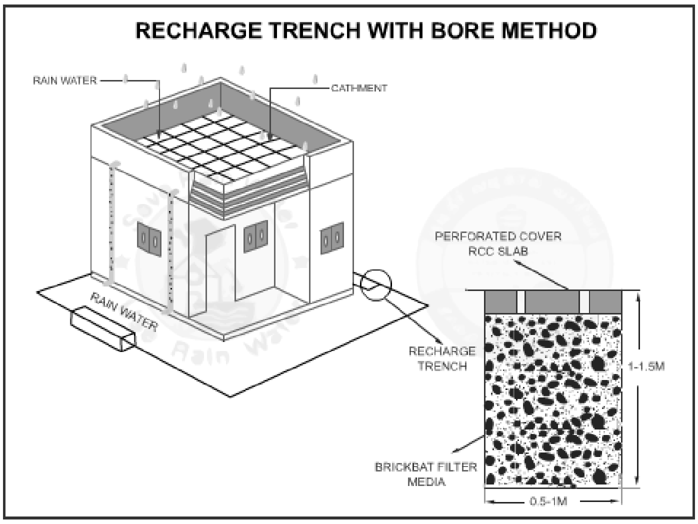

Fig. 2 Pecolation Pit [7]

- Bore well with settlement tank (Fig.3) - roof top rain water may also be diverted to a borewell; settlement / filter tank of required size has to be provided; overflow water may be diverted to a percolation pit nearby; the rate of recharge through borewell is less effective than open wells; defunct borewells may also be used.

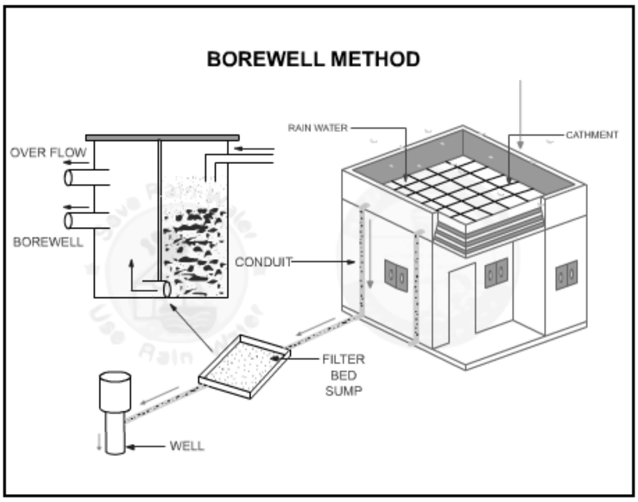

Fig. 3 Borewell method [7]

- Open well method with filter bed sump (Fig.4) - rainwater from the terrace is diverted to the existing open well using PVC pipes through a filter chamber. The minimum size of the filter chamber is 2" x 2" x 2" filled with broken bricks in the bottom and sand on the top. The chamber may be covered with RCC slab.
- RWH in grouped houses (flat) - is the modern methods of rainwater harvesting for grouped houses. It utilise the open well if any, within the complex to divert the rainwater from the terrace into it. If not, construct a well for this purpose. The rainwater falling on the open space around the complex can be collected near the gate by providing a gutter with perforated lid. The collected water can be led through necessary piping arrangements into a recharge well of 1 metre dia and 5 metre deep.

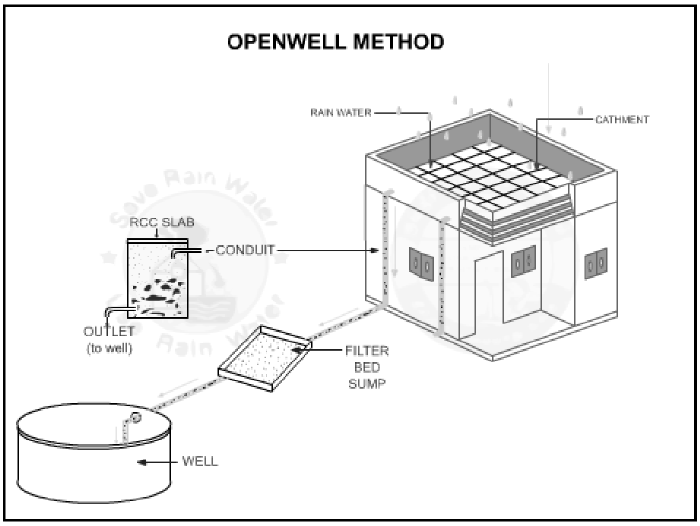

Fig. 4 Open well method [7]

Whilst centralized systems are necessary in densely populated urban areas, precedence is normally given to appropriate decentralized facilities in semi-urban areas. The essential advantage of such non-centralized systems is their flexibility and they can adapt easily to the local conditions of the urban area as well as grow with community as its population increases. The reduction of size and length of sewers can also contribute to the investment and maintenance cost. Also, neighbourhoods can become involved in the construction and operation of their own sanitation systems, thus mitigate the burden on the governmental finance and increasing the system suitability [2].

9. Conclusion

Wastewater, is water that has been supplied to support life, maintain a standard of living and satisfy the needs of industry. After use, if not drained properly, it could cause pollution and create health risks. Wastewater contains dissolved material, fine solids and larger solids, originating from WCs, from washing of various sorts, from industry and from other water uses. In many urban areas, drainage is based on a completely artificial system of sewers: pipes and structures that collect and dispose of this water. In contrast, isolated or low-income communities normally have no main drainage. Wastewater is treated locally (or not at all) and stormwater is drained naturally into the ground.

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STORMWATER MANAGEMENT – A BASIC CONCEPTS

Summary

The paper presents the basic concepts of wasterwater – domestic, non-domestic as well as rainwater. The concept of drainage in cities, which aims to mitigate the impact of urbanization on the hydrological regime of the country and on aquatic ecosystems, come from our experiences and knowledge of current method of sewerage. New concept of capture and use water from surface run-off provides a platform for a new technical and non-technical measures, both in drained on each property, as well as the public part of urban drainage area.