Drainage Design for Water Quality Management: Overview

Saju Kumar L.
Lecturer in Civil Engineering, Govt. Polytechnic College, Adoor, Kerala, India

ABSTRACT
Hydrodynamic and chemical models that model the movement and movement of water and chemical components from infiltration to drainage discharge should now be used in drainage planning. Before taking action to control the amount and quality of drainage output, management should be able to work with the models. Sustainability concerns are not addressed by the traditional drainage design method. Going forward, a different strategy that makes use of green infrastructures is advised. Apart from the flood and flow control offered by traditional techniques, green infrastructures can also result in increased groundwater recharge and amenity value. The new strategy does not have the software or technical references to back it up like the old method had. In the framework of cities' and regions' sustainable development, monitoring water supply and drainage design models is a crucial duty. Climate change and population growth make efficient management of water resources essential. Design models are monitored to make sure they adjust to changing circumstances and to assist determine the projects' strengths and weaknesses. Numerous issues, including inadequate efficiency, instability in response to changing conditions, and technological advances constraints, may plague current water supply and drainage design models. It is critical to look into these issues and create tools and monitoring techniques that will enhance the caliber of project design and execution. We will talk about it in this paper. Designing Drains to Manage Water Quality.

Keywords: *Drainage Design, Water Quality Management, Hydrodynamic, Chemical Models, Surface Water, Sustainable Drainage Systems, Slow Runoff Down, Pipe Sizes, Layouts, Sewerage Systems, Manhole Locations.*

INTRODUCTION
After air, water is one of the most fundamental elements of our environment. Water resources are essential to human culture and civilization. Early human settlements were always found by the banks of rivers. With a huge population and a rapid rate of growth, India is a country where the government finds it extremely challenging to ensure a sufficient supply of drinking water given its limited resources. Safe drinking water is one of the most fundamental human necessities that India has failed to provide for all of its population in more than 50 years of political independence and economic growth. The majority of people without access to clean water live in rural areas.

Designing drainage systems is a crucial component of civil engineering and city planning. Controlling surface water levels is the main objective in order to prevent flooding, soil erosion, and waterlogging. A well-designed drainage system that effectively eliminates overflow water can benefit highways, residential areas, industries, and agricultural regions. Consequently, people are kept secure and infrastructure is safeguarded. [1]

The most accessible and contaminated water in many nations is surface water, which includes streams, rivers, wetlands, lakes, estuaries, and coastlines. Surface water is also essential for human life and industrial activity. Monitoring efforts can aid in the comprehension, preservation, and enhancement of aquatic environments, and the analysis of water quality data can help to measure environmental changes and provide best management practices for well-informed decision-making. Because it gathers data on the conditions of water systems, the water quality monitoring network (WQMN) is therefore essential to controlling and safeguarding the water environment.

The Importance of Drainage System Design
Making sure the drainage system diverts water away from your house or place of business is one of the most important design considerations. It can result in

permanent damage if the water is not diverted away from the property. For this reason, it's crucial to make sure you execute the concept accurately.

Making sure all drains are at the right height to avoid flood hazards or other surface problems is another component of a well-designed drainage system.

Additionally, the correct operation of your septic tank depends on the design of your drainage system. If the drainage system is not set up properly, the tank may overflow and back up, which could result in serious issues like the water supply on your property becoming contaminated.

Sustainable Drainage

By balancing the various opportunities and difficulties that affect urban planning and community development, drainage systems may support sustainable development and enhance the areas where we live, work, and play.

Sustainable Drainage Systems (SuDS) are methods of managing surface water that consider biodiversity (plants and animals), water quality (pollution), water quantity (flooding), and amenity.

SuDS typically control rainfall near its source by imitating nature. SuDS can be used to allow water to soak (infiltrate) into the ground or evaporate from surface water and evaporate or transpire from vegetation (evapotranspiration). They can also be designed to transport (convey) surface water and slow down (attenuate) runoff before it enters watercourses. [2]

To create a thorough drainage layout on a site plan, detailed drainage design can incorporate the following elements:

Foul drainage

- Pipe sizes, layouts and connections to existing sewerage systems;
- Manhole locations;
- Connections to private systems;
- Suitability of septic tanks, package treatment plants, pumping stations;
- Liaison with sewerage operator for adoption;
- Liaison with Environment Agency (EA), Natural Resources Wales (NRW), or Scottish Environment Protection Agency (SEPA) for discharge consent; and

Surface Water Drainage Systems

- Pipe sizes, layouts and connections to existing systems;
- Suitability and viability of soak ways/other focused infiltration SuDS features;
- Alternative sustainable solutions, such as discharge offsite to surface water or public sewer;
- Details of how rainwater harvesting might be incorporated;
- Flow control specification;
- Oil interceptors for commercial developments /car parks;
- Connections to existing systems;
- Adoption liaison;
- Details of discharges to watercourses and outfall design, including liaison with the Environment Agency;
- Interface with headwalls and culverts; and

Verification of the plans for the drainage system's ongoing operation and maintenance is typically incorporated into the design as part of a management and maintenance plan. The comprehensive drainage design plans also include standard information of the suggested SuDS features that will be utilized in the development. [3]

Review of Literature:

In order to build urban drainage systems, it is frequently necessary to examine various types of rainfall in order to meet various drainage design criteria and receiving water usage objectives. Different parts of the long-term rainfall record can be used to address these various (and frequently incompatible) stormwater drainage system goals. The necessity of looking at a variety of rain events for drainage design has also been examined in a number of historical analyses (Heaney et al., 1977). However, in the past, long-term evaluations were severely limited by the absence of effective computing resources. Nowadays, there are a lot more computer resources available, and they can do far more thorough investigations. [4]

Reexamining some of the basic assumptions of urban hydrological modeling is also required, in addition to having more effective computational resources (Pitt 1987). For significant "design" storms, the majority of the urban hydrology techniques currently employed for drainage design have proven effective. Clearly, the most important goal of urban drainage is to protect urban areas from excessive floods and the damages that come with it. However, the provision of urban drainage systems that also reduce other issues related to urban stormwater is now feasible (and mandated by law in many places). A more comprehensive approach to drainage planning and the application of hydrological techniques with various assumptions and simplifications are necessary to meet this wider range of urban drainage goals. [5]

Renowned specialists from across the nation conducted a number of studies on drainage and water management. Five Year Plans and Rural Water Supply in India: A Critical Analysis was the subject of a study conducted by Brij Pal (2012). In this study, he examined the evolution of rural water delivery in ancient India and briefly covered the recommendations made by several committees. An effort was made to draw attention to the distribution of funds under the several Five-Year Plans. He concluded from his study of rural water supply and sanitation policies and programs that the government had made a real attempt to address these issues. Although more funding was allocated under the Five-Year Plans, overall operational success was only moderate. [6]

Initially identified as a concern in California (SJVDP 1990), the discharge of saline subsurface drainage water carrying potentially harmful metals was later detected elsewhere in western irrigated agriculture. New management techniques and irrigation technologies are therefore being developed to lessen the amount of drainage that needs to be disposed of. When managed water application based on modeled evapotranspiration significantly decreased drainage flows, the relationship between irrigation water management and drainage volumes or flows became clear. Reduced drain water volumes were roughly correlated with a decrease in salt mass discharge as well. [7]

Objectives:

- Evaluate alternative drainage designs, drainage conservation practices, soil and crop management practices, and overall drainage management to reduce nutrient loss from drained farmland.
- To integrate the framework with common drainage design software platforms.
- To promote a well-balanced design philosophy for drainage considering water quantity, quality as well as amenity.

Research Methodology:

The overall design of this study was exploratory. The research paper is an effort that is based on secondary data that was gathered from credible publications, the internet, articles, textbooks, and newspapers. The study's research design is primarily descriptive in nature.

Result and Discussion:

Drainage Design:

Roads have an impact on the natural surface and subsurface drainage patterns of a watershed or a single hillslope. The basic purpose of road drainage design is to reduce or eliminate the energy released by flowing water.

The importance of providing adequate drainage in road design cannot be overstated. Excessive moisture or water will have a negative impact on the engineering properties of the materials used to build the roadway.

A road's location, design, and construction all depend on hydrology and hillslope geomorphology. Road drainage and, eventually, road stability are impacted by slope morphology. A slope's shape (uniform, convex, or concave), gradient, length, stream drainage features (braided, dendritic), depth to bedrock, bedrock properties (fractured, hard, or bedded), and soil texture and permeability are all significant aspects. The slope shape (Figure 1) indicates the concentration or dispersion of water on the surface and below. Wide ridges and other convex slopes will tend to spread water as it descends. Straight slopes help to build up hydrostatic pressure by concentrating water on the lower slopes. Usually, concave slopes have draws and swales. Since the water in these places is concentrated at the slope's lowest point, it is the least desirable place for a road. [8]

The number of stream crossings, side slope, and moisture regime are hydrologic parameters to take into account when locating roadways. For instance, only one or two stream crossings might be necessary at the slope's lowest point. Similarly, side slopes typically require less excavation because they are not as steep. However, because water gathered from top points on the slope would concentrate in the lower positions, side cast fills and drainage requirements will demand particular consideration. Because of the superior soil moisture conditions found on the upper third of a slope, roads constructed there are typically more stable than those constructed on the lower third.

Generally speaking, a hillslope's natural drainage features shouldn't be altered. For instance, in order to collect and move runoff, a drainage network will enlarge to accommodate the tiniest depression and draw during a storm. Therefore, to avoid interfering with stormflow's natural disposition, a culvert ought to be installed in each draw. Culverts ought to be positioned parallel to the channel's centerline and at grade. Soils above and below the culvert frequently erode excessively as a result of failure to do this. Additionally, debris cannot flow freely through the culvert, which hinders flow and frequently results in the road prism being completely destroyed. Since it is widely believed that the measurable flows cannot be produced from the moisture gathering area above the crossings, headwater streams are especially concerning (point A, Figure 2). Road crossings in these locations, particularly those situated on convex slope breaks, are known for producing significant slide and debris torrents due to inadequate or nonexistent drainage.

Points A and B increase the likelihood of road failures. Water will either flow downslope through the roadside ditch to point B or pond above the road fill at point A. Ponding at A could erode and/or damage the subgrade. Water and debris will flow to point A and from point A to point B if the culvert on Stream 1 plugs. As a result, all three streams' discharge is handled by the culvert at B. It is unlikely that the ditch or the culvert at point B will be able to effectively discharge flow and debris from all three streams if it is designed to minimum requirements. This could lead to overflow and potential road failure at point B. [9]

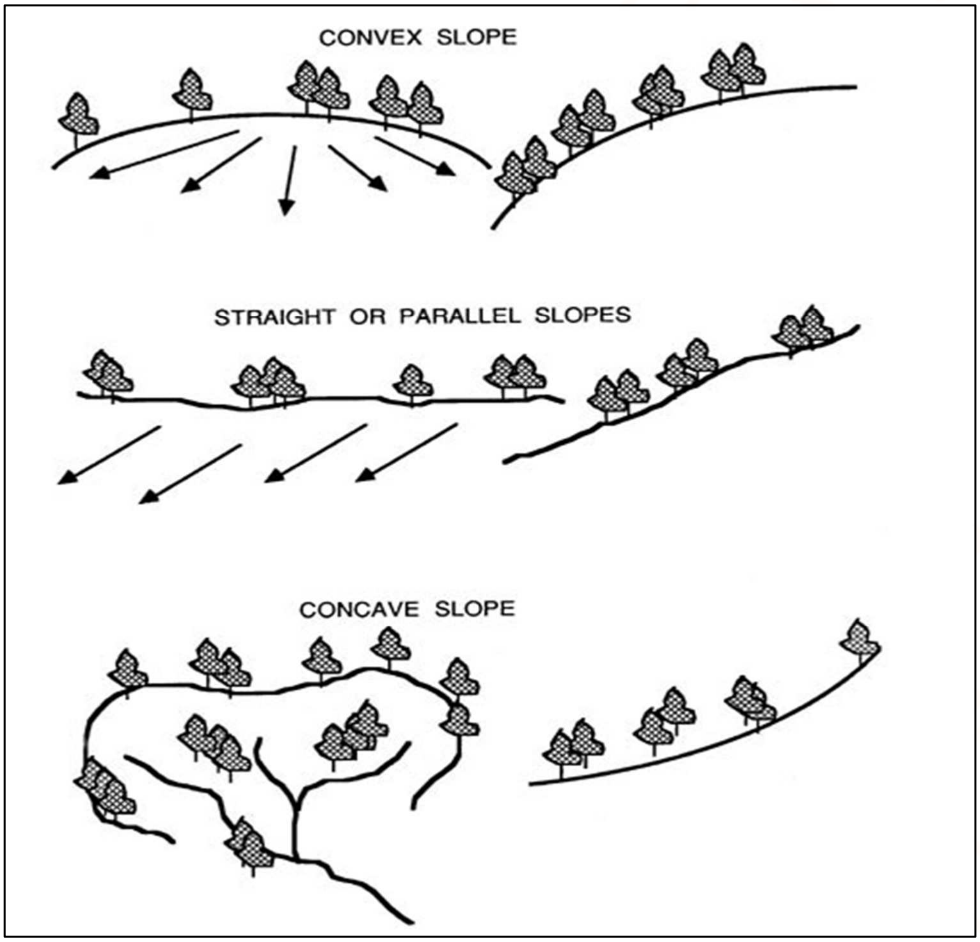

Figure 1. Slope shape and its impact on slope hydrology. Slope shape determines whether water is dispersed or concentrated. (US Forest Service, 1979).

For a road drainage system to be functional for the duration of its design life, it must meet two primary requirements:
It must permit the least amount of disruption to the natural drainage pattern.

In order to avoid excessive water accumulation in unstable places and consequent erosion downstream, it must disperse surface and subsurface water away from the roadway.

The sciences of hydrology and hydraulics—the former studying the occurrence and form of water in the natural environment (precipitation, streamflow, soil moisture, etc.) and the latter studying the engineering properties of fluids in motion—are the foundation for the construction of drainage infrastructure.

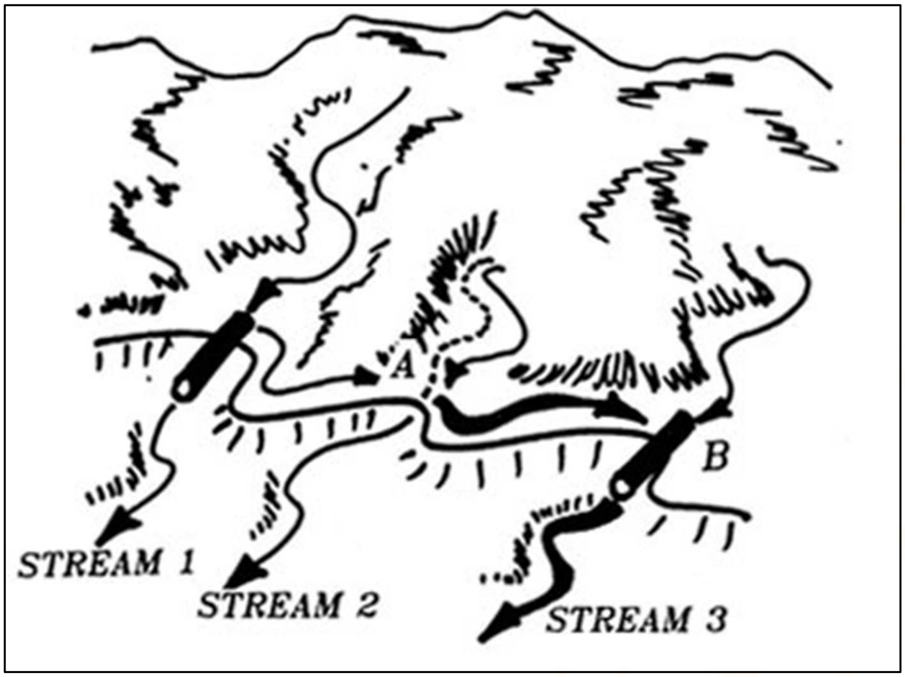

Figure 2. Ephemeral streams 2 and 3 have altered drainage patterns at culvert and road locations. A and B turn become possible places for failure. Because of insufficient drainage at A, stream 3 must take in more water below B. (Source: https://www.fao.org/)

Conveyance and drainage network capacity used to be the main design requirements. To ascertain the ideal size and slope of subterranean drainage infrastructures, such as pipelines and storages, necessary to provide adequate capacity and conveyance, the drainage industry mostly relied on regulations, technical guidelines, and best practice examples. In the Wallingford Procedures, HR Wallingford (1981) initially outlined the iterative process for this reason. The drainage sector and government in the United Kingdom had praised the effective processes. Decision-makers, particularly drainage engineers and planners, found the methodical approach intriguing. Early in the 1980s, related computer software packages were made available, and in order to improve productivity, the majority of laborious jobs were automated. Computer-aided pipe and storage design became the industry standard following years of practice and improvement. Long-term sustainability concerns were not taken into account as important design criteria in the old method, despite years of success. In the past, this strategy was valid and widely accepted; nevertheless, going forward, we must take sustainability into account. Stakeholders and the general public are being advised to adopt an alternate strategy that combines green infrastructures (such as ponds, swales, and wetlands) with grey infrastructures (such as pipes and storage). Examples of conventional and sustainable drainage systems that are frequently found in the UK are shown in Figure 3 below.

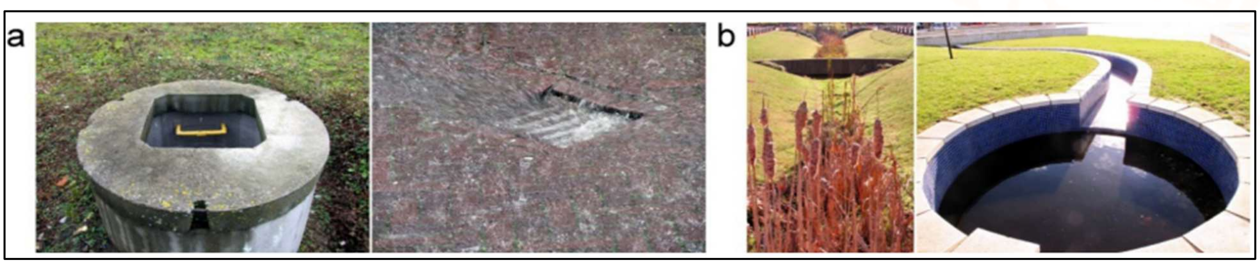

Figure 3: (a) Traditional drainage systems; (b) Sustainable drainage systems. (Photo's courtesy of Micro Drainage Limited.)

The primary benefit of the sustainable strategy is the extra advantages it offers, including energy savings, runoff reduction, natural groundwater recharge, and environmental enhancement. [10]

Sustainable Drainage:

SuDS are more environmentally friendly than conventional drainage techniques because they

- Control hard surface runoff volumes and flow rates to lessen the effect of urbanization on flooding.
- Give people the chance to use runoff where it falls.
- Preserve or improve water quality by lowering runoff pollutants.
- Preserve watercourses' natural flow patterns.
- have empathy for the local community's needs and the environment.
- Make urban watercourses a desirable habitat for wildlife.
- Give surface water and vegetation the chance to evapotranspirate.
- Promote aquifer and groundwater recharge naturally (where appropriate)
- Improve the areas where people live, work, and play.

Urbanization decreases a catchment's permeability and increases surface water runoff, as shown in Figure 4. As a result, there are less chances for natural water management, which increases the risk of contamination and localized flooding when the piped systems are unable to handle rainfall. [11]

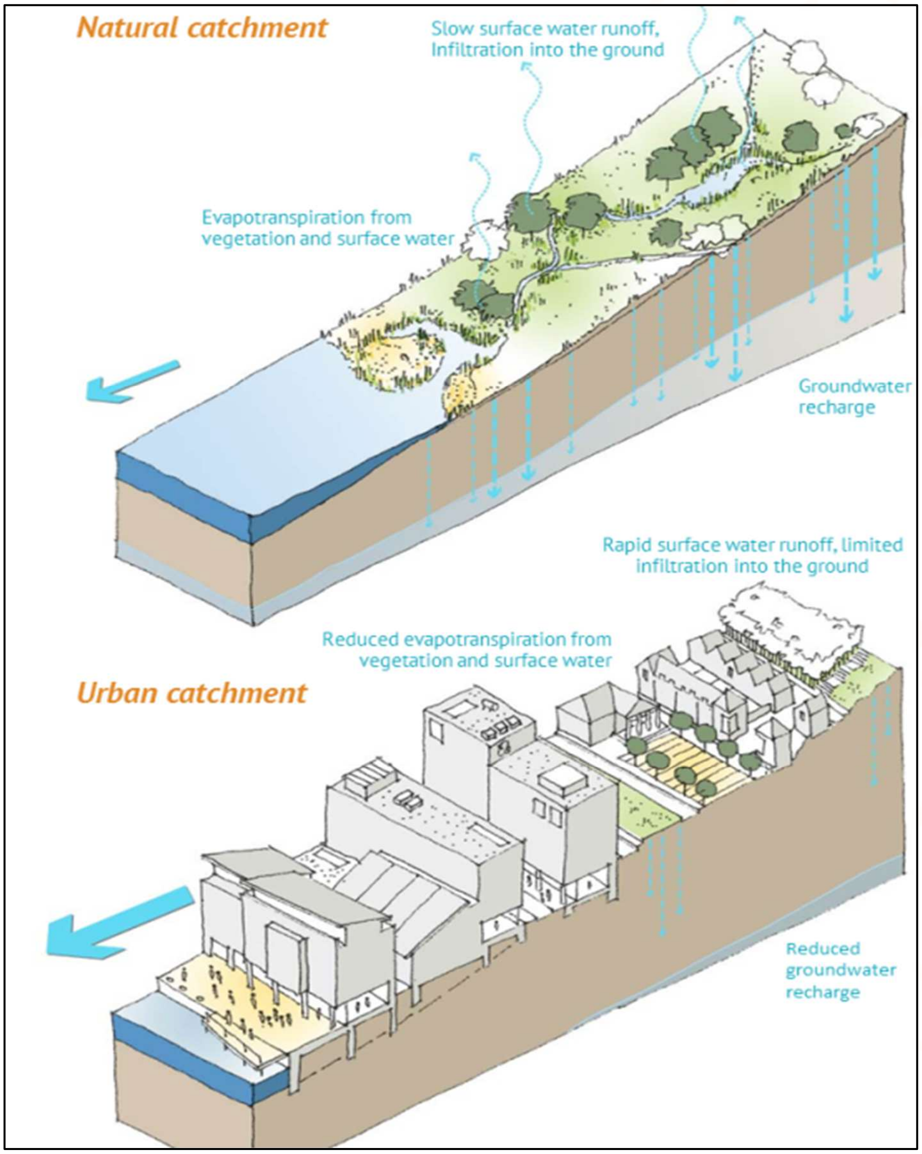

Figure 4: The impacts of urbanization on a catchment by reducing its permeability and increasing surface water runoff

In places where the current sewerage systems are nearly full, SuDS may also permit new construction, allowing for development inside already-existing metropolitan areas.

Conclusion:

Hydrology and hydraulics are used to design effective drainage systems. By integrating these ideas with legal mandates and pragmatic concerns, engineers may create systems that better manage water, protect infrastructure, and enhance the quality of both urban and rural environments. The idea of sustainable drainage incorporates long-term social and environmental considerations when making drainage decisions. It considers surface water's aesthetic value and amenity in the urban setting, as well as the amount and quality of runoff.

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