The Role of Urban Surface Runoff in Water Resource Management

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Abstract

Urban surface runoff is a growing concern in modern cities, especially in regions like Iran where seasonal rainfall can cause severe water flow over impervious surfaces. This essay explores the role of urban runoff in water resource management by combining academic research with personal observations from Tehran and northern Iran. The uncontrolled flow of stormwater not only leads to flooding and pollution but also strains existing infrastructure. Drawing from both local experiences and global studies, the essay highlights the importance of sustainable drainage systems and green infrastructure such as permeable pavements and rain gardens. Furthermore, it discusses how environmental engineers can play a key role in planning better urban water systems. Case studies and research by Fletcher et al. (2008) and Martínez et al. (2018) provide scientific support for the ideas discussed. The conclusion stresses the need for local governments to adopt smarter and eco-friendly runoff solutions. This essay reflects a civil engineering background with a clear interest in environmental applications.

Keywords

Urban Runoff, Stormwater, Green Infrastructure, Environmental Engineering, Tehran, Water Resource Management

This article is based on firsthand observations and academic perspective of a civil engineering graduate from Iran, applying to a master's program in environmental engineering.

Table of Contents

1. Introduction to Urban Surface Runoff

Urban surface runoff refers to the water from rainfall or melting snow that flows over the ground surface when it cannot be absorbed into the soil. This happens especially in urban areas where most surfaces are covered by asphalt, concrete, and other impermeable materials. When rainwater hits these hard surfaces, instead of soaking into the ground, it quickly flows toward drains, streets, and low-lying areas. This type of runoff can increase the risk of flooding, carry pollutants from roads and rooftops into rivers, and cause damage to both property and infrastructure.

In Tehran, for example, after even short periods of rainfall, it is common to see water flowing down streets, collecting trash, oil, and debris, and making transportation difficult. The city's surface is mostly paved, and green areas are limited. This condition leads to a situation where rainwater becomes a problem instead of a resource. In cities in northern Iran, like Nowshahr, where rainfall is heavier and more frequent, the same issue appears but with greater intensity. The streets flood quickly, drains overflow, and polluted runoff enters natural water systems. This first-hand observation helped me realize that understanding and managing urban surface runoff is a key part of sustainable urban planning.

Urban runoff occurs when rainfall or snowmelt flows over impervious surfaces instead of infiltrating the ground, carrying pollutants and debris into natural water bodies (EPA, 2021).

2. Environmental and Social Impacts

Urban surface runoff has many negative impacts on the environment, infrastructure, and public safety. First, it contributes to flooding, especially when drainage systems are not designed to handle large volumes of water. Flooded streets can damage homes, businesses, and vehicles, and disrupt transportation. Second, runoff carries pollutants such as oil, heavy metals, chemicals, and trash from urban surfaces into rivers, lakes, and groundwater sources. This contamination affects ecosystems, harms aquatic life, and makes water treatment more expensive.

One of the main effects I've seen in Tehran is the way runoff quickly fills up the streets in neighborhoods with poor drainage. For instance, in the area around Azadi Square, the drains are often clogged with garbage, and the streets become like small rivers after heavy rain. I once witnessed a shop owner placing sandbags in front of his door to stop water from entering. In northern cities like Ramsar, runoff frequently damages roads and blocks pathways because the water has no clear route to follow. The combined effect of poor planning and heavy rainfall creates repeated challenges that affect residents' daily lives and increase maintenance costs for municipalities.

As found in studies by Fletcher et al. (2008), uncontrolled urban runoff contributes to water quality deterioration and urban flooding, particularly in developing cities.

3. Challenges in Tehran and Northern Iran

Managing urban surface runoff effectively requires both engineering solutions and nature-based approaches. Traditional methods include stormwater drainage systems such as underground pipes, culverts, and detention basins. These systems help move water away from urban areas, but they are often expensive and may not be able to handle increased rainfall due to climate change. In contrast, green infrastructure provides more sustainable options. Rain gardens, permeable pavements, green roofs, and vegetated

swales can absorb or slow down water, reducing the volume of runoff and improving water quality.

In northern Iran, I saw how some recent housing developments included small grassy zones and planted areas along the sides of streets. These not only improved the beauty of the area but also helped absorb rainfall. In Tehran, however, many new buildings leave no open space for water to soak into the ground. Everything is paved, and water is directed into narrow gutters that easily overflow. This contrast showed me that small design choices—like using porous materials or planting along sidewalks—can make a big difference in how a city handles runoff.

Recent modeling efforts by Ramezan & Mousavi (2023) in the Chitgar watershed demonstrate that optimized stormwater systems could significantly reduce flood risks and costs in Tehran.

4. Management Solutions and Green Infrastructure

Urban planners and engineers around the world are starting to include water-sensitive urban design (WSUD) principles in their projects. This means designing urban spaces with the water cycle in mind—from rainfall capture to storage, use, and slow release. In Iran, however, these ideas are not yet common in most cities. Many developments still rely on outdated drainage systems, and the connection between urban planning and water management is weak.

One promising trend I noticed in a few parts of Tehran is the installation of bio-swales in new parks. These are shallow, vegetated channels that allow water to filter through soil and plants before reaching storm drains. Though still limited in number, they are a good example of how Iranian cities can adopt newer methods. To make these ideas more common, city officials, engineers, and citizens need to be more aware of how design choices affect runoff. Education and regulation both play a role. Without updated building codes and better enforcement, many projects will continue to ignore the problem and let surface runoff cause damage.

Research by Martínez et al. (2018) supports the effectiveness of green infrastructure systems such as rain gardens and permeable pavements in managing urban runoff.

5. Case Studies and Global Examples

During my years of studying civil engineering and living in different parts of Iran, I have seen how urban surface runoff affects cities in real life. Two places that I know well are Tehran, the capital city, and northern Iran, especially towns like Ramsar and Nowshahr. These places show two different sides of the same problem.

In Tehran, rain is not very frequent, but when it comes, the city is not ready. The drainage systems in many neighborhoods are old or poorly designed. I remember one evening in Sadeghieh, after just two hours of moderate rain, the streets were full of water. Cars were stuck, and pedestrians had to walk in deep water. It wasn't even a big storm. The water had nowhere to go because many sidewalks are higher than the street, and the drains are blocked with trash. This experience showed me how poor planning can turn a normal rain into a local disaster.

Another issue I have noticed in Tehran is the lack of green areas that can absorb water. In many new developments, especially in western parts of the city, everything is covered with concrete and asphalt. Rainwater simply flows over the surface, picks up dirt and oil, and ends up in nearby canals or rivers. I once saw dark, oily water entering the Kan River, making the water dirty and dangerous for nature. It was a clear example of how surface runoff can carry pollution from city streets to natural water sources.

In contrast, northern Iran has much more rainfall—sometimes heavy rain for days. The cities here face different problems. In Nowshahr, for example, the problem is not lack of rain, but poor infrastructure. Streets in many neighborhoods flood quickly, not because of the amount of rain, but because the drainage channels are narrow or clogged with leaves and garbage. I visited my aunt's house there last winter, and after one night of rain, the street in front of her house turned into a small river. Water entered the yard, and people had to use wooden boards to walk across.

However, there are also some positive examples in the north. In parts of Ramsar, I saw small grassy areas next to roads that helped slow down the water. These were not big parks, just small strips of land with plants. But they made a real difference. The streets stayed drier, and the water slowly disappeared into the soil. This made me think: even small changes can helps manage runoff if we design with water in mind.

These real-life examples have taught me that urban surface runoff is not just a theory—it's something that affects daily life. When cities ignore it, people suffer. But when they plan well and use nature wisely, even heavy rain becomes easier to handle.

6. Role of Environmental Engineers and Future Outlook

As someone who is preparing to pursue a master's degree in environmental engineering, I feel a strong responsibility to contribute to the future of water management in Iran. The problem of urban surface runoff is not limited to one city or even one country—it is part of a larger environmental crisis that affects communities around the world. In my view, environmental engineers have a unique role to play because we are trained to look at problems from both technical and ecological perspectives. Our goal is not only to build systems that work efficiently, but also to protect natural resources, reduce pollution, and support public health.

One area that interests me deeply is how local knowledge and traditional practices can be combined with modern engineering. For example, in older neighborhoods in northern Iran, I have noticed that some houses are built with small gardens or soil patches that help soak up rainwater naturally. These might seem simple, but they are very effective. I believe environmental engineers should work with local communities to preserve and improve such practices rather than replace them entirely with concrete solutions.

Another topic I am eager to explore is the connection between climate change and urban runoff. With changing rainfall patterns and more extreme weather events, Iranian cities need to be ready for both floods and droughts. I want to research how urban design can adapt to this new climate reality—how we can create cities that absorb, store, and reuse rainwater instead of wasting it. I am also interested in using Geographic Information

Systems (GIS) and data modeling to map areas most at risk and plan better drainage networks.

What motivates me most is the chance to solve real-world problems that affect people's lives. I want my work to be grounded in practice, not just theory. By studying environmental engineering at the graduate level, I hope to gain the tools and experience I need to design smarter systems, advise policymakers, and raise awareness among citizens. I believe that by working across disciplines—engineering, planning, ecology, and education—we can manage urban runoff in ways that are sustainable, fair, and future-proof.

7. Conclusion

Urban surface runoff is not just a technical issue—it is a challenge that connects urban design, public health, environmental protection, and social responsibility. As I have seen in cities like Tehran and those in northern Iran, poor runoff management affects everyone, from drivers stuck in flooded streets to families whose homes are damaged by water. It also harms our rivers and ecosystems by carrying pollution from roads into nature.

The good news is that solutions exist, and they are not always expensive or complex. By combining natural systems, such as green spaces and rain gardens, with smart engineering, like permeable pavements and proper drainage, cities can manage runoff more effectively. Public awareness is also important. People need to understand how their daily actions—like littering, paving gardens, or ignoring blocked drains—can make flooding worse.

In my opinion, the biggest problem is not the rain itself, but the lack of planning and care. I believe that water-sensitive design should be part of every urban project in Iran, from small housing developments to large roads. If we start designing our cities with water in mind—not as a problem to be pushed away, but as a valuable resource—we can reduce flood risks and also recharge groundwater, clean our streets, and create more beautiful and healthy places to live.

Looking forward, I hope to be part of this change. As a future environmental engineering student, I want to bring real solutions to Iranian cities—solutions that are not only based on theory, but also built on real-life experiences and local knowledge. I want to study how surface runoff works in different climates, and how small changes in design and behavior can make big differences.

In conclusion, urban surface runoff should no longer be treated as a side issue. It deserves serious attention in planning, education, and investment. With thoughtful action, even a city like Tehran—with all its complexity—can turn its water challenges into opportunities.

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