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الأمطار الحضرية: استراتيجيات لتحسين إدارة المياه في المدن المستقبلية

Urban Rainwater: Strategies to Improve Water Management in Future Cities

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مستخلص

تهدف هذه الدراسة بشكل أساسي الى تحليل الاستراتيجيات المتبعة في المدن الحضرية فيما يتعلق بإدارة المياه، مع التركيز على البنية التحتية الخضراء وأنظمة التصريف المستدامة وتوظيف المياه الرمادية. قام الباحث باستخدام المنهج النوعي، حيث عمل على مراجعة الأدبيات السابقة وتحليل البيانات. كما اعتمد على اجراء الاستبيانات والمقابلات الممنهجة في مجال إدارة المياه الحضرية، حيث شملت عينة الدراسة 50 خبير في مجال المياه من مختلف المدن الكبرى.

أفادت نتائج الدراسة ان البنية التحتية التي تتمثل في المساحات الخضراء تعمل على تحسين إدارة مياه الامطار بشكل كبير، وأظهرت النتائج وجود أثر إيجابي لأنظمة التصريف المستدامة في التقليل من مخاطر الفيضانات. يوصي الباحث بتبني السياسات التي تعزز من استخدام البنية التحتية الخضراء وأنظمة التصريف المستدامة اثناء التخطيط الحضري للمدن المستقبلية.

الكلمات المفتاحية

التخطيط الحضري/ البنية التحتية الخضراء/ إدارة مياه الأمطار/ التصريف المستدام/ المياه الرمادية

ABSTARCT

This study primarily aims at analyzing urban city strategies for water management, focusing on green infrastructure, sustainable drainage systems and gray water employment. The researcher used a qualitative approach, reviewing previous literature, academic researches and reports and analyzing data. The researcher also relied on systematic questionnaires and interviews in the field of urban water management, with a sample study involving 50 water experts from various major cities.

The main results of the study indicated that the infrastructure of green spaces greatly improve rainwater management, and the results showed a positive impact of sustainable drainage systems in reducing the risk of flooding. The researcher recommends adopting policies that promote the use of green infrastructure and sustainable drainage systems during urban planning for future cities.

Key Words

Urban planning/green infrastructure/rainwater management/sustainable drainage/grey water

INTRODUCTION

Due to the direct impact of rainwater in urban cities on the quality of life and keep infrastructure safe, it is considered as a vital environmental issue requiring further attention. The need has increased in recent times for effective strategies to manage rainwater in sustainable ways that reduce the negative effects of flood and pollution and preserve the environment, especially as population growth and urbanization increase.

Owing to climate changes leading to increased rainfall, urban cities have faced many challenges related to rainwater management. These increases in rainfall rates exacerbate the risk of flooding and water pollution, which in turn has a negative impact on public health and infrastructure. In addition, the problem is intensified and further complicated in cities that suffer from inadequate infrastructure development that enables it to accommodate and absorb increased rainfall.

This research aims to highlight mechanisms that contribute to improving infrastructure and water drainage systems through strategies for managing rainwater in urban cities. The main

objective of this paper is to provide some suggestions that can be considered practical, effective and applicable in major cities in order to strengthen rainwater management processes and reduce the negative impacts of water pollution and floods.

The researcher used a qualitative approach during this study, reviewing previous literature and studies covering in whole or in part the subject of water management. The researcher also analyzed field data through a case study, thus interviewing experienced urban water experts. This methodology has helped the researcher gather comprehensive and in-depth insights into the potential and proposed challenges and solutions that help in the rainwater management process in major cities.

PREVIOUS LITERATURE

The researcher has reviewed several previous studies, literature and researches on the effectiveness of green infrastructure and sustainable drainage systems in managing rainwater in urban cities. Through this review, the researcher aims to analyze the effectiveness of such strategies by studying modern and old strategies in the same field. The researcher also seeks to identify research gaps that can be addressed when completing this research.

Green Infrastructure

Being one of the innovative sustainable solutions, green infrastructure contributes to improving urban rainwater management and reducing flood risk. Technologies and means that absorb rainwater and reduce runoff are varied, such as green surfaces, vertical gardens and vegetation. Many previous studies indicate the contribution of green infrastructure to enhancing and improving water quality, reducing floods and providing green flats that improve the quality of life in cities. Andrew et al. (2016), carried out a study that indicates the impact of different climates on the retention of green surfaces in various climates. The study aims at recognizing the impact of different climates on the ability of green surfaces to retain rainwater, depending on the impact of the previous state of humidity on rainfall retention performance. One of the most important findings of the study is that green surfaces help to retain rainwater better than other means and strategies due to the previous humidity situation.

Anwar et al. (2016), carried out a study in which they provide a comprehensive assessment of the benefits provided by green surfaces in rainwater management, where researchers highlight ways and machinery that contribute to reducing rainwater runoff on green surfaces, as well as discussing water quality improvement strategies. Through this review, researchers also provide numerous guidance and advice related to the design, installation and maintenance of green surfaces.

Hoang and Fenner (2016), explore the system's interactions with rainwater management solutions using a sustainable urban drainage system and green infrastructure. The researchers connect many urban elements related to rainwater management and identifies dependencies among urban components, including physical, cognitive and organizational challenges.

Sustainable Drainage Systems

Abd Elkader and Haroun (2020), in their study, focus on the latest research on biological control for rainwater, where the researchers discuss the design and construction of biological control systems, as well as how they perform. The researchers also focus on the axes of utilization as well as the challenges that such systems can face.

For their part, Yang and Zhang (2021) highlight multiple criteria for assessing sustainable urban sanitation performance. In their study, they aim at striking a balance between universality and objectivity in assessing the performance of sustainable urban sanitation system development through the use of a multi-standard decision analysis framework and several different indicators. This study reveals several hydraulic improvements resulting from gray strategies, and the overall assessment show that using a variety of strategies contributes to enhancing the overall performance of the sanitation system.

Using Greywater

Filali et al. (2021) review many aspects of grey water, pointing out that it ranges from 50-80% of the world's total wastewater. The researchers review the techniques used to treat and restore gray water, and the risks that this entails, such as the possibility of some viruses such as coronaviruses. The researchers also discuss different approaches and methods that would evaluate grey water treatment performance by studying a living example in Tunisia that aimed to reduce freshwater consumption in areas with water shortages.

In a case of study on the Egyptian Republic regarding the use of gray water as a non-traditional resource in order to preserve its large urban projects, the researcher of this study quantitatively assessed gray resources. The results indicated that grey resources support the sustainable future of non-traditional water resources in a positive way, as the amount of water provided by the State in this way is a contribution to the support of water resources in Egypt. The results reported that Egypt should maximize the share of the use of gray water resources in future mega-projects.

Materials and Methods

The researcher collected data through questionnaires and interviews with 50 experts in urban water management, where this sample is a diverse source of expertise and knowledge in the field. The data obtained were then analyzed using qualitative analysis techniques that describe and interpret the data obtained. Reference was made to several previous studies, literature and academic references, as well as relevant reports on the subject of research, in order to enhance the basic understanding and qualitative analysis of the subject and the findings of the research.

Sustainable rainwater management

With significant climatic shifts causing changes in rainfall ratios, there is a need to create and innovate many smart solutions that promote rainwater management. In the past few years, the rains in Denmark have caused floods that have damaged homes and infrastructure. The researcher reported experts' prediction of many more frequent and extreme weather events in the next few years. This calls for stakeholders to find appropriate solutions for proper rainwater management (Hoffmann et al., 2015).

Another study which was carried out by Khan and others (2022), researchers emphasize significant climatic changes affecting rainfall and urban runoff. The researchers also emphasize the urgent need for actionable planning to reduce the impacts of ecosystem services and assess infrastructure requirements for water management. Researchers in this study presented a simple simulation tool as described, as this tool determines the benefits of green rainwater management practices in small watersheds. The results of the study showed significant physical differences in green rainwater management alternatives, as they were less costly than the cost of planning, establishing and building grey infrastructure on small watersheds ranges.

As Uvini and Upaka point out (2017), the topic of rainwater management is a complex one and many actions that help to mitigate water runoff need to be examined, with specialists considering running rainwater as a major carrier of various contaminants. The main objective of this research is to study and implement strategies related to rainwater management and use the best strategies to reduce the amount of sediment and chemicals loaded with running rainwater before reaching the riverbed or natural waterways. The researchers also sought to focus on flood mitigation methods. The researchers emphasize that geophysical factors such as climate, soil and topography, diverse social factors, as well as technical and economic factors should be taken into account when adopting rainwater management measures, owing to the trend of the world's experts and specialists towards green concepts to mitigate water runoff.

RESULTS AND DISCUSSION

After collecting data from its reliable sources and interpreting and analyzing these research-based data, the researcher presents the main findings of this research on the performance of rainwater management strategies in urban cities, and then discusses the results in detail in order to gain an in-depth understanding of the impact of these strategies and their future guidance.

Results

The researcher concludes that there are many significant positive effects of rainwater management strategies, including green infrastructure, sustainable drainage systems and the use of gray water. These aspects have had a positive impact on water quality, flood risk mitigation and sustainability support for urban water resources.

Discussion

Data has been analyzed and interpreted in depth in the Results Discussion Section, where previous literature has been linked, and factors that have a direct impact on the effectiveness of sustainable rainwater management strategies have been identified. How much can there be a discussion of the environmental and social impacts of these different strategies and focus

on the challenges they accompany, and therefore propose recommendations for future application.

CONCLUSION

Green infrastructure and sustainable drainage systems as explained in the results and discussed earlier represent an effective solution that contributes to the management of rainwater in future cities. These economic environmental strategies can provide some opportunities that contribute to mitigating the impact of floods, improving water quality and supporting the sustainability of water resources.

At the end of this research, the researcher recommends the adoption of policies and actions that will promote and encourage the use of green infrastructure and sustainable drainage systems in urban planning. Such planning and strategies can improve environmental sustainability and bring economic benefit to cities, which in turn improves the quality of life in cities and reduces the impact of climate change.

The researcher also recommends that research be completed and that the recommendations put forward be applied through joint cooperation between the Government, the private sector and the community as well, so as to build sustainable cities and reduce water challenges and shorts in the future.

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