

城”共生关系，在西湖从未间断的营造和疏浚过程中，为顺应自然而进行的适度人工干预，保证了西湖景观与杭州城持久的繁荣。又如开封市的“四水灌都”，城市内引入的四条水系与黄河、淮河连通，同时承担着漕运、商业、公共空间等多种功能。

以上这些古人的理水筑城案例对于当代的水系统生态设计具有重要的借鉴意义。将“理水”理念与城市的防洪、蓄水、交通、文化发展等相结合，再加上持续适度的人工介入，将对区域景观产生深刻影响，并使其成为景观基础设施和孕育繁荣文化的载体。

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作为一名景观教育者，您在教学过程中是如何安排生态设计的教学工作的？

郑：我在学校主要教授设计课程，教学计划中安排了较多与生态和设计相关的专业课程。设计课的主要任务是培养学生综合应用包括生态学知识在内的所学知识，解决项目实际问题的能力。所以在课堂上并不会专门详细地介绍生态设计，而是将引导学生探索和分析设计中场地所面临的各个层面的问题，以及可能的相关解决方式作为教学重点。

您认为生态的思想应用于实践存在哪些困难？

郑：开发者的经济利益考量和缺少以量化数据支撑生态设计发挥生态效能的评估体系是当前生态思想应用于实践中存在的较大问题。生态并不一定代表投资减少，相反可能会增加投资，而增加的部分大多是在“看不见”的地方。如何通过有效的评估体系对生态设计做出评价，并据此说服开发者支持生态设计的实践，是我们目前面临的主要困难。LAF

Another example is Kaifeng City, where “four rivers pour into the city”. Here the city introduced four new rivers to connect the Yellow River and Huai River. The new canals took on a variety of functions, such as transportation, and commercial and public space.

These water management and city-making examples come with significant lessons and principles that can be applied to contemporary water system design. Applying the ancient concept of “water management” in flood control, water storage, transportation, and culture development, combined with the continuous, moderate human interventions will have a profound impact on regional landscape, serving as a base that builds landscape infrastructures and nurtures prosperous cultures.

As a landscape educator, how do you teach students eco-design?

ZHENG: I mainly teach design classes. The syllabus includes some professional courses in ecology and general design. The main purpose of the design courses is to develop the students' ability to apply their own knowledge (including knowledge of ecology) to site issues. I do not specifically teach eco-design in the classroom. I focus on guiding them to explore and analyze design problems at the project site and develop possible solutions.

What are the difficulties of incorporating ecological ideas into design practice?

ZHENG: It depends on the client. Developers are concerned with economics, so making an argument for the monetary value of ecological design is one challenge. The lack of quantified data, which is needed to evaluate the effectiveness of eco-design is another major issue of applying ecological thinking to design practice. A focus on ecology is not necessarily equal to a reduced investment. On the contrary, it may increase the initial money spent, while most of the return is seen in “invisible” places. How to evaluate eco-design with an effective evaluation system and how to convince developers to support the practice of eco-design are the major difficulties we are currently facing. LAF

人性化的城市雨水景观设计对策 People-oriented Design Solutions in Urban Rainwater Landscapes



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摘要

城市雨洪综合利用的根本目的在于促进地方水文的良性循环，解决地方水问题。城市是人类活动的集中地区，城市中的大多数工程设施都无可避免地要考虑人的使用需求，然而这一点却常常为传统的工程设计所忽视。本文提出了两种人性化的城市雨洪综合利用对策——弹性对策以及防御对策，并归纳总结了针对不同策略的设计手法，以期进一步促进雨洪综合利用在城市中的推广，从而构建城市中的“人水和谐”。

关键词

人类活动；景观设计；城市水文；雨洪利用

Abstract

The fundamental purpose of the comprehensive utilization of urban stormwater is to improve the cycle of local hydrology, and respond to local water issues. Most of urban engineering facilities cannot avoid considering human uses and needs, because a city is a concentrated area of human activities. However, this point is often overlooked by the traditional design in engineering. In this paper, two people-oriented design strategies of comprehensive stormwater utilization are proposed: adaptive strategy and protective strategy. Moreover, it summarizes the design solutions for different strategies to further promote the comprehensive stormwater utilization in cities to establish a harmonious relationship between human and water.

Key words

Human Activities; Landscape Design; Urban Hydrology; Stormwater Utilization

近年来，旱涝灾害频繁、饮用水匮乏、地下水位降低以及河流污染等水问题一直困扰着中国城市的发展^[1]。为了应对这些问题，中国于21世纪开始逐步展开对城市雨洪综合利用的研究，目前已在北京^{[2]-[4]}、上海^[5]、深圳^[1]等城市出现诸多试点建设工程。城市作为人口高度密集的地区，是人类生产、生活的基本场所，因此，城市雨水利用需要考虑怎样能够在实现合理利用的同时兼顾人的使用与需要。人性化的城市雨水景观设计正是基于此提出的。本文概括出两大策略：弹性对策以及防御对策（表1），并针对不同对策归纳总结了一些国内外的设计途径，以期完善人性化的雨水景观设计方法，促进雨洪综合利用在城市中的进一步推广。

In recent years, water issues such as frequent droughts and floods, shortage of drinking water, lowering of underground water level and river pollution, have been besetting urban development in China^[1]. To address these problems, China has gradually begun the study of comprehensive utilization of urban stormwater since the beginning of the 21st century. Currently, many pilot projects have already been launched in China's cities like Beijing^{[2]-[4]}, Shanghai^[5], and Shenzhen^[1]. Cities are highly populated areas, and primary places for human production and living. Thus, how to reasonably use the stormwater while fulfilling the human needs should be taken into consideration

表1 人性化的雨水景观设计对策
Table 1 People-oriented Design Solutions in Rainwater Landscape

Type of Solution 对策类型	People-oriented Design Approaches 人性化的设计措施
Adaptive Solution 弹性对策	Spatial appearance changes with a site's wet / dry conditions 空间表现随干湿条件变化
	Landscape functions to utilize the stormwater and meet human uses 景观功能兼顾雨洪利用与人的使用
Protective Solution 防御对策	To avert the deterioration of water quality 防止水质恶化
	To reduce mosquito and insect nuisances 减少蚊虫滋扰
	To guard against drowning 防范溺水

Note: This paper cannot cover all the design principles. There are many possibilities worthy of further exploration.

注：文中提及的设计原则未能涵盖全部，还有多种可能性值得进一步探索。

1 弹性对策的设计措施

弹性对策主要针对的是雨水景观设计中的水量不确定性，并试图兼顾城市雨洪综合利用以及人类活动的使用功能。然而这些环境条件却处于不断的变化之中，因此该对策为非固定性的功能的结合。

城市雨洪利用与人类活动之间的关系可以归纳为交替和变换关系。交替性设计常常出现在雨洪综合利用中，尤其在一些临时性的蓄洪池或蓄水区，这些地方通常被设计成运动场地，雨季时可用于短期蓄洪，旱季时则能够满足人们的日常活动与体育运动需求（图1）。变换关系是多种即兴关系的变换组合，是指根据季节以及雨洪综合利用设施蓄水量的不同，人们在场地中的活动也会产生相应的变化。例如，利用雨水径流所设计的水景在雨量较多时能够形成供人嬉水的景观，雨量不足时则可被视作一个雕塑或儿童游乐设施（图2）。弹性对策的设计途径可以从如下两个



方面来考虑：

1.1 设计形式随水量条件而变化

设计应考虑在不同季节、不同水量条件及水文过程下，采用不同的空间表现形式，营造出富于变化的雨水景观。这意味着：1) 应清楚地了解该地区的水文过程及季节变化，以期从中找出能够被人类活动所利用的过程和要素；2) 应将公共空间与城市蓄/排水设施相结合，并根据不同的空间尺度、功能使用及蓄/排水能力设计适应于场地特点的雨水景观；3) 应尽可能地展现雨水过滤、净化及滞蓄过程，创造可视化的、可供人近距离接触的雨洪景观。

1.2 设计兼顾雨洪过程与人的使用

在功能上，设计应当兼顾人类使用与雨洪利用过程的交替进行。因此，设计应从便于人的安全使用的角度出发，考虑如下几个方面：1) 合理制定雨洪处理设施的规格及细部，使其能够在实现雨洪利用的同时亦可供人类活动使用；2) 场地应设有良好的下渗或排水渠道，使雨水能够顺畅地排出，以避免水质恶化，方便人们的使用；3) 在场地周围设置预警系统或标示系统，使人们能够清楚地知晓场地状态和使用时间。

2 防御对策的设计措施

防御对策考虑的是在雨洪综合利用中，一些常见的会对人类活动造成干扰的问题，主要包括水质恶化、蚊虫滋扰及安全隐患等。这些问题将大大影响和减少人们的使用活动。防御对策强调的是通过良好的规划设计，尽可能将这些会对人类活动造成负面影响的干扰因素降到最低。

2.1 防治水质恶化

水质恶化是水景观最常被诟病的问题之一，主要表现为水体变黑发臭，鱼类等生物的大量死亡等。如果这些水景观位于社区或公园中，将直接影响附近居民的正常生活及身体健康。造成水质恶化的原因包括水景内水体无法循环、外界污染等，但由于城市雨洪综合利用所形成的景观往往采用自然降水，而非市政管网中的饮用水使得水质的问题变得更为严峻。在设计中可以采取如下措施来进行防治：1) 采用生态设计的途径使水体具备自身循环净化的功能，例如种植各种具有较强净水能力的植物，或设计活水设施以促进水体循环；2) 对水质进行监控，当水质不达标时需及时采取处理措施；3) 当利用蓄积的雨水来构建水景时，应弃用初期雨水，或对雨水进行一定的处理后再进行利用；4) 定期对水

to urban rainwater utilization upon which the people-oriented urban rainwater landscapes are proposed. This paper frames two major strategies: adaptive solutions and protective solutions (Table 1), and summarizes several design approaches both in China and abroad for each type of solutions, aiming to improve design methods for people-oriented rainwater landscape and facilitate further promotion of stormwater comprehensive utilization in China's cities.

1 Design Approaches of Adaptive Solution

Adaptive solution mainly addresses the volume uncertainty of rainwater in landscape design, it seeks to function for both comprehensive urban stormwater utilization and human activities. The fact that all the relative conditions are dynamic results in a constantly changing combination of these two functions.

The relationship between urban stormwater utilization and human activities can be summarized as an alternative and variable relationship. Alternative designs are often seen in comprehensive utilization of urban stormwater. A retention or storage basin, as a typical alternative landscape work, is often designed for temporary rainwater-storage use during the rainy days, and becomes a play field after rain providing spaces for people's daily activities and sports (Fig. 1). Variable relationship is a changing combination depending on various relative dynamic conditions. It means that human activities change corresponding to different seasons and different storage capacities of different stormwater comprehensive utilization devices. For example, a waterscape supplied by runoff water can be seen as a water-playing feature when the rain is heavy, and it also serves as a sculpture or a children's play facility when the rain is less, or in the dry days (Fig. 2). Design approaches of adaptive solution can be considered from the following two aspects:

1.1 Design Form Changes with Water Volume

Design should employ different spatial expressions to create richly varied rainwater landscape based on the consideration of different seasons, different water volumes and hydrological processes. This means to: 1) have a clear understanding of hydrological processes and seasonal changes of the site in order to find out which processes and elements can be utilized for human activities; 2) combine public space and urban storage / drainage facilities together, and design site-specific rainwater landscape according to its spatial scale, functional serves,



1. 社区中随微地形起伏的草地可以作为临时性的雨水蓄积与下渗空间；降雨过后，又成为供人活动的公共绿地。
 2. 街头广场上的雨水景观，无雨水利用时可作为儿童的游乐设施。
1. The micro-topography of the lawn allows for temporary detention and infiltration during the rain; after the rain, it returns to a public green space for human activities.
 2. The rainwater landscape on street square becomes a children's play facility when there is no rain.

and storage / drainage capacity; 3) showcase the rainwater processes of filtration, purification and retention as much as possible, creating visible and accessible stormwater landscapes.

1.2 Designing for both Stormwater Processes and Human Uses

Functionally, the site should be designed to alternately serve for both human uses and the process of stormwater utilization. Therefore, starting from the reasons of security and convenience of human uses, the following aspects should be given emphatic attention: 1) to develop a reasonable scale and details for stormwater treatment device in order to fulfill both purposes of stormwater utilization and human activities; 2) to ensure the site's infiltration or drainage ditches / pipes are well performed for rainwater discharging, which is key to mitigate water quality deterioration and enhance human's usage efficiency; 3) to establish an alarm system or signage system in the surroundings, allowing the users to have clear awareness of the site's conditions and the service time they can access and use.

2 Design Approaches of Protective Solution

Protective solution addresses the common problems that interfere with human activities in the process of comprehensive stormwater utilization. Such problems, mainly including deterioration of water

体进行清理，以减少树叶、枯枝等造成的污染。

2.2 预防蚊虫滋生

雨洪集中处理带来的另一大问题是蚊虫滋生。蚊虫不仅会使人感到不适，而且可能会传播登革热、乙型脑炎和疟疾等疫病，而大面积的蓄水池和湿地可能会成为其繁殖的主要栖息地。施放杀虫剂虽然可适当减少蚊虫的繁衍，但会造成水体污染，同时对生活在其中的其他生物造成危害。因此，有必要通过设计途径来防治蚊虫滋生。在设计雨水处理设施时，可以采取以下设计策略以减少和阻止蚊虫滋生：1) 确保所有的雨水能够在72小时之内下渗，这样由于雨水滞留时间较短，不足以滋生蚊虫；2) 必需时，蓄水深度不得小于1.2m，如此一来，可促进水生生物群落的建立，以保证那些捕食蚊虫的生物能够长期生存并繁衍。此外，可增大蓄水池边坡的坡度，以减少那些作为蚊虫栖息地的边缘植被；3) 采取一定的措施使水体流动起来，例如可采用喷泉、水流等设计方式。这些措施尤其适用于那些无法建立足够水深的场地^[6]；4) 在人类的活动区域中，可通过大量种植驱蚊草等驱蚊植物来减少蚊虫滋扰。驱蚊植物种类繁多，不同植物可能含有不同的驱蚊成分。由于常见的蚊虫已经产生了一定的抗性，所以多种植物混合种植的效果要好于种植单一植物的效果。

2.3 降低安全隐患

对于雨水景观安全方面的考虑，主要目的在于既增加人与雨水景观的接触，又能够降低溺水事故的隐患。降低雨洪系统的风险、增强安全系数主要包括限制亲近距离（图3）、降低水位和减缓流速速度等设计措施^[7]。但对于是否要在设计中将风险降到最低，目前仍存在争议。研究表明，让儿童长期生活在经过过度安全设计的地方会降低他们未来应对风险的能力。同时，某些情况下，适度的风险能够增加水景的趣味性和吸引力（图4）；相反，过于注重安全的设计可能会导致水景功能单一、形式枯燥。

3 结语

人性化的雨水景观不仅能够有效地解决多方面的城市水问题，而且能够在综合利用雨洪资源的同时，最大限度地兼顾人的活动、方便人的使用。景观设计是促使城市雨洪综合利用更加人性化的有效途径之一。对于雨水景观的人性化设计方法，仍有许多值得总结和思考的方面，上述提及的设计手法尚不能完全涵盖。此文旨在抛砖引玉，希望能够引起从业人员的关注和思考，促进雨洪综合利用在城市中的应用与推广，进而创造城市中的“人水和谐”。LAF



quality, mosquito and insect nuisance, as well as potential safety hazards, will greatly impact and decline the efficiency of human activities. Protective solution emphasizes on minimizing these negative factors in the design of comprehensive stormwater utilization.

2.1 Mitigating Deterioration of Water Quality

Deterioration of water quality is one of the common reasons for waterscape being abominated. It represents as smelly black water, and mass mortality of fish and other living beings. If such waterscape is located in a neighborhood or a park, it will directly impact on the lives and physical health of surrounding residents. The reasons caused the deterioration include the uncirculated water body, pollutants from external environments, and etc. Furthermore, in urban rainwater comprehensive utilization, the waterscapes are usually directly supplied by rainfall, instead of the municipal drinking water, which leads the deterioration problem more severe. The following protective approaches can be taken: 1) using eco-design approaches that enable the water body can purify itself through self-circulation, such as planting aquatic plants with strong decontamination ability, or employing running water devices to help water circulation; 2) monitoring water quality, and taking actions immediately when the water quality does not meet the standards; 3) discarding the early rainfall when creating water features with rainwater, or only using the rainwater after treatment; 4) cleaning the water regularly to reduce pollutants such as dead leaves and branches.

2.2 Preventing Mosquito and Insect Breeding

Mosquito and insect breeding is another big problem caused by the

collection of stormwater. Mosquitoes not only make people sick, they may also spread epidemic diseases such as dengue fever, Japanese encephalitis and malaria epidemics. Large rainwater retention basins and wetlands may provide major habitats for mosquitoes. Although spraying pesticide may be helpful to reduce mosquito and insect breeding, it will also cause water pollution, and harm other living beings in the water. Thus, it is highly necessary to prevent mosquito breeding through design approaches. The following strategies can be taken in designing rainwater treatment devices: 1) to ensure that all rainwater can be infiltrated within 72 hours, so it is not long enough for mosquito breeding; 2) to ensure the depth of a detaining basin, when it is necessary, is no lower than 1.2 m. This will facilitate the establishment and long-term survival of the aquatic biological communities of mosquito-catching plants. Besides, increasing the slope grade of the retention basins' edge slope will reduce the vegetation area in where mosquitoes and insects can inhabit; 3) to use certain methods to keep water body running, such as fountains, and stream flows. This is particularly suitable to the places without enough water^[6]; 4) to largely apply repellent plants in human activity areas to discourage mosquitoes. There are many different kinds of repellent plants, and each one may contain different repellent ingredients. Given mosquitoes have developed resistance to certain plants, a mixed combination can be more efficient than single-species.

2.3 Reducing Potential Safety Risks

In terms of the security consideration of rainwater landscapes, the key is to not only create accessible, people-friendly rainwater landscapes, but also to reduce the potential hazards of accidents such like drowning. Relative design approaches include restrict the accessible distance (Fig. 3), decline the water depth, slower the flow^[7] and etc. However, there is no clear conclusion about to what extent we should minimize the risk. Researches have shown that children's ability of coping with risks in future will be impeded if live in an overly designed safe place for a long time. Meanwhile, some cases demonstrate that moderate adventures can increase the interest and attractiveness of waterscapes (Fig. 4). Overly safe water feature may result in monotonous function and form.

3 Conclusion

People-oriented rainwater landscape can not only effectively

solve urban water problems at many aspects, but also maximize and optimize the human uses in the comprehensive utilization of stormwater resources. Landscape design is one of the effective ways to improve a more people-oriented comprehensive utilization of urban stormwater. There are still many thoughts and design approaches that can be summarized and explored in the development of people-oriented rainwater landscape design solutions, and this paper cannot cover them all. Hoping to stimulate more valuable contributions, the paper intends to inspire design practitioners to promote the comprehensive stormwater utilization in cities, and establish a harmonious relationship between human and water. LAF

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3. 美国波特兰市唐纳德溪公园利用波型艺术墙分隔空间，引导人们穿过曲桥以观赏雨水景观。
4. 美国德州沃斯堡市20世纪70年代建成的水公园。由于当时的设计没有过多地对安全进行限制，设计师设计出了极富趣味性的人与水的接触空间。
3. Portland Donald Brook Park, USA. It uses wavy art walls to separate space and guide people through the bridge for rainwater viewing.
4. Waterpark built in the 1970s, Fort Worth, Texas, USA. There were not many restrictions on the safety of design back then, and the designers created a very interesting space for people to immediately contact with water.

