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Research and exploration on rational utilization of urban water resources and environment

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ABSTRACT

Sponge city construction is an effective way to solve urban water shortage, water pollution, water security risk, and water ecological damage. In developed countries, there are abundant theoretical and practical models, while the construction of sponge city in China is still in the initial stage, and the problems of urban development need to be solved urgently. Pilot construction of sponge city has been carried out in China, which has achieved initial success. During the construction, attention should also be paid to the ecological balance and perfecting legislation, the integration of planning, construction, and management pattern by the idea of holistic and systemic, and become a smart sponge city with the rapid development of artificial intelligence, which can promote its construction process and the level of construction.

Keywords: Sponge city, Construction, Water resources, Rain

1. Introduction

Water is an essential resource for all life on the planet. Of the water resources on the earth, only 3% is freshwater of which two-thirds is locked up in ice caps and glaciers. In the remaining 1%, a fifth is in remote, inaccessible areas, and much seasonal rainfall comes in monsoonal deluges and floods and cannot be easily used. Water is becoming scarcer, and access to clean and safe drinking water is becoming a problem in many countries. At present, only about 0.08% of the world's freshwater is exploited by mankind with the ever increasing demand for sanitation, drinking, manufacturing, leisure, and agriculture. Due to limited water resources, optimizing the freshwater becomes a worldwide problem.

Successful management of any resources requires accurate knowledge of the available resource, the ways it is used, the competing demands, approaches, and processes to evaluate the significance of competing demands and mechanisms so as to translate policy decisions into actions. For water resource, this is particularly difficult because sources of water and water body may locate in and belong to different countries. In such cases, the uses of water involve difficult financial values and may conflict with the conventional terms. Examples include rare species, ecosystems, or the very long-term value of ancient groundwater reserves. Comrade Xi [1] proposed in the 19th convention report that management and maintenance of the ecological environment is one of the important historical missions of the communist party of China and explicitly proposed "adhere to the harmonious coexistence of man and nature," "ecological environment with the consideration humans extend to other life," "practice the strictest possible system for ecological environment protection," etc. The rational use and management of urban water resources play an important role to China's social and economic development and ecological environment construction. In recent years, the construction of "sponge city" has become the guiding principle of urban water resource utilization and management. The concept of "sponge city"

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in "low-carbon urban and regional development technology BBS" was proposed for the first time in 2012. Issued by the State Council on October 2015, "about promoting urban construction guidance" was to impel sponge city construction. The concept of sponge city construction has been considered as a national strategy in less than 3 years. It can be seen that the sponge city construction is the need of construction of ecological civilization and necessary for national development strategy. So the sponge city construction is a long-term and arduous task [2].

Sponge city is flexible to adapt to the environment change, natural disasters, etc. which is like a sponge. It can absorb, store, seep, and purify water when raining and release the accumulation of water and use it when needed, like a sponge [3]. Sponge city can maximize the realization of rainwater in some urban areas, such as stockpile, infiltration, and purification, and promote the use of rainwater resources and ecological environment protection under the premise of the safe operation of urban drainage.

2. Problems of urban water resources utilization

2.1. Rapid urbanization is accompanied by excessive development of water resources and serious water pollution

In recent years, China's urbanization has entered a fast track of development. Because of the extensive development, the capacity of water resources cannot keep up with the pace of urbanization, which has caused a series of problems, such as water shortage, water pollution, groundwater overdraft, geological subsidence, and safe drinking water. The problem of serious overmining of groundwater is also increasing, especially in the northern regions, where there is a discontinuous flow in the lower reaches of the Yellow River, Tarim River, and Heihe River, and the wetlands and lakes are disappearing in an alarming rate. The overmining area of groundwater in China has exceeded 200, km^2, and many cone of depression in the north already face serious crisis of depleted groundwater resources [4]. Currently, there are more than 420 cities in the country with insufficient water supply, 110 of which are seriously short of water, and the water shortage reaches 10.5 billion m^3. On the other hand, due to urbanization and industrialization, the industrial pollution causes a sharp shortage of water resources. Municipal wastewater in the city has a high recycling value, and it can be effectively used in reclaimed water through the treatment of wastewater, which can greatly reduce the demand for water resources. Taking Qingdao as an example, there are 23 urban sewage treatment plants with total daily processing capacity of 2.02 million m3, which is about 1.5 times of the water supply from Yellow River and Yangtze rivers. These plants help Qingdao meet its water demand.

2.2. Inadequate drainage infrastructure in the city

With the rapid development of urbanization, early drainage cannot bear the drainage capability as the lack of planning, less underground drain, small drainage pipe diameter, etc cause "light rain into the lake, the rain into the sea," phenomenon. After the rain, "look at the sea" has become a topic of people joking. The drainage system urgently needs renewal and/or replacement. However, at the present stage, there is a shortage of professional personnel in drainage engineering in China, making water resources management more difficult.

2.3. Insufficient protection of drainage facilities and insufficient management

Among them, pipe drainage is not good because of small and medium-sized city residents' protection consciousness. Some residents carelessly dump waste into rainwater wells, resulting in poor drainage of pipes. When cleaning roads, some sanitation workers sweep sand, leaves, and other debris into the rainwater easily causing pipeline deposition and resulting in poor drainage. On the other hand, drainage facilities are often used in the construction without acceptance, and cannot get the normal maintenance, leading to insufficient and/or delayed cleaning, which cause sedimentation and even blockage.

2.4. The irrational use of rainwater resource

In the construction of modern cities, road has been built in order to facilitate people's life. Most of the materials used in hardened pavement are cement and asphalt. In order to prevent the road from fatigue cracks, the surface layer thickness of the pavement is more than 10cm. At the same time, in order to improve the anti-seepage performance, other building materials are added in the construction. Although the road hardening is conducive to the development of economy, it also causes the loss of rainwater, thus worsening the drainage of the city. Limited water resources cannot be timely and effective supplement of below groundwater resources. But the development of transportation industry is vital for the development of the city. The two complement each other. But now the urban drainage system cannot accommodate the development of urban economy. Experience shows that under normal climatic conditions, the typical sponge city can collect more than 60% of the rainwater, as shown in Fig. 1 [5].

3. The connotation of sponge city construction

Ecological priority should be taken into account in sponge urban construction combined with the natural and artificial

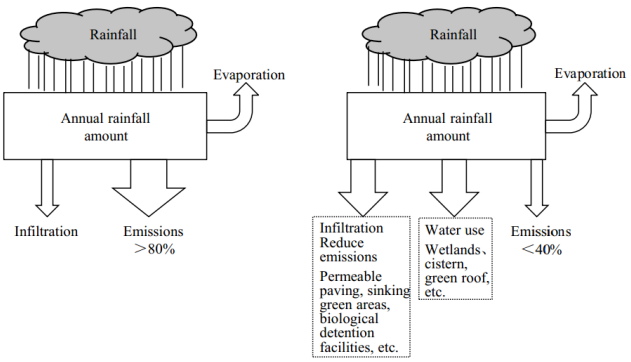

Fig. 1. Traditional emission patterns and sponge emission patterns.

measures to maximize the usage of rainwater in urban areas of stockpile, infiltration, and purification. This will promote the use of rainwater resources and ecological environment protection under the premise of the safe operation of urban drainage, as shown in Figs. 2 and 3.

Sponge ecological city corridor restoring the urban water circulation path is complement to traditional water cycle system. It maximizes the role of the city. Sponge city is flexible to adapt to the environment change and natural disasters, like a sponge. Through sponge city construction process that includes full use of urban water ecological purification function, the sponge city facilities for rainwater collection and utilization, surface water resources, water resources, ecological water use, natural precipitation, and groundwater are protected to ensure urban water cycle and the natural water cycle through each other. A steady water ecosystem will be established and can gradually realize clean water and controlled drainage and urban heat island [6].

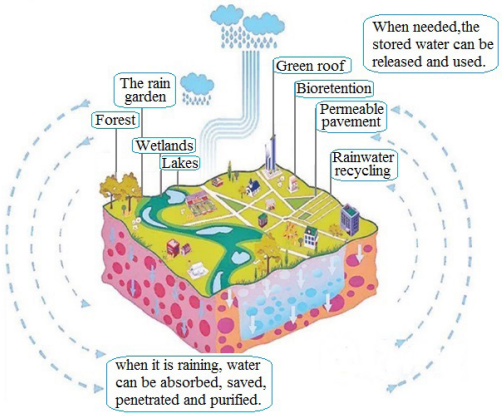

Fig. 2. Schematic diagram of sponge city construction.

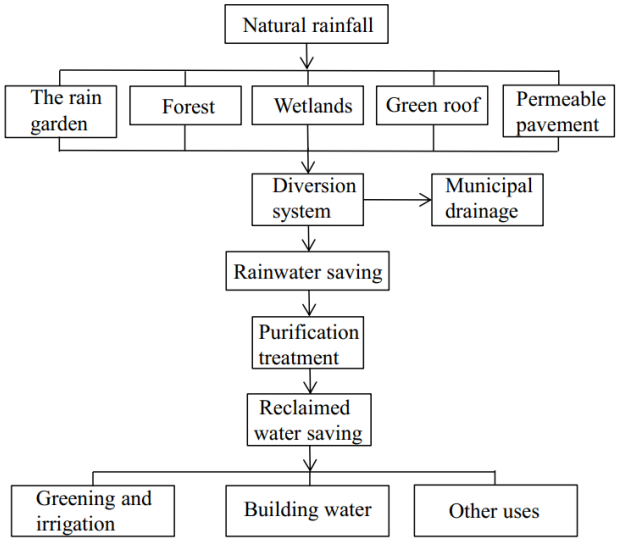

Fig. 3. The rainwater collection and utilization system diagram of the sponge city.

4. The status of sponge city construction in China and abroad

The prototype of the sponge city began in the United States. Today, the United States has put forward the best management scheme about management of urban rainwater resources and rainwater runoff pollution control. The famous downspout river closure and rain garden road which can infiltrate and purify rainwater runoff were built in Portland. A green roof top was built in the 911 memorial centre in New York where the plants are watered with rainwater runoff. The green roof can intercept nearly 100% of the rain, and the top floor of the 911 memorial can recycle about 6,000 m^3 of rain each year. In Germany, the government has established rules and regulations on urban rainwater control to encourage the use of rainwater in the principle of "efficient collection of water, balanced ecology." Edinburgh Gardens, Melbourne, Australia, collects rainwater through a variety of water features and the corresponding measures. Water is purified through the filter medium and a variety of natural vegetation for both local water and vegetation irrigation water. According to Japan's earthquake resistance experience, each city park has a rainwater storage pool, which can supply the surrounding residents for 3 d. In addition, Switzerland, New Zealand, South Korea, Singapore, and other overseas cities have different forms of rainwater resources development project, though the policies and regulations, technical research and development, and model research to realize rainwater resources utilization and promotion, which provides the technical support for construction of sponge city in China.

Since 2015, China has fully promoted the pilot work of sponge city construction. Nearly 100 cities have been involved in the construction. In order to proceed with the sponge city construction, since 2015, the government has organized the Ministries of treasury, housing and urban–rural, and water resources to select sponge city for pilot projects. Several good sponge cities, such as Nanning, Shenzhen, Xiamen, Wuhan, etc were funded. The government requires each pilot city to build and run 3 years of not less than 15 km^2 sponge city demonstration zone, the central government grants subsidies of 600, 500, and 400 million Yuan each year to municipalities, capital cities, and other cities for a total of more than 20 billion Yuan within 3 years [7]. In April 2015, Nanning was listed as the first pilot city in the construction of sponge cities in China. The project turned the black and smelly water into a scenic wetland park. Qingxiushan Garden recycled rainwater 22,000 tons per year, saving water cost of 1.2 million Yuan. The pilot project has brought beautiful butterflies to the city, and the urban sponge effect is emerging gradually. Shenzhen is one of the earliest ones to introduce the concept of the urban construction sponge cities. It is listed in the nation's second batch of pilot cities in 2016. Urban construction sponge 2017 project will add sponge urban construction area of more than 30 km^2, facilities throughout the year sponge renovation project of 150 items. Xiamen in 2015 was included in the national pilot city construction, after 3 years' construction, with remarkable achievements. By the end of October 2017, 9.88 km^2 test area has completed. Totally, 25.52 km^2 was constructed, 73 projects have completed, 93 construction projects finished, with the total investment being nearly 6 billion

Yuan. Other pilot cities for the construction also have their own characteristics. Thus, under the leading of the government, the early stage of the pilot cities for the construction shows its result, which has an important guiding significance to our country's urban construction [8].

5. The thinking of the construction of sponge city

5.1. Improve the legal protection system of water resources and build natural water conservancy projects

Water is not only a natural resource, but also an environmental factor, which has important economic value and ecological environmental value. The economic and ecological environmental functions of water resources are interdependent and influential, and only under the premise of the balanced development of the aquatic ecosystem can ensure the sustainability of water resources. Firstly, the principle of the basic security interests should be clarified, safeguard mechanism of basic security interests should be established, and the behavior of people and environment should be regulated to protect integrity and continuity of the life support system and ecological system. The natural systems that support the life on earth do not be damaged. Do not be over the bearing capacity of water resources and the environment. The water environment security should be established. In order to strengthen the legal protection of water environment safety, the legal system of environmental risk identification, evaluation, forecast, prevention, control, and elimination should be established [9].

The sponge city construction gives us an ecological concept that emphasizes water resources "to be natural and natural" [10]. Therefore, before the urban construction, adhering to the concept of nature at the beginning of the design ensures the balance of water conservancy engineering construction and ensures the relationship between the natural environment and the water conservancy project construction in harmony. At the same time, on the basis of guaranteeing the original water system, the construction of water conservancy projects should be strengthened to lay a good foundation for the "sponge" function [11].

5.2. Overall planning, system design, and construction of ecological sponge city

The construction of sponge city should strengthen design of the whole and systematic, so as to "plan a picture, build a chess game, manage a net" [12]. Sponge urban construction should be the most important municipal engineering's project, which was established by a series control system from the demonstration, designing, construction, acceptance, and management. Each department should strengthen communication and cohesion, make whole construction process to form a closed loop (as shown in Fig. 4), form thinking unified, and carry out the construction of sponge city.

In the process of urban construction, it is necessary to take into account the correlation between the various construction projects, permeability, hysteresis, storage, net, etc., which can satisfy the goal of construction of urban about the total runoff control, water quality purification, and can realize intensive economy. Sponge-type park construction, for example, involves a variety of sponge city construction such as projects of permeable brick, permeable asphalt, permeable pavement, and ecological tree pool-subsided green space [13]. The goal-orientation project takes water treating volume and quantity as the goal. At the same time makes rational calculation, for example, permeable pavement, ecological pool, falling tree green space to avoid repeated construction and waste of sponge city technology.

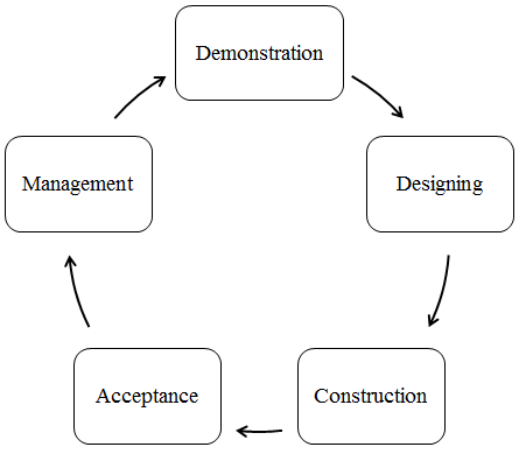

Fig. 4. The systematic construction process of sponge city.

5.3. Build a smart sponge city

The rapid development of artificial intelligence provide favorable technical support for nationwide construction of sponge cities as well as intelligent sponge city. The intelligent sponge city construction is conducive for social benefit, improving ecological environment, and dealing with sudden natural disasters. Surface runoff and pollution-monitoring parameter are difficult to access because at early time there is no real-time online monitoring. With Internet, cloud computing, big data, accurate and real-time monitoring is possible [14]. In the future, network-based rain drainage monitoring system can monitor rainfall and rainwater drainage in real time. Blockage can be found quickly and alarm reported timely. By using of intelligent monitoring system, water can be recycled and used to save water resources. Through the surface water pollution remote sensing, remote sensing system, and real-time monitoring of surface water pollution situation, stealing the domestic sewage and water pollution can be found immediately. The water monitoring system also can have information of the stretch of road surface and the water in heavy storm water situation on real time and remind municipal drainage in time. At the same time, through a comprehensive control and monitoring system the sewage water, rainwater, and reclaimed water can be used efficiently. All these can be realized through the management of cloud dispatch. Every government computer and every citizen mobile terminal can query and master relevant information timely [15]. At present, New Zealand and Australia are best in this area in the world. In their practice they use geographic information system, cloud computing, and Internet of things technology. Through the design of digital model, use of the monitoring system, and information management,

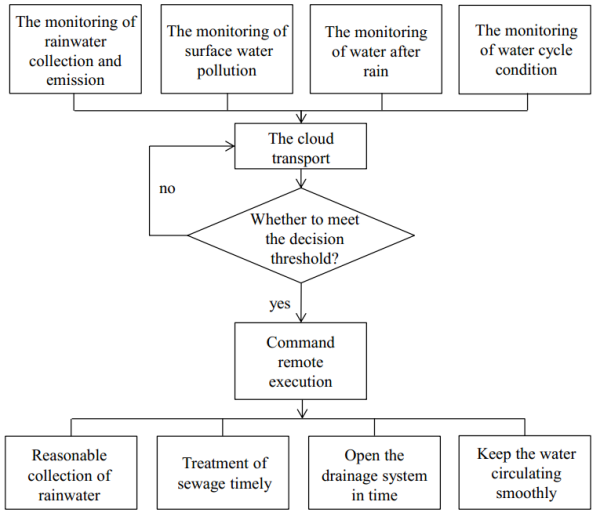

Fig. 5. Smart sponge city operation flow chart.

they have successfully managed water resources [16]. The design is a systematic project. The whole project is about recycling, acquiring IoT sensor information, cloud terminal transmission of information, big data decision, remote command execution, and error correction. The procedures are as follows: firstly, set up the appropriate classification of the IoT sensor about rainfall, runoff, and sewage indicators by components classifying and sensor information collecting. Secondly, transmit the collected information from sensors to the cloud through a data network, WIFI. The cloud technologies make decisions based on information of sensors, different parts of the information, and then decision-making through the network to the terminal. Finally, information is collected again, feedback and correction. Finally, information is collected again for feedback and correction. With such an approach, a city can respond effectively to water problem and initiatives be taken depending on problem. Problems can be solved quickly and a real intelligent sponge city be realized, as shown in Fig. 5.

6. Conclusion

The sponge city construction is a difficult and magnificent engineering. Especially in our country, due to poor experience and theory, the sponge city construction is still in the initial stage. Some developed countries have good experience and example, however, sponge city construction must adjust to local conditions and in a long-term planning, starting from the basic research and from the aspects such as local legislation and social promotion. Persistent efforts are needed to explore the technologies and solutions of the sponge city construction to adjust to local conditions. Sponge pilot city construction is steadily advancing. Mature project, timely summary and effectively management will make our country's sponge urban construction blossom everywhere. With sponge city construction, a magnificent landscape of ecological civilization can be realized for the beautiful blueprint of China.

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