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Ecological Environment Based on the Expo Architectural Design Project

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Abstract

In order to realize the perfect combination of ecological environment and exposition building design, SWAT model is used to simulate the runoff and non-point source pollution of eco-wetland park in this experiment. The causes of the emergence of a large number of wetland parks in China's current social construction environment are analyzed, and the basic composition of their functional framework is summarized. The results show that the SWAT model is basically good in runoff simulation of eco-wetland park, which can provide a reliable model basis for non-point source pollution simulation. Combined with the actual data of quality of imported and exported water in 2017, the degradation capacity of nitrogen and phosphorus pollutants can be calculated. Through the above discussion, analysis and summary of the characteristics and development trend of the eco-wetland-type exhibition building, theoretical research is used to guide the architectural design, to meet its comprehensive function of ecological protection and give full play to the important role of this new type of exhibition building in the urban and wetland environment.

Keywords: wetland, Expo building, coordination, ecotype, SWAT model

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RESEARCH BACKGROUND AND MOTIVATION

In today's society, ecological protection has become a global theme. The propaganda and exhibition exchanges on ecological protection are increasingly frequent in various countries and regions of the world. The exhibition activities play an important role in the process of propaganda, exchange and protection, and promote the popularization of natural science knowledge and the enhancement of public awareness of ecological protection. With the extensive publicity of various international organizations concerned with the protection of ecological environment all over the world, countries around the world attach great importance to the protection and development of the ecological environment of protected areas, and a variety of large-scale exhibitions combined with the ecological environment are increasing day by day. This kind of activity is playing a huge role in today's world which pays more and more attention to the living environment of mankind (Spencer et al. 2016, Tessler et al. 2016).

Wetland, as an important part of the earth's ecological environment system, is in the transition zone between terrestrial and aquatic ecological environment. It is composed of terrestrial, moist, swampy, aquatic animals and plants, as well as microorganisms and their corresponding light environment, water environment, thermal environment, and nutrient environment. It is mutually restrictive and dynamic balance ecosystem and an important component of the terrestrial hydrological and atmospheric cycles (Palta et al. 2017). Wetland resources, oceans and forests are known as the three major ecosystems, with the reputation of the "kidney" of the earth. It is one of the most important environmental capitals of mankind, and it is closely related to human survival, development and reproduction. Wetland resources are widely distributed all over the world. The global wetland area is about 850 million hm^2, accounting for about 6% of the global land area.

The rapid development of urbanization has brought unprecedented opportunities for development. However, due to the lack of reasonable, effective and comprehensive theoretical guidance on urbanization, the blindness of urbanization planning and development and the rapid expansion of urban space make the overall framework of urban and rural areas unbalanced. And a series of problems and

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contradictions to be urgently solved have emerged, among which urban ecological and environmental problems are particularly prominent (Kalantari and Zahra 2017). In the process of urban development from its birth to the present situation, the scale of the city is expanded, the population is aggravated, and the road traffic is highly intensive. The emergence of new organic building materials and the rapid development of wireless communications result in a series of environmental problems, such as the increasing vulnerability of the urban ecological environment, the increasing urban ecological pressure, the decreasing area of urban green space, the increasingly tense urban land and the seriously polluted surface water sources around the city. Some cities abandon the river system - an important natural environment ecological resource, or use the river resources for development funds by “selling out”. It results in the lack of effective planning control and utilization of land along the river in some cities, even making a large number of rivers filled and self-purification capacity of some urban wetland seriously tested. Fortunately, in the process of urbanization, people have come to realize that destroying the ecological environment especially the urban ecological environment, will seriously threaten the normal life and physical and mental health of human beings, and restrict the development of human beings themselves.

Urban ecological wetland, as an important part of urban green space planning system, is most seriously affected by human activities, and has the closest relationship with human life and production. It has the reputation of “urban back garden” and it has many ecological environment functions, such as supplementing urban water amount, regulating regional microclimate, and improving urban ecology and living environment. It is an indispensable link in the process of waterfront urban planning and construction (Campbell et al. 2016). Therefore, in the process of urban planning and construction in recent ten years, large and medium-sized cities at home and abroad have paid great attention to the planning and construction of urban ecological wetlands. Additionally, some developed areas have built a number of urban ecological wetland parks with important environmental, ecological, economic and social functions. Especially in the field of construction and planning of urban river ecological wetlands, gratifying results are achieved (Wei et al. 2017). The study on the landscape planning and construction system of urban river ecological wetland is not only a new research field, but also a new difficult problem faced by the development and utilization of urban wetland resources in the process of urbanization. It is necessary to clearly realize that the theoretical research and concrete practice of planning and construction of urban river ecological wetland in China are still in the initial stage, and there is relatively few planning, construction, development mode and experience to be used for reference. Therefore, it is necessary to establish a set of guidance for planning and construction of different levels, different regions, different scales of urban river ecological wetland. As a result, to seek sustainable protection and to use different river wetland landscape and ecological resources will be the important content in the field of current urban river ecological wetland.

LITERATURE REVIEW

Theoretical Research and Current Situation Abroad

Modern society and economy promote the rapid development of exhibition, the scope of influence is expanded to a region or even the world, special exhibition buildings emerge, independent venues are formed, and exhibition activities are organized orderly. Modern exhibitions began with the World Industrial and Commercial Exposition held in Britain in 1851, and until World War I, world exhibitions were mainly in the form of the World Expo. The emergence and development of the World Expo prompted the emergence of permanent exhibition buildings. Since 1980s, ecological environment protection and sustainable development have become a worldwide development theme. As an effective way to promote the protection and development, the exhibition buildings have developed rapidly to multi-function and diversification. As the best medium to promote the interactive experience of human beings on the ecological environment, exhibitions of various combinations with the environment began to emerge on the stage of exhibition buildings and develop rapidly. According to the development situation of each country, the development of wetland ecological exhibition buildings in different countries is unbalanced because of the different economic strength and ecological protection level. At present, western countries, Japan, South Korea, Singapore and other Asian countries are eco-environmental protection powers, and a variety of eco-environmental protection-related protected areas, observatories, exhibition halls and other buildings are also very popular.

In Asia, South Korea, Japan and Singapore are the pioneers in wetland protection. Wetland exposition buildings with functions of protection, popularization of science and leisure are widely seen in the newly built wetland parks in these countries. The use of wetland landscape to form a new type of tourism is very common in South Korea. Especially the "Niupu Marsh" and "Chun Nan Water Storage Pool" visited by environmental experts in Changning, South Gyeongshang Road, and "Shuntian Wan" on South Quanlao Road, they are all the representative natural ecotourism scenic spots in South Korea. The Eco-Exhibition Hall at Niupu Marsh entrance mainly displays and preserves the records, specimens and images of various animals and plants related to the wetland environment. The Eco-Exhibition Hall becomes a medium for introducing the Niupu Marsh environment (Im et al. 2017). At present, Shuntian Wetland Exhibition Center with large scale still in the design stage creates the impression of the visitors on Shuntian Wan Wetland in the winding and changeable form with the experience route travel of visitors in Shuntian Wan and the expression of "ebb tide" as the major design concept.

Theoretical Research and Current Situation in China

In 1992, China joined the Convention on Wetlands and issued the *China Wetland Protection Action Plan* in 2000. It is estimated that by 2030, nearly 700 wetland protection zones will be planned and constructed in China, and 1.4 million hectares of wetland ecological areas will be restored. Wetland biodiversity and ecosystem benefits can be exploited on the premise of protection, so as to achieve sustainable development of ecological resources. The National Urban Wetland Park is approved by the Ministry of Housing and Urban Rural Development. Up to now, there are 43 national urban wetland parks in China. At the same time, the number of eco-wetland exposition buildings planned to be built is also astonishing. For a time, such buildings have become an essential element in the planning of wetland parks. In the built and planned to be constructed buildings, the good and the bad are widespread, even having the serious impact that buildings damage the wetland environment. But there are also many good works in line with the ecological environment and functional requirements, such as the Xixi Wetland Museum in Hangzhou, the Hong Kong Wetland Park Exhibition Center and so on (Lu et al. 2016).

Hangzhou Xixi Wetland Science Popularization Research and Exhibition Center attracted a large number of international palace-class architects through international bidding. In May 2007, the China Wetland Museum completed the evaluation of the bidding scheme for the architectural planning and design. By adopting the new Hill-type architectural design scheme of Japanese architect Isaki and taking "hills" as the expression carrier, almost the whole museum "buried" into the organic "hills". The whole architectural form is organically integrated with the Xixi wetland landform. It embodies the principle of eco-environmental protection and the coordination with the natural and geomorphic environment of Xixi, and fully shows the harmony of architecture landscape and wetland (Xu et al. 2018).

In the study of Chinese academic journals, there are few systematic theoretical studies on the construction of ecological exposition architecture subject with Chinese characteristics, which combines with wetland park and wetland environment. Professor Qian Xuesen, a distinguished scientist at home and abroad, attached great importance to exhibition Science in the early 1970s. He believed that modern exhibition science could convey information to people through various kinds of physical exhibitions and it was a specialty needed to be set up urgently. He therefore proposed the establishment of a special exhibition institute, thus opening up the prelude to development of exhibition science and exhibition industry in China. Overall, these studies lack the necessary theoretical guidance and sufficient data analysis (Fang et al. 2016). As a result, it is far from meeting the requirements for the construction of a large number of wetland ecological expo buildings in the current social buildings. Therefore, wetland eco-exposition architecture needs a new summary and exploration of the current development situation.

RESEARCH METHOD AND DESIGN

Ecological Level Positioning

According to the preservation of natural wetland environment, urban wetland parks divide the park wetland into three different ecological protection levels. The first one is the core conservation level in urgent need of protection; the second is the buffer protection level that is relatively fragile but allows a small amount of scientific activities; and the last is the open level that can undertake a certain degree of man-made construction and activities. Through wetland environmental assessment, the natural environment of wetland is divided into different levels, and the basic requirements of distinguishing types, key protection and rational development in the process of wetland park protection are realized (Laughlin Fang et al. 2017).

On the basis of these three ecological levels, according to their geographical location, the wetland park has basically formed four geographical areas: peripheral area, open area, buffer zone, and protected area. According to the different layers of wetland environment in each geographical area, a reasonable artificial building and environment layout can be carried out. The protected area is an area in urgent need of wetland environment conservation. It is necessary to establish scientific observation points to record and pay attention to the conservation while ensuring no human disturbance. The buffer zone allows a small number of man-made facilities and simple buildings to ensure the smooth progress of environmental experiments and cultivation. In this case, the functional buildings in the park can only exist in the open area in the ecological open level. Between the area and the surrounding area, buildings with management, service and reception and many other functions are constructed, to meet the management and reception needs of wetland parks.

Regional Network Positioning

In the urban planning, each area and function of the city are divided. The regional positioning of the ecological exposition building of the wetland park constructed by the natural wetland environment is not only determined by the location of the natural wetland, but also guided by the network and iconization in the overall planning of the park. Therefore, the network park regional standard positioning is also the basis for planning and site selection of eco expo building in wetland park (Páez 2017). Wetland Park ecological exposition building is integrated with wetland tourism, urban culture, commercial entertainment and other new industrial functions, forming a multi-functional space system to improve public cultural benefits while providing a recreational and leisure environment.

The network formed by the planning and design of leisure, recreation, commerce and potential axis in the overall planning of wetland park is regarded as a development direction of wetland ecological economy in the future. In different construction sites, the expo architecture can cooperate with various buildings, structures, scenic spots and natural landscapes to form a network according to the tour path, amusement path and leisure business path in the planning of the wetland park. The objective is to find the most suitable site for the expo architecture in the existing park network, achieve the best park tour effect, and increase ecological economic benefits. According to the location and state of the natural terrain, the architectural layout in this network presents a trend of agglomeration or diffusion. Sometimes, because of the limitation of terrain and the need of overall planning, many types of buildings are centralized; sometimes, due to the dispersal of the ecological hierarchy area, the buildings also have discrete layout and it is combined through the tour path.

Table 1. Scale and level of expo buildings

Building scale	Total exhibition area S (m^2)
Super large	S>100000
Large	30000<S≤100000
Medium	10000<S≤30000
Small	S≤10000

Traffic Accessibility Positioning

The site selection of the exhibition building is a very important link in the planning and architectural planning of the wetland park. The proper site selection not only ensures the normal operation and social benefits of the exhibition building itself, but also relates to the coordinated development of all public buildings in the wetland park and the operation and development of the whole park (Liu and Ping 2018).

There should be convenient public transportation around the location of the expo buildings to ensure the accessibility of traffic. Expo building is a public building with mass and cultural service that needs to receive a large number of audiences. But it is different from those buildings with relatively fixed users, such as education and office buildings. Expo building needs to gather the active participation of audiences through its own attraction. This self-attraction except the splendid exhibition of the eco-exposition building itself, also includes the city traffic where it is located. Convenient traffic accessibility is the basic condition for attracting visitors and facilitating the transportation of goods.

Building Scale Positioning

The scale of the exhibition building can be divided into super large, large, medium and small according to the total exhibition area within the base, as shown in **Table 1**. The level of the exhibition hall can be divided into Class A, Class B and Class C according to the exhibition area, as shown in **Table 2**. According to the overall planning basis of the park, building scale positioning based on the land conservation as the main design principle is very important to control the impact of man-made environment on natural wetlands (Deng et al. 2016).

Table 2. Scale and level of exhibition hall

Level of exhibition hall	The exhibition area S of exhibition hall (m^2)
Class A	S>10000
Class B	5000<S≤10000
Class C	S≤5000

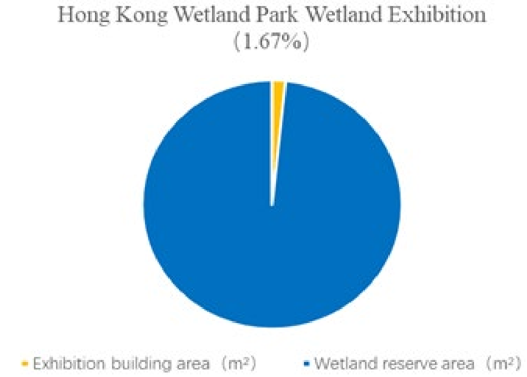

Fig. 1. Coverage proportion of exhibition buildings in Hongkong Wetland Park

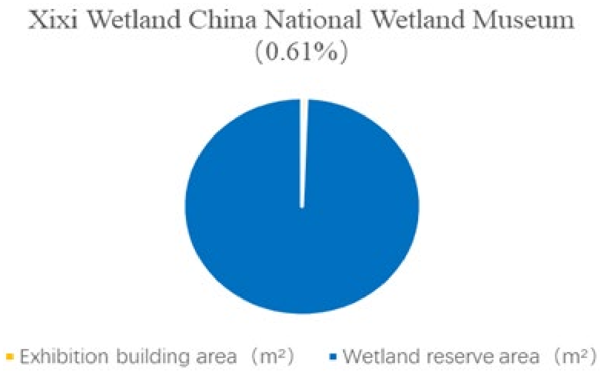

Fig. 2. Coverage proportion of exhibition buildings in the XiXi Wetland area

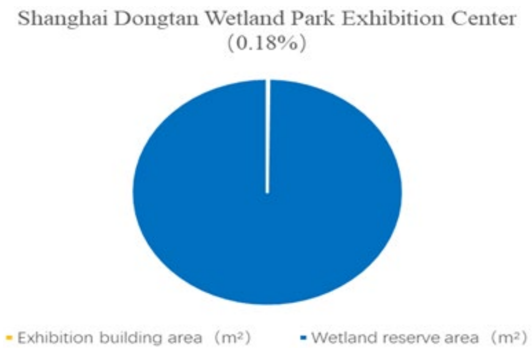

Fig. 3. Coverage proportion of exhibition buildings in Shanghai Dongtan Wetland Park

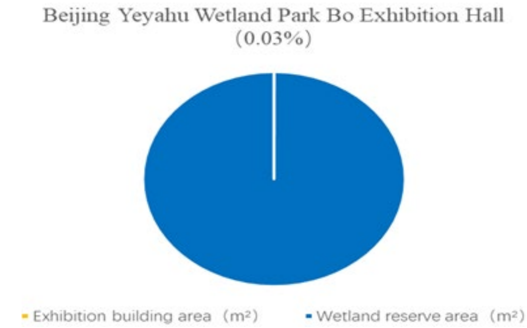

Fig. 4. Coverage proportion of exhibition buildings in Beijing Yeyahu Wetland Park

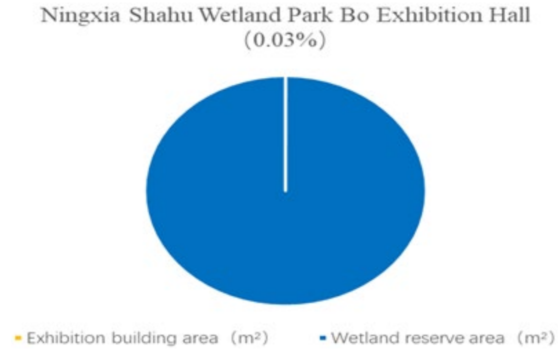

Fig. 5. Coverage proportion of exhibition buildings in Ningxia Shahu Wetland Park

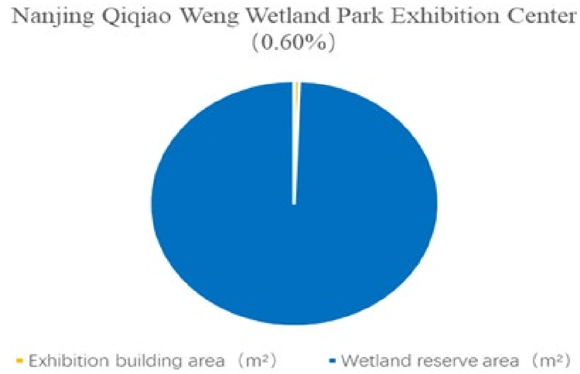

Fig. 6. Coverage proportion of exhibition buildings in Nanjing Qiqiao Weng Wetland Park

Ecological protection is one of the most basic responsibilities of wetland parks. If buildings are built in wetland environment without attention to land conservation, it will cause too large construction scale, which is not practical and also leads to many environmental problems, such as blocking biological habitat paths, producing a large number of building noise and waste pollution, and destroying the overall natural landscape (Merrington et al. 2017, Zeng et al. 2016). At present, the problem of land conservation has been noticed in the exhibition buildings of wetland parks. Taking several domestic exhibition buildings of wetland parks as examples, the chart analysis shows that, except the exhibition hall of Hong Kong Wetland Park, other parts all occupy less than 1% of the total area. The coverage proportion of exhibition buildings in Hongkong Wetland Park, XiXi Wetland area, Shanghai Dongtan Wetland Park, Beijing Yeyahu Wetland Park, Ningxia Shahu Wetland Park, and Nanjing Qiqiao Weng Wetland Park is shown in **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, and **Fig. 6**, respectively.

Table 3. Area ratio of different land cover types in the study area

Land cover types	LanduseSwat code	Area ratio (%)
Housing equipment	UCOM	2.26
No-forest wetland	WETN	0.20
Road traffic	UTRN	20.55
Mixed forest	FRST	49.07
Water	WATR	14.36
Wetland	WETL	13.57

Table 4. Area ratio of different soil types in the study area

Soil type	SU-SYM90 code	Area ratio (%)
Water leaching soil	LVj	33.35
Leached soil	Lgs	52.29
Water	WR	14.36

Table 5. Calibration of sensitive parameters for runoff simulation

Parameters	Parameter code	Parameter range	Parameter value
Runoff curve number	CN2	-0.2～0.2	0.105
Soil evaporation compensation coefficient	ESCO	0.8～1.0	0.8475
Effective field capacity	SOL-AWC	-0.2～0.4	0.3775
Minimum depth threshold for subsurface flow	GWQMN	0～2.0	1.025

RESULTS AND DISCUSSION

SWAT Model Construction

Search for basic data: the basic data needed to establish SWAT model include DEM, land use map, soil type distribution map, soil attribute data and hydro-meteorological data.

Establish model database: the model database is built to produce data that can be directly imported into the SWAT model. Based on the 2013 TM remote sensing images, the landuse grid data are obtained and imported into the model, and the area ratios of different land cover types in the study area were obtained, as shown in **Table 3**. According to HWSD, landsoil grid data were obtained and the area ratios of different soil types in the study area were obtained by establishing a soil type index import model, as shown in **Table 4**.

Import database into model and operate: land cover threshold is defined as 5%, soil type threshold is 20%, and slope threshold is 20%. The model is imported and operated and the watershed is divided into 12 hydrological response units. Continue to load the hydrological and meteorological data and of hydrological stations and rainfall stations needed by the model and operate the model.

Parameter Calibration and Verification

There are many parameters in the SWAT simulation. The sensitive parameters of runoff simulation, as shown in **Table 5**, are selected for calibration.

The key factors to be considered in parameter calibration include total water balance, time lag or dislocation of rainstorm runoff and the shape of discharge process line. Nash simulation coefficient (E_{ns}), daily average relative error (E_r) and determinant coefficient (r^2) are used to evaluate the simulation results, as shown in Formulas (1) to (3). E_{ns} is used to measure the fitting degree between simulated runoff and measured runoff. The closer it is to 1, the higher the fitting degree between simulated runoff and measured runoff is. It is generally considered that, when $E_{ns}>0.5$, it meets the requirement of model simulation; Er evaluates the deviation between the simulated runoff value and the measured runoff value, and the smaller the value is, the closer the simulated runoff value to the measured runoff value is. It is considered that when $r^2>0.6$, it satisfies the requirement of model simulation.

$$E_{ns} = 1 - \frac{\sum_{i=1}^{n}(Q_s - Q_m)^2}{\sum_{i=1}^{n}\left(Q_s - \overline{Q_s}\right)^2} \quad (1)$$

$$E_r = \frac{|Q_s - Q_m\,|}{Q_s} \quad (2)$$

$$r^2 = \frac{\left(\sum_{i=1}^{n}\left(Q_s - \overline{Q_s}\right)\left(Q_m - \overline{Q_m}\right)\right)^2}{\sum_{i=1}^{n}\left(Q_s - \overline{Q_s}\right)^2 \sum_{i=1}^{n}\left(Q_m - \overline{Q_m}\right)^2} \quad (2)$$

In the above formulas, i suggests serial number for analog data; n indicates total analog data; Q_s and Q_m are measured and simulated values of runoff, respectively, m^3/s; $\overline{Q_s}$ and $\overline{Q_m}$ are runoff measurement and simulation average, respectively, m^3/s.

From Formulas (1) to (3) and **Fig. 7**, it is known that, $\overline{Q_s}$ and $\overline{Q_m}$ are 45.4465 and 45.4564m^3/s, respectively, E_{ns}=0.972, E_r=0.000219, and r^2=0.96. The model data are available, and although the simulated values are somewhat different from the measured values, the overall simulation results are good.

Formulas (1) to (3) and **Fig. 8** show that, $\overline{Q_s}$ and $\overline{Q_m}$ are 45.4465 and 45.4539m^3/s, respectively, E_{ns}=0.910, E_r=0.000207 and r^2=0.90. The change trend of rainfall during validation period is consistent, and the simulation is good, but the runoff simulation value is too large.

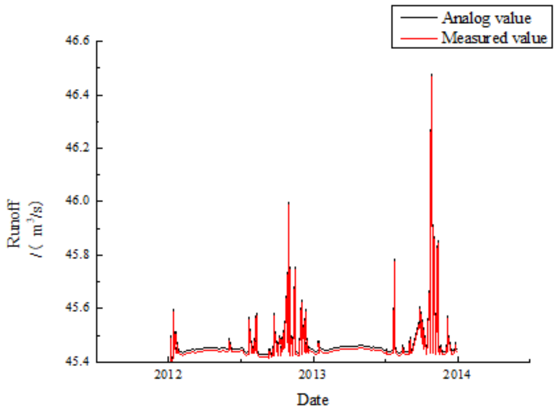

Fig. 7. Rainfall runoff simulation calibration

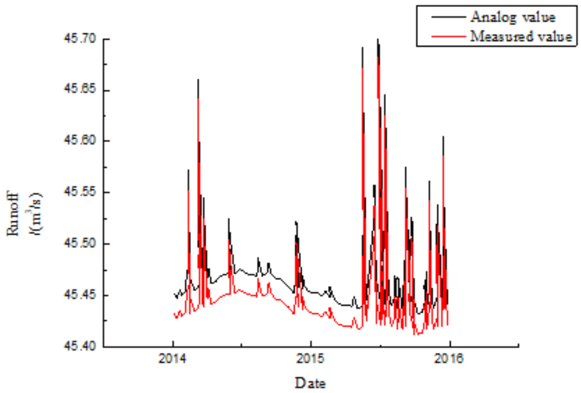

Fig. 8. Validation of rainfall runoff simulation

Table 6. Nitrogen and phosphorus losses from non-point sources in the study area

Month	Rainfall /mm	Phosphorus loss /kg	Nitrogen loss /10^{-5}kg
January	0	6.79×10^{-5}	0
February	0	7.07×10^{-5}	119
March	6.20	2.57×10^{-4}	0
April	54.50	2.23×10^{-3}	0
May	6.90	2.48×10^{-5}	0
June	76.95	33.53×10^{-3}	75519
July	284.75	368.09×10^{-3}	805752
August	167.60	1195.01×10^{-3}	2712709
September	67.95	207.98×10^{-3}	486662
October	21.80	3.46×10^{-3}	779
November	58.05	12.62×10^{-3}	4061
December	11.55	6.58×10^{-3}	5557

Results and Analysis

Calculation of non-point source pollution in park green space: taking 2017 as an example, the annual rainfall is 756mm and the annual runoff is 1.430 thousand m^3. According to SWAT model, the loss of nitrogen and phosphorus in Lingang Wetland Park is 41 kg and 1.83kg, respectively. From **Table 6**, it can be seen that the loss of nitrogen and phosphorus from non-point source is positively correlated with rainfall, that is, with the increase of rainfall, the loss of nitrogen and phosphorus from non-point source increases. The low loss of nitrogen and phosphorus from non-point sources in spring is low due to less rainfall, while the maximum loss of nitrogen and phosphorus from non-point sources in August is related to rainfall and the application of quick-acting fertilizer in summer.

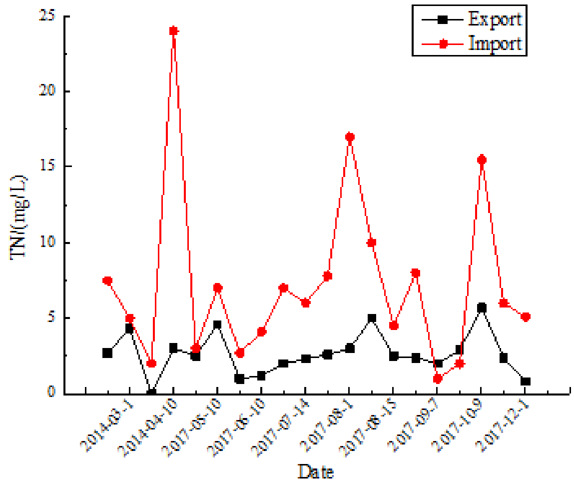

Fig. 9. Comparison of imported and exported TN in the study area

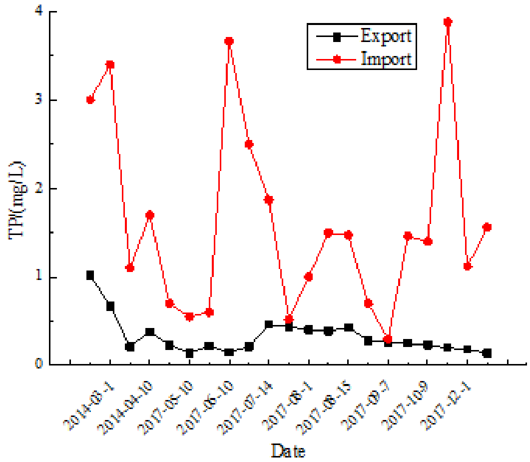

Fig. 10. Comparison of imported and exported TP in the study area

Analysis of pollution capacity of wetland system: water quality monitoring is conducted on the inlet and outlet of the park water, and the monitoring time is 1-12 months in 2017. In order to increase the frequency of water quality monitoring during the flood season, the water quality of the park is monitored once a month in January-March and November-December, twice a month in April-June and September-October, and four times a month in July-August.

It can be seen from **Fig. 9** and **Fig. 10** that, the water quality at the outlet of the park is much better than that at the entrance, and the wetland has a remarkable ability to degrade pollutants. According to the calculation, the degradation of nitrogen and phosphorus in Lingang Eco-Wetland Park in 2017 were 5764.38kg and 2070.79kg, respectively.

CONCLUSION

Urban wetland parks are of great significance to urban planning, urban geography and urban ecology: to meet the green leisure needs of citizens, and to inject new vitality into the urban tertiary industry, including tourism and exhibition industry. The terrain in the urban geographic network plays the role of flood control and water storage and conservation of freshwater resources. It is an ecological buffer zone that restores natural ecosystems and regulates conflicts between humans and nature. Eco-wetland type exhibition building is bred in this background. As a bridge and medium between human and natural environment, it has become one of the widespread building types in urban wetland park planning, and it is also a new type of exhibition building appearing in recent years. The runoff simulation of the SWAT model in the coastal wetland park is basically good. At present, most domestic studies think that SWAT model is more adaptable in large watershed, mountainous and hilly areas with large topographic undulations, but the influencing factors of model efficiency coefficient are not single. Therefore, the exploration of the applicability of the model and the verification of simulation results still need a lot of research work. The study takes non-point source pollution measurement model SWAT as the processing tool. The non-point source pollution status of Lingang Eco-Wetland Park is simulated, and the degradation capacity of pollutants in Lingang Eco-Wetland Park is evaluated with the monitoring data in 2017, which provides a reference for the water quality standard of wetland park.

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