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Research on Watershed Pollution Control and Intelligent Ecological Remediation Mechanisms in Housing Ecosystem Construction

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Abstract This paper verifies and investigates the main sources of pollution in the watershed through the combination of data collection and field research, and comprehensively organises the basic data of each source of pollution in the construction of housing ecological environment. In order to more accurately calculate the nitrogen and phosphorus pollution load emitted by each watershed pollution source, this topic uses the field monitoring of pollution sources to measure the pollutant emission coefficients, while the watershed pollution in the housing ecological environment construction mainly contains agricultural cultivation, agro-industrial and domestic sewage, atmospheric wet deposition, and decentralised aquaculture. Based on the concept of ecological restoration, an intelligent ecological restoration mechanism was designed to decipher the components of each part of the mechanism. The above theoretical knowledge and research data are synthesised to discuss the watershed pollution control and intelligent ecological restoration technology. The contribution of each pollution source to COD pollution is in the order of agricultural cultivation (245.47t/a) > rural domestic sewage (212.35t/a) > farmhouse wastewater (98.42t/a) > decentralised aquaculture (66.72t/a) > atmospheric wet deposition pollution (45.53t/a), with the best oxygen permeability in Sink 3, which has a depth of permeable substrate up to 7.25mm, and the depth of permeable substrate in Sink The depth of permeable substrate of Sink 1 is only 2.45mm, and lowering the water level can effectively increase the nitrification rate of the surface layer of substrate and achieve the simultaneous removal of pollutants, which is conducive to the green and sustainable development of the ecological environment.

Index Terms housing, ecological restoration mechanism, watershed pollution control, sustainable development, emission factor

I. Introduction

In the first 20 years of the 21st century, if China wants to accomplish the great strategic task of building a moderately prosperous society in an all-round way and accelerating the socialist modernization, accelerating the urbanization process should be the way to play the role of the city center and improve the economic efficiency, as well as the way to eliminate the binary structure and realize the social equity. Since the reform and opening up, the face of Chinese cities has undergone radical changes, and the level of urbanization has been increasing [1]-[4]. Undeniably, the strategies of urban modernization and rural urbanization have played a crucial role in accelerating economic and social development, actively enhancing the level of modernization, and the continuous advancement of rural urbanization has greatly contributed to the development of rural modernization and industrialization, and the people's living standards have been greatly improved [5]-[8]. However, for a long time, China's form of urban development, which takes the pure pursuit of economic growth as its main goal, has also brought about serious ecological and environmental problems. In the process of housing environment construction, people pay more attention to the direct economic benefits and directly ignore the social and environmental benefits [9]-[12].

At the same time of the rapid development of housing environment construction, people have seen that the society is facing the plague of increasingly serious environmental problems, such as serious pollution of water bodies, serious shortage of water resources, scarcity of land resources, the area of arable land is decreasing year by year, excessive consumption of resources and energy consumption of residential houses, low ecological degree of outdoor environment of residential houses, and indoor environmental problems of residential houses, and so on [13]-[15]. This obviously has a serious impact on the realization of China's future urban development goal (to build a modern international metropolis suitable for entrepreneurship and residence at home and abroad). Under these conditions, the only way for China to ultimately realize the sustainable development of urban settlements is to develop ecological housing [16]-[18]. Recognizing the importance of the ecological environment, research on how to achieve watershed pollution control and intelligent ecological restoration has begun to emerge in recent years, and these studies have helped to promote and guide the rapid and healthy development of ecological housing environment construction [19]-[22].

Compared with the traditional field survey, this paper explores the mechanism of watershed pollution control and intelligent ecological restoration in housing ecological environment construction by means of experimental testing, which is very innovative and persuasive. In order to accurately reflect the nitrogen and phosphorus pollution loads emitted by watershed pollution sources in housing ecological environment construction, the pollutant emission coefficients are measured by field monitoring of pollution sources, and the distribution of watershed pollution loads is reflected through the pollutant emission coefficients. Take the form of consulting References to define the concept of ecological restoration, and take A watershed as the research subject of this paper to formulate the intelligent ecological restoration mechanism. Determine the data sources and experimental equipment to analyse the watershed pollution control and ecological remediation technology by example.

II. Research on watershed pollution control and intelligent ecological restoration mechanisms

II. A. Watershed Pollution Control

II. A. 1) Survey of major sources of pollution in watersheds

As the upper basin of the two reservoirs are important water source protection area, most of the factories have been shut down, stopped, merged and transferred, small bamboo processing plant wastewater are collected and transported for uniform treatment, the basin is now basically no distribution of industrial enterprises, pollutants are mainly from agricultural cultivation, rural sewage, agricultural sewage, decentralised aquaculture, and atmospheric wet deposition pollution. This paper through the collection of information and field research combined with the main sources of pollution in the watershed to verify and investigate, and the basic data of each source of pollution for the comprehensive collation, calculation, the basic data of pollution source survey results as shown in Table 1. As can be seen from the table, the total number of users of housing area C in watershed A is 10857 households, and the number of people is 33746.

Table 1: Survey results of pollution source basic data

River basin	Region	Household	Population (person)	Male (person)	Female (person)	Rural population(person)	Man/house
A	C	10857	33746	16940	16806	30054	2.83
B	D	5669	17962	9068	8894	12753	2.25
	E	4768	15229	7657	7572	7887	1.65

II. A. 2) Pollutant Source Water Quality Testing Locations and Sampling

In order to more accurately calculate the nitrogen and phosphorus pollution loads discharged by pollution sources in each watershed, the pollutant discharge coefficients were measured by field monitoring of pollution sources in this project. The watershed pollution in housing ecosystem construction mainly contains agricultural planting, agricultural and domestic sewage, atmospheric wet deposition, and decentralized farming.

(1) Agricultural cultivation

Through field research, it is found that the plantation industry in the upper watershed of the two reservoirs is mainly dominated by chestnut forests, white tea, vegetable land (watered land), seedlings, paddy fields, and dry land. On the basis of literature review and relevant experience, suitable representative locations in the two reservoir basins were selected to set up standard runoff fields for chestnut, white tea, vegetable fields and seedlings, each with an area of 5 × 20 m and corresponding to a catchment bucket, which was used to collect surface runoff water in the small area. The diameter of the bucket was 50cm and the height was 80cm, and the water samples in the bucket were collected after each rainfall and the height of the water samples in the bucket was recorded, and the bucket was cleaned up after the water samples were collected in order to collect the next runoff water samples. The collected water samples will be brought back to the laboratory for direct measurement or stored in the refrigerator at -20℃ for measurement, and the storage time will not exceed one week.

(2) Agricultural and domestic wastewater

Utilizing the existing statistical data and sampling surveys, the basic information of domestic sewage and farmhouse sewage is obtained, and the monitoring points are set up in conjunction with the direction of discharge. A total of 19 monitoring points are set up for residential sewage treatment facilities, including 14 monitoring points in the watershed and 5 monitoring points in the watershed upstream of Reservoir A. Nine monitoring points are set up in the agricultural wastewater treatment facility. Domestic wastewater and farmhouse wastewater are collected on a quarterly basis in the watershed selected domestic wastewater and farmhouse wastewater typical treatment facilities in the incoming and outgoing water samples, to monitor the dynamic changes in wastewater quality indicators. Each time before sampling, with raw water will be clean bucket wet wash 3 times, and then use the bucket to draw water, remove debris on the surface of the water, garbage and other floating objects poured into the 250mL sampling bottle encapsulated and well labeled (marked with the point number, in and out of the water samples sign and sampling date, etc.). After the completion of the collection of all water samples to bring back to the laboratory for immediate measurement or saved in -20 ℃ refrigerator to be measured, save time not more than 1 week.

(3) Atmospheric wet deposition

Since the two reservoirs are geographically not far from each other, the meteorological conditions do not differ much and the atmospheric deposition is similar, one meteorological station was set up as a sampling and monitoring point in Area C.

(4) Decentralized Farming

The aquaculture industry in the upper basin of the reservoir mainly includes livestock and poultry farming and aquaculture. Due to the fact that in recent years, with the livestock and poultry farming remedial action, the farms in the prohibited area have basically been shut down, and at the same time, due to the limitation of the terrain, the basin is not suitable for large-scale aquaculture and the amount of dispersed aquaculture is also decreasing, and the threat of pollution to the water body is also decreasing gradually, and the emission coefficients of the measured The "cost-effectiveness" is relatively low.

II. A. 3) Monitoring indicators and analytical methods

The main sources of watershed pollution control in the construction of housing ecosystems are domestic sewage, farmhouse sewage, rainwater, and plantation runoff field water samples of the main monitoring pollutant indicators are ammonia nitrogen, total phosphorus and total nitrogen, which are determined using the Hash Rapid Determination Instrument (HRDI) kit.

II. A. 4) Methods for estimating emission factors and pollution loads

(1) Domestic sewage

Rural domestic pollutant discharge coefficient refers to the amount of pollutants produced by normal daily life of each person in a certain area with a certain economic income level, and the amount of pollutants that enter the environment after direct discharge or reduction. The emission coefficient and pollution load of each pollution indicator is calculated by the formula:

$$W_{p,k} = \frac{1}{1000 \times n} \times \left(Q_p \times \rho_{i,k}\right) \tag{1}$$

$$W_{d,k} = W_{p,k} \times \left(1 - \frac{Q_u}{Q_p}\right) \times \left(1 - \gamma_k\right) \tag{2}$$

$$L_{kw} = W_{d,k} \times N \times 365 \times 10^{-6} \tag{3}$$

where $W_{p,k}$ is the production coefficient of pollutant k in sewage, unit $g/d \cdot$ people. Q_p for the amount of sewage produced, unit $L/d \cdot$ households. $\rho_{i,k}$ is the mass concentration of the k th pollutant in the effluent of the i th farm household, unit mg/L, this value is the monitoring value. n is the population of the i th farm household, unit person/household, and this value is the survey value. $W_{d,k}$ is the discharge coefficient of the k th pollutant in the effluent, unit $g/d \cdot$ household. L_{kw} is the removal rate of the k th pollutant, unit %, and this value is the monitoring value. Q_u is the amount of sewage utilization, unit $L/d \cdot$ household. L_{kw} is the k th pollutant discharge volume, unit t/a. N is the total number of people in the study area, unit people.

(2) Nongjiale sewage

Agricultural household sewage discharge coefficient calculation reference to the rural household sewage discharge coefficient calculation method.

(3) Agricultural Cultivation

The coefficient estimation method is used to determine the pollution emissions from planting industry, and the calculation formula is shown in Equation (4) ~ (6). That is:

$$W_{zj} = p_{Year} \times S_l \times C_i \times \rho_{ave} \times 10^{-4} \tag{4}$$

$$\rho_{ave} = \frac{\sum_{m=1}^{n} \frac{Z_m}{Y_m}}{n} \tag{5}$$

$$L_{pj} = W_{zj} \times \frac{U_{zj}}{R_j \times 100\%} \tag{6}$$

where, W_{zj} is the pollution loss intensity coefficient for plantation, unit $t/a \cdot khm^2$. p_{Year} is the annual rainfall, unit mm. S_l is the area of runoff field, unit m^2. C_i is the concentration of runoff pollutant i, unit mg/L. ρ_{ave} is the runoff coefficient. Z_m is the total amount of m th rainfall runoff, unit m^3. Y_m is the total amount of m th rainfall, unit m^3. R_j is the replanting index for each land use type. L_{pj} is the amount of pollutant loss from cultivation, unit t/a. U_{zj} is the area of land use for each type of cultivation, unit khm^2.

(4) Decentralized farming

(a) Livestock and poultry farming

The formula for calculating the amount of sewage discharged from livestock and poultry farming is as follows:

$$L_{lb} = \sum_{i=1}^{n} \left(\delta_{i1} \times \alpha_{i1} + \delta_{i2} \times \alpha_{i2} \right) \times N_i \times 10^4 \times 10^{-3} \times \left(1 - \beta_i\right) \tag{7}$$

where, L_{lb} indicates the total amount of drainage from livestock and poultry farming in the basin, unit t/a. n for the types of livestock and poultry. δ_{i1}, δ_{i2} are various types of livestock and poultry individual annual production of feces and annual production of urine, unit t/a. α_{i1}, α_{i2} are livestock and poultry feces and urine in the average content of pollutants, unit kg/t. N_i for the total number of various types of ï¿½ poultry rearing, unit 10,000 heads / 10,000 feathers. β_i for the various types of ï¿½ in the pollution treatment rate.

(b) Aquaculture

In this study, the estimation of aquaculture discharge is based on the production estimation method, and the specific algorithm is as follows:

$$L_{al} = \sum A_i \times S_i \times 10^{-3} \tag{8}$$

where, L_{al} for aquaculture emissions, unit t/a, A_i for various types of aquatic products per unit of production of sewage equivalent coefficient, unit kg/t, S_i for the production of various types of aquatic products, unit t.

(5) Atmospheric wet deposition

Atmospheric wet deposition of each pollutant annual pollution load in accordance with the formula (9) for calculation. That is:

$$L_{ri} = C_i * p_{Year} * S_j * 10^{-3} \tag{9}$$

where L_{ri} is the annual pollution load of a pollutant indicator for stormwater, in units t/a. C_i is the average annual concentration of the pollutant indicator, in units mg/L. p_{Year} +is the annual rainfall, in units mm. S_j is the rainfall catchment area of the watershed, in units km^2.

II. B. Intelligent ecological restoration mechanisms

II. B. 1) The concept of ecological restoration

In ecological restoration, “restoration” emphasizes more on the subjective initiative of human beings and their actions, and the reconstruction of damaged ecosystems by human beings [23], [24]. Scholars at home and abroad have different understandings of ecological restoration, and the international definition of ecological restoration is the process of restoring the diversity and dynamics of native ecosystems damaged by human beings [25], [26]. In a specific region or watershed, relying on the self-organization and self-regulation ability of the ecosystem itself alone, or relying on the combination of the self-organization and self-regulation ability of the ecosystem itself and the artificial regulation ability, the partially or completely damaged ecosystems are restored to a relatively healthy state. Ecological restoration should not be a completely natural process, scientific and reasonable artificial auxiliary measures, such as replanting measures in the restoration area of local soil erosion is more serious, etc., is conducive to accelerating the natural restoration of ecosystems and make it to the direction of benign development [27]. Ecological restoration is to follow the laws of ecology, relying on the self-regulating ability of the ecosystem to repair the damaged ecosystem, and then appropriate human guidance to curb the further deterioration of the environment, so that it restores the ecological function of the process.

II. B. 2) Overview of the study area

Basin A is dominated by a subtropical monsoon climate zone, followed by a temperate continental climate. The climate in the whole basin is mild and humid, but the seasonal distribution of precipitation is uneven, with hot and rainy summer and cold and little rain in winter. The annual precipitation is 844 mm, which is relatively abundant, and the runoff from May to October accounts for about 80% of the year, which is the most variable river among the major tributaries of the Yangtze River. The basin covers an area of 168,000km², and flows through 78 counties (cities) in 20 districts (cities) in 6 provinces.Basin A has a fast pace of economic development, rich variety of natural resources and excellent ecological conditions, and is an important grain-producing area in China.Historically, it was one of the five corridors from the western plateau of China to the central basin and the eastern plain, and it is a strategic corridor connecting the Yangtze River Economic Belt and the New Silk Road Economic Belt now. Basin A is one of the richest regions in terms of resource elements. Convenient transportation provides better conditions for socio-economic development and is an important corridor connecting resource exchange and economic exchanges between different regions. In March 2022, the construction of the ecological and economic belt was incorporated into the national “13th Five-Year Plan”, which was formally upgraded to a national strategy. The Han River Basin, with its rich natural resources, strong economic foundation and favorable ecological conditions, is an important grain-producing area and ecological functional area in China, historically one of the five major corridors from the western plateau to the central basin and the eastern plains of China, and now a strategic corridor connecting the Yangtze River Economic Belt and the New Silk Road Economic Belt. Watershed A has a long history of development and is now subject to rapid economic development throughout the watershed as a result of the country's reform and liberalization policies.

II. B. 3) Establishment of an assessment mechanism for rehabilitation projects

The stages, types, constraints and restoration objectives of ecological restoration are different. Therefore, the quantity standard and technical standard of ecological restoration are not the same, and the feasibility reports of different types of restoration project works should be formulated according to the stage of ecological restoration, different types, and the degree of pollution, respectively. First, the funds required for the restoration (the funds required to meet the standard) are measured, and the funds that can be provided annually are estimated, including the financial funds from the central government, the province, the city and the county levels, and the special fund. Funds from individual social funds of enterprises and social organizations. Funds from the World Bank and foreign governments. Government purchase of public services to get services and funds. Secondly, whether the budget of project funds is reasonable, whether there is overestimation and waste. Third, whether the technical standards are scientific and advanced, how feasible the specific operation is, and whether it can meet the expected standards and governance goals, etc. Experts from relevant departments need to be hired to evaluate the feasibility report.

II. B. 4) Ecological restoration techniques

Establishment of environmental resource databases and sharing of information on the water environment. For example, the government has invested in collecting nationwide data and information on watershed boundaries, water flow, water quality, soil, land use, etc., and has made all the data publicly available on the Internet. Japan is more advanced in water ecological management and water pollution control technology, using physical, chemical and biological/ecological methods of three technologies for the management of polluted waters and ecological remediation, and this paper mainly adopts the chemical method of remediation of pollution in the watershed, the main principle of which is the synergistic drive of aerobic nitrification - anaerobic denitrification for ecological remediation of the substrate, and to realize simultaneous removal of oxygen-consuming substances, such as carbon, nitrogen, and sulfur, from polluted substrate, which will be described in the following section. The effect of this ecological remediation technology will be analyzed in the following.

II. B. 5) Establishment of an efficient organizational management structure

Relying on the relevant functional departments of provinces, cities and counties, different types of management subsystems have been set up, such as mine ecological restoration, water resource protection, vegetation restoration, land reclamation, geologic disasters, soil erosion, and pollution of solid wastes such as coal gangue. Absorb a variety of technical experts into the management organization, responsible for planning and demonstration of ecological restoration, investment consulting of ecological environment restoration and management projects, project feasibility study and technical review and assessment of the effect of the implementation of the project, and carrying out scientific research on ecological environment protection in coal mining. Carry out monitoring of ecological environment quality in mining areas. It coordinates the relationship in terms of ecological restoration work and is responsible for the organization, implementation and supervision of such work.

II. B. 6) Broadening the sources of funding for ecological compensation

Strive for the support of the national ecological compensation funds and the central financial funds, therefore, for the ecological restoration debts formed in history, according to the principle of combining financial and administrative rights, the central government should be responsible for the ecological restoration and compensation of the historical debts formed in history, and increase the support of the provincial financial ecological restoration. Broaden the channels for raising funds from enterprises, social groups and individuals. Mobilize social funds for ecological restoration and management by formulating preferential policies. Use economic means such as financial subsidies, tax exemptions and reductions, sewage fee trading, cost sharing, subsidized loans, land use and other preferential policies to encourage and mobilize social funds to actively invest in ecological restoration projects.

III. Example analysis of watershed pollution control and ecological restoration mechanisms

III. A. Analysis of the effectiveness of watershed pollution control

III. A. 1) Emission factors for watershed sources

Watershed pollution source loads in housing ecosystems are usually categorized into two main groups, namely, point source pollution and surface source pollution. There is no industrial pollution inflow into the Pingtian Lake watershed, and its pollution sources mainly come from agricultural cultivation, rural domestic sewage, farmhouse sewage, decentralized farming, and atmospheric wet deposition pollution. According to the current population of the basin to estimate the number of rural domestic pollution into the lake COD (potassium dichromate method), TN (alkaline potassium persulfate digestion UV spectrophotometry) and TP (ammonium molybdate spectrophotometry), domestic pollution discharge coefficients with reference to the “National Technical Guidelines for the Approval of the Capacity of the Water Environment,” to determine the relevant provisions of the watershed pollution discharge coefficients as shown in Figure 1. It is obvious from the figure that the discharge coefficients of agricultural plantation in COD, TN and TP are 64.361, 5.708 and 1.053 respectively, and the discharge coefficients of agricultural plantation in the watershed pollution sources are the highest compared to the rural domestic wastewater, agro-industrial wastewater, decentralized aquaculture and atmospheric wet deposition pollution.

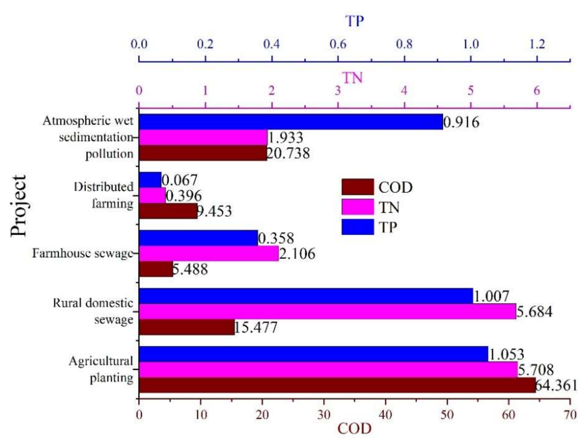


Figure 1: Emission coefficient of watershed pollution sources

The main pollutants entering the lake from various pollution sources in basin A in 2022 are shown in Fig. 2. The pollution load of COD in basin A in 2022 amounted to 668.49t/a, and the contribution of various pollution sources to COD pollution was in the following order: agricultural cultivation (245.47t/a) > rural domestic sewage (212.35t/a) > farmhouse wastewater (98.42t/a) > decentralized aquaculture (66.72t/a) > atmospheric wet fallout pollution (45.53t/a).The load of TN was 79.6t/a, of which the pollution from agricultural farming contributed the most, accounting for 29.84%, followed by agro-industrial wastewater and rural domestic wastewater, which accounted for 24.80% and 18.73%, respectively, and the other sources of pollution discharged less. The amount of TP entering the lake in the watershed was 8.47t/a, with rural plantation (29.28%), agricultural household sewage (32.82%) and rural domestic sewage (14.05%) as the main sources of pollution, accounting for a total of 76.15%.

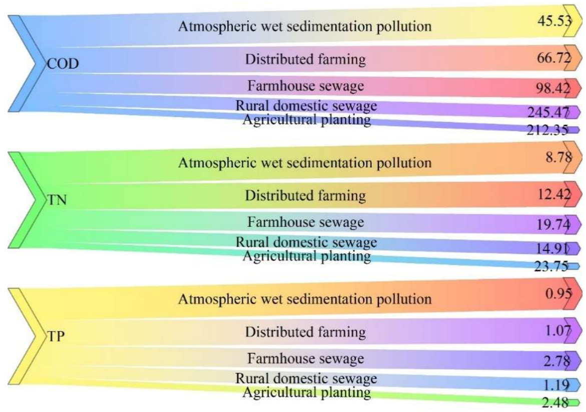


Figure 2: A Main pollutants from various pollution sources in the basin into the lake

III. A. 2) Characterize the distribution of pollution loads in the watershed

The raw data come from the field research in a region and the statistical information provided by local government departments for the years 2022-2024, including statistical yearbooks, environmental statistics data, and river water quality monitoring data. Based on the watershed pollution load calculation method given in 2.1.4 above, the watershed pollution load distribution characterization was carried out for the five categories of agricultural cultivation, rural domestic sewage, farmhouse sewage, decentralized aquaculture, and atmospheric wet deposition pollution, and the results of the watershed pollution load distribution characterization are shown in Fig. 3, in which (a) to (c) are chemical oxygen demand (COD), ammonia nitrogen, and total phosphorus as the main pollutants, respectively. In order to show more intuitively the spatial distribution characteristics of pollution in each major watercourse basin in Nansha District, the pollution level of each control unit was evaluated according to the control unit it was divided into. Since the size of different control units is not the same, the pollution load per unit area is used to characterize the pollution degree of each control unit, since the amount of pollution entering the river is not the same scale for comparison. It can be seen that the areas where the distribution of the three pollution factors is more concentrated are mainly in area L, area I and area R. It can be seen that the areas with higher pollution load pressure are mainly in the northern part of the region, whose zones coincide with area L, area I and area R. The pollution loads are mainly in the northern part of the region. This situation is due on the one hand, the northern L region, I region, R region in recent years, the population growth is faster and clustered in the center of the township, resulting in pollution is also more concentrated, on the other hand, the center of the township sewage network and treatment facilities built a long time ago, the construction scale and standards have been difficult to meet the current situation of the needs. Therefore, in the process of water environment management, should be targeted to these areas as a key management area, on the one hand, actively strengthen the sewage collection and treatment facilities for the expansion project, on the other hand, through the ecological management of the watershed and other comprehensive means to improve the water quality of the above areas. For areas with a low level of pollution and where industry, agriculture and tourism are the main industries in the future, pollution into the river should be further reduced on the basis of maintaining the status quo by means of enterprise interception of sewage pipes, cleaner production renovation, zoning management of livestock and poultry, ecological farming and resource utilization of waste.

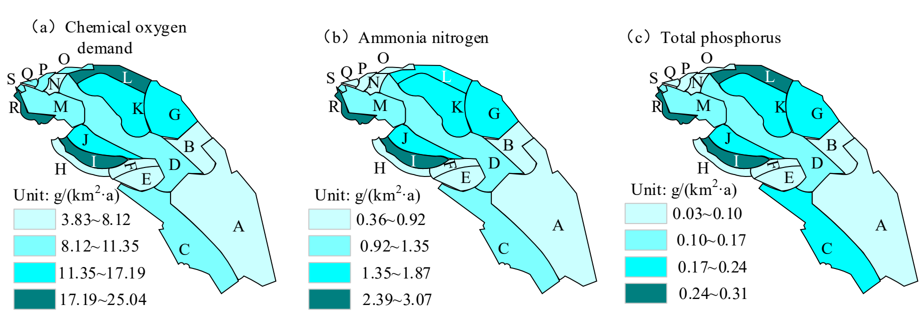


Figure 3: Analysis of the distribution characteristics of the pollution load in the basin

III. B. Analysis of the effects of ecological restoration techniques

III. B. 1) Description of the experiment

In order to explore the effect of in-situ restoration of urban river substrate and the mechanism of water ecological restoration under the low-water operation mode, an indoor simulated river channel was constructed to carry out the ecological restoration experiment of low-water operation. The simulated river channel adopts a brick circulating flume with a width of 1.5m, a height of 1.5m and a bottom slope of about 0.1%. According to the direction of water flow, the inlet pool, the test section and the outlet pool are in order, with lengths of 1.0, 6.0 and 1.0m respectively, separated by a brick wall in the middle. The outlet pool is equipped with a circulating water pump and electromagnetic flow meter, controlling the water flow rate of 0.006m³/s, running continuously for 24h throughout the day, and the whole test cycle is 60d. Compared with the ground, the test section of the water tank is uniformly controlled at a height of 85cm, and different thicknesses of padded river sand are paved at the bottom of the water tank 1, water tank 2, and water tank 3 from the left to the right, which are 0, 30, and 60cm, respectively, and the top of the river sand is covered with a 25cm thickness of black smelly bottom mud, reserving the upper part of the water tank for the water tank. Black smelly substrate, the depth of the reserved upper cover water was 60cm, 30cm and 10cm respectively, so as to investigate the effect of three different water levels, high, medium and low, on the substrate restoration effect.

III. B. 2) Experimental results

Illuminance is one of the important conditions to accelerate the material and energy transformation in the water ecosystem, and sunlight irradiation to the surface layer of the substrate can promote algal photosynthesis and release DO. The results of the indoor test showed that the illuminance at the mud-water interface of sink 1, sink 2 and sink 3 were 60, 1800 and 6550lx, respectively, and it was seen that the illuminance in sink 3 exceeded that of sink 2 by a factor of 3.6, and that of sink 1 by a factor of 100. Figure 4 shows the variation of DO mass concentration with water depth for different sinks, where the negative value of water depth indicates below the mud-water interface. It can be seen that the DO mass concentration in the water phase at the mud-water interface is 5.77 mg/L in Sink 3 and 2.35 mg/L in Sink 1. The vertical distribution shows that Sink 3 has the best oxygen permeability, with a depth of permeable substrate of 7.25 mm, while the depth of permeable substrate in Sink 1 is only 2.45 mm. The results of the indoor simulation experiments show that lowering the water level can significantly increase the illumination, water temperature, and DO mass concentration at the mud-water interface, and the water depth can be increased by 100 times, water temperature and DO mass concentration.

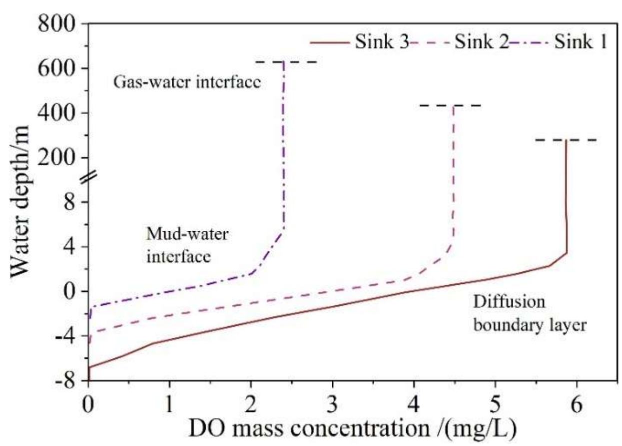
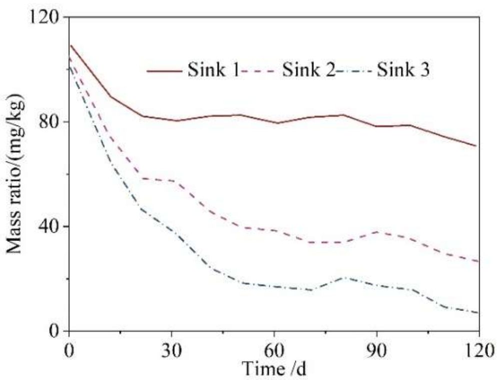
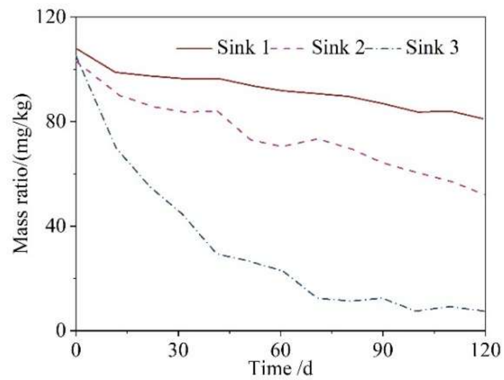


Figure 4: The variation of DO mass concentration with water depth in different sinks

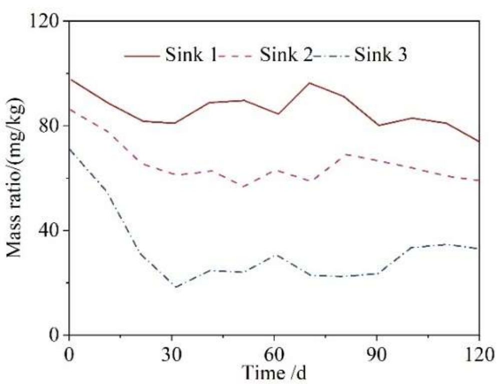
Figure 5 shows the vertical variation of the mass ratio of major pollutants in the substrates of different flumes, where (a) to (l) denote the four layers of $NH_4^+ - N$, $NO_3^- - N$ and AVS, respectively. Significant differences ($p<0.05$) were observed between the contents of $NH_4^+ - N$ and AVS in the substrate of Sink 3 and Sink 1. The mass ratio of $NH_4^+ - N$ in the substrate of Sink 3 decreased to 6.11 mg/kg at the depth of layers I and II, and the removal rate was about 93.72%. After that, the $NH_4^+ - N$ removal rate gradually decreased with depth, and the $NH_4^+ - N$ removal rate in layer IV decreased to 52.7%. In contrast, the removal rate in the substrate of Sink 1 $NH_4^+ - N$ in layer I was only about 28.72%. It can be seen that the thickness of the oxidized layer in the surface layer of the substrate is the result of the interaction between the downward infiltration of the overlying water DO and the upward release of the deeper substrate $NH_4^+ - N$. The layer III $NO_3^- - N$ mass ratio of the substrate in Sink 3 was the highest, reaching 237 mg/kg at the peak, and its denitrification rate was also the highest, reaching 63.75 mg/(kg.d), which was 3.98 times higher than that of the same depth in Sink 1. In the first 20 d of the test operation, $NO_3^- - N$ accumulated in the substrate, and in the 20-60 d of the test, the content of substrate $NO_3^- - N$ showed a rapid decline due to the occurrence of denitrification, resulting in a higher content of $NO_3^- - N$ in layers II and III than that in the upper and lower layers, indicating that there may be a vertical infiltration of $NO_3^- - N$ produced in the surface layer of the substrate. In summary, lowering the water level can effectively increase the nitrification rate in the surface layer of the substrate, and the produced $NO_3^- - N$ infiltration and increase the denitrification rate in the deeper layer of the substrate. By improving the environmental factors at the mud-water interface, we can lay the foundation for the natural remediation of contaminated mud, and realize the simultaneous removal of carbon, nitrogen, sulfur and other oxygen-consuming substances from the contaminated mud through the synergistic driving of the ecological remediation of the mud by the highly efficient aerobic nitrification and anaerobic denitrification.



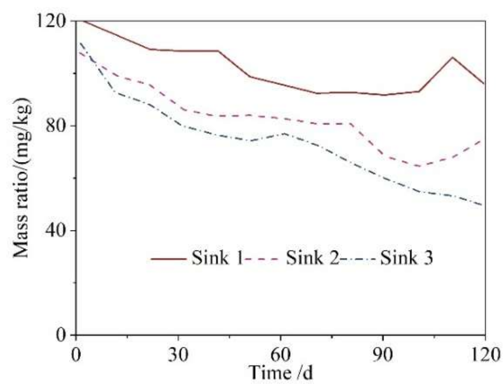
(a) $NH_4^+ - N$ (Floor 1)



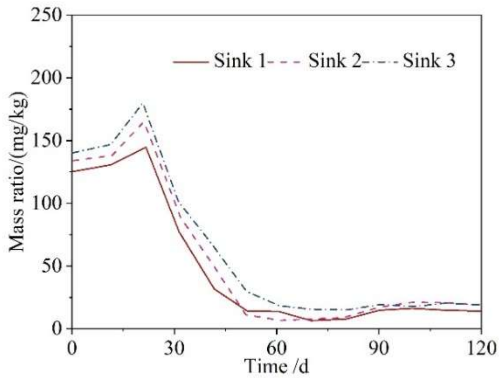
(b) $NH_4^+ - N$ (Floor 2)



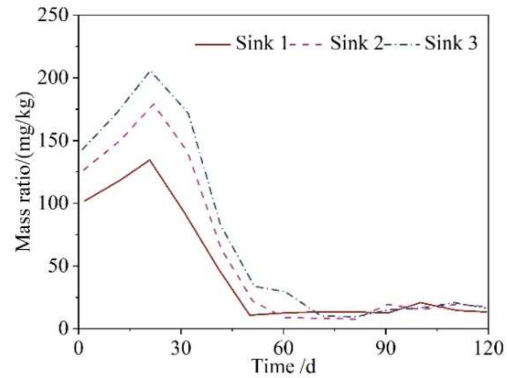
(c) $NH_4^+ - N$ (Floor 3)



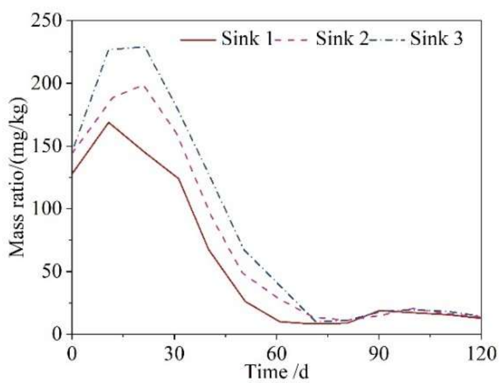
(d) $NH_4^+ - N$ (Floor 4)



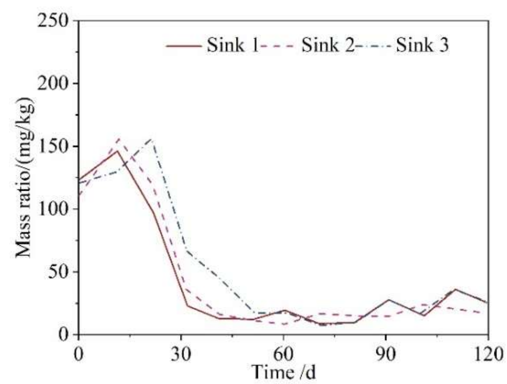
(e) $NO_3^- - N$ (Floor 1)



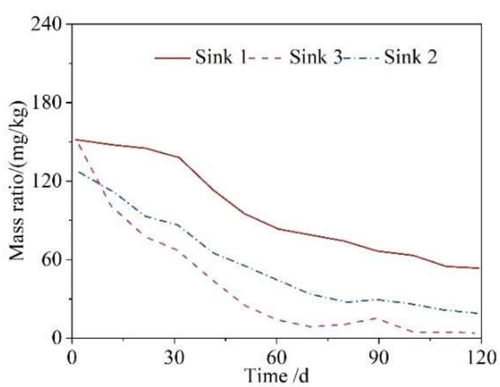
(f) $NO_3^- - N$ (Floor 2)



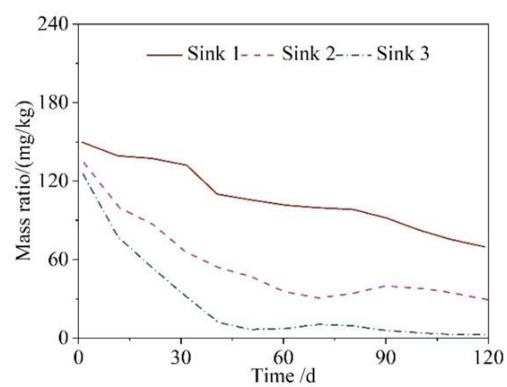
(g) $NO_3^- - N$ (Floor 3)



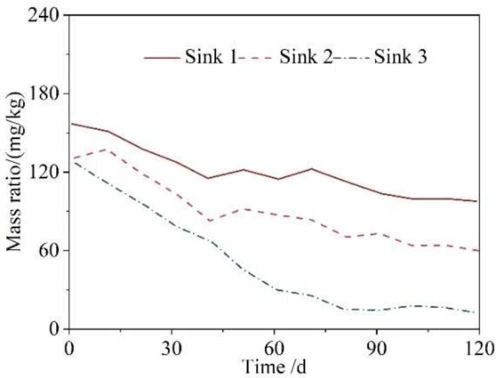
(h) $NO_3^- - N$ (Floor 4)



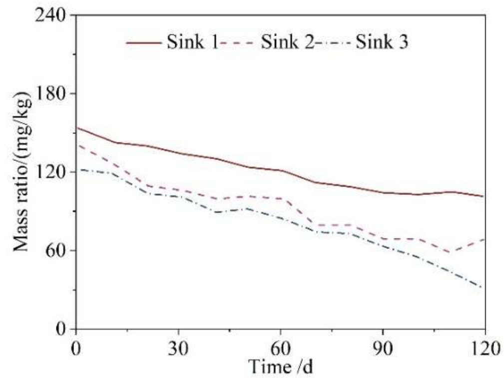
(i) AVS (Floor 1)



(j) AVS (Floor 2)



(k) AVS (Floor 3)



(l) AVS (Floor 4)

Figure 5: Vertical variation of main pollutant content in bottom mud of water tank

IV. Conclusion

This paper uses experimental investigation methods to conduct experimental research on watershed pollution control and intelligent ecological restoration technology in housing ecological environment construction, aiming to promote sustainable green development of housing ecological environment.

(1) The emission coefficients of agricultural plantation in COD, TN, and TP are 64.361, 5.708, and 1.053, respectively, which are higher than those of other four watershed pollution sources. The order of contribution of each source to COD pollution was agricultural plantation (245.47t/a) > rural domestic sewage (212.35t/a) > farmhouse wastewater (98.42t/a) > decentralized aquaculture (66.72t/a) > atmospheric wet fallout pollution (45.53t/a).The distribution of the three pollutant factors was concentrated in the areas of L area, I area, and R area, which was in line with actual situation.

(2) The DO mass concentration in the aqueous phase at the mud-water interface of Sink 3 was 5.77 mg/L, while that of Sink 1 was only 2.35 mg/L. It can be seen that Sink 3 has the best oxygen permeability, with a depth of permeable substrate of 7.25 mm, while the depth of permeable substrate in Sink 1 was only 2.45 mm. Sulfur and other oxygen-consuming substances synchronized removal.

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