Study on Ecological Landscape Design in Rural Sewage Treatment—Taking Sanmenxia Lushi Sewage Treatment Station as an Example

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Abstract: The problem of water pollution is one of the long-term difficulties in the process of rural environmental construction and economic development in China. In order to meet the requirements of the country’s green and sustainable development, many regions actively promote the construction of rural sewage treatment and fill in the shortcomings of the rural habitat environment to accelerate the construction of beautiful and livable villages. Through a lot of literature and case studies, this paper explores the environmental problems that are common in rural sewage treatment in the northern region of China, explores advanced domestic and foreign cases and technologies on this topic, and summarizes the landscape design strategies on this issue. From the perspective of ecological landscape design, the thesis seeks the theoretical and technical support for rural sewage treatment in river valley areas, and establishes a bridge between rural sewage treatment technology and ecological landscape. Finally, combining theory with practice, taking the project of Lushi sewage treatment in Sanmenxia as an example, the team completed the landscape design of ecological sewage purification display area in Zhangjiacun. The design focuses on presenting the application of internal sewage treatment technology and external landscape aesthetics. According to the main points of ecological landscape design and the theory of ecological edge effect, the local ecological system is effectively protected, and a rural domestic sewage purification display area with economic benefits is constructed.

Key Words: Rural sewage treatment, ecological landscape design, Zhangjia Village, Lu County, Sanmenxia.

1. Research Background

1.1 Strategy of Rural Revitalization

The effective treatment of rural sewage is an important indicator for the improvement of the rural habitat environment. It is also an important measure for the implementation of the rural revitalization strategy, and an inherent requirement for the comprehensive construction of a well-off society. China pays more and more attention to rural ecological and sustainable development, emphasizes that the rural sewage treatment should be done according to local conditions, and continuously improves the quality of life of farmers [1, 2]. In recent years, relevant departments in many regions have actively promoted the constructions of rural sewage treatment, and have achieved ideal results. They have played an important role in improving the rural ecological environment, upgrading the quality of life in rural areas, and promoting the modernization of agriculture. We must also realize that the treatment of rural sewage is still the most prominent shortcoming of the rural residential environment. Rural domestic sewage treatment is a livelihood project, and it is also an important part of effectively improving rural people’s sense of happiness.

1.2 The Dilemma of Rural Sewage Treatment

Due to historical reasons, the daily treatment rate of rural residents’ sewage is low, and sewage discharged disorderly and randomly for a long time. Rural daily...
wastewater of production, livestock manure and wastewater from breeding, etc., are discharged into nearby drains or river channels through simple drainage ways, and basically without any purification process, which is a common problem in many rural places [3-5]. The direct discharge of rural sewage can easily cause pollution of rivers and ponds, and has become one of the main factors of rural water pollution. The continuous destruction of the water environment is difficult to repair leading to increasing deterioration of environmental conditions in rural areas. This directly affects the living environment of residents posing a great threat to the physical and mental health of residents, and restricting the overall healthy development of villages [6-13].

2. Rural Sewage Treatment Technology

From the perspective of technological principles, the commonly used rural sewage treatment technologies can generally be classified into two categories. The ecological treatment system is a set of very effective compound ecological sewage treatment system formed by the comprehensive utilization of various organic organisms such as animals, plants, microorganisms, etc., through physical, chemical and other multiple means. For potentially effective resources in sewage, the compound ecosystem will take effective methods for re-extraction and recycling. At the same time, the pollutants in the sewage can also be degraded and purified step by step by the system. Stabilization pond treatment technology, constructed wetland treatment technology, ecological integrated system pond, earthworm ecological filter, high-efficiency microbial treatment technology, soil infiltration technology and other methods are the main means of creating a composite ecosystem [14]. Sewage treatment technologies can also be used in combination. Many scholars first combine various sewage treatment technologies, evaluate them, and then classify them according to different combinations of sewage treatment technologies. These are mainly anaerobic—anaerobic treatment mode, anaerobic—ecological treatment mode, anaerobic—aerobic treatment mode, anaerobic—aerobic—ecological treatment mode. The diversified sewage treatment technology processes and models also have their own advantages, disadvantages and scope of application [15].

The second category is biological treatment systems, which is a system that effectively cleans and removes pollutants under the conditions of anaerobic and aerobic microorganisms. This treatment mainly including “FILTER” sewage treatment and reuse system, anaerobic biogas treatment technology, constructed wetland technology, biological Membrane technology, soil capillary infiltration system and integrated device processing technology, etc. [16].

3. The Ecological Landscape Design Project of Lushi Sewage Treatment in Sanmenxia

3.1 Analysis of Regional Location

The project is located about 5.8 kilometers far from the county town of Lushi in Sanmenxia City in northwest direction, and is on the bank of the Yuhe
River which is a tributary of the Luo River. The design area is close to the villager’s living area of Zhangjia Village and is located at the entrance of the village on the south side. The functions of surrounding lands are relatively simple, mainly based on village homesteads, including Guangjia Village, Zhoujia Village and Mengjia Village.

The mountainous area of Lushi County has deep river valleys. The design area belongs to the Yuhe River Basin, and the Puyu River is injected into the Luo River from north to south. Lushi County is a treasure trove of fossils. A large number of paleontological fossils including the Lushi tarsus monkey, Luohe’s beast, Lushi dinosaur, and Lushi Homo sapiens were unearthed. It provides precious specimens for biology and ancient human research. A large number of sites such as Neolithic cultural sites and historical and cultural sites of the Shang Dynasty are here. Lushi County is also one of the important birthplaces of Heluo culture, attracting historical and cultural lovers from all over the world. Here, there are many mineral deposits and abundant reserves; there are many biological species and good natural vegetation. It is one of the top ten Chinese herbal medicine base counties in
the country, and is known as “one step and three herbs” and “Chinese natural medicine library”[17]. It was once a guerrilla base, a revolutionary base in Henan, Hubei, Shaanxi, and an anti-Japanese base. Thousands of mountains in Lushi County are undulating, with dense rivers and lush forests. At present, the tourist attractions that have been developed include Tanghe Hot Spring, Scenic Area of Xiong’er Mountain, Scenic Area of Jiulongdong and so on.

3.2 Present Situation of Site

The design area is located in the bank of Puyu River, a tributary of the Luohe River, the terrain is relatively flat. The north side of the site is residential houses, and the south side is an open space. The project covers an area of 8 mu, about 5,333 square meters, and the ground elevation is between 710.01-703.98 meters. Due to historical, transportation, and natural factors, Zhangjiacun’s economic development is relatively lagging, living standards are low, and pollution control measures are very weak. The traditional mode of sewage discharge combined with the use of chemical fertilizers and pesticides means the local ecological environment urgently needs to be rectified [18-21].

3.3 Design Strategy

This design focuses on the key points of ecological landscape design, supported by ecological edge effect theory [22, 23]. First, the atmospheric precipitation and sewage to be treated are collected through surface runoff and concentrated pipelines, and then enter the sedimentation tank to precipitate large particles in the water [24]. Then, the compound biological treatment technology with strong stability, denitrification and dephosphorization effect is used to gradually remove nitrogen, phosphorus elements and organic pollutants.
in the water, effectively adsorb heavy metal pollutants, and then form a stable water system environment [25]. At the same time, combined with the stabilization pond sewage treatment technology, comprehensive purification is carried out to stabilize the water body. The two purification technologies complement each other to ensure that a rural sewage purification display area that exerts economic benefits is formed while stably meeting the requirements of the water purification function. The display area closely follows the theme of “ecological purification” and combines the indoor space of the glass house to show the visitors the ecological purification process in detail. The design combines sewage treatment and tourist experience, popular science knowledge and entertainment, and establishes an in-depth dialogue between people and artificial technology, people and ecological landscapes. Together these form a strong interactive rural education sewage treatment demonstration area with great educational significance.

4. Design Content

4.1 Layout

The design area is divided into the following three functional areas based on design elements, the current terrain and other factors of the site (Fig. 6).

Ecological purification display area—located in the center of the site for sewage treatment display, with stepped water storage purification tanks and other waterfront activity areas that form a rich shoreline, and have both landscape and popular science functions;

Sunshine science popularization area—located at the west end of the site, next to the central purification display area, mainly used for science popularization display;

![Diagram by the authors (2020).](image)
Leisure activities area—mainly located on the northeast side of the site, close to the villager’s residential area, providing a gathering place, combined with rich plant displays and cultural corridors, to create a living and leisure area rich in local culture and natural characteristics.

The plan layout takes the rural sewage purification display and the rural culture display as the main starting point, and chooses the theme of “purified water” (Fig. 7). The project extracts the elements of water droplets for simplified use, forms a design language, integrates into the site, and combines the topography in the design area to divide respective functional areas. In addition to meeting the basic sewage purification display function, it also satisfies the cultural and recreational needs of surrounding residents and tourists. A tourist service center is set up at the main entrance to maintain daily operations. The design strengthens the natural degradation and sewage ecological oxygen enrichment self-purification in the exhibition area to meeting the display function requirements. Considering that the maximum height difference between the east and west in the design area is about 3 meters, this design uses a stepped purification method. Multistage purification tanks are connected in series to ensure good purification effect display.
The project uses water storage ponds in the area to set up rich purification ponds on the shoreline. While ensuring that the functional requirements are met, a monitoring system is set up to monitor the purification effect. The south side of the exhibition area is a green ecological cultural trail. The ecologically purified water is used for landscape water, combined with the water viewing pavilion, presenting a good ecological experience. The leisure activity area on the north side is equipped with a secondary entrance and multiple rest seats to provide sufficient space for residents’ daily activities. At the same time, it is equipped with a cultural wall and also provides visitors with a leisure area with local cultural characteristics.

4.2 Road System and Landscape Node Analysis

The design aims to establish a reasonable road traffic system. The first-grade road is 5.5 meters, surrounds the entire site, meets the needs of motor vehicles, and is the main road connecting the entrance and each node (Fig. 8). The secondary road is about 3.5 meters wide and connects the entire site to meet the needs of walking, taking into account the maintenance of plants in the entire area and the traffic demand for essential vehicles (Fig. 9). The three-level road is about 2.5 meters wide and mainly meets the function of viewing and walking, connecting multiple landscape nodes to form a complete on-site transportation system. The landscape nodes are mainly divided into two parts. The central nodes include an ecological purification pool and a sun room for popular science, and the main nodes include various landscape sketches design.

4.3 Plant Configuration

The ecological purification display area focuses on further purifying water quality, and designs plants with good root purification effects, such as water hyacinth, cattail, reed, etc., supplemented by planting pampas grass, sclerophyllum, etc. to further purify water Quality [26]. According to the growth characteristics
of aquatic plants in Henan province, designers choose
the hydroponic plants such as Chlorophyllum chinense,
Wenzhu, Monstera, etc. Submerged plants include
waterwheel, water shield grass, etc. [27]. Emerging
water plants include Alisma, Calamus, Crown Grass,
etc.; Floating plants include Sophora japonica,
Manjianghong, and duckweed [28, 29]. The plant
construction of the stepped purification ecological pool
is in order of emergent plants, floating plants and
submerged plants. Other plant designs include
Ligustrum lucidum, Metasequoia, Osmanthus fragrans,
octagonal gold plate, Buxus chinensis, etc..

5. Analysis of Important Landscape Nodes

5.1 Sunshine Area of Science Education

Popular science education is one of the main
purposes of this project. The 800-square-meter popular
science conservatory and the popular science square
provide people with space to visit and enjoy; The
Sunshine Room has a water quality monitoring station
and a sewage purification science sign to show tourists
the process of rural sewage purification and provide a
learning place for schools and related practitioners.
Three nodes are set up at the detection equipment and
the popular science point, which are located at the
entrance of the square, the midpoint of the ecological
purification zone and the end of purification. The three
nodes are connected to each other by the Internet.
Through real-time signage and QR code technology,
they show people the ecological purification process of
domestic sewage, related technology application
instructions, and the water quality detection index on
the corresponding node. The science glass house is also
equipped with a simulation model to demonstrate the
effect of ecological landscape sewage treatment,
combined with the actual ecological landscape
treatment system outside the house, so that people can
more clearly feel the effective use of ecological
landscape design in the field of rural domestic sewage
treatment.
5.2 Ecological Water Purification Area

The sewage in the water purification display area has undergone three purification treatments, including first-order, second-order and third-order purification tanks with height differences and a wetland biological system [30] (Fig. 10, Table 1). The entire purification process includes physical, chemical and biological treatment methods, of which the biological ecological treatment method is the main method to strengthen natural degradation and the sewage is oxygen-enriched and self-purifying [31]. At the same time, combined with the stabilization pond domestic sewage treatment technology, the use of aquatic biological systems, relying on natural biological purification function to make the sewage purified [32] (Fig. 11). Among them, the first-order and second-order purification ponds are mainly made of calamus and reeds with strong purification ability [33], while the third-order and wetland biological purification systems are based on the premise of satisfying the purification function, and more consideration is given to the beauty of the landscape to meet people’s viewing needs for the landscape [34] (Fig. 12).

![Fig. 10  Three Kinds of Barge Schematic.](image)

Diagram by the authors (2020).

| Type       | Shape             | Intensity of sewage treatment | Suitable type of barge       | Participation | Landscape value       |
|------------|-------------------|-------------------------------|------------------------------|---------------|-----------------------|
| First step | regular           | strong                        | hard bank, stone masonry    | weak          | weak ecological value |
| Second step| relatively regular| weak                          | Natural revetment, stone masonry | strong        | strong educational value |
| Third step | free style        | relatively strong             | natural revetment            | relatively strong | strong landscape value |
5.3 Leisure Activity Area

The leisure activity area is located in the northwest of the site, with a sub-entrance for the site, which mainly meets the daily leisure activities of villagers (Fig. 13). The main paving is local stone, with wooden seating seats around the site, which occupies a large area. It is an important part of the design area and the main area for villagers’ leisure activities. At the same time, the green cultural corridor runs through it, enriching the connotation of the site and meeting the spiritual and cultural needs [35].

5.4 Green Culture Trail

The green ecological cultural trail is mainly located in the southern part of the site, close to the ecological water purification area, forming a perfect road traffic system (Fig. 14). Tall local trees such as Metasequoia glyptostroboides, Ligustrum lucidum, etc. are planted on both sides of the trail, and at the same time, bamboo forests, small trees and bushes are combined to form a green trail with great ecological and local culture. In addition, landscape sketches are set beside the road to show the local culture, strengthen the local people’s
sense of cultural identity and pride, and also meet the tourists’ cognition needs of local culture and customs, and experience the unique local culture [36, 37].

6. Conclusion

According to the influencing factors such as sewage water quantity and water quality, Zhangjia Village Sewage Treatment Station of Lushi County mainly adopts landscape biological purification technology to establish stepped ecological purification ponds for rural sewage treatment. The design will show the complete treatment process of rural sewage, so that the treated water quality meets the three types of water standards of “Surface Water Environmental Quality Standards” (GB3838-2002) promulgated by China. It will help the locals solve environmental problems and play a role in promoting the construction of an ecological garden city in Lushi County.

Through theoretical research and practical application of rural sewage treatment project, the following conclusions are drawn:

Faced with the special climate of Lushi County, composite biological treatment technology should be selected when applying ecological landscape design. It has strong stability, high purification efficiency, and is relatively less affected by weather and precipitation.
At the same time, combined with the topography of the site, a stable pond of sewage treatment technology with a high degree of integration with the landscape is selected to establish a multilayer ecological purification pool to increase purification efficiency [39-43]. The designers use the soil characteristics of the river valley itself to improve the site purification system.

Plant selection and configuration is an important part in the design of ecological landscape, and also an important landscaping element. It is a bridge between landscape biological purification technology and landscape. To build an ecological landscape model suitable for rural sewage treatment in the Yellow River Valley requires effective utilization and consideration of plants [44, 45].

The ecology of the Yellow River Valley is relatively fragile compared to other areas. In addition, there are a large number of residents’ living and production activities around the site, which also have a destructive impact on the overall ecological environment. Therefore, in the construction process, make full use of the Ecological Edge Effect Theory. The application of this theory makes the rural sewage treatment system more beautiful, landscaped and artistic, and also exerts ecological benefits and educational significance.

This article not only provides a new idea for the treatment of rural sewage in the Valley area of tributaries of the Yellow River, but also explores the development direction of rural ecological landscape design. The paper takes technical landscape as an entry point to study the application of ecological landscape design in rural sewage treatment. The compound biological treatment technology with strong stability and nitrogen and phosphorus removal effect is used for pre-treatment. At the same time, combined with the ecological landscape design, the stable pond sewage treatment technology is used [46], and the two complement each other. It is hoped that this practice can provide reference for rural sewage treatment in the area of Yellow River Valley.

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