Combination of Wastewater Treatment Measures and Landscape Ecological Design in Traditional Villages Based on Sustainability Theory: A Case Study of Miao Village in Xiangxi, China

Yuanqiang Tang, Yuanxing Tang, Mengmiao Zhang, Jianmin Zhao, Yunguo Liu, Shaoqiu Long, Can Xiao, Yu Chen, Shaoyao He and Chunping Yang

1College of Environmental Science and Engineering, Hunan University, Changsha 410082, PR China
2Key Laboratory of Environmental Biology and Pollution Control (Hunan University), Ministry of Education, Changsha 410082, PR China
3Secondary School of Industrial and Commercial & Vocational of Yongzhou, Hunan, Yongzhou425006, PR China
4School of Architecture, Hunan University, Changsha 410082, PR China
5College of Natural Resources and Environment of South China Agricultural University, Guangdong, Guangzhou510642, PR China
6Guangdong Provincial Key Laboratory of Petrochemical Pollution Processes and Control, School of Environmental Science and Engineering, Guangdong University of Petrochemical Technology, Maoming, Guangdong 525000, China

*Correspondence:
1Yuanqiang Tang: bobtang2016@hnu.edu.cn;
2Yunguo Liu: liuyunguo@hnu.edu.cn;
3Shaoqiu Long: sq_long2019@163.com;
4Shaoyao He: syhe829@163.com.

Abstract: The aim of protecting traditional villages is to maintain the population; thus, these villages must be suitable for living. A prerequisite for the liveability of traditional villages is treatment of point and non-point sources of pollution to improve the ecological value of the village. The combination of water pollution control measures and landscape design improves the aesthetic and ecological sustainability. This article takes China's fourth batch of traditional villages, Xiangxi Wengcao Miao Village, as an example. Interviews, field surveys and various discussions were conducted, and the study believes that by connecting the various sewage outlets, they are collected in the first, second and third levels. Treatment ponds (tanks) transformed curved rice fields into secondary treatment tanks and stabilised ponds. Native plants were classified before stable and treatment ponds were excavated. Submerged, floating and emergent plants were artificially planted in the water, and medicinal plants were cultivated.
around the pond and banks of the creek. These biomass plants are relatively large for the nutrition in the wastewater. Adsorption and digestion of the substance can not only reduce the direct discharge of sewage to downstream regions but also beautify the landscape of the sewage treatment facility.

1. Introduction

Relevant statistics show that the annual discharge of domestic sewage in rural areas of China is 10.95 billion tones[1]. A direct consequence of differentiated management between urban and rural areas is that rural environmental pollution control has not received enough attention. According to reports, 90% of villages has not yet been effectively wastewater managed and do not have centralized channels similar to urban sewage treatment [1,2]. Developments in economy have resulted in a large proportion of the rural population working and purchasing houses in urban cities and towns; however, most of this population continues to live in the countryside. Thus, China's rural population is large, and most of its residential areas are scattered, resulting in a large amount of domestic sewage in rural areas. As most rural areas are economically underdeveloped, domestic sewage in these areas is not treated well. Untreated sewage can enter the human body through direct contact and food produced by sewage irrigation, causing great risk to the health of rural residents in the valley. Environmental problems, such as rural domestic sewage, have attracted the attention of high-level leaders of the state, especially General Secretary Xi Jinping, who emphasized that rural environmental renovation should be done well in 2020[3]. The Chinese government has made great achievements after three decades of reform and opening up[4]. The country is deeply interested in restoring ecosystems damaged by industrialization and urbanization and minimizing the impact of new developments on the environment. In conjunction with the construction of beautiful country sides[5], state and local governments have invested a large amount of funds to renovate rural human settlements. Academic circles have reported different opinions on point source treatment in rural areas; generally speaking, however, the approaches identified can be summarized in two strategies: (1) investigation of rural domestic sewage pollution and (2) research and development of domestic sewage treatment technologies[6]. However, there are few reports about the combination of rural domestic sewage treatment and landscape.

Geographical conditions vary considerably in China, and the diversity in nationalities leads to the construction of a variety of traditional dwellings and villages possessing distinct architectural features. Most traditional villages in China are farming villages, the establishment and development of which are closely related to agricultural and agricultural development. Indeed, the related living habits are still in use today[7,8]. Wengcao Miao Village, a traditional village located in Tujia and Miao Autonomous Prefecture in Western Hunan, was studied in this paper. Most of the houses in Miao Village are built on sunny ridges or concave hillsides, which is called ‘Yishan Village’, which means the building near to the hill. Prior to toilet renovation, the entire village used only basic, straight-row toilets with septic tanks connected to streams. During flooding, however, the water in the septic tank was discharged into the stream without any treatment and drifted downward (Figures 1–3).

The Beautiful Rural Construction and the Poverty Alleviation Offices, as the government's department management agencies, are tasked with implementing the rural revitalization and poverty alleviation measures put forward by the government. Provincial directly affiliated units send staff to Wengcao village to guide and assist the construction of a beautiful countryside, enhance the ecological and tourism value of Wengcao village, and build ecologically liveable traditional villages[9,10]. These measures are implemented by the government to improve the comfort of residents of traditional villages.

According to the discovery of cultural heritage, Xiangxi Weng Cao village possesses traditional architectural. The village has a well-preserved overall pattern and historical features, including a large number of traditional buildings, good quality, and certain in the sense of appreciation [11]. Because Wengcao Miao Village is located deep in the mountains of western Hunan, traffic is inconvenient and the village is relatively unaffected by the outside world. Therefore, natural resources, including forests,
have been maintained well. The creek stretches throughout the village and surrounds the building community to form a beautiful landscape belt (Figures 4–6).

The best known origins of the five major civilizations are the Tigris and Euphrates Rivers, the Nile Valley, the Indus Valley, the Aegean Islands and the Yellow River Basin[12]. This finding reveals that humans generally consider the availability of water resources when choosing an area in which to live. The earliest recorded list of You Youquan(a spring name) under the Youyou Miao Village was the water source of the Chiyou tribe in the past. This water source continues to flow and has nurtured several generations[13]. Miao who migrated from the north to the mountains in the south followed a similar principle when choosing a place of residence. Thus, human reproduction and coexistence with the natural environment is inseparable from water. The use and treatment of water reflects the history of the development of human civilization[14]. Similarly, the comprehensive utilization and treatment of the stream in Wengcao village reflects the historical development of the village. The soundness of the aquatic ecosystem will combine sewage ecological treatment and landscape design to create a special aesthetic and build Weng Cao Village into a truly beautiful village.

2. Materials and Methods

2.1. Study scope and area
Wengcao Village (latitude 28°33′0″–latitude 28°34′0″, longitude 109°51′30″–longitude 109°52′0″) is 15 km away from Morong Town (Figure 7-10) from Guzhang County. The well is about 18 kilometers. The research period of this article is from June 2018 to April 2019. This study aims to improve the environment on both sides of the stream in the village (Figure 11). The economy depends largely on the export of agriculture and labor services.

2.2. Research methods
This research was conducted via a mixed-mode method for cross-sectional analysis of the village resources. Individual interviews, household surveys and random sampling questionnaires were used in the paper.

The main water source of the village is mountain springs, and Kaner wells excavated by each household are sometimes used. However, the well water flows near the sewage drainage ditch, which can cause cross-infection and presents a high risk of pollution. Streams passing through the village show numerous wet and dry seasons under the influence of climate and annual rainfall. Therefore, water is a scarce resource in the village.

During our investigation, several instances of water shortage occurred. Nearly 90% of the houses in the village have no toilets. When available, the toilet is built outside the house without any treatment. Some people use the water to clean vegetables, whilst others directly discharge the water from the toilet into the stream without septic treatment. In addition, open drainage ditches run through every household; thus, open and flowing household wastewater and sewage are common (Figures 12–18). Detailed investigation revealed 26 sewage outlets in the stream running through the village (Figure 18).

3. Composite Design of Sewage Treatment and Landscape Architecture

3.1. Design program setting for the Wengcao village
The concept of sustainable development continues to pose enormous challenges in developing countries, including China. Because the design itself presents great individual differences, to capture the common law in the vague concept and summarizing the design procedure are difficult. However, the existence of academic difficulties, on the contrary, it means that the key value is also here. Promoted by the background of this era, it is of great practical significance to study the design process by taking the sustainable development of sewage treatment and landscape design in Wengcao village, western Hunan, as an example. Such an approach is not a new strategy but a revival of the essence of
Referring to the book *Generation and Evaluation of Sustainable Architectural Design* [15], the researcher believes that the design process can be divided into four dimensions: space and technology, humanities and society, environment and ecology and economy and management. These four dimensions respectively solve the problems of form and construction, demand and heart, environment and resources and efficiency and efficiency in the design stage (Figure 19). These four sustainable building objectives may be used to create a concrete and implementable plan that combines wastewater treatment equipment construction and landscape design in Wengcao village.

### 3.2. Specific design scheme

Based on the above design procedures and the four dimensions of sustainable architectural design framework (Figure 19). Firstly, according to the theory of sustainable development, landscape ecology, RS and GIS technology, sewage treatment technology and other multi-disciplinary theoretical knowledge, following the construction of the local cultural context, in line with the principle of originating from nature but higher than nature, sewage treatment construction equipment is made into a modern, natural, wild and interesting, containing profound here and historical and cultural knowledge. Secondly, according to the actual situation and local conditions, we designed Wengcao village buildings with sewage collection function, sewage treatment buildings and their related accessories and transformed it into an ecological landscape with local characteristics, differences, scientificity, simplicity and far-near combination.

#### 3.2.1. Coordination of sewage treatment construction facilities and the rural landscape

In-depth investigation revealed three areas in Wengcao village wherein oxidation ponds can be built. However, due to inherent defects, oxidation ponds cannot be directly used for sewage treatment. Thus, improvement of oxidation ponds is necessary to render them suitable use in Wengcao village (Figure 18). The improved oxidation pond consists of two parts, the first of which is a pre-aerobic section (mainly for aeration). The energy necessary to operate this pond can come from solar energy, wind energy or mountain water energy in the second part.

#### 3.2.2. Combination of point view design and sewage treatment functional buildings

In this study, microorganisms in the sewage waste can obtain dissolved oxygen, and sediments in the water can be mixed uniformly.

After understanding the functions of sewage treatment, we apply design and sustainability theories. We compare various schemes and consider the use of solar energy for aeration in the front section of the oxidation ponds. Hereafter referring to relevant information available locally and abroad for the characteristics of the straw hat in Wengcao village, we design a building which is shaped like a straw hat for solar energy architecture, which can capture solar energy (Figure 21) around the improved oxidation pond. Eco-vegetation and cultivation of medicinal or economic crops in water can be conducted to enhance the ornamental and ecological value of oxidation ponds (Figure 22). Selected submerged, emergent and floating plants are shown in Table 1.
Table 1: Submerged, emergent and floating plants

| Plant types            | Plant species (example)                                                                 | Value                          |
|------------------------|----------------------------------------------------------------------------------------|--------------------------------|
| Submerged plants       | Ceratophyllum demersum L.; Ceratophyllum demersum L.; Hydrilla                         | Economic value or medicinal value |
| Emergent plants        | Phragmites communis (Cav.) Trin. ex Steud.; Alternanthera bettzickiana (syn. A. amoena); Alternanthera philoxeroides (Mart.) Griseb; olygonum Hydropiper. Ranunculus scleratus L. Sp. pl.; Ipomoea aquatica Forsk. Kalimeris indica (L.) Sch. -Bip.; Acorus calamus; Typha angustifolia; Alisma canaliculatum; Artemisia lancea Van; Helocharis dulcis (Burm. f.) Trin. etc. | Economic value or medicinal value |
| Floating plants        | Nymphaea L., Euryale ferox; Brasenia schreberi; Azolla imbricata (Roxb.) Nakai; etc.   | Economic value or medicinal value |

A total of 26 sewage outlets are found along the stream (Figure 18). These sewage outlets often discharge treated sewage into the stream, which seriously pollutes the water body, destroys its ecological balance and poses a threat to the health of the villagers. According to the author’s investigation, the sewage in these ditches originates from houses at the top of the hillside. Many other residents along the slope discharge waste into the sewage. The accumulated sewage is discharged into the small streams in the village due to gravity, and the water in these streams is polluted.

To change the sewage discharge habits of Wengcao village residents, we put forward a design scheme based on the principle of adapting measures to local conditions as follows. In the sub-central area, where households are relatively concentrated, a branch catchment basin similar to a septic tank is constructed, and their natural self-gravity mode is used to change the catchment collection mode. These sub-central areas are then connected through the pipeline network. Because of the shortage of land in the village, we build a water catchment, which is similar to a toilet improvement, for nearly all residents. If a household is located far from other residential houses, we consider a single-family construction plan (Figure 22). Finally, we connect these catchments in series to form a water network (Figure 23); these measures address the point source of pollution. In order to ensure that the sewage containing heavy metals, antibiotics and other pollutants is effectively controlled before discharged into the stream water[16], Besides applying adsorption methods, advanced oxidation technology[17, 18] and membrane bioreactor technology[19], we also plant local landscaping plants (Figure 24) at the junction of the stream and sewage outlet. Besides fixing trace harmful components in the sewage, these plants are also designed as a small landscape, which is integrated with the natural landscape in the village. The surveys revealed that flash floods occurred in 2018 due to steep and narrow dikes built along small- and medium-sized streams in the village. These dikes caused water levels to rise sharply and flood houses. After the floods subsided, the dikes showed serious collapse. Therefore, in the proposed design, we implement a specially designed ecological slope protection feature for streams after considering local geological conditions and hydrological records comprehensively (Figure 25). In all of these catchments, we decided to adopt design principles, which originated from nature and transcend nature in the design process[20], based on the slope topography. Design renderings similar to Figure 25 and 26. The hydrophilic design of the riverside focuses on a few corners (Figure 18). Besides treating pollutants by the multi-dimensional medium system (Figure 26), the authors also adopt a one-step method to create a hydrophilic function and enhance the ecological value, as shown in the Figures 28–32.

3.3. Landscape of the village borrow from wastewater treatment construction building

The natural pastoral landscape of traditional villages and modern sewage treatment buildings can not only turn modern sewage treatment buildings into ecological elements through controllable human treatment, but also make the ecological elements coordinate with each other, and finally achieve a dynamic balance. Combining with the actual conditions of the village, it highlights the original
simplicity and simplicity, and creates unique and colorful natural and cultural landscape with limited materials and technology. Wengcao village is situated on a sunny slope surrounded by mountains, rolling hills and a beautiful environment. The newly built composite sewage treatment system is like a brilliant pearl embedded in the village (Figure 33). Thus, a modern and primitive landscape with a high degree of harmony between natural and man-made environments is created.

4. Discussion
As shown in Figures 20–22, 24, 26 and 28–32, the construction technology of sewage treatment equipment and the combined design effect of ecological landscape in the village show that the polluted point source wastewater after the pre-treatment of sewage flows into the improved compound-oxidation pond. Through the infiltration, adsorption and denitrification of the building, and referring to the experimental research done in some literature, it has proved that it has good wastewater treatment function. The sewage outlet in the stream channel can filter sand after the functional transformation. By optimizing the layout of the pipe network and planting various native medicinal plants, such as calamus, the plant landscape can ingeniously conceal views of the sewage outlet.

In this study, besides establishing a suitable sewage treatment technology, different kinds of plants were planted to change the shape of the vegetation cover so that it is more in line with the traditional Chinese villager's landscape and plant artistic conception.

The focus of this paper is to put forward a design of rural pollution control and some ideas of design labeling. The next step is to implement the construction technology and evaluate acceptance standards after construction.

5. Conclusion
Combining the functionality of sewage treatment equipment with the aesthetics of the landscape can reduce point and non-point sources of pollution in Miao Village. The newly constructed compound-stable pond at the entrance of the village treated the environment as the last wastewater, ensuring the safety of water out of the village.

Previous research identified 10 medicinal plants in the grass family that are suitable for planting around stable ponds through investigations of ornamental and medicinal plants in other villages[21]. These plants present added ecological value and enhance the aesthetic value of the landscape.

● This paper reveals, for the first time, how environmental pollution control can be combined with landscape design, filling the gap of the field of environmental pollution control during re-treating the process for the aesthetics of architecture art are lacking. Active integration of landscape design into the environmental governance process can promote the organic integration of the functional and artistic aspects of building. Thus, villages need better designs to ensure sustainable development.

● This study demonstrates that approaches to adapt to local conditions and choose a suitable wastewater treatment process are very important for the environmental management and sustainability of economically underdeveloped villages.

● Medicinal plants cultivated around sewage treatment facilities have a certain ornamental value; these plants may also be harvested and processed to provide extra income to the village.

● The results of this study will help improve the ecological soundness of traditional villages in western Hunan, provide better eco-tourism resources for tourists with a preference for traditional villages, and make villages being the most desirable leisure destination for tourists. Therefore, villagers will become more confident, and the protection and development of traditional villages have a better prospect.

Author Contributions
Under the guidance of Professors, Dr. Tang Yuanqiang designed, completed the survey about Wengeao Villiage and finished the paper with the help of M.R. Tang Yuanxing and Zhao Jianming who processed some figures. Professor Xiao Can and Dr. Chen Yu assisted check in the manuscript etc.
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