# Comprehensive Regulation and Landscape Design of Mayuanxi River in Chongqing City

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**Abstract** The comprehensive treatment of river courses and their landscape environments have attracted more and more attention of the society. However, due to its wide coverage, technical difficulties and long restoration period, designers need to explore, research and design with a more comprehensive and longer-term planning perspective, and a more comprehensive professional strength. Taking the comprehensive regulation and landscape design of Mayuanxi River in Chongqing as an example, this paper integrated the regulation, ecological restoration, landscape construction, project planning and cultural display of the river, and systematically put forward ideas and strategies for the comprehensive regulation and landscape design of the river, with a view to making a beneficial exploration for the research in this field. Notably, the paper highlighted innovative techniques such as vegetation concrete for revetment and rainwater gardens for ecological rainwater management.

**Key words** River; Comprehensive renovation; Landscape design; Mayuanxi
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Rivers are the flowing veins in cities, playing an extremely important role in the development of urban economy, the improvement of human habitat, and the creation of urban characteristics. While China's remarkable developmental achievements over recent decades are widely recognized, the rapid expansion of modern industry has concurrently caused severe ecological damage, particularly unprecedented pollution levels in water systems where massive untreated effluents are directly discharged into river channels, catastrophically degrading urban water quality and surrounding ecosystems, ultimately threatening human productivity, livelihoods, and sustainable development[1]. Consequently, river improvement has attracted great attention from all walks of life, and governments at all levels have also taken a series of measures to vigorously regulate rivers. However, because the comprehensive river regulation involves multidisciplinary expertise, decision makers and designers need to make decisions and designs with a higher pattern from a more comprehensive perspective. There have been a series of problems in the comprehensive river regulation in the past, such as repeated river regulation, inadequate ecological environment restoration, single river function and lack of river landscape culture[2].

Taking the comprehensive regulation and landscape design of Mayuanxi River in Chongqing as a case study, this paper expounded the ideas of comprehensive regulation and landscape design of the river from the aspects of river bed regulation, revetment construction, ecological environment restoration, landscape construction, spatial activity planning and cultural restoration, and put forward some new technical methods for discussion, so as to provide some inspiration and reference for the study of comprehensive river regulation.

## Overview of Current Conditions

The Mayuanxi River Comprehensive Improvement and Landscape Design Project is located in the Water and Soil Industrial Park of Liangjiang New District, Chongqing, covering a total area of approximately 55 $hm^2$. The main characteristics of the river include: ① Mayuanxi River is located 16 km away from Chongqing Jiangbei Airport, 20 km away from the main urban area of Chongqing, and close to Jialing River. It situates on the urban economic development corridors and also in the commercial hubs. Its prominent regional positioning grants it significant strategic importance in showcasing local cultural identity and driving regional economic growth. ② The riverbanks accommodate urban roads, residential communities, schools, parks, factories, and office buildings, making its ecological restoration and landscape development crucial for providing functional spaces and cultural venues for surrounding users. ③ The height difference between the upstream river channel and the banks is small, while the downstream height difference is large, forming a canyon landform feature. The height difference between the upstream normal water level and the downstream normal water level is as high as 46 m.

## Analysis of Current Main Problems and Countermeasures

Based on field surveys, as well as a review of climate, hydrological, geological, historical, and cultural data of Mayuanxi

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River, along with relevant geological investigations and water quality testing, the current issues have been comprehensively identified and analyzed. The key problems and solutions are summarized as follows:

**Thick sediment deposits in the riverbed and narrow local sections**

River dredging and riverbed restoration should be implemented.

**Severe erosion in certain revetment areas, unstable slopes leading to collapses and exposed riverbanks**

Eco-friendly revetments can be constructed using innovative techniques such as vegetated concrete to restore the ecological environment. Biological communities, including aquatic plants, animals and microorganisms should be rebuilt, creating a sustainable, cyclical, and healthy river ecosystem.

**Low water flow with occasional instances of drying up**

Existing water sources should be protected and conserved. Additional low-impact water sources can be developed, and narrow local river sections should be widened or sub-channels should be established[3].

**Poor water quality with severe pollution**

Physical and biological measures can be taken to improve water quality, such as relocating pipelines to cut off external pollution sources, and implementing rain gardens for the biological purification of lightly contaminated stormwater.

**Poor landscape aesthetics, damaged natural scenery and lack of cultural elements**

It is necessary to comprehensively plan and design the riverside ecological landscape. The strategy of "point-to-area" development that combines key highlights with general improvements can be adopted to enhance overall landscape effect and meet functional landscape requirements.

**Lack of spatial vitality and absence of riverine culture**

While ensuring functional and aesthetic aspects of the river space, we can strengthen connectivity with the surrounding environment and organize year-round and all-weather activities to meet the demand for high-quality and personalized social engagement, attracting visitors and enhancing spatial vitality[4].

It is necessary to investigate the historical evolution and local cultural characteristics of Mayuanxi River, and showcase cultural elements by leverage its geographical advantages and strategic significance through landscape nodes, river facilities, sculptures, installations, cultural walls and other mediums, so as to highlight regional identity and provide environmental education. It will sublimate the significance of the comprehensive river restoration project[5].

## Solutions and Overall Design Ideas

**Objectives of comprehensive river restoration**

The objectives encompass fully restoring the functional characteristics of the river, creating a healthy and stable ecological environment, providing a comfortable and elegant landscape space, and fulfilling its unique cultural and economic mission.

**River and water body improvement**

**River dredging** Dredging can be conducted along the existing river, with an average depth of 40 – 60 cm. In local areas with severe sedimentation, reinforcement measures can be applied before deeper sludge removal. The dredged surface sludge can be recycled. On the one hand, partial surface sludge can be used as nutrient soil for later ecological vegetation, and on the other hand, partial surface sludge can be used for the cultivation of benthos and microorganisms in the process of river ecological construction[1].

**River widening** Narrow or fast-flowing sections of the river can be widened, or sub-channels can be constructed. sub-channels (60 – 100 cm deep and 5 – 10 m wide) can be built along the sides or in the middle of narrow river sections to expand the water surface, reduce erosion, minimize evaporation and leakage, and enhance water retention[1].

**Construction of ecological revetments** The Mayuanxi River has multiple exposed earthen banks severely eroded by water flow, damaging both the river and its ecosystem (Fig. 1). Proposed solutions: In most areas of the whole line, ecological grass slope revetments can be constructed by sowing and planting grass (Fig. 2). In high-traffic or visually prominent areas, decorative stones and aquatic plants can be adopted to enhance aesthetics (Fig. 3). Local loose soil sections suffering to severe erosion can be reinforced with stone-filled gabions (Fig. 4). However, vegetation concrete can be used for slope protection and ecological restoration in large-scale steep slope areas[3].

**Vegetation concrete revetment** Vegetation concrete is applicable for various slopes including earthen slopes with 60 – 80° gradients, saline-alkali soil slopes, soft rock slopes, hard rock slopes, and concrete slopes. Its physical properties include a unit weight of 14 – 15 KN/$m^3$, porosity of 30% – 45%, and strength of 0.30 – 0.45 MPa. The vegetation concrete demonstrates stable performance with excellent resistance to moisture variation and sunlight exposure. It can effectively withstand adverse environmental conditions such as heavy rainfall (120 mm/h), intense sunlight exposure, and sudden temperature changes, thereby providing effective shallow-layer ecological protection for slopes and riverbanks. The construction process is similar to shotcrete, consisting of three main steps: base layer concrete spraying, surface layer concrete spraying, and vegetation seed spraying (Fig. 5)[3]. Based on the current conditions of Mayuanxi River, the vegetation concrete technique has been implemented for ecological bank protection at unstable slope sections along the river, including areas near the Herun Residential Community and No. 1 Road Bridge (Fig. 6).

**Addressing the issue of insufficient water sources** To resolve the water resource problem in Mayuanxi River, various low-impact development measures can be implemented. These include constructing wetlands and sub-channel systems in the upper reaches of the river (Fig. 7), installing landscape water drop with dams (Fig. 8), and deploying rain gardens (Fig. 9). These approaches

aim to prevent or reduce flow interruptions, so as to achieve an optimal balance of environmental, ecological, and social benefits[6].

**Fig. 1 Current situation of partial revetment of Mayuanxi River**

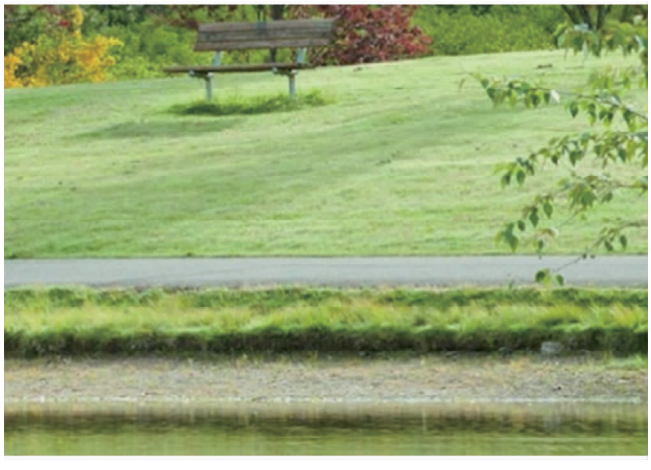

**Fig. 2 Ecological grass slope revetment**

**Fig. 3 Landscape revetment of stone placing and aquatic plants**

Combined with the construction of the sub-channel water system for the river, a water network can be formed, and aquatic plants can be configured to create the best combination of water conservation and ecological restoration. Leisure boardwalks are integrated into the network, offering recreational and viewing spaces, so as to realize the multifunctional potential of sites.

**Fig. 4 Ecological gabion revetment**

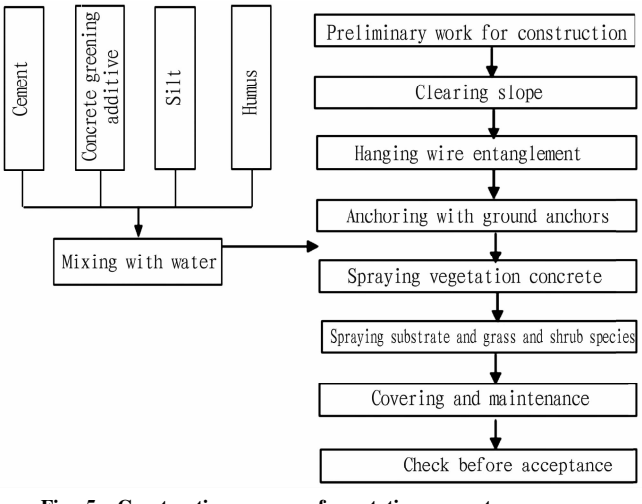


**Fig. 5 Construction process of vegetation concrete**

**Fig. 6 Actual picture of vegetation concrete revetment**

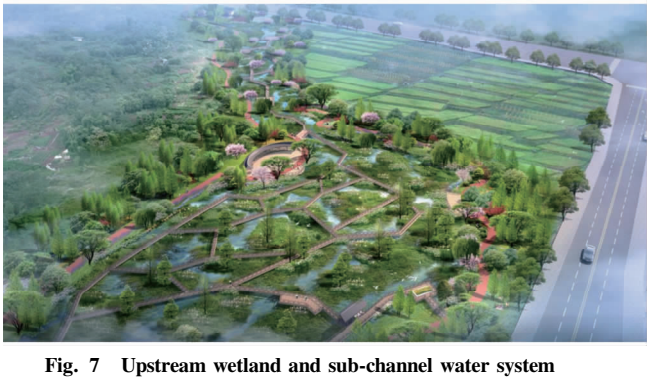

**Fig. 7 Upstream wetland and sub-channel water system**

**Solutions for water pollution issues**

(1) Addressing external water pollution by cutting off pollution sources: Industrial wastewater with moderate or higher pollution levels should be strictly prohibited from direct discharge into Mayuanxi River. Existing discharge pipelines should be relocated to connect to the nearest municipal sewage network. Lightly polluted industrial wastewater, domestic sewage and stormwater must undergo physical or biological treatment before being discharged into Mayuanxi River.

(2) Addressing external water pollution by rain garden purification: Rain gardens can not only effectively reduce surface runoff and replenish river water sources, but also function as an important biological treatment method for stormwater and sewage in the design. After passing through distributed drainage systems, open ditches, and blind drains, the stormwater and sewage flow into rain gardens for biological purification. The treatment measures: Grit tanks, filtration ponds, and biological filter tanks can be set at river inlets. Large-grained impurities are removed by grit tanks and filter tanks, and then pollutants such as N and P are absorbed and degraded by aquatic plant communities in rain gardens. Additionally, the consumption of microorganisms and plankton by insects, birds and fish helps achieve a pollutant removal rate of 60% – 70% before the water is discharged into Mayuanxi River[7]. The construction of rain gardens from bottom to top follows following sequence: compacting soil, laying impermeable membrane, laying impermeable membrane and coarse sand protective layer, setting water inlets and outlets and considering overflow ports, laying ecological filler, and planting aquatic plants (Fig. 9).

Based on the current distribution of drainage outlets, four rain gardens can be constructed along Mayuanxi River for stormwater and sewage control. Water quality tests were conducted on current drainage (Table 1). The design area of the rain gardens was determined using the Watershed-to-Wetland Area Ratio (WWAR) method. Based on predetermined influent and effluent water quality standards and target removal rates for various pollutants, with a typical ratio of rain garden area to catchment area (R) in the range of 0.5% – 5.0%, and in compliance with *Technical Specification of Constructed Wetlands for Wastewater Treatment Engineering*, the rain gardens were systematically designed (Table 2).

**Table 1 Water quality inspection for designed inlet and outlet of each rainwater garden**

| Water quality of designed inlet and outlet | COD//mg/L | TN//mg/L | TP//mg/L | $NH_3$-N//mg/L |
|---|---|---|---|---|
| Water quality of 1# rainwater garden | 24 | 8.54 | 0.66 | 6.81 |
| Water quality of 2# rainwater garden | 19 | 9.41 | 0.51 | <0.2 |
| Water quality of 3# rainwater garden | 30 | 2.72 | 0.70 | <0.2 |
| Water quality of 4# rainwater garden | 35 | 9.0 | 0.42 | <0.2 |
| Water quality of rainwater garden effluent (quasi-V standard) | ≤40 | ≤2.0 | ≤0.4 | ≤2.0 |

**Table 2 Main design parameters of each rainwater garden**

| Unit number/project | Facility area//$m^2$ | Hydraulic retention time//d | Hydraulic loading//$m^3/(m^2 \cdot d)$ | Porosity//% | Water treatment capacity//$m^3$ |
|---|---|---|---|---|---|
| 1# rainwater garden | 1 270 | 1 | 0.48 | 70 | 609.6 |
| 2# rainwater garden | 312 | 1 | 0.48 | 70 | 149.8 |
| 3# rainwater garden | 478 | 1 | 0.48 | 70 | 229.5 |
| 4# rainwater garden | 753 | 1 | 0.48 | 70 | 361.5 |

(3) Addressing internal river pollution: Multiple wetland organisms can be introduced to establish the fundamental framework of the river wetland ecosystem. An appropriate amount of sediment can be collected to cultivate benthic organisms such as *Filinia longiseta*, *Cladocera*, and *Bellamya aeruginosa*. Aquatic plants including *Phragmites australis*, *Acorus calamus*, *Typha orientalis*, *Nymphaea* L., *Lythrum salicaria*, *Nelumbo* sp., *Sagittaria trifolia*, *Scirpus validus*, *Monochoria korsakowii*, and *Monochoria vaginalis* can be planted. Various aquatic animals can also be introduced, including benthic species such as *Anodonta*, *Neocaridina denticulata sinensis*, *Trionyx sinensis* and *Hypophthalmichthys molitrix*, herbivores and predators[8].

(4) Establishing water quality monitoring points: To ensure controlled water quality conditions throughout Mayuanxi River, seven water quality monitoring points can be strategically positioned along its entire length. An intelligent ecological monitoring system can be adopted. It can utilize wireless data transmission terminals, and is equipped with customized monitoring and control instruments. The system enables real-time collection of large-scale data including soil moisture, meteorological conditions, water resources, and water pollution levels. After analyzing the data gathered by the intelligent terminals, appropriate prevention and control measures can be implemented[1].

**Ecological vegetation restoration**

(1) Aquatic plant configuration: Common aquatic plants such as *Phragmites australis*, *Arundo donax*, *Juncus effusus*, and *S. validus* can be planted in appropriate proportions according to landscape requirements[3]. Table 3 shows common aquatic plants, as well as their planting specifications and densities.

(2) Plant configuration for riverside flat land: In general areas, ecological restoration should be prioritized through "simulated planting" using native tree species that blend with the surrounding vegetation in color and form, such as willows, *Pterocarya stenoptera*, bamboo species, and *Metasequoia glyptostroboides*. These are planted in clusters at small sizes (DBH 5 – 7 cm) to restore ecology and form riparian shelterbelt, and to conserve water and reduce the threat of flood to riparian and downstream areas. In key construction areas or at visual focal points, and areas close to

the riverbank, ornamental species like peach trees, weeping willows, *Lagerstroemia indica* and *Acer* rubrum (DBH 6 – 8 cm) are introduced. Backbone plants like *Glyptostrobus pensilis*, *Metasequoia glyptostroboides*, and *Taxodium distichum* (DBH 18 – 20 cm). Accent plants like *Podocarpus macrophyllus*, *Osmanthus fragrans*, *Ginkgo biloba*, *Jacaranda mimosifolia* and *Ficus virens* (DBH 18 – 20 cm) can be strategically configured. From the perspectives of shrubs, vines such as *Jasminum nudiflorum* and *Bougainvillea* spp. and broad-leaved plants such as *Alocasia macrorrhiza*, *Cycas*, *Alpinia vittata* and *Canna indica* can be planted.

**Table 3 Common aquatic plants**

| No. | Latin name | Height // mm | Crown diameter // mm | Remark |
|---|---|---|---|---|
| 1 | *Iris tectorum* Maxim. | 250 – 300 | 150 – 200 | 5 – 10 plants/$m^2$ |
| 2 | *Acorus calamus L.* | 300 – 350 | 150 – 200 | 5 – 10 plants/$m^2$ |
| 3 | *Phragmites australis* (*Cav.*) *Trin. ex Steud* | 800 – 1 000 | 300 – 350 | 5 – 10 plants/$m^2$ |
| 4 | *Thalia dealbata Fraser* | 300 – 350 | 150 – 200 | 5 – 10 plants/$m^2$ |
| 5 | *Juncus effusus L.* | 500 – 600 | 150 – 200 | 5 – 10 plants/$m^2$ |
| 6 | *Lythrum salicaria L.* | 400 – 500 | 200 – 250 | 5 – 10 plants/$m^2$ |
| 7 | *Typha orientalis Presl* | 300 – 400 | 200 – 250 | 5 – 10 plants/$m^2$ |
| 8 | *Nelumbo sp.* | | | |
| 9 | *Nymphaea L.* | | | |
| 10 | *Pontederia cordata L.* | 300 – 400 | 200 – 250 | 5 – 10 plants/$m^2$ |
| 11 | *Scirpus validus Vahl* | 700 – 800 | 150 – 200 | 5 – 10 plants/$m^2$ |
| 12 | *Pratia nummularia* | 350 – 400 | 350 – 400 | 5 – 10 plants/$m^2$ |
| 13 | *Sagittaria trifolia var. sinensis* | 400 – 500 | 300 – 350 | 5 – 10 plants/$m^2$ |
| 14 | *Canna glauca L.* | 500 – 600 | 250 – 300 | 5 – 10 plants/$m^2$ |
| 15 | *Pontederia cordata L.* | 300 – 350 | 300 – 350 | 5 – 10 plants/$m^2$ |

(2) Vegetation configuration for riverside slopes: For general areas, ecological restoration should be prioritized, primarily by broadcast sowing or spray-sowing grass or shrub species such as ryegrass, Bermuda grass, tall fescue, zoysia grass, *Cassia bicapsularis*, *Indigofera amblyantha*, ferns, and leguminous plants. For key landscape areas or visual focal points, in addition to spray-sowing grass or shrub species (which may include flowering species like garden cosmos, clover, oxalis, and *Orychophragmus violaceus*), spot planting of rhododendron, bougainvillea, *Loropetalum chinense* var. *rubrum*, gardenia, and oleander can be implemented. Alternatively, color-block planting with foliage plants like *L. chinense* var. *rubrum* and boxwood may be adopted, or herbaceous species such as verbena, hairawn muhly, and miscanthus can be selected for mass planting.

(3) Design of bird-attracting forests: During the plant configuration in bird-attracting forests, attention should be paid to the reduction of tall trees to provide clear flight and landing space for birds. Diverse habitats such as wetlands, marshes, and islands should be created along the river and surrounding areas. Large areas of bird-friendly plants including *Crataegus* spp., *Prunus* spp. and *Vitis* spp. should be planted in suitable zones to provide food sources and attract birds. To minimize human disturbance, bird-watching areas should be separated from bird-attracting zones by rivers or forest belts, with a minimum buffer distance of 20 m[1]. The designed area for the bird-attracting forests along Mayuanxi River is approximately 5 000 $m^2$.

## Landscape design

### Overall landscape layout: meeting multifunctional needs

Based on the land use characteristics along the river course, the landscape layout of Mayuanxi River is divided into four distinct zones: Ecological Conservation Zone, Sports and Wellness Zone, Cultural Heritage Zone, and Slow-living Green Corridor (Fig. 10). The Ecological Conservation Zone, located in the upstream section, is primarily distributed with original forest, vegetation and grassland, but sparse human activity. Accordingly, its functional focus emphasizes ecological restoration, water conservation, flood control and drainage systems, while incorporating limited recreational spaces for scenic appreciation (Fig. 7). Adjacent to municipal roads and resettlement housing communities, the Sports and Wellness Zone is specifically designed to provide surrounding residents with sports and recreational facilities. The Cultural Heritage Zone borders the Affiliated High School of Southwest University, serving dense populations with special demographic characteristics. This area is programmed to showcase local cultural identity and historical evolution while fulfilling environmental and public education missions. As the downstream section neighboring industrial and office complexes, the Slow-living Green Corridor offers workers stress-relieving and relaxing leisure spaces.

### Project planning: addressing the problem of vitality deficiency along the river course

Field surveys along Mayuanxi River revealed that the primary user groups consist of factory workers, local residents, and faculty/students from the Affiliated High School of Southwest University. Therefore, the planning objectives of this project focus on meeting users' needs for environmental improvement, recreational activities, social interaction, as well as cultural and environmental education. Accordingly, the proposal puts forward the demand for activities in two time dimensions: all-season and all-weather. First, the all-season experience emphasizes distinctive seasonal characteristics. In spring, ecological slow travel, flower appreciation with tea ceremonies, cycling outings and outdoor sports can be organized. Forest oxygen bar, waterside cooling, scenic

viewing and aquatic entertainment are applicable in summer. Outdoor picnics, stargazing and camping and folk culture leisure activities can be planned in autumn. In winter, photography, hiking and mountain vista viewing activities can be held.

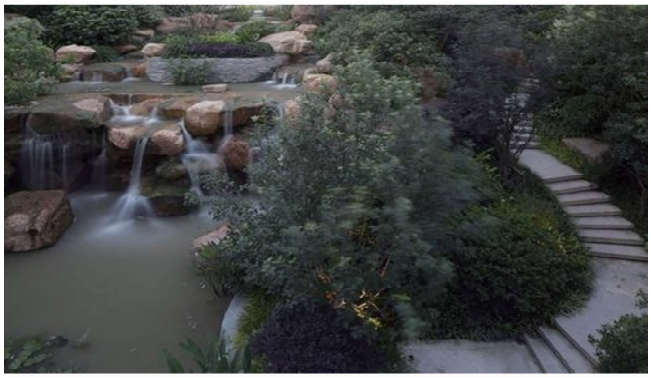

**Fig. 8 Landscape water drop with dam**

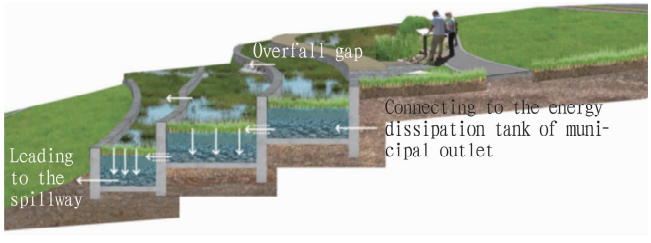


**Fig. 9 Illustration for practice of rainwater garden**

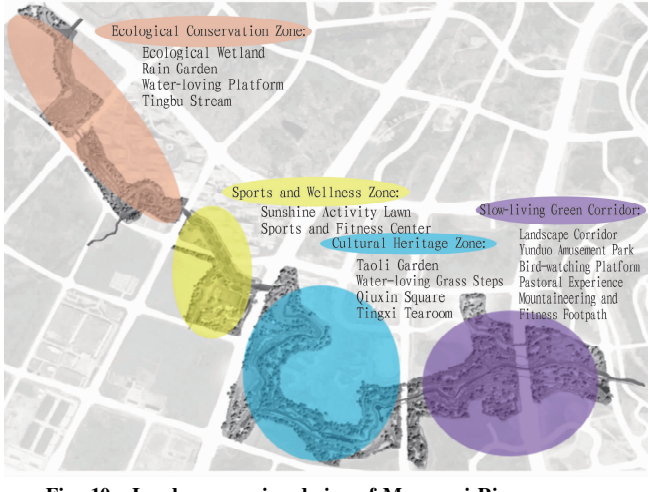


**Fig. 10 Landscape zoning design of Mayuanxi River**

**Restoration of river culture: addressing the problem of cultural deficiency** The project survey revealed a lack of historical and cultural representation along Mayuanxi River. To address this problem, the design incorporated comprehensive research on the river course's historical evolution and local culture, and key cultural elements including wharf culture (alum, night markets, boatmen's chants, lighthouses), Southeast Chongqing folk traditions (lantern festivals) and traditional crafts (liquor brewing, sesame cakes, pottery) are extracted. These elements are creatively integrated through characteristic landscape nodes, retaining dams, cultural walls, interpretive steles, signage systems, sculptures, and installations. Specific implementations in the Cultural Heritage Zone include inspirational educational sculptures (Fig. 11), cultural walls displaying the river course's historical context, special signage, and the "Taoli Garden" landscape node (Fig. 12) arranged to provide special activity space for teachers and students in the Affiliated High School of Southwest University. These interventions foster emotional resonance and contemplation while enhancing builders and users' sense of responsibility and local belonging[2].

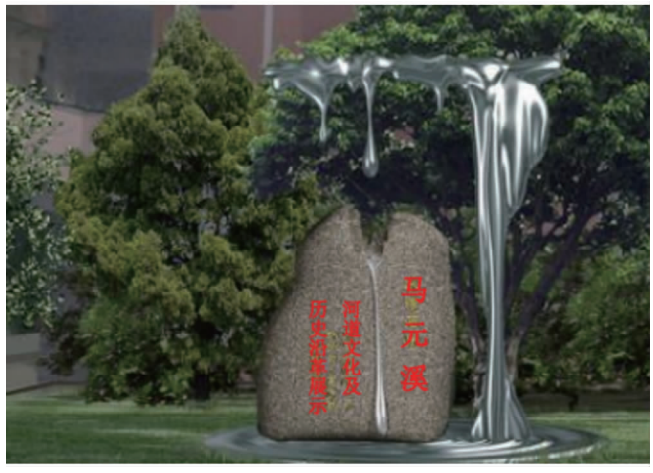

**Fig. 11 Sculpture intention of "drops of water outwear the stone"**

**Fig. 12 Effect picture of "Taoli Garden"**

## Conclusions and Prospects

Currently, the comprehensive management of river courses has aroused widespread concern in the society. However, due to the breadth and depth of issues involved, past governance approaches have often been characterized by one-sidedness. Taking the comprehensive regulation and landscape design of Mayuanxi River in Chongqing as a case study, this study systematically elaborated on various aspects including river course and water body management, revetment construction, ecological vegetation restoration, landscape development, activity planning, and cultural revitalization. Furthermore, from a more comprehensive and in-depth perspective, comprehensive river management ideas and solutions were put forward, while incorporating innovative approaches to river

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*from B. frutescens* and verified that they could inhibit the proliferation of tumor cells such as human lung cancer cells. According to the polarity table of organic solvents, the polarity of extraction solvents ranks as petroleum ether > chloroform > ethyl acetate > n-butanol. However, ethyl acetate and n-butanol are lipophilic organic solvents with low polarity, which are easy to dissolve flavonoids such as cyclopentenone and furanone derivatives and phloroglucinol derivatives, suggesting that the substances that inhibit the proliferation of human colon cancer LOVO cells in this study may be cyclopentenone and furanone derivatives and phloroglucinol derivatives.

In this study, it was found that ethyl acetate fraction and n-butanol fraction of *B. frutescens* could inhibit the proliferation of colon cancer cells, which provides a scientific basis for further research *in vivo*.

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ecological environment management. The study aimed to provide reference and inspiration for comprehensive river management and landscape design, representing an active attempt to promote the healthy development of river construction in China.

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