A Study on Application of Ecological Engineering Methods to a River Pollution Remediation– Case study of Liuchuan River

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Abstract. The Liuchuan River is an urban river in Taichung City of Taiwan. It was been affected by the pollution of domestic sewage and commercial wastewater for many years, resulting in the degeneration of water quality in rivers. Because of the hard bank revetment along the coast, the urban blue ribbon are unable to interact with residents. In order to improve water quality pollution and waterway environment, the Taichung Water Resources Bureau prioritizes water quality improvement. Under the goal of ensuring flood control and drainage, it actively diversifies the waterway space to enhance the city's local culture and life value. The purpose of this study is to analyze the improvement of water quality through the discussion of low-impact development engineering remediation projects. The water permeability of the riverbank before repair is almost 0%. After the improvement, the water permeability is increased by 50%, the green area is increased by 3,322 square meters, and the water quality RPI index is reduced from 7.25 “serious pollution” to 5. “moderately pollution”. This result shows that the Liuchuan River remediation project has successfully improved the water quality and river channel. Re-injecting green elements to create a hydrophilic environment for urban blue-green belts, improving the quality of residents’ living environment, and promoting the benefits of surrounding businesses and tourism.

1. Introduction

The problems of urban river pollution and ecological damage are becoming more and more critical. According to the statistics, by the early 20th century, there is not almost a complete natural river in the world [1]. Therefore, it is urgent to develop a cost effective technique to manage the river water quality. Low impact development (LID) is a land development strategy for managing storm water at the source with decentralized micro-scale control measures. Since the emergence of LID practices, they were been used successfully to manage storm water runoff, improve water quality, and protect the environment. [2]. Liuchuan River, is an urban river with functions such as flood discharge and sewage discharge channels. In the past, due to the impact of the surrounding population and economic growth, the channel water quality has deteriorated. It has only gradually improved in recent years. In 2012, the Environmental Protection Agency approved the Liuchuan River pollution remediation and environmental improvement plan, and built a pebbly contact oxidation facility and a low-impact development method in Liuchuan River. The four-year construction period has officially launched in...
2016 and received great repercussions. After the renovation project in Taichung, Liuchuan River became a well-known attraction. The Goal of the research is to explore the pollution remediation and environmental improvement in Liuchuan River and the methods of its use. The results show that water quality improvement is the core, and the urban blue belt space creates a hydrophilic environment to improve the living environment quality of residents. This historical water mill has a different look. Liuchuan River passes through the city and has been polluted by domestic wastewater in the past, becoming an urban drainage ditch. In 2014, the Taichung City Government carried out the “Liuchuan river Pollution Remediation and Environmental Improvement Project” to build a river that can be hydrophilic. The improvement of water quality has become the primary task of remediation. The city uses parking space, set up a sewage treatment plant, and filters through the cobble layer to provide a clean water source. With many polluted urban river affecting the environment of the cities, improvement work have become necessary. Therefore, Literature reviews, method development, water quality and specification analysis were conducted to further understand the core of the project.

2. Study area
Liuchuan River is an urban river with functions such as flood discharge and sewage discharge channels. In the past, due to the impact of the surrounding population and economic growth, the channel water quality has deteriorated. It has only gradually improved in recent years.

3. Strategy analysis of river renovation engineering
Analysis of river ecological engineering rectification project. Ecological engineering was defined as the practice of joining the economy of society to the environment symbiotically by fitting technological design with ecological self-design. [3]. This ecological engineering introduce the low-impact development method. The concept of low-impact development (LID) integrates environmental concerns with land development, focusing on water and pollutant balances. LID represents a fundamental change in the way residential, commercial, and institutional properties are developed and minimizes negative impacts on the environment and local ecology.[4]. This method is mainly by widening the river to 8 meters on both sides, changing to the gentle slope type, using the near-natural method to increase the permeable area, reducing the ecological impact, and reducing the disturbance of the land. It hopes to transform the waterfront environment of Liuchan River by strengthening sewage interception, water quality treatment, and waterfront environment construction. The project has turned the canal into a popular recreational area.

3.1 Permeable pavement
Permeable pavements have commonly used around commercial and industrial buildings to reduce the environmental impact. Permeable pavement is a specific type of pavement with a high porosity that allows rainwater to pass through it into the ground below.

3.2 Infiltration trench
A percolation trench, also called an infiltration trench, is a type of best management practice (BMP) that have used to manage storm water runoff, prevent flooding and downstream erosion, and improve water quality in an adjacent river, stream, lake or bay. [5].

3.3 Rain garden
A rain garden is a shallow planted depression designed to hold water until it soaks into the soil. A key feature of eco-friendly landscape design, rain gardens—also known as bio-infiltration basins—are gaining credibility and converts as an important solution to storm water runoff and pollution. Rain gardens were been recommended as a best management practice to treat storm water runoff. Rainwater garden, which is an ecological facility used for storm and flood control and utilization, is widely used for retention and purification of storm and flood runoff from buildings, parking lots and roads in public spaces, urban residential areas, commercial areas and industrial areas.
3.4 Dry well / seepage pit
A dry well, or seepage pit, is a small underground pit filled with stone that collects storm water from roof gutters and allows it to absorb into the surrounding soil. Underground piping can connect the dry well to the roof downspout. A filtration system have provided for a dry well in the form of a buffer tank made of concrete to remove sediment and pollutants from water supplied from a header to an inlet pipe in the tank, so that the water exiting from an outlet pipe is free of particulate matter and pollutants [6].

3.5 Vegetative filter strip
Vegetative filter strips have only intended to provide runoff treatment and have therefore situated between the pavement surface and a water collection system, pond, wetland, or river. Vegetated filter strips (VFS) are used recently for removal, at or near the source, of sediment and sediment-bound chemicals from cropland runoff. Vegetation within the flowpath increases water infiltration and decreases water turbulence, thus enhancing pollutant removal by sedimentation within filter media and infiltration through the filter surface.

3.6 Vegetated swale
A vegetated swale is a gently sloping landscaped depression that collects and conveys storm water runoff. Vegetated swales are an accepted and commonly implemented sustainable urban drainage system in the built urban environment. Event mean concentrations of suspended and bed load sediment have been calculated using current best analytical practice, providing single runoff event specific sediment conveyance volumes through the swale.

4. Data resource
We collect the data on Water Quality to discover the trend of the river pollution over these years
This research collects relevant monitoring data information on water quality monthly from the Yuan EPA National Environmental Quality Monitoring Information Network providing information which it has collected in a total five year from 2012 to 2016, in which the information was obtained from Taichung County Water Pollution Control Inspection and basin management plan. Every monthly water quality monitoring data builds relevant data, and builds a water quality database [7]

5. Result & discussion
The research is to adopt Taichung City's metropolitan river (Liuchuan) pollution remediation and Environmental Improvement Demonstration Project, and to evaluate the Project.

5.1. The low-impact development method
The low-impact development method includes Permeable Paving, Infiltration Trench, Rain Garden, Dry Well / Seepage Pit, Vegetated Filter Strip, and Vegetative Swale, etc. Through the filtration, adsorption and microbial decomposition of the soil to achieve the effect of water purification, according to the application area. The pollution reduction amount have shown in Table 1. It was expected that the daily pollution of suspended solids, total phosphorus and nitrates will be 20.6, 0.085 and 0.04 kg respectively. It was expected that the suspended solids, total phosphorus and nitrates will reduce the pollution rate. Each is 69%, 67% and 24% (see table 1).

| Structural project | Area (m²) | Facility infiltration volume (m³) | Collection volume (m³) | sum of SS decreased (kg) | Phosphorus Decreased (kg) | Nitrate Decreased (kg) |
|--------------------|-----------|----------------------------------|------------------------|--------------------------|--------------------------|------------------------|
| Permeable Paving   | 626       | 11.268                           | 41.316                 | 3.020                    | 0.013                    | 0.006                  |

Table 1. Low-impact development method to reduce pollution benefit analysis.
5.2. Water quality improvement benefits
To improve the water quality of the Liuchan River. Clean-up efforts will be devoted to three major problems: nutrient over enrichment, toxic substances, and the decline of submerged aquatic vegetation. In order to improve the efficiency of water quality, we compared the four pollution indicators such as water quality DO, BOD, SS and (NH3-N).

5.3. River pollution before remediation
Liuchuan River pollution mainly comes from domestic sewage. According to Taichung City Environmental Protection Bureau’s water quality monitoring stations in Liuchuan River, although the sewage sewer construction has actively promoted in the basin, the sewage take-over rate is still not popular, and most of the sewage has not been properly disposed and directly discharged. Liuchuan River, resulting in poor water quality for many years, except for the water quality of the downstream stations is between moderate to severe pollution, the other 2 stations are serious pollution.

5.4. After river remediation
From 2016 to March 2018, the river pollution (RPI) index of the rectification section of Liuchuan River was reduced from 7.25 to 3.5, from "severe pollution" to "light and moderate pollution". From 2014 to March 2018, the downstream river pollution (RPI) index of Liuchuan River was reduced from 8 to 3.75, from "severe pollution" to "moderate pollution" (see Table 2). It is obvious that the Liuchuan River remediation project has successfully improved the water quality.

### Table 2. The outcomes of sampling and analysis in the LiuChuan River.

| Monitoring stations | Sampling date | SS (mg/L) | DO (mg/L) | BOD (mg/L) | NH3-N (mg/L) | RPI | Degree of pollution         |
|---------------------|---------------|-----------|-----------|-------------|--------------|-----|-----------------------------|
| Upstream            | 2014          | 16.95     | 3.14      | 7.82        | 5.38         | 8   | Serious pollution            |
| Midstream           |               |           |           |             |              |     |                             |
| Downstream          | March 2018    | 12.2      | 7         | 4.9         | 4.5          | 3.75| Moderately polluted         |

6. Conclusion
Urban river renovation is a way to solution floodwaters and river pollution. In the short term, building a riverbank which getting instant results to protect our safety is a very common way. However, this
way does not involve in the concept of ecological environment and all things on earth environmental symbiosis.

The completion of the rectification of Liuchuan River in Taichung City is the first scenic riverbank to be developed with low impact. The fishery in the river were be seen in the river. Even the "damselfly fish", which has extremely high water quality requirements, has also recirculated. The value of the Liuchuan River pollution index has dropped significantly and the water quality will be safe. After the transformation, Liuchuan River, the concrete revetment has greatly widened. The original willows had removed and replaced with large green plants and bright flowers. The river and the bridge were set with hanging LED lights. The installation art, however, is this urban highlight really in line with residents' expectations? Most people hold a positive attitude and think that the rectification of Liuchuan River has indeed become beautiful, and the stench of the scatter also a lot weaker. However, some people think that the artificial landscaping of Liuchuan’s LED lights not only destroys the ecology, but also drives away the animals that inhabit them. It also makes the quaint elegance of Liuchuan River in the past disappear. When the city and rivers begin to be valued and rehabilitated, under the beautiful riverbank, how much ecology can be restored, so that the river is not only a landscape park, but also a biological habitat.

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