Access the Change of Water Quality in the Sponge City of LCTIP

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Abstract. The construction of Sponge City (SPC) in China has caused a huge social transformation, and the application of its core low-impact development facilities (LIDs) has changed the lives of residents from the details. Controlling runoff water quantity and its water quality are the two main objectives of low impact development measures. This paper discusses the results of water quality testing, comparing content changes of total phosphorus (TP), total nitrogen (TN), and chemical oxygen demand (COD) and total suspended solids (TSS) measured from water samples collected from the same LID facilities established by LCTIP three times a month during 2018 the local rainy season. The values changes of various pollutants from sampling points to the outlet show that the water quality of after LID facilities is close to the state of natural rain before development. The water purification effect of the LID facility was verified. At the same time, it is necessary to understand that more factors will have an impact on water quality. Therefore, the limitations of current knowledge and recommendations for future research are also discussed.

1. Introduction

According to EPA, the term low impact development (LID) refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat. LID is a sustainable concept in land use management that aims to maintain hydrological conditions at a predevelopment level without deteriorating water quality during land development. Based on the sustainable, the Sponge City (SPC) for urban stormwater management was proposed in China. [1] It was first mentioned by the Chinese President in 2013 and proposed in 2014. SPC is a comprehensive concept, focusing on not only the source control (as LID) but also the process control and drainage management. The aim of SPC construction is the detention, onsite storage, infiltration, filtration, reuse, and drainage of stormwater. [2-5] The two main purposes of the series of LID measures are controlling the quantity of storm runoff and improving its quality. Only the removal of pollutants was involved in this study, and the relevant practice measures mainly included rain barrels, bio-filtration facilities, green roofs, permeable pavements, and swale systems, measures that have been commonly applied.

Nutrients, such as Total Nitrogen (TN) and Total Phosphorous (TP) in stormwater can have adverse impacts on receiving water bodies. While these nutrients are necessary for growth by aquatic plants, excessive levels of these nutrients do cause excessive growth these plants, especially algae.
This excessive growth leads to eutrophication of surface waters. Nitrogen is a limiting pollutant in tidal areas, while phosphorous is a limiting pollutant in freshwater systems, particularly ponds and lakes. The common sources of TN and TP are the application of inorganic and organic fertilizers for crop production, lawn fertilization and the disposal of waste residues (bio-solids, animal manure, and compost). As noted above, decomposition of excessive vegetated growth leads to lower dissolved oxygen levels in the water. [6-10]

The chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. It is commonly expressed in mass of oxygen consumed over the volume of solution which in SI units is milligrams per liter (mg/L). A COD test can be used to easily quantify the number of organics in water. The most common application of COD is in quantifying the number of oxidizable pollutants found in surface water (e.g. lakes and rivers) or wastewater.

Total suspended solids (TSS) is the dry-weight of suspended particles, that are not dissolved, which could block light from reaching aquatic vegetation, while the less light in the water, the less photosynthesis is generated. As photosynthesis is reduced, less oxygen is produced by the vegetation thus affecting many aquatic species. When dead vegetation decomposes, more oxygen is used in the decomposition process thus further reducing oxygen levels in the water. TSS can also clog gravel substrate in breeding streams, affecting insect larvae and fish eggs. In a sample of water that can be trapped by a filter that is analyzed using a filtration apparatus. Meanwhile TSS is a water quality parameter used to assess the quality of a specimen of any type of water or water body, ocean water for example, or wastewater after treatment in a wastewater treatment plant. It is listed as a conventional pollutant in the U.S. Clean Water Act.

These pollutants cannot only kill some forms of aquatic life human beings also could be adversely affected by these pollutants thru the consumption of these higher aquatic species. After they accumulate on impervious surfaces, they are easily washed into the storm drainage with the next rain event. Within this study, water samples tested from two rain barrels and three bio-retentions in LCTIP used for discussion. Through experiments, monitoring the varieties of TP, TN, COD and TSS loads from them

2. Materials and method

2.1. Site description

The Lincang Technology Innovation Park (LCTIP) is located in Lincang City industrial park, Yunnan Province, China. Lincang City lies in the southwest of Yunnan Province, approximately between east longitude from 98°40’ to100°34’ and north latitude from 23°05’ to 25°02’. The east adjoins to Pu'er City and the west is adjacent to Baoshan City. Dali Bai Autonomous Prefecture is close to the north. Burma is neighboring the southern borders. And our lab which is just located in Lincang science and Technology Innovation Park(LCTIP). It is an innovation park based on its overall and controls specific
planning. It is the first paradigm of SPC in Lincang. Fig.1 illustrates the LID layout. The climate is subtropical with an annual rainfall of 1.158 mm and an average temperature of 17 °C.

The land use type is M1 (Department 2012). The area is 3.78 ha, which was occupied by buildings, roads, and green space. The total construction square is 78,500 m². The land use is a combined use of commercial, residential, and public facilities. The soil belongs to type B and C (clay). The groundwater level is about 1 m – 6.8 m. The slope is 4.5 % on the east side higher than the west side. This project was designed in Mar, 2016 by WALD and construction completed at the end of July 2016.

Both design and construction have been approved as qualified SPC project by the local authority. The investment is 1.15 million RMB for LIDs.

2.2. Experiment

2.2.1. Purpose. The data of total phosphorus (TP), total nitrogen (TN), turbidity (TUB) and chemistry oxygen demand (COD) in different water samples from water samples were tested to determine the filtering and purifying effects of plants on water quality and the filtering and purifying effects of sponge facilities on rainwater.

2.2.2. Materials.

As seen in Table 1 respectively collected from roof rainwater (A0) a, rain barrel 1 (A), rain barrel 3 (B), aquatic plants pool (C), semi-aquatic plants pool (D), terrestrial plants pool (E), and sample collection pool (F)b in different rainy days three times a month. Test for changes in total phosphorus, total nitrogen, chemical requirements, and total suspended solids, like Fig.2.

a A0 is the rainwater collected on the day using the rain gauge as a rainwater control before entering the LID facilities.
b Since the rockery collection pond (F) was connected to the outlet, the collected water samples from the rockery collection pond were considered as the outlet after purification in all LIDs in this study. Using spectrophotometry to obtain the tested data.

Figure 2. LIDs of the test in LCTIP

Total Phosphorus reagent powder, potassium per-sulfate, 1.54N sodium hydroxide solution, deionized water, total nitrogen reagent a, b, c powder pack, per-sulfate powder pack, HR total nitrogen
digestion test tube, total phosphorus test tube, COD Reactor, DRB200 Digester, Hach DR6000 UV Spectrophotomet

3. Results

3.1. Rainwater Record
In Fig.3, the rainfall record in 2018 rainy season from May to August reached a cumulative maximum of 538 mm on June 27, with an overall average of 63 mm. Samples were taken on the recorded rainy days, and the corresponding water quality test was carried out.

![Figure 3. Rainfall record (May-August, 2018)](image)

3.2. Total Pollutants

**Table 2. Test for total pollutants situation**

| SAMPLES | TP  | TN  | COD | TSS | Total |
|---------|-----|-----|-----|-----|-------|
| A0      | 1.15| 2.27| 8.75| 0.87| 3.26  |
| A       | 2.48| 4.17| 11.75|2.45| 5.21  |
| B       | 2.29| 4.02| 10.75|2.18| 4.81  |
| C       | 2.10| 3.39| 15.75|1.75| 5.75  |
| D       | 2.13| 3.55| 16.00|1.80| 5.87  |
| E       | 4.86| 8.36| 28.25|4.63|11.52  |
| F       | 2.26| 3.14| 13.00|1.49| 4.97  |

![Figure 4. Comparison of total pollutants](image)
As can be seen from Table 2 and Fig.4, that in the different experiment days from rainy season (May to August) in 2018 the mean values of total pollutants in the water collected from sampling points A to F present similar change trends. The same as in LIDs, at sampling point E that terrestrial plants pool got the highest loads, at sampling point F got a drop.

4. Conclusion
In comparison figures could be seen TP, TN, COD and TSS in stormwater would have a drop in values, and the water quality of the collection pond was close to that of undeveloped roof rainwater. Overall, in the collection pool (F) where the discharge (outlet) is located, the pollutants have curtailed apparently. That means that the entire processes from roof rainwater to the outlet collection pond, which will gradually reduce contains of contaminant in the water and improve water quality, through various LID facilities set in LCTIP. This verifies the water purification function of the LID facilities. Meanwhile, compared rain barrels to plants flitting pools, from aquatic plants pool (C) to terrestrial plant pool (E), there was a poof of the filtering and purifying effects of plants especially aquatic plants.

Above all, it can also be seen that the values of various pollutants indicators fluctuate greatly. In addition to the error of the experiment and the improper preservation of the samples, vitalities and metabolic activities of various living beings themselves in the biological filter. Weather and temperature changes and so on, will have certain impacts on the test. Later in the test operation and sample collection should strengthen the specification. Treatment of stormwater for contaminants is necessary in order to sustain ecological and economic benefits related to aquatic resources. For the purpose of further verify the purification effect and effectiveness of the LIDs, the monitoring of other pollutants such as NH3-N, BOD, etc., should be been increased and integration. Follow-up needs to continuously improve for maximize the effectiveness of LIDs.

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