Evaluating the Change of Contaminants in the Sponge City of LCTIP

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Abstract. Since many cities in China have carried out the construction of the sponge city and the low impact development, which has brought about a lot of great changes to the society. Especially in the discharge of water quality has changed. This paper is developed and discussed as well as compared to experimental results. Confirmed the water quality filtration and purification of the LIDs (low impact development facilities) by measuring the change in the content of pollutants in different water samples taken in them. Only detailed analyses of the turbidity (TUB), total nitrogen (TN), total phosphorus (TP) and Chemical Oxygen Demand (COD) in them are shown in this paper. From the comparison, it can be seen that the contaminant contains from the rainwater barrel to the outlet has indeed decreased. Meanwhile, there was a point in understanding more factors of influencing the quality of water. So limitations in current knowledge and recommendations for future research were also discussed.

1. Introduction

Low impact development (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.

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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.

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 turbidity (TUB) total nitrogen (TN), total phosphorus (TP) and Chemical Oxygen Demand (COD) loads from them.

2. Materials and method

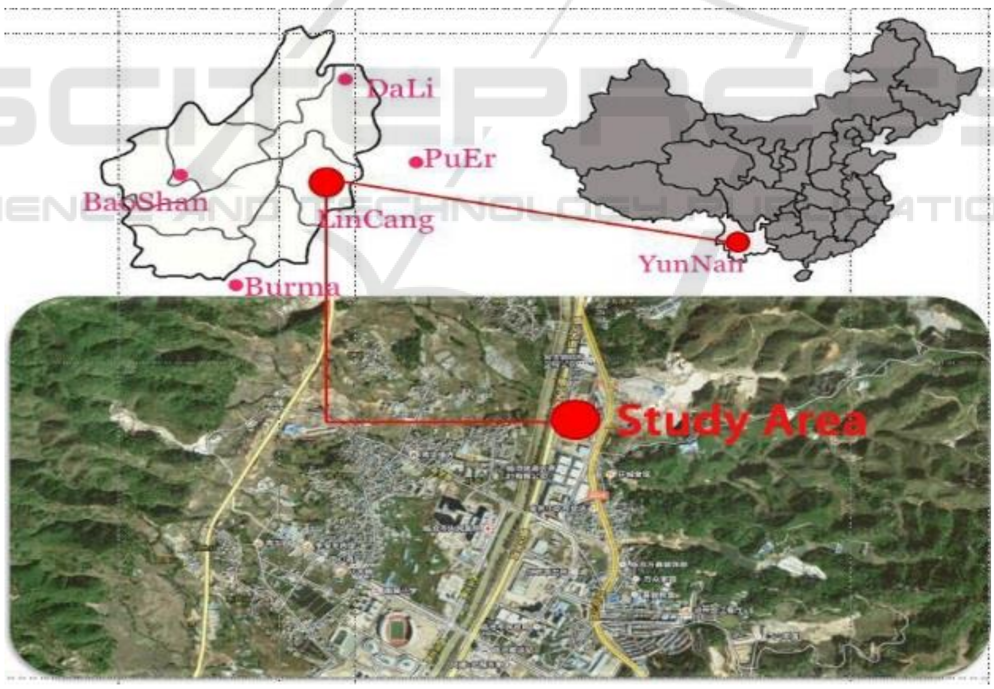

Figure 1. LCTIP Location.

Figure 2. LID Layout.

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. Figure 1 depicts the location and Figure 2 illustrates the LID layout. The climate is subtropical with an annual rainfall of 1.158 mm and an average temperature of 17 ℃.

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 m^2. 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. Took water samples from LIDs in LCTIP on rainy days like July.5th, Aug.1st, Aug.29th, Dec.5th, and Dec.7th.Total Phosphorus reagent powder, potassium persulfate, 1.54N sodium hydroxide solution, deionized water, total nitrogen reagent a, b, c powder pack, persulfate powder pack, HR total nitrogen digestion test tube, total phosphorus test tube, COD Reactor, DRB200 Digester, Hach DR6000 UV Spectrophotometer, 2100Q Portable Turbidimeter.

2.2.3. Method. Respectively collected water samples from Rain Barrel 1 (A), Rain Barrel 3 (B), Aquatic plants pool (C), Semi-Aquatic plants pond (D), and Terrestrial plants pond (E) and Rockery collection pond (F)[b], like Figure 3.

[b] Since the rockery collection pond 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 3. LIDs of the test in LCTIP.

3. Results

3.1. Turbidity (TUB)

Table 1. Turbidity situation.

DATE	Test TUB NTU					
	A	B	C	D	E	F
7.5	1.33	1.21	2.85	4.78	1.81	1.13
8.1	1.00	0.97	1.53	3.27	0.33	0.59
8.29	4.32	4.01	3.33	8.27	3.18	2.12
12.5	2.43	1.99	0.92	4.44	1.16	1.66
12.7	1.83	1.66	1.07	2.46	0.92	1.29

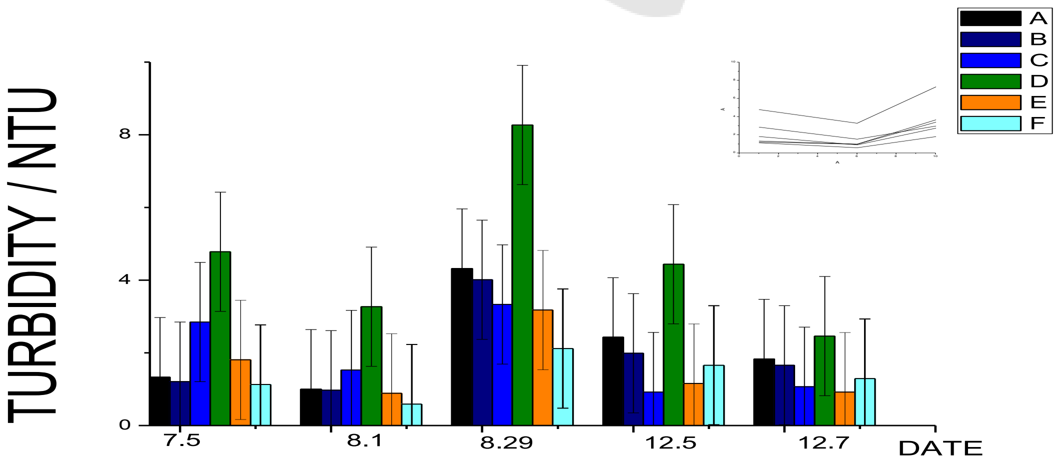

Figure 4. Comparison of turbidity.

3.2. Total nitrogen (TN)

Table 2. Total Nitrogen situation.

DATE	Test TN mg/L					
	A	B	C	D	E	F
7.5	3.30	3.20	2.70	6.20	1.30	2.40
8.1	9.10	8.90	6.90	12.20	5.70	6.30
8.29	3.76	3.24	3.01	2.76	2.24	2.01
12.5	5.20	4.90	4.30	8.90	2.70	3.50
12.7	3.40	3.20	2.80	7.60	1.70	2.10

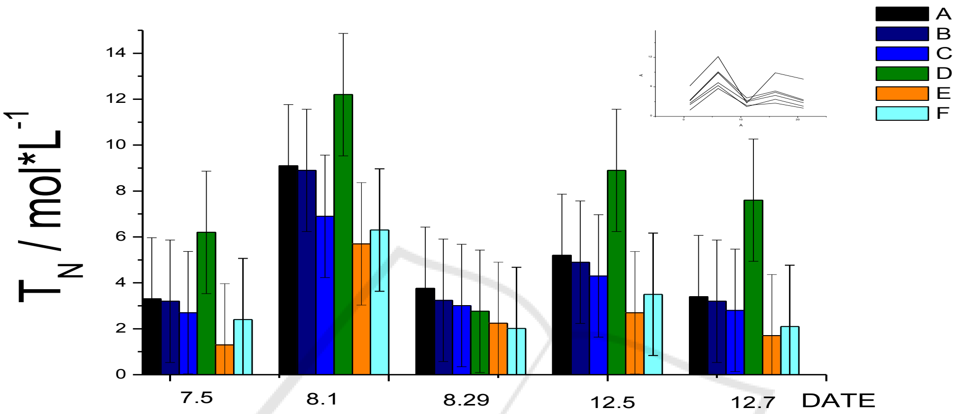

Figure 5. Comparison of total nitrogen.

3.3. Total phosphorus(TP)

Table 3. Total Phosphorus situation.

DATE	Test TP mg/L					
	A	B	C	D	E	F
7.5	0.73	0.72	0.47	0.57	0.35	0.3
8.1	0.72	0.71	0.83	0.98	0.75	0.52
8.29	0.95	0.76	0.52	0.68	0.44	0.38
12.5	0.85	0.8	0.64	0.79	0.59	0.45
12.7	0.83	0.79	0.66	0.76	0.51	0.38

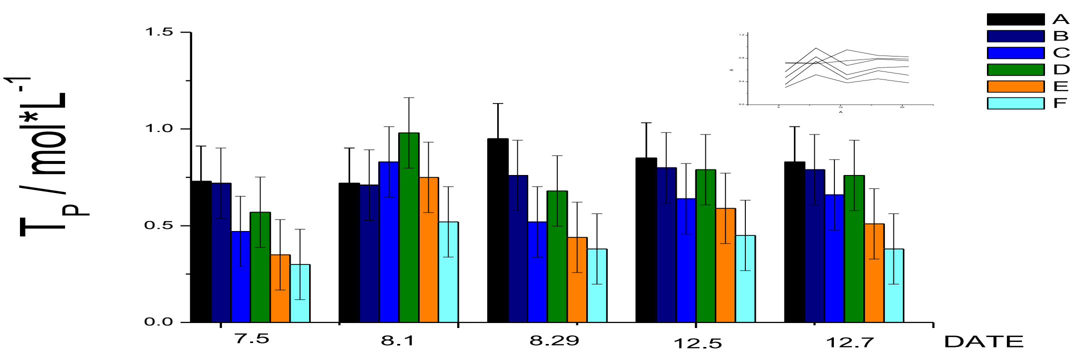

Figure 6. Comparison of total phosphorus.

3.4. Chemical oxygen demand (COD)

Table 4. Chemical Oxygen Demand situation.

DATE	Test COD mg/L					
	A	B	C	D	E	F
7.5	20	13	9	11	24	5
8.1	22	18	12	15	28	9
8.29	24	19	13	14	25	7
12.5	28	21	15	19	31	12
12.7	25	19	11	16	27	10

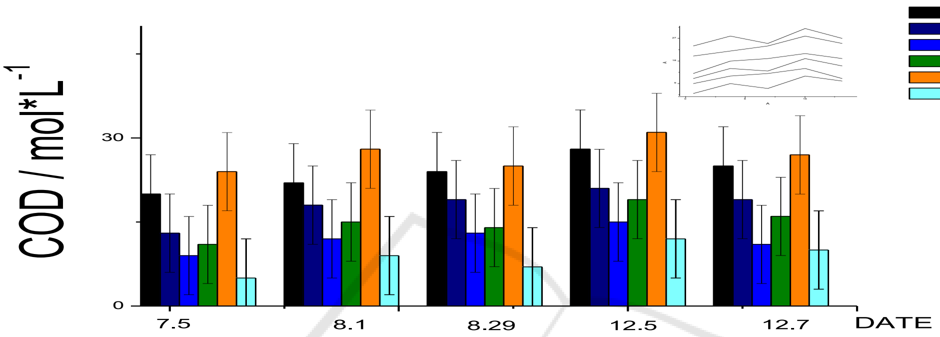

Figure 7. Comparison of chemical oxygen demand.

4. Conclusions

As can be seen from Figure 4, 5, 6, 7 could be seen on different rainy days, the values of TUB, TN, TP and COD in the water samples collected from sampling point A to F present the same change trend. That is TUB, TN, TP, and COD in stormwater would have a drop in values after being purified by a series of LIDs. Meanwhile, at sampling point C (aquatic plants pool), the content of various pollutants reached the minimum. The same as the average value.

Overall, the water that flows into the sampling point F (rocky collection pond), just the water from the rain barrel to outlet, whose kinds of pollutants indicators gradually declines and quality reaches a certain level improvement. The purification of LIDs has been confirmed.

5. Discussion

From the figures, 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, [11-13] weather changes and so on, will have certain impacts on the test. Later in the test operation and sample collection should strengthen the specification. In order to further verify the purification effect and effectiveness of the LIDs, the monitoring of other pollutants such as TSS, BOD, etc., should be been increased then summarized after comparison and integration.

As well known, excessive loadings of phosphorus and nitrogen in stormwater discharged to surface water bodies can result in eutrophication. In order to sustain ecological and economic benefits related to aquatic resources, [14-17] it is necessary to improve and increase the treatments of stormwater for phosphorus and nitrogen, just like LIDs. If phosphorus and nitrogen are removed, the water can be sustained for other uses, such as irrigation and industrial applications. Furthermore, under the background of increasing demand for population growth, climate change and availability of resources, bacteria, metals, microorganisms, and other pollutants in water could take advantage of bio-accumulation and the consumption of the food chain to exacerbate the effects on human beings. The corresponding increase in water demand has led to a continuous interest in alternative and decentralized potable and non-potable water resources, [18-20] especially in the city like Lincang which frequently is stopped the water. The transformation of rainwater is one kind of the ideas. It is worth following up on how to convert the rainwater after the LIDs to the standard potable water in the future.

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References
[1] Neil A, Rolley F and Walmsley J 2008 The Sponge City Hypothesis: Does It Hold Water? *Australian Geographer* 39(2):109–30
[2] Li X N, Li J Q, Xing F, Gong Y W and Wang W L 2016 Case Studies of the Sponge City Program in China P 295–308 in *World Environmental and Water Resources Congress 2016*
[3] Dai L P and et al 2017 Governance of the Sponge City Programme in China with Wuhan as a Case Study *International Journal of Water Resources Development* 1–19
[4] Jun X and et al 2017 Opportunities and Challenges of the Sponge City Construction Related to Urban Water Issues in China *Science China Earth Sciences* 60(4):652–58
[5] Shao W W and et al 2016 Data Integration and Its Application in the Sponge City Construction of China P779–86 in *Procedia Engineering* vol. 154
[6] Reilly O, Wanielista A M, M P, Chang N B, Xuan Z M and Harris W G 2012 Nutrient Removal Using Biosorption Activated Media: Preliminary Biogeochemical Assessment of an Innovative Stormwater Infiltration Basin *The science of the Total Environment* 432:227–42
[7] P E G I, Fletcher T D, Cook P L M, Deletic A and Hatt B E 2014 Processes and Drivers of Nitrogen Removal in Stormwater Biofiltration *Critical Reviews in Environmental Science and Technology* 44(7):796–846
[8] Wang S M and et al 2017 Nitrogen Removal from Urban Stormwater Runoff by Stepped Bioretention Systems *Ecological Engineering* 106:340–48
[9] S D J and et al 2012 Assessing Performance of Manufactured Treatment Devices for the Removal of Phosphorus from Urban Stormwater *Journal of Environmental Management* 113:279–91
[10] Chi-Hsu H, Davis A P and Needelman B 2007 Bioretention Column Studies of Phosphorus Removal from Urban Stormwater Runoff *Water Environment Research: A Research Publication of the Water Environment Federation* 79(2):177–84
[11] Chen X L, Peltier E, Sturm B S M and Young C B 2013 Nitrogen Removal and Nitrifying and Denitrifying Bacteria Quantification in a Stormwater Bioretention System *Water Research* 47(4):1691–1700
[12] R K R, Xie T and Dastgheibi S 2014 Removal of Heavy Metals from Urban Stormwater Runoff Using Different Filter Materials *Journal of Environmental Chemical Engineering* 2(1):282–92
[13] Geronimo F K F, Maniquiz-Redillas M C, Tobio J A S and Kim L H 2014 Treatment of Suspended Solids and Heavy Metals from Urban Stormwater Runoff by a Tree Box Filter *Water Science and Technology* 69(12):2460–67
[14] Johnson, Jeffrey P and Hunt W F 2016 Evaluating the Spatial Distribution of Pollutants and

Associated Maintenance Requirements in an 11-Year-Old Bioretention Cell in Urban Charlotte, NC *Journal of Environmental Management* 184:363–70

[15] Belis C A, Gianelle V, Stefani G D, Colombia C and T L B 2603913 Magnani 2008 The Influence of Orography And Meteorology On The Spatial Distribution Of Pollutants In The Alpine City Of Sondrio (Northern Italy)

[16] Lim H S, Lim W, Hu J Y, Ziegler A and Ong S L 2015 Comparison of Filter Media Materials for Heavy Metal Removal from Urban Stormwater Runoff Using Biofiltration Systems *Journal of Environmental Management* 147:24–33

[17] Kim, Min J, Hong T H and Koo C W 2012 Economic and Environmental Evaluation Model for Selecting the Optimum Design of Green Roof Systems in Elementary Schools *Environmental Science & Technology* 46(15):8475–83

[18] Mukta S and et al 2015 An Overview of Hybrid Water Supply Systems in the Context of Urban Water Management: Challenges and Opportunities *Water* 7:153–74

[19] Wang Y T, Sun M X and Song B M 2017 Public Perceptions of and Willingness to Pay for Sponge City Initiatives in China *Resources, Conservation and Recycling* 122:11–20