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Ecological Pond Installation using LID Technique and Water Quality Monitoring

Chang Hyuk Ahn[1*], Ho Myeon Song[2], Joon-Ha Park[3], Jum-Ok Park[4]

[1]Senior Researcher, Korea Institute of Civil Engineering and Building Technology, 2311, Daehwa-Dong, Ilsanseo-Gu, Goyang-Si, Gyeonggi-Do, 411-712, Republic of Korea

[2]Senior Research Fellow, Korea Institute of Civil Engineering and Building Technology, 2311, Daehwa-Dong, Ilsanseo-Gu, Goyang-Si, Gyeonggi-Do, 411-712, Republic of Korea

[3]Senior Managing Director, NUVOTEC Co., Ltd., Technical Research Center, 254, Yeongdeungpo-Ro, Yeongdeungpo-Gu, Seoul, Republic of Korea

[4]Deputy General Manager, NUVOTEC Co., Ltd., Technical Research Center, 254, Yeongdeungpo-Ro, Yeongdeungpo-Gu, Seoul, Republic of Korea

** Corresponding author*

Abstract

An ecological pond is an eco-friendly facility that can store and utilize rainwater in various areas. In particular, a pond installed on an idle or non-utilized site in a city can promote ecological health and enhance the aesthetic environment. A LID (low impact development) technique-based ecological pond using rainwater was established in this study, and an ADP (artificial deep pool) which serves as a shelter for fish was installed additionally. The ecological pond was established in phases by considering the urban water circulation system which is an urban planning technique. As a result of monitoring the water quality in the completed ecological pond for one year, the water temperature and DO in the ADP revealed the functional ability to mitigate the high water temperature period during summer and DO supersaturation during winter.

Key words: Ecological pond, LID, idle site, ADP, fish shelter

INTRODUCTION

A pond installed in an urban area improves ecological health as well as reproducing a corridor between separated ecosystems. When an ecological pond is installed in an urban area in terms of LID strategy, a previously idle or non-utilized site can be made available for public use and the quantitative and qualitative functions of the closed water environment system can be improved. Such an approach requires various types of information related to urban planning, landscape and ecology. Generally, LID aims to reduce the occurrence of floods in a wide area and it also has various functions such as water treatment, preservation and use of rainwater, improvement of ecological function and landscaping in a narrow space [1]. In this study, an idle site in urban area was used in order to create an ecological pond using the efficient LID technique. Also, an ADP that serves as a fish shelter was installed to enhance fish survival, and the water quality was monitored in order to see if a healthy ecological environment was maintained or not.

MATERIALS AND METHODS

Ecological pond installation

The installation of an ecological pond was carried out in the order shown in Figure 1. Since the LID technique is used for this kind of facility, the possibility of securing the location, maintenance flow and water quality was investigated in order to determine the likelihood of applying the relevant facility. Next, the appropriate size of the ecological pond was selected and the maintenance flow was determined through an analysis of the water balance. When the size was determined, detailed designing with respect to sediment, shore, habitat and landscape facilities was carried out. If this procedure is deemed to be not satisfactory, a reexamination is carried out after returning to the previous step.

When the basic designing is completed, the ecological pond management plan step is carried out. Setting of the target water quality is one of the methods to maintain the ecological pond for a long period of time, and a water treatment facility is installed if necessary. Living organisms (plant, fish, amphibian, etc.) that can adapt to the relevant environmental parameters such as the target water quality are introduced to inhabit the pond. The management plan includes all plans (facilities, landscaping, electricity management, etc.) related to the overall operation of the ecological pond, and when all these steps are carried out, the LID ecological pond is completed.

These steps are similar to the steps for the 'urban water circulation system' used recently for constructing new towns in republic of Korea. Since the LID technique seeks to use rainwater efficiently, systematic prior planning in terms of urban development is necessary. Therefore, the establishment of an ecological pond using the LID technique should be carried out in phases using the procedure for 'urban water circulation system' partially.

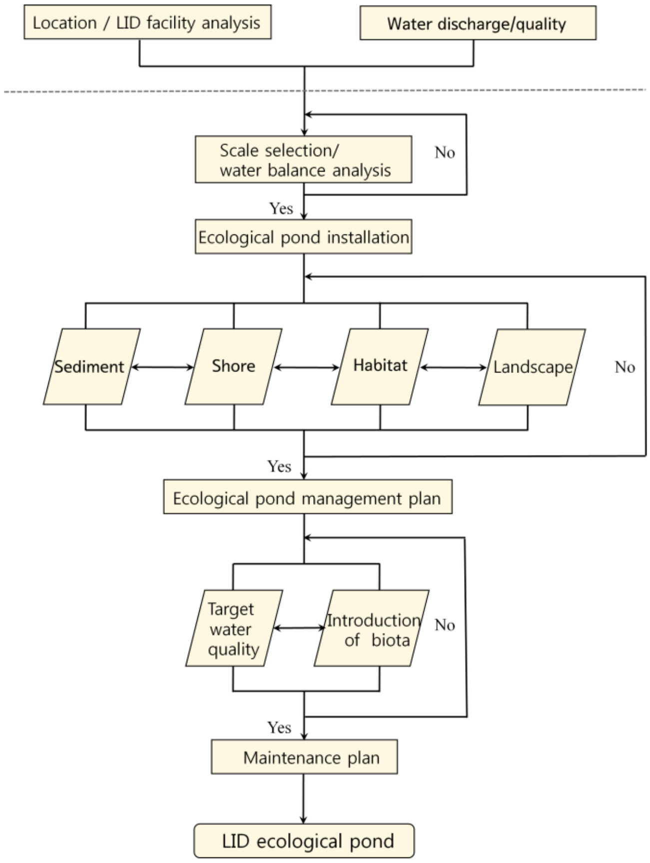

Figure 1: Implementation of LID ecological pond process.

Fish shelter

Since the ecological pond constructed in the idle site is shallow and small, a biological habitat is necessary. An ADP was installed as a fish shelter in the middle of the ecological pond we established.

The ADP is a 1.5 m wide, 1.5 m long and 1.5 m high concrete structure. Simply, an ADP is a fish shelter facility buried underground at the bottom of the pond. There is a space where fish can move inside the ADP and perforated entrances (diameter 20 cm, 9 entrances) where fish can enter at its top. An ADP has an advantage that fish can shelter promptly in an emergency situation when the water level is low or the water quality suddenly changes. If such a facility is introduced, the breeding of fish can be maintained continuously even though the ecological pond is constructed in the middle of the city where there are many surrounding buildings.

Water quality monitoring

Basic water quality (water temperature, pH, DO, EC) is one of the most fundamental conditions for fish to survive in a biological habitat or shelter. In order to measure basic water quality, we designated the open space in the pond as St. 1 and the underground space where the ADP was placed as St. 2. A water quality measurement device (XLM6000, YSI, USA) was installed at a depth of 0.4 m in St. 1 and 1.5 m in St. 2, and monitoring was carried out continuously for one year in order to compare the open space and ADP. During the whole period, an underwater pump inside the ADP was operated from April 2013 to September 2013 and then was not operated after that.

RESULTS AND DISCUSSION

Result of ecological pond installation

The ecological pond was constructed on an idle site belonging to the Korea Institute of Civil Engineering and Building Technology (KICT) located in Gyeonggi-do Province,republic of Korea in April 2011. The pond area was 110 m^2 and the average water depth was 0.5 m (up to 0.7 m), and the sediment material consisted of gravel and sand. For the maintenance flow of the pond, rainwater collected from the roof top of a surrounding building was utilized after transporting by means of a pipe and storing it in an underground rainwater retaining facility. However, tap water attached with a water level control sensor was utilized as a supplemental water source in preparation for circumstances in which it would be impossible to provide the necessary flow rate. The flow rate of approximately 1.5 L/min was maintained continuously by taking into account evaporation after analyzing the water balance, and the water quality of influent water was within BOD 3 mg/L, SS 10 mg/L, TN 0.7 mg/L and TP 0.03 mg/L.

The installation procedure of ecological pond is shown in Figure 2. In the first construction step, the selected idle space was secured and bed excavation was carried out. Since the purpose of this facility was to use rainwater as maintenance flow, a rain gutter was installed on a surrounding buffer zone or the roof top of a building along with the LID facility and a pipe was connected. Second, a water proofing sheet was installed. Generally, water can permeate an idle space in a city, so a water proofing sheet such as bentonite or clay is necessary. Bentonite was used in this study. The third and fourth steps were the transportation and installation of the ADP. The ADP was placed in the middle of pond (0.7 m deep), improving its usability by fish. The cover was placed on top of the placed ADP and basalt was installed on both sides and on the top of the ADP, enabling the smooth inflow of fish. The installed ADP secures additional depth in a shallow pond, providing an efficient shelter space for fish during the dry season in winter or high water temperature period in summer. The sixth step was the placement of sediment material at the bottom of the pond. Gravel and sand were mainly used in this study. When the installation was completed up to this point, water was supplied to the pond, plantation was carried out, and fish were introduced. After two years had passed after the construction was completed, it was confirmed that plants such as *Nymphoides peltata and Typha orientalis* were growing densely and various aquatic organisms existed in the pond.

Figure 2: Ecological pond installation process.

WATER QUALITY MONITORING RESULT

In this study, the whole period was divided into three phases after taking into account seasonal variations and pond operating conditions and St. 1 and St. 2 were compared and analyzed. Phase 1 refers to the blending by an underwater pump, Phase 2 refers to the frozen status in winter, and Phase 3 refers to the next spring when ice melts.

In Phase 1, the water quality of St. 1 and St. 2 was relatively similar due to the circulation of water currents regardless of seasonal dynamics. However, a clear difference in the water quality between St. 1 and St. 2 (particularly, pH and DO) was revealed in Phase 2. Phase 3 is the period when ice melts and the water temperature rises. Since the circulation of water currents was not provided during this period, the water quality between St. 1 and St. 2 was clearly different. In general, there was a significant difference in the water quality between St. 1 and St. 2 depending on the circulation of water currents and, particularly pH and DO, were greatly affected according to whether the circulation of water current occurred or not.

Noticeable items in this study are water temperature and DO. St. 2 recorded water temperatures 1~2 °C lower than St. 1 for the whole period except for winter season. It is judged that this phenomenon occurred because of the shading effect of the ADP cover regardless of whether the smooth circulation of the water current by the underwater pump was maintained or not. If a high water temperature persists or the water temperature rises rapidly during summer, it may cause thermal stress to fish, [2], so fish tend to escape to a space where the water temperature is relatively low [3,4]. However, St. 2 recorded a higher water temperature range than St. 1 during winter (St. 1: 4.6±0.7 °C, St. 2: 4.6±0.5 °C). Theoretically, a higher water temperature can be maintained in the inside of an ADP, where there is deep water, rather than the outside of an ADP due to a difference in the density of water during winter. In this way, the inside of an ADP can be a relatively comfortable biological habitat by buffering extreme water temperature situations.

The average DO range was 1.6~21.4 mg/L, maintaining various aerobic conditions. The most characteristic behavior of DO in this study was shown in Phase 2. DO in Phase 2 increased continuously as the water temperature decreased and DO supersaturation occurred in St. 1. At first, the cause of the occurrence of DO supersaturation was the supply of oxygen from the atmosphere. Generally, DO is influenced by the solubility of oxygen gas due to air pressure, and as the temperature decreases, the oxygen transfer rate increases so that the oxygen concentration in water increases [5].

DO ranged between 1.6~21.4 mg/L on average, showing various aerobic ranges. Characteristically, DO in Phase 2 increased continuously as the water temperature decreased and DO supersaturation occurred in St. 1. When DO supersaturation occurs, the swimming ability of fish is hindered and panic may be displayed among fish or diseased conditions such as a gas bubble disease may appear on the subcutaneous tissues of fish [6]. However, DO supersaturation was inhibited in St. 2 unlike St. 1. When DO supersaturation occurs in a shallow pond just like the target site of this study, there is nowhere fish can escape, so fish are likely to die. Also, if DO supersaturation persists, it produces physiologically adverse effects on fish, so it is necessary to secure a proper fish shelter. In this respect, it is judged that St. 2, where the ADP is placed, may be utilized as a fish shelter in winter. However, a decrease in DO while water temperature rises, as shown in Phase 3, may make it difficult for fish to inhabit continuously, so measures such as additional oxygen supply or the securing of a corridor for fish would be necessary.

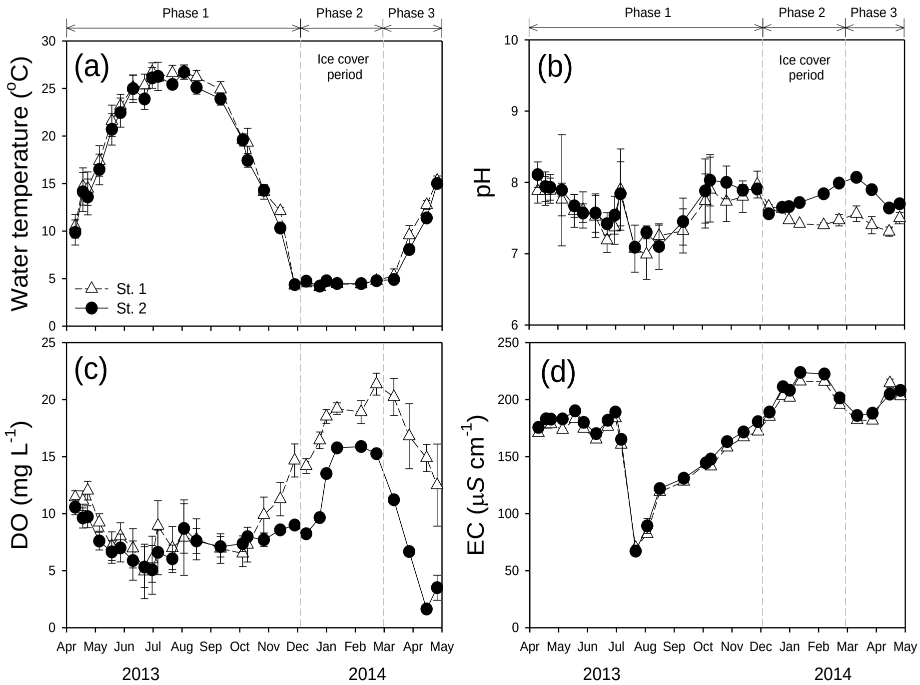

Figure 3: Water quality monitoring result during different phases.

CONCLUSIONS

In this study, the process to create a pond using the LID technique on an idle site was proposed. Also, an ecological pond including an ADP that serves as a fish shelter was established on the idle site located in a city. Urban planning techniques were used for the ecological pond establishment procedure with the LID technique carried out in this study, and an ADP was installed so that it could serve as an adequate fish shelter although it is small in size. In particular, as a result of monitoring the water quality, the water temperature and DO in the ADP displayed an ability to mitigate the high water temperature period during summer and DO supersaturation during winter. This is merely a preliminary study and is still ongoing. Accordingly, it will be necessary to engage in more systematic monitoring and study the various application methods in the future to understand how the capacity of ponds can be best used.

ACKNOWLEDGMENT

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