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Evaluation of Water Temperature, pH, DO and Conductivity of Freshwater Fish Shelter in Shallow Pond

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***Abstract*—This study analyzed the water environment of an artificial deep pool (ADP), underground type fish shelter installed in shallow pond, during late spring to summer season. The inside of ADP was stable daily water quality fluctuation and it was suggested as shelter space for fish when high water temperatures persisted in open water space. Analysis of St. 1 and St. 2 statistically indicated that, they were distinctly different spaces, with respect to water temperature, pH, DO, and conductivity (two-way ANOVA, *P*＜0.05). It was determined that these water environment conditions can affect the inhabitation and spawning of fish in shallow ponds. In the study area, *Rhodeus uyekii* was dominant and it was determined that an appropriate spawning temperature (16.5~18.5 ℃) for *Rhodeus uyekii* was formed, due to the use of an ADP. Ultimately, since ADP can maintain a steady temperature that is lower than the external temperature during summer, it can serve as good shelter for types of fish that are sensitive to high temperature or temperature fluctuations.**

***Keywords*—ADP, water temperature fluctuation, thermal stress, fish**

I. Introduction

Fish face much stress during their lifetime [1]. Since fish spend their entire lives in water, water environment is the most directly limiting factor in their survival. In particular, factors such as water temperature, pH, and DO can have major influences on the physiological changes in fish, with slight different in optimal ranges between species [2].

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Although littoral zone is good habitat for fish, but because the littoral zone is shallow and receive abundant radiation energy, they are subject to significant changes in water quality, such as water temperature, pH, DO, and conductivity [3]. Among these, water temperature is an especially sensitive water quality factor for fish. For fish, excessively high water temperatures or high daily fluctuations can lead to serious stress [4]. Therefore, in the present study, an artificial deep pool (ADP) was installed and operated to act as shelter for freshwater fish in shallow ponds to reduce the thermal stress.

The ADP is an underground type structure built to secure shelter space for fish when the water level drop in the freshwater ecosystem [5]. The ADP was cuboid shaped and separated into a cover and the main body. The ADP cover had a perforation (diameter 0.2m) and side space (height 0.2m), which prevents damage from misstep by human, as well as secures a passage way for the fish. In the present study, the basic water quality in the ADP was analyzed during late spring to summer, when thermal stress in fish can increase, to determine the water environment for the fish shelter.

II. Materials and Methods

A. *Site description*

The present study was conducted at the eco-pond inside Korea Institute of Civil Engineering and Building Technology (KICT), located in Daehwa-dong, Insanseo-gu, Goyang-si, Geyonggi-do, Republic of Korea. The area, average depth, and maximum depth of the pond were 110 m^2, 0.5 m, and 0.7 m, respectively, and the bed material consisted of gravel (diameter ≤60 mm), sand (diameter ≤2 mm), and bentonite. The water supply for the pond used a reservoir with tap water and rainwater. A control sensor for water level was installed on the inlet to allow set the water level to be maintained even in dry or heavy rain seasons.

The specifications of ADP were 1.5 m x 1.5 m x 1.5 m (width x length x height), which was constructed with zero-cement concrete and installed in the deepest point in the middle of the pond (depth 0.7 m). Inside the ADP contained space for fish to use as shelter and a cover with a perforation (diameter 0.2m) and side space (height 0.2m) was placed on top to attract the fish to seek shelter in it. Moreover, basalt (diameter ≤250 mm) was installed on top of the cover to emphasize the natural look of the structure (Figure 1).

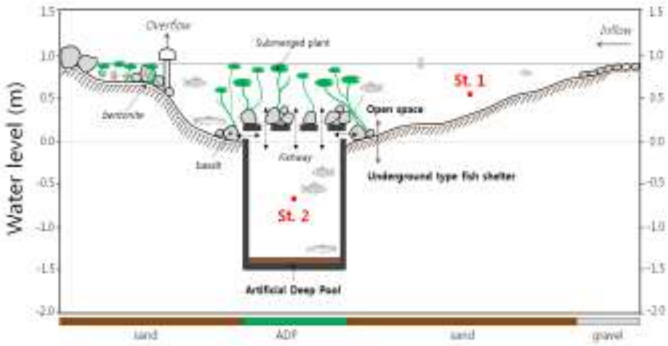

Figure 1. Cross section view of the study site.

B. Water quality measurement

The open water space in the pond was assigned as St. 1 and the underground space where ADP was located was assigned as St. 2 (Figure 1). A water quality measurement sensor (XLM6000, YSI, USA) was installed in each of the two locations and measurements were taken in 1 hr increments between May 21 and July 25, 2012 (66 days). The sensors were installed at depths of 0.4 m at St. 1 and 1.5 m at St. 2 and the measured parameters were water temperature, pH, DO, and conductivity. The measurement data were classified according to season, as normal season or rainy season, and were organized in a chronological order. Rain data was used by Korea Aviation Meteorological Agency in this study.

The analysis of experimental data was conducted via two-way ANOVA, which analyzed the significance and interactions of water quality parameters for each space. A two-way ANOVA is a method used for mean comparisons of multiple factors and is widely used in various fields [7].

III. Results

A. Water quality result

The results of analyzing the water quality in St. 1 and St. 2 during the entire study period showed significant differences based on season and water quality parameters ($P < 0.05$). During normal season, the measurements from St. 1 were water temperature 22.0±1.5 °C, pH 7.6±0.3, DO 8.5±0.8 mg/L, and conductivity 196±13 μS/cm; while that of St. 2 were water temperature 18.8±0.5 °C, pH 7.4±0.1, DO 4.9±0.3 mg/L, and conductivity 219±4 μS/cm (Figure 1). Overall, water temperature and DO were low in St. 2, which is believed to have been caused by the shading effect by ADP cover.

During rainy season, in comparison to normal season, the differences at each location were smaller. The measurements from St. 1 were water temperature 25.1±1.7 °C, pH 7.4±0.2, DO 8.3 ± 1.8 mg/L, and conductivity 133 ± 30 μS/cm; whereas, the measurements from St. 2 were water temperature 23.7 ± 1.0 °C, pH 7.3 ± 0.1, DO 5.9 ± 1.3 mg/L, and conductivity 134±9 μS/cm. The waterbody used as the study site was small (approximately 55 m^3), and considering the fact that the distance between the two locations were not very far from each other, it is showed that the waterbody mixing caused by heavy rain may have been the primary cause. As for evidence of mixing, first, water temperature and DO from both locations were shown to be at same levels during heavy rain; second, it is assumed that it is a phenomenon of decrease in conductivity from being diluted after high inflow of rainfall.

The diurnal variations in water quality from St. 1 and St. 2 showed different patterns ($P < 0.05$). The diurnal variations in water quality from St. 1 were shown to be high than from St. 2, and the diurnal variations were high during rainy season than normal season. During normal season, the differences between the minimum and maximum values at St. 1 for water temperature, pH, and DO were 7.1 °C, 1.3, and 4.1 mg/L, respectively; and 1.9 °C, 0.4, and 2.3 mg/L, respectively, at St. 2. On the other hand, the differences between the minimum and maximum values at St. 1 during rainy season for water temperature, pH, and DO were 8.4 °C, 1.2, and 8.6 mg/L, respectively; and 4.5 °C, 0.6, and 6.4, respectively at St. 2. In other words, under the conditions of no movement by the waterbody and active photosynthesis occurring, water quality parameters were showed high spatial and seasonal variations.

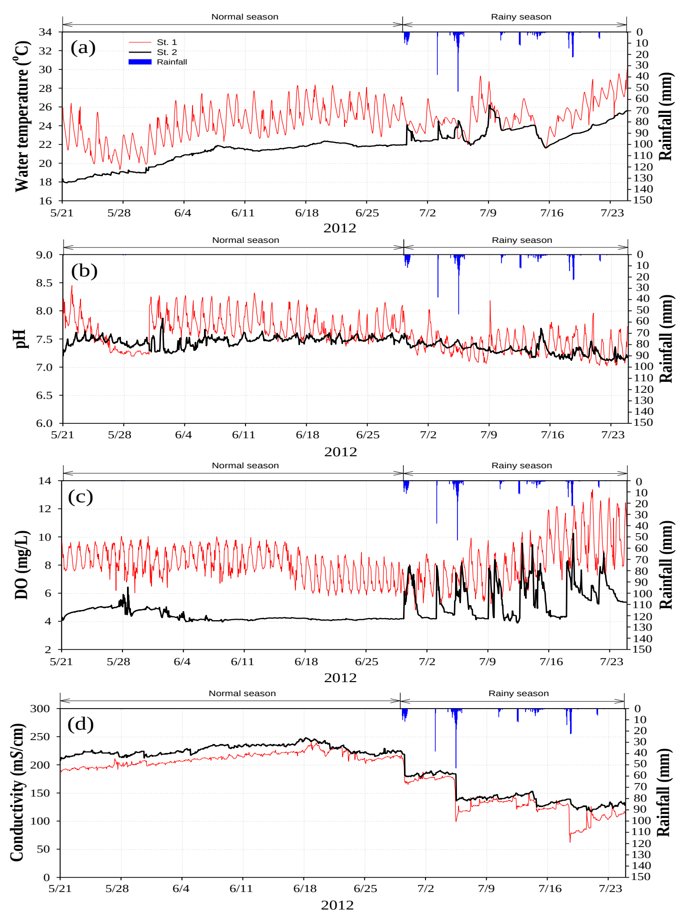

Figure 2. Water quality result in St. 1 and St. 2 during normal and rainy season.

B. *Comparison of St. 1 and St. 2*

The values of water temperature, pH, DO, and conductivity measured at St. 1 and St. 2 were compared (Figure 3). Overall, the differences between the water quality parameters were lower in rainy season than in normal season. It is determined that during rainy season, there was a circulation due to waterbody movement due to heavy rain.

The water temperature appeared higher, for the most part, in St. 1 (Figure 3a). Between St. 1 and St. 2, the maximum difference in water temperature was 8.4 °C, with average difference of 2.7±1.6 °C. These results indicate the fact that the inside of ADP can provide good shelter for fish to relieve thermal stress. Large differences in pH and DO were generally seen during non-heavy rain season (Figure 3b, c). The fact that pH and DO generally showed higher values in St. 1 suggests that photosynthesis was relatively more active outside than inside. Conductivity showed relatively consistent differences between the two locations, with St. 2 exhibiting higher values (Figure 4d).

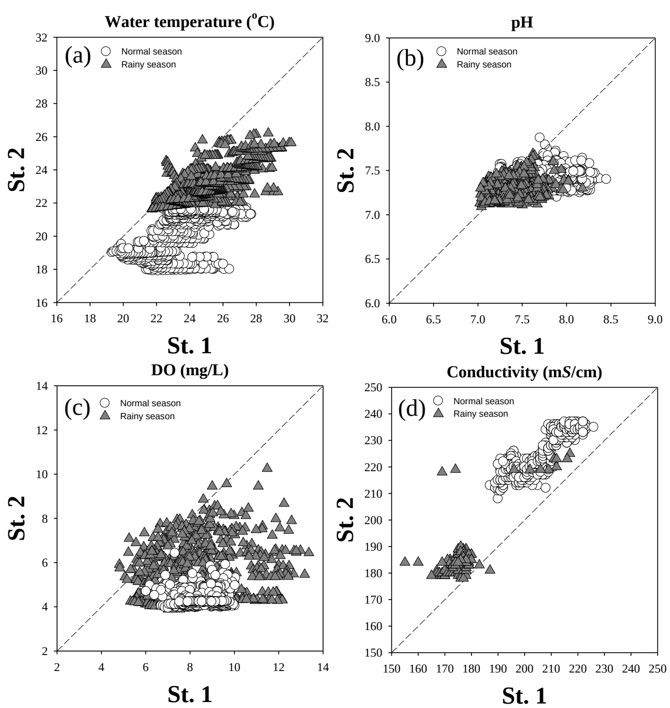

Figure 3. Comparison of St. 1 and St. 2 for water quality result.

IV. Discussions

The present study aimed to identify the potential for using an ADP, an underground type structure, as a shelter for freshwater fish by analyzing the internal and external water qualities of ADP. The main characteristics of ADP include having less daily water quality variations compared to the outside and not showing diurnal phenomenon, as well as showing temperature that is lower by 4.0 °C than the outside during late spring to summer seasons.

Among the functions of ADP that appeared in the present study, the most important role as a fish shelter is securing stable water temperature. The experimental results in the present study showed that ADP's internal water temperature was measured to be lower and more stable than the outside. When water temperature rises, fish move to find the proper water temperature. For example, when high water temperature persists, longfin dace (*Agosia chrysogaster*), Cyprinidae family, utilizes a strategy of evacuating to shaded pools where the water temperature is 3 °C lower [8]. Since the results of the present study were obtained during the investigation period of late spring to summer, when water temperature rises, and considering the severe fluctuations in water temperature of open water, it is believed that fish can use the inside of ADP as an effective shelter.

In this study site, the dominant specie was *Rhodeus uyekii*, Acheilognathinae family. For *Rhodeus uyekii*, the optimal water temperature for habitation is 20~24 °C, while the optimal water temperature for spawning is 16.5~18.5 °C [35]. Since ADP's average internal temperature was 18.8±0.5 °C, the water temperature was optimal for *Rhodeus uyekii* to spawn. Furthermore, when the temperature rises to above 20 °C, it can cause gonadal degeneration in *Rhodeus uyekii* [9], Therefore, it is determined that the inside of ADP represents more favorable condition than open space for *Rhodeus uyekii* spawning.

Although a littoral zone may have favorable conditions for habitation, but, because it is an area with high fluctuations in water temperature, not having a shelter can limit the reproductive and spawning activities due to high stress. At this study site, daily water temperature fluctuation of over 4 °C was seen, which meant it was environment that can induce thermal stress. However, the study results indicated that the fish were most active near ADP, where the water temperature was cool and stable.

V. Conclusions

The present study aimed to evaluate and identify the water environment characteristics of ADP, an underground type fish shelter. St. 2, in comparison to St. 1, had relatively lower average water temperature and DO, whereas, pH and conductivity were at similar levels. In particular, St. 1 showed large daily fluctuations in water temperature, pH, and DO, in contrast to St. 2 showing very stable values. In terms of seasons, considering the fact that smaller deviations in measured values from each location were seen during rainy season showed than normal season, it is suspected that heavy rain led to mixing and diluting effects. The results from two-way ANOVA performed on the two locations indicated that St. 1 and St. 2 were distinctly different spaces from each other ($P<0.05$). Based on the results of the present study, it is determined that ADP is sufficient for use as a fish shelter and spawning location, since it can create a cooler and more stable space than the external environment during summer.

Acknowledgment

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