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Development of HABs Management Focused on Pre-post Technique Applicable to the Field in the Republic of Korea River

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Abstract

Although harmful algae blooms (HABs) are a natural phenomenon, this phenomenon occurs in rivers frequently, thus making it a social problem. The four major rivers in republic of Korea are increasingly being influenced by climate changes and physical residence time recently, and the issue of the occurrence of HABs has arisen in this context. In order to solve this problem, the water quality of the four major rivers was analyzed in this study, and the conclusion was drawn that the limiting factor for algal growth was the level of phosphorus (P). That is, the less phosphorus, the less chance of algal growth. Also, algal control technologies that could be commercialized and applied to the field were analyzed by investigating various domestic and foreign algal control technologies. As a result, such technologies were classified into HABs control technologies in water and HABs preventive technologies on land and it was judged that the integrated test-bed could be applied to Geum and Yeongsan Rivers as they show a high probability of Chl-a occurrence in the future.

Keywords: HABs, four major rivers, HABs control technology in water, HABs preventive technology on land

INTRODUCTION

Algal bloom refers to a phenomenon where phytoplankton proliferate massively in eutrophic waters. Algal blooms that mainly come into question are HABs, and HABs occur frequently in rivers during summer in republic of Korea, creating a social problem. HABs change the color of water surface to green, creating an aesthetically adverse effect as well as producing various other harmful circumstances including the depletion of dissolved oxygen and release of toxic substances [1,2].

There are various elements including light, water temperature and nutrients that increase HABs. Recently, increased water temperature due to climate change and increased non-point pollutant source loading accelerate the occurrence of HABs [1,2,3]. In addition, various emission sources including point pollution sources are still significant factors that contribute to the occurrence of HABs. It is also considered that increased residence time in rivers according to the Four Major Rivers Project (FMRP) in republic of in Korea is one of factors for the occurrence of HABs.

Various studies regarding algae control have been promoted in the country in order to solve this problem. Many domestic algae-related technologies have been developed accordingly but they are still not sufficiently developed for commercialization and post-management purposes. Therefore, it is necessary to develop and examine proper HABs control technology that can be applied in the field in the future. The goal of this study was to analyze the status of the four major rivers in the country, comprehensively analyze and present HABs control technologies that can provide responses in an efficient and effective manner.

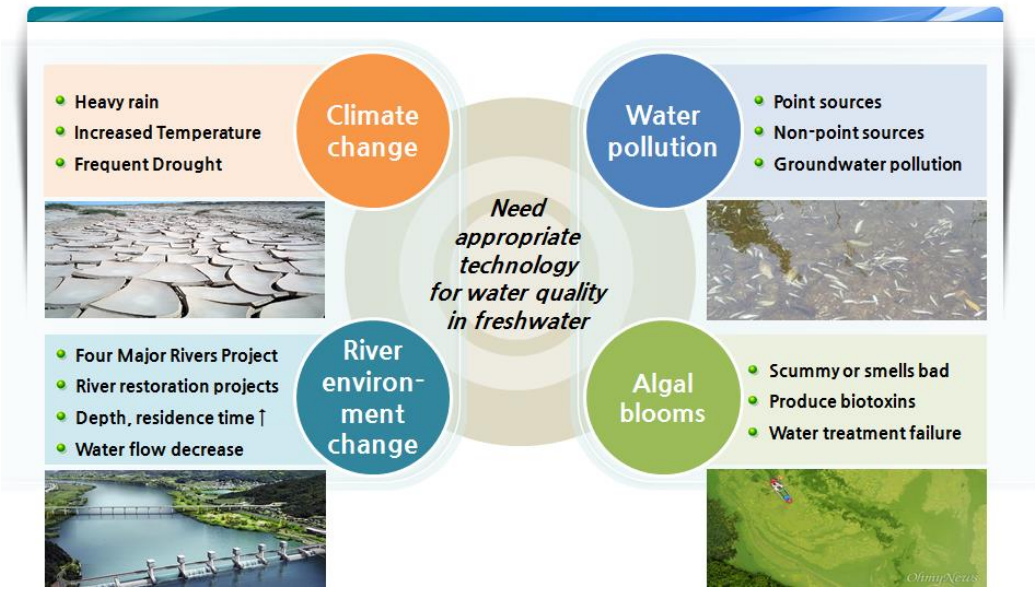

Figure 1: The main causes for the occurrence of HABs.

MATERIALS AND METHODS

Assessment of water quality in the four major rivers

Monthly changes in water quality were analyzed based on the four major rivers (Han, Nakdong, Geum and Yeongsan Rivers) in republic of Korea. Water quality parameters were BOD, COD, TN, TP and Chl-a, and the analysis was carried out based on data collected from 2000 to 2016 by the Ministry of Environment. Also, a comparative analysis was carried out using annual average data (n=19) from the Ministry of Environment in order to determine differences in Chl-a between the four major rivers during 2016 to 2017.

Application method of pre-post techniques

An investigation of preceding technologies was carried out in order to determine the status of previously developed technologies. An analysis was carried out in terms of capacity, efficiency and economic targeting various algae reduction technologies developed in Korea and analysis data was summarized. Pre-post techniques that could control HABs were selected and classified into HABs control technologies in water and HABs preventive technologies on land. The selected techniques were classified based on techniques that were adequate for circumstances in Korea and could be applied in the field and such techniques were finally discussed and confirmed through relevant expert assessment.

RESULTS AND DISCUSSION

Result of water quality in the four major rivers

Figure 2 shows long-term water quality variation in the four major rivers. We can see that the quality of water in the four major rivers shown by BOD, COD, TN, TP and Chl-a varied significantly. Typical nutrients required for algae to grow are nitrogen (N) and phosphorus (P) [4]. Algae can grow with a slight amount of nutrients and the four major rivers in republic of Korea have eutrophic and standing water conditions, ensuring enough potential for HABs. As a result of carrying out the analysis using Redfield ratio in the four major rivers in order to judge the algal growth limiting factors, the average TN/TP ratio significantly exceeded 10 (Han River: 10.9~124.9, Geum River: 16.5~146.7, Yeongsan River: 12.5~131.3, Nakdong River: 24.2~180.9), indicating strong phosphorus (P) limitation on algae growth [5]. Chl-a was high every winter in Nakdong River, and it was determined to be a diatom bloom, not a HAB. Also, we can see the improvement of overall water quality in the four major rivers, starting from 2011, resulting from the continuous implementation of water quality management policies.

In order to determine Chl-a levels in the four major rivers more easily, annual average data in 2016 and 2017 were compared and analyzed (Figure 3). For efficient comparison and analysis, data were classified into three stages including bloom, alert and caution based on the domestic algae alarm system established in 2015. The result showed that the Han River and Nakdong River were on "Caution" level and Geum River and Yeongsan River were on "Alert". In other words, Chl-a levels in the Geum River and Yeongsan River were higher in comparison to other rivers and it was judged that these two rivers had favorable conditions for testing technologies which would be developed in the future in the field.

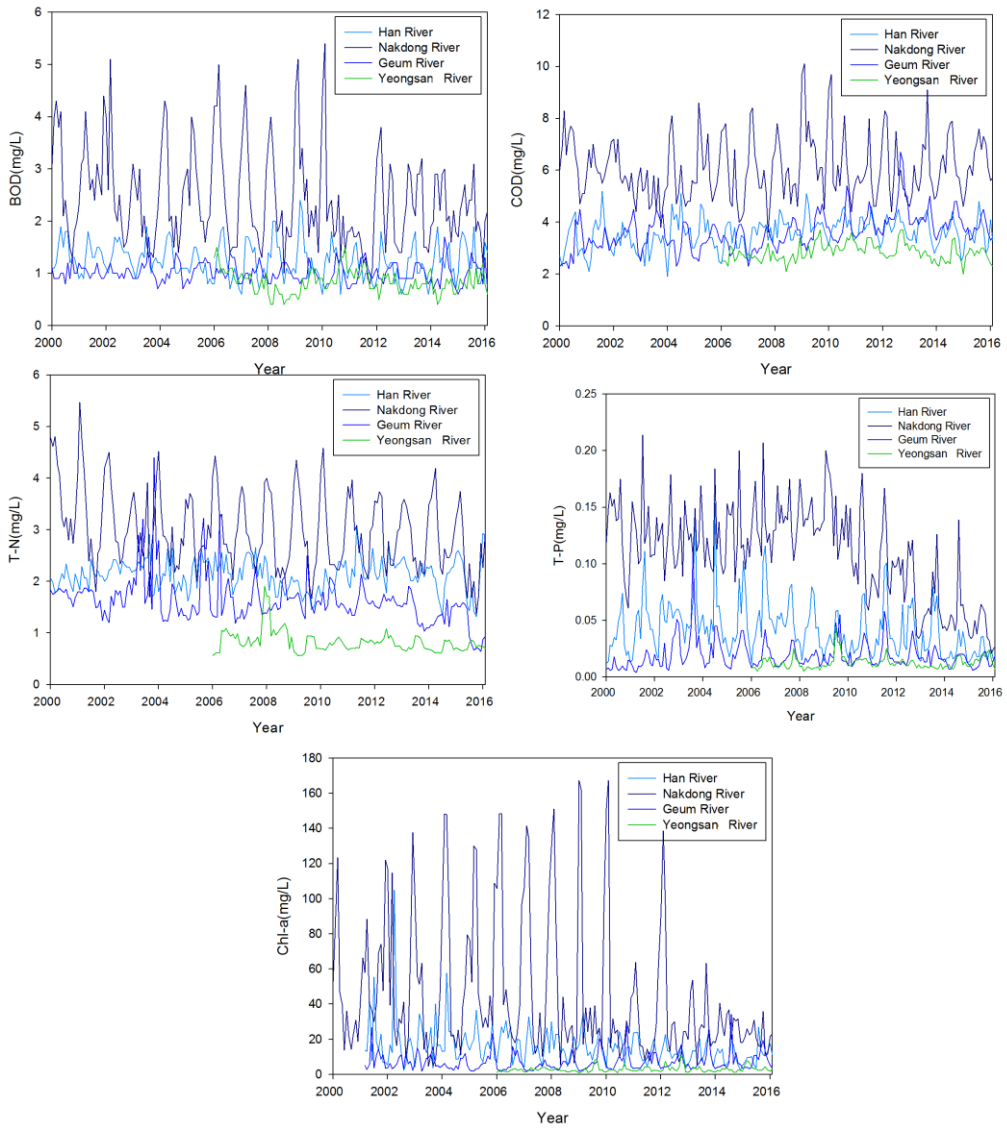

Figure 2: Water quality result in the four major rivers in the Republic of Korea (2000~2016).

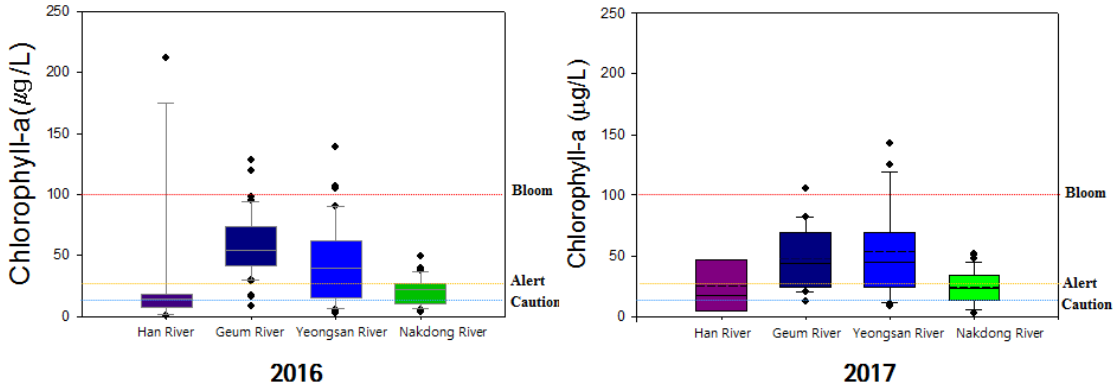

Figure 3: Comparison of annual average concentrations of Chl-a in the four major rivers.

Suggested pre-post techniques to reduce HABs

Techniques that could control algae in rivers were constructed and suggested in a comprehensive manner and such techniques were classified into HABs control technologies in water and HABs preventive technologies on land. When HABs occur massively in a river, it is necessary to promptly identify severely affected regions, level of occurrence, and the degree to which management is required in the field. By considering such elements, the preparation of maps for HABs using UAV-S, vehicle linked dissolved air flotation (VDAF) techniques, natural coagulants and algae collection vessels were used as element techniques for HABs control technologies in water. At first, UAV-S prepares a HABs map in the field promptly in order to determine the occurrence of a HABs. The degree to which management is required is judged based on the prepared data, and the VDAF technique is used for a tributary or a waterfront area or natural coagulants and algae collection vessels are used to collect algae promptly in the case of the main stream or if the level of its occurrence is significant.

Once a HABs occurs, it is difficult to control. Therefore, it is important to inhibit its occurrence in advance, and the technology for such purpose is the HABs preventive technology on land. The HABs preventive technology on land is the technology that reduces phosphorous (P), which causes the occurrence of algae in connection, with structures existing in a river, and this technology can inhibit the inflow of the point source or non-point source in advance. Element techniques include a filter medium inserted unit block, module type wetland and intercepting channel and these techniques are placed near a river, retaining, sinking, adsorbing and decomposing pollution sources. The integrated testbed was established in Osan Stream located in Gyeonggi Province, Korea in this study in order to derive more empirical results, and

60~80% TP reduction efficiency was shown in the laboratory test carried out in advance according to operating conditions.

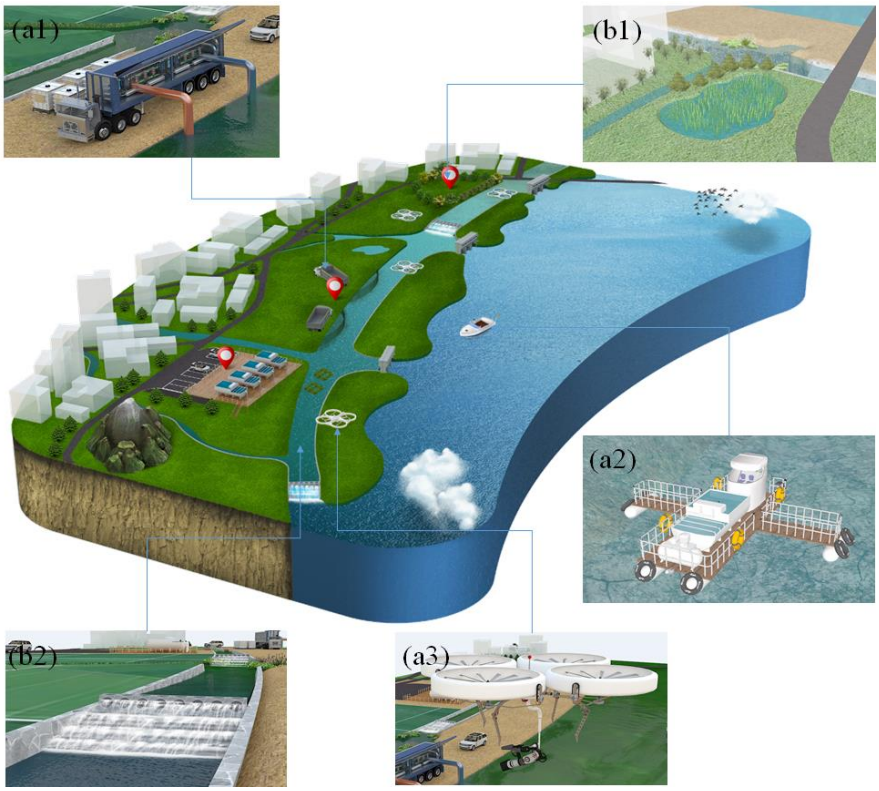

Figure 4: Conceptual picture of integration techniques to reduce HABs. (a) HABs control technology. (b) HABs prevention technology on land.

CONCLUSIONS

In this study, the water quality of the four major rivers was analyzed in order to control HABs that occur in a river, and the relevant techniques were summarized, integrated and suggested. Although the four major rivers have partially improved since 2011, the potential for algal blooms is still high and the limiting factor for algal growth was phosphorus (P). That is, the less phosphorus, the less chance of algal growth. Also, Chl-a in the Geum River and Yeongsan River was high, requiring management, and it was judged that the Geum River and Yeongsan River would provide excellent opportunities for the field application of a test-bed.

The HABs control technology in water and HABs preventive technology on land were suggested as integrated techniques that could be applied in the field by considering environmental conditions in the country. The HABs control technology in water makes up a system that can respond promptly when HABs occurs, and the HABs

preventive technology on land is related to techniques that can reduce phosphorus (P) that causes the occurrence of algae by using river structures for preventing the occurrence of HABs in advance.

This study is still in progress and ongoing, and it will be necessary to establish an integrated test-bed for each detailed technique and review the field applicability comprehensively in the future. It is possible to improve the performance of element techniques and draw optimal design conditions in this process, and additional technical verification would be necessary in the future.

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