Treatment Techniques of Urban Artificial Landscape Water Bodies

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Throughout the literature, terminologies such as “urban artificial water bodies”, “landscape water bodies”, “scenic water bodies”, and “landscape water” are all used to refer to any body of water that is created artificially or organically to enhance the aesthetic of towns, cities, and tourist destinations. They are referred to as artificial landscape water bodies (ALWs). ALWs are among the many green strategies adopted to improve the biodiversity, aesthetics, and general environmental health of urban environments. The challenge of pollution control in ALWs has seen the implementation of physical, chemical, and bio-ecological techniques. Generally, chemical techniques have been credited with providing rapid and effective solution to ALWs eutrophication and algae bloom, however their use may result in secondary pollution and harm to the ecological integrity of these water bodies. Physical techniques have also achieved some success in the control and remedy of ALWs.

Keywords: artificial landscape water ; reclaimed water ; eutrophic landscape water

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1. Physical Techniques

The treatment and remediation of polluted water bodies have seen the application of mechanical or physical interventions, some of which include water diversion, sediment dredging, filtration, and construction of hydraulic structures, just to name a few. These techniques yielded positive results in reducing eutrophication and limiting algae growth in water bodies.

1.1. Water Diversion and Dilution

Water diversion and dilution, which is also termed pollution flushing, is among the physical methods of mitigating pollution in artificial landscape water bodies (ALWs). This technique moves vast amounts of treated water into polluted waters to dilute pollutants [1]. Incoming treated water typically contains sufficient dissolved oxygen and increases the flow of the existing water body. The introduction of dissolved oxygen also further promotes biological degradation of organic pollutants to obviously reduce the concentration of contaminants by self-purification function/process [2]. This technique has been successfully utilized in small-sized water bodies with the need for rapid remediation. This technique, however, causes the reintroduction of sediments into the water body during the flushing process, leading to secondary pollution in the downstream basins of the water body. Consequently, the water body is likely to divert as a result of the injection of a substantial volume of water and solids. Also, the typically enormous expense of water diversion projects illustrates that this strategy is incapable of addressing the core cause of the problem [3]. According to Yang et al. [2], the amount and quality of fresh water and water left to be diluted, the flow rate, the relative position to the freshwater inlet, and the direction of the flow field’s circulation are crucial to the efficiency of water diversion technique in ALWs.

1.2. Sediment Dredging

This approach uses the necessary mechanical equipment to remove the mud from the bottom of the water body, and the mud removal process aims at lowering the concentrations of hazardous chemicals and precipitated contaminants [4]. This approach has effectively been used to enhance the quality of rivers and lakes, as well as the surrounding ecosystem. However, this technique has many downsides. It requires the installation of specialized equipment and also critical consideration of the excavation depth and the extent of evacuation. This results in high cost of construction and maintenance and room for further challenges [5].

1.3. Aeration

Aeration is simply the introduction of oxygen into the water basin, thereby increasing the dissolved oxygen content of the water body and boosting the purifying capacity of the polluted water body and the surrounding ecological circle. The principle of aeration lies in the microbial activity promotion with oxygen-enhanced respiration. This results in a positive impact on the decrease in COD or BOD_5, total nitrogen via nitrification, and even total phosphorus concentrations via biological phosphorus removal [6]. Additionally, the impact helps to tighten the loose bottom silt and keep pollutants in the bottom of the water and prevent sludge from contaminating the top of the water body [7]. Aeration broadens and multiplies the microbial communities that break down organic chemicals in wastewater and river water [8]. This technique yielded efficient results in pollutant removal efficiencies in water bodies, especially when adopted in combination with other techniques. The major drawback of this treatment is the high cost of maintaining the aeration pumps/machines in the water column. The higher energy consumption of this technique, however, makes it unsuitable for the pollution treatment of additional water bodies. Although aeration as a technique is straightforward, simple to use, sustainable, and broadly applicable, the aeration pumps are often costly to install. More significantly, aeration can also be passively achieved via waterfall, weir, cascade aerator, or water surface renewal, provided the gravity grade permits this, in order to save energy input (**Figure 1**), thereby presenting a cost reduction option to aeration. This makes it possible to obtain the benefits of aeration at comparatively minimized cost. The adoption of the moderately affordable aeration strategies will successfully eliminate one major drawback of this technique [9][10].

Figure 1. Aeration via river bubbling (**a**), pond water spreading (**b**), and canal waterfall (**c**).

1.4. Mechanical Algal Removal

This technology employs a variety of mechanical approaches to control water contamination caused by algal growth. Mechanical methods, processes, and equipment have successfully been applied in mitigating eutrophication in rivers and lakes vary widely. Popular among the mechanical techniques are the air flotation technology, the mixed method, the ultrasonic method, and artificial arching, ultrasonic method. These have proven potent in combating excessive algae growth. The application of mechanical processes for algal removal can successfully avoid secondary pollution by eliminating the growth of algae caused by nutritional temples. Though effective, the need for heavy machinery and equipment in mechanical processes makes them expensive and is only recommended for use in remediating limited quantities of polluted water. Mechanical intervention alone is deficient in addressing eutrophication of water bodies produced by algae outbreaks. They are only suitable for emergency removal, due to its limitations [11].

2. Chemical Techniques

Among the commonly used chemical treatment techniques are flocculation, photocatalytic degradation, oxidative disinfection, chemical alga-killing, stabilization, and solidification [12]. Using flocculation, oxidation, precipitation, and algaecides, polluted water can be chemically treated to remove suspended solids (SS) and algae [4]. Chemical methods can quickly remove SS from contaminated river water, but they only provide a temporary fix, and are also highly likely to also generate secondary pollutants that pose further risks. In addition, the precipitated/flocculated solids accumulate as sludge at the bottom of the ALWs, gradually reducing the effective volume of the water body and eventually requiring the costly procedure of mechanically removing the bottom sludge. Therefore, the primary focus of flocculation or precipitation operations should be on the use of environmentally friendly chemicals for chemical treatment of algae and suspended particles under controlled conditions. Chemicals such as poly aluminum chloride have been used in several experiments as non-polluting flocculation foam that can successfully remove algae from water [13]. Also, the introduction of calcium peroxide (CaO_2) can control the pollutants released from the sediment, lower the N and P concentrations in the surrounding water by increasing dissolved oxygen and oxidation-reduction potential in the eutrophic water and, to a lesser extent, changing the microbial community in the sediment. Wang et al. [14] reported the use of CaO_2 in purification and restoration of a severely eutrophic scenic water body. Overall, chemical techniques can significantly improve the water quality of eutrophic landscapes in a short amount of time. However, these methods frequently have the drawbacks of high costs, short durations, secondary contamination, and potential dangers to the environment.

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