

Study on Qianling Lake Restoration with Artificial Wetland

AO Zi-qiang¹, PENG Shi-shou², YAN Chong-ling^{1*}, DU Jing-na¹, YE Juan¹, DOU Yang-yang¹

1. School of Life Sciences, Xiamen University, Xiamen 361005; 2. Water and Soil Conservation Supervision and Monitoring Station in Guizhou, Guiyang 550002

Abstract The ecological restoration of water quality in Qianling Lake was conducted by artificial wetland, which transformed N and P in wastewater into essential matters in organism tissues, so pollutants discharged into Qianling Lake were reduced for the purpose of restoration.

Key words Qianling Lake; Artificial wetland; Ecosystem restoration

Qianling Lake (106°47' E, 26°33' N) is located in the mid-west of Qianling Park in Guiyang, Guizhou. When Qianling Lake was firstly built, there was beautiful and peaceful scenery with shimmering fishes and prawns shoals. The source of water quality deterioration in Qianling Lake can be traced back to Xiaoguan Lake, the upstream of Qianling Lake. The headstream of Xiaoguan Lake is located in Pianpo and Yaguan County of Qianling Town, Guiyang, where domestic sewage is directly discharged into Xiaoguan Lake. Qianling Lake and Xiaoguan Lake were not polluted significantly, because there was no industry and large-scale breeding industry. Since 1990s, the principal work of pig raising has developed gradually, while 600 t human and livestock sewage or domestic waste leachate have been disorderly discharged into the source area of Yaguan County every day, and then flows into Xiaoguan Lake or Qianling Lake finally. Accordingly, algae in Qianling Lake and Xiaoguan Lake grows, and water develops into eutrophication rapidly or even water quality deterioration^[1].

Advantages of Artificial Wetland

Artificial wetland, constituted by substrate with a certain proportion of gravel, cinder, sand and soil, is an aquatic plant after being cultivated and selected, which also constitutes a special ecosystem for animals and plants^[2]. Meanwhile, root of plants also release enough oxygen for microorganisms in swage with respiration^[3]. The water purification with wetland is a complex process, and also a result of the comprehensively physical and chemical or biological effect for wetland, which contains precipitation, absorption, ion exchange, complex reaction, nitration, denitrification, nutrient absorption, biotransformation and microorganism decomposition. Wetland has the following distinctive advantages in non-point source pollution control due to its special ecological effect and existing form^[4].

Biological purification of sewage

There is nitrogen, phosphorus, inorganic matter, organic matter and microorganism for plant growth in sewage, which is hard to decompose in wastewater treatment process and af-

so a big problem for wastewater treatment. Canna, lucky-bamboo and reed are planted in artificial wetland based on certain filler, so sewage is discharged into artificial wetland like swamp. When eutrophic water flows through artificial wetland or is filtrated by sand and stone, various microbial activities in plant rhizosphere including aerobic or anaerobic process and plant absorption decompose pollutants in water, so water has been purified by the combined action of plant, microorganism and soil, which utilizes sewage resource in a better way^[5]. Toxic substance is not found in human and livestock sewage of the upstream of Qianling Lake, but nitrogen, phosphorus, inorganic matter and organic matter are with high concentration. Thus, it's harmful for discharging into the lake, but a better fertilizer for aquatic plants.

Favorable environmental controlling effect

Artificial wetland technology by cooperation of Shenzhen and European Union has achieved ecological and economic benefits significantly through many years' practice. Their water quality purification engineering with artificial wetland system means that tropical or subtropical plants such as reed and Canna with certain proportion are planted into the ditch constituted by fillers of sand and fine stone. Accordingly, the original sewage with serious pollution is purified when flowing through pools, and comes up to the standard of national surface water^[5]. The demonstration project of pollution remediation in a biological way for Hongqi River in Yunnan mainly involves planting demonstration area for aquatic plant and purification area for phytoplankton, which is located in north and south of Hongqi River in Qilu Lake respectively. This project belongs to natural wetland restoration engineering of surface water system with the total area of 35 hm² and the total engineering investment of 1 214.8 thousand Yuan, which has been constructed since early 2002 and constituted two shoreline wetlands with mainly emerged plants such as cattail or *Zizania latifolia* and water hyacinth or water chestnut, while its vegetation coverage reaches over 90%. It has rich biodiversity with over thirty kinds of artificial or natural grown aquatic plants, so a wetland ecosystem with complete structure and rational distribution has been constituted by emerged plant, floating-leaved macrophyte, floating plant and submerged plant, which has realized its propagation and development basically. After the artificial salvaging or treating of aquatic plants in the wetland, the secondary pollution has been pro-

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* Corresponding author. E-mail: ycl@xmu.edu.cn

hibited when removing the lake nutrient load. According to the tracing monitoring and statistical analysis of this project area, the total removal of N and P pollution load reaches 37.4 t and 8.31 t respectively, accounting for 17.7% and 26.8% of the whole removal of total N and P pollution load in Hongqi River, which reduces the pollution of Hongqi River to Qianling Lake. When the whole water quality of Qianling Lake is categorized V-, the water quality is up to category IV surface water in engineering area, while pollution index of the total P is even categorized I-III standard water^[6].

Solving problems for fund deficiency

The operation cost of sewage treatment in artificial wetland is low with 0.1 - 0.2 Yuan per ton accounting for 1/10 - 1/5 of the traditional secondary treatment. Furthermore, the capital investment is also low with 150 - 180 Yuan per ton accounting for 1/5 - 1/2 of the traditional secondary treatment plant^[5]. Meanwhile, wetland plants can also be used as industrial raw material and life resources. Reeds with an area of 2 267 hm² are planted along the lake by Jiangsu Yancheng SUND Paper Co., Ltd, and then irrigated with papermaking wastewater for a large amount of reeds harvest per year, which solves the supply problem for papermaking raw materials effectively. Yunnan Yaonigou wetland is located in Yaonigou lake inlet with an area of 1.5 hm², the total engineering investment of 1 679.8 thousand Yuan including 585 thousand Yuan land requisition cost and 5 720 t treatment capacity each day, which is the first large-scale artificial wetland in Yunnan. The wetland was constructed and put into operation in early 2002, and then the status is good with stable operation after nearly two years' operation test, the removal rate of each pollution index is as follows respectively: CODCr 87.8%, BOD 568.7%, SS 96.3%, TP 32.4% and TN 36.0%, while the outlet water quality changes from category IV before treatment to category III. Compared with sewage treatment plants of the same scale, the wastewater treatment cost of sewage treatment plants is much higher than that of wetlands in investment and operation. For example, Luchong sewage treatment plant was put into operation in August 2001, while it can treat 1 000 t sewage with less pollution each day, and the wastewater treatment cost is 0.55 Yuan per ton. However, the wastewater treatment cost of Yaonigou wetland per ton is only 0.05 Yuan, which is 1/10 of Luchong sewage treatment plant, and the construction cost of wetland is much lower than that of sewage treatment plant. For example, two sewage treatment plants in Chengjiang County costs almost 40 million Yuan for construction cost, including 26 million Yuan construction cost invested by county sewage treatment plant and 3.79 million Yuan construction cost invested by Luchong sewage treatment plant. As for the treatment effect, artificial wetland is the same effective as sewage treatment plant, but as for sewage with less pollution, the water quality from artificial wetland is much better than that from sewage treatment plant^[6].

Strong ecosystem restoration

Artificial wetland plays an important role in water resource, climatic regulation, water conservation, flood storage and regulation, promoting deposition and creating land, pollutant degradation, maintenance of biological diversity and providing life resources for human, which not only can absorb SO₂, nitrogen oxide and CO₂, increase O₂, purify air, remove urban heat island effect or light pollution and absorb noise, but also is helpful for protecting wild animals and en-

hancing aesthetic value of landscape in local areas. For example, after reed wetland being constructed in Yancheng, the amount of birds increases to twice as before, while condense reeds can not only absorb a large amount of municipal wastewater, but also attract many red-crowned cranes to inhabit^[5]. Thus, artificial wetland has strong environmental regulating function and ecological benefits, which finds a way out of urban wastewater and forms an ecological landscape and tourist site to beautify or purify environment, so artificial wetland overcomes deficiencies such as sewage sludge after traditional sewage treatment to protect natural ecological effect.

Qianling Lake Restorations Combined Artificial Wetland and Xiaoguan Reservoir

Nitrogen and phosphorus removal by Xiaoguan reservoir with local conditions

From Fig 1, the water quality of Qianling Lake is mainly influenced by swine wastewater, where no toxic matters are found, while the main pollutants are nitrogen, phosphorus, inorganic matter, organic matter and microorganism. Therefore, the key to solve problems is to remove nitrogen and phosphorus, but nitrogen and phosphorus are nutrient elements for plant growth and components for organism. In this case, nitrogen and phosphorus in sewage are transformed into that in organism tissues by different ways, and water eutrophication leads to mass propagation of microorganisms after sewage is discharged into Xiaoguan reservoir. On the one hand, microorganism can decompose or transform N and P in wastewater into essential matters in organism tissues to purify water, but on the other hand, the death and excessive propagation of microorganisms will lead to water quality deterioration due to oxygen deficiency. Accordingly, Guizhou Institute of Environmental Science Designing introduces advanced technology from Japan, and supply oxygen for water with water tunnel, so water quality of Xiaoguan reservoir has been improved greatly, but the supplied oxygen has not been utilized completely. Phytoplankton can absorb nitrogen, phosphorus, inorganic matter and organic matter in water to reduce nutrients in water, so water eutrophication can also be promoted. Meanwhile, phytoplankton can also be used as forage for swine, which constitutes an ecological cycle to solve water pollution and increase economic benefits. Hydroponics has been developed by waters of Xiaoguan reservoir, while vegetables have been planted to meet people's demands, and some forage crops have been used for pig raising. Aquaculture can also be developed by Xiaoguan reservoir, and aquatic animals can live on aquatic plants and microorganisms, which absorbs nitrogen, phosphorus, inorganic matter and organic matter fundamentally to reduce water pollution and gain certain economic benefits.

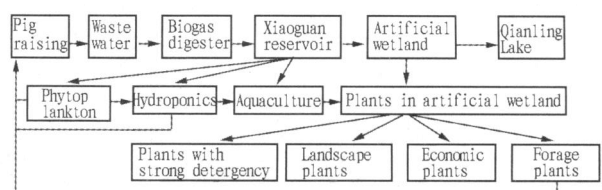


Fig. 1 Process of Qianling Lake restoration with artificial wetland

Further water purification with artificial wetland

With the help of Xiaoguan reservoir, nitrogen, phosphorus, inorganic matter and organic matter in water decreases. Artificial wetland has been constructed in the downstream of Xiaoguan reservoir to purify water, which also reduces nitrogen, phosphorus, inorganic matter and organic matter. On the one hand, nutrients in water have been decomposed by microorganisms, and on the other hand, nitrogen, phosphorus, inorganic matter and organic matter in water have been transformed into essential matters for plant growth. The plants should be easy to grow in local areas, and have strong detergency, developed roots and flourish leaves, tolerance against pollution, cold-hardiness or high disease and insect resistance^[7]. Besides tolerance against pollution, the plants should have certain enjoyment, and some economic plants should also be selected based on above function or even some forage crops can be used for pig raising.

Potential Benefits of Artificial Wetland

Nitrogen and phosphorus removal

Artificial wetland solves the most serious problem of nitrogen and phosphorus removal in sewage treatment, while water quality can reach category III surface water after being treated by artificial wetland and be discharged into natural water^[31].

Rich animal or plant-based products

Phytoplankton such as water hyacinth and duckweed planted in Xiaoguan Lake can provide forage for swine, while fish, shrimp and shellfish bred in Xiaoguan reservoir or btius rhizome, water caltrop, euryale ferox and waterpack planted in wetlands along the downstream of Xiaoguan Lake are all nutritious subsidiary food, and even some wetland animals and plants can be used as medicine. Thus, artificial wetland provides rich animal or plant-based products for local people^[8]. Many animals and plants are also important raw materials for light industry. For example, reed is an important papermaking raw material.

Tourist value and environmental beautification

From plant distribution, color collocation, construction of landscape style pavilion or view enjoying pool and coordination of the surrounding environment, some ornamental plants are cultivated in the wetland to beautify environment and increase tourist value.

Educational and scientific value

Artificial wetland ecosystem has rich species of animals and plants, which plays an important role in natural science education and research. Some artificial wetlands can offer objects, materials and test bases for education and scientific research. Moreover, artificial wetland can also be an education centre for wetland protection, which concentrates on wetland ecological restoration, wetland ecotourism or coordinative development of environment and socio-economy to develop colorful propaganda and education activity.

Conclusions

Nitrogen, phosphorus, inorganic matter and organic matter in swine wastewater and domestic sewage of the downstream can be removed by artificial wetland technology, and N or P in wastewater is transformed into essential matters in organism tissues, which reduces the water quality deterioration resulted from water bloom caused by excessive propagation of microorganisms. Meanwhile, a series of biological products are obtained by the biological cycling, and Qianling Park is also beautified, which has important educational meaning and practical value.

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利用人工湿地修复黔灵湖的研究

敖子强¹, 彭世寿², 严重玲^{1*}, 杜静娜¹, 叶娟¹, 龚扬扬¹

(1. 厦门大学生命科学学院, 福建厦门 361005; 2. 贵州省水土保持监测站, 贵州贵阳 550002)

摘要 黔灵湖水质变坏的根源可以追溯到黔灵湖的上游小关湖, 影响水质的根源是养猪废水, 其中, 主要污染物质为氮、磷、无机质、有机质和微生物等。在小关水库的下游建造人工湿地, 种植的植物首先应选择一些去污力强, 又宜于本土生长, 根系发达, 茎叶繁茂, 具有耐污能力和抗寒能力、抗病虫能力强的植物, 同时还应具有一定的观赏性。用人工湿地技术可以除去上游养猪废水和生活污水中的氮、磷、无机物质和有机物质等, 将废水中的氮和磷转化为生物体组织中的氮和磷, 从而减少了微生物的大量繁殖形成的“水华”, 导致黔灵湖水质变坏。同时, 通过生物循环可获得一系列的生物产品 (小关湖种植凤眼莲、浮萍等浮游植物可以为养猪提供饲料; 在小关水库养殖的鱼、虾和贝等和在小

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基于自组织特征映射神经网络算法的生态服务功能分区

战金艳¹, 史娜娜¹, 吴红², 邓祥征^{3,4*}

(1. 北京师范大学环境学院水环境模拟国家重点实验室, 北京 100875; 2. 中国地质大学(武汉)数学与物理学院, 湖北武汉 430074; 3. 中国科学院地理科学与资源研究所, 北京 100101; 4. 中国科学院农业政策研究中心, 北京 100101)

摘要 探索了一种基于自组织特征映射神经网络算法识别区域尺度生态系统服务功能分区的新方法。在此基础上, 依据新千年生态系统评估框架构建了生态服务功能评价指标体系, 并运用自组织特征映射神经网络算法开展了生态服务功能空间聚类分析, 在 1 km 栅格上识别并排定了各类生态服务功能的重要性。在案例区锡林郭勒盟的研究表明, 利用基于自组织特征映射神经网络算法划分出的该区 6 个生态服务功能分区比较科学、合理, 所形成的分区结论为案例区生态系统的可持续管理提供有时空针对性的决策参考信息。

关键词 神经网络算法; 生态服务功能; 生态服务功能分区; 生态系统可持续管理

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作者简介 战金艳 (1974 -), 女, 山东潍坊人, 博士, 副教授, 从事环境生态、生态服务功能评价。* 通讯作者。

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关湖下游的湿地种植藕、菱、芡和茨菰等是富有营养的副食品; 有些湿地动植物还可入药或作为发展轻工业的重要原材料, 还可以美化黔灵公园, 从而具有重要的教育意义和实用价值。

关键词 黔灵湖; 人工湿地; 生态修复

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作者简介 敖子强 (1975 -), 男, 贵州德江人, 博士研究生, 研究方向: 环境生态和污染生态学。* 通讯作者。

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