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Water Resources Management in Practices at National Pingtung University of Science and Technology Campus

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Abstract. NPUST was the top Taiwan university for the 9th consecutive year on the UI GreenMetric World University Ranking, and placed 27th out of 1,050 schools from 85 countries. This achievement is the result of our commitments to sustainable development. NPUST has been building green transportation for carbon and air pollution reduction, green energy system for effective use of electricity generated by renewable energy, and campus waste water recycling system for the goal of zero discharge. We also implement policies on waste reduction and waste sorting and recycling, as well as encourage planting in school campus. The practice of water resources management is crucial in various aspects that contribute to this sustainable campus. The sustainable management strategies include water consumption management, water conservation and water saving, and water recycling management. In this paper, we are going to share our practical experience in waste water treatment, recycling system set-up, waste water reuse, sustainable development for water resources and how we implement the policies on water saving at campus and spread water resources knowledge. The information is provided as references for more advanced plans and strategies in the future.

Keyword:
Water Consumption Management, Water Conservation, Water Saving, Water Recycling Management, Wastewater Treatment

1. Introduction

Taiwan is located on the northwest side of the Pacific Ocean in east Asia. With an area of around 36,000 square kilometres, the entire island is covered with high mountains. The climate is hot and rainy, with an annual rainfall of about 2500 mm (approx. 2.6 times the world average). Taiwan has rich and diverse natural landscapes and ecological resources. National Pingtung University of Science and Technology (NPUST) was founded in 1924 and is located in the tropical climate area at the southern end of Taiwan. It was originally established as the Kaohsiung State Pingtung Extension School of Agriculture, but changed its name to Kaohsiung State Pingtung Agricultural School in 1928 as it expanded in scale.

When the KMT government ruled Taiwan, the school was restructured into Taiwan Provincial Institute of Agriculture in 1954. In 1964, it was renamed as the Taiwan Provincial Pingtung Institute of Agriculture. In 1991, the school was upgraded and became the National Pingtung Polytechnic Institute until 1997, when it was restructured further to become the National Pingtung University of Science and Technology.

In 1986, the school moved from Pingtung City to the current location in Neipu Township, Pingtung County. It is situated next to Dawu Mountain and the Donggang River and has a vast campus (298.3 hectares), which is the largest in Taiwan. The vegetated area on campus is 119 hectares and its afforested area is 106 hectares. Building area on campus is 16 hectares and floor space accounts for area 26 hectares. The school was built according to the terrain and has simple features. With wide open spaces and a beautiful and picturesque landscape, the campus has earned it a reputation of "National Park University". A bird's-eye view of the campus and the view of the main road at the school entrance are shown in Figure 1 and Figure 2, respectively. In terms of academic organization, there are currently 7 colleges and 50 departments in the school. There are about 10,630 students and about 1,381 faculty members (2022 Academic Year). From basic and core academic knowledge to special practical research and studies, the departments and institutes are fully developed and are engaged in cross-domain horizontal cooperation. The teachers and learning resources in various fields are also rich and comprehensive.

Figure 1. University Campus

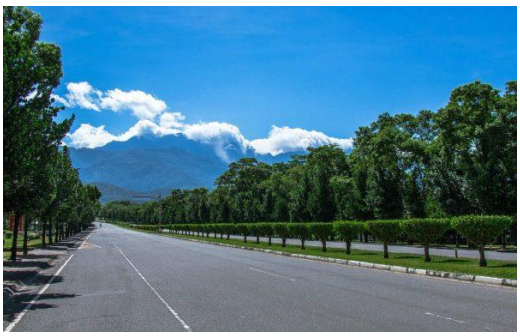

Figure 2. Main Campus Road

2. Campus Water Sources and Demands

The area in Pingtung where NPUST is located is rich in groundwater. The main source of public water on campus is groundwater. Through legal groundwater pumping, an average of 210,000 tons of groundwater are pumped every year to be used in 8 student dormitories and 2 restaurants on campus as well as the domestic water for daily use of faculty members, experiment areas of animal husbandry and for swimming pool, in farms, and for plant irrigation. The tropical climate in Pingtung has a short rainy season, so in order to make effective use of rainwater, many buildings in the school are also equipped with rainwater recovery systems [2, 3], as shown in Figure 3 (Agricultural College Building), Figure 4 (Engineering College Building) and Figure 5 (Research Center for Environmental Science and Technology), which intercept and store rainwater during the hydrological cycle. The method depicted in Figure 6 can recycle an average of about 600 tons of rainwater every year [5], which can be used for toilet flushing or plant irrigation. This is how the school — effectively

utilizes natural rainwater to save water resources.

Figure 3. College of Agriculture Rooftop Rainwater Recycling System

Figure 4. College of Engineering Recycled Rainwater Watering System

Figure 5. Research Center for Environmental Science and Technology Rainwater Recycling System

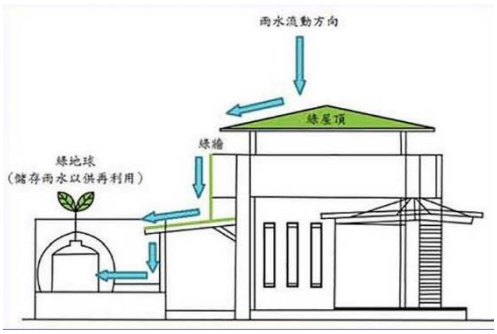

Figure 6. Research Center for Environmental Science and Technology Water Recycling System

3. Water resources management policy

The school's sustainable management strategy for water resources is divided into water management, water conservation, and reduction and reuse management [9]. Major measures include promoting water conservation facilities and related education and research. Increasing domestic sewage recycle and reuse.

Water resource conservation methods include permeable pavement [11] for parking lots, sidewalks and roads on the campus to increase rainwater infiltration and replenish groundwater, (as shown in Figure 7a and 7b), artificial wetlands and ecological lakes (Jingsi Lake and Yingxia Lake Park), the Environmental Protection Park, and the discharge pond at the Environmental Safety and Sanitation Center. These are used for irrigation, replenishing groundwater, conserving groundwater. In order to reduce water consumption for plant irrigation, perennial and more drought-tolerant native shrubs and trees are mainly used for landscaping, and the planting of grass and flowers is avoided to reduce irrigation needs. Newly planted crops are planted in conjunction with the rainy season to reduce water consumption at initial maintenance. Vegetation currently planted on campus include Taiwan tree orchids, persimmons, orange jessamine, Five-stamens China Laurel, Cinnamomum reticulatum Hayata, Palaquium formosanum, Griffith's ash, Pongame oiltree, Cryptocarya concinna Hance, Heritiera littoralis, Cinnamomum osmophloeum, Large-leaved Nanmu, Liquidambar formosana, Barringtonia racemose and other drought-tolerant plants.

In order meet water saving objectives, the school is replacing older equipment with water-saving equipment year by year. The urinals and faucets used for public restrooms are

designed to save water and are appropriately labeled to avoid unnecessary water waste (as shown in Figures 8a and 8b). These included dual-flush toilets, water-saving urinals with sensors, nano-coated non-flush urinals and water-saving faucets. At present, 75% of the campus has dual-flush toilets, which can save 68% of water when compared with traditional toilets. A total of 790 sensor-type water-saving urinals have been installed in various buildings, which can save up to 75% of urinal flushing. Additionally, 20 nano-coated non-flush urinals with patented filter elements for completely deodorization have been installed. There is no need to install flush pipes or electric flushers in these units. Traditional faucets have replaced with shower-mode water-saving faucets to reduce unnecessary water use. In order to ensure the quality of water use, the school regularly cleans the reservoir and inspects the water quality. It also publicizes the school-wide water-saving policy and installs water-saving devices to reduce water consumption. Old pipelines with leakages are immediately replaced to avoid waste when the such situation are discovered, and drip irrigation [7] and water-saving planting technology was developed and is used at the campus Smart Farm (as shown in Figures 9a and 9b).

In order to reduce the impact waste water has on the environment, the school recycles and purifies domestic sewage on campus and uses it for plant irrigation and toilet flushing [15]. It also recycles and purifies the discharge water from the swimming pool and uses it to irrigate the practice orchard. A rainwater storage and recovery system was also set up to water the vegetation plant walls (as shown in Figure 10a and 10b).

Figure 7a. Water permeable asphalt roads

Figure 7b. Water permeable walkways and parking lots

Figure 8a. Dual flush toilettes

Figure 8b. Dual flush toilettes

Figure 9a. Drip irrigation water conservation system

Figure 9b. Drip irrigation water conservation crops

Figure 10a. Plants cultivated with treated wastewater

Figure 10a. Plant wall cultivated with treated wastewater

4. Wastewater treatment and utilization

The school's domestic sewage management [6] emphasizes on: flood control, efficient use of water, water conservation, natural waterway planning, water reuse for different purposes. Through biological oxidation and artificial wetland and aquatic plant purification processes [1, 10, 14], the wastewater is reused, and a biologically diverse natural ecology is created. Water purification, water storage, reuse and ecological conservation are achieved by applying ecological engineering methods. This following section describes the characteristics of the school wastewater treatment processes [4, 8, 13].

After the sewage treatment plant directs the domestic sewage to the raw water pool through underground pipelines, trash rack, grit chamber, and oil-water separation decontamination equipment are used to remove large suspended matter, heavy inorganic matter and grease. Flow aeration is conducted via the mixing tank to keep suspended particles from settling, and the water quality and quantity are mixed to stabilize it [12]. The water then flows to the oxidation channel where microorganisms decompose the organic matter in the water. It then flows through the artificial wetland so that the microorganisms in the soil and the plant roots can remove pollutants. The water is then released to the discharge pool (Figure 11).

With the intertwined roots of aquatic plant growing in the pond, there are segments with different levels of oxygen saturation in the water so that aerobic and anaerobic microorganisms can survive at the same time. Each plays a role in decomposing the pollutants, which greatly improves the effect of sewage purification. The entire processing procedure is shown in Figure 12.

The sewage treatment plant treats about 600 tons of domestic sewage from student dormitories, restaurants and various buildings every day, and uses ecological engineering

methods to purify the water before it is discharged into Ying Xia Lake (Figure 13) where it becomes a water source for toilet flushing in adjacent buildings and landscape and plant watering. Domestic sewage on the school campus is fully recycled for a net-zero effect. It is estimated that the BOD load of the water bodies outside the campus are reduced by 1,461 kg/year, and the secondary water consumption is reduced by about 180,000 cubic meters/year on account of the school's processing systems.

The treated wastewater from the Department of Aquaculture and the university's livestock farm is discharged into the "Jingsi Lake" artificial wetland (Figure 14). Jingsi Lake comprises four pools. The 1st and 2nd pools are mainly used for sewage purification and as a recreational landscape. The 3rd and 4th pools are for flood detention to control water levels. When the rainy season brings heavy rains, these are able to store floodwater that has nowhere to drain, thus preventing rainwater from flooding the trails. In addition to serving as ecological conservation and recreation areas, the wetlands also allow for water conservation, flood regulation and water purification. The wetlands can reduce the BOD (biochemical oxygen demand), COD (chemical oxygen demand), SS (suspended solids), and nutrient salts (nitrogen and phosphorus-containing substances). Even metal substances, trace organic substances and pathogenic bacteria contained in wastewater can be removed by wetland systems, thereby purifying the water. The entire livestock water recovery and reuse system is shown in Figure 15.

The overflow water of the university swimming pool flows through pipelines to the air quality purification area (Figure 16). In addition to being used for watering landscapes, it is also used for plant irrigation. The process of recycling and reusing the swimming pool overflow water is shown in Figure 17. The artificial wetlands, ecological lakes and rainwater recovery and storage systems set up on the campus allow for effective reuse of treated domestic sewage for landscape watering and plant irrigation, as shown in Figure 18. This improves biodiversity and helps replenish groundwater sources and meet sustainable water usage objectives.

Figure 11. Research Center for Environmental Science and Technology discharge pond

Figure 12. Domestic wastewater treatment process

Figure 13. Ying Xia Lake Park

Figure 14. Jingsi Lake

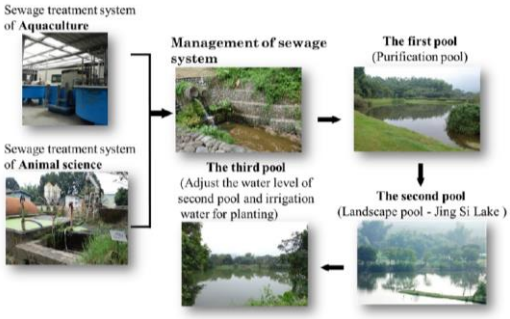

Figure 15. Recycling of livestock wastewater

Figure 16. Air quality purification area

Figure 17. Recycling and reuse of swimming pool water

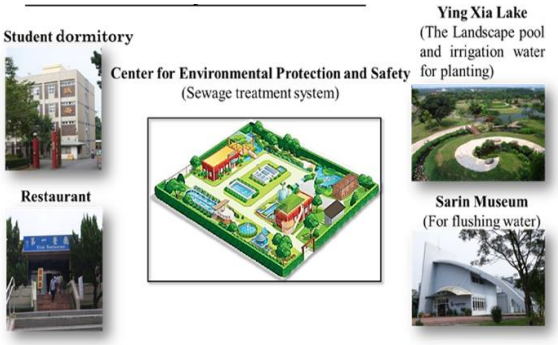

Figure 18. Recycling and reuse of domestic water

5. Water resources education promotion

The university has set up a "Water Resources Education and Research Center", which mainly promotes water resources education, including water resource-related teaching visitations and wetland ecological education. Water resources education combined with ecological environment and conservation awareness are promoted at the university, in the community, and at various colleges. This acts as a driving force for promoting concepts related to the sustainable development of resources. The school has also invited government and non-governmental organizations, community members, and more than 100 teachers and students to its promotional event, "NPUST Responds to World Rivers Day – Investigation into Challenges and Opportunities for Livestock Wastewater". The event was simultaneously conducted in a physical format and online. The event included ecological field trips, and sharing and discussions by representatives from various regions. The response to National Rivers Day was for all those concerned about the river environments, culture, and ecology. Hopes were to raise people's awareness of river conservation so that

we can protect natural resources together. By bringing attention to environmental areas and through guided tours, the school is promoting sustainable resources and water use. Explanations and experiences were shared to allow participating students to understand the problems related to insufficient water resources—and more importantly, to conveyed how to effectively save water.

Figure 19. Promoting sustainable water use at kindergarten

Figure 20. Promoting sustainable water use at elementary school

Figure 21. Promoting sustainable water use to teachers/students on campus

Figure 22. Promoting sustainable water use to campus visitors

6. Conclusion

"Water" is a limited and irreplaceable resource. It is the foundation of human well-being, and an essential resource of the earth's surface. However, development of water resources is becoming increasingly difficult with such problems as water shortages. In addition to adopting such clear response measures as "improving water efficiency" and "reducing water demand", NPUST is implementing domestic sewage recycling and reuse work on campus to reduce pollution loads on natural water bodies. It is also implementing measures to reduce the domestic sewage sources. NPUST will continue to promote concepts related to sustainable water resource use and environmental education. These objectives are being promoted through demonstrations, explanations, and teaching. By encouraging people to cherish water and strengthening the development and restoration of water resources, precious water resources will continue to flow and we will be able to irrigate a better future.

References

[1] Alramthi SM, Ali GH, Elthagafi AM, Eldosari SH, Zhu BK, and Safaa HM. Oxidation ditches for recycling and reusing wastewater are critical for long-term sustainability- a case study. Sustainability. 2022; 14: 16737.

[2] Campisano A, Butler D, Ward S, Burns MJ, Friedler E, DeBusk K, Fisher-Jeffes LN, Ghisi E, Rahman A, Furumai H, and Han M. Urban rainwater harvesting systems: Research, implementation and future perspectives. Water Research. 2017; 115: 195-209.

[3] Chilton JC, Maidment GG, Marriott D, Francis A, and Tobias G. Case study of a rainwater recovery system in a commercial building with a large roof. Urban Water. 2000; 1(4):345–354. doi:10.1016/S1462-0758(00)00032-7

[4] Dhote J, Ingole S, and Chavhan A. Review on Waste Water Treatment Technologies. International Journal of Engineering Research & Technology. 2012; 1(5): 1-10.

[5] Han N, Zhang J, Hoang M, Gray S, and Xie Z. A review of process and wastewater reuse in the recycled paper industry. Environmental Technology & Innovation. 2021; 24: 101860. https://doi.org/10.1016/j.eti.2021.101860

[6] Ibiam OFA and Igewnyi IO. Sewage management and its benefits to man. International Research Journal of Biotechnology. 2012; 3(10): 174-189.

[7] Jayant B, Dahiya K, Rukhiyar A, Raj R, and Meena RK. A review of the drip irrigation system. Journal of Engineering Research and Application. 2022; 1: 22-29. http://dx.doi.org/10.55953/JERA.1103

[8] Kivaisi AK. The potential for constructed wetlands for wastewater treatment and reuse in developing countries: a review. Ecological Engineering. 2001; 16:545- 560.

[9] Kumari M and Singh J. Water conservation: strategies and solutions. International Journal of Research and Review. 2016; 1(4):75-79.

[10] Kyambadde J, Kansiime F, Gumaelius L, and Dalhammar G. A comparative study of Cyperus papyrus and Miscanthidium violaceum-based constructed wetlands for wastewater treatment in a tropical climate. Water Research. 2004; 38: 475–485.

[11] Pantsi C, Arthur S, Wright G, and Alsubih M. Permeable pavement systems: state of the art. In ICUD Conference Proceedings 2017.

[12] Puri D, Sihag P, and Thakur MS. A review: Aeration efficiency of hydraulic structures in diffusing DO in water. MethodsX. 2023; 10: 102092. https://doi.org/10.1016/j.mex.2023.102092

[13] Stottmeister U, Wießner A, Kuschk P, Kappelmeyer U, Ka¨stner M, Bederski O, Mu¨ller RA, and Moormann H. Effects of plants and microorganisms in constructed wetlands for wastewater treatment. Biotechnology Advances. 2003; 22: 93- 117.

[14] Vymazal J. Removal of nutrients in various types of constructed wetlands. Science of the Total Environment. 2007; 380: 48–65.

[15] Vymazal J. Emergent plants used in free water surface constructed wetlands:A review. Ecological Engineering. 2013; 61P: 582-592.