Engineering Innovations
ISSN: 2813-1002, Vol. 13, pp 37-42
doi:10.4028/p-MZM0Qd

Submitted: 2024-07-20
Revised: 2024-10-24
Accepted: 2024-11-06
Online: 2025-02-06

Exploring Environmental Sustainability Research Using Experimental Methods - Taking the Vegetated Swales Facility

Fu-Ming Chang[1,a*], Yi-Pin Wu[2,b]

[1]National Taitung University, No. 369, Sec. 2, University R d., Taitung City 950, Taitung, Taiwan

[2]National Taichung University of Education, No.140, Minsheng Rd., West Dist., Taichung City 403514, Taichung, Taiwan

[a*]Changfm@nttu.edu.tw, [b]a0979464992@gmail.com

Keywords: Sustainable Development Goals(SDGs), Climate change, Environmental adjust-ment, Laboratory experiment.

Abstract. Due to the impact of climate change, the accompanying disasters affect the operation of the world. In addition, the development of urbanization has also increased the frequency of disasters. Therefore, the United Nations has established the Sustainable Development Goals (SDGs) to guide the global joint efforts towards sustainable goals. Vegetated Swales are a ubiquitous and growing green storm water type, primarily Low Impact Development (LID) that attenuates peak flow, reduces storm water volume, and treats storm water. Aiming at environmental factors, the research in this paper mainly uses the innovative method of low-impact development, using Vegetated Swales to reduce surface runoff and store The role of water. This study mainly uses the method of Laboratory experiment to simulate the surface runoff caused by urbanization floods, and uses Vegetated Swales to reduce the surface runoff and increase the water permeability. In the experiment, the 5-year, 25-year, and 50-year frequency floods were used as the inflow flow. The common grass species-Paspalum conjugatum Berg. was used as the test species, and the test slopes is 1%. The results show that, from the test data, with a slope of 1% and a 5-year frequency flood; 25-year frequency flood; 50-year frequency flood the water retention capacity is 6.01%, 5.78%, 2.35%, and the flood peak value is reduced by 3.45%, 2.5%, 3.3%. The low-impact development of Vegetated Swales facilities in the initial stage of establishment can be used as a reference for flood treatment.

Introduction

In recent years, global warming has affected climate and environmental changes, making extreme weather more frequent, not only increasing the incidence of dis-asters, but also increasing the intensity of disasters. There are many environmentally disadvantaged areas in Taiwan, which are bound to become flooded during typhoons and heavy rains. In the past few years, the Taiwan government has actively promoted flood control plans in areas prone to flooding and stepped up water control work, which has achieved remarkable results. However, as global warming causes extreme weather and changes in typhoon rainfall, it is difficult to completely prevent and control extreme weather solely through engineering construction. According to the United Nations Office for Disaster Risk Reduction, the impact of climate change on urban space is increasing. There are many factors, including the increasing urban population and density, as well as the impact on land and infrastructure carrying capacity. Many pressures have resulted in considerable environmental risks and dis-asters in Taiwan's urban areas. To this end, Taiwan must use non-engineering means, coordinate with land planning adjustments, and use the United Nations 2030 sustainable development framework to target the 17 ideals and 169 sustainable development goals in the SDGs in a horizontally connected manner towards sustainability. Sexual development is oriented towards integration, and finally achieves the purpose of coping with extreme climates. This study mainly focuses on the SDG11 goal strategy and SDG13 goal strategy in the United Nations 2030 Sustainable Development Goals (SDGs) to strengthen the ability to adapt to climate change, extreme weather, drought, floods and other disasters, and gradually improve land and soil quality. Utilize low-impact development facility units - grass ditches, which are commonly used in parks and green spaces. Understand the characteristics of grass ditches, by reducing surface runoff and a little water storage, through experiments, and through experimental settings and The experimental results can reduce surface runoff and flood peak flow, and can be used to alleviate problems caused by urbanization.

Literature Review and Discussion

As the impact of global climate change and the greenhouse effect becomes increasingly apparent, how to respond to the impact of climate change and achieve a stable balance of natural systems to ensure national security and sustainable development is a challenge that must be faced and should be actively resolved [1]. Since the greenhouse effect was discovered and scientists raised the alarm, the United Nations, governments and non-governmental organizations have begun to develop various types of mitigation strategies, including: saving energy [2] and improving energy efficiency[3], develop emerging and renewable energy [4], develop greenhouse gas reduction technology [5]; however, the trends of global warming and climate change are no longer dependent on human beings can be avoided by reducing greenhouse gas emissions. Therefore, how to adjust social and economic development models so that humans can adapt to the impacts of climate change and continue to survive, live and develop under extreme weather events and warming effects is as important as mitigation. For this reason, mitigation and adaptation have become two important strategies for governments to respond to the threat of climate change [6]. Low Impact Development (LID) facilities, or Green Infrastructure (GI), are mainly used to alleviate problems caused by urbanization [7] and improve the environment by coexisting with water. In addition to reducing the impervious area in urban areas, it can increase the infiltration and evaporation functions of soil and vegetation, reduce surface runoff and reduce peak flow, and conduct rainwater management at the source in a decentralized manner [8], and current research rarely discusses the flood hazards caused by development in non-urban areas and the benefits of location of low-impact development facilities. This study uses grass planting trenches in low-impact development facility units to explore how storage of rainwater through infiltration behavior during the installation process can reduce surface runoff and reduce flow at peak flood times. Through experiments, the main functionality can be under-stood.

Research Methods

This study adopted the method of grass ditches, that is, most The runoff flows away from the surface and only a small amount of water infiltrates. The inflow conditions in the study are based on the Horner design rain pattern of the Taiwan rainfall station. Common heavy rainfalls are used to simulate the 5-year flood frequency (Figure 1), 25-year flood frequency (Figure 2), and 50-year flood frequency (Figure 3). The experimental conditions of each group of this study are shown in Table 1. Each group of conditions is given a number to facilitate identification. The numbers of Vegetated Swales are V1-V3. In the experimental configuration of this grass ditch facility unit, the layers from bottom to top are: filtering water storage layer, geotextile fabric, growth medium (improved mixed layer), and covering layer. This study uses the common grass species Amphora as the test grass species, and the common set-ting slope of 1% as the research and discussion. The growth medium uses the com-mon red soil.

Table 1. Vegetated Swales facility test conditions

Experiment number	Slope	Inflow conditions
V1		5-year frequency floods
V2	1%	25-year frequency floods
V3		50-year frequency floods

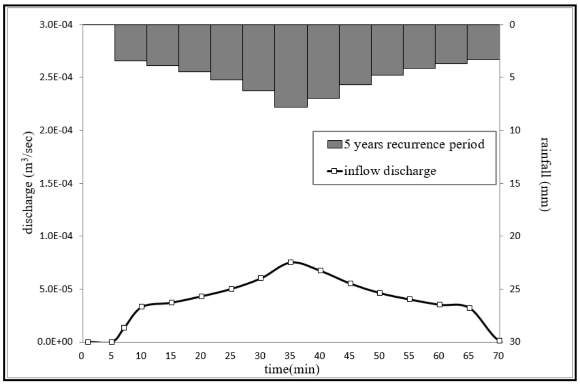

Fig. 1 The rainstorm hydrograph with the recurrence period of 5 years

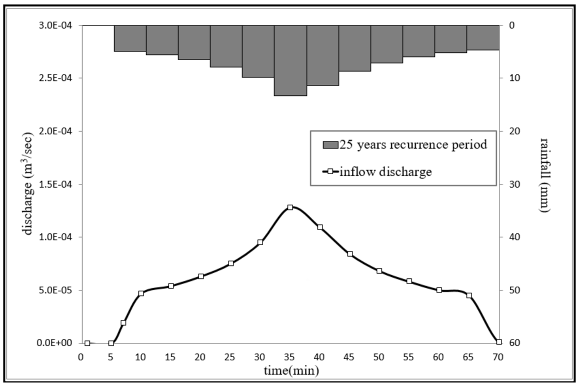

Fig. 2 The rainstorm hydrograph with the recurrence period of 25 years

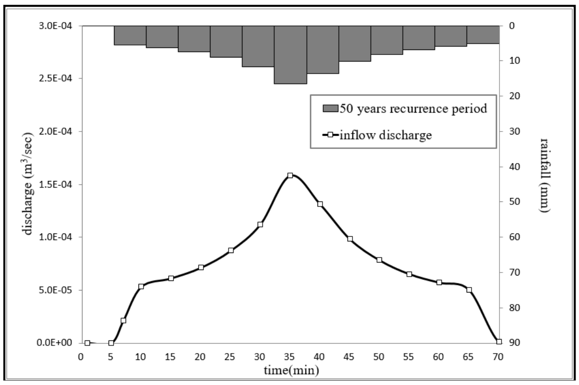

Fig. 3 The rainstorm hydrograph with the recurrence period of 50 years

This study uses a slope of 1% and three inflow conditions of 5, 25, and 50-year design storm water inflows. Based on the experience of the United States [9], a good LID design area ratio must be able to reduce the surface runoff volume. Use effective impermeability as an indicator to deduce appropriate low-impact development (LID) facilities, the ratio to impervious area is about 1/3-1/4. The planting ditches in this study can be divided into two types: dry ditches and grass ditches. Because the principle of dry ditches is to allow most of the water to penetrate into the subsurface, similar to the rain garden test. In order to avoid repetition, this study adopts the method of grass ditches, that is, most of the runoff flows out from the surface, and only a small amount of water infiltrates.

This study used a 1% slope, combined with the three inflow conditions shown in Figures 1 to 3, to design heavy rain inflows in 5, 25, and 50 years respectively, and placed them in an acrylic box of 60cm (length) * 120cm (width) * The test is carried out in a 60cm (high) container. The conditions of each group are as shown in Table 1. Each group of conditions is given a number to facilitate identification. The planting trench numbers are V1-V3. The configuration and elevation of the test unit is shown in Figure 4. In this facility unit, the layers from bottom to top are: filtering water storage layer, geotextile fabric, growth medium (improved mixed layer), and covering layer. In this study, two-legged grass was used as a test grass species to explore

According to the design conditions and according to the layers in Figure 4, lay gravel grading (coarse aggregate) on the graded base layer, and place a water guide plate on the 2mm*20cm rectangular opening of the PVC pipe. The water board uses capillary holes to conduct water from the water body into the PVC pipe to maintain uniform water conduction in the acrylic box. Finally, the gravel is graded to cover it to 20 cm, and a layer of non-woven fabric is laid on the graded bottom layer. The growing medium, fresh sea red soil, is laid on it with a thickness of 30 cm, and finally the two-eared grass is laid on top as a covering layer (Picture 5). The predetermined design storm water inflow is applied, and the entire water volume of the vegetation ditch unit is directly runoff. Overall unit (Figure 6). Use a triangular weir to measure the outflow of the outflow box. Based on the water depth at the top of the triangular weir, compare the calibration curve and deduce the test outflow.

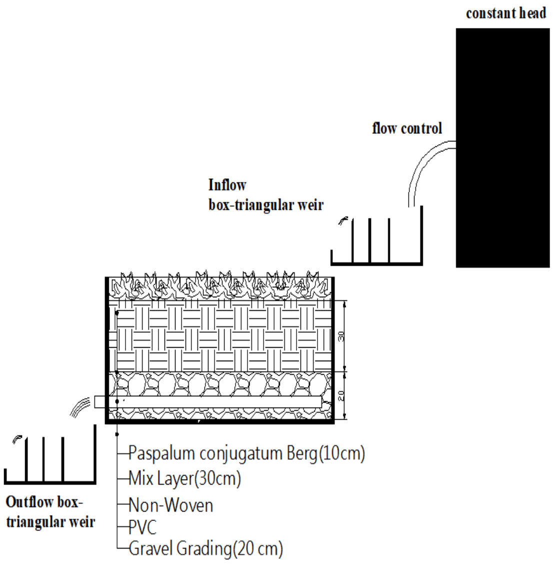

Fig. 4 Configuration and elevation of Vegetated Swales test unit.

Fig. 5 Paspalum conjugatum Berg. Plant laying.

Fig. 6 Vegetated Swales Facility test unit overall.

Experimental Results and Discussion

Conduct 3 types of inflow tests (5 years, 25 years, 50 years) on the LID unit. Conduct 3 tests each, and select one set of results that is more reasonable. Draw the test results and draw the inflow calendar and outflow calendar. The acrylic test chamber used in this study is equipped with three types of inflow flow rates (5 years, 25 years, and 50 years) and a configuration with a slope of 1 degree. Due to the experimental design, it is similar to the traditional grass ditch flow mechanism. If a dry grass ditch is used, the mechanism is similar to a line-ar rain garden). The water retention capacity of the grass ditch is summarized in Table 2. Here, the rainfall conditions and test slope are discussed. Effect on water retention capacity. Draw the inflow and outflow calendars of each group of tests in Vegetated Swales, as shown in Figures 7 to Figures 9. Due to the poor permeability of the soil used in the unit test, soil in general areas will cause soil compaction over time, resulting in poor soil permeability, so most of the water is surface runoff. This experiment is also in line with the on-site conditions. It flows out from the outlet at the top of the test box. Even if it infiltrates, the amount of infiltration is very small. It mostly accumulates at the bottom of the sand box and cannot be measured. Therefore, regardless of whether the rainfall conditions are 5 years, 25 years, or 50 years, the water retention capacity in the Vegetated Swales test is less than 10%. The final results of this experiment show that when the slope of the vegetation ditch is 1%, the water retention capacity of floods occurring once in 5 years, floods occurring once in 25 years, and floods occurring once in 50 years is 6.01%, 5.78%, and 2.35% respectively, and the peak flood peak is reduced by 3.45% and 2.5%. , 3.3%. Low-impact development in the initial stage of construction of vegetation swale facilities can be used as a reference for flood treatment. Grass-planting ditches can be set up according to specific needs. Abroad, they are mainly used to filter dirt and purify water. In subtropical climate areas, maintenance costs will increase due to excessive growth of grass seeds. . In addition, planting turf can also have the effect of cooling and reducing carbon, so as to achieve the purpose of sustainable environment.

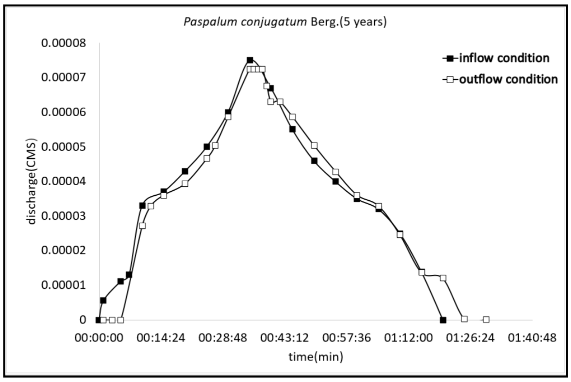

Fig. 7 Vegetated Swales experiment results for 5-year return period

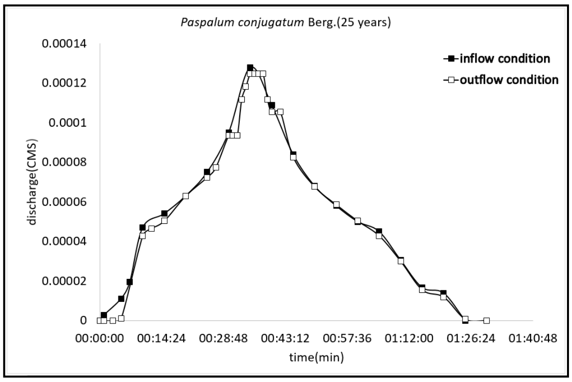

Fig. 8 Vegetated Swales experiment results for 25-year return period

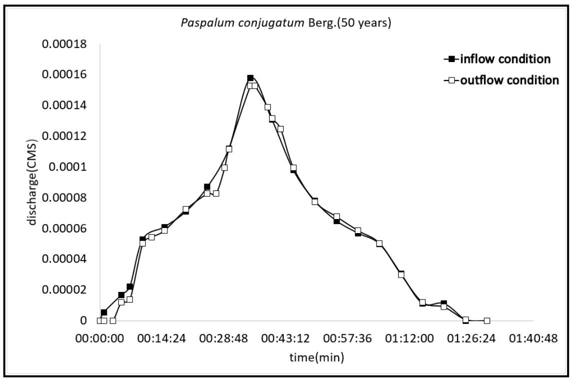

Fig. 9 Vegetated Swales experiment results for 50-year return period

Table 2. Water retention capacity of Vegetated Swales planting trench test conditions

Slope	1%		
Experiment number	V1	V2	V3
Flood conditions	5-year frequency floods	25-year frequency floods	50-year frequency floods
storage capacity (%)	6.01	5.78	2.35
Peak reduction (%)	3.45	2.5	3.3

References

[1] Hecht, Alan D. Making America green and safe: A history of sustainable development and climate change. Cambridge Scholars Publishing, (2018).

[2] Aboelata, Amir. "Assessment of green roof benefits on buildings' energy-saving by cooling outdoor spaces in different urban densities in arid cities." Energy 219: 119514(2021).

[3] O'Rielly, K., and J. Jeswiet. "Strategies to improve industrial energy efficiency." Procedia Cirp 15: pp. 325-330 (2014).

[4] Raihan, Asif, et al. "The role of renewable energy use, technological innovation, and forest cover toward green development: Evidence from Indonesia." Innovation and Green Development 2.1: 100035(2023).

[5] DeLisi, Charles, et al. "The role of synthetic biology in atmospheric greenhouse gas reduc-tion: prospects and challenges." BioDesign Research (2020).

[6] Gan, Rong, et al. "Effects of projected climate change on the glacier and runoff generation in the Naryn River Basin, Central Asia." Journal of Hydrology 523: pp. 240-251(2015).

[7] Ahiablame, Laurent M., Bernard A. Engel, and Indrajeet Chaubey. "Effectiveness of low impact development practices: literature review and suggestions for future research." Water, Air, & Soil Pollution 223: pp. 4253-4273 (2012).

[8] Tansar, Husnain, Huan-Feng Duan, and Ole Mark. "Catchment-scale and local-scale based evaluation of LID effectiveness on urban drainage system performance." Water Resources Management: 1-20 (2022).

[9] Blackler, Gerald E., and James CY Guo. "Paved area reduction factors under temporally varied rainfall and infiltration." Journal of irrigation and drainage engineering 139.2: pp. 173-179(2013).