Journal of Civil Engineering Researchers

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JOURNAL OF CIVIL ENGINEERING RESEARCHERS

Influence of Vegetation in The Flood Drainage Ditch

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Journals-Researchers use only: Received date: 2023.06.21; revised date: 2023.08.10; accepted date: 2023.09.26

Abstract

Flood drainage ditches serve as critical infrastructure, directing and managing floodwaters to prevent indiscriminate flow, reduce flooding risks, and curb erosion. Vegetation plays a crucial role in enhancing the effectiveness of these ditches. It acts as a natural barrier, mitigating floodwater speed and impact while stabilizing soil and preventing erosion. Furthermore, vegetation aids in water quality improvement by filtering pollutants and nutrients, making it safer for humans, animals, and plants. It also reduces peak flows and attenuates floodwaters, thereby minimizing urban flooding risks. Additionally, the presence of vegetation in floodplains provides extra storage capacity for excess water, supporting floodplain management and biodiversity conservation. The study emphasizes the importance of carefully considering vegetation type, characteristics, and management practices to optimize flood drainage ditch performance. Selection of suitable plant species and morphological optimization significantly enhances drainage capacity and infiltration rates. Proper maintenance and management practices are vital to ensure unimpeded water flow and prevent obstruction. (DOI:**https//doi.org/10.52547/JCER.5.4.16**)

Keywords: Vegetation; Flood drainage ditches; Soil stabilization; Erosion.

1. Introduction

Flood drainage ditches are essential in reducing the impact of floods. These ditches help to control the water flow by directing it to a safe location where it can be absorbed into the ground or diverted away from property and communities. Without flood drainage ditches, water would flow indiscriminately, leading to severe flooding and erosion. They play a crucial role in preventing floods by providing a way for water to move away from areas where it can cause damage [1, 2].

Vegetation is equally important in the prevention of floods. Vegetation acts as a natural buffer against floods by reducing the speed and impact of floodwaters. Trees, grasses, and other vegetation hold the soil in place, preventing erosion and reducing the amount of sediment that can be carried away by floodwaters. Vegetation also increases the absorption of water, reducing the amount of water that reaches streams and rivers, and thus reducing the risk of flooding [3-5].

When vegetation is planted near a flood drainage ditch, it not only provides an additional barrier to the flow of water but also helps to filter the water.

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Vegetation helps to remove pollutants from the water, preventing them from entering rivers and streams. As a result, flood drainage ditches and vegetation work together to provide multiple benefits for the environment and communities [7, 8].

Figure 1. Vegetation in The Flood Drainage Ditch after and before flood [6]

Flood drainage ditches and vegetation are also essential for the preservation of wildlife habitats. The ditches provide a source of water for many animals, while vegetation provides food and shelter. This makes it possible for wildlife to thrive in areas prone to flooding, improving the overall health and diversity of the ecosystem [9].

Finally, flood drainage ditches and vegetation have economic benefits. By reducing the risk of flooding, they protect property and infrastructure, reducing the need for costly repairs and insurance claims. Additionally, they can increase the value of nearby properties by improving the quality of life in the area. These benefits make the installation of flood drainage ditches and vegetation a worthwhile investment for both individuals and communities [10, 11].

2. The Role of Vegetation in Enhancing Flood Water Quality in Drainage Ditches

The presence of vegetation helps to filter the floodwater by removing pollutants and other harmful substances from the water. This enhances the quality of the water, making it safer for people, animals, and plants. Vegetation also helps to slow down the flow of water, reducing the likelihood of erosion and sedimentation, which can lead to further water quality issues [12].

Vegetation acts as a natural filter, removing nutrients and other pollutants from the floodwater. The roots of the plants absorb and retain nutrients, preventing them from entering streams and rivers, where they can cause harmful algal blooms and other water quality issues. The plants also absorb heavy metals, pesticides, and other chemicals, preventing them from entering the water supply and harming aquatic life [13, 14].

The presence of vegetation in drainage ditches helps to stabilize the soil, reducing erosion and sedimentation. When soil erodes, it can carry pollutants, nutrients, and other harmful substances into waterways, leading to water quality issues. Vegetation helps to prevent this by holding the soil in place with their roots. As a result, the floodwater that passes through the drainage ditches is cleaner and less likely to cause damage to the surrounding environment [15, 16]. Vegetation also provides habitat and food for wildlife. By enhancing the water quality in drainage ditches, vegetation creates a healthy ecosystem that supports a diverse range of wildlife, including fish, birds, insects, and mammals. This, in turn, helps to maintain the overall health and balance of the ecosystem [17].

3. Vegetation Effects on Hydraulic Performance of Flood Drainage Ditches

Vegetation has a significant impact on the hydraulic performance of flood drainage ditches. The presence of vegetation can affect the flow of water through the ditches, the amount of sediment that is carried away, and the overall capacity of the ditches to manage floodwaters. Understanding these effects is essential for designing effective drainage systems that can minimize the risk of flooding and erosion [18].

The presence of vegetation along a river causes an increase in roughness, leading to a reduction in the average speed of water flow, diminished flow energy, and alterations in the velocity profile across the river's cross-section. During floods, many natural canals and rivers become covered with vegetation. The roughness of a canal is significantly influenced by plants, thereby exerting a substantial impact on flow resistance during floods. The resistance to flow caused by the roughness of plants is dependent on flow conditions and the type of vegetation present. Therefore, when modeling the current velocity in a canal, it is essential to consider the effects of velocity, flow depth, and the specific vegetation type along the canal. A total of 48 models were simulated to examine the impact of roughness in the canal. The results revealed that when the velocity is increased, the influence of vegetation on reducing the velocity of the riverbed is negligible. However, when the current speed is lower, the effect of vegetation on decreasing the riverbed velocity is significantly notable [19, 20].

[21] research examines how foliage and reconfiguration of riparian plants impact water flow and mixing in partially vegetated channels. The study investigates velocity patterns, turbulent structures, and momentum transport at the vegetation-water interface. Findings show that foliage increases velocity differences, enhances shear layer mixing, and complex plant reconfiguration improves lateral momentum transport.

Vegetation also plays a critical role in stabilizing the soil in flood drainage ditches. The roots of the plants help to hold the soil in place, preventing erosion and sedimentation. This is particularly important in areas with high water flows, where soil erosion can cause significant damage to surrounding property and infrastructure. In addition, vegetation can help to trap sediment, preventing it from being carried away and reducing the overall capacity of the drainage system [22].

The type of vegetation present in flood drainage ditches can also affect their hydraulic performance. Trees, for example, can have a significant impact on the capacity of the drainage system, as their roots can grow into the ditch and reduce its overall capacity. On the other hand, grasses and other smaller plants can be beneficial in improving the hydraulic performance of the drainage system, as they can help to filter the water and reduce the amount of sediment that is carried away [23].

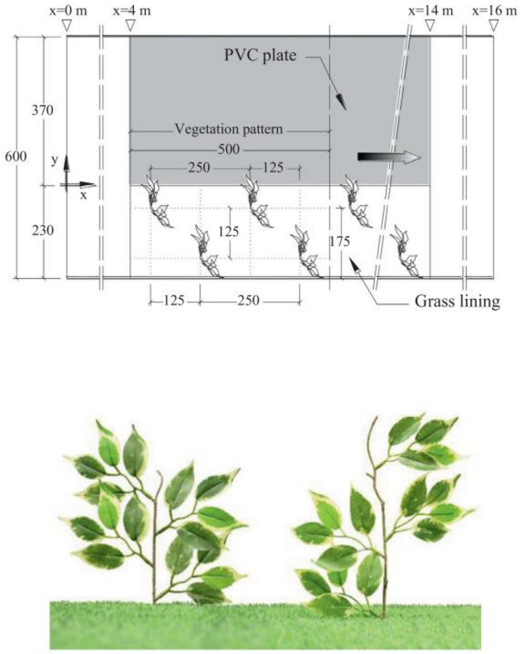

Figure 2. Top view of the experimental flume with the repetitive vegetation pattern and flume coordinate system [21]

Different categories of aquatic vegetation: submerged, emerged, and suspended investigated by [24]. Suspended vegetation, which floats without rooting, can have negative effects by blocking sunlight and clogging waterways, but also positive aspects like biogas production. While ecological impacts of suspended vegetation have been studied, hydrodynamic properties of its flow are less explored. Previous research on open-channel flow with submerged vegetation focused on phenomena like shearing vortices. [25]'s study examined turbulent flow through suspended vegetation, developing an analytical model for vertical velocity and Reynolds stress distribution.

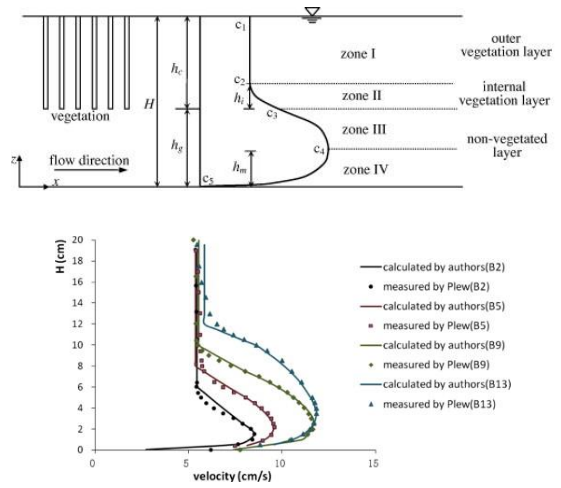

Figure 3. a) experiment flume [24] b) [24] vs [25] results

4. The Effectiveness of Vegetation in Flood Control and Management

4.1. Vegetation as a Natural Barrier

Vegetation, including trees, shrubs, and grasses, acts as a natural barrier against flooding. Their roots help to stabilize soil, reducing erosion and maintaining the integrity of riverbanks. By holding the soil together, vegetation minimizes sedimentation in rivers and streams, thus preventing the accumulation of debris that can obstruct water flow [26-28].

4.2. Absorption and Retention of Water

Vegetation plays a vital role in absorbing and retaining excess water during heavy rainfall. The leaves and branches of plants intercept rainfall, reducing the speed at which water reaches the ground. This process, known as interception, helps to delay and slow down the runoff, allowing more time for infiltration into the soil. Vegetation also enhances soil permeability, promoting water absorption and reducing surface runoff [29].

4.3. Reduction of Peak Flows

The presence of vegetation along riverbanks and in floodplains can significantly reduce the peak flows during flood events. Vegetation acts as a buffer, absorbing and storing water, thereby attenuating the intensity of floodwaters. By slowing down the flow rate, vegetation reduces the pressure on river channels and flood control infrastructure, reducing the risk of breaches and overflow [30].

4.4. Improved Floodplain Management

Vegetation in floodplains plays a crucial role in flood management strategies. Floodplain vegetation acts as a natural floodwater storage area, allowing excess water to spread out horizontally. This process, known as floodplain attenuation, reduces the volume and velocity of floodwaters downstream, minimizing the risk of flooding in urban areas. Additionally, floodplain vegetation provides habitat for diverse plant and animal species, contributing to biodiversity conservation [31, 32].

4.5. Long-Term Benefits and Sustainability

The effectiveness of vegetation in flood control and management extends beyond immediate flood events. By promoting sustainable land management practices, including reforestation and the preservation of wetlands, vegetation contributes to long-term flood risk reduction. Vegetation also improves water quality by filtering pollutants and nutrients, enhancing overall ecosystem health [33].

5. The Influence of Vegetation Type and Characteristics on Flood Drainage Ditch Performance

5.1. Vegetation Type

The type of vegetation present in flood drainage ditches can have a profound impact on their performance. Different plant species exhibit varying characteristics, such as root structure, density, and water absorption capacity. Grasses, for example, with their fibrous root systems, can effectively stabilize the soil, preventing erosion and maintaining the structural integrity of the ditch. Additionally, grasses can enhance infiltration rates, allowing water to penetrate the soil more readily [34-36].

5.2. Root Characteristics

The root characteristics of vegetation within flood drainage ditches significantly influence their drainage capacity. Plants with deep and extensive root systems, such as certain tree species, can help to enhance water infiltration and improve soil permeability. These roots create pathways for water to move vertically and horizontally, reducing the potential for waterlogging and enhancing drainage efficiency [37].

5.3. Vegetation Density

The density of vegetation in flood drainage ditches is another crucial factor by affecting Manning coefficient. A dense cover of vegetation can effectively slow down the flow of water, allowing more time for infiltration and reducing the velocity of runoff. This reduced flow velocity minimizes erosion and sedimentation, preventing the accumulation of debris that may impede drainage. However, excessive vegetation density should be avoided, as it may impede the flow of water and increase the risk of blockages [38, 39].

5.4. Plant Growth Patterns

The growth patterns of vegetation within flood drainage ditches also impact their performance. Plants that exhibit rapid growth and regrowth rates can help maintain the effectiveness of the ditch over time. Such vegetation can quickly recover from flood events, ensuring continuous drainage capacity and reducing the need for frequent maintenance interventions [40, 41].

6. Future Directions for Research and Implementation of Vegetation in Flood Drainage Ditches

Future research and implementation of vegetation in flood drainage ditches should focus on key areas. This includes selecting plant species suitable for the conditions of flood drainage ditches and understanding the relationships between vegetation morphology and drainage performance. Research should investigate root depth, density, leaf characteristics, and growth rates. Additionally, the impact of climate change on vegetation performance in flood drainage ditches must be examined. Optimization of maintenance practices, such as vegetation trimming and control of density, is necessary for unimpeded water flow and ecological benefits. Integration of modeling approaches, like hydrological and vegetation growth models, can enhance understanding of vegetation-drainage interactions. Collaboration between researchers, engineers, policymakers, and communities is essential for successful implementation and resilient flood management strategies.

7. Conclusion

In conclusion, the combination of flood drainage ditches and vegetation offers a highly effective approach to flood control and management. Flood drainage ditches serve as essential infrastructure for directing and managing floodwaters, preventing indiscriminate water flow, and reducing the risk of flooding and erosion. Vegetation, on the other hand, plays a crucial role in enhancing the effectiveness of flood drainage ditches.

Vegetation acts as a natural barrier against floods, reducing the speed and impact of floodwaters while stabilizing soil and preventing erosion. It improves water quality by filtering pollutants and nutrients, making it safer for humans, animals, and plants. Moreover, vegetation helps to reduce peak flows and attenuate floodwaters, minimizing the risk of flooding in urban areas. The presence of vegetation in floodplains provides additional storage capacity for excess water, enhancing floodplain management and supporting biodiversity conservation.

Furthermore, the influence of vegetation type, characteristics, and management practices on flood drainage ditch performance should be carefully considered. Selecting suitable plant species and optimizing vegetation morphology can significantly enhance drainage capacity and infiltration rates. Proper maintenance and management practices are essential for ensuring unimpeded water flow while preventing obstruction.

Future research should focus on species adaptation to changing climatic conditions, modeling and simulation of vegetation-drainage interactions, and promoting interdisciplinary collaboration to bridge the gap between research and practical implementation. By addressing these future directions, the effectiveness of vegetation in flood control and management can be further improved, leading to resilient flood management strategies, enhanced water quality, ecological benefits, and economic advantages.

Overall, the integration of flood drainage ditches and vegetation provides multiple benefits, including flood risk reduction, improved water quality, wildlife habitat preservation, and economic advantages. Embracing and implementing this approach will contribute to more sustainable and effective flood management practices, ensuring the safety and well-being of communities and the environment.

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