Study on Hydraulic Properties and Sediment Transport Law of Grasse Waterway

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Abstract. Ecological grassed waterway not only has the function of drainage, but also has the ecological function of sediment, nitrogen and phosphorus and other materials transmission, filtering or blocking, material and energy source or convergence. Ecological grassed waterway plays an important role in preventing and controlling soil erosion and purifying water quality. As one of the ecological ditches, the ecological grassed waterway is widely used. As a new type of ecological restoration of soil and water conservation measures, the ecological grassed waterway has the characteristics of convenient construction and low cost. It is the effective combination of soil and water conservation measures, engineering measures and grassland. Ecological grassed waterway are composed of drainage ditches and the plants planted in them. Due to the existence of plants, the hydraulic characteristics and sediment transport rules of the ditches are changed. Therefore, based on the definition and significance of ditches and ecological grassed waterway, the study on hydraulic characteristics and sediment transport rules of ecological grassed waterway are summarized and analyzed, which is of important practical value for the technical development and scheme design of ecological grassed waterway, and can provide scientific reference for relevant research on ecological grassed waterway.

1. Introduction
Drainage ditches usually refer to artificial waterway for the purpose of drainage [1~2], which are the transition zone connecting sloping land and receiving water bodies (lakes, rivers, wetlands, etc.). They are a sink for slope runoff and a source for receiving water bodies [3], which have an important impact on ecological environment and agricultural production [4]. Ecological grassed waterway are composed of drainage ditches and plants planted in them [5~7], which transform slope runoff from scattered to concentrated flow [8]. Meanwhile, due to the presence of plants, the characteristics of water flow movement and sediment transport of ditches are changed. Ecological grassed waterway is an ecological drainage widely used in slope management. Therefore, it is of great practical value for the technical development and scheme design of ecological grass waterway to study the hydraulic characteristics and sediment transport law of ecological grass waterway and reveal the hydraulic characteristics and sediment transport law of ecological grassed waterway.
2. Research Overview

In regions with frequent human disturbance, natural interception and filtration of slope surface in the region are weakened or even lost due to artificial activities such as cultivation and production, causing soil erosion and causing a certain load on the environment [9]. Therefore, it is necessary to set up small water conservancy and water protection project on slope. As a widely used small water conservancy and water conservation project, drainage ditch is an important channel connecting small watershed ditches and even river channels on the slope, which collects runoff and sediment on the slope and directly affects the confluence of runoff and sediment in the small watershed. Traditional soil drainage ditches are easy to cause soil erosion and poor soil conservation ability. Although rigid lined ditches such as concrete do not have these shortcomings and conform to the principle of optimal hydraulic section in hydraulics, in the long run, they can only play the role of drainage, which will also cause ecological environment problems. Ecological ditch is a new type of ditch which takes into account drainage, ecology and efficient utilization of water resources. Ecological ditch refers to the ditch ecosystem with a certain width and depth, which is composed of water, soil and plants, and has its own unique structure and corresponding ecological functions [10]. Ecological ditches can reduce soil and water loss and soil erosion through a series of functions such as sediment interception, soil adsorption, plant absorption and biodegradation, thus reducing non-point source pollution. Baocai ZHU et al. (2015) studied the erosion and sediment yield of road drains on the loess plateau with the water releasing test method, and found that the erosion of exposed drains and ecological ditches was affected by the water flow and slope, and the erosion and sediment yield of exposed drains was greater than that of vegetation drains.

Ecological grassed waterway is a kind of ecological ditch that is widely used in practice. As a new type of ecological restoration soil and water conservation measure, it has the characteristics of easy construction and low cost. It is an effective combination of soil and water conservation engineering measures and forest and grass measures. At present, researches on ecological ditches mainly focus on ditch design [12–14], non-point source pollutant transport and pollution reduction benefits [15–16]. The following illustration shows one of the more widely used grassed waterway.

![Cross section map of shallow dish type grassed waterway](image-url)
Figure 2  Grassed waterway scour test site

Ecological grassed waterway not only have the function of drainage, but also have the ecological functions of sediment, nitrogen, phosphorus and other materials transmission, filtering or blocking, material energy source or convergence, etc. [8]. Now more and more attention has been paid to agricultural non-point source pollution. Ecological grassed waterway project is applied to intercept nitrogen and phosphorus non-point source pollutants in runoff [17~18]. At the same time, soil erosion is an important form of non-point source pollution and a transport carrier, and a major source of water pollution [19~21]. Therefore, the study of the mechanism of ecological grassed waterway on the regulation of soil and water loss, runoff and sediment, and the design and construction of ecological grassed waterway with vegetation have an important role in preventing soil and water loss, controlling eutrophication of water bodies and purifying water quality.

For the ecological grassed waterway, the species and quantity of vegetation affect its hydrological effect. The ecological ditch with rich vegetation species and high density can slow down the drainage speed of slope land. On the contrary, ditches with no or few plants can drain water very quickly, especially those matrix ditches [22]. The hydrological process of drainage basin with high vegetation coverage is characterized by slow rise and fall, and the flood peak is flat. The hydrological process of the drainage basin with low vegetation coverage is characterized by steep rise and fall, short duration and sharp peak [23]. On the scale of river basin or region, the ditch system with high vegetation coverage can store water and delay water discharge into rivers and lakes, and can play a role in regulating flood peak [24~25]. Deletic and Fletcher (2006) established a storm runoff model for grassed waterway treatment, and believed that the notional flow of waterway was 10~47% [26]. The movement of sediment in ditch is related to the section size of ditch and the hydraulic characteristics such as water level and velocity in ditch. The retention time of runoff in the ditch is determined by the hydraulic characteristics such as section size and flow velocity. The retention time has a great relationship with sediment removal rate.

In the early stage of research in this field, some scholars have successively established runoff and sediment transport equations under ditch conditions. The widely quoted Kentucky equation used artificial medium instead of straw to simulate the sediment transport in this case, but it turned out not to be applicable to the simulation of lower sediment input and small particles. Based on urban rainstorm control, Deletic and Fletcher (2006) using wave equation and correction of Green-Ampt infiltration equation to simulate the runoff process. At the same time, with its proposed Aberdeen process as a comprehensive sedimentation equation is proposed TRAVA equation, the equation of sediment goes on quality is 25%, the accuracy of simulation grassed waterway output accuracy of 17%, the total quantity of sediment transport is 11~50%[26]. In ditches with high vegetation coverage, the sediment entrainment capacity decreases with the decrease of water flow velocity, and solid materials such as sediment gradually settle to the bottom of ditches [23]. Peidong Xiet al. (2018) studied the
sediment reduction capacity of ecological grassed waterway by means of runoff scouring experiments[27].

3. Conclusion
To sum up, relevant studies mainly focus on the study of ecological grassed waterway hydrodynamic characteristics and sediment transport rate of ecological grassed waterway[23]. Needleman et al. (2007) believed that ecological ditches were unique engineered ecosystems with river and wetland characteristics, and unified definitions were made for naturally formed ditches and man-made engineered ditches, emphasizing the wetland characteristics of ditches[1].

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