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The Currant Research of Subsurfaceflow

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Abstract

Subsurfaceflow is an important part of runoff. It plays a very important role in the regulation of watershed runoff, water conservation, sediment migration, and nutrient loss. It is a difficult point and a frontier scientific problem in hydrology research. This paper introduces the concept, research background and importance of soil midstream. The domestic and foreign development trends and hot research contents of soil midflow research are summarized. At the same time, the influencing factors of the formation of soil interflow were analyzed. The problems existing in the current research on soil mesoflow are put forward and the future research on soil mesoflow is prospected.

Keywords

Subsurfaceflow; Hydrologic.

1. Introduction

Soil subsurfaceflow is the flow of water that flows through different permeable interfaces in the soil. It is an important part of run-off [1]. Soil subsurfaceflowis related to the regulation of watershed run-off, water conservation, sediment migration, nutrient loss and the calculation of the watershed's hydrological cycle [2]. As an important hydrological cycle element, soil subsurfaceflowbelongs to runoff. Compared with underground runoff, Its confluence speed is high. And because the soil flow in the porous medium flows in the porous medium, its confluence speed is lower than the surface runoff. The physical condition of the soil flow is that there is a relatively impermeable layer in the vadose zone and the water content of the upper soil at least reaches the level of the field. water holding capacity [3].

According to the migration form of the soil flow, the soil flow can be divided into the matrix flow that follows Darcy's law and the dominant flow that does not follow Darcy's law. The flow rate of water is uniform when water is transported in soils with small porosity and relatively uniform properties. However, when Darcy's law is applied to soils containing macropores, the results are often quite different from those described by Darcy's law, because soil macropores can be channels for rapid water migration, so Darcy's law is not very good. To describe the movement of water in macropores, this part of the water flow transmitted through the macropore channels is called "dominant flow" [4]. The dominant flow in the soil unsaturated zone is divided into different types according to the formation method of dominant flow, such

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as macropore flow, finger flow, funnel flow, bypass flow, groove flow, short-circuit flow and pipe flow [4]. Due to the nonlinear characteristics of the dominant flow, it is very important to describe the heterogeneity of the dominant flow. At present, there are methods based on dyeing experiments to describe the distribution characteristics of the migration path of the dominant flow in the soil, and there are also methods based on probability statistics and distribution models. The heterogeneity characteristics of the dominant flow are characterized, and the study of the flow in the soil from homogeneous to heterogeneous is reflected in the study of the dominant flow.

Soil subsurfaceflowis an important source of recharge for underground runoff, rivers and lakes. It is an important part of the watershed run-off process. It is very important for the formation of water resources and the generation of run-off in the whole watershed. There are many factors affecting the flow in the soil and the interaction is more complicated. Soil properties, vegetation cover, rainfall characteristics, soil surface crust, soil initial water content and slope and other factors can affect the formation and migration of flow in soil. At the same time, due to the complicated formation and migration conditions of soil subsurfaceflow, the experimental observation of soil subsurfaceflow is very difficult. At present, the study of subsurfaceflow has become a hot and difficult area in the cross-study of hydrology and soil science. From the analysis of the highly cited papers in the field of soil subsurfaceflow from 1990 to 2020, the research content of the cited papers mainly focuses on the characteristics of the run-off of the soil subsurfaceflow, the effect of the soil subsurfaceflow on the transport of solutes (nutrients), material circulation and the impact of subsurfaceflow on engineering construction[Figure 1].

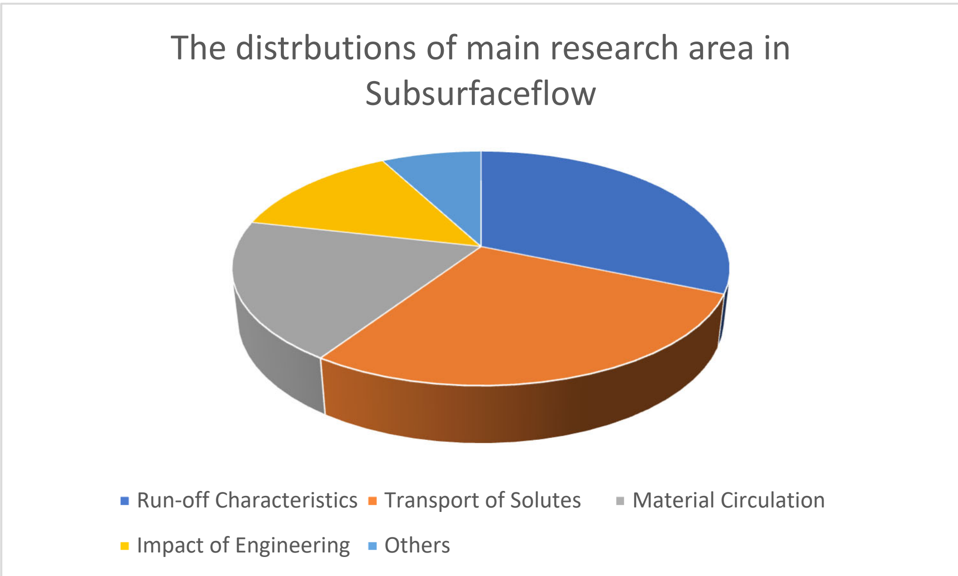

Figure 1. The distrbutions of main research area in subsurfaceflow

2. Characteristics of Run-off in Soil Subsurfaceflow

Due to the differences in the climatic characteristics, spatial scale, pre-soil water content, catchment area, hillside slope, soil thickness, soil porosity and soil hydraulic conductivity, the runoff characteristics of the soil flow and the contribution rate to the watershed runoff will occur [5]. Boulet's research on surface runoff and inter-soil flow in the eucalyptus forest area in northern Spain found that surface runoff is not the most important form of runoff in the region. Spatial heterogeneity, the abortion rate was only between 0.6% and 6%. Soil midstream is the main form of runoff in this area. Among them, the pipe flow and matrix flow generated at the rock-soil interface are the main forms of flow in the soil [6]. Xie Songhua's research shows that under different surface treatment conditions, the soil subsurfaceflowcan account for

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68.4%-90% of the total yield [7]. Hopp's study of rainfall runoff in the overlying soil area of the warm-wet ground rock in southeastern Alaska found that lateral subsurfaceflowcan account for 68% of total rainfall [8]. In the same area, the difference of rainfall process, rainfall and soil water content before rain is also an important factor leading to the difference of abortive flow in soil. Van's research on the hydrological process of slope land in a semi-arid area in southwestern Spain found that in the event of heavy rainfall, the flow pattern of slope land was hyperosmotic runoff. The runoff mode is mainly surface runoff, and the runoff in the soil accounts for 13% of the total runoff. In the weak rainfall event, the pores in the soil are gradually moistened, and the macropore flow becomes the main form of the flow in the soil, and the runoff flow in the soil can account for 80% of the total runoff flow. At the same time, during a rainfall runoff process, the contribution ratio of soil interflow to the basin runoff also changed with the rainfall process [9]. Burns used an endmember analysis model to quantify the contribution of several major water sources to river runoff on the slopes of the Panola Mountains in Georgia, and found that slope runoff was mainly produced in the form of mid-soil flow. The corresponding relationship between the contribution rate of the soil subsurfaceflowto the river and the rainfall intensity is obvious, and the contribution rate of the soil subsurfaceflowto the total runoff is between 15% and 20% [10].

3. Effects of Subsurfaceflow on Nutrient Transport and Substance Cycle

The transport characteristics of solutes in soils have great temporal and spatial heterogeneity under different climates, topography and other conditions. The paths of transport also vary widely. Through systematic observation, the influence mechanism of soil interflow on the spatial distribution of soil nutrients can be explored more comprehensively. Shen systematically discussed the effect of soil interflow on nutrient distribution in swamp areas and pointed out that although topography, soil properties, stratigraphic distribution, evapotranspiration and other factors have an important impact on the distribution of nutrients in the region, the role of soil interflow cannot be ignored. For example, the dominant flow generated by the salinity gradient can effectively increase the connection and exchange of water between surface water and groundwater, and between streams and swamps [11]. For some basins with relatively gentle terrain, good vegetation coverage, high groundwater level and humid climate, the intersoil flow in unsaturated soil can carry a large amount of nutrients [12] [13]. The migration of nutrients in the soil flow occurs in the leaching process in the soil and in the dominant flow, and nitrogen and phosphorus initially migrate downward.

Under the condition of excess water supply, the main way of soil nitrogen loss in farmland is leaching. It is also an important way for nitrogen to enter the soil. In some specific cases, the nitrogen concentration in the soil flow can reach 5-22 times the nitrogen concentration in the surface runoff. After a long period of observation, Wang A found that the main form of nitrogen loss in purple soil is intersoil flow, accounting for 22% of the total loss, while the proportion of loss through surface runoff is only 0.6% [14]. Phosphorus is generally considered to have a strong affinity for soil. In the absence of leaching and large-scale downward migration of phosphorus, phosphorus loss was mainly caused by surface runoff [15]. However, some experiments have shown that the inter-soil flow is also an important way of phosphorus loss. For example, in the water accumulation area of sandy soil, the inter-soil flow is the main way for dissolved and suspended particulate phosphorus to migrate to the river [16].

The total phosphorus and particulate phosphorus in soil midstream can peak at the early stage of runoff. In surface runoff and subsoil flow, dissolved inorganic phosphorus accounted for a higher proportion of dissolved total phosphorus [17]. The research on the influence of nutrients, pollutants, bacterial colonies and hydraulic effects in constructed wetlands has also become a hot issue in soil subflow research in recent years. For example, Yu explored the spatial heterogeneity of the horizontal and vertical soil interflow on the phosphorus fixation capacity of a simulated constructed wetland system. The results showed that although the small-scale distribution of inorganic phosphorus in the simulated constructed wetland system had obvious root zone and inflow/outflow effects, there was a significant positive correlation between the distribution of inorganic phosphorus and the horizontal flow in the soil [18]. The above research results show that subsurfaceflow plays an important role in nutrient transport, and the study of subsurfaceflow can provide a practical and effective scientific basis for reducing soil nutrient loss and improving agricultural nutrient use efficiency.

4. Influence of subsurfaceflow on Engineering Construction

Subsurfaceflow is also one of the important factors that must be considered in engineering construction and mountain disaster prevention. Studies have shown that in granite areas with strong weathering degree, long-term and heavy rainfall infiltrates from rock crevices to become the water source of soil flow. Even after the rainfall has ceased, the soil midstream will gradually seep up into the overlying soil layer. Landslides are induced when the water level rises to a critical value [19]. The impact of subsurfaceflow also needs to be considered in the process of highway construction. For example, when constructing drainage ditches and intercepting ditches for highways, if only the influence of surface runoff is considered, but the subsurfaceflow is not considered, the subsurfaceflow continuously leaks out from the soil water after precipitation. Because it cannot flow smoothly to the foot of the slope, it accumulates in the middle of the slope, resulting in a large area of collapse. Especially during the construction of the project, the mountain will be fractured at the edge of the mountain, so it is necessary to design a drainage ditch that can guide the flow in the soil [20].

5. Conclusion

Subsurfaceflow is closely related to human survival, and many studies have been carried out on subsurfaceflow at home and abroad. At present, many important research results have been achieved on the research methods of the mechanism of abortion and confluence in soil. Deepen our understanding of the interaction of hydrological processes, soil erosion processes, and solute transport processes in key Earth zones. It has better explained the solute transport process and path in the key zone of the earth, and also promoted the development of distributed hydrological model and water resources management.

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