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Soil and Water Loss Characteristics of Different Forest Stands in the Dongjiang Lake of Zixing City

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Abstract In this paper, different stands in Dongjiang Lake Reservoir area of Zixing were selected as the research objects, and the runoff generation and soil loss characteristics of different stands were studied. The results showed that the annual surface runoff of each model in Zixing was between 43.24 and 50.99 mm, and there was no significant difference in the annual runoff between each stand and its control. There were significant differences in soil erosion modulus among the models, and the number ranged from 127.37 to 165.58 t/(km^2 · y).

Key words Dongjiang Lake Reservoir area; Forest stand; Surface runoff; Forest management

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Soil erosion is a global ecological and environmental problem, which seriously threatens the ecological security and the sustainable development of social economy. As the main body of terrestrial ecosystem, forest plays an irreplaceable role in regulating hydrological processes, conserving water and soil, and conserving water sources. However, due to the differences in structure, function and management mode of different forest stand types, there are also significant differences in the inhibition of soil and water loss. Therefore, it is of great significance for scientific evaluation of forest ecological service function, optimization of forest management mode, and formulation of soil and water conservation measures by in-depth study on the characteristics of soil and water loss in different stands.

In recent years, scholars at home and abroad have carried out a large number of studies on the characteristics of soil and water loss in different stands. The results show that stand type, stand age, canopy density, litter layer thickness and other factors have a significant impact on soil and water loss. The study found that the soil and water conservation capacity of broad-leaved forest was better than that of coniferous forest[1]; the amount of soil and water loss in mature forest was significantly lower than that in young forest[2]; the stands with high canopy density can effectively intercept rainfall and reduce surface runoff and soil erosion[3]. However, there are still some deficiencies in the current research on the characteristics of soil and water loss in different forest stands. For example, the in-depth study on the mechanism of soil and water loss in different forest stand types is not enough, and there is a lack of long-term positioning observation data.

The purpose of this paper was to explore the differences in soil and water loss characteristics of different forest types in the Dongjiang Lake and its influencing factors through the combination of field investigation and indoor analysis, so as to provide a theoretical basis for scientific evaluation of forest ecological service function, optimization of forest management mode, and formulation of soil and water conservation measures.

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1 Overview of the study area

1.1 General situation The Dongjiang Lake Reservoir area in Zixing City belongs to a subtropical monsoon humid climate, with four distinct seasons, drought in summer and autumn and abundant rainfall. The average annual temperature is 17.7 ℃, the average annual rainfall is 1 487.6 mm, and the average annual sunshine is 1 700 h.

1.2 Stand location Tree - shrub mixed afforestation (*Pinus massoniana* + *Camphora officinarum* + *Liquidambar formosana* + *Schima superba*) and artificial regeneration (*Cupressus funebris* + *Ziziphus jujuba* + *Michelia figo* + *Taxus wallichiana*) were used as monitoring objects for soil and water conservation monitoring (Table 1).

2 Materials and methods

2.1 Rainfall observation The data were collected continuously at rainfall observation field.

2.2 Surface runoff observation The surface runoff was monitored by the method of slope runoff plot location. Slope runoff plots were set up for forest stand type in each project area and each non project area for location monitoring, with 3 replicates.

2.3 Determination and calculation method of soil water holding capacity The soil profile was excavated in the sample plot, and the soil layer and the thickness were recorded. The ring knife was used to sample in layers, and it was taken back to the laboratory to determine the soil bulk density, capillary porosity, non capillary porosity, water content, and soil water holding capacity. Meanwhile, the volume content of gravel was determined.

2.4 Determination of soil erosion Determination of suspended load: 500 ml of sediment mixed sample was collected and put into a marked plastic bottle, and the sediment content of surface runoff was calculated. Determination of bed load: the bed load in the launder and sediment sampling tank was collected after each rain, and sample was taken and dried to constant weight, to calculate the bed load loss.

2.5 Data processing In this paper, Excel 2010 was used for consolidated analysis and chart output of the observed statistical data.

Table 1 Information of each stand

Model	Stand type	Small place name	Longitude and latitude
Tree-shrub mixed afforestation XZ I	*P. massoniana* + *C. officinarum* + *L. formosana* + *S. superba*	Huangmao Mountain of Zixing Forestry Institute	113°15′28.705″ E, 25°57′04.399″ N
Control CK-XZ	*M. figo* + *C. officinarum* + *Paulownia fortunei*	Huangmao Mountain of Zixing Forestry Institute	113°15′28.705″ E, 25°57′04.399″ N
Artificial regeneration model GP II	*C. funebris* + *Choerospondias axillaris* + *M. figo* + *T. wallichiana*	Liangshu Bay of the Dongjiang River of Zixing Forestry Institute	113°18′15″ E, 25°51′54″ N
Control CK II	*C. axillaris* + *Sassafras tzumu* + *Melia azedarach* + *C. funebris*	Liangshu Bay of the Dongjiang River of Zixing Forestry Institute	113°18′15″ E, 25°51′54″ N

3 Results

3.1 Rainfall characteristics in Zixing According to the rainfall data of Zixing monitoring point from 2022 to 2023, the total rainfall of Zixing point was 1 657.6 mm in 2022 and 1 469 mm in 2023. According to the statistics of daily rainfall < 10 mm, 10 – 20 mm, 20 – 30 mm, 30 – 40 mm, 40 – 50 mm and ≥50 mm (Table 2), the annual total rainfall of each interval varied greatly. The rainfall order in 2022 was (≥50 mm) > 30 – 40 mm > 10 – 20 mm > 20 – 30 mm > (< 10 mm) > 40 – 50 mm, and the maximum interval rainfall was about 1.97 times of the minimum interval rainfall. In 2023, the rainfall order was (≥50 mm) > 10 – 20 mm > 20 – 30 mm > (< 10 mm) > 30 – 40 mm > 40 – 50 mm, and the maximum interval rainfall was about 2.14 times of the minimum interval rainfall.

Table 2 Rainfall characteristics in Zixing from 2022 to 2023 mm

Year	Rainfall interval // mm						Annual rainfall
	< 10	10 – 20	20 – 30	30 – 40	40 – 50	≥50	
2022	213.8	287.6	237.3	332.4	197.6	388.9	1 657.6
2023	222.4	283.7	249.2	195.4	165.1	353.2	1 469.0

3.2 Soil water storage Seen from Table 3, the annual soil water storage of Zixing's various model plots ranged from 532.6 to 625.7 mm in 2022. Of the six rainfall ranges, there was a lot of soil water storage in the interval of ≥50 mm and 10 – 20 mm. There were significant differences in annual soil water storage between XZ I and GP II and their respective controls, but there was no significant difference between XZ I and GP II. The order of soil water storage was GP II (625.7 mm) > XZ I (606.4 mm) > CK II (574.7 mm) > CK-XZ (551 mm). Compared with 2022, the annual soil water storage in 2023 decreased, mainly due to the reduction of rainfall in 2023, and the order was GP II (597.3 mm) > XZ I (586.1 mm) > CK II (548.7 mm) > CK-XZ (532.6 mm).

Table 3 Soil water storage of each forest stand in Zixing mm

Rainfall interval // mm	XZ I		CK-XZ		GP II		CK II	
	2022	2023	2022	2023	2022	2023	2022	2023
< 10	82.2	81.5	72.1	72.4	81.6	78.5	77.1	70.4
10 – 20	162.3	155.1	152.1	144.9	181.4	170.9	169.7	152.2
20 – 30	97.7	96.6	90.3	89.2	101.1	99.4	90.2	89.9
30 – 40	72.3	71.1	67.2	65.7	75.3	73.2	64.9	73.8
40 – 50	21.4	20.3	12.2	11.2	10.4	9.1	8.4	6.1
≥50	170.5	161.5	157.1	149.2	175.9	166.2	164.4	156.3
Total	606.4	586.1	551.0	532.6	625.7	597.3	574.7	548.7

3.3 Surface runoff From 2022 to 2023, the annual surface runoff of Zixing's various model plots was between 43.24 and 50.99 mm. The annual runoff difference between XZ I and GP II was not significant, and the difference between each stand and its control was not significant. The order of runoff in the same year was CK-XZ > CK II > XZ I > GP II. Among the six rainfall intervals, the runoff of each model stand was the lowest in the range of 0 – 10 mm, and there was more runoff in the intervals of 10 – 20 mm and ≥50 mm (Table 4).

Table 4 Interval distribution of annual runoff in each forest stand of Zixing mm

Rainfall interval//mm	XZ I		CK-XZ		GP II		CK II	
	2022	2023	2022	2023	2022	2023	2022	2023
<10	5.62	5.19	7.01	6.47	5.58	5.41	6.68	5.68
10-20	9.64	9.95	9.84	9.34	9.60	9.62	9.88	9.47
20-30	6.41	6.42	7.40	7.17	6.62	6.34	7.63	7.66
30-40	6.94	6.85	7.47	6.64	5.97	5.45	6.72	6.29
40-50	6.68	6.12	7.63	7.43	6.24	7.24	7.03	7.52
≥50	11.61	9.97	11.64	11.83	10.98	9.18	10.12	10.36
Total	46.90	44.50	50.99	48.88	44.99	43.24	48.06	46.98

3.4 Characteristics of soil loss The difference of soil erosion modulus between XZ I and GP II in Zixing monitoring area was significant (Table 5). From 2022 to 2023, the order was XZ I > GP II, and the number was between 127.37 and 165.58 t/(km^2 · y), indicating that the artificial interference in the process of replanting of GP II model had little impact on it, and water and soil loss was less. There was a significant difference between the stands and the control, which may be mainly because the implementation time of the project was still short, and the soil and water conservation effect of understory replanting has not been fully displayed in a short time. The difference of the same stand in different years was not significant, which showed that the soil and water loss of the same stand was mainly affected by the rainfall characteristics in different years.

Table 5 Changes of annual soil loss in various forest stands of Zixing t/(km^2 · y)

Rainfall interval//mm	XZ I		CK-XZ		GP II		CK II	
	2022	2023	2022	2023	2022	2023	2022	2023
<10	5.35	4.79	4.96	7.37	4.21	5.15	6.83	7.03
10-20	35.29	15.34	26.47	24.66	15.83	11.23	28.08	25.37
20-30	28.64	25.91	36.14	35.13	26.35	25.81	36.80	36.13
30-40	28.37	27.34	35.84	42.98	35.91	32.28	37.24	43.98
40-50	22.61	22.68	23.62	27.23	20.89	20.99	21.35	26.23
≥50	45.32	43.75	65.03	43.95	32.67	31.91	63.85	41.28
Total	165.58	139.81	192.06	181.32	135.86	127.37	194.15	180.02

4 Discussion

As an important ecological function area, the water conservation and soil and water conservation functions of the forest ecosystem in the Dongjiang Lake basin are very important for regional ecological security and sustainable utilization of water resources. It is of great practical significance to effectively improve the efficient water conservation and soil and water conservation functions of secondary forests and plantations in the Dongjiang Lake basin by regulating the structure of forest plant communities and improving their functions.

The research showed that the water conservation capacity of forest can be significantly improved by replanting native tree species and optimizing stand structure[1]. It was pointed out that the soil and water conservation capacity of mixed forest was better than that of pure forest, because the mixed forest had more complex root structure and richer litter layer, which can effectively intercept rainfall, and reduce surface runoff and soil erosion[2].

Function upgrading and transformation refers to the adoption of a series of measures to improve the material circulation and energy flow of forest ecosystem and improve its ecological service function. For example, studies have shown that through fertilization, irrigation and other measures, the growth and biomass of forest vegetation can be improved, so as to enhance its water conservation capacity[3]. It was pointed out that soil and water loss can be effectively reduced by building sand retaining dams, horizontal ditches and other soil and water conservation projects[4].

Through the structural regulation and functional upgrading of forest plant communities[5-7], the efficient water conservation and soil and water conservation functions of secondary forests and plantations in the Dongjiang Lake basin can be effectively improved, which is of great significance for ensuring regional ecological security and sustainable utilization of water resources.

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