EXPERIMENTAL STUDY ON THE EFFECT OF WATER QUALITY ON RAINFALL EROSION

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水质对土壤降雨侵蚀影响的实验研究

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ABSTRACT

Considering the serious soil and water losses that impede the development of agricultural production in Loess Plateau in China, this study investigated the soil water infiltration, runoff yield, and sediment yield through simulated rainfall using rainfall water of different qualities; additionally, this study investigated the influence of water quality on rainfall-induced erosion. The effects of rainfall water quality on soil erosion under artificial simulation were studied in the State Key Laboratory of Soil Erosion and Dryland Farming on the Loess Plateau from 2015 to 2016. This experiment used four rainfall water types (water, natural precipitation, natural hydrops, and tap water) and three typical loess plateau soil samples (Loessal soil, Lou soil, and laminated Lou-Sand). The effect of water quality on soil erosion under the same rainfall intensity (60mm/H) and slope (5°) was determined. Results showed that the intensity of rainfall erosion was significantly affected by water quality, and soil erosion intensity gradually decreased with increased sodium adsorption ratio and conductivity (water<natural precipitation<natural hydrops<tap water) under natural hydrops; the runoff coefficient of soil erosion was the lowest (29.3%) under natural hydrops; stable infiltration rate and rainfall erosion were the lowest under rainfall hydrops; and soil erosion was the highest under water. Moreover, the influence of water quality on rainfall erosion was affected by soil type. Compared with the Loessal soil, which contains low amount of clay particles, the erosion of rainfall to the Lou soil with higher content of clay particle was more susceptible to the water quality. Water quality plays an important role in soil erosion and exerts more significant effects on soil with higher clay content. Therefore, water quality factors must be fully considered in studying and simulating rainfall erosion.

摘要

针对中国黄土高原水土流失严重，阻碍农业生产发展的现状，研究不同水质的水在模拟降雨条件下的土壤入渗和产流产沙特征，揭示水质对降雨侵蚀过程的影响。于 2015-2016 年在黄土高原土壤侵蚀与旱地农业国家重点实验室，开展了人工模拟条件下不同降雨水质对土壤侵蚀影响的研究。本实验设计了 4 种降雨水质（去离子水、天然降水、天然积水、自来水）和 3 种典型的黄土高原土壤（黄绵土、塿土和层状塿-砂）,在相同降雨强度（60mm/h）和坡度（5°）的条件下，水质对土壤的侵蚀状况的影响。研究结果表明，降雨侵蚀的强度受水质的显著影响，随着水中钠吸附比和电导率的增加(去离子水<天然降水<天然积水< 自来水)，土壤侵蚀强度逐渐降低（天然积水下的塿土径流系数最低,为 29.3%）；降雨积水条件下，土壤稳定入渗率最高，降雨侵蚀程度最低，而去离子水对土壤的侵蚀程度最大。水质对降雨侵蚀的影响特征还受土壤类型的影响，粘粒含量较高的塿土降雨侵蚀受水质影响比粘粒含量较低的黄绵土更加明显。因此，水质在土壤侵蚀过程中起着重要作用，且对粘粒含量较高的土壤作用更加明显，在模拟降雨侵蚀研究方面需要充分考虑水质因素.

INTRODUCTION

Agricultural development in arid and semiarid areas is achieved mainly by fully utilizing natural precipitation, by reducing surface runoff, and by increasing soil moisture. Given the fragility of the ecological environment, sustainable development of modern agriculture and the possibility of obtaining high yield of existing agricultural land have become very difficult. The quality of atmospheric precipitation will exert a direct impact on soil quality and crop yield.

The Loess Plateau in China has a fragmented terrain and scarce vegetation cover; moreover, rainfall commonly occurs as heavy rain, and variation in land is lacking. Erosion resistance of Loessal soil, especially its antiscourability, is quite weak and thus is not suitable for the implementation of agricultural cultivation measures, which in turn become the common leading factors of soil erosion *(Jie et al., 2004)*. For a long time, the erosion resistance of Loessal soil not only limited the sustainable development of agriculture in this area but also became the root cause of the low income of farmers. Loess Plateau mainly consists of loose Loessal soil, which is characterized by low fertility, low content of agglomerates, and high vulnerability to rainfall erosion. This region has a heterogeneous land structure, showing a layered distribution; with intensified rainfall erosion, the fertile topsoil thickness gradually decreases, and land production efficiency has become low and unstable.

Artificial rainfall simulation effectively regulates rainfall and rapidly realizes the erosion process; this approach is widely used in soil and water conservation research *(Wenyan et al., 2005; Guangyan et al., 2011)*. The results have shown that the simulated rainfall water quality exerts a significant impact on soil erosion process, and the degree of influence is significantly affected by soil type (*Lili et al., 2015*). Lorenzo found that rainfall water quality can change the process of soil erosion, and the influence of water quality on silty clay soil is larger than that on silty loam (*Borselli et al., 2001)*. Zhang showed that the soil erosion amount increases as the sodium adsorption ratio (SAR) of irrigation water increases, whereas it gradually decreases as conductivity increases *(Lijun et al., 2010)*. Therefore, studying the impact of water quality on rainfall erosion has important theoretical and practical significance in revealing the characteristics of rainfall erosion and the choice of water quality in simulated rainfall experiment. Moreover, the present research was conducted to provide some data useful in preventing soil and water losses in Loess Plateau region and improve the utilization rate of natural precipitation and promote agricultural development.

The physical and chemical properties of aqueous solution can significantly affect soil water potential and hydraulic conductivity *(Yuli Zhao and Jianzhi Niu, 2012)*. Studies have shown that the type and content of solute in water affects the density, surface tension, and viscosity of water, affecting the movement of water in soil pores *(Caijing Zhou, 2008)*. At present, the effects of solute on soil hydrodynamic parameters are mostly saline material. The hydraulic conductivity of soil has been suggested to be related to the composition and content of exchangeable cations in soil solution and soluble electrolyte concentration *(Carter and Robbins, 1978; De and Wierenga, 1984)*, and the hydraulic conductivity decreases as SAR increases; when distilled water was used to simulate rainfall, hydraulic conductivity decreases *(Oster and Frenkel, 1980)*. Xiao studied the impact of irrigation water quality on the hydraulic properties of unsaturated soil and found that highly mineralized irrigation water could increase soil hydraulic conductivity *(Zhenhua Xiao and Hongfu Wan, 1998*); Feign found that increased sodium ion content of irrigation water can cause soil particle contraction and colloidal particle dispersion and expansion, thereby affecting soil permeability (*Feigin et al., 1991)*. To a certain extent, increase in soil salt concentration can promote flocculation of soil particles, increase in aggregate ability, stabilization of soil structure, increase in soil macrospores, and enhancement of permeability. Therefore, water quality is quite important in soil moisture movement and soil structure. However, studies on rainfall erosion have devoted little attention on the impact of water quality. Investigations on soil erosion will not only help to improve the existing theory on soil erosion but will also provide an important basis for accurate prediction of soil erosion under different rainfall conditions.

Loess Plateau is characterized by loose soil, sparse vegetation, serious erosion, and fragile ecology. Soil erosion has long been a core problem that constrains ecological civilization construction and regional sustainable development in Loess Plateau. Discussing the influence of water quality on rainfall erosion process is of great significance in understanding the process, intensity, and model prediction of soil erosion in this area, and it is a kind of sustainable circular agriculture with very important ecological protection significance. In Loess Plateau, a large number of artificial simulated rainfall experiments were conducted, and the water used for the simulated rainfall was mostly tap water or well water. Given that water quality in different places obviously varies, the effects of water qualities on rainfall erosion will also vary in artificial simulated rainfall experiments. In this study, where Loessal soil and Lou soil were used as research objects, artificial simulated rainfall experiments were conducted using deionized water, tap water, natural precipitation, and natural hydrops, and the influence of water quality on slope runoff and sediment yield and soil water infiltration was analysed to reveal the influence of water quality on rainfall erosion, providing a scientific basis for accurate prediction of soil erosion process.

MATERIAL AND METHODS

Rainfall simulator

A simulated rainfall experiment was conducted in the Hall of Artificial Simulated Rainfall in the State Key Laboratory of Soil Erosion and Dryland Farming of Loess Plateau, Northwest A & F University, China from 2015 to 2016. Disturbed soils were studied, and homogenous Lou soil, Loessal soil, and Lou-sand laminated soil were used as samples. Loessal soil was collected from Ansai County of Shaanxi Province (109°19′46″N,36°51′44″E); Lou soil was collected from Yangling Demonstration Zone of Shaanxi Province (108°5′40″N, 34°16′20″E); and river sand was collected from the riverbed of Weihe, Yangling (108°4′39″N, 34°14′9″E). Table 1 shows the physical and chemical properties of the soil samples. The soil samples were air-dried, pressed, crushed, screened through 5 mm sifter, and mixed for subsequent use. Bulk density was controlled based on the bulk density of the undisturbed soils (Sandy soil, Lou soil, and Loessal soil). For the air-dried soils, the required soil quality for each processing was calculated according to the volumetric moisture content (approximately 2%) and soil bulk density for layered filling. Special plate was used to blur the layer to prevent vertical layering of soil.

Table 1

Physical and chemical properties of soil samples

	Particle composition /% Non-mulching			**Texture**	**Dry bulk density [g/cm^3]**	**Ks [mm/min]**
Particle sizes [mm]	0-0.002	0.002-0.05	0.05-1.00			
Homogenous Lou soil	22.8	68.5	8.7	silty loam	1.4	0.020
Sand soil	4.49	20.87	75.64	medium sand soil	1.8	2.791
Loessal soil	9.10	61.80	29.10	silt loam soil	1.2	0.577

Materials and experimental design

Experiments were performed using a fully saturated design. Three types of soil exist: Lou soil (L), Loessal soil (Lo), Lou soil (L)-Sandy soil (S); four types of rainfall water exist: water (C), natural precipitation (R), natural hydrops (J), and tap water (Z). After different combinations of soil types and rainfall water quality were made, 12 treatments were designed, and each treatment was performed three times.

The experiment involved the use of water supply device, rainfall simulator, and soil bin (Figs.1 and Figs.2). The rainfall simulator was a movable needle-type sealed box with a height of H_2=40cm, a length of L_1=145cm, a width of W_1=145cm, and a needle spacing of D=2 cm. The average diameter of the raindrops is d = 2.97 ± 0.05 mm, the rainfall height is H_1=220 cm and the rainfall uniformity was greater than 94%. Rain intensity was controlled by a peristaltic vacuum pump. An erosion soil bin (100 cm × 40 cm × 30 cm) was self-manufactured. Evenly distributed holes were created at the bottom of the soil bin to exclude gravity water. The rainfall intensity was 60 mm/h, and the soil bin slope was set as 5°, which was quite common in Loess Plateau, and the duration of rainfall was 60 min.

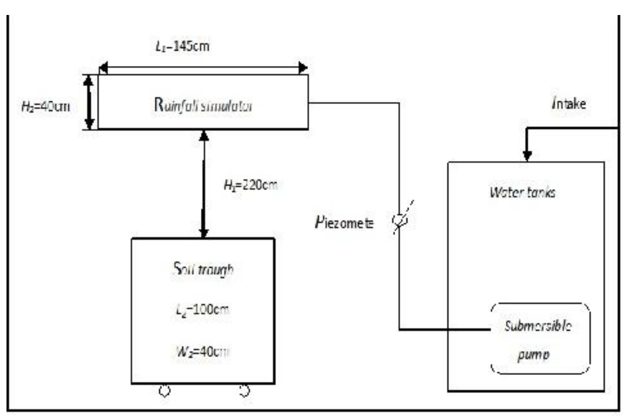

Fig.1 - Schematic of artificial simulated rainfall device

Fig.2 - Artificial simulated rainfall device

During rainfall, runoff and sediment samples were collected every 3 min from the time when the flow yield was observed on the slope. After the rainfall was finished, the runoff collected was measured, the sediment was separated, and the amount of sediment was measured by using the drying method. The infiltration rate was calculated as follows equation (1) *(Yuanjun Zhu and Ming-an Shao, 2006)*:

$$i = R\cos^{-} - \frac{F-A}{K \cdot A \cdot T} \quad \text{[cm/min]} \tag{1}$$

where:

i is the infiltration rate, [cm/min]; R is the rainfall [cm]; T is the duration of rainfall [min]; θ is the slope of soil bin [°]; F is the flow yield within the interval [g/min]; S is the sediment yield within the interval [g/min]; K is the conversion ratio [1g/cm^3]; A is the cross sectional area of soil bin [cm^2].

Prior to the rainfall test, three rain gauges were placed in the areas where the soil bins were located. Calibration was performed after the rainfall intensity stabilized. The mean was determined and taken as the rainfall intensity. The formula was as in the following equation (2) *(Qianhua et al., 2015)*:

$$P = \frac{P_1 + P_2 + P_3}{3 \times T} \qquad \text{[mm/min]} \tag{2}$$

where:

P is the average rainfall intensity [mm/min]; T is the rainfall duration [min].

The water types used in the artificial simulated rainfall include water, tap water, natural precipitation, and rainfall hydrops. The water was produced by the Institute of Soil and Water Conservation, CAS&MWR; compounds and ions were not detected. The tap water was collected from the residents of Yangling District, Shaanxi; natural precipitation was collected from natural rainfall in Yangling, Shaanxi. Rainfall hydrops was a natural precipitation that has been stored for more than one year. Table 2 shows the SAR, pH value, and conductivity of the four water types.

Table 2

Physical and chemical properties of different types of rainfall water

Type of water quality	sodium adsorption ratio [m•Mol/L]	pH	conductivity [μS/cm]
Water[D]	0.00	7.04	3
Natural precipitation[P]	0.03	7.76	36
Natural hydrops[H]	1.47	7.97	452
Tap water[T]	2.24	7.78	634

Data analysis

SPSS software was used for correlation analysis, and Excel and Origin were used for correlation calculation and chart drawing.

RESULTS

Changes in soil flow yield and runoff coefficient

Flow yield time and runoff coefficient are important indexes that characterize soil water infiltration; these indexes are affected by factors such as soil type, rainfall intensity, and slope *(Zhixin Xu and Mengli Zhao, 2001)*. Initially, rainfall completely infiltrates into the soil, and no runoff yield is observed in the slope. When the rainfall intensity is greater than the infiltration capability of the soil, the excess rainfall will cause slope runoff. The initial flow yield time is the main factor affecting the runoff process and the degree of rainfall (*Tianxu et al., 2011*).

Table 3 shows the flow yield time and runoff coefficient in different soils as a function of water quality. We could see that:

Table 3

Flow yield time of soils under different water qualities

	Flow yield time, s			Runoff coefficient, α		
Water quality	**Lou soil**	**Loessal soil**	**Lou soil-sandy soil**	**Lou soil**	**Loessal soil**	**Lou soil-sandy soil**
Water [D]	240.0	1800.0	180.0	0.618	0.264	0.683
Natural precipitation [P]	480.0	1560.0	360.0	0.458	0.297	0.502
Natural hydrops [H]	978.0	1320.0	840.0	0.293	0.299	0.378
Tap water [T]	540.0	1620.0	360.0	0.440	0.287	0.498

For the homogenous Lou soil and Lou soil-sandy soil (Top Lou soil layer and bottom Sand layer), as SAR and conductivity of rainfall water increased, the flow yield time was postponed and the duration of natural hydrops was extended. Moreover, as soil and water erosions and conductivity of rainfall increased, the flow yield time started to decrease, indicating that SAR and conductivity of rainfall water showed the highest threshold values. This result suggested that water quality could reduce the intensity of rainfall-induced soil and water erosions. The flow yield time of Loessal soil was longer than that of Lou soil because the infiltration capability of the Loessal soil was stronger than that of Lou soil, and it was characterized by loose particles and strong water absorption capacity. For the Loessal soil, as the SAR of rainfall, the flow yield time decreased and the natural hydrops showed the shortest duration. Moreover, as the SAR of rainfall increases, the flow yield time decreased once again; this pattern was opposite that of the variations in Lou soil and Lou soil-sandy soil. The infiltration rate was related to the physical properties of oil, as follows: (1) Soil texture. The structure and texture of soil were not uniform, facilitating blockade of water. Therefore, the infiltration capability of Lou soil-sandy soil was weaker than that of Lou soil. (2) Bulk density of soil. Previous results showed that the higher the bulk density, the lower the infiltration rate (*Jiangsu Wen, 2012*) and the shorter the flow yield time. The increasing flow yield times were as follows: Lou soil-sandy soil < homogenous Lou soil < Loessal soil. The slope runoff was calculated using the water balance method, that is, runoff was the difference between rainfall amount and infiltration amount. Therefore, the slope runoff was closely related to soil water infiltration rate. If the infiltration rate was large, the runoff amount was small. If the soil pores of Loessal soil were large, the flow yield time was long, and the runoff generation time would be postponed. Therefore, the runoff coefficient would be low. The soil water infiltration rates of Lou soil and Lou soil-sandy soil were low, the bulk densities were large, the flow yield times were short, and the runoff coefficients were large. Additionally, due to the laminated structure of Lou soil-sand soil, the sandy soil of lower layer blocks the water (*Wenyan et al., 1995; Wenyan et al., 2005*). As a result, the permeability of the soil to water was considerably small, the runoff increased, and the runoff coefficient was the greatest. From the perspective of rainfall water quality, the runoff coefficient of natural hydrops was the lowest, whereas that of the deionized water was the highest. The type of rainfall water displaying the appropriate SAR and conductivity can relatively relieve the erosion effect of soil with high viscosity.

Influence of water quality on soil water infiltration

Infiltration rate is the amount of water that infiltrated the soil within a given time, reflecting the infiltration capability of soil. Generally, for the three soil types under any rainfall water quality, soil water infiltration rates decreased as time was shortened (Fig.3). The results of the independent sample T examination showed that for Lou soil and Lou soil-sandy soil, the soil water infiltration rate of the deionized water was significantly lower than that of the three other rainfall water types ($p<0.05$), and the rainfall hydrops showed the highest soil water infiltration rate. The soil water infiltration rate of tap water and natural precipitation did not significantly differ ($p>0.05$). Different from Lou soil, under four water qualities, the Loessal soil didn't display significant difference in terms of soil water infiltration rate ($p> 0.05$). The soil water infiltration rates of the four water types were quite close for the first 30 min after infiltration. Therefore, the influence of water quality on soil water infiltration rate depends on soil type.

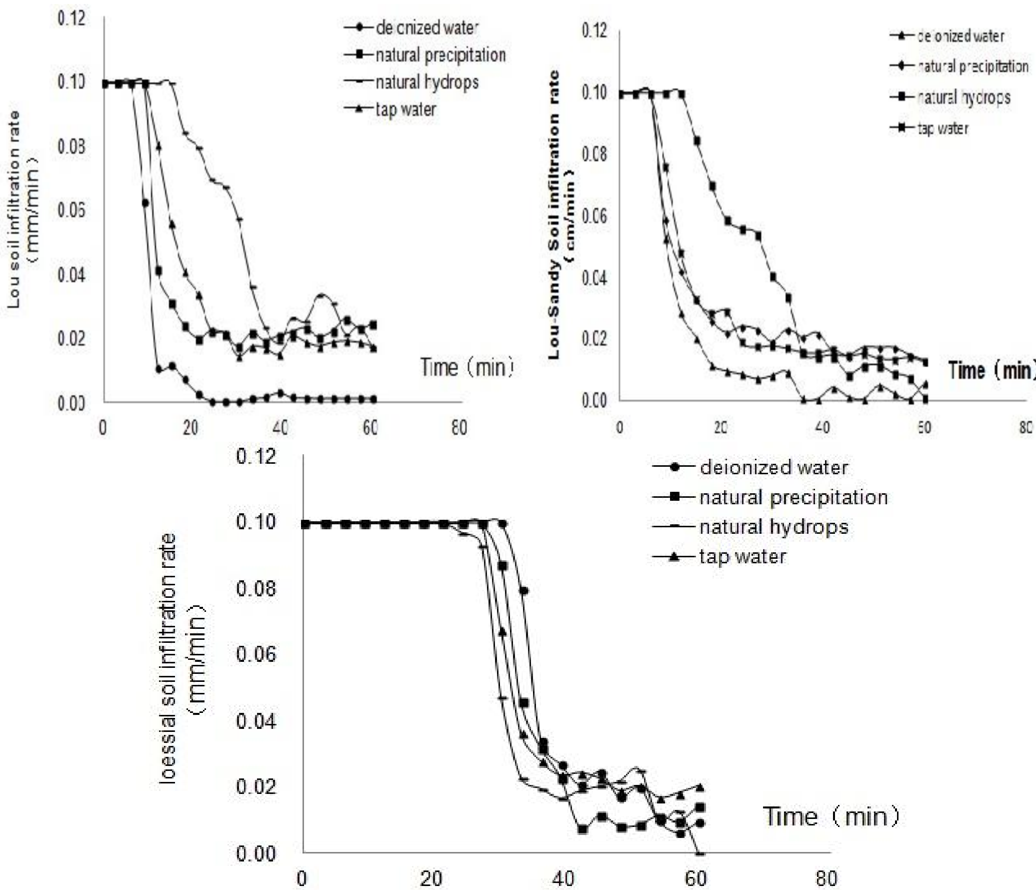

Fig.3 - Changes in soil water infiltration rate of artificial simulated rainfall

Water quality matters only for heavy clay soil; thus, for Lou soil and Lou soil-sandy soil, the soil water infiltration rate was higher under the natural hydrops than that under the four other rainfall water types. The decreasing infiltration rate of the different water types was as follows: natural precipitation > tap water > natural precipitation > deionized water. With the SAR and conductivity of rainfall, the infiltration rate of soil increased while the soil erosion decreased. However, the rate of soil erosion was the lowest under natural hydrops. As the SAR increased, the soil water infiltration rate decreased, whereas the erosion worsened, indicating that the SAR and conductivity had a range of threshold values. The SAR of deionized water was 0; thus, when deionized water infiltrated into the soil, no spectrometer exchange occurred. By contrast, the sodium ions would be dissolved, which changed the flocculation of clay particle and promoted the dispersion. As a result, soil pores were blocked, and soil water infiltration rate decreased. Figure showed that in terms of SAR, an inflection point was observed under the effect of natural hydrops. The tap water showed the highest SAR, and the infiltration rate of tap water was lower than that of natural hydrops. Therefore, the SAR of rainfall water that promotes soil water infiltration was confined within a certain range.

Flocculation of soil clay particle and the stability of soil aggregates are determined by the composition of ion concentration of soil solution, which further determine the conductive capability and infiltration rate in soil and the difficulty of runoff generation on earth's surface *(Fahu Li and Guojing Rong,2004)*. The different water qualities of artificial simulated rainfall will lead to the different electrolyte concentrations and conductivities. The increase in electrolyte concentration in soil solution will promote the formation and development of soil crust, and the increase in conductivity of soil solution will inhibit the formation of soil crust, which will further affect the runoff and sediment yield during rainfall erosion. Hydration will occur if rainfall water of different qualities acts on the soil. The base cations will cause the soil to swell and explode. The aggregates are damaged, and the particles are dispersed, blocking the pores. As a result, the hydraulic conductivity or infiltration rate of soil decreases. In this study, the clay particle content of Lou soil (22.8%) was higher than that of Loessal soil (9.1%). The influence of water quality on the infiltration rate of Lou soil is higher than that on the infiltration rate of Loessal soil, consistent with the results of Ben-Hur et al. (*Ben-Hur et al., 1985*).

Influence of water quality on flow and sediment yields

Fig.4 showed the runoff and sediment yield caused by erosion of Lou soil, Loessal soil, and laminated soil under the four types of rainfall water. During erosion, natural hydrops showed the lowest runoff and sediment yield, whereas the water showed the highest runoff and sediment yield (Fig.4). In the two-layered structure of Lou soil and laminated Lou soil-sandy soil, the decreasing erosion capabilities of rainfall water types were as follows: water > natural precipitation > tap water and natural hydrops. Therefore, in the artificial simulated rainfall experiment, the water quality greatly influenced the test results and thus was a factor that cannot be ignored. Moreover, a proper increase in SAR of rainfall water with different qualities (contents of sodium, magnesium, and calcium ions in aqueous solution) can prevent slope erosion. These ions will prevent slope erosion to some extent.

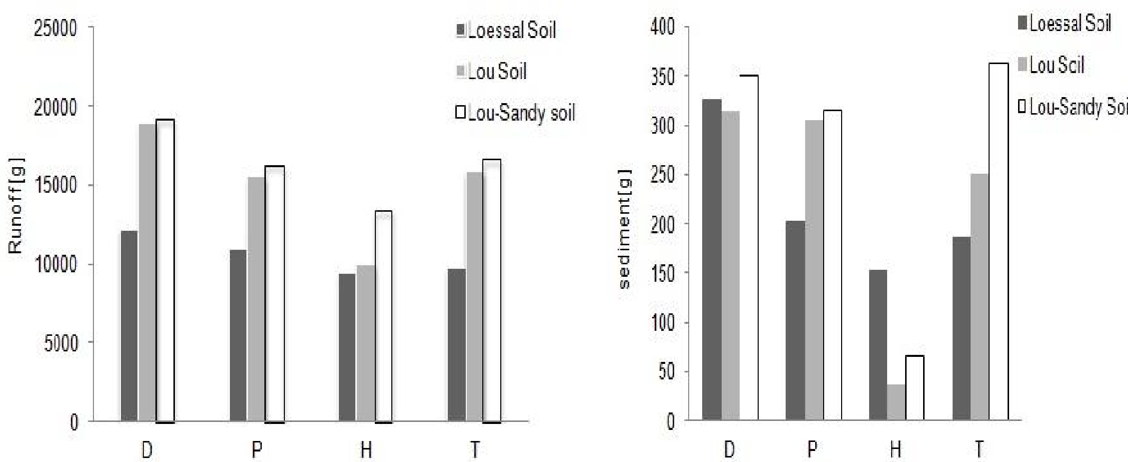

Fig.4- Changes in rainfall runoff and sediment yield under different types of rainfall water.

Application of Philip infiltration model in rainfall infiltration process by using different SARS

The influence of SAR on the characteristics of soil water infiltration is simulated using a Philip infiltration model, and the infiltration of rainfall water types with different SAR changes with time. The Philip model assumes that at any moment of infiltration, the infiltration rate displays the relationship of power series with time, and the specific infiltration model was as follows equation (3) (*Zhongdong Wu and Quanjiu Wang, 2008*):

$$I(t) = S t^{0.5} + A \quad [cm] \tag{3}$$

Where:

I is the accumulated infiltration amount [cm]; S is the infiltration rate [cm/min$^{0.5}$]; *A* is the stable infiltration rate [cm/min]; and *t* is the infiltration time of rainfall [min].

In equation (3), the relationship between accumulated infiltration amount and was expressed as a quadratic equation (the intercept is 0). After being fitted, the coefficients of the quadratic term were the stable infiltration rate A. The coefficient of one degree term was the infiltration rate S. Moreover, because *A* = i(∞), during rapid infiltration, it could be considered as *A* = 0 (*A* = *i*(∞)). The fitted equation was the straight line passing through the origin, and its slope was the soil infiltration rate *S*.

Table 4

Physical and chemical properties of different types of rainfall water

Type of water quality	Type of water quality	Water	Natural precipitation	Natural hydrops	Tap water
Homogenous Lou soil	*S*	0.277	0.302	0.338	0.329
	R^2	0.988	0.955	0.971	0.978
	Fitting equation (I)	$0.277t^{0.5}$	$0.302\ t^{0.5}$	$0.338\ t^{0.5}$	$0.329\ t^{0.5}$
Lou soil-sandy soil	*S*	0.257	0.301	0.391	0.292
	R^2	0.995	0.980	0.954	0.990
	Fitting equation (I)	$0.257\ t^{0.5}$	$0.301\ t^{0.5}$	$0.391\ t^{0.5}$	$0.292\ t^{0.5}$

Note: R^2-Pearson product-moment correlation coefficient

The water quality did not significantly influence the Loessal soil. Therefore, the Philip infiltration model was used to simulate the Lou soil and Lou soil-sandy soil. Table 4 showed that the sequence of infiltration rate (as determined using the Philip model) for the homogenous soil and the Lou soil-sandy soil with similar initial moisture content under the one-dimensional rainfall infiltration was as follows: natural hydrops → tap water → natural precipitation → water. Comparison of the result of the Philip model with the observation results suggested that when SAR was relatively low, (its SAR was smaller than that of natural hydrops), the results of the Philip infiltration model is similar to the experimental results; when the SAR was relatively high (its SAR was smaller than that of natural hydrops), and the experimental demonstrated that as SAR increases, the infiltration rate of soil reached the highest when the SAR was the one of natural hydrops. As the SAR increased, the infiltration rate decreased. Therefore, when SAR was relatively low (its SAR was smaller than that of natural precipitation), the results of the Philip infiltration model was opposite to the experimental results. This finding indicated that when the Philip infiltration model was applied to study the infiltration rates of rainfall waters of different qualities, the calculation results would be more accurate for the rainfall water type with low SAR. For the water quality with a relatively high SAR, the calculation results showed certain deviations, consistent with the results of Zhongdong Wu, although the specific mechanism remains to be studied.

CONCLUSIONS

Artificial simulated rainfall experiment was conducted to study the influence of the quality of four types of rainfall water (water, tap water, natural precipitation, and natural hydrops) on soil water infiltration and soil erosion under the same rainfall intensity and slope, as well as determine the influence of the water quality of rainfall and farmland irrigation on soil quality. In this study, Loessal soil and Lou soil were used as soil samples. The following conclusions were drawn.

(1) Water quality significantly influenced the infiltration rate in Lou soil and Lou soil-sandy soil. Water showed the lowest soil water infiltration rate, which was significantly different from that of tap water, natural precipitation, and rainfall hydrops, whose soil water infiltration rates did not significantly vary. Water quality did not significantly influence the rainfall infiltration rate. Therefore, the influence of water quality on soil water infiltration rate depended on soil type. The low infiltration rate worsened the soil condition, promoted water erosion, and reduced soil quality, affecting soil productivity.

(2) Water quality significantly influenced the characteristics of erosion runoff and sediment yield. As the salt concentration of rainfall water increased, the erosion intensity of the soil gradually decreased. The influence of water quality was considerably more significant in Lou soil with relatively high clay particle contents; in Loessal soil, as salt concentration of rainfall water increased, the degree of soil erosion gradually decreased, indicating that the influence of transportation process of eroded sediment was made more complicated by water quality relative to the influence of the runoff process. For this reason, the influence of water quality on the erosion intensity varied depending on the soil type.

(3) When the Philip model was adopted in simulating the infiltration of rainfall water of different qualities, relatively accurate calculation results for the rainfall water with relatively low SAR were obtained. For the aqueous solution with relatively high SAR, the results obtained using the Philip model displayed a certain

degree of deviation. That is, the SAR of rainfall water had certain range of threshold value. In this experiment, rainfall erosion was lowest when the SAR equals the SAR of natural hydrops.

Studies on water quality are conducted in irrigated farmland. In this work, the problem on water quality was incorporated in the rainfall experiment to study the influence of water quality on soil erosion process. Meanwhile, it is combined with the laminated soil stricture, providing a new theoretical basis for soil infiltration mechanism. Given that the water containing different solutes enters into the soil, the solute content of soil solution will change, and the soil solute will undergo chemical and physical processes during movement of solution on the earth's surface and underground. A complex material migration system is formed due to multiple factors and the interactions of these factors. A more comprehensive analysis of the quantitative relationship between soil erosion and migration of soil is necessary, and a mathematical model of soil erosion must be established to provide scientific basis for agricultural production and disaster prevention and control.

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