Under artificial rainfall the transport law of pollutants with runoff in farmland in southwest mountains of Henan Province

Guozhong Wang[1] ,Yingchao Tian[2], Jiangang Qu[2] , Jianzhao Xu[2], Zhanxin Liu[2] ,Dongfeng Yan[3]

[1]Hydrology and water resources of Yellow River scientific research institute

[2]Soil and water conservation supervision and inspection station in Henan Province

[3]Forestry college of Henan agricultural university

KEYWORDS: artificial rainfall, surface runoff, farmland, pollutant, rainfall intensity
ABSTRACT: Slope cropland and terrace are common land use types in Danjiangkou reservoir catchment areas and indoor artificial rainfall simulation methods are employed to study nutrients' loss law of the two soils under different rainfall intensities, for the layout of soil conservation measures in farmland and the improvement of farming practices. The results are as follows: the pollutants TN, TP and COD in the two kind soils are wavy variation with rainfall time, the greater the rainfall intensity, the more loss of TP and COD, but some exceptions for TN, the accumulation concentration reaches the largest when the rainfall intensity is at 2.5 mm/min, second of 3.0 mm/min and the least of 0.5 mm/min.

INTRODUCTION

Rainfall can induce agricultural nonpoint source pollution，which not only makes the surface water quality deterioration, also brings a series of social problems [1-3]. So it's necessary to carry out the research on nutrients loss of farmland in rainfall and runoff. Artificial rainfall method can test the conclusions under the condition of natural rainfall also can make up for the results the natural rainfall in short duration can't access to [4-6].

Hilly land and terrace are common agricultural land types of Danjiangkou reservoir catchment areas, the contaminants from which, such as fertilizer, pesticides, pesticide residues etc. will inevitably produce serious non-point source pollution and impact on water quality of the reservoir by soil erosion [7-8]. The two types soil in the reservoir were as the research object, indoor artificial rainfall simulation equipment from Chinese academy of sciences institute of soil and water conservation was adopted to study pollutants in the two kinds of soil transporting law under different rainfall intensity, to provide the basis for zonal land use, soil and water conservation, and rainfall resources efficient utilization.

MATERIALS AND METHOD

Test materials and conditions

The experiments are done by slope village and test equipment includes five parts: artificial rainfall simulator, trial soil bin, sampling system of runoff and sediment, runoff measurement system and nutrients testing system. Artificial rainfall device is made of steel plate with two millimeter thickness keeping five degrees inclined, total height of which is 1.6 meters. The water distributor with uniform pore size is installed above the device and raining height is 1.05 meters, rotor flow meter is setup to control rainfall intensity. The soil bin size is 70 centimeters length, 40centimeters width and 20 centimeters height; runoff exporting size is 30centimeters length, 3centimeters width and 3centimeter height, a basin is placed at the exit of runoff.

The experiments of artificial rainfall had been done during April to August in 2012 in institute of soil and water conservation CAS and rainfall intensity was respectively designed as 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 mm/min. Rainfall simulation device was turned on after a soil being filled into the soil bin and a rainfall intensity selected, the time was recorded and samples of water and soil were collected every 10 minutes when runoff appearing. 500 milliliters of runoff sample were taken out from basin after rainfall into the basin and standing for 10 minutes, filtering and drying, weighed value of the soil was the amount of silt load and the rest of soil in basin was bed load collecting, drying and weighing. After 100 minutes the rainfall was stopped and the soil was dug up, another kind of soil was put into the bin to continue the rainfall test in the same rainfall intensity. The tested soil was placed in the container dried naturally and waiting for next rainfall intensity. The nutrients loss of five kinds of soil was tested in sequence under six types of rainfall intensity.

The tested soil was from five land use types in southwest mountains of Henan Province near Danjiangkou Reservoir: woodland (timber forest and shrubby grassland)，farmland (terraces and slope cropland) and waste-grassland. Firstly, sample plots of the five kinds of soil were selected and then the soil of plough layer were collected respectively, no sieved, kept original state and carried back to the laboratory. The amount of soil need fill were calculated by the area of soil bin and bulk weight. The soil was compacted one time each 2.5 cm thickness filled and grabbed the lower soil surface before filling the upper soil to prevent the soil appearing phenomenon of delamination.

Test items and method

The content of total phosphorus (TP)，total nitrogen (TN) and chemical oxygen demand (COD) need be tested in the samples of sediment and runoff, tested methods of which are shown in table 1.

Table 1: The test items and methods

Indexes	Tested methods	Test standard
TN	Alkaline potassium persulfate digestion-UV spectro photometric method	GB 11894-89
TP	Ammonium molybdate spectrophotometric	GB 11893-89
COD	Rapid spectrophotometric method	HJ/T399-2007

RESULTS AND DISCUSSION

Three kinds of rainfall intensities were selected for TN: 0.5, 2.5, 3.0 mm/min, four to TP: 0.5, 2.0, 2.5, 2.0 mm/min and three for COD: 1.0, 2.0, 3.0 mm/min.

Raining test result analysis in hilly land

The nutrient loss in farmland is an interaction process of infiltration, runoff and soil [9]. The nutrient loss law with runoff in the slope cropland soil of research area was shown in table 2.

From table 2, TN changed by wave variation trend would be some reduced when rainfall intensity was larger in hilly land, which was the role of rain splash erosion, runoff scouring and the turbulence diffusion of solute that made concentration of TN increasing in runoff at early producing flow, and it would be attenuation after reaching a peak value because continuous rainfall turned splash erosion into a thin layer of water erosion and reduced the ability of solute into runoff in the soil. In addition, the cumulative loss of TN was the most at 2.5 mm/min instead of 3.0, which was out of runoff increased to reduce TN content with rainfall intensity increasing to a certain range due to dissolved nitrogen content being constant.

The phosphorus in soil was adsorbed basically, so the loss of TP with the rainfall time was roughly undulated change and the loss was the greater with the increase of rainfall intensity out of raindrops' disturbance. The changing trend of COD with rainfall duration was approximately wavy, the cumulative values was higher with rainfall intensity increasing that showed the organic matter content was relatively rich in the hilly land soil.

variation with rainfall duration, the

Table 2: The changing law of pollutants with rainfall intensity and duration in hilly land soil

Rainfall duration /min	Rainfall intensity/mm/min									
	0.5	2.5	3.0	0.5	2.0	2.5	3.0	1.0	2.0	3.0
	TN (mg/l)			TP (mg/l)				COD (mg/l)		
10	0.16	0.46	0.41	0.05	0.15	0.03	0.26	28.08	81.92	67.31
20	0.36	0.41	0.41	0.07	0.12	0.03	0.21	48.46	61.54	67.31
30	0.15	0.47	0.39	0.07	0.12	0.05	0.20	48.46	61.54	67.31
40	0.31	0.46	0.44	0.09	0.14	0.05	0.20	41.35	73.85	80.00
50	0.13	0.42	0.39	0.03	0.12	0.08	0.20	54.81	67.31	80.00
60	0.44	0.49	0.42	0.05	0.11	0.11	0.18	48.46	54.81	79.81
70	0.19	0.47	0.39	0.02	0.1	0.05	0.19	48.46	66.54	79.81
80	0.32	0.46	0.43	0.05	0.1	0.08	0.20	33.85	61.15	66.54
90	0.26	0.43	0.44	0.07	0.08	0.07	0.19	33.85	61.15	66.54
100	0.34	0.49	0.46	0.09	0.06	0.07	0.21	33.85	54.81	66.54
accumulation	2.66	4.56	4.18	0.59	1.03	0.62	2.04	419.63	644.62	721.17

Raining test result analysis in terrace soil

As an agricultural land type, terrace exists generally in the study area, whose nutrient loss station with runoff in different rainfall intensities was shown in table 3.

Table 3: The changing law of pollutants with rainfall intensity and duration in terrace soil

Rainfall duration / min	Rainfall intensity (mm/min)									
	0.5	2.5	3.0	0.5	2.0	2.5	3.0	1.0	2.0	3.0
	TN (mg/l)			TP (mg/l)				COD (mg/l)		
10	0.31	0.57	0.49	0.09	0.10	0.20	0.42	34.12	102.82	70.59
20	0.39	0.40	0.43	0.07	0.12	0.19	0.47	34.12	82.35	75.29
30	0.19	0.52	0.37	0.07	0.09	0.18	0.31	48.24	75.29	75.29
40	0.43	0.63	0.46	0.09	0.11	0.15	0.26	28.24	75.29	48.24
50	0.31	0.50	0.41	0.06	0.10	0.14	0.21	28.24	55.29	48.24
60	0.35	0.51	0.41	0.06	0.11	0.19	0.25	20.00	70.59	70.59
70	0.23	0.46	0.43	0.07	0.05	0.16	0.12	20.00	62.35	70.59
80	0.46	0.52	0.41	0.07	0.09	0.13	0.16	34.12	50.59	48.24
90	0.34	0.56	0.43	0.07	0.10	0.09	0.18	28.24	62.35	62.35
100	0.35	0.51	0.43	0.16	0.06	0.13	0.15	28.24	48.24	48.24
accumulation	3.36	5.18	4.27	0.81	0.92	1.56	2.53	303.56	685.16	617.66

By table 3, the loss law of TN in terrace was basically same to slope cropland soil, the cumulative loss of TN was the largest on the rainfall intensity in 2.5 mm/min, then in 3.0 and the minimum in 0.5 mm/min. The loss volume of TP also changed hackly with rainfall duration, the greater of loss and the greater of rainfall intensity, the trend of TP concentration was up firstly and then fall but total cumulative amount was much higher than that in other rainfall intensity on 3.0 mm/min. The wavy change trend of COD in terrace was more obvious than that in hilly land, the content of COD in runoff was relatively close when rainfall intensity was greater and the difference was bigger on the smaller of rainfall intensity.

Comparison of the two soils

Comparison table 2 and 3, it’s not difficult to find that: (1) the TN concentration in terrace was higher than that of slope cropland soil on same rainfall time, so changing slope fields into terrace which would reduce greatly soil loss and the loss of nutrients. (2) the TP concentration in the two soils both changed hackly with rainfall time on same rainfall intensity, the changing would constantly reduce with the increase in terrace and it was stable in slope cropland. (3) the organic matter content in hilly land soil was slightly higher than that in terrace because chemical fertilizers and pesticides were used relatively more; Furthermore, the COD content in terrace soil continuously reduced hackly with rainfall duration while it was eventually stable in the attenuation in slope cropland soil.

CONCLUSIONS

(1) The TN concentration in the two soils changed hackly with rainfall time, the accumulated concentration was highest on rainfall intensity of 2.5 mm/min, and then 3.0, 0.5 mm/min at least.
(2) The TP loss in the two soils changed wavy with rainfall time, the greater rainfall intensity the more of TP loss. The TP content in hilly land decreased firstly then stable and it raised then fall in terrace on rainfall intensity of 3.0 mm/min.
(3) The COD content in the two soils varied hackly with rainfall time, the change was more obvious in terrace soil wavy changing continuously reduced while it was eventually stable in the attenuation.

ACKNOWLEDGEMENTS

The paper is written by reliable and detailed data which are from staff of institute of soil and water conservation CAS, they ought to be respected paying for more efforts to the experiments of artificial simulated rainfall.

REFERENCES

[1]Jiao Pingjin，Wang Shaoli，XuDi，Wang Youzhen. 2009. Effect of crop vegetation type on nitrogen and phosphorus runoff losses from farmland in one rainstorm event. *Journal of hydraulic engineering* 40(3): 296-302.
[2]Ventura M, Scandellari F, Ventura F, Guzzon B, Pisa P R, Tagliavini M. 2008. Nitrogen balance and losses through drainage waters in an agricultural watershed of the Po Valley (Italy). *European journal of agronomy* 29(2): 108-115.
[3]Olarewaju O.E, Adetunji MT, Adeofun C.O, Adekunle I M. 2009. Nitrate and phosphorus loss from agricultural land: Implications for nonpoint pollution. *Nutrient cycling in agro-eco systems* 85(1): 79-85.
[4]Li Guang & Huang Gaobao. 2008 . Experiment of simulated rainfall, water and soil erosion in loess upland area. *System sciences and comprehensive studies in agriculture* 24(4): 443-445.
[5]Shi Yinzhi & Lei Xiao. 2008. Experimental study on the soil erosion of north brae in Yining based on artificial simulation of rainfall. *Journal of Shihezi university (natural science)* 26(4): 487-490.
[6] Li Guang & Huang Gaobao. 2009. Effects of rainfall intensity and land use on soil and water loss in loess hilly region. *Transactions of the Chinese society of agricultural engineering* 25(11): 85-90.
[7]Bai Dan, Wang Wei, Sun Jian, Deng Minxing. 2010. The water and soft conservation ecological construction of the middle-route of the South-to-North Water Diversion Project's water district. *Journal of northwest university (natural science edition)* 40(2): 348-350.
[8]Yin Wei, Shi Zhihua & Lei Alin. 2011. Research on water environment of Danjiangkou Reservoir. *Yangtze River* 42(13): 90-94.

[9]Liang Peipei, Jiang Xianjun, Yuan Junji, Xie Deti. 2012. Main features of the loss of nitrogen and phosphorus and rainfall intensity influence in the slope farmland of the three gorges reservoir area. *Journal of soil and water conservation* 26(4): 81-85.

