Effects of Rainfall and Topography on Total Phosphorus Loss from Purple Soil under Simulated Rainfall Conditions

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PART 1

Importance
Importance

Heavier nonpoint source pollution

Amount of Pesticide application in past decade

<table>
<thead>
<tr>
<th>Date (year)</th>
<th>Amount of Pesticide application (million tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>1.46</td>
</tr>
<tr>
<td>2006</td>
<td>1.54</td>
</tr>
<tr>
<td>2007</td>
<td>1.62</td>
</tr>
<tr>
<td>2008</td>
<td>1.67</td>
</tr>
<tr>
<td>2009</td>
<td>1.71</td>
</tr>
<tr>
<td>2010</td>
<td>1.76</td>
</tr>
<tr>
<td>2011</td>
<td>1.79</td>
</tr>
<tr>
<td>2012</td>
<td>1.81</td>
</tr>
<tr>
<td>2013</td>
<td>1.8</td>
</tr>
<tr>
<td>2014</td>
<td>1.81</td>
</tr>
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</table>
Purple soil is an important kind of unirrigated tilth soil and accounting for 68% of the total cultivated area in Sichuan Basin of China.
Properties of purple soil

• Rich in phosphorus, potassium, and other nutrients
• Fast soil erosion and fast weathering
• Shallow soil

Importance

Easily eroded
PART 2

Materials

Experiment device
Experiment design
Experiment device

- Soil box for experiment

Photos were took in January 2015.

1.0 × 0.6 × 0.25 m
Two wheels
Apertures at the bottom of box
Extended 0.1 m
Set a groove with small holes
A regulating screw
The Norton nozzle-type rainfall simulator is an experiment device. Photos were taken in January 2015.

- The height of the nozzle was 2.5 m and the hydraulic pressure was 0.04 MPa, which made the distribution and size of raindrops similar to those in nature.
- Rainfall intensity could be set in different levels by changing the frequency of nozzle flaps and was stable under a determined condition.
Experiment design

Pretreatment steps

• Passed by a 7-mm sieve to avoid sticky soil jammed meshes
• Air-dried to make water content rate of soil reduced to about 12%
• Mixed thoroughly

• Physical and chemical properties

<table>
<thead>
<tr>
<th>Soil layers (cm)</th>
<th>Unit weight (g cm$^{-3}$)</th>
<th>Initial water content (%)</th>
<th>Organic matter (g kg$^{-1}$)</th>
<th>TN (g kg$^{-1}$)</th>
<th>TP (g kg$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>1.30</td>
<td>12.16</td>
<td>8.75</td>
<td>0.76</td>
<td>0.68</td>
</tr>
</tbody>
</table>
Process procedure before experiment

Five 5-cm layers of soil were compacted in a soil box to prevent the soil stratification, and the surface of the lower soil layer was loosed before the upper soil layer was filled in.
### Experiment design

**Designed scenarios for experiment**

<table>
<thead>
<tr>
<th>Slope (A)</th>
<th>Rainfall Intensity (B)</th>
<th>30 mm h⁻¹</th>
<th>60 mm h⁻¹</th>
<th>90 mm h⁻¹</th>
<th>120 mm h⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>5°</td>
<td>A1B1</td>
<td>A1B2</td>
<td>A1B3</td>
<td>A1B4</td>
<td></td>
</tr>
<tr>
<td>10°</td>
<td>A2B1</td>
<td>A2B2</td>
<td>A2B3</td>
<td>A2B4</td>
<td></td>
</tr>
<tr>
<td>15°</td>
<td>A3B1</td>
<td>A3B2</td>
<td>A3B3</td>
<td>A3B4</td>
<td></td>
</tr>
<tr>
<td>20°</td>
<td>A4B1</td>
<td>A4B2</td>
<td>A4B3</td>
<td>A4B4</td>
<td></td>
</tr>
<tr>
<td>25°</td>
<td>A5B1</td>
<td>A5B2</td>
<td>A5B3</td>
<td>A5B4</td>
<td></td>
</tr>
</tbody>
</table>
Analysis and discussion
Effects of precipitation on TP loss
Effects of rainfall intensity on TP loss
Effects of slope on TP loss
1) Effects of precipitation on TP loss--load

The correlation between precipitation and TP load under the slope of 25°

\[ y = 0.4751 + 0.1282x \]

\[ R^2 = 0.9983 \]
1) Effects of precipitation on TP loss--load

- The total phosphorus load was increased with the increase of precipitation at each slope.
- It could be explained that the more the precipitation fell, the larger amount of rainfall runoff and the eroded soil increased, and the more the TP was carried.
1) Effects of precipitation on TP loss--load

- An initial runoff-yielding time could be found before runoff generation in this figure.
- The water content rate was relatively low at the beginning of rainfall. With the increase of precipitation, the infiltration effect led the water content to saturation, the runoff formed, and the TP began to loss by washing and carrying of rainfall runoff as well as soil erosion.
2) Effects of precipitation on TP loss--concentration

It could be found that total phosphorus concentration presented an increase trend with the increase of precipitation. During the process of rainfall, dissolved phosphorus, including dissolved organic phosphorus, orthophosphate and polyphosphate, was melted and carried by the rainfall runoff. Meanwhile, the more was adsorbed phosphorus was combined with soil sediments and then transported in the process of water and soil loss.
3) Effects of **rainfall intensity** on TP loss---concentration

- The five slopes in certain rainfall intensity were integrated as value by calculating mean in order to eliminate the influence of slope on TP concentration in this figure.
- TP concentration **rose** when the rainfall intensity increased.
- The higher the rainfall intensity was, the more the rainfall runoff and sediments transported, which carried more TP adsorbed on sediments and made the concentration increased.
4) Effects of rainfall intensity on initial runoff-yielding time

- The relationship between rainfall intensity and the initial runoff-yielding time was a negative correlation.
- The difference of slopes reduced as the rainfall intensity increased which stood for rainfall intensity played a more and more important role in affecting the initial runoff-yielding time with the rise of rainfall intensity.
5) Effects of slope on TP loss--load

- When slope increased, TP load grew generally under various rainfall intensity conditions.
- It could be explained that the effect of scouring was more powerful at steeper slopes, a larger amount of rainfall runoff would generated, more sediments would be carried, and more serious TP loss occurred.
6) Effects of slope on TP loss—concentration

- Five rainfall intensities in certain slope were integrated an average value, in order to ignore the influence of rainfall intensity on TP concentration.
- TP concentration showed a positive correlation with the increase of slope before degree 15, and then TP concentration decreased with the increase of slope.
6) Effects of slope on TP loss—concentration

There was a critical slope of TP loss and the critical slope was degree 15 in this research.
7) Effects of slope on initial runoff-yielding time

- The relationship between the slope and the initial runoff-yielding time was a negative correlation.
- For a steeper slope, contact angle between rainfall and ground was smaller, less unconsolidated soil was generated by splash erosion, rainfall infiltration was more weakened, and the slope runoff was easier to form, hence the initial runoff-yielding time was shorter.
PART 4

Conclusions
The critical slope of TP loss appeared at **degree 15** in this research.

<table>
<thead>
<tr>
<th></th>
<th>Precipitation</th>
<th>Rainfall intensity</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP load</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>TP precipitation</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive before 15°</td>
</tr>
<tr>
<td>Initial runoff-yielding time</td>
<td>Uncorrelated</td>
<td>Negative</td>
<td>Negative</td>
</tr>
</tbody>
</table>
Conclusions

Extension

• The research on critical slope of TP loss from purple soil
• Influential mechanism of underlying surface on nonpoint source pollutants under multiple continuous precipitation scenarios
THANKS!