

Monitoring System for Soil Erosion in Shixia Pilot Small Watershed in Beijing

Duan Shuhuai, Zhou Yuxi, Li Wuqin and Li Yonggui

Beijing Water Resources Bureau
E-mail: duanshh@beic.gov.cn

1 Purpose in monitoring soil and water losses

Water is the source of all lives and soil is the essence of all living things. Soil and water loss is the most concerned environmental issue in our country. In Beijing, the capital of China, the mountain area accounts for 62% of total area, among which there are still 4,383 km² erosion area in spite of erosion control for about 50 years. As the capital of China, controlling erosion, improving environment and making “blue sky, clean water and green land” should be done to meet sustainable development.

Based on 《The Soil and Water Conservation Law of People’s Republic of China》, 《Implementation Means of <Soil and Water Conservation Law of People’s Republic of China> in Beijing》 and 《Report of Prevention and control area in Beijing made by Beijing government》, “Monitoring Bulletin of Soil and Water Loss” should be given by related water resource department in the government in regular time. Monitoring system for soil erosion in Shixia pilot small watershed in Beijing has been set up to observe losses of water, soil and infectants on all kinds of slopes by the measures of observing in runoff plots and using RS and GIS technologies. The system has provided data for policy making and erosion control. Many experiences have been get from it.

2 Technical method for the monitoring

The information such as erosion type, erosion area and erosion control measures on the slope, is surveyed by using technologies of GIS and RS. Runoff plots are built up on all kinds of slopes with serious erosion, middle erosion, low erosion and with all kinds of erosion control measures. The Items of rainfall, soil moisture, runoff, sediment and infectant loss are observed and intensities of the losses for water, soil and infectants are calculated in every runoff plot. The results from every plot are extended to whole watershed and all amounts of the losses are get from all slopes in whole small watershed.

3 Monitoring system in Shixia pilot small watershed

Electric relief map and TM image map taken in secondary planet for Shixia small watershed have been collected.

22 runoff plots have been build with 5 meter in width, 5 meter, 10 meter and 20 meter in length, 3° to 23° in slope gradient, representing most kinds of slop condition in the watershed.

One weather station and 6 ombrometers have been installed.

One laboratory for sediment and moisture analyzing in water and soil samples is build.



Shixia runoff plots



Weather station

3.1 Monitoring items

3.1.1 The earth's surface information

Include coverage of vegetable, land use, slope gradient, erosion type and erosion area.

3.1.2 Runoff, Sediment and infectant losses during a rainfall on the slopes

Rainfall, soil moisture, runoff, sediment and losses of infectants.

3.1.3 Erosion control benefits on the slopes

All kinds of erosion control measures on the slopes, including terrace, forestry for erosion control, fruit trees, grass, narrow terrace and protected area for vegetation reconverting.

Runoff, sediment and infectants coming from the runoff plots with all kind of erosion control measures on the slopes.

3.2 Monitoring for surface erosion area

3.2.1 Monitoring method for the earth's surface information

The surveys for the earth's surface information have been made two times in Shixia small watershed, the first survey is in 1992 before erosion control and the second one is in 1999 after erosion control.

In the first survey, fieldwork is main method to be used. Investigators divided whole Shixia small watershed into 265 plots on the slopes and 164 gullies in gully areas based on that land use, slope, vegetation coverage, soil should be uniform in each plot. Investigators went to every plot and gully to investigate land use, slope gradient, vegetation type and vegetation coverage, soil type, plot area, gully area and so on. Soil erosion was estimated to each plot by meeting "Surface Erosion Class Table" published by Water Resource Ministry.

In the second survey, RS and GIS technologies are used. Remote sensing is main information source, field work only be done to verify the information out of the films. Relief map, soil and rock information have been collected. Land use maps and vegetation coverage maps are made from TM image maps pictured in secondary planet.

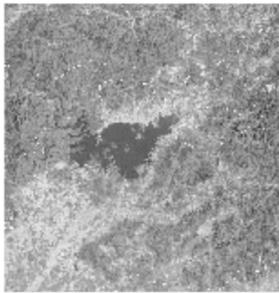


Fig. 1 TM image map

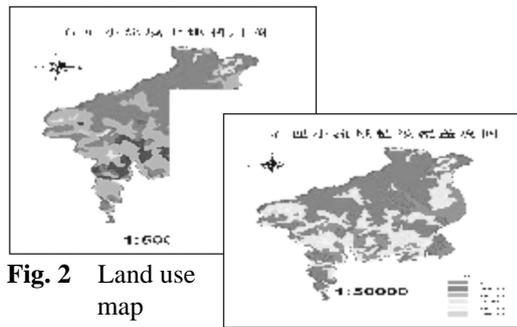
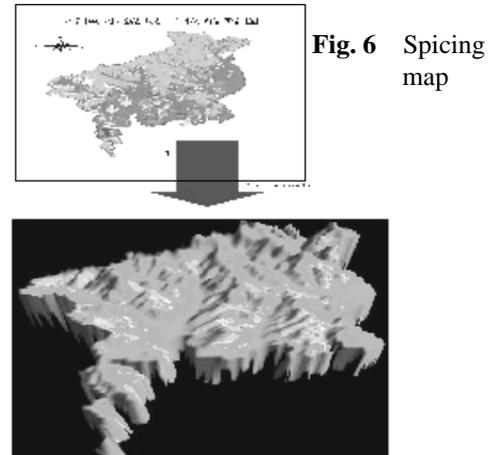
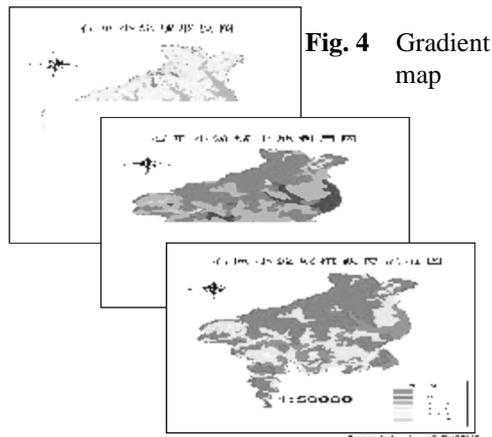


Fig. 2 Land use map

Fig. 3 Vegetation coverage map

Gradient maps on slopes are made from the electronic relief maps. A new map is produced by spicing land use map, vegetation coverage map and slop gradient map together to make it containing all the information from last three maps and holding main erosion factors together in same map. Surfacing erosion is estimated in this map by meeting "Surface Erosion Class Table" published by Water Resource Ministry of People's Republic of China.



3.2.2 Surface erosion class table

“Surface Erosion Class Table” published by China Water Resource Ministry is as following:

Table 1 Surface erosion class

The earth's surface information		5°—8°	8°—15°	15°—25°	25°—35°	>35°
vegetation coverage (%)	60—75	Low erosion			Serious erosion	More serious erosion
	45—60	Middle erosion		Serious erosion		
	30—45	Middle erosion			Serious erosion	More serious erosion
	<30	Middle erosion		Serious erosion		
Slope farming		Low erosion	Middle erosion		Serious erosion	More serious erosion

3.2.3 Erosion area in Shixia small watershed

Results of two erosion surveys in Shixia small watershed are as following:

Table 2 Soil erosion condition in Shixia small watershed

Erosion class	Erosion area in 1999			Erosion area in 1992		variability
	Amount of plots	area (hm ²)	proportion (%)	Area (hm ²)	Proportion (%)	(%)
Mini-erosion	59	2,615.44	79.31	1,317.07	39.94	39.37
Low erosion	129	100.67	3.05	394.07	11.95	(8.90)
Middle erosion	105	572.46	17.36	420.67	12.76	4.60
Serious erosion	17	9.04	0.27	704.60	21.37	(21.09)
More serious erosion	0	0.00	0.00	432.47	13.11	(13.11)
Intensity erosion	0	0.00	0.00	28.93	0.88	(0.88)
Total	310	3,298	100	3,298	100	0.00

3.3 Monitoring system for observing soil erosion intensity

3.3.1 Monitoring method

Based on the earth's surface information, plots are built up to represent all kinds of slope types. After each rainfall, amount of runoff is observed and water samples are taken from which sediments and water quality are analyzed. Extending plot data to whole watershed, all runoff, sediment and infectant coming from whole watershed can be calculated.

3.3.2 Runoff plot disposing

Table 3 Runoff plots in Shixia small watershed

The earth's surface information		<5°	5—8°	8—15°	15—25°	25—35°	>35°
vegetation coverage (%)	>75					No.08	
	60—75						
	45—60		No.19	No.05	No.13	No.09	
	30—45						
	<30				No.16		
Slope farming		No.18	No.20	No.06	No.01		

Note: No.05, No.06... are Runoff plot's serial numbers.

There are two ombrometers near runoff plot field.

3.3.3 Runoff plots design

Runoff plot dimension: 5 meter in width (paralleling contour line), most of runoff plots are 10 meter in length and 100 m² in large (level projection area), a few is 5meter or 20 meter in length.

Runoff containers: There are two runoff containers in every runoff plot. All the runoff from the plot goes down to the containers.

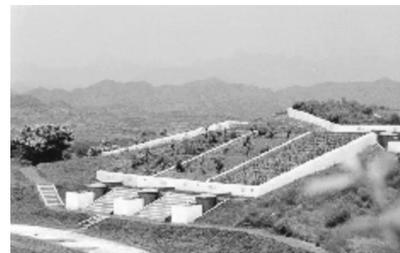


Fig. 8 Shixia runoff plots

3.3.4 Observation items and methods

Rainfall: amount of rainfall(mm), intensity of rainfall(mm/min).

Runoff: Measuring depth of runoff in the container to know the amount of runoff from the runoff plot after every rainfall.

Sediment: Taking water samples from container after each rainfall, amount of sediment in the water samples are analyzed in the laboratory. All sediment in the runoff is calculated from it.

Soil moisture: Soil moisture is measured in every ten days in flood season.

Water quality (TP, TN, COD): Taking water samples from containers after each rainfall, water qualities are analyzed in the laboratory.

3.4 Monitoring system for benefits coming from erosion control

3.4.1 Monitoring method

All erosion control projects on the slope in the watershed have been investigated, including terrace, forestry for erosion control, fruit trees, grass, small terrace, fish-scale pits and so on. Some runoff plots with erosion control projects are built, the data from which are compared with the data from runoff plots without erosion control and erosion control benefits are get.

3.4.2 Runoff plots with erosion control projects

Runoff plots with main erosion control projects on the slope in the watershed are built.

Table 4 Runoff plots with erosion control projects

	3°—8°	8°—15°	15°—25°	>25°
Terrace plot	No.17 (corn cropped)			
Small terrace plot		No.07 (with fruit tree)	No.02 (with fruit tree)	
Fish-scale plot			No.12 (planting)	No.10 (planting)
Grass plot			No.15	
Protected area plot				No.08
Sample plot		No.04	No.03	

3.4.3 Benefit evaluation

Erosion control benefits are get by comparing the data from plots with erosion control projects with the data from the runoff plots without erosion control projects.

Benefits=(Data from erosion plots - data from the plots with projects) / plot area * project area.

4 Observing Results in flood season in the year of 2000

The system has been worked in flood season of 2000.

4.1 Runoff and sediment from the slopes of Shixia small watershed

In flood season of 2000, monitoring system has worked. Total rainfall is 227.3mm, among which runoff happened three times with responsible rainfall of 159mm and biggest rainfall intensity of 25mm in 30 min.

Runoff, sediment and contamination come from every runoff plot are calculated and the results are extending to whole slopes in the watershed.

Table 5 Observing results in food season of year 2000 in Shixia small watershed

Erosion Intensity	Area (hm ²)	Runoff and Sediment				contamination in the runoff					
		Runoff (m ³ /km ²)	Sediment (T/km ²)	Runoff (10 ⁴ m ³)	Sediment (10 ⁴ t)	TP (kg/km ²)	TN (kg/km ²)	COD _{mn} (kg/km ²)	TP (kg)	TN (kg)	COD _{mn} (kg)
total	3,298			10.98	0.46				63.71	415.40	1,371.70
Mini-erosion	2,615.44	1,117.3	4.3	2.92	0.01	1.364	8.395	12.126	35.67	219.57	317.15
Low-erosion	100.67	1,344.53	4.75	0.14	0.00	0.508	6.120	11.000	0.51	6.16	11.07
Middle erosion	572.46	13,525.05	768.79	7.74	0.44	4.740	32.470	179.060	27.13	185.88	1,025.04
Serious erosion	9.04	20,307.47	1,378.74	0.18	0.01	4.270	42.020	204.090	0.39	3.80	18.44

4.2 Benefits from soil erosion control

Benefits from soil erosion control in flood season of year 2000 are as following:

Table 6 The table for benefits from soil erosion control

Measures of erosion control	Area (hm ²)	Water and soil loss		Water and soil conservation		Contamination in the runoff			Reduced contamination in the runoff		
		Runoff (M ³ /km ²)	Sediment (T/km ²)	Reduced runoff (10,000m ³)	Reduced sediment (10,000t)	TP (kg/km ²)	TN (kg/km ²)	COD _{mn} (kg/km ²)	TP (t)	TN (t)	COD _{mn} (t)
total	3,011.00			61.27	4.016				0.124	0.971	5.734
terrace	25.00	3,818.29	28.220	0.412	0.034	0.310	9.610	29.900	0.001	0.008	0.044
Small terrace, Planting sancer	1,706.00	2,913.97	73.841	36.249	2.226	0.231	13.697	19.372	0.069	0.483	3.151
Planting	592.00	0	0	12.022	0.816	0	0	0	0.025	0.249	1.208
Protected area	688.00	2,009.65	12.187	12.589	0.940	0.091	8.45	10.722	0.029	0.231	1.330
Data from compared plots		20,307.5	1,378.69			4.270	42.023	204.095			

5 Expectation for the monitoring work in the future

(1) We think the methods of using RS and GIS technologies to survey land use, vegetation coverage and slope are very advanced, which greatly reduce field works and save surveying time and man-labors. In these methods data come from maps by using of computer and GIS, that makes data management very easily.

(2) Observing runoff, sediment and contamination in runoff plots is good method to know erosion intensity in all kinds of slope condition. The data provides a basis for erosion control plan.

(3) This erosion monitoring system has made a sample for Beijing mountain area, Now the monitoring system in Beijing mountain area is planning and building. The data is being used to set up erosion models by which soil and water loss will be forecasted in related area.

References

- [1] The plan of soil erosion monitoring system in Shixia small watershed by Beijing drinking water protection office in 1997.
- [2] Erosion survey in Beijing by using technologies of remote sensing and GIS. Published in "Beijing Water Resources" No.1, 2000. Author: Duan Shuhuai and Zhou Yuxi in 2000.