Impact of Agricultural Contaminants in Surface Water Quality: A Case Study from SW China

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1. Introduction

Water is a very precious natural resource and the matter foundation that the whole lives rely on in the earth, and it is also the matter that cannot be replaced in the natural resources on the earth again. With increasingly intensive population, various community economy activity's demand for water increases, and the space-time distribution of water resource become uneven, and the supply of water resource in the whole world become tight. Soil erosion has taken away the mass of rich topsoil and makes soil become more and more thin, reduces land productive, and poses serious threat to water environment. In addition, water body pollution has negative effect on effective use of water resource and aggravates the contradiction. The management of point source pollution and circularly making use of in the developed countries currently up make more ideally, but a lot of still directly exhaust in various water body in the extensive developing countries.

Soil erosion is the reason that results in surface source pollution, and runoff is the medium of surface source pollution, while the amount of runoff and water and soil conservation are closed tightly, therefore, the basic way to resolving surface source pollution is reducing soil erosion by water and soil conservation measures. Most of analysis of runoff pollution mechanism and runoff creation, space-time distribution of runoff, and the effect analysis of different measures are all carried on runoff plots.

With the improvement of the controlling of point source pollution, water environment issues caused by the non-point source pollution are increasingly conspicuous. Especially in the developed countries, such as the America, the non-point source pollution has been major factor of the water environment pollution (Fu et al., 2011). The agriculture runoff pollution is the main fraction of surface source pollution, and agriculture surface source pollution and soil erosion is a pair of symbiosis (Zhang & Huang, 2011). Thus the most effective and the most practical approach to solve agriculture pollution problem is to implement water and soil conservation measure. With the development of small watershed comprehensive management and surface source pollution in China, the way to resolve surface source pollution by the effective small watershed comprehensive management has been a hot point in the environment science and water and soil conservation science field nowadays.

The environmental benefit of small watershed comprehensive management includes natural environment, eco-environment and social environment. The water and soil conservation works since 1980s indicate that the small watershed comprehensive management could produce obvious environmental benefit (David et al., 1998).

Water eutrophication is one of the water pollution issues that perplexed developed countries nowadays and is also the realistic issue that the developing countries facing (Leeds-Harrison et al., 1999; Heitz et al., 2000). After the water eutrophication, the excessive reproduction of algae had leaded to water hypoxia, clarity step-down, smelly, even some toxins, thus had damaged the normal function of water body. According to calculating, the eutrophication degree of most lack in china will turn worse further with the development of the industrial and agricultural. The pollutants resulting in Water eutrophication were mainly plant nutritional substances, such as nitrogen and phosphorus etc. The search indicate that it mainly exist in closed water area, such as lake, reservoir etc.

The control of runoff pollution is an important aspect in the whole water pollution controlling progress. The search and control for non-point source pollution start relatively late in china, and the search for the control way about non-point source pollution has been valued since the last few years, But the abroad has made a great deal of works and has accumulated prolific experience in this field (Chartes & Roben, 2000; Prato & Shi, 1990). For example, In 70's, the United states proposed "BMP-Best Management Practices" in the control and management fulfillment of non-point source pollution. What it points is the combination of several measures after analysis and compassion by the government or designation which is the most useful practical measure for making the identified water by perverting and cutting non-point source pollution burden. Usually it can be divided into the control of source and the runoff pollution.

To know what effects does the watershed comprehensive management had on the runoff pollution, this search adapt the combined method of runoff plot and small watershed. The small watershed model is the main demonstration for water and soil conservation - the reservoir peripheral of Gezi channel, Lianglu town, Yubei plot, Chongqing city (managed watershed) and Changxi small basin(not managed watershed), the soil in experimental runoff plot is the same as the adapted soil in small watershed. The reservoir in Gezi has played a key role in the development of agriculture economy, and the water of reservoir is the source of peripheral farmland irrigation and the headwaters that the farm tourism keeps fish again. To know the influences of different measures on runoff pollution, the search of the distribution regulation in time and space about the reservoir agriculture runoff, the estimating of amount runoff pollutant burden of reservoir stores in warehouse by the methods of synchronous monitor and field investigation to the runoff water and sediment respectively in runoff plot and basin, and calculated the decreasing runoff pollution burden after management by the compassion of the density of runoff pollutant in managed plot and not managed plot's, and then to analyze the dimension of synthesize management and measure the effect after administering.

Therefore, there are three purposes to establish this search, the first one is evaluating the control action of small watershed comprehensive management to runoff pollution; The second one is directing the measure of water and soil conservation; The third one is defining the best sloping plant model from ecology direction. Thus it can offer a certain theory basis for predicting the control action of small watershed comprehensive management to the surface source pollution in this region.

2. Research content

The soil erosion is the main reason of slope runoff pollution, the different land use and different cropping-plants influence the occurrence and development of runoff. According to the spot investigation, it indicated that the local resident plant some farm crops, such as bean, maize, sweet potato and fruit tree under the 25° sloping fields, these farm plant are been planted alone or been intercropped, and the different intercropped area proportion could had different influence on runoff. This search adapt the method of monitoring surface runoff in plot in consideration of that the natural water is the main recharge source of surface runoff, the amount of burden of different using type of land's surface runoff is relevant with this area, which also has something to do with the pollutant density of surface runoff.

This search mainly investigates the relevant intensity of surface runoff pollutant of different type of using land, thus we can use surface runoff pollutant total nitrogen and total phosphorus, Pb and Cd, chemical oxygen demand and the average density of the amount of sediment to express the discussion of different plant model's impacts on the runoff pollution. According to it, we can compare the differences of the degree of influence of different plant model's impact on runoff pollution. The study contents were as follows: 1) the influence of different plant models on runoff pollution; 2) the timely distribution of runoff pollution; 3) the spatial distribution of runoff pollutant.

2.1 Basic situation of experimental plot and research methods

The experimental plot located in Lushan village, Lianglu town, Yubei district, Chongqing city and was shallow landform, soil type is purple soil which belongs to the Jurassic formation, the soil texture was formed by the physical chemistry elegance of sandstone and shale, soil bulk density was 1.42-1.68g/cm^3, total porosity was 40.28%. And perennial mean temperature was 18.2 °C, annual yearly rainfall was 1110mm, the rainfall in May to October was about 80.62% of the whole year's, and the amount of rainfall in August was the most largest. Before the planting tillage in plot, to know what influence does different land use and slope will have on runoff pollution, we adapt the method of runoff plot to research, and the soil texture fertilizer applications was the same in each plot. The basic situation of experimental plots was as follows:

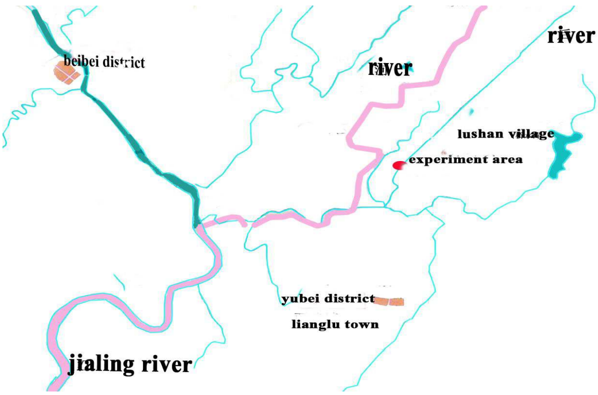

Fig. 1. Experiment Area

Plot number	Slope(°)	Aspect	Specification	Crop and planting pattern	Coverage (%)
1	25	SE	5m×20 m	bean (50%)+ sweet potato(50%)(intercropping along the slope)	20
2	25	SE	5m×20 m	seedlings of economic fruit forest(along the slope)(20cm*20cm)	5
3	25	SE	5m×20 m	seedlings of economic fruit forest (transforming slope into terrace)+ (20cm*20cm)	5
4	15	SE	5m×20 m	bean + sweet potato(25% intercropping)+ sweet potato(75%)(along the slope)	30
5	15	SE	5m×20 m	seedlings of economic fruit forest (transforming slope into terrace) (20cm*20cm)	5
6	15	SE	5m×20 m	sweet potato +maize(intercropping along the slope)	30

Table 1. Basic situation of experimental plots

Index	Plot number					
	1	2	3	4	5	6
Minimum permeability (mm/h)	3.64	3.61	3.72	3.66	3.70	3.67
Bulk density (g/cm^3)	1.47	1.48	1.45	1.34	1.44	1.30
Water content(100%)	17.5	16.9	19.5	19.8	19.5	21.2

Table 2. The physical characteristic of soil in plots Basic situation of experimental plots

Soil samples were collected from five sampling spots ("S" type) of two replicates in each plot, then combined within plots before analysis. Once after a runoff, swept the sludge of gutter into runoff pool mixed it with water, and collected three columnar samples from pool (gross 1000-3000ml). Then put mixing sample (500-2500ml) into closed container, 4ml concentrated H_2SO_4 to terminate microbial activity, and then put it in the refrigerator. The surplus water sample (500ml) was precipitated, filtered and dried, to determine sediment content.

Precipitation capacity was determined by hydrocone type journal rain gauge; Runoff capacity was calculated by SWZ type journal water column and 45° triangular weir; Sediment content was measured by oven drying method, and measure method of water sample: total nitrogen(semimicro Kjeldahl), total phosphorus(molybdo-antimony anti-colorimetry), Cd (atomic absorption spectrometry), chemical oxygen demand (potassium dichromate method).

2.2 Variation and analysis of runoff pollution

On the basis of the size of runoff pollution index content , the order of effect of runoff pollution among six cropping patterns was plot 5 > plot 3 > plot 6 > plot 4 > plot 1 > plot 2. To reduce the slope runoff pollution, the slope farmland under 25 degree should be transformed into terrace, and at the seedlings of economic fruit forest, it didn't show a strong controlling effect on runoff pollution, so it should intercrop other plants according to fruit tree's biological habit and ecological characteristics.

The species of crop and the reasonable density and its structure of ecological function should be considered when adapted to the intercropping pattern.The management effect of plot 1 and plot 2 was the most obvious in the total ratio of rainfall collection, but the management effect of plot 5 and plot 6 was the worst, the Cd content of plot 4 was the highest, and Pb content of plot 5 and plot 6 was the highest.

To decrease the slope runoff pollution, the slope farmland under 25 degree should be transformed into terrace, and at the seedlings of economic fruit forest, it didn't show a strong controlling effect on runoff pollution, so it should intercrop other plants according to fruit tree's biological habit and ecological characteristics. The species of crop and the reasonable density and its structure of ecological function should be considered when adapted to the intercropping pattern. Analyzing the each index and getting its average by the runoff samples of three times, the results were as follows:

Date	Plot number	Total nitrogen (mg/l)	Total phosphorus (mg/l)	Pb (mg/l)	Cd (mg/l)	Chemical oxygen demand (mg/l)	Sediment amount (mg/l)
8.16	1	5.9	0.68	0.1064	0.0109	14.3	6.3
	2	6.29	0.71	0.1086	0.0111	14.38	6.7
	3	4.45	0.54	0.0919	0.0099	10.32	4.7
	4	5.81	0.64	0.1092	0.0107	13.94	5.9
	5	3.95	0.49	0.0897	0.0095	9.87	4.2
	6	5.47	0.62	0.106	0.0104	13.02	5.6
8.20	1	5.82	0.61	0.1057	0.0102	12.7	5.6
	2	6.22	0.64	0.1079	0.0104	13.92	6
	3	4.4	0.47	0.0912	0.0092	9.58	4
	4	5.74	0.57	0.1087	0.01	11.72	5.2
	5	3.92	0.43	0.089	0.0088	8.88	3.5
	6	5.4	0.55	0.1055	0.0097	11.81	4.9
8.23	1	5.83	0.6	0.1056	0.0101	11.78	5.5
	2	6.23	0.63	0.1078	0.0103	12.64	5.9
	3	4.39	0.46	0.0911	0.0091	9.32	3.9
	4	5.73	0.56	0.1085	0.0099	11.08	5.1
	5	3.91	0.42	0.0889	0.0087	7.76	3.4
	6	5.39	0.54	0.1053	0.0096	10.05	4.8
the average of index of three runoff pollution	1	5.85	0.63	0.1059	0.0104	12.93	5.8
	2	6.24	0.66	0.1081	0.0106	13.65	6.2
	3	4.42	0.49	0.0914	0.0094	9.74	4.3
	4	5.76	0.59	0.1088	0.0102	12.25	5.4
	5	3.94	0.45	0.0892	0.009	8.84	3.7
	6	5.42	0.57	0.1056	0.0099	11.63	5.1

Table 3. The index value of three runoff

The general order of change rate is sediment>total nitrogen> chemical oxygen demand > total phosphorus > Pb > Cd except of a little deviation of the change of pollution index. Evaluation of different planting patterns on the environmental quality pollution is as follows:

Index	Evaluation standard				
	I	II	III	IV	V
Total nitrogen	0.5	0.5	1	2	2
Total phosphorus	0.02	0.025	0.05	0.2	0.2
Pb	0.01	0.05	0.05	0.05	0.1
Cd	0.001	0.005	0.005	0.005	0.01
Chemical oxygen demand	lower than 15	lower than 15	15	20	25

Table 4. The environmental standard of surface water (GB3838-88) (mg/L)

Index	Plot number					
	1	2	3	4	5	6
Total nitrogen	0.185	0.197	0.140	0.182	0.125	0.171
Total phosphorus	0.186	0.195	0.145	0.174	0.133	0.168
Pb	0.174	0.178	0.150	0.179	0.146	0.173
Cd	0.175	0.178	0.158	0.171	0.151	0.166
Chemical oxygen demand	0.187	0.198	0.141	0.177	0.128	0.168

Table 5. Index weight under different land utilization patterns

Index	Plot number					
	1	2	3	4	5	6
Total nitrogen	4.875	5.200	3.683	4.800	3.283	4.517
Total phosphorus	6.364	6.667	4.949	5.960	4.545	5.758
Pb	2.037	2.079	1.758	2.092	1.715	2.031
Cd	2.000	2.038	1.808	1.962	1.731	1.904
Chemical oxygen demand	0.718	0.758	0.541	0.681	0.491	0.646
Total	2.92	3.21	1.86	2.74	1.59	2.52

Table 6. Composite index of runoff pollution in plots

The total tendency of pollutant content by observing the experimental data of each plot's visually was plot 5 < plot 3 < plot 6 < plot 4 < plot 1 < plot 2, and by the calculation of pollution integrated index in each plot and the average of three runoff pollutant, runoff pollutant had a same tendency in the six cropping patterns, so it was reasonable and feasible to conduct environmental quality assessment by the organic combination of the evaluation method of environmental pollution index and the one-level fuzzy evaluation method. Compared to the expert evaluation, this method could reduce workload greatly.

There were economic fruit forest in plot 2, 3 and 5, and there were not obvious differences of the runoff pollutant content between plot 3 and plot 5 , but the runoff pollutant content of plot 3 and plot 5 was smaller than the runoff pollutant content of plot 2, which indicated that slope's effects on runoff pollution is not obvious, while it made a remarkable effect on the control action of runoff pollution by transforming slope into terrace; the effect of the economic fruit forest in plot 2 was the worst because of its stage of seedlings and the small converge that couldn't control soil erosion well.

The pollutant loss in plot 6 was smaller than the effect in plot 1, which indicated that the model of maize intercropping sweet potato was better than the model of bean intercropping sweet potato, because the underground root system and big leaf of maize could make a stronger effect on loosing soil and the rainfall interception than the root and leaf of bean during the experimental period, we can also explained this phenomenon according to soil bulk density, water content and permeability; the effect of controlling pollutant loss in plot 4 was better than that in plot 1, that was to say, planting the single sweet potato on slope land had a stronger controlling effect on runoff pollutant than the model of bean intercropping sweet potato, but which didn't match the former regulation that intercropping pattern was better than single planting pattern, that because the bean was too young in plot 1, so the rainfall interception was not strong, and for planting bean, the row spacing of sweet potato extended, the total coverage of plot 1 changed small.

2.3 The spatial distribution characteristics of runoff pollution

The runoff pollution degree of the downhill of plot 2 by the filtration of buffer plot was the smallest, and the runoff pollution degree of new citrus located in the downhill of plot 4 was the maximum. Total nitrogen content and Cd content in runoff had significant correlations with sediment, and total phosphorus content and Pb content had extremely significant correlations with sediment. And chemical oxygen demand content had the extremely significant correlations with total nitrogen, Pb and Cd, chemical oxygen demand content had significant correlations with total phosphorus and sediment, and total nitrogen content was the main affecting factor of chemical oxygen demand content. During the management of basin, we could adopt intercropping pattern to increase the vegetation coverage of initial harnessing area to come to the target of controlling runoff pollutant. Moreover, it also needed to take measures to control the quality of runoff from upslope.

The total tendency in runoff was that total nitrogen, total phosphorus, Pb and chemical oxygen demand content increased at first then decreased. Total nitrogen content came to peak during one hour to two hours, and the last content had a tendency to stability and was lower than the initial value, the time of runoff pollutant content coming into peak varied with the difference of pollutant and plot, and during the time of peak appearing, there was a big difference between each plot, the total nitrogen content of each plot was generally same at the last period of the occurrence of runoff; Total phosphorus content came to peak during 0.8 hour to two hours, the total tendency of total phosphorus content at the same time was 4>5>6>7>3>1>2, during the period of peak's appearance, there were big differences between each plot, total phosphorus content had a tendency to stability at the last time of the occurrence of runoff; Pb content came to peak during one hour to two hours, the order of Pb content of each plot after the former one hour of occurrence of runoff was 1>3>7>2>6>5>4, during the period of peak's appearance, there were big differences between each plot; Total nitrogen content of each plot was generally same at the last time of the occurrence of runoff; The order of Pb content after the one hour to three hours and a half of the occurrence of runoff was 5>6>4>7, there were no differences of Pb content between 1 plot 1, plot 2 and plot 3. And Pb content of each plot had a tendency to same at the last period runoff. Cd content of each plot came to peak during 1.8 hours to two hours, the order of Cd content after the occurrences of runoff but the former two hours before the occurrence of runoff peak was 1>3>7>2>6>5>4, Cd content of each plot was generally same after the appearance of runoff peak; Cd content of plot 4, 5, 6 and 7 changed sharply, Cd content of plot 1,2 and 3 changed gently; Chemical oxygen demand content of each plot came to peak during 1.8 hours to two hours, the order of chemical oxygen demand content in the total runoff progress was 5>6>3>7; Chemical oxygen demand content of plot 1, 2, 4 and 7 changed irregularly. Generally speaking, the change range of chemical oxygen demand content of plot 4, 5, 6 and 7 was larger than plot 1,2 and 3's. The effect of runoff management of plot 1, 2 and 3 was stronger, secondly for plot 4 and 7, the effect of runoff management of plot 5 and 6 was the worst; the time of the appearance of runoff pollution peak was fixed.

Plot number	pH	Organic matter (g/kg)	Total nitrogen (g/kg)	Total phosphorus (g/kg	Total potassium (g/kg)	Cd (mg/kg)	Pb (mg/kg)
1	7.96	22.54	1.431	0.657	10.2	0.498	27.58
2	8.19	4.69	0.786	0.716	14.6	0.4	29.64
3	6.64	22.31	1.447	0.904	12.9	0.243	24.69
4	8.17	4.87	1.426	0.992	14.8	0.552	25.01
5	8.11	22.21	1.431	0.667	12.8	0.346	29.12
6	8.14	22.19	1.429	0.662	12.7	0.345	29.12
7	6.94	4.91	0.786	0.772	15	0.377	24.68
8	8.18	4.69	1.084	0.828	13.8	0.483	26.66

Table 7. The physicochemical characteristic of soil

Plot number	Slope position	Aspect	Total nitrogen (g/kg)	Total phosphorus (g/kg)	Pb (mg/kg)	Cd (mg/kg)	Chemical oxygen demand (mg/kg)	Sediment Amount (mg/kg)
1	incomingwater	NE	3.525	0.136	0.0628	0.0086	19.567	2.9
	upslope	NE	1.872	0.088	0.0431	0.0058	10.269	1.4
	midslope	NE	1.47	0.191	0.0322	0.0027	9.157	2.6
	downslope	NE	1.311	0.152	0.0257	0.001	7.683	2.2
2	incoming water	NE	2.521	0.137	0.0555	0.0063	20.233	3.3
	upslope	NE	1.966	0.112	0.0501	0.0047	12.565	2
	midslope	NE	1.659	0.159	0.0554	0.0055	8.461	3.1
	downslope	NE	1.085	0.126	0.0252	0.0008	8.282	0.8
3	incoming water	E	2.349	0.161	0.0489	0.0057	16.243	3.1
	upslope	E	1.693	0.142	0.0432	0.0044	10.856	2.2
	midslope	E	2.344	0.199	0.0456	0.0048	15.381	2.6
	downslope	E	1.192	0.161	0.0451	0.0026	7.416	2.1
4	incoming water	SE	2.657	0.136	0.0550	0.0068	16.835	2.9
	upslope	SE	2.615	0.102	0.0441	0.006	11.235	3.8
	midslope	SE	2.057	0.208	0.0487	0.0098	26.261	3
	downslope	SE	1.878	0.341	0.0537	0.0011	12.541	2.2
5	incoming water	S	2.101	0.161	0.0612	0.0052	14.235	2.6
	upslope	S	1.898	0.159	0.0551	0.0052	8.561	2.2
	midslope	S	2.551	0.188	0.0594	0.0076	15.623	2.7
	downslope	S	3.002	0.234	0.0664	0.009	24.652	3.8
6	incoming water	SW	1.921	0.167	0.0619	0.0051	14.237	2.4
	upslope	SW	1.797	0.134	0.0431	0.0049	8.141	2
	midslope	SW	2.349	0.09	0.069	0.008	12.563	2.6
	downslope	SW	3.015	0.216	0.0584	0.0092	21.695	3.7
7	incoming water	NW	2.43	0.145	0.0432	0.0051	15.623	3.3
	upslope	NW	2.234	0.099	0.0392	0.0042	12.666	2.4
	midslope	NW	2.001	0.252	0.0414	0.0071	9.283	3.2
	downslope	NW	1.647	0.206	0.0554	0.0083	8.28	2.8
8	incoming water	NW	2.53	0.147	0.0445	0.0062	15.741	3.6
	upslope	NW	2.66	0.245	0.0524	0.0071	18.564	4.1
	midslope	NW	4.36	0.612	0.0926	0.0113	51.48	5.8
	downslope	NW	5.21	0.633	0.0942	0.0113	51.88	6.1

Table 8. The spatial distribution characteristics of runoff pollution

The management effect of plot 1 and plot 2 was the most obvious in the total ratio of rainfall collection, but the management effect of plot 5 and plot 6 was the worst, and the Cd content of plot 4 was the highest, Pb content of plot 5 and 6 plot was the highest. the runoff pollution degree of the downhill of plot 2 by the filtration of buffer plot was the smallest, and the runoff pollution degree of new citrus located in the downhill of plot 4 was the biggest. Total nitrogen content and Cd content in runoff had significant correlations with sediment, and total phosphorus content and Pb content had extremely significant correlations with sediment. And chemical oxygen demand content had the extremely significant correlations with total nitrogen, Pb and Cd, chemical oxygen demand content had significant correlations with total phosphorus and sediment, and total nitrogen content was the main affecting factor of chemical oxygen demand content. During the management of basin, we could adopt intercropping pattern to increase the vegetation coverage of initial harnessing area to come to the target of controlling runoff pollutant. Moreover, it also needed to take measures to control the quality of runoff from upslope.

2.4 The evaluation of water quality of space runoff in watershed

According to the comments on runoff quality, it indicated the runoff pollution degree of the downhill of plot 2 by the filtration of buffer plot was the smallest and the runoff pollution degree of new citrus located in the downhill of plot 4 was the biggest. The not managed slope pollution index was higher than the managed slope's, which indicated that the regulation effect was significant in Gezi channel. To analyze the sample clustering of interval runoff quality by conducting the spatial runoff pollution synthetic index using SPSS and analyze the variable cluster of runoff quality in all position of the whole reservoir, the cluster result were as Fig.2 and Fig.3.

Slope position	Plot number							
	1	2	3	4	5	6	7	8
upslope	1.09 (1-1)	1.14 (2-1)	1.13 (3-1)	1.39 (4-1)	1.29 (5-1)	1.15 (6-1)	1.20 (7-1)	1.593 (8-1)
midslope	1.25 (1-2)	1.24 (2-2)	1.54 (3-2)	1.88 (4-2)	1.64 (5-2)	1.41 (6-2)	1.70 (7-2)	6.558 (8-2)
downslope	1.05 (1-3)	0.88 (2-3)	1.09 (3-3)	2.22 (4-3)	2.00 (5-3)	1.95 (6-3)	1.56 (7-3)	7.333 (8-3)

Table 9. Average of Composite index of runoff pollution in plots on Aug 16th and Aug 20th

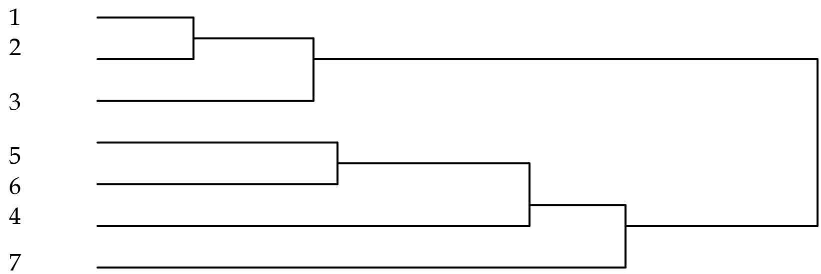

Fig. 2. Runoff water quality clustering in plots

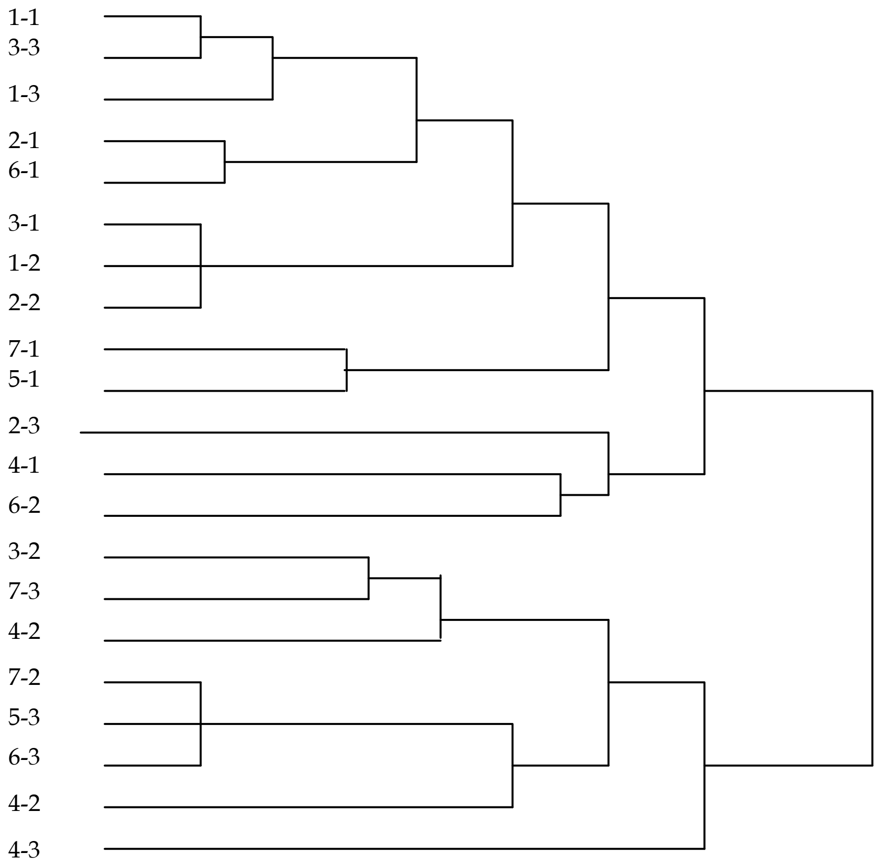

Fig. 3. Runoff water quality clustering of different position in plots

2.5 The space-time distribution characteristics of runoff pollution

The degree of runoff pollution in each plot first increased to peak then decreased gradually, and the degree of runoff pollution at the beginning was larger than in the end; the runoff pollution synthetic index of plot 1, 2 and 3 changed slowly, it appeared peak at the period 5. While the runoff pollution synthetic index of plot 5 and 6 changed sharply, the runoff pollution synthetic index of plot 4 and 7 also changed sharply.

The latter four plot appeared peak much earlier, it indicated that the runoff regulation effect of plot 1, 2 and 3 was stronger, secondly for plot 4 and 7, the runoff regulation effect of plot 5 and 6 was the worst.

The evaluation method of runoff quality is as mentioned above, the evaluation results are as follows:

Plot number	Date								
	16.50-17.20	17.20-17.40	17.40-18.00	18.00-18.30	18.30-18.50	18.50-19.20	19.20-19.50	19.50-20.20	20.20-20.50
1	0.841	0.934	0.963	1.053	1.107	0.827	0.651	0.537	0.536
2	0.786	0.856	0.911	0.973	1.027	0.803	0.657	0.603	0.551
3	0.952	1.012	1.150	1.225	1.309	0.975	0.818	0.742	0.669
4	1.444	1.738	2.125	2.154	1.959	1.730	1.332	1.074	0.976
5	1.389	1.563	1.940	2.243	2.111	1.574	1.165	0.838	1.013
6	1.293	1.422	1.727	2.115	2.019	1.312	1.041	0.903	0.887
7	1.199	1.164	1.407	1.607	1.416	1.077	0.912	0.821	0.780

Table 10. The space-time distribution characteristics of runoff pollution composite index

2.6 The timely clustering of runoff pollution composite index

The period cluster of each section: the nine periods mentioned above could be expressed by TIME1-TIME9, to cluster the runoff pollution synthetic index in each period by the Hierarchical Cluster to Q cluster, the cluster method was Euclidean distance, the cluster results were as follows:

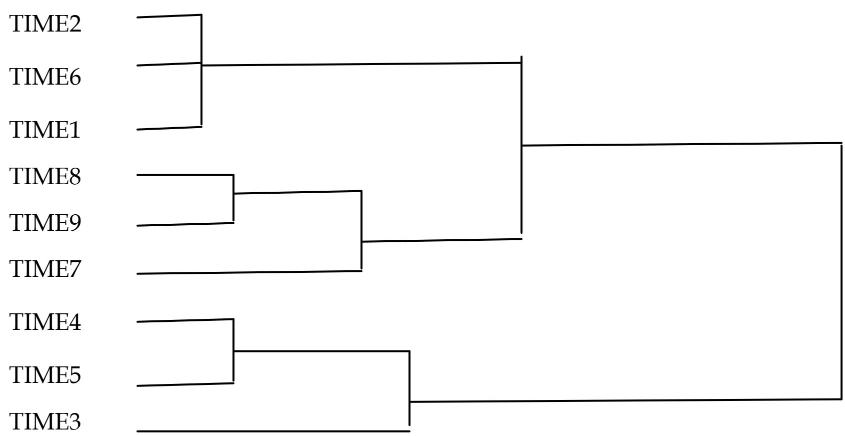

Fig. 4. The timely clustering of runoff water quality in the same plot

In the term of cluster graph, the temporal and spatial distribution characteristics of the degree of runoff pollution were as follows: the degree of runoff pollution of TIME1, TIME2 and TIME6 were the same, the degree of runoff pollution of TIME4 and TIME5 were the same, and the degree of runoff pollution of TIME8 and TIME9 were the same, the runoff pollution synthetic index of TIME4 and TIME5 were the highest, that was to say, the time of coming into peak of runoff pollution is fixed. The interval cluster results of each period were as follows:

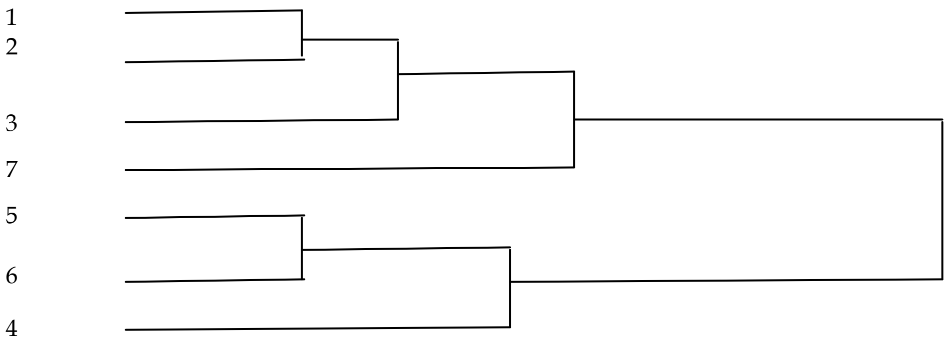

Fig. 5. Runoff water quality clustering during the same time in different plots

The cluster results were that the degree of runoff pollution of plot 1 was similar to the plot 2's and the degree of runoff pollution of plot 4 was similar to the plot 5's, the degree of runoff pollution of plot 7 was different with the other plots, it also showed the land use method and vegetation conditions influenced the development and progression of runoff pollution, which matched the chapter about the analysis of the spatial distribution characteristics of runoff pollution.

3. Conclusion

The effect of planting pattern on the runoff contamination: Adopt total nitrogen, total phosphrous, Pb, Cd, chemical oxygen demand, sedimentation and heavy metal content in surface runoff to evaluate the comprehensive effect. The order is : terrace of 15°+ economic fruit tree seedling>terrace of 25° + economic fruit tree seedling > sweet potato +maize(intercrop and along with the slope)> bean + sweet potato(25% intercropping)+ sweet potato(75%)(along with the slope)> bean(50%)+ sweet potato(50%)(intercrop and along with the slope)> economic fruit tree seedling(along with the slope).

The spatial distribution characteristic of runoff contaminate: the Gezigou reservoir small watershed is divided into 7 sections based on the land-use ways and the planting canopy percent and the origin of runoff around the watershed. In a whole, the first and the second sections are harnessed effectively, the 5th and 6th are mostly worst. The content of Cd in the 4th and the content of Pb in 5th and 6th are the highest.

The contamination degree in the second section is the least in which the lower slope is filtrated trough buffer zone, but the most contamination degree appealed in 4th in which the lower slope planted newly orange. There are remarkably correlation between total nitrogen, total phosphrous, Pb, Cd, chemical oxygen demand and sedimentation in surface runoff; there are also remarkably correlation between the content of chemical oxygen demand and total phosphrous sedimentation, moreover the content of total nitrogen is the principal factor affected chemical oxygen demand in surface runoff.

The timely distribution characteristic of runoff contaminate: In the runoff, the general trend of the content of total nitrogen, total phosphrous, Pb, Cd, chemical oxygen demand increase at first and decrease at end. The time of the contents reach the peak value different from the kinds of the contamination and the sections. At the latest time, the content of the contamination is steady to every section. The content of total nitrogen will reach the peak value within the first to second hour, at end which become steady and less than the initial value. The content of total phosphrous reach the peak valve within 0.8-2 hour; At the same time, the rank of the content of total phosphrous in every section is 4>5>6>7>3>1>2.

The content of Pb will reach the peak value within the first to second hour and at the first hour after the runoff appealed the rank of the content in every section is 1>3>7>2>6>5>4, after 1-3.5 hour is 5>6>4>7 and the difference of the content in 1, 2, 3 section is tiny; At the latest time, they are consistent. The content of Cd reach the peak value within 1.8-2 hour and at the former two hours between the runoff and peak valve appealed the rank of the content in every section is 1>3>7>2>6>5>4, the content in 4, 5, 6, 7 sections changed rapidly, but smoothly in 1, 2, 3 sections. The content of chemical oxygen demand reach the peak value within 1.8-2 hour, the content rank is 5>6>3>7 trough the whole runoff time, but the content change have not regulation in 1, 2, 4, 7 sections. In general the time of peak value of contamination is within 1.5-3.5 hours after runoff happened.

The estimation of total contamination entered into reservoir: To linearity regression between runoff and contamination of total nitrogen, total phosphrous, Pb, Cd, chemical oxygen demand according with SPSS and build a model. Based the model the contamination load of total nitrogen, total phosphrous, Pb, Cd, chemical oxygen demand in runoff in Gezigou reservoir small watershed on Aug 16th respectively 8411.69g, 1014.43g, 402.65g, 25.90g, 59829.82g, the total runoff is 6181.598m^3.

Effect analysis of comprehensive Harness: Apply with the runoff load model in Zhuchangxi small watershed to calculate the runoff load of un-harnssed Gezigou reservoir small watershed and compare with the load based on the build model on Aug 16th, results show out: the total of total nitrogen, total phosphrous and Pb are less 7.87%, 44.66%, 47.09% than un-harnessed respectively.

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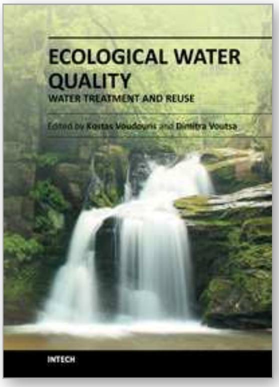

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This book attempts to cover various issues of water quality in the fields of Hydroecology and Hydrobiology and present various Water Treatment Technologies. Sustainable choices of water use that prevent water quality problems aiming at the protection of available water resources and the enhancement of the aquatic ecosystems should be our main target.

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