Causes and Control Countermeasures of Agricultural Non-Point Source Pollution in Shaanxi Section of Wei River Basin

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Abstract: The situation of agricultural non-point source (AGNPS) pollution in Wei River basin has been analyzed. AGNPS caused by the enrichment of nitrogen and phosphorus, the excessive usage of pesticides, herbicides, agricultural films and the random discharge of livestock waste and sewage from diffuse sources is degrading surface water quality throughout the watershed. The relevant measures and countermeasures have been put forward to prevent water body pollution, such as enhancing farmers' awareness of environmental protection, adopting environmental economic means, establishing monitoring and evaluation system of AGNPS and improving related policies and laws.

Keywords: agricultural non-point source pollution; water quality; Wei River basin; control countermeasures

1. Introduction

Wei River is the largest tributary of Yellow River, flowing through Shaanxi, Gansu and Ningxia provinces, China, holding a drainage area of 134.8 thousand square kilometers. Most of its area lies in Shaanxi province, about 67.5 thousand square kilometers. The length of Wei River mainstream is about 818 kilometer. Shaanxi section is 502 kilometer, the middle reaches of which is from Baoji to Xianyang, the downstream from Xianyang to Tongguan.

Over the past several decades, the agricultural non-point source (AGNPS) pollution has become one of major factors of degradation of Wei River watershed of China following the industrial and municipal wastewater pollution. While modern agriculture tremendously meets the need of urban and rural life, the excessive use of chemical fertilizers, pesticides, agricultural films, and the discharge of livestock waste and sewage without disposal have polluted Wei River water bodies and brought great harm to ecological health of river systems. Agricultural non-point source pollution and water environmental deterioration in Shaanxi section of Wei River basin should be paid more and more attention to.

2. Overview of Water Quality

According to the water quality report data from 2007 to 2009 by Environmental Protection Bureau of Shaanxi province in [1], the pollution status of Wei River in all previous environmental monitoring was the most serious in Shanxi's six bigger river systems. Nine sections can not meet the water function standard among twenty-six monitoring sections (including seven state control sections) in Wei River. The major contamination indexes are permanganate index, chemical oxygen demand (COD), biochemistry oxygen demand (BOD), ammonia nitrogen and petroleum. In May and June 2007-2009 the water quality monitoring data of the mainstream are shown in Table 1, and the changes of potassium permanganate index, chemical oxygen demand and ammonia nitrogen along the main river are seen respectively in Fig. 1, Fig. 2 and Fig. 3.

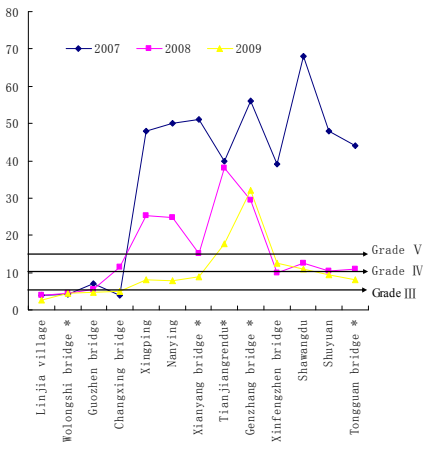

Figure 1. Change of potassium permanganate index along the river.

Obviously, these major contamination indexes exceeded the National Standard of Surface Water Environmental Quality, especially, the Shawangdu monitoring sector in 2007. Although the major contamination indexes in 2009 were decreased, Wei River water quality was worse than Grade V, and still belonged to heavy pollution grade.

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3. Reason Analyses

3.1. Agricultural Chemical Pollution

Table 1. Water quality monitoring data

Num	Section name	Water quality			Water quality standards
		2007	2008	2009	
1	Linjia village	II	II	II	II
2	Wolongshi bridge *	III	III	III	III
3	Guozhen bridge	IV	IV	IV	IV
4	Changxing bridge	III	V	III	III
5	Xingping	>V	>V	V	IV
6	Nanying	>V	>V	V	III
7	Xianyang bridge *	>V	>V	V	IV
8	Tianjiangrendu*	>V	>V	>V	III
9	Genzhang bridge *	>V	>V	>V	IV
10	Xinfengzhen bridge	>V	>V	>V	III
11	Shawangdu	>V	>V	>V	III
12	Shuyuan	>V	>V	>V	IV
13	Tongguan bridge *	>V	>V	>V	IV

***: State-controlled section**

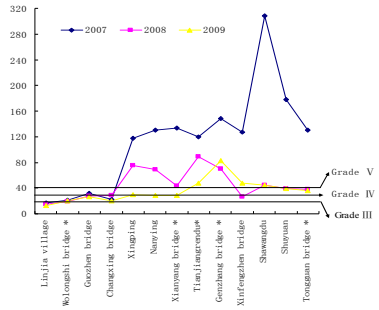

Figure 2. Change of chemical oxygen demand(COD) along the river.

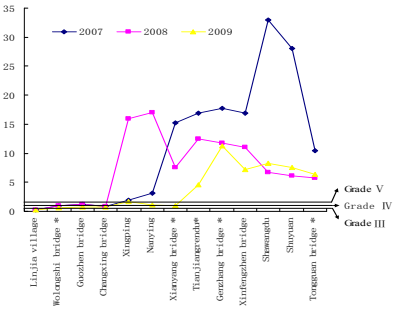

Figure 3. Change of ammonia nitrogen along the river.

The Agricultural chemical pollution is the most serious AGNPS pollution due to the excessive usage of fertilizers, pesticides, agricultural plastic films etc in agriculture production activities. Shaanxi section of Wei River Basin has 61% of population, 56% of cultivated land, 72% of irrigated area, 81% of the total industrial output and 50% of agricultural gross output of Shaanxi Province. In the process of modernization of agriculture economy, the chemical fertilizers have made important contribution to the agricultural production. However, the heavy use of fertilizers has caused the decline of soil fertility and nutrient loss, in consequence, unfortunately, becoming one of the main reasons for AGNPS pollution.

Pesticides have played an important role in eliminating pests and plant diseases, raising agriculture output and lightening peasant labor intensity, but the large amount of chemical pesticides not only caused atmospheric pollution through volatilization, but also brought about water body deterioration by way of infiltration, farm drainage and surface runoff, and did great harm an aquatic ecosystem and human health. Under the guidance of the agriculture development of "high-yield, high-quality and the high-effect", the dosage of plastic films has rapidly increased with the widespread application of film mulching technology, which has caused the potential environmental damage, soil infiltration degeneration and plant root suffocation. Furthermore, many of the difficult degradation organic components have aggravated water body pollution.

Table 2 showed application situation of the fertilizers, plastic films, mulching films and pesticides in Shaanxi section of Wei River basin from 2002 to 2007 in [2-4]. The statistical data manifested that the dosage of the chemical fertilizers, nitrogen fertilizers, phosphate fertilizers, compound fertilizers, farm-oriented plastic films, mulch films, pesticides and herbicides was increasing year by year. Among them, the phosphate fertilizers increased from 162,000 ton in 2002 to 166,000 ton in 2006, the growth rate amounted to 25%, other fertilizers still reached up to the growth rate of 20%. If the loss was estimated by 50 percent of the chemical fertilizer dosage, the only fertilizer loss would cause that more than 70,000 ton fertilizers rushed into soil and water environment. Concerned researches have showed that the utilization ratio of nitrogen fertilizers is only between 30 and 50 percent in [5], about 10 percent of which can wash into surface water with rainfall and runoff, and 15 percent of which can enter groundwater with nitrate forms by leaching. Undoubtedly, above-mentioned reasons have aggravated agricultural environment, and threatened the sustainable development of agricultural production.

3.2. Livestock Farm Pollution

With the improvement of people's living standard, a high demand for meat, eggs, milk has promoted rapid development of the livestock and poultry farming. But plenty of untreated or simple processed livestock excrement and waste have become one of the important non-point pollution sources. Table 3 showed the situation of the livestock pollutant discharge in Shaanxi section of

Wei River from China Agricultural Statistical Yearbook in 2007 in [3]. Amount of livestock on hand was 67.495 million heads, including 1.66 million cattle, 8.515 million pigs, 6.675 million sheep and 50.645 million poultry. Unfortunately, livestock farms of urban and rural areas in Shaanxi had few sewage treatment facilities, which caused to directly discharge pollutants. A lot of nitrogen and phosphorus that contained in livestock excrement and waste rushed into the soil and transformed nitrate and phosphate, which not only brought about surface water and groundwater pollution, but also caused excessive breeding of mosquito, algae, decline of dissolved oxygen, death of aquatic creatures. According to the livestock pollution discharge coefficient, the environmental pollution load of these livestock was calculated:COD_{Cr} was 8219.75t·a^{-1}, TN was 3606.385t·a^{-1}, TP was 12452.84t·a^{-1}, the total of emission was 12452.84t·a^{-1}.

3.3. Rural Domestic Pollution

Rural domestic pollution mostly results from domestic sewage, life garbage and human excrement. Because of the restrictions of economic condition and the influence of traditional custom, rural sewage and garbage basically directly let out, or dump in roadsides, channels, ponds, which causes that most of pollutants flow into the river with surface runoff, infiltration and precipitation. Shaanxi section of Wei River basin generated 30533.85 ton pollutants in 2007, and COD_{Cr} was main pollutant, accounting for 88 percent of the total emissions. The urban sewage treatment rate is still less than 30 percent in Wei River basin according to the concerned data. Although the environmental protection department invested and constructed some sewage treatment facilities in recent years, the sewage discharge failed to meet the goal without deep treatment, resulting in the tail water with a large of nitrogen and phosphorus flowing into water environment.

Except for above several factors, farmland runoff, soil erosion, burned straw, leaching and volatilization are also important causes for AGNPS pollution, because they bring nitrogen and phosphorus into rivers, lakes. Of course, the excessive use of chemical fertilizers and pesticides should be responsible for agricultural non-point source pollution.

Table 2. The consumption of fertilizers, plastic films, and pesticides from 2002 to 2007 in Shaanxi(M/ten thousand ton).

Year	Fertilizers	Nitrogen fertilizers	Phosphorus fertilizers	Potassium fertilizers	Compound fertilizers	Agricultural plastic film	Mulching film	Pesticide
2002	131.9	71.4	16.2	8.4	29.8	2.06	1.45	1.020
2003	142.7	77.8	15.8	9.0	40.2	2.18	1.34	0.976
2004	143.1	77.5	16.1	8.8	34.1	2.30	1.55	0.014
2005	147.3	76.7	16.9	10.8	43.1	2.36	1.63	0.015
2006	149.7	76.5	16.6	11.0	45.6	2.49	1.75	1.014
2007	158.8	81.1	14.8	11.4	51.5	2.68	1.90	1.070

Table 3. Discharge of livestock waste in 2007 in Shaanxi section of Wei River basin.

Year	Livestock on hand	Type	COD_{Cr}(t·a^{-1})	TN(t·a^{-1})	TP(t·a^{-1})
cow	166	cow dung	4252.92	1127.14	220.78
		cow urine	411.68	1030.86	36.52
pig	851.5	pig manure	1992.51	425.75	178.815
		pig urine	570.505	391.69	42.575
sheep	667．5	manure and urine	333.75	327.075	46.725
poultry	5064.5	manure and urine	658.385	303.87	101.29
total	6749.5		8219.75	3606.385	626.705

4. Control Measures

Agricultural non-point source pollution is complex, disorder and severe. It is a very difficult and arduous task to control non-point source pollution in Shaanxi section of Wei River basin. To effectively control the non-point pollution, the prevention means and control measures should be adopted simultaneously, and the source controlling should be combined with the terminal purification, and policy guidance should be combined with ecological compensation. Emphasis should be put on the whole basin coordinated administration, scientific sustainable development in order to achieve the goal of ecological restoration.

4.1. Improvement of Environmental Consciousness

AGNPS pollution is largely due to improper behaviors and ways in agricultural activities and the peasants' daily life, which has difficulty in solving non-point source pollution issues because of being related to every family. It is very important for controlling AGNPS pollution to strengthen environmental education and improve peasant environmental consciousness.

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To make sure environmental protection consciousness into agricultural activities and peasant life, improving environmental consciousness should be regarded as the important content of training new generation farmers and rural surplus labors. Making full use of radio, television, and scientific literature popularizes concerned knowledge of AGNPS pollution to the broad masses. The whole society shall support the green economy and the scientific development view in order to reduce agricultural non-point source pollution and realize the harmonious development between man and nature.

4.2. Agricultural Scientific Research and Extension

Agriculture and environmental protection department should guide peasants to scientifically and reasonably apply modern techniques, such as organic fertilizers, compound fertilizers and high efficiency, low toxicity, low residual pesticides and easy-degradation films that made from natural products and agricultural sideline products of the straw, and implement the biological precaution of plant diseases and insect pests in order to minimize agricultural non-point source pollution. In addition, "the balanced fertilization technology" should be adopted to meet the demand of crop nutrient and soil fertility according to the soil condition and crop species. It is necessary to introduce the sewage treatment technology, the rural sewage biogas purification treatment technology and the sewage ecological wetland technology into the construction of socialism new countryside. At the same time, building the waste designated repository, conducting the solid waste classification treatment and making human excrement and living garbage and waste directly into the pool are all very meaningful tasks for preventing and reducing agricultural non-point pollution.

Most of the regions that conditions permit in Shaanxi province may establish the biogas digester in order to process excrement and urine of human, livestock and poultry, deal with life sewage and solid waste, which can not only process a large number of pollutants, but also develop the methane comprehensive utilization technology for replacing electricity and gas. For large livestock farms, except for biogas fermentation, biomass energy and efficient organic manure are what agriculture science and technology are to be working towards.

4.3. Rewards and Punishment Mechanism

AGNPS pollution is related to agricultural operators' constant pursuit to economic benefits. In market economic system, it is of importance to apply env- ironmental economic means to coordinate the relationship between environment and economic, and promote agricultural enterprises to select and implement the best technical measures for controlling agricultural non-point source pollution of Wei River basin. The authorities of Wei River basin should consider envi- ronmental economic means as adjusting the agricultural operators' behaviors, for example, the incentives and preferential policies for voluntary participation in agricultural non-point source pollution reduction programs, the cost of regulatory oversight, the right trade of pollution-discharge, the taxes or fees of fertilizers and pesticides, the subsidies of cropland to forest or grassland etc. There is no doubt that economic means and rewards and punishment mechanism will help Shaanxi agricultural economic development put on a scientific administration track.

4.4. Monitoring and Evaluation System

That is difficult and lasting to restore the destruction of agricultural non-point source pollution on soil and water. Therefore, it is necessary to establish and perfect the agricultural environmental monitoring system, and gradually implement regular bulletins on agricultural environmental quality and situation for timely forecast and evaluation of environmental conditions.

According to the situation and characteristics of agricultural non-point source pollution, different terrains, planting and breeding patterns, soil types, rural lifestyle in Shaanxi section of Wei River basin, the monitoring spots should be set to monitor the characteristics and the influence factors of the local agricultural non-point pollutant, and find out the pollution situation as well as the change trend for real-time adjustment prevention and control means and technology. In the meantime the environmental monitoring system can provide basic data in order to objectively evaluate agricultural non-point source pollution and establish pollution warning system.

4.5. Strict Laws and Regulations

A series of existing laws and regulations on agricultural chemical pollution has played an inc- reasingly important part in preventing agricultural non-point source pollution, but the government should make further efforts to reinforce law enforcement and improve relevant agricultural environmental protection provisions in order for more effective environmental conservation in political and legal means. The local authorities and environmental protection department also should establish local river non-point pollution laws and improve the maneuverability of relevant rules and measures, actively develop the technical consultation and arbitration of agricultural pollution accidents, and strengthen the environmental management of the construction of agricultural projects.

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