Non-Point Source Pollution and Its Countermeasures in China*

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Abstract: Main aspect of non-point pollution (NPS) and main difficulties in controlling NPS were briefly discussed in rural region of China. Technologies for the control of NPS in Chinese rural areas are constructed wetlands, multipond systems, ecotone engineering, biogas fermentation, hilly area ecological agriculture and others. To control NPS, the cooperation with farmers and other residents in the countryside is the key to success, and the program has to consider their benefits. There are still many difficulties with the control, and more efforts are needed in developing suitable technologies and environmental education.
Keywords: control technology, nonpoint pollution, rural area

1 The general situation of nonpoint pollution in china

Although urbanization is developing rapidly, 71% of the population still live in rural areas without sewer networks and sewage treatment. In the past twenty years, the waste recycling in the land was decreased greatly with labor costs increasing and more chemical fertilizer being used. In 2000, the chemical fertilizer application in China was 42 million tons, with a 16.1 million tons increase on the basis of 1990. The application rate per unit area was 2.6 times more than that of the world average. The large-scale animal breeding by farmer families has become a new pollution source. Presently the pig population has reached 400 million and the population of large animals, such as horses and cows, is more than 100 million. In 1995, the manure produced by breeding animals was 2.49 billion tons in the whole country and it was 32% more than that in 1988 (CYA Editorial Committee, 1990—1996). The wastewater discharged from the breeding farms usually contains higher contents of nutrients and organic pollutants than sewage.

In China, the areas of rapid development are facing more serious nonpoint pollution problems. The people in the countryside produce much more solid wastes, which are not treated. Many township factories have been constructed and they have become new pollution sources. In 1998, the waste-solid discharged from the township factories accounts for 74.3% of total factories. The energy structure in the countryside is changing rapidly. Instead of being burned as fuel, much of the agricultural waste is accumulated in the villages and by the riversides. The runoff can wash them into the water after rains. The other causes for accelerating non-point source pollution are deforesting activities, degradation of wetlands, bad sanitation, improper tillage and wastewater irrigation. The area of wastewater irrigation in 1998 was 3.62 million hectares, with a 3.29 million hectares increase on the basis of 1978.

The NPS from rural areas makes more than half of the phosphorus and nitrogen load to most lakes and reservoirs in the eastern part of China. Table 1 listed the contribution of different pollution sources on total N, P load in “three Lake” i.e. Taihu Lake in Jiangsu Province, Dianchi Lake in Yunnan Province and Chaohu Lake in Anhui Province. The serious NPS causes great degradation of water quality in most lakes and reservoirs in China. People begin to realize that to control the NPS is an important part in the overall environmental improvement program.

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Table 1 The contribution of different pollution sources on total N, P load (%)

Lake	Industry wastewater		Domestic sewage		NPS pollutants	
	N	P	N	P	N	P
Taihu Lake	16	10	25	60	59	30
Dianchi Lake	10	14	57	45	33	41
Chaohu Lake	14	10	23	17	63	73

2 Major difficulties in control of nonpoint pollution in china

Non-point source control is a heavy-duty task in China. Though we have made some progress, there are many difficulties to doing it. According to the development history of different regions in China and other countries, we think that the economic growing stage of GNP per capita from 1,000 to 3,000 US dollars is a critical period for the NPS increase. In this stage, the production and living standards of the people rise rapidly but government regulation and people's environmental consciousness lags behind. At present, GNP per capita in China is 800 US dollars and it is just the beginning stage of the critical period. It is expected that NPS will be developing in China and we should be in great concern about it. At present, the major difficulties in controlling NPS in China are the following:

(1) The control of most point source pollution has not been completed. The governments usually put their priority on controlling the point source pollution. Non-point pollution control efforts have not been made in most regions.

(2) The people in the countryside are in a less developed stage. They are poorer and less educated than those in the cities. People in the countryside are struggling to gain their basic needs for life at present. Their environmental consciousness is relatively low.

(3) In many areas, the agricultural network is greatly weakened. The agronomists and technicians cannot get enough support from the government in many of the counties. The farmers cannot obtain guidance in running environmental friendly technologies. In many regions, the farmers apply much higher doses of chemical fertilizer with no potassium. In some extreme cases, the dose is five or six times higher than crop needs.

(4) There are not enough suitable techniques for the control of NPS as well as for the benefits of the local people.

(5) There is no legal system to control the NPS in China.

Much more effort is needed in the future. Otherwise, the situation of pollution will reach a point in which the costs to pay for the restoration are enormously high.

3 Control technologies and management used in china

In China, same as other developing countries, the basic need is to feed the people with enough grain production in order to support the large increasing population. The key of success in reducing NPS is a program that also benefits the local farmers, so that they are willing to cooperate. The maintenance costs of NPS control can not be paid always by the government. And it is the farmers who should do it for their own benefit. This is a great challenge for the scientists in this field. With many efforts, several ecological technologies have been developed successfully on the principles of material cycling and minimization of wastes with product chains.

The following are some example countermeasures suitable for different conditions and they are quite successful in the control of nonpoint pollution.

3.1 Constructed wetlands to remove nonpoint source nutrients

Dianchi Lake in Yunnan Province receives extensive nonpoint source pollutants from the watershed. The scientists cooperated to make extensive research on how to reduce the nonpoint pollution (Jin *et al.*,

1995). They constructed several constructed wetlands and sedimentation beds as demonstration facilities in the lake tributaries for removal of nutrients and suspended sediments. Such systems are composed of ditches, sedimentation dams, wetlands and ponds. The effects are very significant. As calculated in their technical report, the total nitrogen (TN) removal was 22%—77% and total phosphorus (TP) removal was 33%—86%. The sediment removal was 52%—96%. The constructed wetlands not only reduce the NPS, but also benefit agricultural production by enlarging the irrigation area and aquaculture production. However, the constructed wetlands and sedimentation beds need more maintenance funds because the government has to take the sediments out every two years. Wetland systems are constructed in many other regions to control nonpoint pollution.

3.2 Restoration of natural wetland

3.2.1 Filtration effects of healthy land/water ecotones

When runoff passes through the healthy ecotone wetlands into a river or lake, the water can be filtered and nutrients are removed. We did experiments in the lakeside wetlands of Baiyangdian Lake and the results show that the wetland ditches and reed field soil retained a large portion of nutrients. The retention of total nitrogen (TN) and total phosphorus (TP) by surface flow through a 300 m ditch was measured to be 42% and 65% respectively. The retention of TN and TP by an 8 m stretch of reed community soil was 59% and 88%. The retention by the reed community mainly happened at the root (rhizosphere) channels below the soil surface. The ecotone engineering stabilizes the river and lake shores and good vegetations enhance the sedimentation of nutrients. It is a good method to reduce non-point pollution.

3.2.2 The multipond system

This is a typical Chinese system and the main purpose of this system is to recycle water in agricultural lands. The system is composed of many tiny ponds scattered in crop fields. The area of each pond varies from 0.05 hectare to 1 hectare. People describe them as “thousands of ponds scattered in thousands of hectares of rice fields”. Each pond has a small catchment of 0.5ha—10ha and the pond provides the surrounding agriculture land irrigation water. Multipond systems have a history of more 1,000 years and their original purpose was for irrigation.

These ponds are connected with small ditches and functioned as recycling centers, close to the nonpoint sources such as villages, dry cropland, rice fields and hilly lands. Long term measurements in the Liuchahe subcatchement of Chaohu Lake, at the river mouth and samples of the individual land plots, were carried out to analyze the flow water, sediments and nutrients. We found that in the five recorded years, the retention of nonpoint source nutrient load in the runoff by multipond system was as follows: 97% in 1997, 98% in 1988, 99% in 1994, 97% in 1995, and 94% in 1998 (Yin *et al*., 2001).

3.3 Biogas fermentation and bio-fertilizer production to reduce agricultural wastes

Bio-gas fermentation takes the organic waste as its raw material and produces biogas as an energy source, avoiding wastes are thrown into the rivers or washed into the river after heavy rains to cause nonpoint pollution. Many provincial administrations do training for the farmers in bio-gas tank construction and it is most successful in Sichuan and Guangxi Provinces. According to 1995 statistics, there are 5.7 millions family biogas tanks running nationally and 25 million people can use biogas as their daily fuel. These biogas tanks treat 29 million tons of manure and 120 million tons of sewage per year (Hong, 1996). Bio-fertilizer production has become a new industry in the countryside. Now it is based on modern technology with good design and in an effort to reduce costs. New fermentation micro-organisms are employed. Some products combine the organic material with inorganic synthesized fertilizer in different compositions for different purposes.

3.4 Hilly area ecological agriculture patterns

The main scope of it is to reduce soil erosion and to increase the farmers’ income. In the agricultural planning of hilly areas, it is designed that the forests should be planted at the hilltop, tea and fruit gardens

planted at the hillside, and crops in the valley terrace and the fish ponds constructed in the low land of the valley (Wang and Yin, 1998). With a combination of crop planting and husbandry feeding, the material and energy is recycled while the wastes are greatly reduced (Fig. 1). This system, with a slightly different structure, is suitable in both the south and north regions of China. The forests, tea trees and fruit trees can greatly reduce soil erosion. Meanwhile, the soil, nutrients and organic material washed downwards to the waters can be intercepted and reused several times by the farmlands and fishponds in the lower part of the valley. With quantitative management of material cycling, the productivity is increased systematically and waste washout by runoff is minimized. The farmers can increase their income from the sale of tea, fruit and fish, meanwhile their basic needs for the grain is guaranteed. There are good demonstration examples at Three Gorges Reservoir regions, hilly areas in Jiangxi Province and Taihang Mountain areas in Hebei Province (Huang *et al.*, 2000). The concept of ecological agriculture was first developed by Professor Shijun Ma in China and different patterns can be applied for different purposes (Ma and Li, 1987; Wu, 1989). Based on these principles, many ecological counties are being constructed in many provinces.

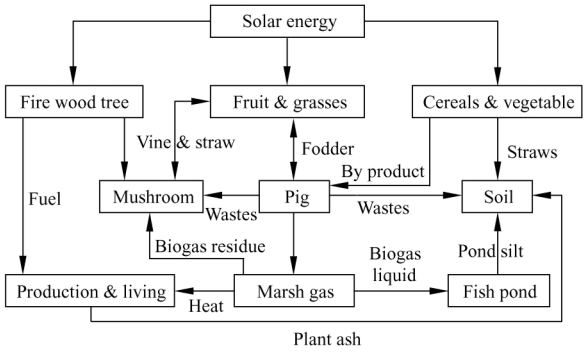

Fig. 1 The material chain recycle with a combination of planting and feeding, an example of the concept of ecological agriculture (figure from Wang and Yin, 1998). There are products and yields for the farmers from most of the compartment

Table 2 shows the characteristics of the above technologies used in China and most of them do have other benefits for the local farmers. Besides engineering methods, there are ecological agricultural techniques, such as no tillage technology, grass planting and eco-fertilization, to reduce nonpoint pollution. Institutional reformation is also important. The actions include the protection of the farmer's right of land use to reduce the soil erosion and training for correct fertilization and better sanitation.

Table 2 Characteristics of control measures used in China to reduce nonpoint pollution

Control measures	Affects to control nonpoint pollution	Other benefits to the local people
Constructed wetlands	Wastewater treatment	Sanitation
Multipond system	To store and recycle polluted runoff	Irrigation, water storage for use
Ecotone engineering	Filtration of polluted runoff	Wood and grass production
Biogas fermentation	Reduction of solid wastes	To provide clean fuel, sanitation
Bio-fertilizer production	Reduction of solid wastes	To provide fertilizer, sanitation
Hilly area eco-agriculture	Soil conservation and material cycling	To increase production

In recent years, the central government has launched a national program to turn improper land use from agriculture to forest, grassland and wetland, in order to protect the environment. The central government provides financial support to aid the farmers in this program. Through April 2001, the first stage, a total area of 80,000 ha has been turned from agriculture to forest, grassland or wetland. This program is showing its positive effects on environmental restoration.

4 Conclusions

The non-point source pollution from rural areas is serious and it threatens water resource safety in China.

China is a developing country. The practical countermeasures to control nonpoint pollution at present are those which also favor the farmers in some respects. Good examples are multipond systems, biogas fermentation, bio-fertilizer production, constructed wetlands, ecotone engineering and hilly area ecological agriculture, etc. Their key contents are material cycling and they are effective in nutrient load reduction.

Being at the critical period of rapid economic development and with nonpoint pollution increasing, China is facing many difficulties with pollution control. The government needs to put nonpoint pollution control into action and there is a need for extensive environmental education. More research should be done on technology development. It is most important to improve the management and develop of a legal system for nonpoint pollution control.

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