Summary and Prospect of Research on Agricultural Non-point Source Pollution in my country’s Watershed

Guobao Xiong¹, Yiming Ma²*, Yuanda Luo³

¹Resource and environmental economics research center, East China University of Technology, Nanchang, China
²School of Economics and Management, East China University of Technology, Nanchang, China
³*Corresponding author: mayiming@ecut.edu.cn

Abstract. Agricultural non-point source pollution poses a serious threat to the quality of water environment in river basins, which has attracted more and more attention from the government, society and academic circles. With the increasingly prominent problem of agricultural non-point source pollution in river basins in China in recent years, domestic scholars have carried out extensive research on it. However, most of them are case studies on a single watershed, and there is a lack of overall grasp on agricultural non-point source pollution in the watershed at present in China. In view of this, this paper sorts out and analyzes the existing research results from the related concepts, characteristics, formation mechanism, measurement methods and other aspects of agricultural non-point source pollution, in order to try to sum up the general laws from the current individual research, and on this basis, puts forward the direction that future research can explore, providing ideas and reference for researchers and practitioners of agricultural non-point source pollution in river basins of China.

1. Introduction
Since the reform and opening-up, China's agriculture has developed rapidly and the living standard in rural areas has been continuously improved. At the same time, it has also caused serious agricultural and rural non-point source pollution problems. According to the second national pollution source survey bulletin in 2020, the chemical oxygen demand, total nitrogen and total phosphorus emissions of major water pollutants in agricultural sources reached 10.6713 million tons, 1.4149 million tons and 212,000 tons respectively, accounting for 49.77%, 46.52% and 66.58% of the total COD, TN and TP emissions in China. Rural living sources also contribute 4,996,200 tons of chemical oxygen demand, 446,500 tons of total nitrogen and 36,900 tons of total phosphorus. Agricultural non-point source pollution has become the main inducement of water pollution in China.

China began to pay attention to non-point source pollution in 1980s [1], and began to study agricultural non-point source pollution with increasingly serious nitrogen and phosphorus load in the Three Lakes Basin in 1990s [2]. Up to now, great efforts have been made to study the eutrophication degree of water quality in many river basins, and new research progress has been made in the related connotation of agricultural non-point source pollution, determination of pollution load and control measures. Study on the characteristics of agricultural non-point source pollution [3]; Exploring the
influencing factors of nitrogen and phosphorus pollution load [4]; Quantitative analysis of pollution load is carried out by using hydrological models such as output coefficient method, SWAT model and MPULSE model [5,7]; Some control measures were put forward, such as strengthening source control and actively promoting soil testing and formula fertilization technology. Although a large number of research achievements have been made, due to the dispersion and uncertainty of agricultural non-point source pollution in river basins, and taking into account both agricultural development and farmers' income, the research and treatment of agricultural non-point source pollution in river basins still have a long way to go in Ren Zhong, and the research methods, techniques and preventive measures need to be continuously improved. Objective understanding of the characteristics and causes of agricultural non-point source pollution is conducive to the follow-up of prevention and control work. Therefore, this paper sorts out and analyzes the research results on the concept, characteristics, formation mechanism and measurement methods of agricultural non-point source pollution in river basins in China, and points out the future research direction on this basis.

2. The relevant connotation of agricultural non-point source pollution in the watershed

2.1. Concept
CWA in the United States put forward the earliest definition of non-point source pollution, and defined pollutants entering the water environment in the form of wide area, dispersion and trace as non-point source pollution [8]. With the development of agriculture in China, the environmental problems in rural areas have become increasingly prominent, which has also led to the continuous study of agricultural non-point source pollution in China. Agricultural non-point source pollution is the pollution of water environment caused by nitrogen and phosphorus in agricultural production activities [9]. Since then, the understanding of agricultural non-point source pollution has developed continuously. Researchers further expanded agricultural non-point source pollution to water, soil, air and agricultural products [10]. The definition of agricultural non-point source pollution has gone through a deepening process from water pollution to air pollution, soil pollution and agricultural and sideline products pollution. However, agricultural non-point source pollution is still the most serious harm to water environment. In addition, water resources are very important to ensure people's health, so scholars focus on the research of agricultural non-point source pollution in river basins. As shown in Figure 1 below, this paper gives the process diagram of agricultural non-point source pollution in the basin, so as to make the formation process of agricultural non-point source pollution in the basin clearer.

2.2. Spatio-temporal distribution characteristics

2.2.1. Temporal characteristics. Seasonal characteristics. The intensity and concentration of agricultural non-point source pollution emissions in river basins have obvious seasonal characteristics, which are obviously related to rainy season and flood season of rivers. The emission intensity and pollution load of agricultural non-point source pollution in most river basins reach the maximum in summer, rainy se
ason or river flood season. On the output and concentration of pollution load, the overall trend of non-point source pollution is larger in spring and summer and smaller in winter [11]. Scholars' research on pollution in Guangxi water basin found that the output of pollutants mainly concentrated in rainy season [12]. There are also seasonal differences in the main components of pollutant emissions. The total nitrogen concentration in the small watershed of Danjiangkou Reservoir shows the seasonal variation characteristics of spring > summer > autumn > winter, while the nitrate nitrogen concentration shows the order of autumn > summer > spring > winter [13]. The main components of nitrogen and phosphorus pollution in Pingqiao River Basin are different in dry season, wet season and normal season. Nitrogen is the dominant component in dry season and normal season, while nitrogen and phosphorus are the dominant components in wet season [14]. Therefore, there are obvious seasonal differences in emission intensity, emission load and main components of pollutant emission of agricultural non-point source pollution in river basins.

2.2.2. Spatial features. Distribution characteristics of land use types. Land use types can be divided into dry land, paddy field, aquaculture land, garden land, woodland, grassland and residential land. Agricultural non-point source pollution load is different in different land use types. The pollution load in planting areas, breeding areas and concentrated rural residential areas in the basin is larger, while the pollution load in gardens, woodlands and grasslands is smaller. Scholars have studied the nitrogen and phosphorus loads of different land types and found that the contribution rate of phosphorus from large to small is rural domestic sewage, livestock and poultry breeding sewage, cultivated land, woodland, garden land and grassland [15]; By studying the temporal and spatial variation of NPS pollution load in Minyun Reservoir Basin from 2005 to 2010, it was found that TN and TP load of agricultural land was the highest, followed by grassland, and the pollution load of forest land per unit area was the smallest [16]. Therefore, the agricultural non-point source pollution load is closely related to the land use types in the basin. The planting industry, breeding industry and residential land contributed the main agricultural non-point source pollution load, while grassland and forest land had a smaller non-point source pollution load.

3. Mechanism of agricultural non point source pollution in River Basin

3.1. Physical and geographical factors
Rainfall runoff is the driving force of agricultural non-point source pollution load, which determines the type and accumulation of pollutants [17]. Rainfall has dual functions of carrying and diluting pollutants. Under rainfall conditions, water quality changes in two directions, and water quality improves or deteriorates. When the carrying effect exceeds the dilution effect, more pollutants will enter the water body, resulting in agricultural non-point source pollution. Terrain, vegetation and soil also affect the loss of agricultural non-point source pollution. When the terrain slope is large, with rainfall, soil particles, nitrogen and phosphorus pollutants and heavy metals are more likely to be lost or washed into the water body, thus causing damage to water quality. In the same basin, the terrain is gradually flat from upstream to downstream. When pollutants are produced, they have a certain enrichment effect from upstream to downstream, which makes pollutants easy to gather downstream, which explains the natural reason why the pollution load in the downstream of the basin is stronger than that in the upstream. Different vegetations have different absorption capacity for pollutants. Forest land and grassland can reduce pollutants and heavy metals more likely to be lost or washed into the water body, thus causing damage to water quality. In the same basin, the terrain is gradually flat from upstream to downstream. When pollutants are produced, they have a certain enrichment effect from upstream to downstream, which makes pollutants easy to gather downstream, which explains the natural reason why the pollution load in the downstream of the basin is stronger than that in the upstream. Different vegetations have different absorption capacity for pollutants. Forest land and grassland can reduce pollutants from runoff into water by conversion and adsorption to achieve the effect of purifying water quality. If the soil is loose, the water will more easily seep down. The higher the degree of ground hardening, the more easily pollutants will be lost along with rainfall and surface runoff.

3.2. Human factor
Agricultural production. In order to ensure the economic purpose of increasing farmers' income, the need for food due to the increase of population in China and the development of agricultural biotechnology, farmers' basic production activities are increasingly dependent on agricultural production materials
such as chemical fertilizers, pesticides and agricultural films. Excessive or unreasonable application of chemical fertilizers will lead to the loss of fertilizer nutrients, and a large number of chemical fertilizers entering water will lead to the eutrophication of nitrogen and phosphorus in water environment. Most farmers will not treat the residual mulch film in the soil in time, which will affect the penetration of water and destroy the soil. Thick smoke is produced in the process of straw burning, which causes air pollution. The formed sulfur dioxide is the main component of acid rain, and rainwater enters the river through surface runoff, which further pollutes the water environment. Livestock and poultry breeding and aquaculture will produce a large amount of livestock and poultry manure, sewage, feed, etc., especially in decentralized breeding, where manure is not treated centrally, and pollutants enter the water body with the action of surface and rainfall, resulting in eutrophication of water body and damage to water environment.

Residents' lives. Nitrogen and phosphorus loss from agricultural production activities and rural domestic sewage have become the main sources of agricultural non-point source pollution. With the development of urbanization in China and the transformation of villages and towns, the degree of ground hardening has increased and the water permeability has decreased, which has accelerated the spread of agricultural non-point source pollutants. With the increase of rural population and consumption capacity, the material life is richer, and the solid waste generated increases. However, in rural areas, there is no centralized garbage treatment, most of the sewage is discharged directly on the spot, and most of the solid domestic garbage is piled up in the open air. Coupled with farmers' weak awareness of environmental protection, human activities have become an important factor in non-point source pollution. Scholars have found that the correlation between population density and NH+4-N is as high as 0.98 [18].

4. Pollution load measurement method
Hydrological model is an important method and tool for planning sustainable utilization of water resources. With the application of hydrological model, the research on agricultural non-point source pollution load in river basins has developed from qualitative analysis to quantitative research, and its scientificity and accuracy have been continuously improved. The quantitative analysis of hydrological model for watershed water quality monitoring originated from abroad. In recent years, China has been continuously applied and developed in the measurement of non-point source pollution load. Output coefficient method, SWAT model and agricultural non-point source estimation model AnnAGNPS model are widely used hydrological models in the world. The output coefficient model adopts the pollution load measurement method of centralized accounting, which requires fewer parameters, is convenient to operate and has certain accuracy [19], and is widely used in the estimation of non-point source pollution load in Chinese river basins. However, the lumped model cannot show the spatial distribution characteristics of non-point source pollution, so it has defects in identifying key risks [20]. Researchers continue to strengthen the exploration of new determination methods; SWAT model subdivides the basin into river sub-basins and further divides hydrological response units, which can be used to simulate runoff, sediment yield and water quality of small basins [21]. AnnAGNPS is an enhanced version of AGNPS, which overcomes the disadvantage that AGNPS is not supported by GIS, and combines the latest progress in GIS data operation and watershed physical characteristics, and is used to evaluate the non-point source pollution load of watershed, providing modeling opportunities for unmeasured areas or areas with limited data [22]. There are other models such as HSPF, DPeRS and QUAL2K. However, we find that most of China's current hydrological models use foreign models, and a few researchers explore China's localized pollution load estimation models. It is an urgent problem to speed up the exploration of pollution load estimation models suitable for China's actual situation.

5. Control measures

5.1. Policy measures
The control of agricultural non-point source pollution needs the joint efforts of the state, the Ministry of Agriculture, the Ministry of Ecology and Environment, the Ministry of Finance and other major relevant
departments as well as local governments at all levels. The Ministry of Agriculture should strengthen
the research and development and promotion of new green agricultural technologies, such as actively
dragging into the soil testing and fertilizer distribution technology of chemical fertilizers; Actively
promote the establishment and improvement of soil information database, and promote the adjustment
of production structure in rural areas. The finance department needs to guide farmers' behavior from the
aspects of financial subsidies and taxes, and gradually form the buyer to supply fertilizers and low-grade
pesticides that are more in line with environmental policies by adjusting the tax policies of fertilizers
and pesticides, while corresponding subsidy policies can be adopted for farmers to purchase fertilizers
and pesticides with low toxicity and pollution. For example, in the early stage of popularization of soil
testing and formula fertilization technology, the price of soil testing and fertilizer application can be
lowered, and agricultural producers can choose soil testing and fertilizer application through price
advantage [23]. The Ministry of Environmental Protection should strengthen the publicity and education
of environmental protection in rural areas, and can regularly organize face-to-face training and education
for environmental protection experts to go to the countryside, and combine various online media
channels to publicize environmental protection to farmers; Improve environmental monitoring,
especially strengthen water quality monitoring, and promote more scientific and efficient automatic
monitoring methods.

5.2. Bioengineering measures
In view of the whole process of agricultural non-point source pollution, scholars put forward the 3R
theory of "source reduction-interception-remediation" [24]. Emphasize the implementation of source
reduction actions by reducing the application of chemical fertilizers and pesticides and standardizing the
treatment of agricultural solid waste from the source; Interception in the process of pollutant migration
is implemented by constructing buffer zone, ecological wetland and other bioengineering measures;
Finally, strengthening the restoration of the whole ecosystem is of great reference significance for the
overall prevention and control of agricultural non-point source pollution in river basins. Generally
speaking, the biological measures such as afforestation, returning farmland to forest, constructed
wetland and shelterbelt construction have remarkable effects on the control of agricultural non-point
source pollution in river basins.

6. Future prospects

6.1. Improving the scientficity of experimental research
In the aspect of pollution load measurement, foreign countries pay more attention to agricultural non-
point source pollution and the research method model is more mature, so it is widely used for reference
by domestic researchers. However, it should be pointed out that foreign measurement methods and
models do not necessarily conform to China's actual situation, and domestic scholars should speed up
the research on methods to deal with localized agricultural non-point source pollution. At the same time,
another problem hindering the quantitative research process of agricultural non-point source pollution
in China is data acquisition. In China, some agricultural data are not made public, and a large number
of agricultural data have not been monitored and counted at all. The data about agricultural non-point
source pollution is insufficient and it is difficult to obtain information, which hinders the use of
agricultural non-point source pollution research methods to a certain extent. Relevant administrative
agencies should establish and improve agricultural data databases, such as establishing more complete
soil and hydrological databases.

6.2. Pay attention to the research of agricultural non-point source pollution in cross-border areas
Cross-basin water pollution is the key and difficult point of water environment control at present.
Because there are many administrative regions involved in cross-border areas, the coordination role of
each administrative region in safeguarding its own economic interests to the environment may decline.
In recent years, there have been policy explorations on cross-administrative regional governance such
as river length system. However, it is still a major difficulty to formulate management policies and measures related to agricultural non-point source pollution in cross-border areas, so the research on cross-basin non-point source pollution should be strengthened in the future.

6.3. Exploring the marketization direction of agricultural non-point source pollution control in River Basin

Judging from the current control effect of agricultural non-point source pollution in river basins, China is still in the stage where the government is mainly responsible, but the control effect is not significant. On the one hand, it is reflected in the lack of national governance policies; on the other hand, the implementation of government-responsible policies is not strong. China should explore the market-oriented direction of agricultural non-point source pollution remediation, and promote the development of multi-subject responsibility for agricultural non-point source pollution. Agricultural producers, consumers of agricultural and sideline products, and users of water resources should all be responsible subjects, and need to pay the price and cost for their actions that do not meet the requirements of healthy environment. Western countries' market schemes, water quality credit transactions, tax and fee control schemes and other measures may not be completely suitable for China, but they should be of reference significance for agricultural non-point source pollution control in China's river basins.

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