Original Research Article

The causes of agricultural non-point source pollution and the governance technology system

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Abstract: The occurrence of agricultural non-point source pollution seriously hinders the green and sustainable development of agriculture. This article analyzes the causes of pollution, such as excessive use of fertilizers and pesticides, livestock and poultry breeding pollution, agricultural film residue, and rural domestic sewage discharge. At the same time, it summarizes the technical system for agricultural non-point source pollution control and proposes control measures that are in line with the actual situation in rural areas, providing reference for the control of rural non-point source pollution.
Keywords: agricultural non-point source pollution; ecological management; green agriculture

1. Introduction

The rural ecological environment is the foundation of ecological civilization construction and is directly related to food security and the high-quality development of agriculture.In recent years, China has vigorously advanced the development of green agriculture through the implementation of technologies for fertilizer and pesticide reduction and efficiency enhancement, the regulation of livestock and poultry pollution, the recycling of agricultural plastic film waste, and the improvement of rural living environments. As a result, the rural ecological environment has been improved to a certain extent.However, rural ecological governance still faces dual pressures. The environmental problems left over from the traditional extensive agriculture and animal husbandry have not been completely eradicated, while the intensive and large-scale modern agricultural production model has given rise to new ecological pollution issues. Previous studies have shown that in regions with a higher level of agricultural intensification, the total emissions and emission intensity of agricultural non-point source pollution are generally higher[1].

Agricultural non-point source pollution has become the main cause of water pollution in China[2]. Therefore, exploring simple, efficient and low-cost methods for preventing agricultural pollution and achieving both increased crop yields and environmental protection is the current focus of agricultural environmental protection efforts.

2. The main sources of agricultural non-point source pollution

2.1. Water and soil pollution caused by improper application of chemical fertilizers

Fertilizers are one of the means to increase grain production in modern agriculture. Research has found that in actual production, problems such as blind fertilization and excessive fertilization are widespread[3]. Farmers, in pursuit of high yields, only apply more nitrogen fertilizer and less phosphorus and potassium fertilizers, and do not pay attention to organic fertilizers. The fertilization methods are rough and the ratios are unreasonable[4]. The overall utilization rate of fertilizers in farmland in our country is relatively low. After farmers apply excessive nitrogen fertilizer, a large amount of nitrogen cannot be absorbed by crops and remains on the soil surface. Under the action of rainfall or field irrigation, the residual nitrogen is washed away with water[5].

2.2. The improper application of pesticides has led to the destruction of the farmland ecosystem

In the prevention and control of crop diseases and pests, the use of chemical pesticides is inevitable. Due to the lack of pesticide knowledge among farmers, their insensitivity to pesticide prices, and loss

aversion, there are still cases where farmers apply excessive amounts of pesticides, do so too frequently, and use pesticides beyond the prescribed limits[6]. The residual pesticides will migrate through surface water and groundwater runoff, atmospheric dispersion, and the migration of wild animals[7]. This poses risks to the field organisms and human health. Moreover, long-term and single application of pesticides will lead to the development of pesticide resistance in pests and diseases, forcing farmers to increase the dosage continuously, thereby further exacerbating pollution.

2.3. Pollution caused by livestock and poultry breeding waste

With the rapid development of large-scale livestock farming, the amount of waste generated by livestock farms, including manure, wastewater, and dead livestock, has significantly increased. Many small-scale farms and individual farmers have rudimentary facilities and lack complete waste treatment equipment. Livestock wastewater is directly discharged into the environment. Livestock manure contains high concentrations of trace elements and antibiotic residues[8], and its random discharge will cause these substances to leach and seep into surface water and underlying groundwater, thereby causing environmental pollution in the surrounding areas. In particular, dead livestock, which carry unknown pathogens, if disposed of randomly, pose a significant risk of environmental pollution[9].

2.4. The pollution caused by agricultural waste resulting from residual plastic films

Residual agricultural films are the most common solid waste in rural areas. The use of agricultural films can still significantly promote agricultural development[10]. These films have the functions of retaining heat and moisture and suppressing weeds. However, many ultra-thin agricultural films on the market are difficult to recycle and cannot degrade naturally. When the fragments of residual agricultural films are mixed into the soil, they will damage the soil structure, reduce the transportation capacity of soil moisture and nutrients, inhibit the growth of crops, and thereby damage the ecological environment of farmland and cause a reduction in crop yields[11].

2.5. Rural domestic sewage discharge

Rural domestic sewage constitutes an important part of agricultural non-point source pollution. Since the launch of the rural environmental improvement and enhancement campaign, through measures such as garbage disposal, sewage treatment, and the toilet revolution, the rural living environment has been improved, promoting the comprehensive revitalization of rural areas. Since the beginning of the "14th Five-Year Plan", the national rural domestic sewage treatment rate has exceeded 51%, which is more than double compared to the "13th Five-Year Plan" period. Due to the large geographical area and large population in China, the treatment of rural domestic sewage remains the most prominent shortcoming in rural environmental improvement. The sewage pipeline treatment facilities are not complete, and villagers discharge domestic sewage at will. The organic matter, nitrogen, phosphorus, and detergent residues in domestic sewage will flow into farmlands and rivers, aggravating water and soil pollution.

3. Methods for the control of agricultural non-point source pollution

3.1. Improve rural production and living conditions to achieve source reduction of waste

By adopting intercropping methods[12], using new fertilizers [13] and biological control agents[14], the use of chemical fertilizers and pesticides can be reduced at the source, thereby minimizing the negative impact on the environment. Regarding white pollution caused by agricultural film residues, PBAT biodegradable plastic films can be used, which can maintain the functions of traditional PE films while achieving natural degradation of the films, effectively reducing agricultural white pollution[15]. Adjusting the feed structure can effectively control the emission of nitrogen and phosphorus in livestock manure[16]. Low-residue and herbal feed additives should be vigorously promoted, and the abuse of veterinary drugs and antibiotics should be strictly controlled[17]. This can reduce the generation of pollutants from livestock farming at the source. For the reduction of source pollution from rural domestic sewage, it should follow the pace of the rural environmental improvement and improvement actions, adopt on-site treatment, integration into urban sewage networks or centralized treatment methods, and comprehensively reduce the non-point source pollution caused by the outward migration of rural domestic sewage.

3.2. Pollutant migration process interception

Agricultural non-point source pollution has scattered sources and occurs irregularly. When pollution

inevitably occurs, effective interception before the pollutants enter the water body is also an effective part of the management of non-point source pollution. The interception technologies used both domestically and internationally are similar in general, such as ecological ditch technology, interception dam technology, ecological combined purification pond technology[18], and vegetation drainage ditch technology[19]. The application of these technologies can effectively intercept the migration of pollutants. The advantages of different interception technologies are different. In practical applications, it is necessary to choose the appropriate interception technology based on the local geographical location and natural environment characteristics, in accordance with the local conditions.

3.3. Nutrient recycling technology

Agricultural non-point source pollution mainly originates from the loss of nitrogen, phosphorus and other pollutants from farmland, improper disposal of livestock manure, and the random discharge of rural domestic sewage[20]. Therefore, conducting resource recovery and utilization of various agricultural wastewater and livestock manure can not only replenish the nitrogen and phosphorus content in farmland but also reduce environmental pollution. Among them, livestock wastewater that has been treated to meet standards (GB 18596—2001) and sterilized is used for irrigation in farmland. This can not only save pumping energy consumption but also recycle nitrogen and phosphorus nutrients and reduce fertilizer input[21]. For solid manure, a rotating composting box can be used, combined with yeast bacteria to assist aerobic fermentation. The decomposed organic fertilizer is returned to the field to achieve resource utilization of manure[22]. In addition, the ash from the incineration of meat chicken manure and wood chips in a suitable ratio has sufficient phosphorus content. Its fertilizer effect can replace 80% of mineral phosphate fertilizer and provide phosphorus for crop growth[23]. Rural domestic sewage can be realized resource utilization through phosphorus recovery. It can be processed indirectly into fertilizer raw materials through methods such as adsorption, MAP crystallization, and microalgae cultivation, or directly irrigated in farmland after harmless treatment[24].

3.4. Ecological restoration technology

Ecological restoration is a crucial means for the final control of agricultural non-point source pollution and the improvement of water body environment. It relies on the purification function of natural ecosystems to reduce pollutants such as nitrogen, phosphorus, and pesticides in water bodies. Current mainstream technologies include ecological floating bed technology[25], artificial wetlands[26], and microbial algae removal technology[27]. Through the synergistic action of aquatic plants, microorganisms, and substrates, pollutants are adsorbed, degraded, and nutrients are retained, thereby treating polluted water bodies.

4. Looking forward

In recent years, significant progress has been made in the treatment of agricultural non-point source pollution in China. However, numerous challenges still remain. The trend of large-scale agricultural development has made pollution control even more difficult. Transforming farmers' farming concepts and promoting strict control of production factor inputs in the production process is an effective way to achieve source reduction of pollutants. Moreover, improving local control policies is equally crucial. By implementing green production subsidies, building environmental monitoring networks, and increasing punishment efforts, policies can be used to guide and constrain farmers to engage in green production, further curbing agricultural non-point source pollution.

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