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厦 门 大 学

博 士 学 位 论 文

九龙江流域畜禽养殖污染研究及粪肥土地消纳容量评估

Study on Livestock Production Pollution & Land Assimilative Capacity for Manure in Jiulong River Watershed

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摘　要

随着我国畜禽养殖业的迅猛发展，畜禽养殖已成为我国农业非点源污染和点源污染的主要来源之一，对生态环境构成了严重威胁。传统的畜禽养殖污染控制只注重末端的工程技术治理，已不能适应我国畜牧业发展与环境保护矛盾突出的国情。从机理上认识养殖污染物流失特征、迁移转化规律及其环境效应，从总量控制原则的管理层次上评估区域的畜禽粪肥土地消纳容量，对养殖污染物的产生、释放、迁移等全过程控制及其环境管理具有重大的理论价值和实践意义。

本文以福建省九龙江流域为例，以环境科学、农业生态学、环境经济学、信息学等基本理论为基础，在循环经济理念的指导下，综合现场调查、野外监测、室内分析、数理统计等研究方法，在 GIS 等技术手段的支持下，系统分析了畜禽养殖废弃物中氮磷流失特征、流失负荷以及养殖区养分收支平衡特征；估算了畜禽粪肥的盈亏平衡运输距离；并在此基础上，建立了区域粪肥还田的土地适宜性评价和土地消纳容量评估体系；进而根据以上研究提出相应的技术和管理措施，取得了如下研究成果：

（1）通过对典型养殖区域地表水、地下水、养殖废弃物氨挥发以及干湿沉降连续定位的监测分析，揭示了养殖区域氮磷的流失特征及流失负荷，建立了污染物流失参数，包括规模和散养的氮磷水体流失率、固粪和液粪的氨挥发参数、大气干湿沉降参数等，该研究结果为其他地区养殖污染排放研究提供了参数。利用养殖污染物氮磷迁移转化规律，对现行的养殖“禁建区”政策进行了评述。

（2）通过对畜禽养殖农场的养分平衡特征分析，对农场的环境污染风险进行了评价，探讨了氮磷的主要来源及流失途径。研究表明，九龙江流域畜禽养殖的环境污染风险极大。其中，外地饲料是主要的养分输入源，而规模养殖污水排放以及氧化塘粪水的氨挥发是氮磷流失的主要途径。通过载畜量与潜在总磷浓度的相关关系，估算了维持农田养分收支平衡的适宜载畜量。

（3）利用环境经济学方法，进行了粪肥还田的经济可行性分析，估算了畜禽粪肥的盈亏平衡运输距离，其中鸡粪的盈亏平衡运输距离范围为 41~44 km，猪粪为 9~13 km，牛粪为 1~5 km。

（4）在 GIS 支持下，采用加权线性组合模型（WLC），综合考虑农艺、自

然环境、社会、经济等影响因素，建立粪肥还田的土地适宜性评价指标体系以及畜禽养殖废弃物还田的土地适宜性多目标评价和土地消纳容量评估模型，并将该模型成功地应用在案例地区九龙江流域的新罗区，结果显示新罗区有较大的耕地空间可供畜禽粪肥还田和资源化，但由于该区域养殖数量过多，超过了其土地消纳容量，造成了严重的环境污染。

关键词：畜禽养殖污染；氮磷流失；环境污染风险；盈亏平衡运输距离；畜禽粪肥的土地消纳容量

Abstract

Due to the rapid growth in the number and size of intensive livestock industries in China, the huge amount of livestock waste is the main source of agricultural non-point source pollution, which threatens the ecosystem severely. The conflict between livestock production development and environmental protection problem couldn't be solved, if just laying emphasis on the end-controlling to livestock pollution using engineering technology. It is important to understand the losses characteristics and transporting pattern of livestock pollution, to evaluate the land assimilative capacity of livestock wastes in the level of management according to "total quantity control" regulation in order to give significant theorical basis and practicing meaning to effectively control the livestock pollution.

Jiulong River Watershed was selected as the study area in this paper. The studies were based on the basic theories of Environmental Science, Agricultural Science and Environmental Economic et al., and were integrated with the research approaches including investigation, field sampling, laboratory analysis, and data statistics et al. The study was carried out from several aspects: studied the nutrient losses characteristics and loads of livestock wastes; accounted the nutrient balances in field and farm levels and evaluated the environmental risks; estimated the break-even hauling distance of livestock manure; established the evaluation system on land suitability and land assimilative capacity for manure based on GIS; finally the mitigation measures from technology and management aspects were suggested. Major conclusions in this study are as following:

(1) The nutrient losses characteristics and loads were analyzed through the long term measurements including surface water, groundwater, ammonia volatilization, and atmospheric deposition which were carried out in typical livestock intensive areas. Based on these studies, the pollution parameters were obtained, which included the nutrient loss rates to water from intensive and diffuse livestock production, ammonia volatilization rate from solid and liquid manure, atmospheric deposition load.

(2) The environmental risk was evaluated based on the method of nutrient budgeting. Main inputting source and loss pathways were discussed. The results showed that majority of farms had potential environmental risk, the feed was the main input and the wastewater discharge and ammonia volatilization were main loss pathways. Finally, the environmental capacity from sustaining optimal nutrient

cycling in pig farms was suggested by the correlationship between the livestock load and potential total phosphorus concentration.

(3) The feasibility of manure application to land was discussed by the approach of environmental economic. The break-even hauling distance (BEHD) was estimated. The results showed that BEHD is 41~44 km for chicken litter, 9~13 km for pig manure, and 1~5 km for cow manure.

(4) The evaluation models of land suitability and land assimilative capacity for livestock wastes based on GIS were established. The weighted linear combination model based on multi-criteria evaluation was adopted in this evaluation. The land suitability and land assimilative capacity for pig manure in Xinluo County, Jiulong River Watershed, were evaluated. The results indicated that there was comparatively large land for manure application in this research site. However, huge amount of livestock manure much more than the land assimilative capacity in this limited area has resulted in the environmental problems. The results from the model can be used as the scientific basis for the integrated controlling on the agricultural non-point source pollution.

Keywords: Livestock production pollution; Nitrogen and phosphorus losses; Environmental pollution risk; Break-even hauling distance(BEHD); Land assimilative capacity for livestock manure

目 录

Table of Contents