

A Study on Pollution in Livestock and Poultry Breeding in Shiyang City

Junxiang JIA¹, Chunhui LI^{1,2*}, Xiaoli JIA, Meng XU¹

1. Key Laboratory for Water and Sediment Sciences of Ministry of Education, School of Environment, Beijing Normal University, 100875, Beijing, China,

2. State Key Laboratory of Water Environment Simulation, School of Environment, Beijing Normal University, 100875, Beijing, China;

*Corresponding author's e-mail: chunhui@bnu.edu.cn

Abstract

With the investigation and research of agricultural ecology situation, the pollution characteristics of livestock manure were indicated by the statistical analysis of data as well as the effect of livestock and poultry breeding on agricultural ecology of Shiyang City. Livestock and poultry breeding industry local pollution load of Shiyang City and the local pollution load ratio of pollution sources from different agriculture industries show that livestock and poultry breeding industry should be comprehensive managed and in strict control as the focus of agricultural pollution sources.

Keywords: livestock and poultry breeding; manure pollution; agricultural ecology

1 Introduction

With the improvement of people's income level, the consumption of livestock increased dramatically, leading to larger scale of livestock and poultry breeding, including large animals, such as sheep, hogs and poultry (Chen et al., 2012, Fu et al., 2012). The output values of livestock industry account for more than 50% of the total agricultural output in many developed countries (Jefferson et al., 2001, Oenema et al., 2004). At the same time, the ecological environment problems will be increasingly serious without comprehensive management and remediation of livestock and poultry manure pollution and pollution of waste water and gas (Li, 2006; Song, 2011). Then it will hinder the sustainable development of the livestock and poultry breeding industry (Su et al., 2004; Chen, 2012). It is also claimed that, such hazards have exceeded the industrial pollution, and solving the environmental problem from the livestock industry is an urgent task at current stage of environmental protection and sustainable development in China (Gan et al., 2006; Liu, 2009). Livestock and poultry breeding has become the main pollution source of rural environment (Dong et al., 2011, Wang, 2012; Yang, 2013).

Shiyang city is in the upstream of Danjiangkou Reservoir, which is the water source area of South-to-North (S-N) Water Diversion Project. Rainwater harvesting area to Danjiangkou Reservoir is about 20.9 thousand km², accounting for 88.1% of the city's landscape area. After heightening the Danjiangkou Dam, water area of Danjiangkou Reservoir in Shiyang city increased from 450 km² to 630 km², accounting for 60% of the total water area of the reservoir, and capacity of Danjiangkou Reservoir increased from 17.45 billion m³ to 29.05 billion m³. Among 12 major tributaries of the Danjiangkou reservoir, there are 10 in Shiyang city. Han River's flowing-through length of Shiyang city is 216 km, and the average annual water embouchements of Danjiangkou Reservoir is 32.8 billion m³, accounting for 90% of the total annual water embouchement. Danjiangkou Reservoir shoreline length in Shiyang city is 3.52 thousand km, accounting for 76.4% of the total coastline length. The first phase of the Danjiangkou reservoir flood land in Shiyang city covers an area of 300 thousand mu, with additional area of 238 thousand

mus after heightening Danjiangkou Dam, accounting for 56.3% of the total flood land area of Danjiangkou Reservoir.

The indiscriminate discharge of livestock and poultry manure without well processed and utilized will make the enrichment of nitrogen and phosphorus content in local water environment (Pang et al., 2012). If the receptor of livestock pollution-Danjiangkou Reservoir is excessively polluted, it means not only ecological environment problems or water pollution, even water security issues in receiving areas of S-N Water Diversion Project. The China's first national pollution sources census bulletin published in 2010 shows that, emissions of COD and ammonia nitrogen by agricultural sources are 13.24 million t and 0.92million t, 43.7% and 53.1% of the total emissions respectively. Emissions of COD, total nitrogen and total phosphorus by livestock and poultry breeding industry are respectively 96.0%, 38.0% and 56.0% of emissions by of agricultural sources. Pollution of livestock and poultry breeding industry has threatened the safety of drinking water in some areas of Hubei province as one of the major causes of eutrophication in rivers, lakes and reservoirs. There are few studies in the field of assessment of livestock pollution surrounding the Danjiangkou Reservoir.

2 Overview of study area

Shiyan city is located in northwestern Hubei province, and Wudang Mountain is in the centre of this city. It has land with a total area of 2.36 km², a population of 3.46 million and urban population of 520 thousand. In the northern city hills and mountains are 300-500m above sea level; southern mountains are more than 700 m, especially the highest peak-the Mount Saiwudang of 1730 m. Du River, tributary of the Han River, flows through the west of the city.

In the upper area of Han River, Danjiangkou Reservoir is the resource of Middle Route Project of S-N water diversion, which solves the water shortage problem of more than 20 large and medium-sized cities along the water diversion project, especially Beijing, Tianjin, Hebei province and Henan province, and takes into account the ecological environment and agricultural water. Middle Route Project of S-N water diversion has a main canal length of 1277 km, classified into two phases. The main goals of the first phase of the project are to flow water of 9.5 billion m³ automatically from Danjiangkou Reservoir, after heightening the Danjiangkou Dam, through open hardening channels to the four provinces and municipalities in Henan, Hebei, Beijing and Tianjin. It will reach 13 billion cubic meters as average annual water transfer forward.

Shiyan city comprises six counties, one centre city, two districts and an economic and technological development zone, namely Maojian District, Zhangwan District, Yun County, Yunxi County, Zhushan County, Zhuxi County, Fang County, Shiyan City Economic Development Zone, Wudang Mountain Tourism Economic Zone and Danjiangkou City. The area of cultivated land in Shiyan city is about 274 thousand acres.

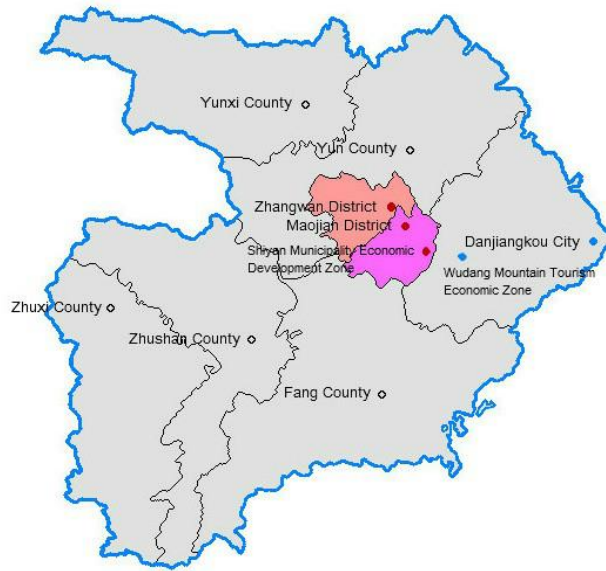


Figure 1 Shiyang City Administrative Map

3 Data and method

3.1 Data sources

The main datasets used in this paper include Hubei province statistical yearbook, Shiyang countryside economic situation analysis and the field research data. The investigation of the content mainly includes:

- (1) The geographical position of farms, whether in Danjiangkou Reservoir reserve;
- (2) Species (cattle, hogs, poultry, sheep, etc.), farming scale (livestock and poultry in stock at year-end, livestock and poultry out of stock and livestock and poultry output). Deficient data is calculated with year-on-year growth rate.

3.2 Method

- (1) Excrement generation of Livestock and poultry

$$GM_i = MC_i \times A_i \times T_i$$

Where GM_i is Generation of Manure (t); i is species of livestock and poultry; MC_i is Daily Manure Generation Coefficient (kg/head); A_i is Amount of livestock and poultry; T_i is Breeding Cycle (day).

$$GU_i = UC_i \times A_i \times T_i$$

Where GU_i is Generation of Urine (t); UC_i is Daily Urine Generation Coefficient (kg/head).

- (2) The TN pollution load of the unit cultivated land area

$$NPL = \sum_i PGC_i \times GM_i / C$$

Where NPL is TN pollution load of the unit cultivated land (kg/acre); PGC is TN Pollution Generation Coefficients of Livestock and Poultry (kg/t); C is the area of cultivated land in

Shiyan city (acre); *GM* is the amount of hogs out of stock, cattle and buffaloes in stock and poultry in stock.

4. Analyses and Results

4.1 Trend Analyses of Livestock and Poultry

In Shiyan city, the amounts of livestock and poultry out of stock at year-end, livestock and poultry in stock and livestock and poultry output mainly have the trend growth to augment year by year (Table 1, Table 2 and Table 3), except the amount of poultry in stock in 2011. Poultry in stock in 2011 decreased for avian influenza epidemic.

Table 1 Livestock and Poultry in Stock at Year-end in Shiyan City

Livestock and Poultry in Stock at Year-end(10 000 heads)	2009	2010	2011	2012
Hogs in Stock	152.28	166.76	181.11	209.00
Cattle and Buffaloes in Stock	26.20	28.40	31.96	37.07
Sheep in Stock	68.92	75.26	84.16	97.44
Poultry in Stock	1403.23	1675.46	1535.75	1941.19

Table 2 Livestock and Poultry out of Stock in Shiyan City

Livestock and Poultry out of Stock(10 000 heads)	2009	2010	2011	2012
Hogs out of Stock	150.66	160.75	170.25	180.81
Cattle and Buffaloes out of Stock	6.06	7.66	9.67	10.10
Sheep out of Stock	66.37	77.32	90.05	92.75
Poultry out of Stock	1669.72	2254.12	2333.01	2832.00

Table 3 Livestock and Poultry Output in Shiyan City

Livestock and Poultry Output(10 000 tons)	2009	2010	2011	2012
Output of Pork	11.30	11.54	12.76	13.56
Output of Beef	0.91	1.14	1.38	1.41
Output of Mutton	1.09	1.19	1.34	1.48
Output of Poultry	2.27	3.03	3.36	4.04
Total Output of Meat	15.59	16.91	18.85	20.50
Output of Eggs	3.45	4.13	4.63	4.72

The trend charts of stock of these data are as follows:

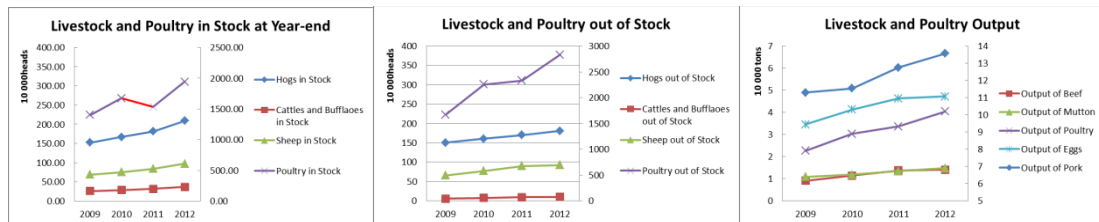


Figure 2 Trend Charts of Livestock and Poultry in Shiyan City from 2009 to 2012

Joint Conferences:

The 2014 Annual Conference of the International Society for Environmental Information Sciences (ISEIS)

The 2014 Atlantic Symposium of the Canadian Association on Water Quality (CAWQ)

The 2014 Annual General Meeting and 30th Anniversary Celebration of the Canadian Society for Civil Engineering Newfoundland and Labrador Section (CSCE-NL)

The 2nd International Conference of Coastal Biotechnology (ICCB) of the Chinese Society of Marine Biotechnology and Chinese Academy of Sciences (CAS)

It can be seen above that hogs and poultry account for principle amount of livestock and poultry breeding industry in Shiyang city.

4.2 Statistical Analysis of Livestock Excrement Pollution

Excrement generation of livestock and poultry has increased with the expansion livestock and poultry breeding industry scale. Manure generation of livestock and poultry of Shiyang city can be calculated based on manure generation coefficient, and urine generation of livestock and poultry can be calculated by daily urine generation (Table 4). Manure generation calculation should use breeding cycle of livestock and poultry. Comprehensive ratio of excrement can be calculated by comparing generation of livestock and poultry species with total excrement generation (Table 5).

Table 4 Manure and Urine Generation Coefficient of Livestock and Poultry

	Cattle and Buffaloes	Hogs	Sheep	Egg Poultry in Stock	Meat Poultry Out of Stock
Daily Manure Generation Coefficient (kg/head)	25.00	2.50	1.50	0.15	0.11
Daily Urine Generation Coefficient (kg/head)	10.00	3.00	0.50	0.15	0.11
Breeding Cycle(day)	365	180	365	365	90

Table 5 Manure and Urine Generation of Livestock and Poultry Breeding in Shiyang City in 2011

	Amount(10000heads)	Generation of Manure(t)	Generation of Urine (t)
Hogs	351.36	1581120	1897344
Cattle and Buffaloes	41.63	3038990	1519495
Sheep	174.21	953800	317933
Egg Poultry	1535.75	840824	840824
Meat Poultry	2333.01	230968	230968
Total		6645702	4806564

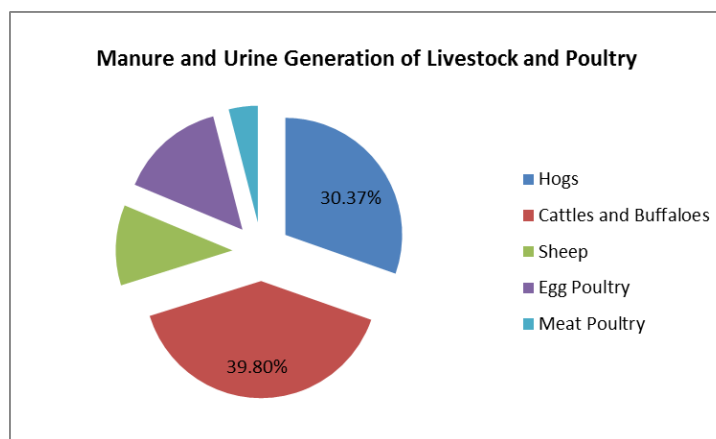


Figure 3 Manure and Urine Generation Ratio of Livestock and Poultry

Large-scale animals' breeding, mainly cattle and buffaloes, accounts for the largest proportion of the amount of livestock and poultry manure and urine generation. Large-scale animals' and hogs' breeding are the focus of livestock pollution treatment in Shiyan city.

4.3 TN pollution load of the unit cultivated land area

Pollution generation can be estimated through coefficients from Agricultural Technology Economic Manual published by Agricultural Press.

Table 6 TN Pollution Generation Coefficients of Livestock and Poultry

	Cattle and Buffaloes (kg/t)	Hogs (kg/t)	Poultry (kg/t)
TN	4.37	5.88	9.84

Agricultural cultivated land is the main way that absorbs TN pollution of livestock and poultry breeding industry. The area of arable land to a large extent affects the TN pollution of livestock and poultry absorbing ability. Therefore the thorough analysis of pollution load for the unit cultivated land area is more objective to reflect the livestock and poultry breeding pollution risk.

The TN pollution load of the unit cultivated land area in Shiyan city in 2011 is 191.74 kg per acre. Researches show that considering the influence of factors such as the soil texture, fertilizer and climate, limited value of TN pollution load is 170 kg per acre in agricultural policy of the European Union regulation, unless environmental pollution will happen extremely easily to farmland and water.

4.4 Pollution of livestock and poultry near the reservoir

The data of pollution of livestock and poultry near the reservoir in Shiyan city in 2011 is especially separated for the particularity of geographic location.

Table 7 Pollution of Livestock and Poultry near the Reservoir in Shiyan City in 2011

		Hogs	Cattle and Buffaloes	Poultry	Total
TN	Generation of TN(kg)	548861.70	336370.80	243200.00	
	Emission of TN(kg)	322284.56	75267.83	62658.90	460211.30
	ratio	70.03%	16.36%	13.62%	
COD	Generation of COD(kg)	5340276.00	3382712.00	2780300.00	
	Emission of COD(kg)	678781.37	176291.20	73975.95	929048.52
	ratio	73.06%	18.98%	7.96%	
TP	Generation of TP(kg)	83070.96	42568.96	69400.00	
	Emission of TP(kg)	49132.32	9525.42	16981.70	75639.44
	ratio	64.96%	12.59%	22.45%	
ammonia nitrogen	Generation of ammonia nitrogen(kg)	267013.80	11972.52	64400.00	
	Emission of ammonia nitrogen(kg)	117332.91	2262.46	6192.50	125787.87
	ratio	93.28%	1.80%	4.92%	

Joint Conferences:

- The 2014 Annual Conference of the International Society for Environmental Information Sciences (ISEIS)
- The 2014 Atlantic Symposium of the Canadian Association on Water Quality (CAWQ)
- The 2014 Annual General Meeting and 30th Anniversary Celebration of the Canadian Society for Civil Engineering Newfoundland and Labrador Section (CSCSE-NL)
- The 2nd International Conference of Coastal Biotechnology (ICCB) of the Chinese Society of Marine Biotechnology and Chinese Academy of Sciences (CAS)

In this study, pollution assessment is based on the situation of livestock and poultry breeding industry near the reservoir in Shiyan city in 2011 (Table 7). The discharge of hogs' manure and urine makes the greatest contribution to emission of TN, TP, COD and ammonia nitrogen, especially the ratio of COD and ammonia nitrogen emission reaches 73.06% and 93.28% respectively.

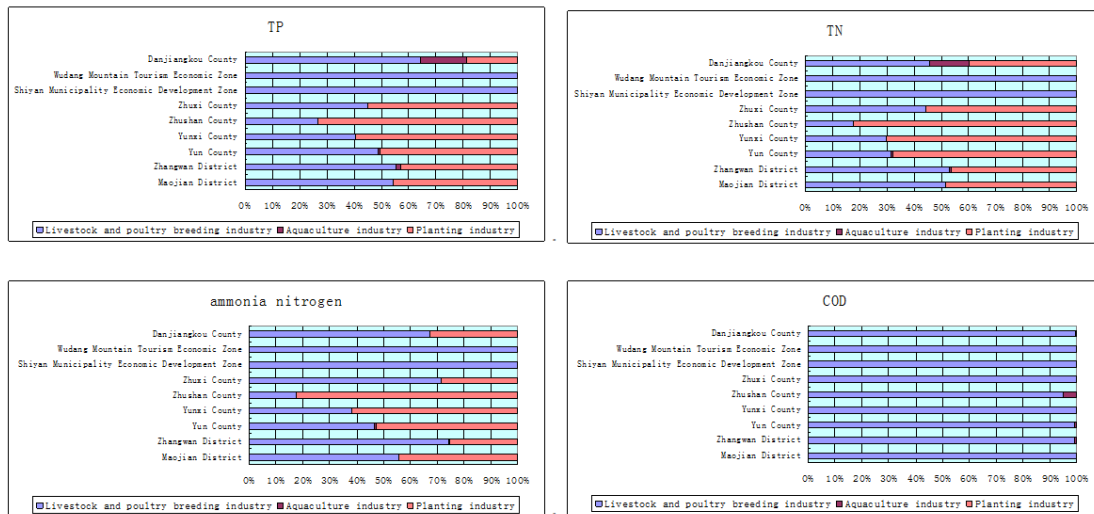


Figure 4 Pollution Load Ratios of Pollution Sources from Different Agriculture Industries of Shiyan City in 2011

These pictures show the local pollution load ratio of pollution sources from different agriculture industries in 2011. In Yun County, Planting industry accounts for 68% of TN pollution load that a larger proportion than livestock and poultry breeding industry which accounts for 31.5%, while aquaculture industry accounts for less than 1%. Livestock and poultry breeding industry almost accounts for the whole TN pollution load of Shiyan City Economic Development Zone and COD pollution load of Danjiangkou County. Livestock and poultry breeding industry, as the focus of agricultural pollution sources, should be in strict control to guarantee sustainable development of Shiyan city and ensure the security of South-to-North Water Diversion Project.

5 Conclusions

The results show that: large-scale animals' breeding, mainly cattle and buffaloes, accounts for the largest proportion of the amount of livestock and poultry manure and urine generation, hogs accounts for the second largest proportion; the TN pollution load of the unit cultivated land area in Shiyan city in 2011 is 191.74 kg per acre, larger than 170 kg per acre, limit value of TN pollution load in agricultural policy of the European Union regulation; the results play an important role to strengthen the prevention work of livestock and poultry pollution and control of livestock and poultry breeding industry. Livestock and poultry breeding industry became the focus of China's agricultural development because of the agricultural generation system and policy support. It appealed to change livestock and poultry breeding methods, to develop the breeding scale, and to increase the level of specialization and intensive breeding.

Joint Conferences:

The 2014 Annual Conference of the International Society for Environmental Information Sciences (ISEIS)

The 2014 Atlantic Symposium of the Canadian Association on Water Quality (CAWQ)

The 2014 Annual General Meeting and 30th Anniversary Celebration of the Canadian Society for Civil Engineering Newfoundland and Labrador Section (CSCE-NL)

The 2nd International Conference of Coastal Biotechnology (ICCB) of the Chinese Society of Marine Biotechnology and Chinese Academy of Sciences (CAS)



Acknowledgement

This study was supported by National Science and Technology Support Program (2011BAC12B02).

References

- Chen Haiyuan, Guo Jianbin, Zhang Baogui, et al (2012). Pollutant Producing Coefficients in Animal Production [J]. *China Biogas*, 30(3):14-16.
- Chen Xiaoyan (2012). A Comparative Study of Countys' Environmental Capacity for Livestock and poultry breeding in Hangzhou [D]. Zhejiang Gongshang University. 12.
- Dong Hongmin, Zhu Zhiping, Huang Hongkun, et al (2011). Pollutant Generation Coefficient and Discharge Coefficient in Animal Production [J]. *Transactions of the CSAE*, 27(1): 303-308.
- Fu Qiang, ZhuYunqiang, KongYunfeng, et al (2012). Spatial Analysis and Districting of the Livestock and Poultry Breeding in China[J].*Geography Science*. 22(6): 1079-1100.
- Gan Lu, Ma Jun, Li Shizhu (2001), Environmental Pollution of the Scale Animal and Poultry Aquaculture and its Prevention and Remedy Counter Measures. *Journal of Agricultural Mechanization Research*, 2006(6): 22–24.
- Jefferson B, Laine A, Stephenson T, et al. Advanced Biological Unit Processes for Domestic Water Recycling [J].*Water Science and Technology*, 43(10): 211–218.
- Li Peng (2006). Research Progress in Pollution Caused by Raising Poultry and its Controlling Counter Measures [J]. *Chinese Journal of Eco-Agriculture*, 14(2): 19-22.
- Liu Jianguo (2009), Research on Prevention and Control System of Livestock and Poultry Excreta [D]. Nanjing Agricultural University.
- Oenema O, Van Liere E, Plette S, et al (2004). Environmental Effects of Manure Policy Options in the Netherlands [J]. *Water Sci Technol*, 49:101-108.
- Pang Zhihua, Ke Bin, Luo Peicong, et al (2012). Strategy Analysis on the Total Emission Reduction of Pollutants of Livestock and Poultry Industry in the Northeast of China [J]. *Environment Protection Science*. 38(3):59-63.
- Song Fuzhong (2011). Study on the Carrying Capacity of Regional Environmental System for Livestock-Poultry Raising and its Precaution [D]. Chongqing University. 5.
- Su Yuping, Zheng Daxian, Lin Wangzhen (2004). A Study on the Prevention and Control of Pollution in Domestic Animal and Poultry Farming in Fujian Province [J]. *Fujian Geography*. 19(3):1-4.
- Wang Lin, Liu Yu, Qi Yunkuan, et al (2012). Investigation on Livestock and Poultry Breeding Pollution to Water Body in Fuxian Lake Basin [J]. *Hubei Agricultural Sciences*. 51(15):3287-3289.
- Yang Fei, Yang Shiqi, ZhuYunqiang, et al (2013). Analysis on Livestock and Poultry Production and Nitrogen Pollution Load of Cultivated Land during Last 30 Years in China [J]. *Transactions of the Chinese Society of Agricultural Engineering (Transactions of the CSAE)*, 29(5):1-11.