NPS POLLUTION ASSESSMENT IN CHAO LAKE WATERSHED BASED ON ECM

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***Abstract*—Chao Lake is one of the five largest fresh lake in China and important to the socio-economy development of Anhui Province. With the enforcement of agricultural development, agriculture planting and stock breeding sectors boosted quickly and None Point Source(NPS) Pollution has become a considerable source contributing to the total pollutants loads into Chao lake. It is essential to study NPS pollutants loading amounts and their spatial distribution for taking effective countermeasures to control NPS pollution. It is a complex task to estimate the contribution of different NPS sources in a large watershed like Chao lake. When there is no extensive pollutant discharge monitoring data, no adequate soil, land use, atmospheric and hydrodynamic data, Export Coefficient Methods (ECM) could be more practical for evaluating NPS pollution and its spatial distribution in large scale watershed. In this paper, ECM was applied using county level statistical datasets(for the year 1990, 2000 and 2009) in Chao lake watershed to assess NPS pollutants loading and their spatial distribution. The research results showed that: The research showed that: i) Total Nitrogen (TN) and Total Phosphorus(TP) generated in Chao lake watershed were 36979, 65042, 77706 and 8973, 23560, 30383 tons respectively for the year 1990, 2000 and 2009, which kept increasing trend for the past three decades; ii) For the year 2009, Livestock/Poultry Breeding sector contributed 73.8% of the TN generation, which followed by domestic waste water(15.2%) and fertilizer using(10.9%). however, Livestock/Poultry Breeding sector contributed 91.7% of the TP generation; iii) The top three counties were Feixi, Feidong and Wuwei, whose amounts of TN and TP generation accounted for 57% and 60% of the whole Chao lake watershed. Therefore effective countermeasures should be taken to control the generation and discharge amount of TP to improve water quality of Chao Lake.**

***Index Terms*—Component, formatting, style, styling, insert. Non Point Source Pollution, Export Coefficient Methods, Chao Lake.**

I. INTRODUCTION

NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries natural and anthropogenic pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground water systems [1]. Studies of NPS modeling have always been a core topic in investigations of NPS [2]. NPS studies in western countries were first conducted in the 1960s, and there have since been many NPS models developed [3]. These models can be divided into two categories, empirical or statistical models and physically based or process-based models[4]. Empirical models use monitoring data in typical experimental plots to build empirical relationships between hydrological parameters, such as the export coefficient method[5], hydrograph separation method [6], etc. Physically based models, which consider the internal mechanism of the pollution process, are capable of calculating long time series and have clearer spatial characteristics distributions. However, due to the enormous number of parameters, requirements for a large body of input data, and limited available information, it is difficult to calibrate and validate these models, which restricts their use for large-scale regions[7]. Estimating the contribution of different NPS sources in a large watershed is a complex task, yet in watershed without extensive pollutant discharge monitoring data, no adequate soil, land use, atmospheric and hydrodynamic data, makes Export Coefficient Methods (ECM) more practical to simulate a large watershed. In this paper, ECM was applied in Chao lake watershed to assess NPS pollutants loading and their spatial distribution. Proportions of different sources of NPS were analyzed. And finally, countermeasures for the control and prevention of NPS in Chao lake watershed were proposed according to our study.

II. METHODOLOGIES

2.1 The Study Area

Chao Lake located at the left bank of the middle and lower reaches of the Yangtze River, facing the Yangtze River to its east and bordering the end of Dabie Mountain Ranges to its west, is located in the middle of Anhui province. The watershed area of Chao Lake is 13,500 km², and the normal water area of the Lake is approximately 800km². There are 11 main tributaries in Chao Lake watershed area including Hangbu River, Nanfei River, Pai River, Zhao River, Shiwuli River, Tangxi River, Baishitian River, Shuangqiao River and Zhegao River, which feed into Chao Lake in a radial pattern and overflow into the Yangtze River through Yuxi River after being regulated in Chao Lake. With rapid development of agriculture, excessive chemical fertilizers was used and huge amounts of livestock and poultries were bred, which made Non-Point Source(NPS) pollution becoming one of considerable contributors influencing the water quality of Chao lake.

2.2 Export coefficient model (ECM)

The export coefficient model(ECM), which is based on the idea that the nutrient load exported from a watershed is the sum of the losses from individual sources, such as land-use, livestock, rural life, etc., has been in general use because of its simplicity and relative robustness. Moreover, the time step of this method is large (monthly, seasonal or annual), and it allows the use of spatially and temporally based lumped data rather than real-time data, as well as the use of agricultural census data rather than field level data[7]. In recent years, there has been a growing number of ECM based studies of water quality relative to different NPS land uses in China. Luo et al. [8] selected 15 catchments of the Hujiashan Watershed to examine the effect of land use on NPS pollution and found that land use was a controlling factor that determined the amount of nitrogen export. Other studies have used simulated rainfall and field-scale monitoring methods to determine the export coefficients of different land use types as well [9,10]. The formulation of ECM is:

$$L = \sum_{i=1}^{n} D_i \times E_i \times Q_i$$

Where L is pollutants loads discharged from NPS; D_i is discharge coefficient of source i ; E_i is pollutant export coefficient for source i ; Q_i is quantity of people, livestock, poultry, aquaculture production or chemical fertilizer utilization in the study area.

In our study, parameters used in the ECM were referenced from the following handbooks: i. Life Source Discharge Coefficient Handbook; ii. Agricultural Pollution Source Fertilizer Loss Coefficient Handbook; iii. Livestock and Poultry Pollution Source Discharge Coefficients Handbook; iv. Aquaculture Pollution Source Discharge Coefficients Handbook. Detail parameters used in our study were shown in Table 1 to 3.

TABLE I. AVERAGE POLLUTANTS DISCHARGING COEFFICIENT FOR RURAL DOMESTIC WASTEWATER AND AQUACULTURE

NPS Sources	unit	TP	TN
Rural Domestic Wastewater	kg/people.year	0.16	1.83
Aquaculture Production	g/kg product	0.5	4.5

TABLE II. CHEMICAL FERTILIZER LOSSES AND MODE PARAMETERS

Mode	Monitor Type	Surface Runoff	
Mode 31	Partition Area	Southern Highland	
	Terrain	Highland	
	Terrace	Yes	
	Land Use Type	Paddy Field	
	Planting Mode	Paddy Rice and Rapeseed Planting Switch	
Loss Coefficients (kg/mu.)	TN	Normal Fertilizer Usage	1.162
		No Fertilizer Usage	1.000
	TP	Normal Fertilizer Usage	0.031
		No Fertilizer Usage	0.022

TABLE III. AVERAGE EXCRETA AND POLLUTANTS PRODUCE COEFFICIENT OF LIVESTOCK AND POULTRY

Livestock/ poultry	Feeding Period (day)	Excretion (kg/year)		Pollutants (kg/ton)	
				TP	TN
cattle	365	Feces	7300	1.18	4.37
		Urine	3650	0.4	8
pig	199	Feces	398	3.41	5.88
		Urine	656.7	0.52	3.3
goat/sheep	90	Feces	234	1.92	9.74
chicken	210	Feces	25.2	5.37	9.84
duck	210	Feces	27.3	6.2	11

Based on above assumptions, ECM models were applied to assess NPS pollution generation using county level statistical datasets (for the year 1990, 2000 and 2009) in Chao lake watershed, which including rural domestic wastewater, chemical fertilizer losses, livestock/poultry and aquaculture NPS pollutants generation (Table 4).

TABLE IV. DIFFERENT NPS SOURCES GENERATED IN COUNTY/CITY LEVEL IN CHAO LAKE WATERSHED

City /County	NPS Sources	1990		2000		2009	
		TN	TP	TN	TP	TN	TP
Hefei City	Rural Domestic Waste water	492	43	467	41	506	44
Feidong		1658	145	1776	155	1718	150
Feixi		1519	133	1528	134	1408	123
Shucheng		1528	134	1653	145	1581	138
Chaohu		1185	104	1136	99	1212	106
Lujiang		1917	168	1902	166	1940	170
Wuwei		2210	193	2318	203	1797	157
Hanshan		643	56	670	59	677	59
He County		1004	88	941	82	953	83
Hefei City	Chemical Fertilizer	221	6	162	4	204	5
Feidong		1613	43	1584	42	1392	37
Feixi		1255	33	1209	32	1051	28
Shucheng		776	21	746	20	725	19
Chaohu		899	24	844	23	833	22
Lujiang		1366	36	1272	34	1269	34
Wuwei		1567	42	1523	41	1498	40
Hanshan		394	11	389	10	606	16
He County		910	24	860	23	859	23
Total		9002	240	8587	229	8437	225
Hefei City	Livestock /Poultry Breeding Sector	596	284	4087	2104	2483	1273
Feidong		2459	1062	6185	2652	10855	4858
Feixi		2749	1341	7575	3734	18221	9404
Shucheng		2630	1278	3657	1747	5504	2757
Chaohu		1146	540	4679	2239	3997	1896
Lujiang		2191	1070	4621	2158	3929	1780
Wuwei		1835	862	7844	3821	6292	2767
Hanshan		712	336	1578	752	1576	768
He County		1481	691	3705	1839	4478	2345
Hefei City	Aquaculture Breeding Sector	2	16	8	76	5	48
Feidong		2	21	17	156	21	187
Feixi		3	23	15	135	17	152
Shucheng		2	17	6	53	17	151
Chaohu		2	20	16	141	16	140
Lujiang		3	24	20	176	19	174
Wuwei		5	41	30	271	28	253
Hanshan		2	14	10	89	9	81
He County		4	32	12	104	10	93

III. RESULTS

The research results showed that: The research showed that: i) Total Nitrogen (TN) and Total Phosphorus(TP) generated in Chao lake watershed were 36979, 65042, 77706 and 8973, 23560, 30383 tons respectively for the year 1990, 2000 and 2009, which kept increasing trend for the past three decades; ii) For the year 2009, Livestock/Poultry Breeding sector contributed 73.8% of the TN generation, which followed by domestic waste water(15.2%) and fertilizer using(10.9%). however, Livestock/Poultry Breeding sector contributed 91.7% of the TP generation (Fig. 1,2); iii) The top three counties were Feixi, Feidong and Wuwei, whose amounts of TN and TP generation accounted for 57% and 60% of the whole Chao lake watershed (Fig.3,4). iv) Water quality of Chao Lake could meet class III according to the standard of surface water quality except for phosphor, therefore effective countermeasures should be taken to control the generation and discharge amount of TP to improve water quality of Chao Lake.

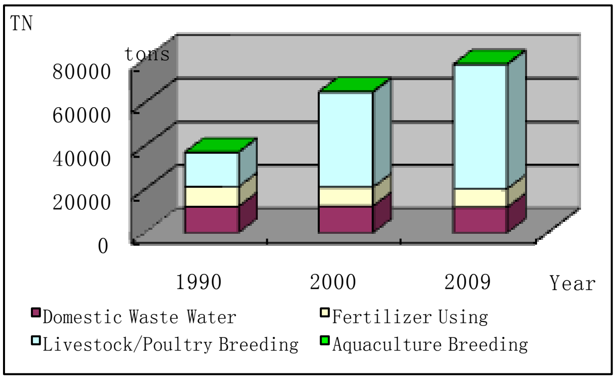

Fig. 1. Contribution of TN Generation in Chao Lake Watershed (1990, 2000, 2009).

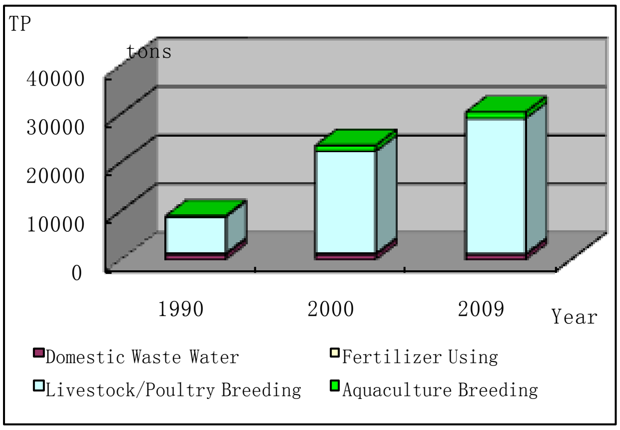

Fig. 2. Contribution of TP Generation in Chao Lake Watershed (1990, 2000, 2009).

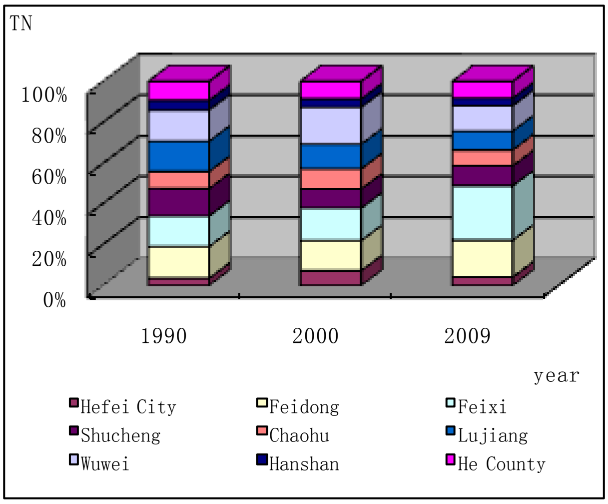

Fig. 3. Proportions of TN Generation in County/City level of Chao Lake Watershed (1990, 2000, 2009).

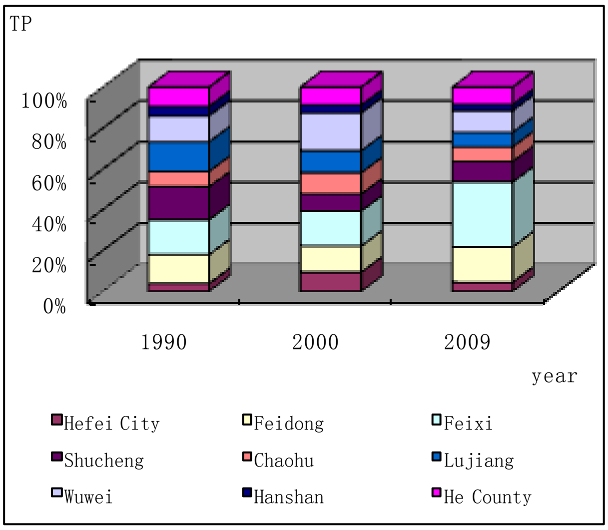

Fig. 4. Proportions of TP Generation in County/City level of Chao Lake Watershed (1990, 2000, 2009).

According to the "Animal Husbandry 12th FYP of Anhui Province", In 2015, the total output of meat, eggs and milk will top 6.3 million tons with an increase of 21% compared with the year 2010. Collective large scale animal husbandry places will be increased from 55% in 2010 to 70% in 2015. The total amount of livestock, poultry, and aquaculture will rise about 21% and large scale animal husbandry breeding places will increase 15% according to this planning. In Chao lake, livestock and poultry breeding plants are still dispersed with livestock and poultry manure disposal is randomly done; thus a considerable part of the excreta pollutants will enter the river system with precipitation runoff and erosion effects. Even if only 1% of the pollutants generated from livestock/poultry breeding sector follow into rivers/lake, it will contribute considerable phosphor loadings to Chao lake.

The export coefficients parameters of ECM are inherently highly variable and reflect particular site conditions for each study, therefore the choice of an export coefficient from the literature is inevitably subject to considerable uncertainty, especially as agricultural land management practices in China differ greatly from those in the US or UK[10]. Nevertheless, ECM are easy to use and can be scaled up to large watersheds and it was still the wises alternatives for the study of large watershed like Chao lake. Due to the restrict of available data and time, there was not enough calibration work done to validate the accuracy of our study and further research work should be done to support NPS physical based process modeling in future.

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