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Estimation of Water Environment Capacity :Example as Four Basin in Shandong Province, China

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Abstract

Estimating of the water environment capacity is an important content of the assessment of regional environmental impact. This article estimates the environmental capacity of surface water of the Yellow River basin, Haihe River basin, Huaihe River basin, Jiaodong Peninsula rivers basin in Shandong based on discussing the concept of water environmental capacity and estimation methods. This article selects the appropriate water quality model and determines the appropriate parameters looking the basin divided unit as the basic unit of the water environment capacity, based on the results of the division of surface water basin and the comprehensive comparison of the multiple water quality model. Then the author calculates the water environmental capacity and gets the control unit of the water environmental capacity, the results will be visualized feedback by GIS. The study has important reference value for assessment of regional environmental and a reasonable estimate of the water environmental capacity.

Keywords: regional environmental impact assessment; water environment capacity; basin; Shandong

1 The concept of water environmental capacity

Scholars proposed many different definitions of water environmental capacity, these definitions can be divided into four categories [1,2,3]:(1)Water environmental capacity is the ratio of the total allowable emissions of pollutants and the corresponding concentration of environmental standards;(2)Water environmental capacity is assimilation of environmental self-purification capacity;(3)Water environmental capacity is the maximum allowable pollutant carrying capacity without environment pollution;(4)Water environmental capacity is the sum of the basic water environmental capacity determined on environmental standards values and background values and the changing water environment capacity determined on self-purification ability. The various definitions reflect different aspects and the part meaning of the water environmental capacity, but not the overall exposition of the water environmental capacity.

Now more consistent concept of water environmental capacity is: under certain environmental goals, territorial waters can take the maximum allowable load of exogenous some (classes) pollutant. Three categories important factors which affect the water environmental capacity Environmental objectives are water environmental characteristics and pollutants characteristics. In addition, the water environmental capacity is closely related to the emission approach s and emissions spatial of pollutant. Water environmental capacity can be seen as a natural

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resource, developing and using of this resource, we can reduce the burden on sewage treatment and reduce the treatment costs.

2 Analysis of water environmental capacity

Water environmental capacity is the management control objectives based on the scientific research of the hydrological characteristics, methods of sewage, pollutant migration and transformation, in the same time combined with environmental management needs. Water environmental capacity can reflect the natural attributes (hydrological characteristics) of river basin, also can reflect the needs of human beings on the environment, water environmental capacity will be changing as the changing of the situation of water resources and the continuous improvement of people's environmental needs.

Analysis methods of water environmental capacity are mathematical models, physical models and analogy survey [4、5、6、7、]. Mathematical models method is the method which calculates the construction project due to changes of water quality using of the mathematical equations which describe water purification system and boundary conditions - water quality mathematical models. The method can give quantitative results, has successful application examples in many river basin. This method is simple, high precision and wide adaptability, but this method requires the calculation of certain conditions and the necessary parameters.

Physical model method is the method which make the water quality simulation experiments on a certain percentage of reduced water quality environment mo to analysis the changes of water quality caused by the construction project based on the similarity theory, this method can reflect the more complex characteristics of water environment, and the degree of quantification is higher, the reproducibility is good, but it needs appropriate experimental conditions and more basic data, and the production of the model spend a lot of manpower, material and time. When mathematical models can not be used in analysis, the evaluation is higher level and has more stringent requirements on the analysis, the method should be used. However, the chemical, biological purification process of the pollutants in water difficult to simulate in the experiment.

Analogy survey method is the method which investigates the projects that similar with the proposed construction projects in nature, also in the size, flow and water quality of pollutant water. We estimated environmental impact of the proposed project according the survey. Such forecasts are qualitative or semi-quantitative nature. Because we likely find the similar projects, but it is difficult to find the similar environmental conditions of water, the results based on the analogy survey tend to be rough. This method can be used when the level of evaluation is lower and the time of assessment is short, enough parameters and data can not be acquired.

3 The division of watershed and basin in Shandong Province

Shandong Province is located in east longitude 114 ° 36 '~ 112 ° 43', latitude 34 ° 25 '~ 38 ° 23', Total land area is more than 150,000 km^2, Rain Source province rivers, river systems development, river network density 0.24km/km.Rivers of province is the rain source river, river systems are developed, density of river network is 0.24km/km. The river which long over 50 km are more than 100. The Yellow River hailed as "the Chinese mother river" cross Shandong from southwest to northeast, circuit is more than 610 km, flow into sea from Bohai Bay. Well-known Beijing-Hangzhou Grand Canal crosses Luxi Plain from the southeast to the northwest, the length of canal is over 630 km. Other important rivers are tuhai river, Ma cheek River, Yihe River, Shuhe, Dawen, Xiaoqing, Jiaolai River, Huaihe River, etc. These rivers belong to the Yellow River, Haihe River, Huaihe River Basin, Shandong Peninsula Rivers Basin. The areas of four basins are respectively 13633 km^2, 30942 km^2, 51048 km^2, 61052 km^2 [9].

4 The estimation of environment capacity of four water basin in Shandong Province

4.1 The approved of environment capacity of water basin in Shandong Province

This article approved “six index” associated with surface water [10] , such as the total emissions of pollutants, the amount of pollutants into the river, ideal environmental capacity, environmental capacity, the maximum allowable point source emissions and pollution reductions in province, The ideal environmental capacity is the maximum number of pollutants of water based on the given water quality objectives, the design hydrology conditions, and the design water quality conditions. Environmental capacity is the rest deducted the load of non point source from the ideal environmental capacity, actually the environmental capacity of point source. In reality, the management of

water environment achieves water quality objectives by controlling the emissions of pollution sources of land-based. Therefore, the environmental capacity of water divided by the coefficient of pollutants flowing into the river, transform into the maximum allowable emissions of point sources.

4.1.1 Approved the total quantity of pollutants

Approved base year: 2008 year

Approved range: all the various sources of pollution row which to the Land of 17 cities in Shandong Province. But along the Bohai Sea of Dongying, Weifang, Binzhou, Yantai and along the Yellow Sea of Qingdao, Yantai, Weihai, Rizhao, some of the sources of pollution directly row into the sea, not in the scope of this approval.

The basic unit of approved: The land area of the basin

The category of approved pollution source: Pollution sources are divided into two categories, namely, point source and non-point source. Point source includes industrial and urban pollution sources. Non-point source includes sources of rural life (including the source of life of rural residents and livestock distributed source), agricultural runoff, large-scale livestock and poultry sources, urban runoff and other types of mining runoff and so on.

4.1.2 Approved amount of pollutants into the river

(1) The estimation method of point source pollutants into the river

The volume of point source pollutants into the river = point source emissions × point source pollutants into the river coefficient. The factor into the river of point source pollutants is the ratio of the accounts into the river which be transported by a certain means from discharge outlet of pollution sources to river discharge outlet and the emissions of pollution sources. There are several ways to determine point source pollutants into the river coefficient:

Experience method. This experience comes mainly environmental management of the daily work, such as environmental monitoring, environmental supervision, environmental impact assessment, environmental statistics, it is accumulation from Daily through on-site observation and multiple authentication. Most point source pollutants into the river coefficient obtain from this method.

Distance determination method. We determine the initial value of factor into the river for the distance of point source outfall and river discharge outlet. Reference values are as follows: $L \leq 1$km, Factor into the river is 1.0; $1 < L \leq 10$km, Factor into the river is 0.9; $10 < L \leq 20$km ; Factor into the river is 0.8; $20 < L \leq 40$km， Factor into the river is 0.7; $L > 40$km; Factor into the river is 0.6. Then, we amend it according to the channel correction factor and the temperature correction factor.

(2) The estimation method of non-point source pollutants into the river

The volume of non-point source pollutants into the river = non-point source emissions × non-point source pollutants into the river coefficient. The factor into the river of various types of non-point source pollutants in Shandong Province is in table1.

Table 1 The factor into the river of various types of non-point source pollutants in Shandong Province

River name	Source Category	The factor into the river of COD	The factor into the river of NH_3-N
Haihe River Basin	The source of life of rural residents	0.05	0.05
	Distributed source of livestock and poultry breeding	0.05	0.05
	The loss of farmland fertilizer	0.05	0.05
	Soil erosion	0.45	0.45
	The sources of large-scale livestock and poultry	0.05	0.05
	Urban runoff	0.80	0.80
Huaiher River basin	The source of life of rural residents	0.10	0.10

	Distributed source of livestock and poultry breeding	0.10	0.10
	The loss of farmland fertilizer	0.10	0.10
	Soil erosion	0.45	0.45
	The sources of large-scale livestock and poultry	0.10	0.10
	Urban runoff	0.80	0.80
Coastal Rivers Basin	The source of life of rural residents	0.12	0.12
	Distributed source of livestock and poultry breeding	0.12	0.12
	The loss of farmland fertilizer	0.12	0.12
	Soil erosion	0.45	0.45
	The sources of large-scale livestock and poultry	0.12	0.12
	Urban runoff	0.80	0.80
Yellow River Basin	The source of life of rural residents	0.10	0.10
	Distributed source of livestock and poultry breeding	0.10	0.10
	The loss of farmland fertilizer	0.10	0.10
	Soil erosion	0.45	0.45
	The sources of large-scale livestock and poultry	0.10	0.10
	Urban runoff	0.80	0.80

4.2.3 The ideal environmental capacity of the river

(1) We can get the ideal environment capacity of COD, NH_3-N of the reach of all rivers in Shandong Province from getting the reach of the river of the water quality objectives and the background concentration of water quality, hydrology parameter design values into the mathematical model.
(2) We can get the ideal environment capacity of COD, NH_3-N of all rivers basin in Shandong Province from superposition the ideal environmental capacity of the reach of all rivers in Shandong province.
(3) We can get the ideal environment capacity of COD, NH_3-N of all rivers in Shandong Province from superposition the ideal environmental capacity of the river of all basins in Shandong province.
(4) We can get the ideal environment capacity of COD, NH_3-N of all rivers or all basins in Shandong Province from superposition the ideal environmental capacity by the river basin, provincial delivery times all rivers (Table2and Table3).

Table 2 The ideal environment capacity of COD in all basins in Shandong Province and Shandong Province
Unit: t / a

River name	90% of the guaranteed rate in the driest month	Average of the past 15 years in the driest month	Average of the past 15 years in the driest season	Average of the past 15 years in dry season
Haihe River Basin	33079.092	35530.928	34994.255	36462.035
Huaiher River basin	36419.196	421714.243	45564.96	47163.067
Coastal Rivers Basin	21631.747	34777.426	37466.177	38938.982
Yellow River Basin	260.802	2209.986	3222.163	3704.133
Total province	91390.837	115232.583	121247.555	126268.217

Table 3 The ideal environment capacity of NH3-N in all basins in Shandong Povince and Shandong Province
Unit: t / a

River name	90% of the guaranteed rate in the driest month	Average of the past 15 years in the driest month	Average of the past 15 years in the driest season	Average of the past 15 years in dry season
Haihe River Basin	1283.03	1386.336	1404.919	1424.745
Huaiher River basin	1480.152	1758.027	1885.463	1958.027
Coastal Rivers Basin	903.162	1446.605	1556.694	1616.697
Yellow River Basin	12.017	95.114	138.88	159.827
Total province	3678.361	4686.082	4985.956	5159.296

4.2.4 Approved environmental capacity of river

(1) Calculation of environmental capacity of river

The environmental capacity of the river basin is approved by the basin as a unit. Environmental Capacity of basin= Ideal environment of capacity Basin — non-point source pollution load. Because we deduct the non-point source load, the environmental capacity is actually the environmental capacity of point source.

(2) We can get the environment capacity of COD, NH_3-N of this river from superposition the ideal environmental capacity the reach of the river based on the environmental capacity of all basins in Shandong province. We also can get the environment capacity of COD, NH_3-N of all rivers or all basins in Shandong Province from superposition the environmental capacity by the river basin, provincial delivery times all rivers(Table 4 and Table 5).

Table 4 The environment capacity of COD in all basins in Shandong Province and Shandong Province
Unit: t / a

River name	90% of the guaranteed rate in the driest month	Average of the past 15 years in the driest month	Average of the past 15 years in the driest season	Average of the past 15 years in dry season
Haihe River Basin	32578.741	35464.585	35627.85	36061.491
Huaiher River basin	32940.988	38526.516	44127.155	45675.211
Coastal Rivers Basin	20159.092	33265.999	36091.338	38646.659
Yellow River Basin	162.008	1694.587	2649.863	3086.627
Total province	85840.829	108951.687	118424.206	123469.988

Table 5 The environment capacity of NH3-N in all basins in Shandong Province and Shandong Province
Unit: t / a

River name	90% of the guaranteed rate in the driest month	Average of the past 15 years in the driest month	Average of the past 15 years in the driest season	Average of the past 15 years in dry season
Haihe River Basin	1331.204	1429.076	1447.976	1448.507
Huaiher River basin	1144.3	1248.522	1432.033	1490.564
Coastal Rivers Basin	582.493	1008.324	1085.454	1127.144
Yellow River Basin	0	11.712	27.777	34.2
Total province	3057.997	3697.632	3993.24	4100.415

4.2.5 Determine the maximum allowable emissions and pollutant reductions of point source

The formula of the maximum allowable emissions of point source: The maximum allowable emissions of point source in basin= environmental capacities in basin/Integrated coefficient of river basin pollution. We can calculate the maximum allowable emissions in Shandong Province (Table 6 and Table7) substituted the COD, NH_3-N environmental capacity of basins in Shandong Province (Table 4 and Table5) and the integrated factor into the river in the watershed point source(Table 1) into the above formula.

Table 6 The COD maximum allowable emissions of The Basin and point source in Shandong Province Unit: t / a

River name	90% of the guaranteed rate in the driest month	Average of the past 15 years in the driest month	Average of the past 15 years in the driest season	Average of the past 15 years in dry season
Haihe River Basin	46984.871	50715.806	51372.231	52069.264
Huaiher River basin	50143.769	57200.223	60776.873	62789.815
Coastal Rivers Basin	27530.116	44710.547	48084.05	50632.269
Yellow River Basin	214.032	1920.268	2977.623	3485.32
Total province	124872.788	15454.844	163209.904	168967.668

Table 7 The NH^3-N maximum allowable emissions of The Basin and point source in Shandong Province Unit: t / a

River name	90% of the guaranteed rate in the driest month	Average of the past 15 years in the driest month	Average of the past 15 years in the driest season	Average of the past 15 years in dry season
Haihe River Basin	1902.771	2402.751	2069.624	2090.003
Huaiher River basin	1769.176	1897.927	2006.165	2101.695
Coastal Rivers Basin	805.878	1364.689	1458.086	1508.905
Yellow River Basin	0	13.273	31.51	38.829
Total province	4477.825	5318.64	5565.385	5739.432

4.2.6 Determine pollutant reductions

If the watershed point source emitting more than their maximum allowable emissions, the amount of point sources in the basin must be cut. The reductions of point source in basin = the emissions of point source in basin — The maximum allowable emissions of point source in basin. Table8 and Table9.

Table 8 COD reductions of The Basin and point source in Shandong Province Unit: t / a

River name	90% of the guaranteed rate in the driest month	Average of the past 15 years in the driest month	Average of the past 15 years in the driest season	Average of the past 15 years in dry season
Haihe River Basin	52538.648	49397.889	48906.758	48570.841
Huaiher River basin	134057.92	128494.515	126343.207	125507.013
Coastal Rivers Basin	202019.162	192228.042	190908.054	190340.555
Yellow River Basin	43278.909	42424.01	42059.6	41915.649
Total province	431894.639	412544.456	408217.619	406034.058

Table9 NH^3-N reductions of The Basin and point source in Shandong Province Unit: t / a

River name	90% of the guaranteed rate in the driest month	Average of the past 15 years in the driest month	Average of the past 15 years in the driest season	Average of the past 15 years in dry season

Haihe River Basin	5516.899	5394.867	5371.844	5353.911
Huaiher River basin	13165.621	13041.214	12591.367	12868.243
Coastal Rivers Basin	22169.515	21788.752	21716.692	21684.995
Yellow River Basin	3474.976	3472.717	3468.839	3467.586
Total province	44327.011	43687.55	43508.742	43374.735

Table 10 Aggregate amount of pollutants into the river in all basins in Shandong Province and Shandong Province Unit: t / a

River name		Haihe River Basin	Haihe River Basin	Haihe River Basin	Haihe River Basin	Haihe River Basin
Wastewater emissions （m /a)	Industry	100910546	238345241	316205810.7	64683274	720144871
	City	71648087	223054625	317641357	80662020	69306089
	Total	172558633	461399866	633847167.7	145345294	1413150960
COD emissions （t/a)	Industry	43175.48	60249.6	68885.93	16692.02	189003.33
	City	30175	83688.66	139143.5	29751.52	282758.68
	non-point	5568.89	29354.49	42092.17	11171.28	88186.83
	Total	78919.37	173293.054	250121.6	57614.82	559948.84
NH^3-N（t/a)	Industry	3606.06	5188.295	7184.6	797.405	16776.36
	City	2781.04	9363.89	14893.73	2919.87	29958.53
	non-point	891.25	11107.02	16884.23	4966.8	34849.3
	Total	8278.35	25659.205	38962.56	8684.08	81584.2

5. Results

5.1 Total amount of kinds of pollution into the river

Table 10 Aggregate amount of pollutants into the river in all basins in Shandong Province and Shandong Province Unit: t / a

River name		Haihe River Basin	Haihe River Basin	Haihe River Basin	Haihe River Basin	Haihe River Basin
Wastewater emissions （m /a)	Industry	100910546	238345241	316205810.7	64683274	720144871
	City	71648087	223054625	317641357	80662020	69306089
	Total	172558633	461399866	633847167.7	145345294	1413150960
COD emissions （t/a)	Industry	43175.48	60249.6	68885.93	16692.02	189003.33
	City	30175	83688.66	139143.5	29751.52	282758.68
	non-point	5568.89	29354.49	42092.17	11171.28	88186.83
	Total	78919.37	173293.054	250121.6	57614.82	559948.84
NH^3-N（t/a)	Industry	3606.06	5188.295	7184.6	797.405	16776.36
	City	2781.04	9363.89	14893.73	2919.87	29958.53
	non-point	891.25	11107.02	16884.23	4966.8	34849.3
	Total	8278.35	25659.205	38962.56	8684.08	81584.2

Table 10 shows that the COD of the various sources of pollution in province is total 559948.84t / a.

5.2 Because of river water pollution situation in Shandong, we should speed up industrial restructuring, reduce waste water discharge, implement of sustainable economic development, good environmental Impact assessment, Speed up the construction of sewage facilities, Increase the sewage treatment efforts; Strengthen Discharged effluent monitoring of the surrounding area.

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