Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 15	No. 4	pp. 1169-1176	2016

Original Research Paper

The Comparison of Different Calculation Methods of Pollution Receiving Capacity for Jilin Province Huifa River

Yao Liwei and Men Baohui†
Renewable Energy Institute, North China Electric Power University, Beijing-102206, China
†Corresponding author: Men Baohui

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 19-12-2015
Accepted: 28-01-2016

Key Words:
Pollution receiving capacity
Water quality model
Sewage outfall
Huifa river

ABSTRACT

Huifa River is the largest tributary of the Second Songhua River. Songhua River Basin is the concentrated area of Northeast Old Industrial Base, and it is also the distribution area of major cities, bearing production task of national commodity grain. In recent years, with the rapid development of economy, the deterioration of water quality is serious and the water environment problem is becoming more and more outstanding, which have affected the sustainable development of the economic and social of Jilin province, so it is necessary to analyse and study the pollution receiving capacity of the river and control the water pollution source to protect the water environment and strengthen water resources protection. Based on one-dimensional water quality model, this paper use three kinds of different generalization methods, such as midpoint generalization, uniform generalization and sewage outfall barycenter generalization, to calculate pollution receiving capacity of the five sections of Huifa River, discussing the pollution receiving capacity of water function area based on different situations of sewage outfall generalization. The results show that: Annual pollution receiving capacity of COD and ammonia nitrogen of Huifa River are 34027.02 t/a and 2242.07 t/a respectively in the case of sewage outfall midpoint generalization; Annual pollution receiving capacity of COD and ammonia nitrogen of Huifa River are 33714.86t/a and 2222.49t/a respectively in the case of sewage outfall uniform generalization; Annual pollution receiving capacity of COD and ammonia nitrogen of Huifa River are 41701.09t/a and 2727.90t/a respectively in the case of sewage outfall barycenter generalization. The calculation results of pollution receiving capacity with midpoint generalization and uniform generalization are approximate, while the calculation result of sewage outfall barycenter generalization has some differences with the first two.

INTRODUCTION

With the rapid development of productivity and the increase of the number of population, the destruction of human to ecological environment is gradually increasing. The discharge of the industrial and domestic wastewater, agricultural fertilizer, and the loss of pesticides pollute water environment seriously, restricting the sustainable development. The Second Songhua River Basin, with developed industry and large population, is the city and industry intensive area in Jilin province. The main tributary, Huifa River, has been polluted severely which has caused great damage to the main water supply source, the Songhua Lake in Jilin province, and has made the water environment in this region worse. The pollution of the Huifa River has attracted widespread attention for a long time. With the development of industry and agriculture in the region, the Huifa River pollution is getting worse which has threatened the water environment security of the Songhua Lake. Although the quantity of pollutants in the Huifa River has decreased by some effective measures, the discharge of wastewater has increased. The water pollution of the Huifa River is mainly ascribed to the discharge of industrial wastewater flowing through cities and counties and domestic sewage and the imperfect construction of municipal wastewater treatment plants, resulting in the downtrend of the water quality year by year. The main pollution factors contain ammonia nitrogen, COD, volatile phenol, and total phosphorus etc. The main water pollution is organic pollution, while the water system pollution mainly consists of point source pollution and non-point source pollution. The environmental monitoring data analysis of the Huifa River suggests that the upstream water quality is acceptable, but the middle and downstream water is seriously contaminated, which worsens water quality. The main cause of the worsened water quality is the point source pollution like the plants in cities and counties along the Huifa River. The water pollution of the Huifa River has wide distribution, long duration, and horrendous pollution depth, which is definitely serious from any perspective (Kong et al. 2004). Therefore, many experts and scholars have done a lot of research such as the combination of point source pollution and non-point source pollution through long-term references of environmental monitoring in order to improve water quality of Huifa River and protect water safety in the Songhua River. The grim reality requires that people must rein in their bad behavior, making the survival and development environment from being destroyed. This paper focuses on the research of total quantity control of pollutant in Huifa River to curb the deterioration of water quality.

Water pollutant capacity refers to the maximum number of some pollutants that water can accommodate, under the case of the design hydrological condition, hydrodynamic condition, the sewage outfall location and discharge patterns meeting water quality goals set by water function zone, which is mentioned in the code of practice for computation on permissible pollution bearing of water bodies. The concentration and toxicity of pollution in water decrease naturally and digest with the change of time and space, after movement process of diffusion, mixing and precipitation and the reaction process of physics, chemistry and biochemistry. So, two aspects of water capacity and water quality are considered to determine the water pollutant capacity. River pollution capacity has relation to objectives of water resources protection, division of water function zone, water and pollutant characters. In the actual calculation process, we should consider the pollutant control factor, generalization of pollution sources and pollutant concentration in section, in addition, we should also consider design hydrological condition and calculation parameters of design flow, design velocity of flow and pollutant comprehensive attenuation coefficient. Lao Guomin (2009) studied the method of pollution sources generalization in calculation of water pollution capacity and analysed the influence of the different generalized way of drain outlet to results. Zhang Wenzhi (2008) discussed design hydrological condition and value method of calculation parameters in one-dimensional river water quality model and its influence on the results. Through the analysis of hydrology and water quality conditions of Huifa River, the calculation of pollution receiving capacity on Hailong reservoir, Meihekou, Huinan, water source of Huadian City and Huadian, which are five sections of Huifa River, use three kinds of different generalization methods, such as midpoint generalization, uniform generalization and sewage outfall barycenter generalization, in order to control pollutant emission of Huifa River and protect water quality security better.

DATA AND RESEARCH METHODS

Survey of research area: Huifa River, as the largest tributary of the Songhua River, is located in Huinan county of Jilin province. It originates from the north of Longgang Mountains in Qingyuan Manchu Autonomous County of Liaoning province, flowing northeastward 33.70 km into Meihekou City, Huinan County, and Panshi City in the Jilin province, finally entering in the Songhua River in Fu'an Village of Jinsha Township in Huadian County. The Huifa River, which has main stream of 267.70 km and river average slope of 0.5‰, flows towards northeast from southwest. In addition, it has drainage area of 14,896 square kilometres, including 14,376 square kilometres in Jilin province, the left bank of 7,401 square kilometres and the right bank of 7,495 square

Table 1: Water function areas of Huifa River.

Primary water function areas	Secondary water function areas	The initial section	The Termination section	Section name	Section property	Water quality objectives	River length (km)
Exploitation and utilization areas in Tonghua City and Jilin City	Drinking and agricultural water in Meihekou City	Provincial boundary	Meihekou City	Hailong reservoir	Convention	II~III	29.25
Exploitation and utilization areas inTonghua City and Jilin City	Drinking and agricultural water in Tonghua City and Jilin City	Meihekou City	Huadian City	Meihekou	Convention	III	41
Exploitation and utilization areas in Tonghua City and Jilin City	Drinking and agricultural water in Tonghua City and Jilin City	Meihekou City	Huadian City	Huinan	Convention	III	50
Exploitation and utilization areas in Tonghua City and Jilin City	Drinking and agricultural water in Tonghua City and Jilin City	Meihekou City	Huadian City	Water source of Huadian City	Convention	III	30.1
Sanhu reserve area in Songhua River		Huadian City	Estuary of Songhua Lake	Huadian	Convention	III	21

kilometres. There are numerous tributaries along the Huifa River, covering the main tributaries in left bank, such as Meihe, Shahe, Dasha River, Dangshi River, Futai River, Hulan River, Jinsha River, and more than 10 tributaries in right bank, such as Yitong River, Santong River, Hama River. The areas of water system cover 6 cities and counties including Dongfeng, Meihekou, Huinan, Liuhe, Panshi and Huadian.

Data information: According to water quality objective of Jilin province, with certain design hydrological condition and calculation parameters as the basis, this paper use one-dimensional river water quality model based on different sewage outfall generalization methods to calculate river pollution receiving capacity and compare the differences of calculation results. Huifa River in Jilin province is divided into two primary water function areas and two secondary water function areas. Primary functional areas include the reserves areas and exploitation and utilization areas. Water quality objectives for each function area is II-III water. See Table 1 for specific information.

One-dimensional river water quality model: The analytical method, model trial method (Xu et al. 2011), system analysis method (Fu et al. 2010) and probability dilution model method (Zhao et al. 2012) are the main methods to calculate and research water pollution receiving capacity, and the main affecting factors are: degradation coefficient of pollutant, design hydrological condition, division of water function zone and the pollution sources (Pang 2010). If the pollutants are uniformly mixed in cross section, pollution receiving capacity of middle and small size rivers can use one-dimensional water quality model to calculate. Pollution receiving capacity of water function zone in Huifa River can use one-dimensional water quality model to calculate, according to calculation rules of pollution receiving capacity promulgated by relevant departments and actual situation of Jilin Province surface water. The computational formula of pollutant concentration:

$$C_x = C_0 \bullet \exp\left(-K \cdot \frac{x}{u}\right) \quad ...(1)$$

In the formula: C_x is the pollutant concentration after x distance (mg/L); C_0 is the pollutant concentration in the initial section (mg/L); K is the pollutant comprehensive attenuation coefficient (1/s); x is longitudinal distance along the river (m); u is the average flow velocity in the section corresponding to the design flow (m/s).

The corresponding computational formula of pollution receiving capacity:

$$M=31.5(C_s-C_x)\cdot(Q+Q_p) \quad ...(2)$$

In the formula: M is the pollution capacity of waters (t/a); C_s is the concentration values to meet water quality goals (mg/L); Q is the design flow of the initial section (m^3/s); Q_p is the wastewater discharge flow (m^3/s). The meaning of the rest symbols is the same with the former.

Design hydrological condition and the main calculation parameters:

1. Controllable factor: In this paper, the two key controllable factors are COD and NH_3-N in the process of studying pollution receiving capacity of rivers in Jilin province, according to the requirement and planning of the national water environment management and the present situation of river water quality and pollution sources in Jilin province. Only the factor whose pollution is common and serious need to be controlled first, we can gradually improve river water quality and protect the security of water environment. In the calculation of pollution receiving capacity in Jilin province, this paper takes COD and NH_3-N as the factors to control total pollutants.

2. The design flow: In the process of calculating the pollution receiving capacity, it needs to determine the design hydrological condition of water function area by calculating. The design flow correspond to different guarantee rate is different for a reach, and the obtained pollution receiving capacity value of waters is also different, namely the pollution receiving capacity value of water function area is relative to the design flow of different guarantee. In present situation, the design flow of the southern area generally uses the average flow of the recent 10 years in the driest months or 90% guarantee rate of the monthly average flow at low. The northern region can adjust the design guarantee rate appropriately according to the actual situation or use dry season flow of some typical years (Lou et al. 2007). The design flow of monthly pollution receiving capacity use 75% guarantee rate of the monthly average flow in 11 years (2000~2010) combined with the water resources condition of Jilin province.

3. The design velocity: The design velocity uses the mean velocity of water function zone corresponding to design flow. River monthly average velocity uses Manning formula (3) to calculate:

$$v=1/n\cdot R^{2/3}J^{1/2} \quad ...(3)$$

In it: $R=A/\div$, $J=h_f/l$

In the formula: n is roughness coefficient, call it roughness for short; R is hydraulic radius (m); A is wetted sectional area of river (m^2); χ is wetted sectional perimeter of river (m); J is hydraulic gradient; h_f is processing head loss (m); l is the length of the river (m).

Wetted sectional area and perimeter of river are calculated by monthly mean water level and large cross section data of 11 years (2000~2010) series. Bed roughness of the natural river course and hydraulic gradient can be measured by hydrological measured data over the years.

4. The pollutant comprehensive attenuation coefficient: The pollutant comprehensive attenuation coefficient refers to degradation degree imposed by water environment through a series of physical, chemical and biochemical reactions after pollutants into the water body, reflecting the changes of pollutant along the way and the degradation speed under the effect of water. For different pollutants and different hydrodynamic force conditions, its value is different, usually determined by experience coefficient or the calibration results. In this paper the pollutant comprehensive attenuation coefficient is provided by the Songliao River Water Resources Protection Bureau in the "national comprehensive planning of water resources", in the process of analysing and borrowing the previous relevant results.

5. The calculation of section pollution receiving capacity: Pollutant concentration of the initial section depends on the water quality target concentration of the last water function zone, while the water quality target concentration of this water function zone use the water quality target value of the function area. In the calculation, the maximum value of water quality objectives in a water function zone is the water quality target concentration of the water function zone, but sometimes the values can change reasonably in the range of water quality objectives to meet water quality target of downstream water function zone.

Sewage outfall generalization: Normally, pollutant discharge port distribute irregularly in the different sections of the river for the corresponding section of the same water function zone, and the average concentration of control section in the function area will be obtained by the superposition of concentration generated on the control section of all the sewage outfall pollution source (Han et al. 2001). According to the relevant regulations, pollution receiving capacity refers to the maximum number of pollutants of all sewage in the calculation reach under the premise of meeting the requirement of water quality. Actual calculation generally uses simplified model taking into account the difficulty of the work is higher and water environment is complicated, namely generalize the distribution of the sewage outfall in the river. In this paper: (1) Pollutant discharge port of the same functional area in river is uniform distribution; (2) Pollution source intensity of the same functional area in river is uniform distribution. This computational model of the sewage outfall generalization is actually an average of the pollutants emission, representing an average distribution state of pollutants. From a statistical point of view, this method has certain rationality, while the method specific to the calculation of a water function zone may exist error, so it can be applied to one-dimensional water quality model to calculate pollution receiving capacity of waters. Currently the methods about sewage outfall generalization mainly have three kinds: midpoint generalization, uniform generalization and sewage outfall barycenter generalization (Lu et al. 2011).

1. Midpoint generalization: The method of midpoint generalization see a number of sewage outfalls of water function zone as one concentrated drain outlet located at the midpoint of a river, namely it is treated as a point of pollution source to calculate the pollution receiving capacity of the river. The actual calculation length of the pollution source is the half the length of the river. Combined with the actual situation, the computation of long river needs to divide the river into several segments to calculate the pollution receiving capacity of each section applying the corresponding formula respectively, finally the calculation results of each reach need to be summed, and it is the pollution receiving capacity of the long river. This generalization method is shown in Fig. 1.

The calculation formula of pollution receiving capacity based on midpoint generalization is:

$$M = C_S Q \exp(K\frac{L}{2u}) - C_0 Q \exp(-K\frac{L}{2u}) \qquad ...(4)$$

In the formula: M is the pollution receiving capacity of pollutant (g/s); C_s is quality concentration of water quality target of downstream section (mg/L); L is the reach length (m); Q is the design flow of the reach (m^3/s). The other parameters sense in formula is the same as the formula (1).

2. Uniform generalization: It is considered that several sewage outlets which are not distributed evenly within water function area are viewed as uniform distribution in the calculation river section, namely the distribution of pollutants in the river reaches is uniform. Uniform generalization is shown in Fig. 2.

The pollutant of this small river segment dx, which is chose in the river and whose distance to beginning channel segment is x, is transported to $x=L$, and the remaining quality is dm. The total mass of $x=L$ section, the degradation of the upstream small segments quality is m, then:

$$dm = \frac{m}{L}\exp(-K\frac{L-x}{u})dx \qquad ...(5)$$

$$m = \int_0^L dm = M\frac{u}{KL}[1-\exp(-K\frac{L}{u})] \qquad ...(6)$$

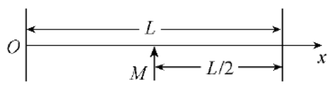

Fig. 1: The sketch map of midpoint generalization.

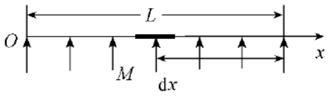

Fig. 2: The sketch map of uniform generalization.

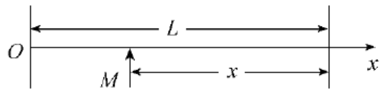

Fig. 3: The sketch map of sewage outfall barycenter generalization.

The calculation formula of pollution receiving capacity based on uniform generalization (Zhang 2008):

$$M = \frac{QKL}{u}\frac{C_S - C_0 \exp(-K\frac{L}{u})}{1-\exp(-K\frac{L}{u})} \quad ...(7)$$

The parameters sense of this formula is the same as the formula (1) and (4).

3. Sewage outfall barycenter generalization: In the method of sewage outfall barycenter generalization, drain outlets within river reach are generalized at the center of barycenter, that is the pollutant discharge in the barycenter section of the functional area. The method of sewage outfall barycenter generalization analyses the pollution receiving capacity about the river, in the case of actual sewage outfall, that is it does not change the original location of the sewage outfall. Sewage outfall barycenter generalization is shown in Fig. 3.

The formula for calculating barycenter:

$$X=(m_1x_1+m_2x_2+\ldots+m_ix_i+\ldots+m_nx_n)/(m_1+m_2+\ldots+m_i+\ldots+m_n) \quad ...(8)$$

In the formula: x is the distance of lower profile to sewage outfall generalized (m); m_i is the pollution emissions of sewage outfall i (i=1,2,…,n)(g/s); x_i is the distance of lower profile to sewage outfall i (m).

The calculation formula of pollution receiving capacity based on sewage outfall barycenter generalization:

$$M = [C_S - C_0 \exp(-K\frac{L}{u})]Q\exp(K\frac{x}{u}) \quad ...(9)$$

The parameters sense of this formula is the same as the formula (1), (4) and (8).

CALCULATION RESULTS AND ANALYSIS

The calculation of monthly pollution receiving capacity:

***The design flow*:** There are 5 conventional sections in Huifa River including Meihekou, Huinan, water source of Huadian City with measured hydrological data and Hailong reservoir, Huadian without measured hydrological data. The design flow is calculated by the monthly average flow in 11 years (2000-2010) under the condition of 75% guarantee rate for sections with measured hydrological data. The design flow of sections without measured hydrological data is calculated by correlational analysis method. The design flow of each section of Huifa River in Jilin province is shown in Fig. 4.

***The design velocity*:** The design velocity is calculated by Manning formula (3). Through the inquiry of hydrological data we obtained: the roughness of Huifa River is about 0.026 and the hydraulic gradient is about 0.000299. Put the data into the Manning formula. Huifa River design velocity of each section is shown in Fig. 5.

Calculation results and analysis of monthly pollution receiving capacity: According to the design flow and the design velocity, the monthly pollution receiving capacity of the three kinds of sewage outfall generalization is calculated by the formula (4), (7) and (9). The results are given in Tables 2-4.

Result analysis**:** Annual pollution receiving capacity of COD and ammonia nitrogen of Huifa River are 28800.46 t/a and 1949.19 t/a respectively in the case of sewage outfall

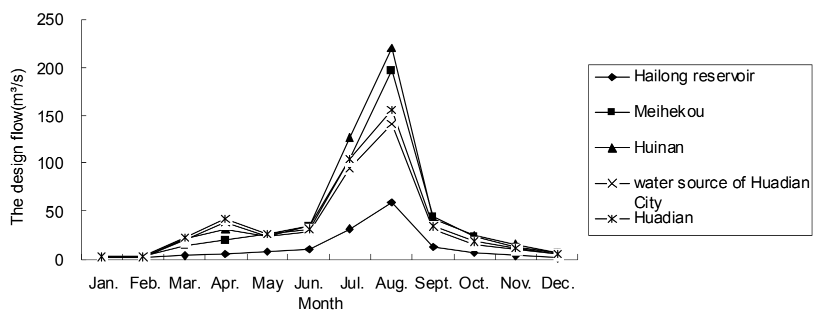

Fig. 4: The calculation results of design flow for Huifa River.

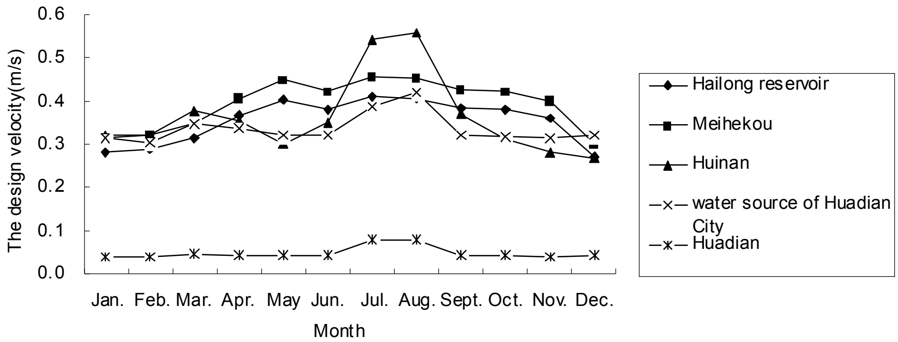

Fig. 5: The calculation results of design velocity for Huifa River.

Table 2: Monthly pollution receiving capacity based on midpoint generalization.

Section name	Hailong reservoir		Meihekou		Huinan		Water source of Huadian City		Huadian	
Pollutant	COD	NH_3-N	COD	NH_3-N	COD	NH_3-N	COD	NH_3-N	COD	NH_3-N
January	8.42	0.55	55.83	5.61	30.72	2.05	15.18	0.99	66.26	2.23
February	8.15	0.54	54.20	5.47	24.79	1.66	15.02	0.97	66.34	2.28
March	50.40	3.39	338.08	34.70	257.85	17.22	146.92	9.54	616.88	19.38
April	60.58	4.22	413.37	43.77	411.92	27.51	288.21	18.71	1223.60	39.28
May	78.88	5.61	544.08	58.72	358.82	23.98	188.10	12.21	815.43	27.18
June	102.83	7.22	704.68	75.19	435.25	29.07	227.37	14.76	983.78	32.68
July	303.39	21.64	2096.55	226.96	1054.25	70.34	620.32	40.26	1133.76	3.62
August	576.29	41.05	3979.46	430.26	1777.87	118.62	853.71	55.40	1688.85	5.39
September	137.13	9.64	940.36	100.45	519.72	34.71	248.79	16.15	1077.52	35.86
October	72.38	5.08	496.15	52.97	371.26	24.81	130.20	8.45	565.08	18.87
November	42.53	2.95	289.66	30.56	266.32	17.81	86.58	5.62	378.28	12.78
December	22.71	1.48	149.82	14.90	104.08	6.96	42.31	2.75	183.15	6.09

Table 3: Monthly pollution receiving capacity based on uniform generalization.

Section name	Hailong reservoir		Meihekou		Huinan		Water source of Huadian City		Huadian	
Pollutant	COD	NH_3-N	COD	NH_3-N	COD	NH_3-N	COD	NH_3-N	COD	NH_3-N
January	8.41	0.55	55.71	5.59	30.63	2.04	15.16	0.98	64.09	2.11
February	8.14	0.54	54.09	5.45	24.72	1.65	15.01	0.97	64.03	2.14
March	50.35	3.38	337.48	34.60	257.28	17.15	146.79	9.52	600.20	18.47
April	60.53	4.21	412.84	43.67	410.89	27.39	287.92	18.68	1188.71	37.32
May	78.82	5.60	543.50	58.61	357.57	23.84	187.89	12.19	789.64	25.68
June	102.75	7.21	703.84	75.03	434.14	28.94	227.11	14.73	952.96	30.89
July	303.20	21.62	2094.42	226.55	1053.12	70.21	619.85	40.21	1124.01	3.57
August	575.91	41.01	3975.35	429.47	1776.08	118.41	853.15	55.34	1674.32	5.31
September	137.03	9.62	939.26	100.24	518.53	34.57	248.51	16.12	1043.59	33.89
October	72.32	5.08	495.56	52.86	370.03	24.67	130.05	8.44	547.10	17.83
November	42.50	2.94	289.27	30.49	265.25	17.68	86.48	5.61	365.83	12.05
December	22.68	1.47	149.47	14.84	103.62	6.91	42.26	2.74	177.40	5.76

midpoint generalization; annual pollution receiving capacity of COD and ammonia nitrogen of Huifa River are 28567.39 t/a and 1934.62 t/a respectively in the case of sewage outfall uniform generalization; and annual pollution receiving capacity of COD and ammonia nitrogen of Huifa River are 34560.26 t/a and 2315.94 t/a respectively in the case of sewage outfall barycenter generalization. The comparison of the pollution receiving capacity with different sewage outfall generalization is given in Table 5.

For different sewage outfall generalization methods, the midpoint generalization method is applied to relatively

Table 4: Monthly pollution receiving capacity based on sewage outfall barycenter generalization.

Section name	Hailong reservoir		Meihekou		Huinan		Water source of Huadian City		Huadian	
Pollutant	COD	NH_3-N	COD	NH_3-N	COD	NH_3-N	COD	NH_3-N	COD	NH_3-N
January	9.22	0.62	62.56	6.52	35.18	2.46	16.50	1.10	103.76	4.06
February	8.90	0.61	60.57	6.34	28.40	1.99	16.38	1.09	105.38	4.23
March	54.66	3.78	374.53	39.78	289.51	20.09	158.49	10.55	926.41	33.34
April	64.95	4.63	451.30	49.21	465.65	32.40	311.54	20.76	1858.29	68.57
May	84.01	6.10	589.12	65.29	414.84	29.11	204.20	13.62	1266.8	48.91
June	109.94	7.89	766.74	84.15	492.56	34.29	246.72	16.46	1525.05	58.64
July	322.80	23.51	2267.17	251.92	1142.15	78.27	663.83	44.07	1423.90	4.91
August	613.41	44.62	4305.56	477.90	1921.62	131.57	908.89	60.23	2121.04	7.31
September	146.56	10.53	1022.69	112.35	584.40	40.59	270.02	18.02	1672.23	64.43
October	77.37	5.56	539.73	59.26	427.38	29.94	141.37	9.43	879.09	34.02
November	45.66	3.24	316.74	34.43	311.00	21.90	94.15	6.29	593.07	23.28
December	24.96	1.67	168.75	17.46	122.55	8.66	45.91	3.06	284.07	10.93

Table 5: Comparison of pollution receiving capacity with different sewage outfall generalization.

		COD			NH_3-N		
River	Functional areas	Midpoint generalization	Uniform generalization	Barycenter generalization	Midpoint generalization	Uniform generalization	Barycenter generalization
Huifa River	Hailong reservoir	1463.694	1462.647	1562.45	103.3595	103.2285	112.7456
	Meihekou	10062.24	10050.8	10925.45	1079.58	1077.407	1204.624
	Huinan	5612.861	5601.866	6235.236	374.7616	373.4578	431.2586
	Water source of Huadian City	2862.727	2860.19	3078.006	185.8185	185.5258	204.6833
	Huadian	8798.937	8591.886	12759.11	205.6652	194.9992	362.6266
	The total	28800.46	28567.39	34560.26	1949.19	1934.62	2315.94

Table 6: Annual pollution receiving capacity of each section in Huifa River.

River	Section name	Annual design flow (m^3/s)	Annual design velocity (m/s)	Midpoint generalization (t/a)		Uniform generalization (t/a)		Barycenter generalization (t/a)	
				COD	NH_3-N	COD	NH_3-N	COD	NH_3-N
Huifa River	Hailong reservoir	12.30	0.35	1559.41	107.72	1558.06	107.56	1675.71	118.56
	Meihekou	40.99	0.39	10601.57	1115.35	10587.04	1112.64	11608.64	1258.8
	Huinan	46.09	0.36	6989.97	466.87	6973.24	464.88	7880.68	547.83
	Water source of Huadian City	34.75	0.33	3177.77	206.29	3174.52	205.91	3436.56	228.99
	Huadian	38.22	0.05	11698.31	345.84	11422.01	331.50	17099.5	573.70

shorter functional areas with simple situation and channel segments with incomplete information of pollutant discharge; the uniform generalization method is applied to those rivers with homogeneous distribution of the volume and the location of pollutant discharge. However, as for relatively longer channel segments, we should consider whether they need a method for calculation of pollution receiving capacity by dividing rivers or using sewage outfall barycenter generalization. The Table 5 shows that the calculation results of pollution receiving capacity under the two calculation methods with midpoint and uniform generalization method is very similar, but the calculation of sewage outfall barycenter generalization method is a bit different from the former two methods. The calculation of the uniform generalization method is slightly smaller than the midpoint generalization method, namely the effect of these two methods in actual calculation is the same.

Accounting of annual pollution receiving capacity: The one-dimensional water quality model considering the position of different drain outlets is used to calculate annual pollution receiving capacity. The design flow use the mean annual discharge in 11 years (2000-2010) under the condition of 75% guarantee rate as the calculation parameter. The design velocity is calculated by Manning formula, while the other calculation parameters are the same as the monthly pollution receiving capacity. This paper also uses Huifa River, primary tributary of Second Songhua River, as an example to show the calculation process of the annual pollution receiving capacity. The calculation results of annual pollution receiving capacity of each section in Huifa River are presented in Table 6.

The analysis of the results: according to the results of the table, we can summarize that the results of water environment capacity of midpoint generalization method and uniform generalization method are similar, but smaller than that of sewage outfall barycenter generalization method. In general, the diversity of the results with different calculation method of water environment capacity will extend with the increase of the length of water functional area. The calculation of the Huifa River illustrates that the diversity of water environment capacity with the two methods is not so obvious, but there is relatively larger difference in the sewage outfall barycenter generalization method comparing the former two methods. However, with regard to the small diversity in the small watershed, the three calculation methods can be seen as equivalent.

CONCLUSIONS

The pollution receiving capacity on each water functional area of Huifa River in Jilin province is calculated based on the theory of one-dimensional water quality model. According to the mode of different pollution source generalization, including midpoint generalization, uniform generalization and sewage outfall barycenter generalization, the paper calculates and compares the results of the monthly and annual pollution receiving capacity of Huifa River. The design flow is calculated by the monthly average flow in 11 years (2000 -2010) under the condition of 75% guarantee rate and the design velocity uses Manning formula to calculate. When there is no flow, the water environment capacity is zero. Annual pollution receiving capacity of COD and ammonia nitrogen of Huifa River are 34027.02 t/a and 2242.07 t/a respectively in the case of sewage outfall midpoint generalization; Annual pollution receiving capacity of COD and ammonia nitrogen of Huifa River are 33714.86t/a and 2222.49t/a respectively in the case of sewage outfall uniform generalization; Annual pollution receiving capacity of COD and ammonia nitrogen of Huifa River are 41701.09 t/a and 2727.90t/a respectively in the case of sewage outfall barycenter generalization. So, the results on pollution receiving capacity of midpoint generalization method and uniform generalization method are similar for shorter water function area, while the calculation results of uniform generalization are more practical for longer functional area. Then, the three calculation methods can be seen as equivalent in the small watershed.

ACKNOWLEDGMENTS

This work was supported by the National Key Research and Development Program of China (Grant No. 2016YFC0401406), and the Famous Teachers Cultivation planning for Teaching of North China Electric Power University (the Fourth Period), the 2014 Education Reform Project of North China Electric Power University (Beijing Department) (Grant NO. 2014JG57).

REFERENCES

Fu, Y.C., Xu, W.X. and Fu, M. 2010. Research on the water environment capacity status in China. China Water Resources, 1: 26-31.

Han, L.X., Zhu, D.S. and Yao, Q. 2001. Water environment capacity calculating method for shallow-broad rivers. Journal of Hehai University: Natural Sciences, 29(4): 72-75.

Kong, F. L., Jiang, H. T. and Zhang, T. 2004. Investigation and Evaluation on Circumstance of Water Quality for Huifahe River. Jilin Water Resources, 4: 1-4.

Lao, G. M. 2009. Impact of pollution source generalization on computation of pollution carrying capacity in 1-D model. Zhejiang Hydrotechnics, 5: 8-10.

Lou, S.C., Liu, X.D. and Wang, L.P. 2007. Study on pollution receiving capacity and the limiting total sewage discharge of Shandong Province, Shang Dong. Water Environment, 113-117.

Lu, Y. and Su, B.L. 2011. Comparison of water environment capacity calculation methods for a river system. Water Resources Protection, 4: 5-9.

Pang, Y. 2010. The calculation theory and application of water environment capacity. Beijing: Science Press.

Xu, Z. X., Sun, J.F., Zhang, X. Z., et al. 2011. Application of water quality model WASP in assimilative capacity of Lan River. Northern Environment, 23(10): 30-33, 36.

Zhang, W. Z. 2008. The influence of the design conditions and parameters of the river pollution receiving capacity by one-dimensional water quality model is analyzed. Pearl River, 1: 19-20.

Zhao, X., Huang, Z. and Li, Q.Y. 2012. Consideration on current calculating method of pollution carrying capacity in China. China Water Resources, 1: 29-32.