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Evaluation and Analysis of Water Quality in Qianwei Junction Project of Minjiang River

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Abstract

Water quality assessment is an important basic work in water environment management. In this paper, the water quality of Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Ammonia Nitrogen (NH_4^+-N), Total Nitrogen (TP) and Total Phosphorus (TP) were evaluated by fuzzy analytic hierarchy process (AHP) and single evaluation standard index method respectively. The results of water quality evaluation based on fuzzy comprehensive analysis method show that the water bodies in the Minjiang River Avion Qianwei Hub Project are all grade I water bodies according to the Environmental Quality Standard of Surface Water (GB3838-2002), and the water quality is in good condition. The results of water quality evaluation based on single evaluation standard index method showed that COD and DO reached the class I standard of Surface Water Environmental Quality Standard"(GB3838-2002). The Total Phosphorus (TP), (TN) and Ammonia Nitrogen(NH_4^+-N) reached class III standard. Fecal coliforms reached the standard of class IV; The water quality is generally good.

Keywords

Water quality assessment; Minjiang river; Single evaluation standard index method; Fuzzy synthesis method.

1. INTRODUCTION

With the rapid development of social economy, industrial and agricultural pollution is increasingly aggravated, and water environment pollution is becoming increasingly prominent . Scientific and appropriate water quality assessment methods can reflect the change law of water quality scientifically, and the evaluation results play an important guiding role in water pollution treatment [1]. Water quality evaluation methods usually include index evaluation method, grey system evaluation method, principal component analysis method, fuzzy comprehensive evaluation method, fuzzy neural network method, etc [2-6].Qianwei hub project is located in the lower reaches of Minjiang River, Leshan City, Qianwei County. It is a comprehensive hub project based on shipping, combined with power generation, water supply, irrigation,which plays a very important role in protecting the local ecological environment and social economy [7].

This article evaluates the water quality of reservoir area of avionics Qianwei minjiang river control project by the fuzzy hierarchy process (ahp) and the index method of monomial evaluation standard,get to the types of water quality each pollutant meet in water levels and exceeding pollutant,making scientific renovation planning, take effective measures to prevent and control, is advantageous to the Qianwei water pollution control and governance. It is of great practical significance to the scientific and long-term water environment management of the engineering reservoir area and even the Minjiang River basin.

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2. STUDY TO THE REGIONAL OVERVIEW

Avionics Qianwei minjiang river hub project is located in the lower reaches of minjiang river in leshan Qianwei county, the reservoir covers leshan wutongqiao district and Qianwei, of minjiang river in leshan to yibin, 162 km long river cascade development level 3 navigation-power junction, avionics dam site is located at the Qianwei Jian for bridge upstream 1.45 km, about 50 km away from the upstream dadu river and the confluence of minjiang river estuary。Its upstream and downstream are connected with the Dongfengyan cascade and Longxikou cascade respectively, about 18.1 km away from the upstream Dongfengyan cascade and about 31.8 km away from the downstream Longxikou cascade.The control basin area above the dam site is 126,862 km^2, the annual average flow of the dam site is 2520 m^3/s, the design navigability standard is class III, the fleet of 1 000 T can pass, the total reservoir capacity is 227 million m^3, and the installed capacity is 500 MW。 The region is a subtropical humid climate zone with four distinct seasons, average temperature is 17.5℃, the frost-free period is 333 days, rainfall abundant, the annual average precipitation is 1141.3 mm, and the annual average sunshine is sufficient, with 957.9 hours.

3. ANALYSIS OF POLLUTION SOURCE

The water pollution sources in the Minjiang Avionics Qianwei Hub Project include industrial wastewater, domestic sewage and agricultural non-point sources. Coastal waste, sewage directly or through small ditch discharge into the Minjiang River.

(1) Industrial pollution sources: According to the survey, the industrial enterprises in Wutongqiao District within the evaluation range are mainly distributed in Jinsu Town. There are two enterprises above the scale discharging wastewater along the river, and the industrial wastewater discharge is about 80000 t/a, among which the COD discharge is about 3.93 T /a and the Ammonia Nitrogen discharge is about 3.41 T /a. The sewage industrial enterprises involved in Qianwei County are mainly 6. The wastewater discharge is about 17,000T/A, in which the COD discharge is about 0.55T/A and the Ammonia Nitrogen discharge is about 0.09T /a. Therefore, the wastewater discharge of the main industrial enterprises in the reservoir area is about 97,000 t/a, among which the COD discharge is about 4.48t/a and the Ammonia Nitrogen discharge is about 3.50t/a. As shown in Table 1.

Table 1. Discharge statistics of industrial wastewater and its pollutants in the reservoir area

Administrative region	Emissions to	Location of sewage (km)	Quantity (10k t/a)	COD total (t/a)	NH_4^+-N(t/a)	remark
wutongqiao	branch ditch	left, 17.82	7.7	3.7	3.38	Process wastewater
wutongqiao	branch ditch	left, 15.78	0.3	0.23	0.03	Modicum mine water gushing and domestic sewage
Qianwei	main stream	left, 10.91	/	/	/	indirect cooling water1000 kt/a
Qianwei	main stream	Right, 8.75	/	/	/	indirect cooling 1500 kt/a
Qianwei	branch ditch	Left, 5.35	0.1	0.11	0.02	Modicum mine water gushing and domestic sewage
Qianwei	branch ditch	Right, 7.85	0.8	0.22	0.03	
Qianwei	branch ditch	Right, 1.14	0.4	0.11	0.02	
Qianwei	branch ditch	Right, 1.14	0.4	0.11	0.02	

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(2) Domestic pollution sources: The main domestic sewage discharge along the coast of the project reservoir area are Jinsu Town, Wutongqiao District, Bullock County Tangba Township, Mindong Township and Shixi Town. According to Leshan wutongqiao district 2020 national economic and social development statistical data collection (June 2021) and the national economic and social development in 2020 by the qianwei statistics collection (qianwei county bureau of statistics April 2021): gold millet, qianwei shuitangba township, town he dongxiang and stony brook town statistical population of about 69000 people.Sewage treatment plants have not yet been built in towns along the river. Domestic sewage is discharged locally after simple treatment by septic tanks or biogas digesters, and part of domestic sewage is directly discharged into the Minjiang River or discharged into the gutter after being imported into the Minjiang River.Calculating Township domestic water as 0.20 m^3/ d, sewage discharge as 80% of water consumption, the annual sewage discharge is about 4,055,100 m^3/a.Pollutants in domestic sewage usually include three categories, Suspended matter (SS), Organic matter (BOD5 or COD), Nutrients (TP and TN), The emission concentrations of various pollutants were calculated according to SS200 mg/L, BOD150 mg/L, COD250 mg/L, TP 3.5 mg/L,TN 30 mg/L, NH_4^+-N 25 mg/L.

There are 2 major industrial enterprises with separate domestic sewage outfall.The domestic sewage of enterprise A is treated by integrated sewage treatment equipment to meet the first-level discharge standard of "Comprehensive Sewage Discharge Standard" (GB8978-1996) and then discharged into Minjiang River. The sewage discharge is about 0.7300 m3/ a. The domestic sewage of enterprise B is treated by septic tank and then discharged into Minjiang River. The sewage discharge is about 15,200 m^3/a.The discharge of domestic sewage and its pollutants in the reservoir area is shown in Table 2.

Table 2. Estimation table of discharge of domestic sewage and its pollutants in the reservoir area

Name of township or enterprise	number of population	Domestic sewage discharge (k m^3/a)	SS (t/a)	BOD5 (t/a)	COD(t/a)	TP (t/a)	TN (t/a)	NH_4^+-N (t/a)
Jinsu town	20750	1211.8	242.36	181.77	302.95	4.24	36.35	30.3
Shixi town	22460	1311.7	262.33	196.75	327.92	4.59	39.35	32.79
Tangba town	16020	935.6	187.11	140.34	233.89	3.27	28.07	23.39
Mindong town	9821	573.5	114.71	86.03	143.39	2.01	17.21	14.34
enterpriseA	140	7.3	1.46	1.09	0.6	0.03	0.22	0.06
enterpriseB	260	15.2	3.04	2.28	7.32	0.05	0.46	0.69
Total	69451	4055.1	811.01	608.26	1016.07	14.19	121.66	101.57

(3) Agricultural pollution sources

Agricultural pollution sources in the reservoir area mainly come from agricultural pesticides and fertilizers, which are carried into surface water and into groundwater through farmland irrigation and surface runoff, resulting in non-point source pollution. The pollution degree is related to many factors, such as local rainfall intensity, soil type, soil fertility, farming methods, and application amount of pesticides and fertilizers. According to Leshan Statistical Yearbook (2020),In 2019, the agricultural chemical fertilizer purity of Jinsu Town was 353.35t (including nitrogen fertilizer, phosphorus fertilizer, potassium fertilizer and compound fertilizer), Shixi Town was 305.08t, Mindong Town was 158.46t, Tangba Town was 277.21t. nitrogen fertilizer, phosphorus fertilizer, potassium fertilizer and compound fertilizer accounted for 23.79%, 8.30%, 25.19% and 42.72% of the total fertilizer application rate, respectively. Showned by statistics, The amount of fertilizer applied in the reservoir area is shown in Table 3.

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Table 3. Fertilizer application rates in the reservoir area

Town	Agricultural acreage(hm²)	Administrative division	Total(t)	Nitrogenous fertilizer(t)	phosphatic fertilizer(t)	potash fertilizer(t)	compound fertilizer(t)	Unit application rate(kg/ hm²)
Jinsu	991.47	Wutongqiao district	353.35	84.06	29.33	89.01	150.95	356.39
Shixi	733.87	Qianwei county	305.08	72.58	25.32	76.85	130.33	415.73
Mindong	381.17	Qianwei county	158.46	37.7	13.15	39.92	67.69	415.73
Tangba	666.8	Qianwei county	277.21	65.95	23.01	69.83	118.42	415.73
Total	2773.31		1094.1	260.29	90.81	275.61	467.39	/

Agricultural pollution sources belong to non-point sources of pollution. After fertilizer and pesticide application, they are absorbed by crops, soil and lost to the air, and few of them enter the water body. The soil nutrient loss prediction equation was used to predict the nitrogen and phosphorus loss of fertilizer:

$$E_{N,P}=F_{N,P}*(1-x)*y$$

According to the calculation, the TN and TP of agricultural non-point source pollutants are 40.05 T/a and 3.44 T/a, respectively.

4. EVALUATION METHOD AND CONTENT

According to the hydrological characteristics of the river along the river and the distribution characteristics of key buildings such as water intake structures, a total of 6 monitoring sections are arranged in the evaluation reach of the Minjiang main stream, from the upstream to the downstream in order: the terminal of reservoir (section 1-1), near Qianfeng Village (section 2-2 Changtan spawning ground), about 100m upstream of the water intake of Shixi Town (section 3-3), near Zhenjiang Dam (section 4-4), about 700m upstream of the dam site (section 5-5), about 200m upstream of Qianwei Bridge (section 6-6), Samples were collected at each monitoring section in January, April, July, and September 2021. The monitoring items are 24 basic items in the "Surface Water Environmental Quality Standard" (GB3838-2002), and the SS items are added. 5 items of sulfate, chloride, nitrate, iron and manganese were added to the monitoring section near the water intake of the water plant.

In this paper, the common pollutantsTP, TN, Ammonia Nitrogen, Chemical Oxygen Demand and Dissolved Oxygen are selected, and their upper and lower limits are taken, as shown in Table 4.

Table 4. Data table of water quality monitoring results of monitoring sections

monitoring index	reservoir tail	Near Qianfeng village	Upstream of Shixi town	Neaer Zhenjiangba	Upstream dam site	Qianwei bridge
TP/mg/L	0.113~0.147	0.109~0.178	0.108~0.189	0.103~0.191	0.103~0.163	0.102~0.164
TN/mg/L	0.884~0.983	0.834~0.969	0.853~0.989	0.901~0.966	0.862~0.988	0.853~0.918
NH_4^+-N/mg/L	0.317~0.651	0.372~0.594	0.343~0.481	0.314~0.439	0.401~0.451	0.362~0.416
COD/mg/L	7~10.2	7~9.6	7.5~9.3	7~9	8.1~12	7.5~9
DO/mg/L	7.85~9.57	8.12~9.6	8.11~9.87	7.96~8.5	7.8~9.5	8.15~9.6

4.1. Water Quality Evaluation Based on Fuzzy Comprehensive Analysis Method

4.1.1 Hierarchical model;

According to the water quality of the monitored and data, DO, COD, NH_4^+-N, TP, TP were selected as evaluation factors, and the evaluation factor subset U was constructed, namely U ={DO, CODCr, NH_4^+-N, TN, TP}. Based on the national surface water environmental quality

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standard (GB3838-2002), the evaluation set S = {I, II, III, IV, V} was determined. The analytic hierarchy process (AHP) is used to comprehensively evaluate the water quality. With the water environmental quality of the reservoir area of Minjiang River as the target layer, the factor subset U as the criterion layer, and the evaluation set S as the scheme layer, the hierarchical structure model is established.

4.1.2 Fuzzy evaluation matrix

The single factor evaluation matrix R is a matrix composed of rows of single factor membership. Matrix R represents the degree of membership of each pollution factor to each level of water quality standard, which can also be regarded as a function of pollutant concentration and environmental quality standard, and the subscripts I and j represent the evaluation factor and evaluation standard respectively. The degree of membership is determined by calculating the membership function, which generally adopts the function of "reduced half trapezoid". For the smaller and better indicator (except DO).

By substituting the monitoring data of each monitored section into the membership function determined above, the membership degree can be calculated, and the single-factor fuzzy evaluation matrix of each section is established as follows.

$$R_1 = \begin{bmatrix} 0.88 & 0.12 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0.61 & 0.39 & 0 & 0 \\ 0 & 0.89 & 0.11 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad R_2 = \begin{bmatrix} 0.84 & 0.16 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0.64 & 0.36 & 0 & 0 \\ 0 & 0.92 & 0.08 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.80 & 0.20 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0.80 & 0.20 & 0 & 0 \\ 0 & 0.91 & 0.09 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad R_4 = \begin{bmatrix} 0.80 & 0.20 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0.80 & 0.13 & 0 & 0 \\ 0 & 0.95 & 0.05 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R_5 = \begin{bmatrix} 0.88 & 0.12 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0.75 & 0.25 & 0 & 0 \\ 0 & 0.70 & 0.30 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad R_6 = \begin{bmatrix} 0.88 & 0.12 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0.85 & 0.15 & 0 & 0 \\ 0 & 0.93 & 0.08 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

4.1.3 Calculate the weight of the evaluation factor

In this paper, "improved EXCEEDING STANDARD method" and "ANALYTIC HIERARCHY PROCESS" are used to calculate the weight values of evaluation factors, in order to make a more scientific and comprehensive evaluation of the target water quality.

(1) Improved superscalar method to calculate weight

In THE "IMPROVED EXCEEDING STANDARD METHOD", the evaluation factors are divided into standard increasing index, standard DECREASING index and increasing and decreasing two-way development index according to the increase and decrease of water quality standard value with grade. Then the weight value of the factor is determined according to the class of the selected evaluation factor.

For standard incremental indicators:

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$$w_i = \begin{cases} 1.0, & C_i < S_{io} \\ C_i/S_{io}, & C_i \geqslant S_{io} \end{cases} \tag{1}$$

For standard decreasing index:

$$w_i = \begin{cases} 1.0, & C_i > S_{io} \\ S_{io}/C_i, & C_i \leqslant S_{io} \end{cases} \tag{2}$$

The weight WI is normalized, namely:

$$\bar{w}_i = w_i / \sum_{i=1}^{n} w_i, \quad \sum_{i=1}^{n} \bar{w}_i = 1 \tag{3}$$

Since the data is selected as the range in this paper, the upper and lower limits are used to calculate the weight respectively:

inferior limit:

w_1=(0.4866,0.1903,0.1077,0.1077,0.1077)

w_2=(0.4829,0.1847,0.1108,0.1108,0.1108)

w_3=(0.4786,0.1890,0.1108,0.1108,0.1108)

w_4=(0.4617,0.2020,0.1121,0.1121,0.1121)

w_5=(0.4658,0.1949,0.1131,0.1131,0.1131)

w_6=(0.4644,0.1942,0.1138,0.1138,0.1138)

upper limit:

w_1=(0.5274,0.1764,0.1168,0.0897,0.0897)

w_2=(0.5814,0.1582,0.0970,0.0817,0.0817)

w_3=(0.6029,0.1577,0.0798,0.0798,0.0798)

w_4=(0.6076,0.1536,0.0796,0.0796,0.0796)

w_5=(0.5672,0.1718,0.0870,0.0870,0.0870)

w_6=(0.5756,0.1613,0.0877,0.0877,0.0877)

(2) Analytic hierarchy process calculates the weights (AHP).

The range method is used to construct the judgment matrix by using the established comparison matrix.

$$f(r_i, r_j) = c_{ij} = c_b^{(r_i - r_j)/R}$$

$$r_i = \sum_{j=1}^{7} a_{ij}, r_j = \sum_{i=1}^{7} a_{ij}, R = r_{\max} - r_{\min}$$

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$$M_i = \prod_{j=1}^{n} c_{ij}, w_i = \sqrt[n]{M_i}, W = w_i / \sum_{i=1}^{n} w_i$$

Calculate the weight wi:

Wi=(0.4532,0.2617,0.1511,0.0670,0.0670)

4.1.4 Results and Discussion

The traditional fuzzy evaluation method is improved according to two different weight calculation methods, and the comprehensive evaluation results are shown in Table 5.

Table 5. Comprehensive evaluation of analytic hierarchy process

assessment sample	Analytic Hierarchy Process(AHP)Bi=wR					water quality grade
reservoir tail	0.399	0.206	0.066	0	0.329	I
Near Qianfeng village	0.381	0.231	0.060	0	0.329	I
Upstream of Shixi town	0.363	0.272	0.036	0	0.329	I
Neaer Zhenjiangba	0.363	0.275	0.023	0	0.329	I
Upstream dam site	0.399	0.215	0.058	0	0.329	I
Qianwei bridge	0.399	0.245	0.028	0	0.329	I

Based on the comprehensive evaluation, the water quality of Qianwei Junction project in the Minjiang River is all grade ⅰ, and there is no obvious pollution.

4.2. Water Quality Evaluation Based on Single Evaluation Standard Index Method

According to the water function zoning of the evaluation reach, class ⅲ standard of "Surface Water Environmental Quality Standard" (GB3838-2002) was adopted in the vicinity of Kuwei, Qianfeng Village and upstream of the dam site. Class ⅱ standard of "Surface Water Environmental Quality Standard" (GB3838-2002) is adopted for the upstream of the water intake of Shixi Town, near Zhenjiang Dam and Jianwei Bridge. The results of water quality monitoring are shown in Table 5.

Table 6. Water quality data table of the avionics Qianwei Project reservoir area of Minjiang River

monitoring index	reservoir tail	Near Qianfeng village	Upstream of Shixi town	Neaer Zhenjiangba	Upstream dam site	Qianwei bridge
TP	0.113-0.147	0.109-0.178	0.108-0.189	0.103-0.191	0.103-0.163	0.102-0.164
TN	0.884-0.983	0.834-0.969	0.853-0.989	0.901-0.966	0.862-0.988	0.853-0.918
NH_4^+-N/	0.317-0.651	0.372-0.594	0.343-0.481	0.314-0.439	0.401-0.451	0.362-0.416
COD	7-10.2	7-9.6	7.5-9.3	7-9	8.1-12	7.5-9
DO	7.85-9.57	8.12-9.6	8.11-9.87	7.96-8.5	7.8-9.5	8.15-9.6
fecal coliform(MPn /L)	6300-13000	7900-13000	6300-13000	6300-13000	6300-13000	7000-13000

As shown in Table 6, based on the requirements of "Surface Water Environmental Quality Standard" (GB3838-2002), among the five evaluation indexes, COD and DO all meet the class I standard. TP, TN and NH_4^+-N reached class III. Fecal coliforms reached class IV; The water quality is generally good. From the analysis of monitoring data, TP, TN and fecal coliform indexes appear to exceed the standard, which is related to the part of domestic sewage in villages and towns along the river that directly enters the water body after simple treatment. In addition, in

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the case of NH_4^+-N index does not appear to exceed bid TN in overweight, may be because the upstream agricultural pollution, pesticide and fertilizer containing high concentration Organic Nitrogen content, through irrigation and carry into the minjiang river and surface runoff in the upstream water TP, TN is higher, so the reservoir in the section of the river nitrate nitrogen, Nitrite Nitrogen and Organic Nitrogen concentration is higher.

5. CONCLUSION AND SUGGESTION

5.1. Conclusion

The water pollution sources in the reservoir area of the Aviation-electric Qianwei hub project of Minjiang River include industrial wastewater, domestic sewage and agricultural non-point source pollution, which are discharged directly into Minjiang River through coastal waste water and sewage or through small branches. The results of water quality evaluation based on fuzzy comprehensive analysis method show that the water bodies in the Minjiang River Avion Qianwei Hub Project are all grade I water bodies according to the Environmental Quality Standard of Surface Water (GB3838-2002), and the water quality is in good condition. The results of water quality evaluation based on single evaluation standard index method showed that COD and DO reached the class I standard of "Surface Water Environmental Quality Standard" (GB3838-2002). The TP, TN and NH_4^+-N reached class III standard. Fecal coliforms reached the standard of class IV; The water quality is generally good. Under the condition of not present excessive amounts of NH_4^+-N indexes in TN, probably because the upstream agricultural use of pesticides and fertilizers containing high concentration Organic Nitrogen content, carried by irrigation and surface runoff into the minjiang river, upstream water lead to Total Phosphorus, Total Nitrogen is higher, so the reservoir section of the river of nitrate nitrogen, Nitrite Nitrogen and Organic Nitrogen concentration is higher.

5.2. Suggestion

In the evaluation of water quality, a variety of water quality evaluation methods should be comprehensively used to make the evaluation result more scientific and reasonable. From the results of water quality assessment in Qianwei Section of Minjiang River, we can conclude that we should continue to carry out planning and management in all aspects:

①To strengthen and standardize the management of sewage outlets and prohibit the construction of seriously polluting enterprises;

②Implement strict water resources management system, strengthen law enforcement and use the media to promote the importance of protecting water sources;

③Strengthen the investigation and monitoring of the environmental pollution background of the whole basin, and systematically grasp the water environmental quality of the whole basin.

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