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Original Research Paper

Study on Sulphate Pollution of Surface Water Environment

Jihong Zhou†, Yamin Wen, Qi Jiang and Xianwei Liu
Hebei Collaborative Innovation Center of Coal Exploitation, Hebei University of Engineering, Handan, China
†Corresponding Author: Jihong Zhou

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ABSTRACT

The subject in this paper is the surface water of Yuecheng Reservoir in Handan. On the premise of analysing variation characteristics of sulphate of Yuecheng Reservoir, we recognized reasons of increased sulphate concentration value resulting in water pollution. It drew conclusions that sulphate concentration in Yuecheng Reservoir varied significantly during winter and reached maximum. At the same time, there was a significant correlation between sulphate concentration of atmospheric precipitation in urban areas and sulphate concentration of Yuecheng Reservoir, which was because that the sulphate of atmospheric precipitation reached to the reservoir by surface runoff, having a certain degree of influence on the sulphate concentration of Yuecheng Reservoir.

INTRODUCTION

As could be seen from the sulphate monitoring data of recent years, the content of sulphate in most reservoirs of north China presented certain seasonal distribution, and the winter season was particularly notable. High sulphate concentration can directly endanger the health of human body and destroy the ecological balance of water (Xiaojun Xu et al. 2007, Yi Qian et al. 2000, Diao Mengchao et al. 2001), causing intractable environmental problems (Mingcheng Hu 2012). If a large area of sulphate pollution is formed, the governance would become extremely difficult. So, attaching importance to and researching the sulphate pollution became imminent (Hu Liang et al. 2010). Most researches were focused on sulphate removal of wastewater at home and abroad (Liping Xiao et al. 2011, Lei Shi 1992, Zhijian Zhao 1996, Wang Yafang 2004), but the analysis of abnormal changes in the sulphate concentration in the reservoir and its formation mechanism remained blank (Jinna Li 1997, Yali Tan et al. 2004).

The economic development of Handan city mainly relied on coal, electricity power, iron and steel, building materials, textile, and other industries. The rapid development of these industries had put great pressure on the environment, and the pollution of surface water caused by the change of sulfate concentration was one of the significant problems. Main sources of sulfate in the reservoir included: atmospheric acid deposition, surface runoff and the release of sulfate in the sediment (Song Liuting et al. 2008). On the premise of analysing variation of sulfate concentration of Yuecheng Reservoir, this paper recognized reasons for the rise in sulfate value in the reservoir and focused on the correlation between sulfate concentration of atmospheric precipitation in urban areas and sulfate concentration of Yuecheng Reservoir, drawing reliable conclusions.

SAMPLING AND MONITORING

Yuecheng Reservoir: In accordance with relevant standards for environmental monitoring of surface water, the reservoir should be monitored once a month and set up a monitoring point in the library and export respectively for sample collections. It was needed to calculate the average to indicate the content of sulfate (Xiuyun Cheng 2012, Xiuling Xue et al. 2013, Liang Peiwei et al. 2011, Sun Gennian et al. 2006) in Yuecheng reservoir. The appearance of Yuecheng Reservoir is shown in Fig. 1 and the water sampler, in Fig. 2.

The urban area of Handan city: To reflect accurately and comprehensively the sulfate content in atmospheric precipitation of the urban area, we had set up four representative sampling points, including the sampling point of cultural and educational area - Hebei University of Engineering, the sampling point of industrial area - The Iron and Steel Plant of Handan, the sampling point of commercial area - Kangde and the sampling point of traffic-intensive area - The New Century. We collected the rainwater on each monitoring point once a month and calculated the average. This could be used to indicate the sulfate content in atmospheric precipitation in urban areas. The layout diagram of sampling points in the urban area of Handan City is shown in Fig. 3.

The study monitored the sulfate concentration by ion chromatography and used the instrument DX-120 ion

Fig. 1: The appearance of Yuecheng Reservoir.

Fig. 2: Water sampler.

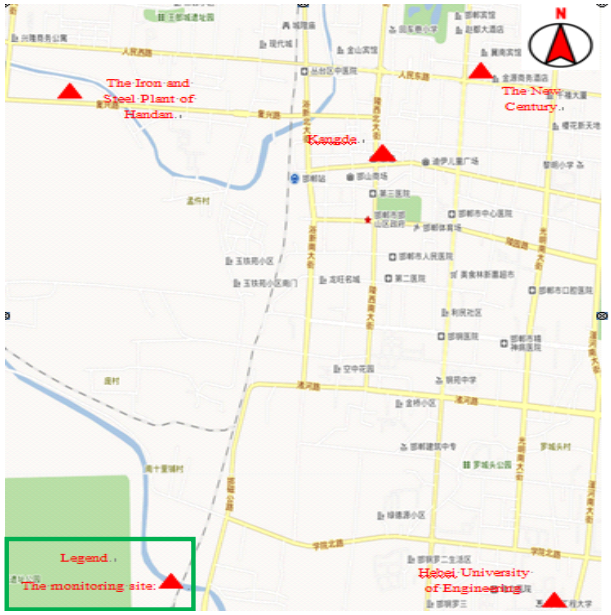

Fig. 3: The layout diagram of sampling points in the urban area of Handan City.

chromatography (Huang Tu 2004).

DATA PROCESSING AND ANALYSIS

Data Processing

Cleaned up sulfate monitoring data of atmospheric precipitation in the Handan urban area and Yuecheng Reservoir, including the data of three years i.e., 2009, 2011 and 2012. The monitoring data are given in Table 1, Table 2 and Table 3.

Analysis of Monitoring Data

The seasonal characteristics of sulfate in Yuecheng Reservoir: In order to display the seasonal characteristic of sulfate concentration, the sulfate concentration curve of Yuecheng Reservoir in 2009, 2011 and 2012 is drawn and shown in Fig. 4, which was analysed.

As can be seen from Fig. 4, the sulfate concentration of Yuecheng Reservoir had a small change during March to August, distributing between 120-160 mg/L. The sulfate concentration had a large change during September to February of the next year, especially during November to Janu-

Table 1: Sulphate monitoring results of atmospheric precipitation in Handan urban area and Yuecheng Reservoir in 2009 (unit: mg/L).

The site	The month											
	1	2	3	4	5	6	7	8	9	10	11	12
Atmospheric precipitation in urban area	100.98	109.4	115.3	20.67	23.49	38.95	28.38	10.64	17.14	87.38	22.50	110.34
Yuecheng reservoir	121	124	143	138	136	141	156	143	161	162	166	182

Table 2: Sulphate monitoring results of atmospheric precipitation in Handan urban area and Yuecheng Reservoir in 2011 (unit: mg/L).

The site	The quarter of a year			
	1	2	3	4
Atmospheric precipitation in urban area	17.61	29.42	18.74	38.35
Yuecheng reservoir	146.33	129	118.67	108.6

Table 3: Sulphate monitoring results of atmospheric precipitation in Handan urban area and Yuecheng Reservoir in 2012 (unit: mg/L).

The site	The quarter of a year			
	1	2	3	4
Atmospheric precipitation in urban area	65.79	78.3	26.41	96.56
Yuecheng reservoir	129.33	125.67	119.67	113.3

ary. At the same time as you can see, the sulfate concentration reached a maximum of 182 mg/L in December 2009, 153 mg/L in February 2011 and 139 mg/L in January 2012. So we could draw a conclusion that sulfate concentration of Yuecheng Reservoir varied significantly during winter and reached the maximum. It was because of the notable increase in the amount of coal used for heating during winter, increasing the concentration of SO_2 in the air (Hua Li 2005), due to which, the sulfate concentration of Yuecheng Reservoir increased significantly.

***The correlation between sulfate concentration of atmospheric precipitation in urban area and sulfate concentration of Yuecheng Reservoir*:** In order to explore the correlation between sulfate concentration of atmospheric precipitation in urban areas and sulfate concentration of Yuecheng Reservoir, the monitoring data of the two were analysed. To analyse the monitoring data of the year 2009, 2011 and 2012, a correlation analysis of sulfate concentration of atmospheric precipitation in urban area and sulfate concentration of Yuecheng Reservoir was performed for each year.

The correlation curve and regression curve for the year 2009 are shown in Fig. 5 and the relevant data of the regression curve are given in Table 4. The regression equation established in Table 4 shows that the correlation coefficient of sulfate concentration of Yuecheng Reservoir and sulfate concentration of atmospheric precipitation in urban area is 0.9346. By the significance test, when n = 12, f = n–2 = 10, we got r (0.01) = 0.7079 by checking the correlation coefficient table. Because 0.9346 > 0.7079, the regression equation established is highly significant. There is a significant correlation between sulfate concentration of atmospheric precipitation in urban area and sulfate concentration of the Yuecheng Reservoir.

The correlation curve and regression curve for the year 2011 are shown in Fig. 6, and the relevant data of the regression curve are given in Table 5. The regression equation established in Table 5 shows that the correlation coefficient of sulfate concentration of Yuecheng Reservoir and sulfate concentration of atmospheric precipitation in urban area is 0.9901. By the significant test, when n = 4, f = n–2 = 2, we got r (0.01) = 0.9900 by checking the correlation coefficient table. Because 0.9901 > 0.9900, the regression equation established is highly significant. There is a significant correlation between sulfate concentration of atmospheric precipitation in urban area and sulfate concentration of Yuecheng Reservoir.

The correlation curve and regression curve for the year 2012 are shown in Fig. 7. The relevant data of the regression curve are given in Table 6. The regression equation estab-

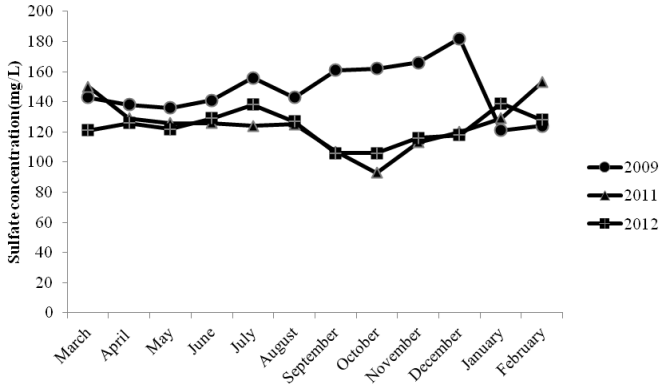

Fig. 4: The change curve of sulphate concentration during the three years in Yuecheng Reservoir of Handan city.

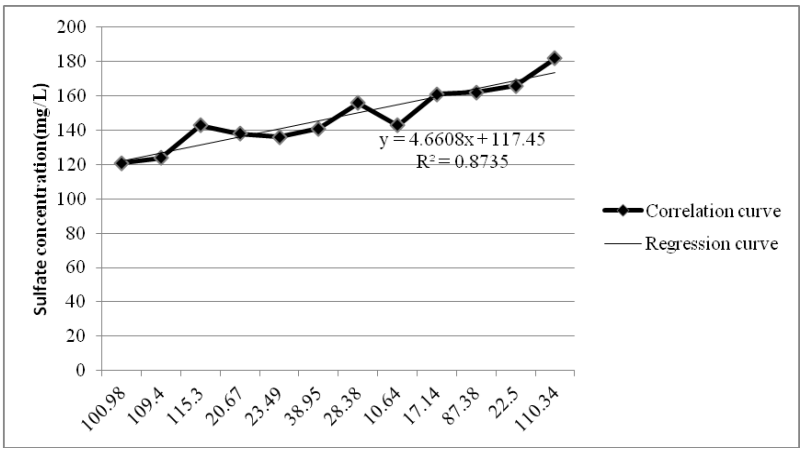

Fig. 5: The correlation curve and regression curve of sulphate concentration of atmospheric precipitation in urban area of Handan and sulphate concentration of Yuecheng Reservoir in 2009.

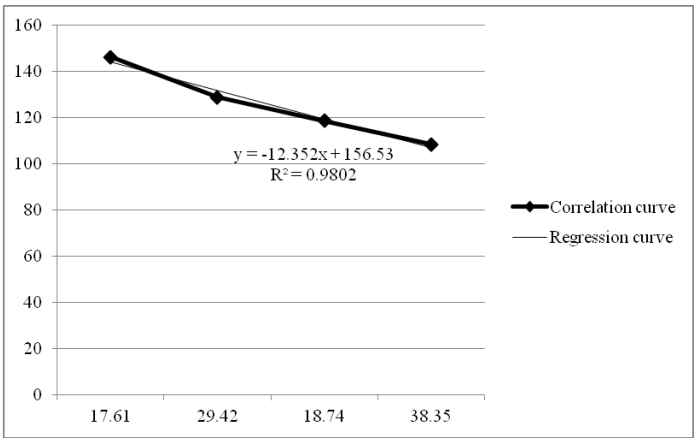

Fig. 6: The correlation curve and regression curve of sulphate concentration of atmospheric precipitation in urban area of Handan and sulphate concentration of Yuecheng Reservoir in 2011.

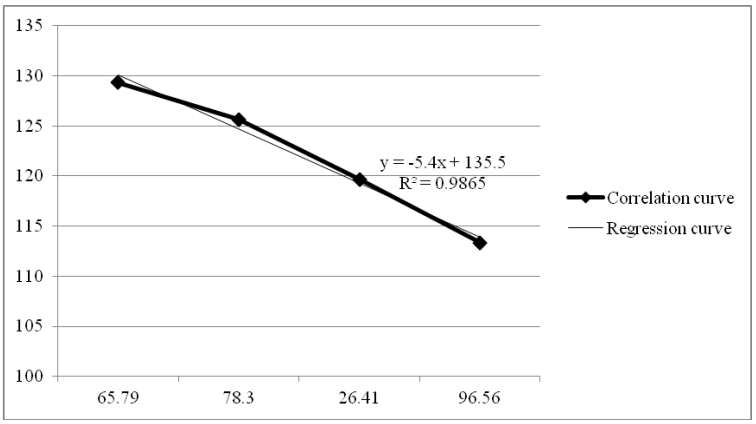

Fig. 7: The correlation curve and regression curve of sulphate concentration of atmospheric precipitation in urban area of Handan and sulphate concentration of Yuecheng Reservoir in 2012.

Table 4. The regression equation of sulphate concentration of atmospheric precipitation in urban area and sulphate concentration of Yuecheng Reservoir in 2009.

X	Y	Equation	Correlation coefficient, r	Sample number	Confidence α	Lookup table, r
Sulphate concentration of atmospheric precipitation in urban area	Sulphate concentration of Yuecheng reservoir	y=4.6608 x+117.45	0.9346	12	0.01	0.7079

Table 5: The regression equation of sulphate concentration of atmospheric precipitation in urban area and sulfate concentration of Yuecheng Reservoir in 2011.

X	Y	Equation	Correlation coefficient, r	Sample number	Confidence α	Lookup table, r
Sulfate concentration atmospheric precipitation in urban area	Sulfate concentration of Yuecheng reservoir	y=-12.352 x+156.53	0.9901	4	0.01	0.9900

Table 6: The regression equation of sulphate concentration of atmospheric precipitation in urban area and sulphate concentration of Yuecheng Reservoir in 2012.

X	Y	Equation	Correlation coefficient, r	Sample number	Confidence α	Lookup table, r
Sulfate concentration of atmospheric precipitation in urban area	Sulfate concentration of Yuecheng reservoir	y=-5.4x+135.5	0.9932	4	0.01	0.9900

lished in Table 6 shows that the correlation coefficient of sulfate concentration of Yuecheng Reservoir and sulfate concentration of atmospheric precipitation in urban area is 0.9932. By the significant test, when n = 4, f = n–2 = 2, we could get r (0.01) = 0.9900 by checking the correlation coefficient table. Because 0.9932 > 0.9900, the regression equation established is highly significant. There was a significant correlation between sulfate concentration of atmospheric precipitation in urban area and sulfate concentration of Yuecheng Reservoir.

CONCLUSIONS

1. Sulfate concentration in Yuecheng Reservoir varied significantly during winter and reached the maximum. It was because of the notable increase in the amount of coal used for heating during winter, increasing the concentration of SO_2 in the air, due to which, the sulfate concentration of Yuecheng Reservoir increased significantly.
2. According to the monitoring data of the year 2009, 2011 and 2012, the correlation coefficient of sulfate concentration of Yuecheng Reservoir and sulfate concentration of atmospheric precipitation in urban area was 0.9346, 0.9901 and 0.9932 respectively. And since 0.9346 > 0.7079, 0.9901 > 0.9900 and 0.9932 > 0.9900, the regression equations established by three sets of data were highly significant, which fully showed that there was a significant correlation between sulfate concentration of atmospheric precipitation in urban area and sulfate concentration of Yuecheng Reservoir.
3. There was a significant correlation between sulfate concentration of atmospheric precipitation in urban area and sulfate concentration of Yuecheng Reservoir, which was because that sulfate of atmospheric precipitation reached to the reservoir by surface runoff, having a certain degree of influence on sulfate concentration of Yuecheng Reservoir. Therefore, if we wanted to achieve

a better effect on the prevention and management of sulfate pollution (Wang et al. 2004, Wang et al. 2001, Gu et al. 2007, Kuanfeng Li et al. 2013) in Yuecheng Reservoir, we must fully consider factors resulting in the change of sulfate in the reservoir. The notable increase in the amount of coal for heating during winter added the emission of SO_2. In addition, the emission of SO_2 in industrial zone is also one of the main sources of sulfate in atmospheric precipitation.

4. The sample point of the highest sulfate concentration is the Iron and Steel Plant of Handan, around which coking plant, equipment factory, etc. produced SO_2 during coal combustion forming sulfate by precipitation. Only by improving the quality of coal vigorously and industrial enterprises start using best SO_2 removal process, the emission of SO_2 can be limited. If the generation of SO_2 can be controlled at the source, the problems of sulfate pollution can be reduced.

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REFERENCES

Diao, Mengchao, Lihe Wang and Yang Bai 2001. The analyses and strategies on the pollution characteristics of ambient sulphatizing rate in the city of Ma'anshan. Fujian Environment, 18(03): 22-23, 27.

Gu, Linu and Yong Wang 2007. Variation regularity of air sulphation rates and control measure in Urumqi. Arid Land Geography, 30(04): 531-535.

Hu, Liang, Chen, Jiaxi and He, Yanming 2010. The pollution status analysis on sulfate-containing sewage. Yunnan Metallurgy, 39(02): 102-105.

Hu, Mingcheng 2012. Environmental hazards by sulfate and treatment method of waste water containing sulfate. Journal of Chengdu University (Natural Science Edition), 31(02): 181-184.

Hua, Li 2005. Analysis on relativity of sulfuric acid salt forming velocity and sulfur dioxide. Arid Environmental Monitoring, 19(01): 36-37.

Huang, Tu 2004. Principles and application of ion chromatograph. Central China Electric Power, 1(17): 69-70.

Jinna, Li 1997. Analysis on relativity of dipping acid salt forming speed rate and sulfur dioxide in the air of Tangshan city. Arid Environmental Monitoring, 11(04): 217-219, 252.

Kuanfeng, Li, Peng, Wu, Yaoliang, Shen, Rong, Xu and Haiqin, Zhang 2013. Development and prospects of the sulfate wastewater treatment. Technology of Water Treatment, 39(11): 17-22.

Lei, Shi 1992. Study on sulfation rate associated with atmospheric sulfur dioxide, sulfate precipitation relationship. Administration and Technique of Environmental, 4(03): 25-28.

Liang, Peiwei and Zhao, Yuehua 2011. The determination of sulfate in groundwater. Guide of Sci-tech Magazine, (29): 253.

Song, L.T., Liu, C.Q., Wang, Z.L. and Liang, L. 2008. Stable sulfur isotopic geochemistry to investigate potential sources and cycling behavior of sulfate in Lake Hongfeng, Guizhgou province. Geochemica, 37(6): 556-564.

Sun, Gennian and Zhang, Jing 2006. Study on spatiotemporal change of the sulphation speed in atmosphere in Xi'an City during the period of 1989-2003. Arid Zone Research, 23(03): 478-483.

Wang, A.J., Wang, L.Y., Ren, N.Q. and Du, D.Z. 2004. Bio-treatment of sulfate-laden wastewater. Journal of Harbin Institute of Technology, 36(11): 1446-1449, 1501.

Wang, Hao-yuan and Miao, Yingqi 2001. Research of high-sulfate wastewater treatment technology. Environment Herald, 01: 22-25.

Wang, Yafang 2004. Analysis on relativity of dipping acid salt forming speed rate and sulfur dioxide concertration in the air of Shihezi City. Journal of Shihezi University (Natural Science), 22(06): 507-509.

Xiao, Liping, Zhang, Lei and Li, Yue 2011. Application of sulfate-reducing bacteria to anaerobic wastewater treatment. Journal of Water Resources and Water Engineering, 22(02): 45-49.

Xiaojun, Xu, Xi jun Guan and Yijin Yang 2007. The Principles of Pollution Control and Recycling Technologies of Solid Waste, Beijing, Metallurgical Industry Press.

Xiuling, Xue and Mengdi, Li 2013. Rapid determination of sulfate in water by turbidimetry. Chinese Journal of Environmental Engineering, 7(04): 1359-1362.

Xiuyun, Cheng 2012. Spatial-temporal characteristics of sulfate-rate concentrations in the city of Huizhou. Guangdong Chemical Industry, 39(10): 133-134.

Yali Tan, Chunlei Niu and Yingchun Zhao 2004. Study on relativity of dipping acid salt forming speed rate and sulfur dioxide in air in Yining City. Arid Environmental Monitoring, 18(02): 98-100.

Yi, Qian and Xiaoyan Tang 2000. Environmental Protection and Sustainable Development, Higher Education Press, Beijing.

Zhijian Zhao 1996. Analysis on relativity of atmospheric sulfur dioxide associated with sulfation rate and sulfate precipitation. Arid Environmental Monitoring, 10(04): 236-238.