E3S Web of Conferences **573**, 03024 (2024) https://doi.org/10.1051/e3sconf/202457303024
SDER 2024

Research on the optimal use of industrial wastewater for sustainable regeneration based on big data background

Yuheng Zhang[1,a], Jiaqi Shi[2,b], Guoli Chen[3,c], Mingchen Wang[3*]

[1]Shandong Experimental High School, Jinan 250001, Shandong, China
[2]Shanxian No.1 High School of Shandong Province, Shanxian 274300, Shandong, China
[3]Jinan Shanyuan Environmental Technology Co., LTD, Shandong, China

Abstract: Industry, as one of the most important areas of water use in China, will use 102.89 billion cubic metres of water in 2020, accounting for 17.7 per cent of the country's total water use, and industrial wastewater discharges will account for about one fifth of the country's sewage discharges. In recent years, positive progress has been made in the recycling of industrial wastewater in China, with the water reuse rate for industries above designated size increasing from 89 per cent in 2015 to 92.5 per cent in 2020, and the water consumption of 10,000 yuan of industrial added value in 2020 decreasing by 39.6 per cent compared with 2015. The current status of research on life cycle carbon emissions of different wastewater recycling technologies and processes was analysed and summarised, taking wastewater recycling products such as reclaimed water, energy, microbial proteins and guano as research targets. The analysis pointed out that wastewater reclamation and value-added utilisation have considerable carbon reduction benefits, but quantitative assessment should be carried out at the system level in conjunction with the utilisation scenarios. This paper researches and analyses industrial wastewater based on the technical foundation of big data. On the basis of analysing the industrial wastewater treatment in China in recent years and at the same time combining the background of big data and treatment technology, it pushes the development of industrial wastewater treatment into a new field and mileage.

1. Introduction

Difficult-to-degrade industrial wastewater is basically characterised by high concentration of organic matter, a wide range of pollutants, low biochemistry, strong biological inhibition and high salt content, which makes it difficult for conventional treatment technologies to meet the corresponding discharge standards, while the distribution characteristics and hazardous effects of trace high-risk pollutants in the wastewater discharge are difficult to be accurately analysed and assessed. Since the Eighth Five-Year Plan period (1991-1995), China has been carrying out research projects on the treatment of non-degradable industrial wastewater, but to date, the efficient treatment of non-degradable industrial wastewater is still a difficult problem that restricts the development of industry and the protection of the environment. Quantifying water environmental security is a basic and very important work in water environmental security research [1]. In the study of water security issues, for the proposed water resources security, water security, water resources carrying capacity, water environment carrying capacity, sustainable use of water and other research directions, Xia Jun, Han Yuping, Jia Shaofeng, Hui Yanghe and many other experts at the forefront of the research in these areas are in the evaluation system research and exploration, and the establishment of a variety of evaluation index system [2]. How to evaluate the safety of the water environment and how to characterise the degree of safety of the water environment are urgent problems in the field of water environment safety research. As water environment safety is getting more and more attention, the establishment of water environment safety evaluation index system and the selection of evaluation methods will become the key work in this field. How to use a suitable evaluation model to effectively evaluate the safety of the water environment, study the water environment and socio-economic and ecological systems in the region, guide the use of the water environment in the region, and realise the comprehensive benefits of socio-economics, ecological environment and the water environment is in a sense also a major event in relation to the country's economy and people's livelihood" [3].

2. Status of industrial wastewater pollution in China

2.1. Analysis of trends in industrial wastewater pollution

Before proceeding to the empirical analyses, a brief introduction to the environmental Kuznets curve is in

---

[a]minyuan1111@126.com; [b]334046673@qq.com; [c]haiyuan009@163.com; *haiyuan1279@163.com

order. Economist Kuznets in the 1950s put forward a study of the relationship between income level and income distribution gap, his research shows that people's income gap with the increase in income level increases and then decreases, that is, the relationship between the two shows an inverted U-shaped curve, which is known as the Kuznets curve [4]. Subsequently, economists Grossman and Krueger applied this doctrine to the study of the relationship between the level of environmental pollution and economic development in 1991, and empirical studies have shown that there is an inverted U-shaped curve between the income level and the level of environmental pollution in most countries, i.e., the level of pollution increases and then decreases with the increase of the income level, which is also known as the environmental Kuznets curve (Fig. 1). In the subsequent research, economists have proved the rationality and scientificity of the existence of the environmental Kuznets curve through a large number of empirical and theoretical studies, among which, in the theoretical studies, the impacts of the three major effects of income growth, namely the scale effect, the structural effect and the technological effect, on the quality of the environment are mainly analysed [5]. At the same time, they enriched and expanded the curve, confirming that the environmental Kuznets curve has not only an inverted U-shape, but also U-, N-, and inverted N-shapes.

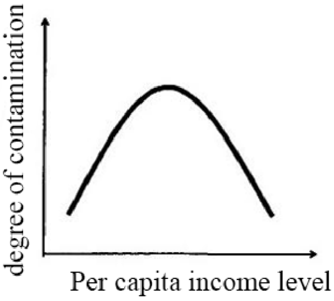

Fig. 1. Environmental Kuznets curve

With reference to previous studies, this paper also uses per capita GDP (x) to represent the level of per capita income, and industrial wastewater discharge (y) to represent the degree of industrial pollution, and applies the theory of the environmental Kuznets curve to empirically analyse the trend of industrial wastewater pollution in China. The empirical results are as follows:

Table 1. Regression results

$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + e$

Without generalised differential correction

	ratio	t-test
β_0	179.6096	10.03849
β_1	0.004874	1.542649
β_2	-1.11E-07	-0.766709
β_3	3.66E-13	0.193845
Adjusted R^2	0.4999	
D.W value	1.1046	

Continued from table 1

$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + e$

Corrected for generalised differences

	ratio	t-test
β_0	123.2487	4.870505
β_1	0.012879	3.492793
β_2	-4.30E-07	-2.819643
β_3	4.11E-12	2.212611
Adjusted R^2	0.8072	
D.W value	2.0122	

As can be seen from Table 1, when the equation is not corrected by generalised difference, the adjusted $R^2 = 0.4999$,indicating that the goodness of fit of the equation is not high; at the same time, $d_2 = 0.998 < DW = 1.1046 < dv = 1.676$,indicating that at this time it is not possible to determine whether the equation has a first-order autocorrelation or not, but the partial correlation coefficient test and the LM test indicate that the equation has a higher order autocorrelation, so the generalised difference method was used to make the correction. After correction, the adjusted R^2=0.8072, indicating that the goodness of fit has been improved; meanwhile, $dv = 1.676 < DW = 2.0122 < 4 - du = 2.324$, the partial correlation coefficient test and the LM test indicate that the equation does not have higher-order autocorrelation. Therefore, there is no autocorrelation in the equation and the estimation of the parameters of the equation is valid. Since $\beta > 0, \beta_2 < 0, \beta_3 > 0$, the environmental Kuznets curve of industrial wastewater discharge in China in the past 20 years is N-shaped rather than inverted U-shape, which indicates that with the high growth of China's GDP, China's industrial wastewater discharge, although it shows a decreasing state for a certain period of time, gradually shows an upward trend after decreasing to a certain extent [6]. Therefore, our government should take timely measures to curb the new rising trend of industrial wastewater pollution in China [7].

2.2. Impact of industrial sector structure on industrial wastewater pollution

For a long time, a large proportion of China's industrial structure has been labour-intensive and resource-intensive industries, mainly in the food, textile, chemical, electric power, mining, metal smelting and other traditional industries, most of which have low technical requirements and are the key industries for industrial wastewater discharge [8]. In recent years, although the government has been strengthening the adjustment of the structure of the industrial sector, but the effect of the adjustment is still not obvious, according to: 2014 Annual Report of Environmental Statistics, in 2014, wastewater emissions in the top four industries in order of papermaking and paper products industry, chemical raw materials and chemical products manufacturing industry, the textile industry, coal mining and washing industry, the wastewater emissions of the four industries arrived at 8.80 billion tonnes [9].(See Table 2)

Table 2. Wastewater discharge from key industries Unit: billion tonnes

vintages	add up the total	Paper and paper products industry
2011	105.4	38.2
2012	99.6	34.3

2013	90.8	28.5
2014	88.0	27.6
Rate of change in per cent %	-3.1	-3.2

Continued from table 2

Chemical raw materials and chemical products manufacturing	textile industry	Coal mining and washing
28.8	24.1	14.3
27.4	23.7	14.2
26.6	21.5	14.3
26.4	19.6	14.5
-0.9	-8.8	1.4

It is not difficult to see that there is a significant gap between the industrial wastewater emissions of different industries, so changes in the structure of industrial industries have an important impact on industrial wastewater emissions, the greater the proportion of industrial wastewater discharges of key industries, industrial wastewater emissions, and vice versa, industrial wastewater emissions, the smaller, which also provides a direction for the adjustment of the structure of the industrial sector in the future [10].

3. Status of industrial wastewater treatment in China

3.1. Analysis of the investment status of industrial wastewater treatment

Environmental pollution cannot be treated without investment in pollution control, and the larger the investment, the better the results of environmental pollution control. The size of investment in pollution control is closely related to the level of economic development of a country. Generally speaking, the higher the level of economic development of a country, the larger the amount of investment in pollution control. In the following, the investment in environmental pollution control, industrial pollution control and industrial wastewater treatment during 2001-2014 are based on three economic indicators to illustrate the investment status of industrial wastewater treatment in China.

Investment in industrial wastewater treatment in China based on three economic indicators.

Table 3. Investment in pollution control, 2001-2014, in billions of dollars

vintages	gross domestic product (GDP)	Investment in environmental pollution control	Investment in industrial pollution control	Investment in industrial wastewater treatment	Investment in industrial wastewater treatment % of GDP
2001	110270	1106.6	174.5	72.9	0.0661105
2002	121002	1363.4	188.4	71.5	0.0590899
2003	136565	1627.3	221.8	87.4	0.0639988
2004	160714	1908.6	308.1	105.6	0.0657068
2005	185896	2388	458.2	133.7	0.0719219
2006	217657	2567.8	485.7	151.1	0.0694212
2007	268019	3387.6	552.4	196.1	0.0731665
2008	316752	4490.3	542.6	194.6	0.0614361
2009	345629	4525.2	442.5	149.5	0.0432545
2010	408903	6654.2	397	130.1	0.0318168
2011	484124	6026.2	444.4	157.7	0.0325743
2012	534123	8253.6	500.5	140.3	0.0262674
2013	588019	9037.2	849.7	124.88	0.0212374
2014	635910	9575.5	997.7	115.2	0.0181158

As can be seen from Table 3, during the period of 2001-2014, the investment in environmental pollution control and industrial pollution control as a whole has been on an upward trend year by year, in which the average annual growth rate of investment in environmental pollution control is 18%, and the average annual growth rate of investment in industrial pollution control is 14.3%, which is higher than the average annual growth rate of GDP, especially during the period of 2011-2014, the growth rate of these two investments has obviously accelerated, which also reflects China's determination to treat environmental pollution in recent years. In particular, during 2011-2014, the growth rate of these two investments accelerated significantly, which also reflects China's determination to treat environmental pollution in recent years. The amount of investment in industrial wastewater treatment, however, has shown a trend of rising and then falling, of which, in 2007 reached a peak of 19.61 billion yuan.

3.2. Methods and calculations for evaluating the safety of the water environment

The grading of water environment safety status can be divided into 3, 4, 5 and other levels, taking into account that if the grading is too little it will be too simple, and if the grading is too much it will be complicated and cumbersome, so this paper divides the water environment safety status into four levels, and the grading standard is shown in Table 4.

Table 4. Criteria for classification of the state of safety of the water environment

Water environment safety value	$0 < E \leq 0.3$	$0.3 < E \leq 0.6$	$0.6 < E \leq 0.8$	$0.8 < E \leq 1$
Safety status value	insecurity	General	Safer	Safer

3.2.1. Calculation of system-level indicator values

The values of the system level indicators are weighted according to the product of the values of the indicator level indicators they contain and their corresponding weights. The system safety is calculated using the model as:

$$E_B = \sum_{i=1}^{m} E_{C_i} \times W_{C_i} \quad (1)$$

Where E_B-the magnitude of system security;

E_{C_i}-Sub-security value for the ith indicator of the indicator layer;

W_{C_i}-weight of the ith indicator of the indicator layer;

m-Number of indicators.

Calculation of the Comprehensive Assessment Index for

3.2.2. Water Environmental Security

The comprehensive evaluation index of water environment safety is calculated by using the safety value of each system layer element multiplied with the corresponding weights and then weighted. The modelling formula is as follows:

$$E_A = \sum_{i=1}^{n} E_{B_i} \times W_{B_i} \quad (2)$$

Where E_A -Comprehensive evaluation index of the safety of the water environment;

E_{B_i}-the value of the safety of the ith system element of the system layer;

W_{B_i}-weight of the ith system element of the system layer;

N-number of subsystems.

4. Conclusion

Although it is clearly stipulated in the mechanism for the use of sewage charges for industrial wastewater in China that sewage charges collected are to be incorporated by the financial sector into the special funds for the protection of the environment, in view of the objective constraints of our country, it has always been the case that the environmental protection department collects the sewage charges on behalf of the Government. In this case, the environmental authority is both the collector of the sewage charge and the custodian of the charge before it is paid to the financial authority. In actual application, these projects cannot be guaranteed to be completed in a qualified manner. Whether in the form of grants and subsidies or loans and interest subsidies, the sewage charges are put into use before the projects are carried out, which will lead to an increase in the risk of recovery of sewage charges, and coupled with the loss of the time value of the charges, the efficiency of the use of the charges will be lowered to an indefinite extent. At the level of treatment theory, the current focus remains on the use of the most advanced analytical techniques and the latest theories in various disciplines to analyse all the physical, chemical and biological processes occurring in the wastewater treatment system and their specific mechanisms, and to map the ‘whole-life’ course of key pollutants from the time they enter the treatment system, which may require the full integration of experimental research with computational chemistry, computational biology and other simulation tools.

References

1. Anna G ,Claudio M ,Eleonora L D , et al. Characterization of recycled nitrile butadiene rubber industrial scraps [J]. Journal of Material Cycles and Waste Management, 2024, 26 (3): 1761-1775.
2. Qiu Yuyi. Unconventional Water Resources Utilisation and Benefit Analysis in Shishi City [J]. Water Resources Science and Technology, 2023, (04): 18-21.
3. WANG Tengfei,LIU Xianglei,WEN Tianyao,et al. Adsorption performance of silver-modified molecular sieve adsorbent on mercury in industrial wastewater [J]. Contemporary Chemical Industry, 2023, 52 (05): 1076-1079+1102. DOI:10.13840/j.cnki.cn21-1457/tq.2023.05.025.
4. Cai J. Selection of wastewater treatment technology for leather industry - A review of Industrial Wastewater Treatment and Recycling [J]. Leather Science and Engineering, 2023, 33 (01): 63.
5. Zhou Yinfei. New Progress in Industrial Wastewater Treatment and Recycling Technology--A Review of Industrial Wastewater Treatment and Recycling [J]. Chemical Engineering, 2022, 50 (09): 4.
6. J. H. Zhang, Key technologies and industrial demonstration of ultra-low discharge of rare earth industrial wastewater. Guangdong Province, Deqing Xingbang Rare-Earth New Material Co, Ltd, 2021-11-03.
7. Continuously promote the quality and efficiency of sewage treatment and make concerted efforts to win the battle for blue water [N]. People's Political Consultative Conference Daily, 2021-09-14 (003). DOI:10.28660/n.cnki.nrmzx.2021.007423.
8. Hou F, Gao JW, Han L, et al. Intensive design of sunken wastewater treatment plant - An example of Guiyang Longdongbao Water Reclamation Plant [J]. Water Purification Technology, 2021, 40 (07): 133-140. DOI:10.15890/j.cnki.jsjs.2021.07.021.
9. Cao Xiaoyao, Yang Lin. On the application of non-wood fibre raw materials in paper industry [J]. Guangdong Chemical Industry, 2021, 48 (02): 272-273+275.
10. Asih R D ,Handayani W ,Ananda Z A , et al. An insight into potential phosphate bioremediation and renewable energy from agricultural waste via integrated wastewater treatment systems in Indonesia [J]. Environmental Research Communications, 2024, 6 (4):