

Outline and management of industrial wastewater in China

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Abstract—The essay covers the discharge and percentage of treatment of industrial wastewater in China before 1992, the analysis of industrial wastewater pollution to the environment and the problems and corrective measures to prevent and control the pollution caused by industrial wastewater in China.

Water pollution is one of main environmental problems in China. And industrial wastewater is a very important source to make water pollution. It is a key task to prevent industrial wastewater pollution and protect water quality of rivers, lakes (reservoirs), underground water in Chinese water environmental management.

Keywords: industrial wastewater; environmental management; China.

1 Outline of industrial wastewater in China

According to China NEPA's statistics, the condition of wastewater discharge is shown in Table 1 and Fig. 1.

Table 1 Amount of industrial wastewater and pollutants in 1992 in China
(national enterprises)

Items	Total wastewater	Industrial wastewater	COD	Heavy metals	Arsenide	Cyanide	Phenol	Oil
Amount, t/a	36.7×10^9	23.4×10^9	7.11×10^6	1.52×10^3	872	3.58×10^3	6.43×10^3	65.1×10^3
Compare with 1991	+9	+0.8	-1	-17.4	-22.6	-23.3	-18.3	-4.8

This study takes Nanjing City, with more than 4 millions residents as an example. The city which gross value of industrial output 30 billions Yuan (RMB) in 1993 is one of the biggest bases of petroleum industry, chemical industry, electronic industry and metallurgical industry in China. The total amount of industrial wastewater discharge was 0.678 billions ton in 1993. The wastewater discharged into the Yangtze River directly or indirectly except 10 percent to the Qinhuai River and 4.5 percent to the Xuanwu Lake. And black and stink-

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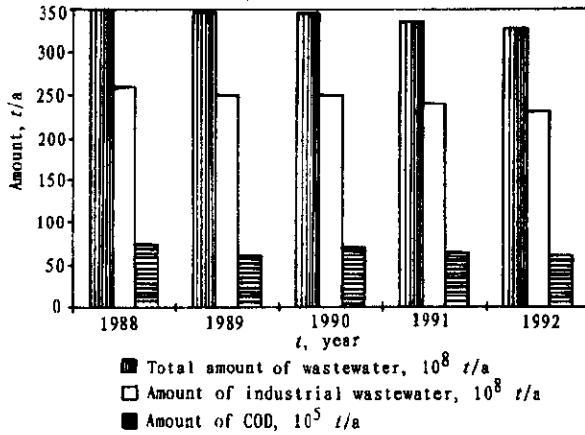


Fig. 1 The wastewater amount changed in China (1988—1992)

ing of Qinhuai River have caused. The lake became eutrophication heavily and dead fish was often found in there. The water quality came down gradually in the Yangtze River through Nanjing. As the China Environment News reported, several factories in Nantong City discharged high concentration organic wastewater, include 500 ton COD per year, to the Hao River directly. The water in the river was black and stinking. The Tong Chang canal system in Tongzhou City was polluted 8 times from 1988, especially in July 8, 1993. Due to the pollution, two waterworks and several factories which produce food and drink stopped production, public utilities were at a half standstill, restaurants and hostels closed down, more than 10 hospitals were out of surgical operation.

Drinking water resource were polluted heavily in China according to the water quality monitoring results in 1980s. Only 10 percent of the resources can meet standard of drinking water quality absolutely, and 20 percent meet it basically. After the "Regulation on Administration of Pollution Prevention and Control in Drinking Water Sources Protecting Zones" was implemented, the quality of drinking water was improved eventually. The monitoring results of 65 sources in 1989 and 74 sources in 1990 indicated that the water quality of 70 percent sources were good, 20 percent were relatively good and the others were bad. The sources which water quality could not meet the standard were in cities there were not a regulation of drinking water source protection. For example, the Miyun Reservoir was identified to be a drinking water source in Beijing. So tourism and net fishing were forbidden in there. The police division which there were 60 people was set up to check on the quality of drinking water and deal with cases of industrial wastewater pollution in Dalian. So it is effective to control the quality of drinking water. There were 77.8 percent underground water for drinking water which were polluted at different stage in many cities.

It indicated 436 rivers were polluted at different stage and took up 82 percent of 532 rivers which were investigated for pollution condition. Water quality of the main stream of the bigger rivers are good, but the tributary of the rivers and the section through cities of the main stream were polluted. For example, the quality in the main parts of the Yangze River

was good, but the parts of the river besides Chongqing, Wuhan, Nanjing and Shanghai were polluted. The quality in the main parts of the Yellow River was good, but the other small parts of the river were polluted; the quality of Pearl River was good, but the Panjing River was polluted; Huai River was polluted heavily, especially in Kui River, Qu River, Tuo River and Xiaoqing River; Songhua River through cities was polluted heavily; Liao River and Ha River were polluted heavily also.

The lakes in China were all polluted by nitrogen, phosphonium and other organic matters. It is worried about eutrophication. Some lakes were polluted by mercury, chromium and other heavy metals. The Dianchi Lake in Yunnan Province was polluted most heavily among the biggest fresh lakes. The Daming Lake and Xuanwu Lake were polluted most heavily among the urban lakes.

2 Analysis of industrial wastewater pollution in China

Now industrial wastewater amount is high in quantitative and pollutant concentration is very high in China. It is mainly because of technology is not advanced, equipment became old, management methods are not affective, middle and small enterprises take up 90 percent of many factories in China. So raw materials and energy were wasted heavily, water was used more than normal. The water usage and discharge for production in China were much more than in developed countries. For example, output of one ton ammonia needed 500—1000 ton water, but only 12 ton water were needed in developed countries; output of one ton paper needed 500—1000 ton water, but only 5—200 ton water were needed in the other countries; output of one ton steel needed 30 ton water, but only 3—5 ton water were needed in U. S. A. The total amount of industrial wastewater discharge were 25 billion ton per year in 1988 in China, of which 7.2 billion ton wastewater were treated, only 30 percent of the total amount. The wastewater treated were 17.59 billion ton in 1992, up to 68.6 percent. According to investigation, treatment effect was not ideal. The operation effective rate of facilities and equipment for wastewater treatment were not high. The facilities and equipment were out of operation, damaged, set aside about 12.5 percent and took up 8.5 percent of total investment. The facilities which operation could reach 80 percent of design capacity were only 48 percent, and 28.7 percent of the facilities could not reach 50 percent of design capacity. The facilities and equipment for treatment could not be utilized fully to make operation fee higher. In addition, water resources were used freely for a long term and the price was too lower to invest to treat wastewater instead of buying fresh water and discharging directly to pollute water environment.

At present, the enterprises of villages and towns in China were developed very well. The wastewater from the enterprises discharged directly instead of treatment and make water pollution more seriously. The total amount of wastewater discharge were 1.83 billion ton in 1991, and more than 43.7 percent belong to small paper mills. It was estimated that there were ten thousand paper factories in China, only 18 factories had paper output of fifty thou-

sand, 180 factories had ten thousand ton paper output, and the others about nine thousand were small paper mills which many were non-wood fibre paper mills of heavy pollution discharged. It was very common that one paper mill polluted a river. The investigation report about Huai River pollution indicated that paper and food (brewery, glutamate) industries were main pollutant sources in the river.

3 Prevention and control, management of industrial wastewater pollution in China

Control and management of industrial wastewater pollution supplemented each other in China. Environmental management promoted prevention and control of industrial wastewater pollution. And prevention and control of wastewater pollution could impel and strengthen the environmental management. The Second National Environmental Conference on Environment of the State Council in end of 1983, indicated "Nowadays, it mainly depended on strengthening environmental management to solve the environmental problems under limited financial resources and backward technology condition in China". According to the instruction we took measure as follows:

(1) The environmental protection organizational apparatus were set up in provinces, autonomous regions, municipalities directly under the State Council and the cities, counties in China. The water environmental or industrial wastewater management division were set up also in the provinces, municipalities directly under the State Council, important cities of environmental protection (52), some cities directly under the provinces and external cities.

(2) Laws and regulations on water environmental protection were established. The system of the laws and regulations was consisted of laws, administrative regulations, standards, local laws and regulations. Details in: "Environmental Protection Law of the People's Republic of China". "Law of the People's Republic of China on the Prevention and Control of Water pollution". "Implementation Rules for Law of the People's Republic of China on the Prevention and Control of Water Pollution". "Water Law of the People's Republic of China". "River Course Administration Regulations of the People's Republic of China". "Technological Regulations on Prevention and Control of Water Pollution". "Regulations of Prevention and Control on Water Pollution of Paper Industry". "Regulation on Administration of Discharge Reporting and Registering". "Measures of Supervision and Management of Sewage Treatment Facilities on Environmental Protection". And "Environmental Quality Standard for Surface Water". "Integrated Wastewater Discharge Standard". "Water Quality Standard for Fisheries". "Standard for Irrigation Water Quality". "Integrated Wastewater Discharge Standard of Hospitals". "Discharge Standard of Water Pollutants for Paper Industry". "Discharge Standard of Water Pollutants for Dyeing and Finishing of Textile Industry". Now, there are 6 water environmental basement standards, 5 standards for the water environmental quality, 31 standards for the water pollutants discharge, 82 standards

for the water analysis methods, 16 standards for the water sample in China. At the same time, a lot of local regulations of water environmental protection and discharge standards of industrial wastewater were promulgated by means of linking local condition in different places of China. So industrial wastewater were prevented and controlled by the laws and regulation. It laid a foundation for environmental management strengthened.

(3) The permit licence system of water pollutants discharge (PLSWPD) was practiced to control the total amount of industrial wastewater pollutants. In order to control industrial wastewater pollution affectedly, our NEPA practiced the permit licence system of water pollutants discharge and conducted tests at selected sites of 18 cities successfully from the end of 1980s. The total amount increased of pollutants discharge were controlled under the economy development promoted in the cities. After the PLSWPD was put into effect, the total amount of pollutants discharge were decreased positively, the control and improvement of water environmental quality were accelerated. For example, the Dan River in Shanxi Province and Huijiang River in the Kaiyun City of Yunan Province were pollutants received rivers in the past, there were no fish and shrimp in the black and stinking water. After the PLSWPD was out into effect, governors's environmental objective system of job responsibility were placed on the government tasks through the PLSWPD. The plans of pollutants discharge index, treatment measures, pollutants reduction were placed on enterprises's run contract system of job responsibility. So the fund of industrial wastewater treatment was guaranteed, and the treatment of pollution sources was accelerated. Normal operation of industrial wastewater treatment equipment built was assured and pollutants were reduced. The industrial output of Kaiyu City was increased 22.4 percent and the total amount of industrial wastewater discharged was decreased 17.7 percent in 1992. The amount of main toxic pollutant (Arsenic) was decreased 60.2 percent. There were many trees beside the Huijiang River and much fish and shrimp in the river. The water quality of the Dan River was improved better. The concentration of chemical oxygen demand (COD) was decreased from 1050.77 mg/L in 1985 to 42 mg/L in 1992 and average value was 20 mg/L in 1993. Fish and shrimp backed to the river and ecological system was recovered.

The Second National Conference on prevention and Control of Water Pollution was convened by Chinese NEPA in Sept. 1989. The second National Conference on Prevention and Control of industrial pollution was convened by Chinese National Economy Committee and NEPA, summed up the experiences of industrial wastewater prevention and control;

(1) It is the first important task to protect drinking water resources better and to prevent and control industrial wastewater pollution in the water environmental management in China. Because drinking water resources concern with thousands people's health, the "Regulations on Administration of Prevention and Control on Drinking Water Resources Protecting Zones" was promulgated by the NEPA and the other four ministries in July, 1989. The regulation of drinking water resources protection was promulgated by 30 cities itself and drinking water resources protecting zones were designated by 27 cities itself among 32 cities which had the system for quantitative examination on integrated control of urban environment. So the

drinking water resources were protected affectedly.

(2) Water environmental protection planning was done better. Irrational industrial distribution was improved through uniting with industry adjustment. It was a main reason that industrial wastewater polluted environment because of irrational distribution of industry. The old enterprises of irrational distribution were adjusted according to the system of shutting down and moving polluting enterprise. The "Regulations of Moving Polluting Enterprise in Nanjing (tentative)" was promulgated by Nanjing Government in March, 1992. The tax, loan, land requisition were supported and preferred to the moving enterprises. 24 enterprises were moved in 1992, and 41 in 1993. The 0.218 billion Yuan RMB were used to shut down and move 130 enterprises uniting with urban transforming in Suzou City. The product kinds of 4 serious polluting enterprises were adjusted at half a year in Wuxi City and 20 percent of COD discharged were reduced. 130 enterprises were shut down and moved from 1985 to 1990 in Shanghai. The centers of leather, electroplate, pulp, dye, pesticide, alcohol industries were set up. Industrial wastewater pollution were controlled affectedly. According to the Environmental Protection Guidance Daily, 5 enterprises which discharged pollutants were instructed to shut down in order to protect water quality of Hujiang River and industrial water from sugar industry needed at the down river in Huning County of Nanning City of Guangxi Provinces.

(3) Constructing projects management was strengthened and new pollution sources were controlled strictly. Environmental management was to stick to environmental protection examination and assessment, system of "the Three Synchronization" to constructing projects. The enterprises which discharge pollutants were forbidden to set up in the environmental sensitive urban areas such as upwind direction, drinking water resources, urban residential areas, scenic tourist spots, protected landscapes areas, culture landscape protected areas. For example, more than 100 heavy polluting constructing projects were forbidden to set up in economic developed zone of Gujiao City by Taiyuan Environmental Protect Bureau. The 42 private gold producing and making sites which polluted surface and underground drinking water were shut down by Qingyuan County government of Liaoning Province in August 9, 1993.

(4) Zero or low discharge and zero or low water resources polluted technology saved of were developed and adopted vigorous. The poisonous raw materials were replaced by nonpoisonous and low-poisonous materials. It is called clean production. It was an ideal method of prevention and control on industrial wastewater pollution that the amount of wastewater and pollutant discharge by industry will be reduced by technology readjust which resources (water resources) usage rate will be raised mostly in order to reduce resources waste and pollutants or wastewater were eliminated in the production process mostly.

For example, only 15—30 percent of plating material were covered on the surface of matter-plated and 70 percent of plating liquor were discharged with rinse water in the electroplating production. The "Principle of Rinse Water Used Repeatedly" was invented by the Xuzou 4813 factory. The 58 percent of restage rate of electroplating rinse water and plating

liquor were designed. And water consumption was only 1 percent of traditional process. The cost of electroplate was decline to 50 percent. The method solved the problem of the wastewater pollution and was listed in the best practical by NEPA in 1993.

(5) The methods of which water was recycled, water was used many times, wastewater was treated and used again were developed. It is best way of prevention and control on industrial wastewater pollution that wastewater will be used as water resources.

According to China Environment News report in Dec. 16, 1993, the technology of all recycling used in distillers grains filter-liquor was spreader by Jiangsu EPB in Rugao Brewery. The technological basement was low temperature distillation which the viscosity of distiller's grains is lower than high temperature. And the separated grains can be used as feeding stuff directly. The output of 5000 ton alcohol per year can produced 50000 ton feeding stuff by-products (net weight) and net value per year increased is 0.247 million Yuan RMB. Because 1200–1500 million ton waste liquor of distiller grains was produced by 100 million ton alcohol production per year in China and was the same amount of urban sewage discharged by 30 million people.

4 Problem

A lot of works were done and many successes were achieved in prevention and control on industrial wastewater pollution in China during recent 20 years. But, because China is developing country, the fund used in environmental pollution control was limited although economic development is fast recently. Now one hand that old pollution sources are not treated due to deficiency of environmental protection fund, the other hand that a lot of new pollution resources are set up due to economic development. The confliction between environmental protection and economic development was more protruding. The condition of water environment was too bad to be controlled effectively. It was one of the main factors that industrial wastewater pollution became to threaten people health and restrict economic development. It is very important to us. Now the main problems were discussed as follows:

4.1 Policies

Management of wastewater is mainly focused on concentration control and last effluent treatment at the end of the tube. The concentration of discharging pollutants was the basis of standards, discharging pollutants fee, environmental impact assessments and so on now. So many factories discharged their wastewater with diluted fresh water or stealing and treated last effluent only instead of whole process control in order to meet the standards. It only achieved half the result with twice the effort for management executor to check last effluent point and treatment facilities.

4.2 Economy

Funds were very lack in preventing and controlling on industrial wastewater due to historic deficiency

Many factories constructed in 1950' and 1960' had no environmental protection facilities

and the old pollution sources treated were lack in funds from our country now. Although the "new constructing projects instead of old one" which new projects should be constructed the same to treat old pollution sources was regulated by the environmental protection departments of many ministries, the loan from banks were not got because environmental projects had environmental and social benefits only, and little economic benefit. It is said that policy bank will be set up by Chinese government and expected to solve environmental protection funds.

The funds for industrial treatment facilities was low benefit rate. NEPA now is discussing methods to solve by raising discharge pollutants fee and strengthening environmental management.

4.3 Technology

Many factories with long history used undeveloped technology and backward equipment, consumption of large amount water and raw materials, discharged lots of pollutants.

Although there were different kinds of treatment technology and facilities in China, there were not better model engineering.

There are not ideal methods of prevention and control on a lot of industrial wastewater till now.

Paper and pulp industry was the largest pollution source in China. The wastewater amount from it was 4.2 billion ton and 17.9 percent of total wastewater in China, the BOD amount was 2 thousands ton and one-third of total industrial BOD in 1992. According to the national regulation, the mill above 10 thousands ton output must have alkaline recovery process which not only had environmental benefit, but also had economical benefit. Although many mills wanted to build the process, it is difficult to collect enough money because the fund is very big. How to solve small mills' wastewater? The alkaline recovery process for small mills was low economical benefit because of irrational design of recovery furnace mainly. The jet alkaline recovery furnace which the technology was applicable, economy was rational and it was developed by Xuzhou Environmental Protection Research Institute needed 1.5 million Yuan (RMB) built, but money was very difficult collected to give up. For black liquid, it can be used to produce lignin but it was limited by the market requirement. The lignin can be reused to produce lignin-gum, asphalt-concrete water reducing, oil-water mixture agent and so on. But it was very slow to make achievements in scientific research to become it in market due to lack in developing funds.

The total amount of dye industrial wastewater discharge was 0.2—0.3 billion ton per year. Many of them was high concentration organic waste liquor including Benzene, Naphthol, Anthracene, Quinone and the other Polycyclic Hydrocarbon which were difficult to be treated.

The total amount of pharmaceutical industrial wastewater and COD were 0.2—0.3 billion ton and 150 thousands ton per year. Less than 30 percent were treated. Especially in the factories which produced the antibiotic. There were 100 factories to produce antibiotic in China, but only wastewater from Jining Pharmaceutical Factory in Shandong Province,

Huabei Pharmaceutical Factory in Hebei Province, Second Pharmaceutical Factory in Shanghai City was treated. And there was not a good method to treat wastewater from producing streptomycin.

High concentration organic wastewater must be prevented and controlled.

The COD concentration was 6000—20000 mg/L, the BOD concentration was 3000—10000 mg/L, in the high concentration organic wastewater mainly from food fermentation, sugar, leather, meat product industries.

There were 230 factories to produce glutamate. They discharged 170 thousand ton wastewater per year which mainly discharged directly instead of treatment. The molasses distiller's grains was waste liquor from molasses alcohol distillation. It was high temperature, high acidity, heavy color. The BOD and COD concentration were more than ten thousand microgram per liter. It was main pollution source in Guangdong and Guangxi Province.

In Guangxi Province there were 99 sugar refineries which produce 2 million ton sugar per year and was the second of China. Every ton sugar production discharged 40—50 ton wastewater. There were 80—100 million ton wastewater per year from sugar industry in the province. The wastewater which did not be treated by good treatment technology now was discharged centrally in the dry season during winter and spring and polluted rivers. So the drinking water was affected.

Now, there are 500 tanneries factories which discharged 50—60 million ton wastewater per year in China. Less than 30 percent of the tanneries had wastewater treatment facilities, the others did not treat their wastewater and discharged them to environment directly. The Nanjing Environmental Protection Institute of NEPA recently developed biological oxidation ditch which it was to treat tannery wastewater. The wastewater recovery technology was being developed also.

The methods of industrial wastewater monitoring were very backward. The COD and BOD could not be detected automatically and continuous, mainly depended on manpower discontinuous detection. Wastewater flowmeter were very expensive and bad quality, and used in half a year only, and had not enough repairing services. So it was difficult to be popularized.

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