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Research on common methods for evaluating the operation effect of integrated wastewater treatment facilities of iron and steel enterprises

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Research on common methods for evaluating the operation effect of integrated wastewater treatment facilities of iron and steel enterprises

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Abstract. Considering the large quantities of wastewater generated from iron and steel enterprises in China, this paper is aimed to research the common methods applied for evaluating the integrated wastewater treatment effect of iron and steel enterprises. Based on survey results on environmental protection performance, technological economy, resource & energy consumption, services and management, an indicator system for evaluating the operation effect of integrated wastewater treatment facilities is set up. By discussing the standards and industrial policies in and out of China, 27 key secondary indicators are further defined on the basis of investigation on main equipment and key processes for wastewater treatment, so as to determine the method for setting key quantitative and qualitative indicators for evaluation indicator system. It is also expected to satisfy the basic requirements of reasonable resource allocation, environmental protection and sustainable economic development, further improve the integrated wastewater treatment effect of iron and steel enterprises, and reduce the emission of hazardous substances and environmental impact.

1. Introduction

China is one of the superpowers in iron and steel in the world. According to the statistics, the production of one ton of steel consumes 200-250m^3 water and generates a large quantity of wastewater. Statistically, as of December 2016, the member enterprises of China Iron and Steel Industry Association discharged 42 million m^3 of wastewater throughout the year, up 5.89% YoY. Among them, COD emission reached 1,050 tons, down 9.31% YoY and up 3.53% MoM; ammonia nitrogen emission reached 134 tons, up 35.66% YoY and up 31.97% MoM; volatile phenol emission reached 0.85 ton; total cyanide emission reached 0.82 ton; suspended-particle emission was up to 600 tons; petroleum emissions were about 19 tons [1]. Currently, most iron and steel enterprises in China have changed their attitude from indifference to water-saving and paying no attention to developing non-traditional water sources to actively using recycling water through water-saving, pollution control and development of new sources[2].

Wastewater from iron and steel enterprises mainly includes wastewater, circulating cooling water, discharge water, desalted water, softened water, strong brine, etc. generated in various production processes, as well as impurities like Calcium, Iron, Manganese, Lead, Zinc, Copper, Arsenic and other heavy metal ions and high-concentration suspended solids[3]. For example, wastewater from a sintering plant mainly contains the wastewater from the wet dust collector and wastewater generated by washing the terrace and conveying belts, while the impurities are mainly the suspended solid of sintered mixtures. Wastewater from a cold rolling plant mainly contains chromate wastewater, acid

wastewater, concentrated alkali emulsification wastewater, dilute alkali oily wastewater, etc. The coking wastewater is the most complicated wastewater containing a large quantity of phenol, ammonia, sulfur, cyanide, tar, pyridine and other pollutants, and it is a kind of unmanageable industrial wastewater that can cause severe pollution [4].

All production processes of iron and steel enterprises will generate industrial wastewater. In order to satisfy the production needs and reduce the concentration of wastewater, it is necessary to regularly discharge the pollution in recycling water treatment even though wastewater recycling or treatment facilities are set. The integrated wastewater of iron and steel enterprises refers to the mixed wastewater of wastewater generated in the recycling of untreated wastewater, a small amount of accidental water from certain processes, treated wastewater that meets the emission standard and a small quantity of domestic wastewater. The standard definition of the integrated wastewater of iron and steel enterprises is the wastewater collected and conveyed by the drainage systems within the plant areas of iron and steel enterprises, and drained out through the main drains. Wastewater discharged from production unit (excluding cool rolling wastewater and salt wastewater in high concentration) shall be collected by the drainage system in the plant area and conveyed to the integrated wastewater treatment facility for processing [5]. The integrated wastewater of iron and steel enterprises mainly contains SS, organic/inorganic substances and other impurities and oils. Moreover, it is featured by relatively high conductivity, which significantly affects its recycling.

This paper is aimed to research the common methods applied for evaluating the integrated wastewater treatment effect of iron and steel enterprises. A tertiary evaluation indicator system from such aspects as environment, resources, management, operation and services is set up by investigating and analyzing the relevant policies, regulations, standards as well as main processes and equipment for integrated wastewater treatment facilities of iron and steel enterprises, so as to determine values of evaluation indicators through the data, site investigation and comparison of standards to evaluate the measures taken by iron and steel enterprises for integrated wastewater treatment, thus improving the integrated wastewater treatment effect of iron and steel enterprises and reducing the emission of hazardous substances and environmental impact.

2. Research Method

2.1. Determination of Indicators
In this paper, the quantitative and qualitative evaluation indicators are combined to determine the 5 primary indicators of environmental protection performance, technological economy, resource & energy consumption, management & service and conditions of main equipment of the integrated wastewater treatment facilities of iron and steel enterprises based on the full life circle by means of project investigation, questionnaire survey, etc. Several lower level indicators are further set to form an indicator system for evaluating the operation effect of integrated wastewater treatment facilities. The integrated wastewater treatment facilities shall have certain technical innovation and economic benefits, while the evaluation of operation effect of the equipment shall conform to relevant standards and regulations for environmental protection. The equipment shall be safe, reliable and energy-saving, and conform to the basic requirements of reasonable resource allocation, environmental protection and sustainable economic development, provided that the environmental protection requirements are satisfied.

2.2. Methods for Determination of Evaluation Values
(1) The indicator value for environmental protection performance shall be determined as per the existing wastewater discharge standards of China, and the environmental protection evaluation class shall be defined as per the requirements for different regions as stated in such standards.

(2) As for technological economy, resource & energy consumption, and conditions of main equipment, it is necessary to fully investigate the situations of wastewater treatment facilities of the same type, and determine the classification according to the investigation data as follows: Class 1 refers to wastewater treatment facilities with excellent performance, accounting for about 20% of the

total number of wastewater treatment facilities in the industry; Class 2 refers to wastewater treatment facilities with good performance, accounting for 70%; the remaining 10% are those with poor environmental protection performance, which shall be rectified or weeded out.

(3) In terms of management and services, it is required to determine the classification and evaluation values in strict accordance with the requirements of the quality management system, energy management system, environmental management system, as well as the relevant safety management regulations of the enterprises.

3. Evaluation Indicator System

After investigating the processes and current situation of application of integrated wastewater treatment facilities of iron and steel enterprises, it is concluded that the indicators in indicator library shall include definitive indicators and general indicators. Specifically, in investigation and indicator selection, the focus is placed on the definitive indicators with significantly impacts on environmental performance or those which shall be strictly adhered to at the request of laws and regulations, indicators covering the limited emission of toxic and hazardous substances, water consumption, energy consumption and power consumption, as well as particular pollutants of the industry, industry access indicators, etc. Moreover, to improve the operation effect of integrated wastewater treatment facilities, importance is attached to investigating general indicators specified in the standards related to the products, mainly including a series of national or industrial standards to be followed by such main equipment as grille cleaner, submersible mixer, oil-water separator, mud scraper, sludge dewatering equipment, air blower, slurry pump, etc.

The method of subjective judgment by experts is applied and factor analysis based on environmental protection, technological economy, resource & energy consumption, management & service and product properties is conducted, so as to build multi-layer indicator architecture for full life cycle of integrated wastewater and finally form an evaluation indicator system containing multiple secondary indicators for purpose of evaluation of operation effect of wastewater treatment facilities of iron and steel enterprises. Specifically, the secondary indicators shall include such key secondary indicators as pH value, SS, COD, ammonia nitrogen, noise emission limit requirement, energy consumption, water consumption, power consumption, hazardous substance content, recycling rate, drug consumption, safe operation, system operation rate and equipment availability, as shown in Figure 1.
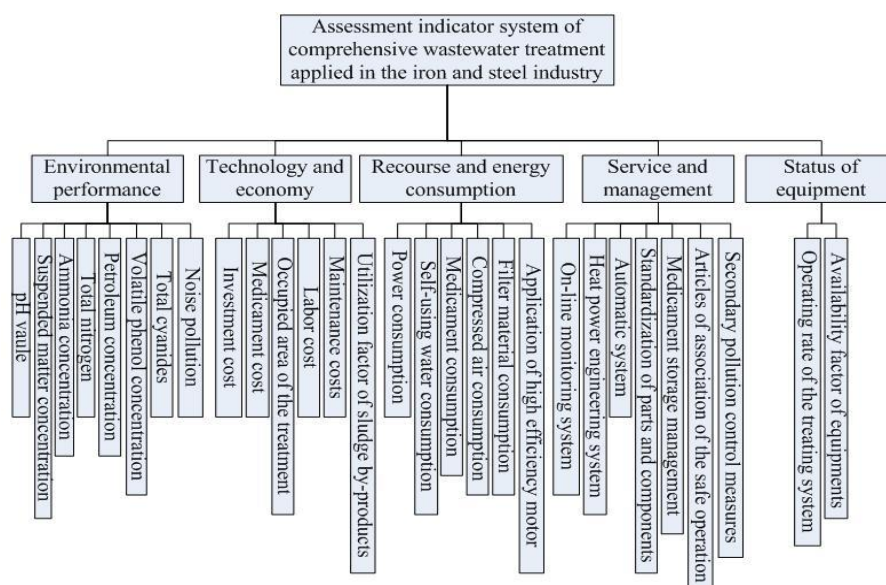

Figure 1. Assessment indicator system of comprehensive wastewater treatment applied in the iron and steel industry

4. Analysis on Rationality of Key Indicators for Evaluating the Operation Effect of Wastewater Treatment System of Iron and Steel Enterprises

According to the evaluation indicator system built herein, the focus is placed to investigating and analyzing the rationality of key indicators for evaluating the operation effect in terms of pH value, SS concentration, COD concentration, system operation rate, online monitoring system, etc.
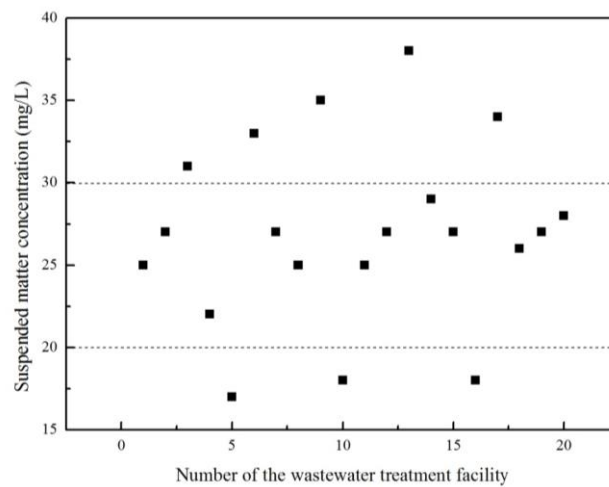
4.1. pH Value

The pH values of wastewater discharged from the integrated wastewater treatment facilities of iron and steel enterprises in China are analyzed, and the statistical results are shown in Figure 2. Among 20 sets of integrated wastewater treatment facilities subject to the investigation and analysis, 18 sets have a pH value larger than 6 but less than 9, accounting for 90%; 0 set has a pH value less than 6, accounting for 0%, and 2 sets have a pH value larger than 9, accounting for 10%. The percent of pass is 90%.
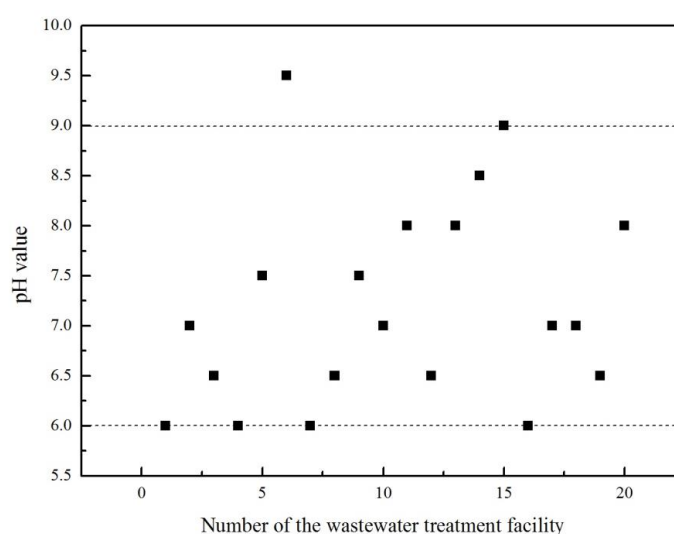
Figure 2. Statistical results on pH values of wastewater discharged from the integrated wastewater treatment facilities of iron and steel enterprises
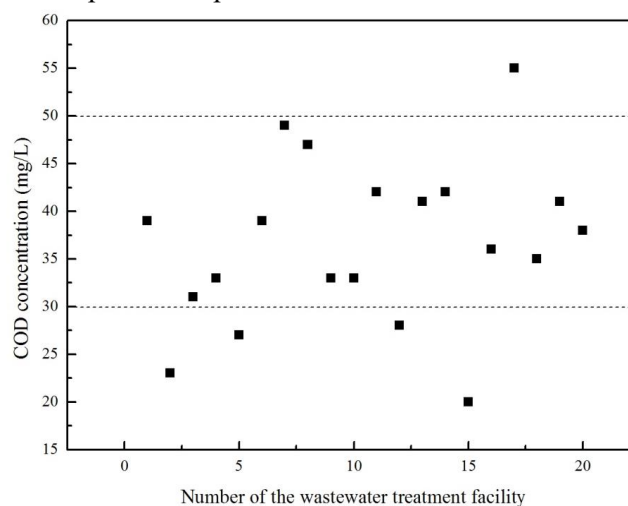
4.2. Suspended matter concentration (SS)

The suspended matter concentration of wastewater discharged from the integrated wastewater treatment facilities of iron and steel enterprises analyzed, and the statistical results are shown in Figure 3. Among 20 sets of integrated wastewater treatment facilities subject to the investigation and analysis, 3 sets have a suspended matter concentration less than 20 mg/L, accounting for 15%; 12 sets has a concentration less than 30 mg/L but larger than 20 mg/L, accounting for 60%, and 5 sets have a concentration larger than 30 mg/L, accounting for 25%. The percent of pass is 75%.

Figure 3. Statistical results on SS concentration of wastewater discharged from the integrated wastewater treatment facilities

4.3. COD concentration

The COD concentration of wastewater discharged from the integrated wastewater treatment facilities of iron and steel enterprises analyzed, and the statistical results are shown in Figure 4. Among 20 sets of integrated wastewater treatment facilities subject to the investigation and analysis, 4 sets have a COD concentration less than 30 mg/L, accounting for 20%; 15 sets has a concentration less than 50 mg/L but larger than 30 mg/L, accounting for 75%, and 1 sets have a concentration larger than 50 mg/L, accounting for 5%. The percent of pass is 95%.

Figure 4. Statistical results on COD concentration of wastewater discharged from the integrated wastewater treatment facilities of iron and steel enterprises

4.4. Operation Rate of the Treating system

The system operation rate refers to the percentage of annual normal operation time of the integrated wastewater treatment facility in the total operation time of the main work, and is one of the important factors affecting the quality of wastewater treatment. The improvement of operational rate can effectively control the emission of water pollutants and improve the wastewater treatment efficiency. Frequent system faults and lower operation rate may not only increase the workload of maintenance

personnel, but also reduce the operation rate and affect the wastewater treatment efficiency. The system reliability and operation rate can be improved by debugging the system for safe, stable and continuous operation.

The operation rate of integrated wastewater treatment facilities of iron and steel enterprises in China is analyzed. Among 20 sets of integrated wastewater treatment facilities subject to the investigation and analysis, the system operation rate reaches 100%.

4.5. On-line Monitoring System

The installation of online monitoring systems for integrated wastewater treatment facilities of iron and steel enterprises in China is analyzed. All of the 20 integrated wastewater treatment facilities subject to the investigation and analysis are equipped with online monitoring systems. The online monitoring system is used to continuously monitor the concentration and total amount of COD, ammonia nitrogen, volatile phenol, oils, phosphorus and other pollutants and particulate matters discharged, and transfer the data to the competent department in real time. The online monitoring system is directly related to the operation conditions of environmental protection device. All wastewater treatment facilities shall be equipped with online monitoring system to satisfy the monitoring requirements proposed by the environmental protection administration and the requirements for comprehensive monitoring of dust removing devices.

5. Conclusions

In this paper, integrated wastewater treatment facilities of iron and steel enterprises are analyzed. An indicator system for evaluating the operation effect of integrated wastewater treatment facilities based on five primary indicators of environmental protection performance, technological economy, resource & energy consumption, services and management is set up by investigating the standards and industrial policies in and out of China to further define 27 key secondary indicators (pH value, concentration of suspended matters, COD concentration, system operation rate, online monitoring system, etc.) on the basis of investigation and survey on main equipment and key processes for wastewater treatment, so as to determine the method for setting the key quantitative and qualitative indicators for evaluation indicator system through the rationality evaluation done on the basis of certain indicator values in existing standards. It is expected to build the evaluation system and determine the relevant evaluation methods for the improvement of operation effect of integrated wastewater treatment facilities of iron and steel enterprises in China.

The focus is further placed on the determination of values and weights of the secondary indicators based on the investigation of evaluation indicator system and relevant values, so as to classify and evaluate the integrated wastewater treatment facilities of iron and steel enterprises in China, and provide a standard for the implementation of relevant policy dividend for third-party governance.

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