Suggestions on Improving the Capacity of Hazardous Waste Disposal, Utilisation, and Supervision - Take the Construction of "Waste Free City" In Sanmenxia City as an Example

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Abstract. The implementation of a complete process assessment and comprehensive upgrade of hazardous waste generation, utilization, and disposal is one of the important tasks that the current urban development process continues to address. Sanmenxia City is a typical resource-based industrial city in China, with abundant mineral resources. In the process of urban transformation and development, the generation of large amounts of hazardous waste has become a significant obstacle to urban green transformation and high-quality development. This has resulted in ecological and environmental problems that need to be addressed. Based on an assessment and analysis of the current situation regarding the generation, collection, and disposal of hazardous waste in Sanmenxia City, this paper aims to address the existing problems and propose solutions. The objective is to improve hazardous waste management by enhancing the construction of collection and disposal facilities, establishing a comprehensive management organization and system, implementing a market system and incentive mechanism, promoting technical innovation and operational efficiency, prioritizing energy conservation and carbon reduction, strengthening supervision and law enforcement, developing an information supervision system, and enhancing risk prevention and control through publicity, education, and training. The enhancement of supervisory capacity is beneficial in addressing the significant environmental issues related to hazardous waste in Sanmenxia City and ensuring high-quality development.

Keywords: hazardous waste; management; resource utilization; improvement of regulatory capacity.

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1. China's Hazardous Waste Management System and Policy Analysis

In 1996, China promulgated “the Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution” [1], which established specific provisions preventing and controlling environmental pollution caused by hazardous waste. The latest revised version of the law has been officially implemented since September 1, 2020. It stipulates the requirements for the entire process management of hazardous waste, including generation, collection, transfer, treatment, and disposal. The law also proposes the implementation of graded and classified management of hazardous waste to ensure refined management of such waste. The law mandates that "the provincial, autonomous regional, and municipal governments under the central government must coordinate with relevant departments to develop construction plans for centralized disposal facilities and sites for hazardous waste. They should also conduct scientific evaluations to determine the need for hazardous waste disposal, strategically plan the locations of centralized disposal facilities and sites, and ensure the appropriate disposal of hazardous waste within their respective administrative areas" [2].

The National Plan for the Construction of Hazardous and Medical Waste Disposal Facilities [3], which was promulgated and implemented in China in 2003, can be considered a significant step forward in promoting the treatment and disposal of hazardous and medical waste in China. The Plan developed a comprehensive strategy for national hazardous waste disposal, including objectives, principles, layout, scale, and investment. The National Hazardous Waste List, adopted in May 2020 [4], introduced an exemption management system for a specific group of hazardous waste that satisfies the relevant conditions in specific sectors[5].

In recent years, China has also issued a series of standards and specifications related to waste management. These include the "Standard for Pollution Control on Hazardous Waste Storage" [6], the "Standard for Pollution Control on Hazardous Waste Incineration" [7], the "Standard for Pollution Control on Hazardous Waste Landfill" [8], and the "Standard for Pollution Control on Medical Waste Treatment and Disposal" [9]. These standards and specifications specify the selection, design, and construction sites for hazardous waste storage incineration and landfill facilities. They also cover waste packaging and storage containers, labels and signs, incineration control indicators, residue disposal, landfill waste entry requirements, pollution control, safety and security of facilities, as well as environmental monitoring and emission requirements. Technical specifications and management measures, such as the "Management Measures for Hazardous Waste Business License" [10], the "Technical Specifications for the Construction of Hazardous Waste Centralized Incineration and Disposal Engineering" [11], the "Technical Requirements for the Construction of Hazardous Waste Safe Landfill and Disposal Engineering" [12], and the "Technical Specifications for Medical Waste Centralized Incineration and Disposal Engineering" [13], have been established to regulate the operation and regulatory requirements of the entire process of hazardous waste treatment and disposal.

In October 2019, the Ministry of Ecology and Environment issued the "Guiding Opinions on Improving the Capacity for Environmental Supervision, Utilization, Disposal, and Environmental Risk Prevention of Hazardous Waste" [5] (Circular Solid State [2019] No. 92). It is explicitly proposed to "scientifically formulate and implement plans for the construction of centralized hazardous waste disposal facilities. This includes promoting the integration of

these facilities into the construction of local public infrastructure by local governments, as well as providing policy guarantees in terms of taxation, capital investment, and construction land for the centralized incineration and disposal of hazardous waste" [14].

In May 2021, the General Office of the State Council of China issued the "Implementation Plan for Strengthening the Supervision, Utilization, and Disposal Capacity of Hazardous Waste" [15] (State Office Letter [2021] No. 47). It requires "adhering to precise, scientific, and legal pollution control measures [16]. The core focus should be on continuously improving the quality, with continuous improvement of ecological environment quality as the core. The goal is to effectively prevent and control the environmental and safety risks of hazardous waste. This can be achieved by deepening the reform of the system and mechanism, and by focusing on improving the capacity of hazardous waste supervision, utilization, and disposal. It is crucial to earnestly safeguard people's health and ecological environment safety [17]. Additionally, there is a proposal to accelerate the promotion and application of advanced appropriate technology achievements [18].

In September 2021, the General Office of the Ministry of Ecology and Environment issued the "14th Five Year Plan for Standardized Environmental Management Assessment of Hazardous Waste in China" [19] (Environmental Affairs Office Solid [2021] No. 20). This plan emphasizes the need for the "reasonable establishment of evaluation indicators, promotion of organizational leadership, preparation of plans, implementation of responsibilities, capacity building, and effective work in various regions and relevant departments to ensure the supervision, utilization, and disposal capacity of hazardous waste."

On December 29, 2020, the General Office of the Ministry of Ecology and Environment issued the Notice on Promoting the Informatization of Environmental Management of Hazardous Wastes [20] (HBSH [2020] No. 733). This notice mandates the full utilization of the solid waste management information system for filing hazardous waste management plans, declaring waste generation, facilitating the electronic transfer of hazardous wastes, and applying for inter-provincial (autonomous regions, municipalities directly under the Central Government) waste transfers. The annual report submission and approval for exporting hazardous waste by units holding hazardous waste licenses shall be conducted systematically to facilitate the monitoring and tracking of the entire process of hazardous waste generation, collection, storage, transfer, utilization, and disposal.

On November 30, 2021, the Ministry of Ecology and Environment, the Ministry of Public Security, and the Ministry of Transport revised and issued the "Management Measures for Hazardous Waste Transfer" (Order No. 23 of the Ministry of Ecology and Environment, the Ministry of Public Security, the Ministry of Transport) [21]. The revised measures state that the transfer of hazardous waste should adhere to the principle of proximity. Additionally, when transferring hazardous waste, the electronic transfer form of hazardous waste must be completed and processed through the National Hazardous Waste Information Management System [22].

On June 20, 2022, the Ministry of Ecology and Environment issued the "Technical Guidelines for the Development of Hazardous Waste Management Plans and Management Accounts" [23] (HJ 1259-2022). These guidelines stipulate the overall requirements for units that produce hazardous waste to develop hazardous waste management plans and management accounts. They also outline the requirements for declaring hazardous waste-related materials, as well as

the development of hazardous waste management plans, management accounts, and the declaration of hazardous waste.

On 24 February 2022, the General Office of the Ministry of Ecology and Environment issued a notice (Environmental Affairs Office Solid Letter C2022, No. 66) on conducting pilot projects for the collection of hazardous waste from small and micro enterprises[24]. The notice states that, in principle, small and micro enterprises within the administrative area that generate less than 10 tons of hazardous waste annually should be designated as the focus of collection services. Additionally, government agencies, research institutions, schools, and other units, as well as social sources, should also be taken into account [25].

Sanmenxia City is located in the western part of Henan Province. As a typical resource-based industrial city in China, it is rich in mineral resources. In the process of urban transformation and development, a large amount of hazardous waste has been produced, and the resulting ecological and environmental problems have become a significant obstacle to urban green transformation and high-quality development. To fully address the requirements for improving the "three capabilities," the Sanmenxia Municipal Ecological Environment Bureau organized a comprehensive assessment and capacity improvement project to research the city's hazardous waste generation, comprehensive utilization, and disposal facilities. The implementation of the project aims to enhance the regulatory capacity of managing hazardous waste and establish a comprehensive network for information management on hazardous waste [15]. It is beneficial for enterprises to improve the utilization and disposal capacity of hazardous waste, achieve energy conservation and carbon reduction, promote new regional economic growth, and encourage green industrial development. Additionally, it helps enhance the ability to prevent environmental risks associated with hazardous waste and effectively curb the high incidence of illegal transfer and dumping of hazardous waste cases [26]. Furthermore, it contributes to addressing prominent environmental issues and ensuring high-quality urban development. Lastly, it aids in comprehensively improving the energy efficiency of government work and promoting the establishment of a modern, well-managed government.

2. Investigation and Assessment of the Current Situation Regarding the Generation, Utilization, and Disposal of Hazardous Waste in Sanmenxia City

2.1 Current Situation of Hazardous Waste Generation, Utilization, and Disposal in Sanmenxia City

Sanmenxia is a resource-based city with a heavy industrial structure and a reliance on coal for energy. The industry still focuses on high energy consumption and high-pollution non-ferrous metal mining, smelting, cement production, alumina production, and coal chemical industry, among others. The generation of industrial solid waste and hazardous waste is high, leading to the issues of "industrial siege" and "solid waste siege". With the comprehensive promotion and implementation of the national industrial regulation policy, Sanmenxia City has continuously improved its industrial layout and production capacity in recent years. The amount of hazardous waste generated from industrial sources has decreased compared to 2018, and the environmental risk prevention and control capacity of the enterprises involved in

hazardous waste has significantly improved. In 2019, the amount of industrial hazardous waste generated in the city is shown in Table 1.

Table 1. Production, utilization, and disposal of industrial hazardous waste in Sanmenxia in 2019.

Industrial hazardous waste		**Unit**	**Quantity**
Generation		10^4 t	15.58
Self-utilization and disposal volume	Comprehensive utilization amount	10^4 t	8.53 (Including the storage capacity from previous years storage capacity)
	Disposal volume	10^4 t	8.25(Including previous years' storage capacity)
Entrusted disposal volume		10^4 t	22.08 (including storage capacity from previous years storage capacity)
Storage capacity		10^4 t	21.16

By 2020, Sanmenxia will have a comprehensive utilization capacity of 22.12×10^4 tons, with an annual comprehensive disposal capacity of 48.57×10^4 tons. This includes an annual design scale for a safe landfill is 33.97×10^4 tons. In 2019, the actual disposal of hazardous waste in the city was 32.81×10^4 tons (including safe landfill 16.98×10^4 tons. The majority of this waste was inorganic cyanide waste (HW33). The hazardous waste disposal load rate for the year was 67.55%.

2.1.1 Analysis of The Current Situation of Waste Production Units

In 2019, the main sources of industrial hazardous waste in Sanmenxia City will include non-ferrous metal smelting, gas production, and supply, manufacturing of chemical raw materials and chemical products, power and thermal power production and supply, non-metallic mineral products industry, and automobile manufacturing. The industrial hazardous waste production industry is shown in Figure 1, and the production situation of various types of industrial hazardous waste is shown in Table 2.

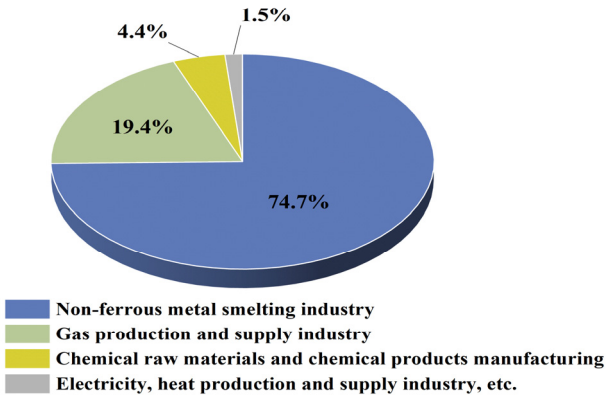

Fig.1. Industrial Hazardous Waste Generation Industry in Sanmenxia

Table 2. List of hazardous waste generation types in Sanmenxia in 2019

Serial Number	Hazardous waste name	Hazardous Waste Code	Hazardous waste generation
1	Nonferrous metal smelting waste	HW48	9.88
2	Refined distillation residue	HW11	4.89
3	Waste acid	HW34	0.36
4	Waste catalyst	HW50	0.16
5	Other hazardous waste	HW02, HW08, HW09, HW12, HW13, HW17, HW21, HW22, HW31, HW33, HW35, HW46, HW49	0.25
Total	\	\	**15.54**

According to the statistical analysis of hazardous waste generation in four counties (cities) and three districts under the jurisdiction of Sanmenxia in 2019, the city produced approximately 155,800 tons of industrial hazardous waste throughout the year. See Figure 2 for the production of industrial hazardous waste in each county or district.

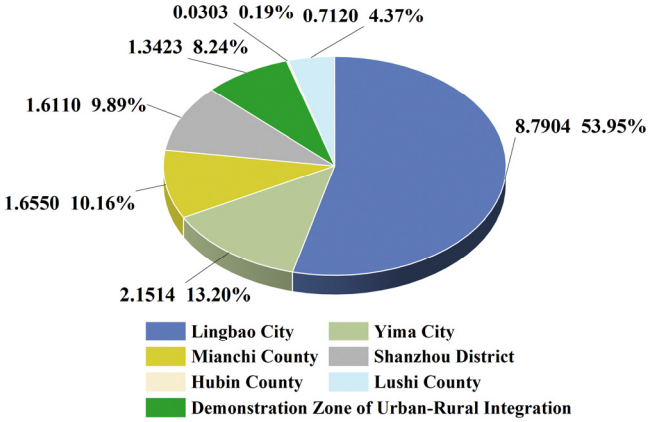

Fig.2. Production of hazardous industrial waste in various counties (cities) of Sanmenxia City

The production, internal utilization, disposal, entrusted disposal, and storage of industrial hazardous waste in various counties (cities) of the city are detailed in Table 3.

Table 3 List of production, utilization, treatment, and storage of industrial hazardous waste in Sanmenxia

County (City)/District	Hazardous waste storage at the end of 2018(t)	Generation of hazardous waste generation in 2019(t)	Internal self-use and disposal volume of enterprises in 2019(t)		Hazardous waste storage at the end of 2019(t)	Entrusted disposal volume in 2019(t)		
			Internal self utilization of enterprises in 2019	Internal self-disposal volume of enterprises in 2019		Transfer to urban disposal volume	Transfer to disposal volume within and outside the province	Transfer to disposal volume outside the province
Shanzhou District	163.39	16110.00	0.00	0.00	64.65	0.00	16208.59	163.39
Lingbao City	434633.42	87903.86	77575.82	82463.85	193861.30	147534.10	4055.99	434633.42
Lushi County	0.26	0.71	0.00	0.00	0.97	0.00	0.00	0.26
Mianchi County	77.54	16549.50	0.00	0.00	25.83	0.00	16601.22	77.54
Hubin District	63.97	302.70	0.32	0.00	13.31	2.73	350.31	63.97
Demonstration area	9212.77	13422.63	4066.20	0.00	17546.22	0.00	463.60	9212.77
Yima City	126.44	21513.80	3611.58	0.00	75.58	14460.80	3492.28	126.44
Total	**444297.1**	**155804.4**	**85254.3**	**824639**	**211581.9**	**161997.6**	**41171.98**	**444297.11**

2.1.2 Analysis of The Current Situation of Comprehensive Utilization Units

The current capacity for the comprehensive utilization of hazardous wastes in Sanmenxia City is primarily demonstrated through its collection and utilization capabilities. According to the "Management Measures for Hazardous Waste Business Licenses," in 2019, the city had five qualified enterprises for comprehensive hazardous waste business licenses issued by the provincial ecological and environmental department. These included three comprehensive disposal enterprises and two comprehensive utilization enterprises. Additionally, there was one unit with a hazardous waste business license issued by the municipal ecological environment department, which is the Sanmenxia Medical Waste Centralized Disposal Center. Furthermore, there were five hazardous waste collection and operation license enterprises issued by counties (cities) and districts, all of which were waste mineral oil (HW08) collection

enterprises. There are a total of eleven holders of hazardous waste operation licenses in the city, with an annual collection and utilization capacity of 24.61×10^4 tons.

2.1.3 Analysis of The Current Situation of Disposal Units

At present, Sanmenxia City has three comprehensive hazardous waste disposal enterprises: Henan Jinrong Cement Co., Ltd., Yima Environmental Protection Power Co., Ltd., and Lingbao Xin'an Solid Waste Disposal Co., Ltd. These three enterprises have a combined capacity for comprehensive hazardous waste disposal of 48.57×10^4 tons. In 2019, the actual disposal amount was 32.81×10^4 tons, primarily consisting of inorganic cyanide waste (HW33). The disposal load rate was 67.55%.

In 2019, Sanmenxia City produced 1753.18 tons of medical waste, which included 1436 tons of infectious waste, 315 tons of injurious waste, 0.61 tons of pharmaceutical waste, 0.99 tons of chemical waste, and 0.58 tons of pathological waste.

2.2 Analysis of Existing Problems

At present, the prevention and control of environmental pollution and hazardous waste in Sanmenxia City still face some urgent problems that need to be addressed. These include an unclear foundation, weak supervision capabilities, and relatively outdated treatment and disposal technologies.

1) The reporting of information regarding industrial hazardous waste is not standardized. At present, according to the industrial structure of Sanmenxia, there are more than 200 hazardous waste-related enterprises included in the "National Solid Waste Management Information System." However, this number still falls short of the actual number of waste-producing enterprises, indicating a significant gap. The information reported by hazardous enterprises is not standardized and timely, resulting in inaccurate and subjective reflection of the types and quantities of hazardous waste generated and treated. This affects the understanding of the actual situation of hazardous waste in the city.

2) The system for recycling hazardous waste from domestic sources is lacking. The management of hazardous waste in Sanmenxia is not perfect, and there is a lack of statistics, proper management, and appropriate disposal methods for hazardous waste from social sources. Social sources of hazardous waste include waste batteries, fluorescent tubes, discarded packaging, and laboratory waste, among others, in daily life. These hazardous wastes are numerous, widespread, dispersed, and present in large quantities. The costs of managing collection, storage, transportation, and safe disposal are high. Random stacking and simple landfill can cause serious pollution to the surrounding groundwater, soil, surface water, and atmospheric environment.

3) The capacity for supervising hazardous waste in the environment needs to be improved. The focus on key hazardous enterprises is relatively high, while the management efforts for enterprises that produce a large quantity of hazardous waste but in small amounts are insufficient. On the one hand, the allocation of personnel for managing hazardous waste at the grassroots level is weak. Municipal ecological and environmental departments generally establish solid waste management departments or solid waste management centres, while most county-level departments are integrated into the comprehensive management of other

departments. On the other hand, the management of hazardous waste cannot be effectively achieved through online monitoring and other information technology methods alone, such as water and gas emission supervision. This limitation somewhat hinders the overall level of environmental supervision for hazardous waste in the city.

4) The treatment and disposal technology for hazardous waste needs to be optimized. Some existing hazardous waste treatment and disposal facilities have been in operation for many years, with outdated equipment and a low level of comprehensive utilization. The effect of harmless disposal needs to be tested. Although the inorganic cyanide waste in the gold smelting industry has undergone detoxification treatment, it still poses certain hazards. In addition, the city's capacity for collaborative disposal is limited, and a significant amount of waste needs to be transferred to other provinces for safe disposal every year. This has become one of the key aspects of hazardous waste management in the city. In addition, some enterprises lack the ability to safely dispose of hazardous waste and lack professional knowledge in chemical and environmental protection. Some enterprises simply seal up or dispose of hazardous waste without proper regulations. Some enterprises may have outdated treatment processes, lack pollution prevention and control facilities, fail to implement necessary environmental management measures, and have rudimentary equipment for handling or comprehensively utilizing hazardous waste.

5) Further shortcomings need to be addressed in the centralized disposal of medical waste. In 2019 and 2020, the Sanmenxia Medical Waste Centralized Disposal Centre collected and disposed of 1,753 tons and 1,487 tons of medical waste, respectively. The average facility operation load rate was 96.1% and 81.5%, indicating a prolonged period of medium and high load operation state. The pressure on medical waste disposal in the city is significant. Furthermore, as a result of the COVID-19 pandemic, there has been an increase in the amount of medical waste generated in the city. However, there is a serious lack of mechanisms in place to ensure the provision of protective materials for emergency disposal and proper environmental emergency management. The problem of insufficient emergency disposal capacity for medical waste in the city is serious. Restricted by factors such as collection and transportation distance, manpower and vehicle costs, medical waste in remote areas such as Lushi County, Sanmenxia City, is generally difficult to collect, transfer, and dispose of in a centralized manner, which has not been effectively incorporated into the city's centralized management system for medical waste, resulting in a large potential health and epidemic prevention and environmental risks.

3. Suggestions for Improving Sanmenxia's Capacity for Hazardous Waste Disposal, Utilization, and Supervision

3.1 Addressing the Limitations of Hazardous Waste Collection, Treatment, and Disposal Facilities

Promote the optimization and upgrading of hazardous waste (including medical waste) utilization and disposal facilities. To effectively manage waste, it is crucial to upgrade and transform existing disposal facilities promptly. Additionally, it is important to carefully select incineration facilities that can adapt to various types of waste for new and expanded facilities.

This will help reduce the amount of hazardous waste that is directly sent to landfills. Furthermore, it is necessary to standardize the development of cement kilns and industrial kilns for collaborative disposal, to eliminate any market or institutional obstacles. Lastly, it is essential to promote the growth of the disposal industry on a large scale, increase industry concentration, and foster the emergence of industry leaders.

Gradually establish a system for recycling hazardous waste from various social sources. Establish a recycling network for hazardous waste from various social sources, including waste lead batteries and waste mineral oil. This network will collect and treat hazardous wastes found in domestic garbage, such as waste fluorescent tubes, waste nickel-cadmium batteries, and electronic hazardous wastes. These wastes are generated in daily life or activities that provide services for daily life.

3.2 Improve the Organization and Institutional Structure of Hazardous Waste Management

Strengthen the establishment of regulatory agencies and teams for hazardous waste management. Strengthen the construction of Sanmenxia's capacity for supervising hazardous waste and supporting emergency disposal technology. Enhance the capacity of the comprehensive law enforcement team for the daily management of hazardous waste and ecological environmental protection. Equip and strengthen the grassroots management personnel. Effectively enhance the capacity for supervising hazardous waste environmental risks and implementing prevention and control measures [16].

Strengthen the supervision of hazardous waste management. According to the national and provincial guidelines and policies for hazardous waste management [27], it is important to establish and enhance a joint prevention and control mechanism for environmental risks associated with hazardous waste in Sanmenxia City [16]. This will effectively strengthen coordination and communication between departments, promote information sharing, and foster collaborative efforts to build a robust safety barrier for hazardous waste.

Consolidate the primary responsibilities of the enterprise. The primary person responsible for preventing and controlling hazardous waste pollution and ensuring safety in production is the individual in charge of hazardous waste production, collection, storage, transportation, utilization, and disposal enterprises [16]. Urge them to strictly implement laws and regulations regarding the prevention and control of hazardous waste pollution and safety production. They should fulfill legal obligations, such as timely disclosing information on hazardous waste pollution prevention and control, and purchasing environmental pollution liability insurance in accordance with laws and regulations.

Enhance the emergency response capability in hazardous waste environments. Establish cooperation mechanisms with emergency management departments to combat the illegal transfer and disposal of hazardous waste, particularly hazardous chemicals. This includes investigating pollution incidents, cracking down on illegal dens, and identifying safety production hazards. Strengthen the establishment of emergency response management teams and expert teams in environmental emergencies, and enhance the rapid response capabilities for joint handling of sudden hazardous waste pollution accidents[28]. Integrate hazardous waste utilization and disposal enterprises into the emergency response system for unexpected environmental incidents [29].

Comprehensively enhance the three capabilities of hazardous waste. Establish and improve a hazardous waste environmental supervision system with strict prevention at the source, strict management of the process, and severe punishment for consequences [30]; Coordinate the construction of hazardous waste disposal capacity, improve the hazardous waste utilization and disposal capacity, achieve the overall balance between the hazardous waste utilization and disposal capacity of Sanmenxia City and the actual needs, and make the layout more reasonable; The ability to prevent environmental risks of hazardous waste has significantly improved, and the high incidence of illegal transfer and dumping of hazardous waste has been effectively curbed [14].

Seriously implement standardized environmental management assessments for hazardous waste. Strengthen the standardized environmental management of hazardous waste by establishing reasonable evaluation indicators. Emphasize the evaluation of key regulatory units for hazardous waste environment based on factors such as hazardous characteristics, production quantity, and environmental risks associated with hazardous waste. Verify the current status of environmental management of hazardous waste in other units through evaluation [31].

3.3 Building a Market System and Incentive Mechanisms

Establish a credit system and assessment mechanism for enterprises involved in the generation, disposal, and utilization of hazardous waste. Conduct an assessment of the production, utilization, and disposal capacity of hazardous waste, as well as the operation of facilities [32]. Implement a robust punishment mechanism, such as a blacklist system, and establish effective assessment management. To achieve a reduction in waste production, it is important to implement measures such as technological upgrades and the transformation of waste-producing enterprises at the source. Additionally, it is crucial to develop comprehensive regulations for rewards and subsidies and to implement a tiered system for rewarding and subsidizing hazardous waste generation, disposal, and utilization enterprises. Furthermore, stricter penalties should be imposed on units that fail assessments, engage in dishonest practices, or fail to perform as expected.

Actively promote green credit and develop green finance. Promote the integration of hazardous waste centralized disposal facilities into the construction of local public infrastructure by local governments. Additionally, policy guarantees should be provided in terms of taxation, capital investment, and construction land for the centralized incineration and landfill disposal of hazardous waste. Promote technological upgrades to enhance the capacity for medical waste disposal in each region. They will enhance market competitiveness by introducing new medical waste disposal enterprises. Additionally, local enterprises should be encouraged to actively engage in internal self-utilization of waste production, and investments in hazardous waste comprehensive utilization projects should be attracted.

3.4 Technical Innovation and Operation Guarantee Supervision

Standardize the collaborative disposal of cement kilns and industrial kilns. Moderate development of collaborative cement kiln disposal projects for hazardous waste serves as a beneficial supplement to the capacity for utilizing and disposing of hazardous waste. Cement kilns that can effectively facilitate the collaborative disposal of hazardous waste may be

exempted from implementing emission reduction measures during periods of heavy pollution weather warnings, based on their actual disposal capacity. Support the research and development of technology for the collaborative disposal of hazardous waste in industrial furnace kilns and rely on qualified enterprises to conduct pilot projects for this disposal method[14]. Additionally, promote the construction of medical waste disposal facilities. Strengthen cooperation with the health department to ensure a balanced local capacity for medical waste disposal that aligns with the amount of medical waste generated. Devise a plan for the establishment of centralized medical waste disposal facilities. Encourage the establishment of mobile medical waste disposal facilities [33], enhance emergency disposal capabilities for medical waste, and provide on-site disposal services for remote grassroots units.

Strengthen technological support for the prevention and control of hazardous waste pollution. Establish regional laboratories for hazardous waste and chemical testing and analysis [16]. Additionally, develop environmental risk assessment and pollution control technology laboratories, and enhance basic research on hazardous waste environmental risk assessment and pollution control technology [14]. Encourage the research, development, application, demonstration, and promotion of pollution prevention, utilization, and disposal technologies [16,34] for difficult-to-treat hazardous wastes such as waste acid, waste salt, domestic incineration fly ash, and others. Conduct a survey of hazardous waste in key industries and develop policies and standards to support pollution prevention and control of hazardous waste in different stages and categories of key industries.

3.5 Implement Energy-Saving and Carbon-Reduction Measures

Fully control carbon emissions and enhance the recycling of carbon resources. Unbalanced and insufficient carbon reduction is the primary issue related to enterprise construction. More waste heat recycling and power generation facilities should be added to enhance energy recycling and reduce carbon emissions. Additionally, rooftop photovoltaics should be installed to accelerate the large-scale development of new energy and further contribute to carbon reduction benefits.

Promote the innovation and application of energy-saving and carbon-reduction technologies in enterprises. Vigorously promoting energy conservation and carbon reduction work is an important strategy to enhance the technological capabilities of enterprises, improve their economic performance, and fulfill their social responsibilities. Adjusting the economic structure of enterprises, reforming their economic growth mode, and promoting technological progress are all important measures to promote energy conservation and carbon reduction [35]. Vigorously promote technological innovation, continuously carry out process technology reform, encourage the transformation of existing production facilities and processes, and strongly emphasize the importance of technological innovation for the production facilities and processes of the proposed project [35]. Provide economic incentives to businesses or parks that achieve significant energy-saving and carbon reduction results.

3.6 Strengthen the Supervision and Enforcement of Hazardous Waste Laws

Strengthen daily supervision and establish a multi-departmental joint supervision and enforcement mechanism. Incorporate daily environmental monitoring of hazardous wastes

into the "double random, public" content of ecological and environmental law enforcement [36], and enhance the investigation and punishment of environmental violations related to hazardous wastes [37]. Include illegal enterprises in the field of ecological environmental protection in the list of illegal and untrustworthy entities [38], and implement collaborative disciplinary measures. Enterprises that conduct self-investigation, take corrective measures, and promptly dispose of their historical hazardous waste, will receive less severe punishment by the law [39].

Strictly implement the assessment requirements for the standardized management of hazardous waste [40]. Incorporate standardized environmental management of hazardous wastes into the indicator system for assessing the environmental protection performance of Sanmenxia City [41], and enhance supervision during and after the event. Strengthen the prevention and risk control of soil and groundwater pollution in hazardous waste utilization and disposal enterprises. Implementing a compensation system for ecological and environmental damage [42] effectively curbs the high incidence of illegal transfer and dumping of hazardous waste cases [14].

3.7 Improving the Information Technology Supervision System for Hazardous Waste

Build a smart information management platform. Relying on the national solid waste information management platform, we will enhance the management network for hazardous waste information in the city. This will cover the generation and operation of hazardous waste, with a focus on the three key stages of "production, transfer, and disposal." Our objective is to accomplish the online declaration of hazardous waste generation, online filing of management plans, online processing of transfer documents, online reporting of utilization and disposal status, and online monitoring of the entire process. We aim to strengthen the entire process of tracking and managing hazardous waste and achieve interoperability and sharing with relevant administrative and judicial authorities [43]. We will promote the development of a convenient and efficient hazardous waste information management system through various methods, including information monitoring, data scanning, onboard satellite positioning systems, and electronic locks. Our objective is to establish a process traceability system that integrates real-time monitoring, business flow, data sharing, pre-warning, and scientific decision-making. and achieve the goal of establishing a unified network for supervising hazardous waste information, thereby enhancing the level of hazardous waste management in the city.

Improve the level of supervision of information technology in managing medical waste. Establish a medical waste management and monitoring system to achieve real-time monitoring of the entire process of medical waste disposal in medical and health institutions at the municipal level 2 or above. This includes blood collection and supply institutions, as well as disease control institutions. This should be done in stages and batches to enhance the level of supervision of information technology in medical waste management and prevent illegal and irregular practices in medical waste disposal from the source.

3.8 Strengthen Public Awareness, Education, and Training on the Prevention and Control of Hazardous Waste

Strengthen training on environmental management of hazardous waste. Implement talent development projects to enhance the cultivation and training of professionals in hazardous

waste management[44]. Additionally, organize various forms of business training related to hazardous waste management every year to improve the effectiveness of the training.

Create a positive public opinion atmosphere. Increase publicity on the investigation and handling of major environmental cases involving hazardous waste to create a strong deterrent [45]. Promote public awareness of the opening of hazardous waste utilization and disposal facilities, protect the public's right to information and oversight, and cultivate positive public opinion and guidance.

4. Conclusion and Suggestions

Based on the research and assessment of hazardous waste generation, utilization, and disposal in Sanmenxia City, this study aims to address the comprehensive assessment and capacity enhancement needs of hazardous waste generation, utilization, and disposal facilities in Sanmenxia. Specific research content includes the technical requirements for the generation, utilization, treatment, and disposal of hazardous waste, the safety management, and assessment method system for hazardous waste disposal, and suggestions for improving the disposal, utilization, and regulatory capacity of hazardous waste in Sanmenxia City.

Considering the complexity of the technical and management support system for evaluating and improving hazardous waste generation, utilization, and disposal facilities, there is still a significant amount of work to be done to establish and enhance the comprehensive evaluation and capacity improvement of these facilities in Sanmenxia. Only through the research conducted in this project can we solve all the problems we face. Therefore, it is recommended to further promote the development of related work during the process of comprehensive evaluation and capacity improvement of facilities. This will allow for further improvement on the existing foundation, ensuring alignment with the development needs of the present time.

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