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Manifest system for management of non-hazardous industrial solid wastes: results from a Tianjin industrial park

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ABSTRACT

Industrial parks pose a significant challenge in industrial solid waste management (ISWM) due to the large quantity of waste they generate. The manifest system, a tool currently used mainly for the management and tracking of hazardous waste, has been employed in a pilot project on non-hazardous industrial solid waste (NHISW) in the Tianjin Economic-Technological Development Area (TEDA). This paper focuses on the implementation of a non-hazardous industrial solid waste manifest system (NHISWMS) in TEDA, which aims to track the NHISW transfer path, and accurately acquire detailed information on each specific company. Using a total of 1456 manifests from 25 tenant companies over one year of research, this paper analyzes the information generated on waste generation, transfer and disposal. The results show that more than 50% of NHISW leaves TEDA but remains in Tianjin province, and more than 65% of NHISW is utilized or disposed by only one waste receiver. The research concludes that the manifest is an effective instrument for analyzing NHISW characteristics and identifying connections between waste handlers in order to establish a waste recycling industry chain. The experiences and methods from this case study are highly applicable to other industrial parks seeking to improve their waste management.

1. Introduction

Industrial parks have prospered as centers for new regional economic development in China. Owing to the centralization of industry in these parks, they consume an enormous amount of resources and generate a large amount of solid waste. Therefore, industrial solid waste management (ISWM) has become crucial to industrial park managers. There are many classifications for industrial solid waste, including hazardous and non-hazardous. Most countries implement the Hazardous Waste Manifest System as a common practice of environmental management, as it permits the tracking and analysis of the generation, transfer, storage, and disposal of potentially dangerous waste materials.

Developed countries, such as the US and Japan, were the first to implement the Hazardous Waste Manifest System. The US Congress passed the Resource Conservation and Recovery Act (RCRA) in 1976 to govern the disposal of solid and hazardous waste. The US EPA revised the Uniform Hazardous Waste Manifest in 2005. The current US hazardous waste manifest system is a set of forms, reports, and procedures designed to seamlessly track hazardous waste from the time it leaves the generator facility until it reaches the off-site waste management facility that will store, treat, or dispose of the hazardous waste (US EPA, 2015). Japan implements a similar procedure in its industrial solid waste management practices: the control manifest of industrial waste. This indicates the type of industrial waste, its quantity, the name of the party commissioned to transport or dispose of the waste, and other matters specified by the Ordinance of the Ministry of the Environment (MOE, 1970). Furthermore, Brazil uses a checklist system to ensure compliance with legal requirement on medical waste management (Moreira and Günther, 2013).

China began to implement its Hazardous Waste Manifest System in 1999, and has so far achieved a good result. The waste manifest system applies to hazardous waste but not to non-hazardous waste (Shen, 2005). However, handling of non-hazardous industrial solid waste (NHISW) also involves many

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problems. First, basic information on NHISW is lacking. Second, the government cannot track the generation, transfer, storage, and disposal of NHISW. Third, NHISW also exerts influence on the environment, through practices such as discarding or open burning of waste, leakage and dust during the transfer process, generation of waste water, waste gas and dust pollution during the storage process, and the absence of pollution prevention and control measures leading to the generation of waste water, waste gas and new solid waste (Wang and Tian, 2012).

As of the end of 2014, there are more than 400 national industrial parks in China. A large proportion of the national NHISW generation stems from these parks. The Environmental Protection Agency (EPA) of the industrial park is usually responsible for waste management within the park, and the departments of industrial and urban construction also have responsibility within the scope of their duties. They both have established corresponding management systems and institutions (Zhong et al., 2013). However, there is yet no effective procedure for NHISW management. Therefore, an appropriate and effective method of NHISW management is crucial to industrial park managers, and research on this topic is of key importance.

This paper describes the implementation of a non-hazardous industrial solid waste manifest system (NHISWMS) in Tianjin Economic-Technological Development Area (TEDA), and analyzes information on waste generation, transfer and disposal, using a total of 1456 manifests from 25 tenant companies over one year of research. A descriptive analysis of these manifests reveals the current situation of non-hazardous industrial solid waste in TEDA. The results of the analysis prove that an NHISWMS is a potent instrument to identify the characteristics of non-hazardous industrial solid waste (NHISW) and the interdependencies of companies in the industrial park. It can provide data and information support to implement reduction, reuse and recycling of waste at the whole industrial park level. The outcome of the research from this case study can be applied in NHISW monitoring and management at other industrial parks.

2. Literature review

As economic development progresses, the quantity of solid waste increases rapidly. It is well known that waste generation and management issues have increasing impact on the socio-economics, human health, and amenities of many communities, states and nations around the world (Meyers et al., 2006), with a greater impact in the US due to its sheer volume and nature of discards (Louis, 2004). Solid waste management (SWM) has been and will continue to be a major issue facing countries worldwide.

Many developed countries are taking the lead in focusing on solid waste management, pointing out problems, and seeking the methods and tools to solve them. A plethora of models developed to explain SWM, like 3Rs (reduce, reuse, recycle), cradle-to-grave (the management of the whole life cycle of products) and integrated waste management, are adding new dimensions for solving waste problems and achieving sustainable resource usage (Kollikkathara et al., 2009). Zamorano et al. (2011) point out that significant weaknesses of waste management in industrial areas are the lack of effective waste management tools and training for waste management personnel. Pires et al. (2011) conclude that considering systems analysis models and tools in a synergistic way would provide opportunities to develop better solid waste management strategies. Zurbrügg et al. (2012) describe an integrated assessment method to assess typical success or failure factors of solid waste projects, including social, institutional and economic elements. Karmperis et al. (2013) survey decision support models that are commonly used in the solid waste management area, finding that most models are developed utilizing the frameworks of lifecycle assessment, cost-benefit analysis and multi-criteria decision-making. Lohri et al. (2014) perform a cost-revenue analysis of solid waste management services and conclude that ensuring financial sustainability is a major challenge.

In recent years, more and more developing countries are beginning to take account of SWM. First, the health and environmental issues associated with ISW are mounting in urgency, particularly in the context of developing countries (Marshall and Farahbakhsh, 2013). Second, resource recovery has considerable potential for improving ISWM, especially in developing countries, since most ISW components are reusable or recyclable (Mbuligwe and Kaseva, 2006). Third, proper SWM has benefits such as increased revenues for municipal bodies, higher productivity rates, improved sanitation standards, and better health conditions (Kofoworola, 2007). Some research even reveals that moving towards ISWM offers a practical solution for mitigating greenhouse gas (GHG) emissions and for realizing socio-economic as well as other environmental benefits (Menikpura et al., 2013).

ISWM warrants particular attention, as China, the world's largest developing country, has become the largest ISW generator in the world and the total amount of ISW it produces continues to increase (Chen et al., 2010). Guerrero et al. (2013) point out that even though a large number of studies have been undertaken to determine influential factors affecting waste management systems in cities, few provided quantitative information. To achieve sustainable SWM, much progress needs to be made in national policy and legal frameworks, institutional arrangements, appropriate technology, operational and financial management, and public awareness and participation (Shekdar, 2009). Marshall and Farahbakhsh (2013) also point out that urbanization, inequality and economic growth, cultural and socio-economic aspects, policy, governance and institutional issues and international influences have all complicated SWM in developing countries. These have limited the applicability of approaches that were successful in the SWM development trajectories of industrialized countries.

Since its establishment in 1984, Tianjin Economic-Technological Development Area (TEDA) ranks as the top national economic-technological development area among industrial parks. In recent years, a growing body of literature examining TEDA has arisen. Many scholars have discussed the process of eco-industrial park development. Shi and Yu (2014) examine the evolutionary process of the TEDA eco-industrial park, and uncover four factors key to its transition: technological trajectory dependency, spaces for experimentation, government as an enabler, and regional embeddedness. Yu et al. (2014) point out TEDA's eco-transformation is a typical government-driven model in China where planning comes first, accompanied by other supporting policies. In addition, many models have been formulated to explain the industrial symbiosis of TEDA. Shi et al. (2010) reveal 81 inter-firm symbiotic relationships formed in TEDA, involving the utility, automobile, electronics, biotechnology, food and beverage and recovery clusters. Tang et al. (2014) examine the organizational and network structure of a typical eco-industrial park (TEDA) by social network analysis.

Solid waste management is one of TEDA's priority issues, as it relates to the protection of the environment and conservation of natural resources. With the rapid development of industrial parks (IPs), where most manufacturers are located, most ISW throughout the world in recent years has been generated by these parks. A solid waste survey conducted by a research team from Dalian University of Technology shows that the total amount of solid waste produced in TEDA in 2003 was 132,000 tons, including 99,800 tons of industrial waste and 32,000 tons of municipal waste (Zhu and Zhao, 2004). Geng et al. (2007) describe how to plan and apply an integrated solid waste management system at TEDA, and identify the