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ASSESSING THE CURRENT STATUS AND PROPOSING THE SOLUTIONS FOR HAZARDOUS WASTE MANAGEMENT AT INDUSTRIAL PARKS IN CHON THANH DISTRICT, BINH PHUOC PROVINCE

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ABSTRACT

This study assesses the current status and proposes solutions for hazardous waste management in industrial parks in Chon Thanh district, Binh Phuoc province. Surveys were conducted across 32 enterprises in three major industrial parks. Industrial parks and their revelant acitities were surveyed, evaluated and analyzed. The findings reveal a high volume of hazardous waste, especially sludge, with Minh Hung – Korea industrial park being the largest contributor. The amount of hazardous waste from operating companies has increased frequently year by year. Although most enterprises complied with basic regulations, issues remain in waste source registration, temporary storage standards, and coordination with waste treatment providers. The study proposes detailed solutions including sludge classification under QCVN 50:2013/BTNMT, enhanced database integration, stricter source-based management, and targeted training for environmental officers.

Keywords: Hazardous waste, industrial park, management, Binh Phuoc

1. INTRODUCTION

Located in the Southern key economic zone, bordering Binh Duong province in the South, being the transit center of goods between the Southeast and Central Highlands regions, Binh Phuoc province is in the process of promoting industrial development and concentrated population. The economic development process in the locality is associated with the formation of large industrial zones, at the same time attracting many domestic and foreign enterprises to invest. Along with the economic

development process is the increase, negative impacts on the environment, the amount of waste generated is increasing, diverse and complex. Especially hazardous waste generated from industrial activities.

World Bank, 2018, assessed the management of industrial (hazardous) waste including the following types of waste and in the following provinces: Mining waste in Thai Nguyen and Bac Kan; Sludge from large wastewater treatment plants; Waste from large industries in Binh Thuan province. The results evaluated the inventorying, identifying treatment options and policies for specific industrial (hazardous) waste streams in the study, identifying key challenges, and proposing actions to address those challenges [1, 2]. According to EPA, 2019, hazardous waste management guidelines for businesses are based on the amount of hazardous waste generated each month: very small (less than 100 kg/month), small (from 100 - 1000 kg/month) and large (over 1000 kg/month). Identify hazardous waste from the classification of waste sources and requirements for those waste sources [3].

With the rapid development of current industries, the use of raw materials and chemicals in the production process is increasingly diverse, many types have led to the emission of hazardous waste into the environment [4] and public health [5]. Along with the development of industrialization and modernization, industrial parks generated a large amount of solid waste including: domestic waste, industrial waste, medical waste, agricultural waste, construction waste... in which there is a significant amount of hazardous waste that has been and is causing environmental pollution and human health [5, 7]. The release of hazardous waste into the environment not only cause serious effects but also violate the the Law of Environmental Protection [8]. Therefore, one of the urgent issues of environmental protection in our country in particular and the world in general today is waste management, especially hazardous waste [9]. Nguyen Thi Thu, 2014, assessed the current status of hazardous waste management in Song Khe - Noi Hoang industrial park, Bac Giang province through a survey of 19 enterprises on the volume of hazardous waste generated, management measures, the status of registering hazardous waste source owners, and making annual periodic reports [10]. Pham Thi Thanh Thuy, 2016, clarifies basic theoretical issues on hazardous waste management laws in industrial zones in Vietnam. Research results showed the current status of the legal system on hazardous waste management in industrial zones [11]. Therefore, the research "**Assessing the current status and proposing solutions for hazardous waste management for Industrial Parks in Chon Thanh district, Binh Phuoc province**" was conducted to solve the current urgent problem and contribute to environmental management for the sustainable development of industrial parks in the key southern region.

2. MATERIALS AND METHODS

2.1. Data collection

Relevant data and documents regarding Chon Thanh I, Becamex – Binh Phuoc, and Minh Hung – Korea industrial parks were collected, including: general information about the industrial parks, geographical location, types of industries attracting investment, and the annual volume of hazardous waste generated.

Documents related to the natural, economic, and social characteristics of Binh Phuoc province, legal documents on hazardous waste management, relevant literature on hazardous waste, and practical experiences from both Vietnam and other countries were also gathered.

2.2. Survey and investigation

Surveys were conducted using questionnaires with the following main contents: For industrial park developers, information on the number of operating enterprises in the industrial parks (Chon Thanh I, Becamex – Binh Phuoc, Minh Hung – Korea), types of secondary industries, and current status of hazardous waste management; For secondary enterprises in the parks, information on the type of production, production capacity, input raw materials and chemicals, current status, volume, and type of hazardous waste generated, as well as methods of collection and treatment.

The number of survey samples were calculated based on the Yamane's formula with an allowable error of 15%. Random sampling was conducted. The questionnaires were distributed among representative industries in each industrial park. There are 88 enterprises currently operating across the three industrial parks, including: (1) Chon Thanh I industrial park: 19 enterprises, 10 surveyed. Main industries: wood processing, metal/plastic packaging production, wood pellet manufacturing, rubber glove production, shoe sole manufacturing, and textile weaving; (2) Becamex – Binh Phuoc industrial park: 15 enterprises, 9 surveyed. Main industries: egg incubation, food processing, animal feed production, VRLA (valve regulated lead-acid) battery manufacturing, fishing rod components production, and fiberglass/carbon fiber product processing; (3) Minh Hung – Korea industrial park: 54 enterprises, 13 surveyed. Main industries: textile dyeing and garment manufacturing, rubber-covered thread and elastic band production, detergent and fabric softener production, rope and fishing net manufacturing, septic tank and oil tank manufacturing, and automobile horn plating and support production. A total of 32 questionnaires were used in this study.

2.3. Statistical methods

Survey data were compiled to create a summary table of hazardous waste generation from the surveyed enterprises in each industrial park. Data were categorized by type and volume of hazardous waste generated annually by each enterprise, allowing calculation of total hazardous waste volume per year and breakdowns by type for each company.

2.4. Data processing and analysis methods

Collected data were entered into Excel, including both textual and numerical data for processing. Data on hazardous waste generation, storage, and treatment volumes were compiled into tables and diagrams for analysis. This facilitated an evaluation of achievements and existing issues in hazardous waste management.

Based on the results, comparisons were made among industrial parks in terms of investment sectors, number of operating enterprises, quantity and types of hazardous waste generated, and waste management practices. Hazardous waste management effectiveness was compared using enterprise counts (per industrial park) and by evaluating companies' compliance with key management activities.

3. RESULTS AND DISCUSSION

3.1. Current status of industrial park operations

At Chon Thanh I industrial park, a total of 32 enterprises have invested in the park, of which 19 are currently operational. These businesses are involved in sectors such as: wood processing; production of metal and plastic packaging; cutting, printing on metal packaging; production of rubber gloves and finger cots; footwear manufacturing; medical cotton production; water pump manufacturing; plastic packaging production; agricultural product storage; steel rolling; honey processing; and cement production.

At Becamex – Binh Phuoc industrial park, around 30 investors have been attracted. Investment sectors mainly include food processing, animal feed production, battery production, fishing rod and reel manufacturing, and carbon/fiberglass product manufacturing. However, only 15 enterprises are currently operational, while the rest are either under construction or yet to begin implementation.

At Minh Hung – Korea industrial park, 54 enterprises are currently operational. Their sectors include: textile dyeing and garment manufacturing; production of electronic components and audio equipment; steel rolling; and other diverse industries.

3.2. Current status of hazardous waste generation and management in industrial parks

The composition of hazardous waste (HW) is diverse, including 35 types corresponding to different waste codes. Most of the hazardous waste is solid, some in liquid and sludge (Table 3.1).

Table 3.1. List of hazardous waste in industrial parks

No.	Name of Hazardous Waste	Physical State	HW Code
1	Wastewater containing lead	Liquid	02 03 03
2	Used absorbents (activated carbon)	Solid	03 01 07
3	Waste absorbents	Solid	03 02 07
4	Slag containing hazardous components (waste lead slag)	Solid	05 03 01
5	Waste aqueous cleaning solutions containing hazardous components	Liquid	07 01 06
6	Weaving needles	Solid	07 03 11
7	Waste ink cartridges containing hazardous components	Solid	08 02 04
8	Waste adhesives containing organic solvents	Liquid	08 03 01
9	Waste leather with hazardous components from tanning and related processes	Solid	10 01 02
10	Waste dyes	Solid	10 02 02
11	Syringe	Solid	13 02 01
12	Non-sharp medical waste	Solid	13 01 01
13	Waste fluorescent lamps and other active glass types	Solid	16 01 06
14	Waste Electronic Equipment	Solid	16 01 13
15	Waste synthetic hydraulic oil	Liquid	17 01 06
16	Waste synthetic engine, gearbox, and lubricating oils	Liquid	17 02 03
17	Heat transfer oil	Liquid	17 03 04
18	Waste soft packaging	Solid	18 01 01
19	Waste hard packaging made of metal	Solid	18 01 02
20	Waste hard packaging made of plastic	Solid	18 01 03

21	Waste rags and protective cloths containing hazardous components	Solid	18 02 01
22	Waste batteries, lead-acid batteries	Solid	19 06 01
23	Types of waste containing hazardous inorganic components	Solid	19 12 01
24	Chemical waste	Liquid	19 05 04
25	Waste water containing hazardouse components	Liquid	19 10 01
26	Waste sludge	Sludge	02 05 01
27	Waste sludge	Sludge	03 02 08
28	Waste sludge	Sludge	03 06 08
29	Waste sludge	Sludge	07 01 05
30	Waste sludge	Sludge	10 02 03
31	Waste sludge	Sludge	12 06 05
32	Waste sludge	Sludge	12 06 06
33	Waste solvents	Liquid	08 01 05
34	Waste ink containing hazardous components	Liquid	08 02 01
35	Waste toner cartridge	Solid	08 02 04

In Chon Thanh I, large volumes of hazardous waste are mainly generated by industries such as: metal packaging production; woven fabric production; plastic packaging manufacturing; footwear sole production; composite wood processing for construction; interior wooden furniture manufacturing; production of metal pump components; and rubber finger cot production. Survey results showed that most companies submitted regular hazardous waste reports, classified the waste, had proper storage facilities in compliance with regulations, and signed contracts with licensed collectors and treatment units.

In Becamex – Binh Phuoc, large volumes of hazardous waste are mainly generated from: VRLA battery manufacturing; processing carbon fiber products and fiberglass; and associated industries. The largest volume of hazardous waste came from Leoch Super Power (Vietnam) Co., Ltd., producing VRLA batteries with a capacity of 786,240 kWh/year for small-sized batteries and 336,960 kWh/year for medium and large ones. The company began operations in 2019, generating mainly hazardous slag (lead slag), with 52,549 kg/year in 2019 and increasing to 72,650 kg/year in 2020. Most companies here also regularly report hazardous waste, classify it, store it properly, and contract with authorized units for collection and treatment.

In Minh Hung – Korea, large volumes of hazardous waste are generated by: manufacturing automotive supports and horn plating; producing septic and oil tanks; manufacturing ropes, belts, fishing nets; and textile dyeing and garment production. The largest amount of waste was generated by Gwang Sung Vina Co., Ltd., including fluorescent lamps, oil-contaminated rags, and most notably, sludge from wastewater treatment systems. Survey results showed most companies classified, reported, and stored hazardous waste properly and signed contracts with licensed service providers. Ten out of 13 surveyed companies had registered hazardous waste source books with the Department of Natural Resources and Environment. The remaining three (Suwoo Chemicals, Nantong Xinfei, and Jiawei Co., Ltd.) had not registered.

3.3. Evaluation of hazardous waste generation and management in industrial parks

Table 3.2. Average daily solid waste generation by enterprises in 2020:

No.	Industrial Park	Domestic Waste (kg/day)	Non-hazardous Industrial Waste (kg/day)	Hazardous Waste (kg/day)
1	Minh Hung – Korea	6,124.67	33,856.98	2,466.04
2	Chon Thanh I	1,524.54	11,507.79	888.8
3	Becamex – Binh Phuoc	1,057.63	428.38	2,569.86
	Total	**8,706.84**	**45,793.15**	**5,924.7**

According to the 2020 report from the Binh Phuoc Economic Zone Authority, Minh Hung – Korea had the highest daily volume of total solid waste due to its large number of operational enterprises (54), compared to the other two parks (Table 3.2).

Regarding hazardous waste, Becamex – Binh Phuoc and Minh Hung – Korea generated significantly more than Chon Thanh I (Table 3.3). This was mainly because Becamex has fewer enterprises but includes two battery producers (Leoch Super Power and Leoch Battery), while Minh Hung - Korea has the largest number of operational enterprises.

Table 3.3. Total hazardous waste by year (kg):

No.	Industrial Park	2018	2019	2020
1	Chon Thanh I	47,790.5	66,453	87,574
2	Becamex – Binh Phuoc	18,049	117,195	202,391.5
3	Minh Hung – Korea	1,266,758.4	1,168,817.4	1,021,473
	Total	**1,332,597.9**	**1,352,465.4**	**1,311,438.5**

All enterprises collected 100% of their regular industrial waste. Only some wood processing companies reused it; the rest sold recyclable waste to collection units. No waste was reported to be landfilled. All facilities generating hazardous waste are managing it per legal regulations [12]. The storage and container of hazardous waste were installed, but somehow they did not meet the environmental requirement (Figure 1).

Figure 1. The storage and container of hazardous waste in enterprises.

Most enterprises with waste source books complied with hazardous waste storage regulations (e.g., waterproof roofing, raised flooring, warning signs, separate containers for different types of waste like oil rags, fluorescent bulbs, batteries, etc.). However, foreign companies were generally more compliant than domestic ones, particularly in reporting and investing in treatment systems. Few companies had designated environmental officers with proper qualifications. Environmental responsibilities were often assigned to staff without expertise, leading to poor awareness of hazardous waste management regulations [13]. The illegal release of hazardous waste into the environment may cause the seriouse problem for human health [14] and future sustainablility for next generations [15].

There was a support relationship between enterprises, industrial park developers, and state management agencies. Waste generators (enterprises and developers) are responsible for registering their waste sources with the Department of Natural Resources and Environment. However, most developers have not manage the hazardous waste of secondary enterprises, leading to incomplete registrations and inaccurate waste volume estimates. On-site waste sorting remains ineffective, and hazardous waste is still being traded as industrial scrap at many enterprises.

3.4. Proposed solutions

For hazardous sludge generated from wastewater treatment systems of enterprises and industrial park developers, which is currently collected and treated in large quantities, it is necessary to classify sludge according to QCVN 50:2013/BTNMT – National Technical Regulation on Hazardous Thresholds for Sludge from Wastewater Treatment Processes, to determine whether it qualifies as hazardous waste or ordinary waste. In cases where the sludge contains no hazardous components, it can be classified as ordinary sludge and potentially used as fertilizer.

Personnel responsible for hazardous waste management should be selected based on professional qualifications and a strong sense of responsibility. At the same time, they should be regularly provided with opportunities to learn and gain experience in management practices to improve the effectiveness of hazardous waste management.

Strengthen the oversight responsibilities of industrial park developers regarding hazardous waste management in secondary enterprises through specific measures: regular inspections of hazardous waste storage warehouses, monitoring the quantity of waste generated, and reviewing contracts with licensed hazardous waste collectors and treatment providers to ensure compliance.

Waste-generating enterprises must take responsibility for implementing resource and energy-saving solutions; using environmentally friendly materials, fuels, and renewable energy; applying cleaner production technologies and environmental control programs to minimize waste generation. Enterprises must update information in the national environmental database when transferring hazardous waste to a facility with appropriate environmental licenses.

CONCLUSION

Among the industrial parks surveyed in Chon Thanh District, Binh Phuoc Province, Becamex – Binh Phuoc Industrial Park has the largest area. However, as it has only recently begun operations and is currently attracting significant foreign investment, the number of operational enterprises remains low. In contrast, Minh Hung – Korea and Chon Thanh I Industrial Parks are almost fully occupied, with Minh Hung – Korea having the highest number of active enterprises at 54.

The volume of hazardous waste generated by enterprises in the industrial parks is significant. Among them, Becamex – Binh Phuoc and Minh Hung – Korea industrial parks have the highest hazardous waste output compared to Chon Thanh I: Becamex – Binh Phuoc Industrial Park generated 2,569.86 kg/day of hazardous waste in 2020, with the highest volume coming from Leoch Super Power Co., Ltd.; Minh Hung – Korea

Industrial Park generated 2,466.04 kg/day, with the highest volume from Gwang Sung Vina Co., Ltd.; Chon Thanh I Industrial Park generated 888.8 kg/day, with the highest amount from VN Chen Lain Metal Co., Ltd.

Most enterprises have carried out proper classification and collection of hazardous waste in designated storage areas in accordance with regulations and have signed contracts with licensed entities for transport and treatment. Both industrial park developers and enterprises manage hazardous waste based on legal documents and guidance from the Ministry of Natural Resources and Environment, the Provincial Department of Natural Resources and Environment, and the Economic Zone Management Board.

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ĐÁNH GIÁ HIỆN TRẠNG VÀ ĐỀ XUẤT GIẢI PHÁP QUẢN LÝ CHẤT THẢI NGUY HẠI TẠI CÁC KHU CÔNG NGHIỆP TRÊN HUYỆN CHƠN THÀNH, TỈNH BÌNH PHƯỚC

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TÓM TẮT

Nghiên cứu này đánh giá hiện trạng và đề xuất các giải pháp quản lý chất thải nguy hại tại các khu công nghiệp trên địa bàn huyện Chơn Thành, tỉnh Bình Phước. Khảo sát được thực hiện tại 32 doanh nghiệp thuộc ba khu công nghiệp lớn trong khu vực. Các khu công nghiệp và các hoạt động liên quan đã được khảo sát, đánh giá và phân tích. Kết quả cho thấy khối lượng chất thải nguy hại, đặc biệt là bùn thải, trong đó khu công nghiệp Minh Hưng - Hàn Quốc là khu vực phát sinh lớn nhất. Lượng chất thải nguy hại từ các doanh nghiệp hoạt động có xu hướng tăng đều qua từng năm. Mặc dù hầu hết các doanh nghiệp đã tuân thủ các quy định cơ bản, nhưng vẫn còn tồn tại một số vấn đề trong việc đăng ký nguồn thải, tiêu chuẩn lưu giữ tạm thời và phối hợp với các đơn vị xử lý chất thải. Nghiên cứu đề xuất các giải pháp chi tiết bao gồm phân loại bùn thải theo QCVN 50:2013/BTNMT, tăng cường tích hợp cơ sở dữ liệu, quản lý theo nguồn chặt chẽ hơn và đào tạo có mục tiêu cho cán bộ môi trường.

Từ khóa: Bình Phước, chất thải nguy hại, khu công nghiệp, quản lý.

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Lĩnh vực nghiên cứu: Hóa môi trường; Độc chất môi trường.