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TYPES, AMOUNTS AND EFFECTS OF INDUSTRIAL SOLID WASTES

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Keywords: Solid waste, hazardous waste, industrial solid waste, waste generation, waste management, environmental protection, waste category, environmental effect, water, air, soil, route, environment pollution

Contents

Summary

The industrial solid wastes have done harm to the environment and human health. The first step towards prevention and control of pollution of industrial solid wastes that the types, is a full understanding of amounts and effects. The intrinsic characteristics of industrial solid wastes include occupying land when stockpiling, dumping, disposing or storing, having large categories and quantity. In this chapter, solid wastes from mining industry, metallurgical industry, power industry, chemical industry, oil chemical industry, and light industry are introduced and the waste generation coefficient in these industries also summarized. The environment effects, including natural environment, atmospheric environment, water environment, and soil environment, of industrial solid wastes are introduced briefly.

1. Introduction

Industrial solid waste refers to solid waste generated in production activities such as industry, traffic, and resource development. They include solid wastes, semi-solid wastes, and liquid and gaseous wastes in vessels that are not permitted to discharge into the environment. Industrial solid wastes are classified into organic wastes and inorganic wastes based on their components; into solid wastes, semi-solid wastes and liquid (gaseous) wastes based on their species; into hazardous wastes and common wastes based on pollution characteristics. Because many industrial solid wastes hold hazardous characteristics, they usually receive special attention.

Industrial solid waste pollution has become an increasingly serious problem in the world. The developing countries have to specially confront it. Every year, large quantities of

industrial solid wastes are generated from the growing industries. However, there are no adequate treatment and disposal facilities and qualified personnel in these developing countries. All these have seriously hindered the development of industries in these countries and done harm to the human being health and the environment.

During 1980s, much attention has been paid to the pollution control of industrial solid wastes. Significant progress has been made in establishing corresponding management and legislation systems, in developing treatment and disposal technologies, and in turning the research results into industrial practice. As a result, the serious situation of hazardous waste pollution has been alleviated in the developed countries although this situation has not completely changed. However, many problems in the management of industrial solid wastes need to be resolved in the developing countries.

2. Types of Industrial Solid Wastes

In general, industrial solid wastes are classified into the following major types:

(1) Solid wastes from the mining industry

This kind of waste includes waste stones generated during mining and tailings. Waste stones mean wall rocks peeled off from major ore during the mining of metal and non-metal mines. Tailings mean the residue slag after distilling refining mines during mill run.

(2) Industrial solid wastes from the metallurgical industry

This kind of waste includes varies of slag from the metallurgical procedure and processing of metals and non-metals. Some industrial solid wastes from the metallurgical industry are listed in Table 1.

Slag	Sources
Blast furnace slag	Generated in blast furnace iron smelting
Steel slag	Generated in steel smelting by level furnace, converter, and electric stove
Non-ferrous metal slag	Generated in smelting processing of the non-ferrous metals, such as copper, nickel, lead, and zinc
Red mud	Generated in abstracting aluminum oxide

Table 1: Industrial solid wastes from metallurgical industry

(3) Solid wastes from the power industry

This kind of waste includes coal fly ash, coal slag, and flue ash from power plants in which coals are used as fuel. It also includes gangue generated from coal excavating and coal-washing.

(4) Solid wastes from the chemical industry

This kind of wastes includes inferior products (semi-finished products), outgrowth, disabled catalysts, waste additives, raw materials that have not reacted, and impurity in raw materials discharged from chemical reaction during production processes, such as chemical combination, decomposition and synthesis. They also include wastes discharged from refining, separating, and washing procedures and from devices. Furthermore, they include the pyritic slag, acidic slag, alkali slag, salt mud, mud from kettle, residues of refining or distillation, pharmaceutical wastes, waste medicines from the producing and processing sectors in the chemical industry, and waste pesticides from medicine and insecticide production. In addition, they include dust from air pollution control facilities, sludge from wastewater treatment facilities, solid wastes from equipment examination and repairing, equipment scraps, vessels, and industrial refuses.

(5) Solid wastes from the oil chemical industry

This kind of wastes includes oil mud, tar shale slag, waste catalysts, and waste organic solvent in oil processing.

(6) Solid wastes from light industry

This kind of wastes includes sludge, animal residues, waste acid, waste alkali, and other wastes from the processing procedure in light industries, such as food industry, paper making and printing industry, spinning and dye-printing industry, and leather industry.

(7) Other industrial solid wastes

These kinds of waste mainly include metal dross from mechanical processing, plating sludge, construction wastes, and slag from processing in other industries.

In the USA, solid wastes means any garbage, refuse, sludge from a wastewater treatment plant, a water supply treatment plant, or an air pollution control facility; and other discarded materials including solid, liquid, semi-solid, or contained gaseous materials arising from industrial, commercial, mining, and agricultural operations, and from community activities; but does not include solid or dissolved materials in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under the Federal Water Pollution Control Act, as amended, or source, special nuclear, or by-product materials as defined by the Atomic Energy Act, as amended. Industrial and special wastes are primarily non-hazardous wastes generated by certain industries and households. Industrial solid wastes come from a broad spectrum of USA industries and are neither municipal nor hazardous wastes under federal and most state laws.

Some industrial solid wastes may be listed in the catalog of hazardous wastes or identified as holding hazardous properties based on the hazardous waste identification standards and identification method. In the USA, hazardous waste is defined by RCRA as a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may either cause, or significantly

contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed. This is a definition used widely. UNEP defined, in the working group meeting of the environmental management of hazardous wastes in December of 1985 that hazardous wastes indicate wastes in solid, sludge, liquid and gases in vessels, which held chemical reactivity, toxicity, explosibility, erosion, or other characteristics that can result in adverse effects to the human health and environment. These wastes are legally called hazardous wastes even if they are mixed with other wastes, have been generated, are in disposal, or are in transportation. UNEP lists 45 categories of wastes that should be controlled, and 2 categories that need to pay special consideration in Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their disposal (Table 2). At the same time, a list of hazardous characteristics is shown (Table 3). In China, hazardous wastes are divided into 47 categories according to the National Catalog of Hazardous Wastes. It includes the 45 categories in the Basle Convention, which are named as HW1 to HW45, and two more items, which are named as HW46 for nickel compound wastes and HW 46 for barium compound wastes.

Categories	Waste source and hazardous components
Y1	Clinical wastes from medical care in hospitals, medical centers and clinics
Y2	Wastes from the production and preparation of pharmaceutical products
Y3	Waste pharmaceuticals, drugs and medicines
Y4	Wastes from the production, formulation and use of biocides and phytopharmaceuticals
Y5	Wastes from the manufacture, formulation and use of wood preserving chemicals
Y6	Wastes from the production, formulation and use of organic solvents
Y7	Wastes from heat treatment and tempering operations containing cyanides
Y8	Waste mineral oils unfit for their originally intended use
Y9	Waste oils/water, hydrocarbons/water mixtures, emulsions
Y10	Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)
Y11	Waste tarry residues arising from refining, distillation and any pyrolytic treatment
Y12	Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish
Y13	Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives
Y14	Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known
Y15	Wastes of an explosive nature not subject to other legislation
Y16	Wastes from production, formulation and use of photographic

	chemicals and processing materials
Y17	Wastes resulting from surface treatment of metals and plastics
Y18	Residues arising from industrial waste disposal operations
Y19	Metal carbonyls
Y20	Beryllium; beryllium compounds
Y21	Hexavalent chromium compounds
Y22	Copper compounds
Y23	Zinc compounds
Y24	Arsenic; arsenic compounds
Y25	Selenium; selenium compounds
Y26	Cadmium; cadmium compounds
Y27	Antimony; antimony compounds
Y28	Tellurium; tellurium compounds
Y29	Mercury; mercury compounds
Y30	Thallium; thallium compounds
Y31	Lead; lead compounds
Y32	Inorganic fluorine compounds excluding calcium fluoride
Y33	Inorganic cyanides
Y34	Acidic solutions or acids in solid form
Y35	Basic solutions or bases in solid form
Y36	Asbestos (dust and fibers)
Y37	Organic phosphorus compounds
Y38	Organic cyanides
Y39	Phenols; phenol compounds including chlorophenols
Y40	Ethers
Y41	Halogenated organic solvents
Y42	Organic solvents excluding halogenated solvents
Y43	Any congenor of polychlorinated dibenzo-furan
Y44	Any congenor of polychlorinated dibenzo-p-dioxin
Y45	Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44)

* : Y1-18: Waste Streams

** : Y19-45: Wastes having as constituents

*** : Categories of wastes requiring special consideration includes: Y46 Wastes collected from households and Y47 Residues arising from the incineration of household wastes

Table 2: Categories of wastes to be controlled in Basel Convention

UN Class	**Code**	**Characteristics**
1	H1	Explosive An explosive substance or waste is a solid or liquid substance or waste (or mixture of substances or wastes) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such speed as to cause damage to the surroundings.

3	H3	Flammable liquids The word "flammable" has the same meaning as "inflammable." Flammable liquids are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc., but not including substances or wastes otherwise classified on account of their dangerous characteristics) which give off a flammable vapor at temperatures of not more than 60.5°C, closed-cup test, or not more than 65.6°C, open-cup test. (Since the results of open-cup tests and of closed-cup tests are not strictly comparable and even individual results by the same test are often variable, regulations varying from the above figures to make allowance for such differences would be within the spirit of this definition.)
4.1	H4.1	Flammable solids Solids, or waste solids, other than those classed as explosives, which under conditions encountered in transport are readily combustible, or may cause or contribute to fire through friction.
4.2	H4.2	Substances or wastes liable to spontaneous combustion Substances or wastes that are liable to spontaneous heating under normal conditions encountered in transport, or to heating up on contact with air, and being then liable to catch fire.
4.3	H4.3	Substances or wastes which, in contact with water emit flammable gases Substances or wastes those, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.
5.1	H5.1	Oxidizing Substances or wastes which, while in themselves not necessarily combustible, may, generally by yielding oxygen cause, or contribute to, the combustion of other materials.
5.2	H5.2	Organic Peroxides Organic substances or wastes that contain the bivalent-O-O-structure are thermally unstable substances that may undergo exothermic self-accelerating decomposition.
6.1	H6.1	Poisonous (Acute) Substances or wastes liable either to cause death or serious injury or to harm health if swallowed or inhaled or by skin contact.
6.2	H6.2	Infectious substances Substances or wastes containing viable microorganisms or their toxins that are known or suspected to cause disease in animals or humans.
8	H8	Corrosives Substances or wastes which, by chemical action, will cause severe damage when in contact with living tissue, or, in the

		case of leakage, will materially damage, or even destroy, other goods or the means of transport; they may also cause other hazards.
9	H10	Liberation of toxic gases in contact with air or water Substances or wastes those, by interaction with air or water, are liable to give off toxic gases in dangerous quantities.
9	H11	Toxic (Delayed or chronic) Substances or wastes which, if they are inhaled or ingested or if they penetrate the skin, may involve delayed or chronic effects, including carcinogenicity.
9	H12	Ecotoxic Substances or wastes which if released present or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon biotic systems.
9	H13	Capable, by any means, after disposal, of yielding another material, e.g., leachate, which possesses any of the characteristics listed above.

Table 3: List of Hazardous Characteristics (UN Class (2) Code Characteristics)

3. Amounts of Industrial Solid Wastes

3.1 Solid waste generation in some key industries

Solid waste generation in some key industries is introduced as followed.

3.1.1 Industrial solid wastes from the mining industry

For open mines, it is necessary to peel off the soil and rock above and around the mine body firstly in order to uncover the mine body for mining. For $1m^3$ of ore, 8-10 m^3 soil and rock will be peeled off. For $1m^3$ of aluminum soil ore, even 13-$16m^3$ of soil and rock will been peeled off (Table 4). In milling run of ores, 0.5-1.0 t tailings will be produced per ton of concentrated ores. In chemical mining, 0.6-1.1 ton tailings will generate for selecting 1t of sulfuric iron ore.

Types of mine body	Large-scale	Middle-scale	Small-scale
Iron mine, manganese mine, non-ferrous heavy metal mine	≤8-10	≤6-8	≤5-6
Limestone mine, dolomite mine, silica mine	≤1.5	≤1.5	≤1.0
Clay mine, bauxite	13-16		

Table 4: Economical and reasonable ratio for open mining (m3 waste /m3 ore)

3.1.2 Solid waste in metallurgical industry

In the processing of iron smelting, 300-900 kg of slag will be generated for 1t of pig iron. In the processing of steel smelting, 130-240 kg of steel slag will be generated for 1t of converter steel according to the common technology level. Moreover, 170-210 kg of steel slag will be generated for 1t of stove steel with initial slag accounting for 60%, refine smelting slag accounting for 10%, steel slag accounting for 30%. In addition, 150-200kg of steel slag will be generated for 1t of electric stove steel with oxide slag accounting for about 55%. In the process of iron alloy smelting, 1t of slag will be generated for 1t iron alloy by pyro-metallurgy. In the aluminum smelting industry, generally, 1-1.75 t of red mud will be generated for 1t of oxide aluminum if low quality ore is used (see Table 5). The dust and sludge from sintering and from iron and steel smelting procedures, steel rolling scraps from production procedures are called iron-contained dust and sludge. The generation of iron-contained dust and sludge is shown in Table 6.

Products (Procedure)	Unit	Waste name	Discharge of slag
Coke	Ton	Coal dust	1.4-5 kg
		Tar	0.3-2 kg
Pig iron of blast furnace	Ton	Washing slag	6-10 t
		Slag	0.3-0.9 t
Steel smelting by oxygen converter	Ton	Steel slag	0.2-0.3 t
		Fluorite slag	0.1 t
Steel smelting by Electric stove	Ton	Slag	0.1-0.2 t
		Dust	8-12 kg
Steel smelting by level furnace	Ton	Slag	0.25-0.35 t
		Dust	0.8-1.2 kg (at most 3.6kg)
Steel materials by acid washing	Ton	Waste acid	About 70 kg (H_2SO_4 11%)
Founding by pig iron of cupola	Ton	Slag	60-100 kg
Silicon-iron alloy	Ton	Slag	2.5-3.5 t
Tungsten-Iron alloy	Ton	Slag	0.5-0.7 t
Silicon-manganese-Iron	Ton	Slag	2-2.5 t
Vanadium-iron alloy	Ton	Slag	3-4 t (wet discharge)
Tungsten-molybdenum alloy	Ton	Slag	1.5-1.8 t
Silicon	Ton	Slag	20t (Including 0.2-0.3 t of ash)
Copper smelting of reverberatory furnace	Ton (Raw material)	Slag	0.65-0.8 t (including 0.3-0.5% of copper)
Copper electrolysis	Ton	Waste acid	About 10% H_2SO_4
Lead smelting	Ton (Raw materials)	Slag	0.37 t (including 2.9-6.7 % of lead)
		Dust	33-35 kg

Zinc distillation	Ton	Slag	About 0.43 t
Nickel smelting	Ton (Raw materials)	Slag	40 t
Nickel smelting of reverberatory furnace by sulfuration cathode	Ton	Slag	0.3 t
Electric furnace smelting of copper and nickel ore	Ton (Raw materials)	Slag	1-1.2 t (Density: 2.7-2.9t/m^3)
Aluminum electrolysis	Ton	Dust	20-100 kg (Including 6-8 kg of fluorine)
		Slag	2-3 t
Mercury smelting by blast furnace (seething furnace)	Ton (Raw materials)	Slag	500-700 t (Including 0.002-0.005%)
Hydro-smelting mercury by gravitation, floatation	Ton (Fine minerals)	Slag	6-13 t (Including 0.05-0.1% of Hg)
Distillation smelting mercury by gravitation, floatation	Ton (Fine minerals)	Slag	3-12 t (Including 0.004-0.01% of Hg)
Aluminum oxide	Ton	Red mud	1.0-1.8 t
Smelting of uranium mineral water	Ton	Slag	0.97-0.99 t

Table 5: Solid waste discharges efficient in metallurgical industry

Dust source	Generation
Sintering dust	20-40kg/t sintering ores
Blast furnace dust (dry)	10-20kg/t iron
Blast furnace dust (wet)	10-20kg/t iron
Converter dust and mud	7-15kg/t steel
Electric furnace dust	10-20kg/t steel
Steel rolling scraping	20-60kg/t steel
Sludge from acid washing	5-10kg/t steel

Table 6: The generation of iron-contained dust and sludge

3.1.3 Solid wastes in chemical industry

Solid wastes in chemical industry include the wastes in inorganic salt, chloride alkali, phosphorous fertilizer, nitrogenous fertilizer, pure alkali, vitriol, organic raw materials, dye, and sensitive material industry. The values of the discharge efficient of some solid wastes in chemical industry are shown in Table 7.

Industry	Product	Procedure	Wastes	Discharge [t (waste)/t (product)]
Inorganic salt	Sodium dichromate	Oxidation baking	Chromium slag	1.8-3
	Sodium Cyanide	Amino-sodium	Cyanogen slag	0.057
	Yellow phosphor	Electric stove	Stove slag	8-12
			Rich phosphor mud	0.1-0.15
Chlor-alkali	Baking alkali	Mercury	Salt mud including mercury	0.04-0.05
		Membrane	Salt mud	0.04-0.05
	Polyvinyl chloride	Calcium carbide ethyne	Calcium carbide slag	1-2
Phosphorous fertilizer	Yellow phosphor	Electric stove	Stove slag	8-12
	Phosphorous acid	Hydro	Phosphorus gypsum	3-4
Nitrogenous fertilizer	Synthetic ammonia	Coal gasification	Stove slag	0.7-0.9
Soda ash	Soda ash	Amino-alkali	Waste liquid from distillation	9-11*
Vitriol	Vitriol	Pyrites	Slag	0.7-1
Organic raw materials and synthetic materials	Quad, pentaerythrite	Low temperature combination	Waste liquid	2-3
	Epoxy ethane	Ethene chlorinate	Saponification liquid	3
	Polyformaldehyde	Aggregation	Waste liquid	3-4
	Polyenthelene with four fluorine	High temperature decomposition	Residue liquid	0.1-0.15
	Neoprene	Calcium carbide ethyne	Calcium carbide slag	3.2
	Titanium powder	Sulfate method	Waste ferrous sulfate	3.8

Note: * indicates m^3/t

Table 7: Discharge efficient of slag in chemical industry

In chemical industry large amounts of solid wastes are generated, and the generation and

composition of solid wastes change with product, production procedure, production scale and raw material quality.

3.2 Solid waste generation in some countries

3.2.1 Generation of industrial solid wastes in China

In the first countrywide solid waste registration in China in 1995, 97654 registered enterprises generated 767.9953 million tons of solid wastes totally. 599.4349 million tons of them were common industrial solid wastes, which constitute 78.05% of total solid wastes, and 26.1840 million tons are hazardous wastes that constitute 3.41% of the total. Other less hazardous wastes were 142.3764 million tons that constitute 18.54%. The top 10 industrial sectors for solid waste generation include coal-mining industry; ferrous metal mining industry; production and supply industry for electricity, vapor and hot water; ferrous metal smelting and process industry; chemical material and chemistry production industry; nonmetal mineral production industry; nonmetal mining industry; nonferrous metal smelting and process industry; and food process industry. The chemical material and chemistry production industry is a most crucial generator for hazardous wastes in China. The solid waste generation from the enterprises at county and above level is shown in Table 8.

Region	Industrial Solid Waste Generation (Ton)	Hazardous Waste Generation (Ton)	Percentage of hazardous wastes in solid wastes
Total	658,970,000	9,930,000	1.51
Beijing	11,160,000	20,000	0.18
Tianjin	5,940,000	20,000	0.34
Hebei	60,580,000	690,000	1.14
Shanxi	45,180,000	360,000	0.80
Inner Mongolia	27,010,000	810,000	3.00
Liaoning	68,910,000	390,000	0.57
Jilin	16,610,000	180,000	1.08
Heilongjiang	32,250,000	40,000	0.12
Shanghai	13,060,000	340,000	2.60
Jiangsu	28,910,000	1,100,000	3.80
Zhejiang	10,270,000	50,000	0.49
Anhui	25,280,000	710,000	2.81
Fujian	7,470,000	290,000	3.88
Jiangxi	40,890,000	30,000	0.07
Shandong	46,520,000	570,000	1.23
Henan	28,950,000	680,000	2.35
Hubei	22,250,000	310,000	1.39
Hunan	18,010,000	290,000	1.61
Guangdong	13,520,000	540,000	3.99
Guangxi	16,660,000	230,000	1.38
Hainan	820,000	No data	No data

Sichuan	39,790,000	730,000	1.83
Guizhou	10,850,000	200,000	1.84
Yunnan	21,370,000	740,000	3.46
Tibet	10,000	No data	No data
Shan'xi	19,840,000	60,000	0.30
Gansu	14,350,000	70,000	0.49
Qinghai	2,770,000	No data	No data
Ningxia	4,120,000	10,000	0.24
Xinjiang	5,620,000	490,000	8.72

Table 8: Generation of industrial solid wastes and hazardous wastes in China in 1996

3.2.2 Generation of industrial solid wastes in the USA

Each year, industrial facilities generate and manage 7.6 billion tons of non-hazardous industrial waste in land application units. Generated by a broad spectrum of USA industries, industrial waste is process waste associated with manufacturing. This waste usually is not classified as either municipal waste or hazardous waste by federal or state laws. Although state, tribal, and some local governments have regulatory responsibility for ensuring proper management of industrial waste, their regulatory programs vary widely. The quantity of RCRA hazardous wastes generated by State, 1997 are shown in Table 9, most of them are from industrial resources.

State	Rank	Generation (Tons)	Generated percentage
Total		40,675,836 *	100
Alabama	14	423,968	1.0
Alaska	47	4,547	0.0
Arizona	35	53,031	0.1
Arkansas	8	1,052,744	2.6
California	12	672,946	1.7
Colorado	28	82,021	0.2
Connecticut	32	60,219	0.1
Delaware	39	19,353	0.0
District of Columbia	54	499	0.0
Florida	16	398,535	1.0
Georgia	20	275,096	0.7
Guam	55	412	0.0
Hawaii	45	7,241	0.0
Idaho	9	1,014,825	2.5
Illinois	3	2,201,025	5.4
Indiana	7	1,077,410	2.6
Iowa	37	33,681	0.1
Kansas	6	1,333,169	3.3
Kentucky	21	192,318	0.5
Louisiana	2	4,624,829	11.4
Maine	46	4,758	0.0

Maryland	31	63,498	0.2
Massachusetts	27	94,467	0.2
Michigan	10	994,047	2.4
Minnesota	13	427,390	1.1
Mississippi	5	1,654,338	4.1
Missouri	25	116,705	0.3
Montana	41	12,266	0.0
Navajo Nation	56	150	0.0
Nebraska	38	23,491	0.1
Nevada	40	12,518	0.0
New Hampshire	44	9,751	0.0
New Jersey	18	348,409	0.9
New Mexico	26	99,474	0.2
New York	15	419,899	1.0
North Carolina	30	66,501	0.2
North Dakota	50	2,686	0.0
Ohio	4	1,693,247	4.2
Oklahoma	19	315,296	0.8
Oregon	36	49,877	0.1
Pennsylvania	17	370,024	0.9
Puerto Rico	34	54,120	0.1
Rhode Island	42	11,643	0.0
South Carolina	43	10,793	0.0
South Dakota	53	948	0.0
Tennessee	11	745,458	1.8
Texas	1	18,973,406	46.6
Trust Territories	52	1,101	0.0
Utah	29	78,555	0.2
Vermont	48	4,064	0.0
Virgin Islands	49	2,811	0.0
Virginia	33	57,395	0.1
Washington	24	126,601	0.3
West Virginia	22	152,843	0.4
Wisconsin	23	147,959	0.4
Wyoming	51	1,478	0.0

Note: Columns may not sum due to rounding.
* Total generation does not include CBI (Confidential Business Information) data.

Table 9: Quantity of RCRA hazardous wastes generated by State, 1997

4. Effects of Industrial Solid Wastes

Large amounts, many species, complex characteristics, wide sources, trans-region and trans-boundary movements are the intrinsic characteristics of solid wastes. Industrial solid wastes can directly or indirectly have adverse effects on the environment and human health by variety of routes and forms. For industrial solid wastes, both instantaneous pollution and potential and long-term pollution may occur. Industrial solid wastes may pollute or/and damage the atmosphere, water, soil, and life form. In case solid waste pollution occurs, or potential pollution becomes practical, a large amount of investment and comprehensive technology will be required in order to eliminate this pollution and to remedy the environment. Generally, these pollution effects cannot be eliminated completely.

4.1 Routes of industrial solid wastes polluting the environment

For the industrial solid wastes dumped in the open air and stored in disposal sites, the hazardous components can directly or indirectly reach the human body by environmental media, such as the atmosphere, soil, surface water and groundwater. This will result in human health damage. The importance of these routes depends on the intrinsic physical, chemical, and biological characteristics of the pollutants and the hydrological and geological environmental status. Figure 1 shows the routes by which hazardous components reach the human body.

4.2 Effect of industrial solid wastes on human health

Industrial solid wastes may result in environmental pollution by a variety of routes and bring disease to the human body.

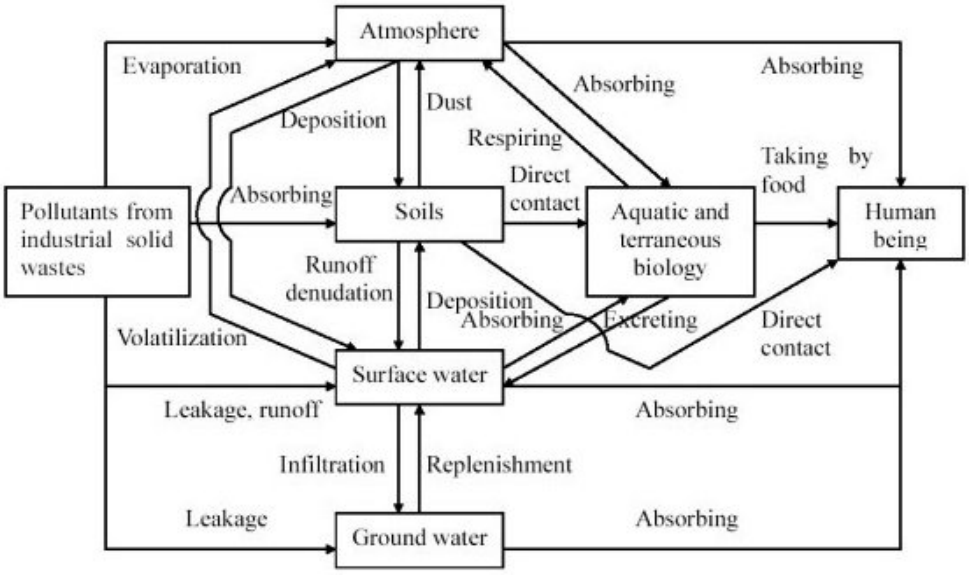

Figure1: Route of industrial solid wastes polluting the environment and affecting human health

When mixed, industrial solid wastes maybe result in chemical reactions based on

chemical properties, including heat reaction (combustion or explosion), hazardous gas generation (hydrogen arsenide, hydrogen cyanide, and hydrogen chloride), and combustible gases (hydrogen, acetylene) generation. When the skin of the human body has contact with waste strong acid and strong alkali, burnable erosion will occur. When insecticides are taken in, acute poisoning, emesis, twitching may occur. Empty vessel storing chemicals can result in serious poisoning events without proper treatment and management.

4.3 Effect of industrial solid wastes on the natural environment

The storage and dumping of industrial solid wastes will occupy a lot of land. Improper disposal and improper disposal operation management will result in hazardous matters entering the environment. When dead creatures occur in the biology community, especially aquatic ones, they may be considered as pre-monitoring the possibility that pollutants are being discharged from waste disposal sites.

4.3.1 Effect on the atmospheric environment

The fine particles, dust in industrial solid wastes can fly with the wind to pollute the atmospheric environment. Based on research result, it is shown that fly ash and the tailings in earth surface with lower Φ=1-1.5 mm will be peeled off under the wind power grade 4, and it can fly far from 20-50m. It will result in 30-70% visibility decrease of the atmosphere. Because of the de-composition and chemical reaction of some compounds in wastes, toxic gas and stench will appear and result in regional air pollution. Marsh gas from waste landfill site can consume ozone in the atmospheric environment and result in plant destruction. The heavy metal in industrial solid wastes can restrain the growth of plants.

4.3.2 Effect on aquatic environment

In the world, many countries directly dump wastes into rivers, lakes, and the sea. Some countries even consider the sea as a disposal site of wastes. It should be mentioned that the international conventions should be obeyed and this should be forbidden. The industrial solid wastes dumped into water will directly pollute the water and affect the existent condition of aquatic biology and the full use of water resources. Alluviation of industrial solid wastes by rainwater and the decomposition, transportation and transformation of the leachate and the hazardous components will result in the pollution of the rivers, lakes, and groundwater in nearby region. The dumping of industrial solid wastes into lakes will also result in the reduction of the lake area and affect the flood-discharging capacity and irrigation capacity. In China, it is estimated that more than one million Hectraes of water area has been lost because of solid wastes being dumped into lakes from the 1950s to the 1980s.

4.3.3 Effect on the soil environment of industrial solid wastes

The hazardous matters in the leachate and lixivium of industrial solid wastes can change the structure and properties of soil, and affect the activities of microorganisms in soil. Not only are the growth of plant roots interfered with by these hazardous components, but also

they accumulate in the organism and are hazardous to humans by means of the food chain. The pollution of hazardous wastes is most serious in industrial solid wastes. The explosibility and corrosiveness properties need to be paid attention to urgently, and the acute toxicity matter in wastes can result in instant serious pollution and produce long-term adverse effect on soil.

5. Remarks

The industrial solid wastes occupy land due to disposal or storage and cover large categories of wastes, and large quantities have been generated. Liquid and gaseous wastes in vessels are also included in industrial solid wastes. These wastes may influence the biosphere on which human beings depend by means of water, soil and atmosphere. Therefore the key for the pollution control of industrial solid wastes is to find good solution to treat, dispose, reuse and recycle them properly. Sustainable development strategy, waste reduction, recycling, and innocuity are the practical solution to industrial solid wastes. The characteristics of the pollution control of industrial solid wastes are generalized as: (1) improving production technology and adopting cleaner production technology to reduce and avoid waste generation; (2) strengthening the strict management from cradle to tomb of wastes; (3) improving the environmental consciousness of the public and effectively conducting communication and education.

Glossary

Φ:	Diameter
Basel Convention:	Basel Convention on the Control of Trans-boundary Movements of Hazardous Waste and their disposal
cm:	Centimeter
kg:	Kilogram
Innocuity:	Reducing hazardous characteristics
m:	Meter
t:	Ton
RCRA:	Resource Conservation and Recovery Act
USA:	United States of America
UNEP:	United Nations Environmental Programme

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Biographical Sketch

Jinhui Li is an associate professor of the Department of Environmental Science and Engineering, Tsinghua University, is also the administrative director of the Asia-Pacific Regional Center for Hazardous Waste Management Training & Technology Transfer. Mr. Jinhui Li got his B. S. degree and M. S. degree in the Department of Environmental Sciences, Nankai University and his Ph. D. in the Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences in 1997. His research interests mainly focus on hazardous waste policy and management, recycling and recovery of wastes, soil pollution remediation, environmental risk assessment, aquatic chemistry of acid rain. The main projects under his management or involvement include: (UNIDO) Cleaner Production and Solid Waste Management; Feasibility Research of the Project on the Treatment and Disposal of Hazardous Wastes in Suzhou; Technological Policies on the Prevention and Control of Hazardous Wastes of China; Guideline of Assessment Technique for the Operation Capacity of Hazardous Wastes of China; SVE Technique for Volatile Organic Matter; Minimization of Solid Wastes; National Action Plan and Regional Decision-making Support System of Hazardous Waste Management of China; (Gemany, GTZ) China Zhejiang Project on Hazardous Waste Management; (World Bank) China Shandong Environmental Project, Hazardous Waste Management-Implementation Support. He has published more than 50 papers on above subjects, and is one of the authors for five books.