Design of Medical Waste System for Sustainable Territorial Development

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First of all, thank our parents. Without their full support, we would not be able to pursue our dreams in Italy and successfully complete our studies. Second, thank the professor Amina Pereno who accompanied us for eleven months. Without your careful guidance, we would not have the thesis may be completed smoothly. Finally, thank every friend in China or Italy, thank you for the journey of life.
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Introduction

The waste emergency has been a global topic for several decades. It is well known that the increase in waste production and their abandonment cause irrevocable damage to the environment and climate, but also to the health and well-being of the citizens themselves. The increase in industrialization and consumption and the concentration of the population in the cities in the 1960s favored the birth of the "disposable cult" with a consequent increase in the production of waste. For many years, the world of design has responded to this problem by offering numerous and different solutions: from reuse design to systemic and holistic design, to craftsmanship, up to the use of newly created technologies.

The harmfulness of medical waste has attracted great attention from all over the world. In the construction of relevant laws and regulations, many countries have strict and clear regulations on the reduction, classified collection, storage, transportation, treatment and disposal of medical waste.

In terms of technology, a lot of manpower, material and financial resources have been invested in the in-depth research on the treatment and disposal of medical waste, including incineration, high-pressure sterilization, chemical treatment, microwave radiation, high-temperature decomposition, plasma and electric arc furnace, etc.

In contrast, there is still a big gap in the formulation of laws and regulations, the improvement of regulatory system, the enhancement of public awareness and the investment in scientific research.

Medical waste is a kind of hazardous waste, which contains a large number of harmful pathogens, toxic and harmful chemical pollutants and radioactive pollutants, which are highly polluting.

In China's list of hazardous waste, medical waste is the number one hazardous waste. For medical waste, the Ministry of health of China clearly stipulates that the medical waste in hospitals must be stored in a closed place, stored at a fixed point, and transported by special personnel.
It is necessary to ensure thorough sterilization and avoid environmental pollution. It is not allowed to recycle and process in any form.

The classification of medical waste in China is based on the classification list of medical waste, which was issued by the national health and Family Planning Commission on October 10, 2003. It mainly includes the management standards of narcotic, psychotropic, radioactive, toxic drugs and related wastes in medical and health institutions.

According to the medical waste classification list, China's medical waste is mainly divided into the following categories:

**Infectious waste**: medical waste carrying pathogenic microorganisms and causing the risk of infectious disease transmission.

**Pathological waste**: human waste and medical laboratory animal corpses produced in the process of diagnosis and treatment.

**Injurious waste**: discarded medical sharp instrument that can stab or cut human body.

**Pharmaceutical waste**: expired, eliminated, deteriorated or contaminated drugs.

**Chemical waste**: toxic, corrosive, flammable and explosive waste chemicals.

Since the 20th century, the treatment of medical waste has attracted wide attention in the world.

Domestic and foreign scholars have been increasingly rich in the research of medical waste treatment technology, and have achieved certain research results.

On this basis, through the comprehensive comparison of incineration treatment, high pressure steam sterilization treatment, chemical treatment, microwave treatment, pyrolysis treatment and other medical waste treatment technologies, the technical parameters and advantages and disadvantages of various treatment processes were comprehensively evaluated.

Finally, it was concluded that the high temperature pyrolysis method has many advantages and is the first medical waste treatment technology at home and abroad. Up to now, China's medical waste treatment industry has the following characteristics: some large hospitals use self built incinerators to treat medical waste, but the incinerators are of low grade and incomplete combustion, causing secondary pollution to the environment.
China’s domestic waste has become a public hazard. In the face of the present situation, it is necessary to actively explore and develop a set of systematic garbage collection and treatment methods suitable for China, so as to realize the recycling, reduction and harmlessness of garbage. With the continuous development of China’s national economy and the increasing living standards of the people, a large number of municipal solid waste is produced every day, which has become an important source of environmental pollution.
CHAPTER 1

Current Status of Shanghai, China
1.1 China's Waste Management Directives

Large cities have issued detailed rules for garbage classification.

At the 14 meeting of the Central Committee in December 21, 2016, general secretary Xi Jinping explicitly called for the implementation of garbage classification system.

On June 2, 2019, we will again give important instructions on waste classification, profoundly clarify the importance of waste classification, and clarify the guidelines and work objectives of garbage classification.

Up to now, 134 central units, 27 troops stationed in Beijing and provincial organs have carried out domestic waste classification in an all-round way. The domestic waste system of 46 key cities has been gradually established, with nearly 5000 kitchen waste sorting transport vehicles and 1000 hazardous waste sorting and transportation vehicles, and will continue to invest 21.3 billion yuan to speed up. In order to meet the needs of domestic waste classification and treatment, the key cities have carried out household classification publicity of domestic waste, covering more than 19 million families and involving more than 700000 volunteers.

Among them, Beijing, Shanghai and Shenzhen are the most advanced cities in China, and they are also the three cities with better implementation of garbage classification system.

**Beijing** as early as 2012, the "Regulations on the management of municipal solid waste" was promulgated. However, due to inadequate management and other reasons, the participation rate of residents in garbage classification is growing slowly.

At present, the revised regulations will clarify the responsibilities of garbage classification not only for units, but also for individuals, so as to implement waste classification by legislation.

According to Beijing's three-year action plan, by 2019, the coverage rate of waste classification areas in Chengquan city will reach 60%, and by the end of 2020, it will reach 90%.

Since then, the standard of MSW classification in Shanghai has been revised from 1995 to now.

**Shanghai** The pilot work of waste sorting started in 1995. The waste was initially classified into organic waste, inorganic waste and toxic and
hazardous waste. Afterwards, it has undergone several revisions to the classification standards. The Shanghai Municipal Measures for Promoting the Classification and Reduction of Domestic Waste was promulgated in 2014. The garbage is officially divided into four types: recyclable garbage, hazardous garbage, wet garbage and dry garbage, which are still used today.

**Shenzhen** in 2000, Shenzhen became the first batch of 8 pilot cities for domestic waste sorting and collection. Since then, it has been exploring scientific and effective garbage classification and treatment mode. In 2015, it took the lead in establishing a large domestic waste separation treatment system in China, and gradually improved the legal system to guide the public to carry out garbage classification.

In recent years, Shenzhen has successively issued a government regulation, three local standards and seven normative documents in the field of waste classification management, forming a relatively complete standard system. In February 2018, the draft for Soliciting Opinions on legislation was issued, which subdivided the waste classification standards into 13 categories. Among the 46 pilot cities, the garbage classification standards are the most detailed.
1.2 Status of China's Urban Waste Classification

China's domestic waste has become a public hazard. In the face of the present situation, it is necessary to actively explore and develop a set of systematic garbage collection and treatment methods suitable for China, so as to realize the recycling, reduction and harmlessness of garbage. With the continuous development of China's national economy and the increasing living standards of the people, a large number of municipal solid waste is produced every day, which has become an important source of environmental pollution.

At present, China's annual output of municipal solid waste is over 100 million tons, accounting for 26.5% of the world's total waste production, and the annual growth rate is 8% - 9%. In 2004, China has surpassed the United States to become the world's largest garbage producing country. In 2010, the output of municipal solid waste was about 352 million tons, ranking first in the world. The accumulated land occupied by urban garbage storage in China is more than 500 million square meters, and the annual economic loss is as high as 30 billion yuan.

In 2012, Beijing officially implemented the "Regulations on the management of domestic waste", which clearly required the implementation of waste classification and waste reduction. However, the speed of garbage generation is far faster than the speed of digestion. Two thirds of China's cities have fallen into "garbage besieged city". In 2017, the volume of urban garbage removal and transportation in China reached 215 million tons. The next 30-50 years will be the peak period of China's population and urbanization. It can be predicted that the system and capacity of municipal solid waste cleaning and transportation will be seriously challenged.

Some waste treatment plants can only carry out a rough sorting of waste, because of the large amount of miscellaneous, it is difficult to distinguish. Due to the progress of science and technology, electronic products appear more frequently in people's lives.
polyvinyl chloride plastic, brominated dioxin and other heavy metals are directly thrown into the urban dustbin. The number of these special pollutants increases exponentially, which is impossible to be treated by general garbage treatment plants or sewage treatment plants. Garbage, through infiltration and bioaccumulation, causes considerable damage to soil, water and human health.

At present, there are three main methods to deal with waste in China, of which landfill is the most important treatment method, accounting for more than 70% of the total treatment capacity; followed by high-temperature composting, accounting for more than 20%; and finally, incineration, but the amount of incineration is very small. At present, China's waste disposal capacity is small and the technical level of treatment facilities is low, but there are many potential pollution hazards.

The current general medical waste disposal mode in China still follows the centralized disposal mode launched in 2003. At present, the power of medical waste disposal mainly depends on the centralized disposal center built around 2005.

Figure 1.4 Unben waste classification situation
These centralized disposal centers of medical waste are mostly distributed in the developed central cities, which play an irreplaceable role in more than ten years from 2005 to now.

With the continuous development of China's medical and health undertakings, China has become the world's largest infusion country, the amount of medical waste produced by hospitals is increasing sharply every year. According to the statistics of prospective industry research institute, in 2016, the weight of medical waste in China reached 1.9674 million tons.

In contrast, according to the annual report on prevention and control of solid waste pollution in large and medium-sized cities in China issued by the Ministry of environmental protection on December 6, 2017, there were 322 medical waste centralized disposal centers with business license in 2016. The treatment capacity of 322 medical waste disposal centers is 830000 tons, and only 42% of the total amount of medical waste is produced. In 2014 and 2015, the proportion was 38% and 41% respectively. At present, the treatment capacity of medical waste in China is seriously insufficient.
At present, the domestic medical waste is contracted by the hospital to the third company, and the hospital pays a large amount of waste treatment fee to the third company every year. The third company is called the medical waste disposal center, and the medical waste treatment qualification is issued by the state. The treatment process mainly includes the following steps: first, the hospital classifies and temporarily stores the waste; secondly, the third party sends medical waste transfer vehicles to collect and transport them to the centralized medical waste disposal center, which then disposes of these wastes.

Different types of medical waste are classified into yellow collection boxes or yellow medical garbage bags, and then stacked in the temporary storage room, waiting for people from the centralized disposal center to transport them away. According to the regulations on the management of medical waste, the longest temporary storage time of medical waste in medical institutions shall not exceed 48 hours. The medical waste disposal center will send a transfer vehicle to collect the medical waste. The body of the transfer vehicle must have eye-catching words and signs.
1.3 Why choose Shanghai as our research city?

Shanghai began to force the classification of urban refuse in 2018, and it is also the first Chinese mainland to classify garbage. Shanghai has become the first pilot city. Environmental pollution is more harmful to big cities. Shanghai produces about 20,000 tons of garbage every day. The waste discharge and pollution energy in big cities are huge. These pollution and discharge will seriously lead to air deterioration, water pollution, food safety and other problems. As the economic center of China, Shanghai is one of the most densely populated cities in the world. The pollution problem is related to everyone’s vital interests, so it is urgent to start the pilot project from big cities. The city of Shanghai is highly inclusive. Shanghai is an international metropolis, the people’s civilized quality and ability to accept new things are also relatively strong, and the acceptance of international popular garbage classification concept is relatively high. The implementation of garbage sorting will be smoother.

Every inch of land and gold in Shanghai
The backward extensive mode of garbage treatment can not meet the development needs of Shanghai as an economically developed region. As mentioned earlier, landfilling accounts for more than 70% of China’s waste disposal methods. If we can change the garbage disposal mode from landfill to incineration, we can save a lot of land resources, and at the same time, we can avoid a lot of land pollution, which is the general direction of environmental protection, but also can quickly solve the current situation of garbage besieged city. This requires waste classification at the source.
1.4 Three regions we choose in Shanghai

The research areas we chose in Shanghai are Jing'an District, Hongkou District and Yangpu District. The total population of these three districts is 3190422. These three districts are connected together and are located in the center of Shanghai, making it one of the most densely populated areas.

Shanghai produces about 20000 tons of garbage every day. The waste discharge and pollution energy in big cities are huge. These pollution and discharge will seriously lead to air deterioration, water pollution, food safety and other problems. As the economic center of China, Shanghai is one of the most densely populated cities in the world.

**Jing'an District** The area of Jing'an District is 37.37 km², the area is small, the permanent population is 1.0662 million, and the population density is high. According to statistics from the fourth census, there are more than 64,000 people per square kilometer, ranking first among all districts in the city. Jing'an District has an advantageous geographical location, convenient transportation, and convenient transportation, forming a railway, elevated, subway, and public transportation network. It is known as the "North Gate on Land" of Shanghai.

At the same time, it has a long history, a beautiful city environment, a well-developed business and commerce, a burst of innovation and vitality, and convenient information transportation. It is an important window for foreign exchanges in Shanghai.

As of the end of 2017, the permanent population of the district was 1.0662 million, a year-on-year decrease of 0.15%. Among them, the permanent resident population is 799,400, and the permanent resident population is 266,800.

*Figure 1.8 map of Three regions in Shanghai*
By the end of the year, the total number of households in the district was 341,700. The total registered population is 939,300, including 461,100 males and 478,200 females. The registered elderly population of 60 years and above is 342,100, accounting for 36.4% of the total population; 59,600 are aged 80 and above, accounting for 6.3% of the total population; there are 217 people aged 100 and above, accounting for 0.02% of the total population.

By the end of 2017, there were 39 hospitals of various types in the district, including 9 tertiary hospitals and 11 secondary hospitals.

There are 80 community health service institutions in the district. By the end of the year, the number of doctors per 1,000 people in the district reached 6.26; the number of beds per 1,000 people was 12.95; the number of general practitioners per 10,000 people was 3.7. By the end of the year, the number of visits by various medical and health institutions in the district reached 26,708,800, including 26,621,100 outpatient and emergency department visits. The number of admissions was 542,200, and the number of health checks was 1,113,700.
Hongkou District

Hongkou District, a district under the jurisdiction of Shanghai, is located in the north east of downtown Shanghai; the territory of Hongkou District was originally a beach on the coast of the East China Sea, with a multi-channel port branch, with a total area of 23.45 square kilometers, including a land area of 22.54 square kilometers. The water area is 0.91 square kilometers. The permanent population is 710,900.

As of the end of 2017, the registered population of Hongkou District was 744,200, a decrease of 15,501 from the previous year. The number of births was 4,921, and the birth rate was 6.5‰; the number of deaths was 7,499, and the death rate was 10.0‰; the natural population growth rate was -3.4‰. Among the registered population, 72,882 people are under 18, accounting for 9.8% of the total population; 282,273 people are 60 years old and above, accounting for 37.9% of the total population.

There were 64 medical and health institutions in Hongkou District, including 8 community health service centers; 10,854 health technicians, including 3,705 licensed (assistant) physicians and 5,211 registered nurses. At the end of 2017, there were 7832 hospital beds in medical institutions; in 2017, 5286 new family hospital beds were added.

Figure 1.12 Proportion of people over 60 years old

Figure 1.13 Proportion of people over 80 years old

Figure 1.14 Population aging ratio in Hongkou District
Yangpu District Located in the northeast of downtown Shanghai, on the northwest bank of the lower reaches of the Huangpu River. The total area is 60.61 square kilometers. As of 2018, the district has a total permanent population of 1.3127 million. There are 155,132 people aged 65 and over, accounting for 12.47% of the total population, an increase of 55,824 people from the 1990 census, a rise of 3.64 percentage points; the population of the elderly (80 years and above) is 21,733, accounting for 1.75% of the total population. In the 1990 census, there were an increase of 10,176 people, a rise of 0.72 percentage points.

By 1990, the number of medical prevention and treatment institutions had increased to 38, an increase of 1.92 times over 1949. The number of beds was 5,676, and the number of beds per 1,000 was 5.30, an increase of 2.74 from 2.56 in 1949.

There were 7,596 health technicians, and the number of health professionals per 1,000. The staff was 7.10, an increase of 5.02 from 2.08 in 1949. The mortality rate of infectious diseases decreased by 94.90% compared with 1953, the maternal mortality rate dropped to 281/10,000, and the infant mortality rate dropped to 10.78‰. Life expectancy increased from 59.98 years for males and 60.9 years for females.
Shanghai is one of the earliest cities in China that has entered the aging process. The three regions we studied are also the oldest regions in the entire Shanghai. They have a high proportion of people aged 60 and above. In recent years, the population aging has shown a high degree of rapidity. Outstanding aging and other characteristics, the elderly living alone, empty-nest families and other urgent need for care are increasing year by year. According to the statistics of the "2012 Shanghai Elderly Population and Elderly Career Monitoring Statistics Information", the registered population of the city is 14,269,300. The number of elderly people aged 60 and over is 3,673,2 million, accounting for 25.7% of the total population.

From the end of 2011 to the end of 2012: the population of 60 years and over has increased by 195,700, an increase of 5.6%; it is estimated that by 2025, the proportion of Shanghai’s aging population will be Up to about 35%.

Generally speaking, Shanghai is the region with the earliest and most serious population aging in my country. The huge elderly population has a huge demand for medical institutions in the region, and supply and demand are the most important issues in medical development.

Under the combined effect of economic and social transformation, government function transformation, and weakening of family pension functions, there is a huge demand for medical institutions in Shanghai. However, the current trend of population aging does not meet the increasing level of demand.

![Figure 1.18 The proportion of men and women in Shanghai's aging population](image)
1.5 Classification of hospital medical waste

The classification of medical waste in my country is formulated according to the "Medical Waste Classification Directory", which is a regulation issued by the National Health and Family Planning Commission on October 10, 2003. It mainly includes the management standards of anesthetic, psychoactive, radioactive, toxic drugs and related wastes discarded by medical and health institutions.

According to the medical waste classification list, China's medical waste is mainly divided into the following categories:

**Infectious waste** medical waste carrying pathogenic microorganisms and causing the risk of infectious disease transmission.

1. Articles contaminated by the patient's blood, body fluid and excreta include: -- cotton ball, cotton swab, drainage tampon, gauze and other dressings; -- disposable sanitary products, disposable medical supplies and disposable medical instruments; -- discarded bedding clothes; -- other articles contaminated by the patient's blood, body fluid and excreta.

2. Domestic garbage produced by isolated infectious disease patients or suspected infectious disease patients admitted and treated by medical institutions.

3. The culture medium, specimen, strain and virus seed preservation solution of pathogen.

4. All kinds of discarded medical specimens.

5. Waste blood and serum.

6. Disposable medical supplies and disposable medical devices after use are regarded as infectious wastes.
Pathological waste  human waste and medical laboratory animal corpses produced in the process of diagnosis and treatment.

1. Waste human tissues and organs produced in the process of operation and other diagnosis and treatment.

2. Tissues and corpses of medical laboratory animals.

3. The discarded human tissue and pathological wax after pathological section.

Injurious waste  discarded medical sharp instrument that can stab or cut human body.

1. Medical needle, suture needle.

2. All kinds of medical sharp instruments, including: scalpel, scalpel, scalpel, surgical saw, etc.

3. Glass slide, glass test tube, glass ampoule, etc.

Pharmaceutical waste  expired, eliminated, deteriorated or contaminated drugs.

1. Abandoned general drugs, such as antibiotics, over-the-counter drugs, etc.

2. Discarded cytotoxic drugs and genotoxic drugs include: - carcinogenic drugs, such as azathioprine, nitrogen mustard phenylbutyrate, naphthalene mustard, cyclosporin, cyclophosphamide, amphetamine nitrogen mustard, simustine, triphenylamine, thiotepa, etc.; suspicious carcinogenic drugs, such as cisplatin, mitomycin, adriamycin, phenobarbital, etc.; immunosuppressants.

3. Abandoned vaccines, blood products, etc.
**Chemical waste** toxic, corrosive, flammable and explosive waste chemicals.

1. Chemical reagents abandoned in medical imaging room and laboratory.

2. Waste chemical disinfectants such as peracetic acid and glutaraldehyde.

3. Waste mercury sphygmomanometers and mercury thermometers.

Disposable sanitary products refer to all kinds of daily necessities that are discarded after one use, which are in direct or indirect contact with human body and are used for the purpose of human physiological hygiene or health care.

Disposable medical supplies refer to all kinds of disposable medical and nursing articles that contact with complete mucosa and skin.

The management of narcotic, psychotropic, radioactive and toxic drugs discarded by medical and health institutions and their related wastes shall be carried out in accordance with the relevant laws, administrative regulations and relevant provisions and standards of the state.

*Figure 1.19 Medical waste classification in hospital*
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From a systematic point of view, Japan’s waste classification system is more integrated not only at the macro level, but also at the micro level. From the perspective of hierarchical structure, the European Union has a clear multilayer structure, while Japan has a clear secondary structure.
CHAPTER 2

Global trends in waste management
According to the latest report of the International Solid Waste Association, the World Association of Waste Treatment and Disposal Operators, billions of tons of waste are generated on average every year. Half of it is generated by municipal waste, single, while the other half involves so-called special waste, that is, waste from industrial and production activities. Given the following facts, this situation is worrying: According to ISWA estimates, about half of the world’s population (3.5 billion people) do not have access to the most basic waste management services, which is why a large number of mountainous areas generate and discard waste every year, usually causing irreparable damage to the environment and health.

The European Union has set its own goal of making better use of resources and encouraging more sustainable forms of production and consumption through preventive measures, thereby greatly reducing waste generation.

According to the European Union directive on waste, the method of waste management is based on three principles:

1. Prevention: If the amount of waste generated and its dangers are reduced, its management will become simpler; this principle is closely related to the improvement of production methods and consumer demand for products with less environmental impact;

2. Recycling and reuse: Inevitable waste should be reused or recycled to minimize the impact on the environment;

3. Improve waste management and final monitoring: where it is impossible to reuse or recycle waste, waste should undergo a safe incineration process; landfills should be the last method of waste management; however, these two methods should be strictly monitored. Because they can cause serious environmental damage.
At the national and international levels, various tools related to cross-border waste transportation are used for waste sorting. Such tools include the European Waste List (EWL) and the Green and Amber Waste List of Regulation (EC) No. 1013/1006. Regardless of the disposal method, various types of waste are classified. The European Waste List (EWL) is responsible for managing the names of wastes in all EU member states, mainly classifying wastes according to their source of generation.

This list has been converted into German law through the "Waste Classification Regulations". The purpose of waste classification involves assigning a given waste to a waste type and waste identification code, and the purpose is to harmonize the names of all types of waste in the European Union. The classification of a given waste also defines its hazard, which in turn determines the registration and reporting obligations of all waste processing participants.
2.1.1 World Health Organization

**Important facts**

- About 85% of the total waste generated by healthcare activities are ordinary non-hazardous waste.

- The remaining 15% are considered hazardous materials and may be infectious, toxic or radioactive.

- An estimated 16 billion injections are performed worldwide each year, but not all needles and syringes are properly disposed of afterwards.

- In some cases, open burning and incineration of healthcare waste can lead to the emission of dioxins, furans and particulates.

- Measures to ensure the safe and environmentally sound management of medical waste can prevent the adverse health and environmental effects of such waste, including accidental release of chemical or biological hazards (including resistant microorganisms) into the environment, thereby protecting patients Health and healthy workers and the public.

Health care activities can protect and restore health and save lives. But what about the waste and by-products they produce?

About 85% of the total waste generated by medical care activities are ordinary non-hazardous waste equivalent to household waste. The remaining 15% are considered hazardous materials and may be infectious, chemical or radioactive.

A waste management plan is the cornerstone of any national, regional or local waste management policy. Making a plan can take stock of the current situation, define the goals that need to be achieved, formulate appropriate strategies, and determine the necessary means of implementation.

The formulation of a waste management plan is an obligation of EU member states and is a requirement of Article 28 of the "Waste Framework Directive" (WFD). Member States can request regional or local authorities to develop regional or local plans.
For Germans, waste collection and disposal are self-evident. However, this is the result of a long development in the field of waste management, waste technology and waste regulations.

The legal framework for waste management in Germany had its beginnings in the early 19th century, when a few regions began adopting waste disposal laws. As the cause and effect relationship between a lack of municipal hygiene and widespread diseases such as cholera became ever clearer, people began to grasp the importance of proper drainage and waste disposal systems, leading to the adoption of appropriate measures in this regard by municipal and regional authorities.

From waste disposal to waste management
Waste management has changed tremendously since these early days, from mere disposal management to full-blown waste management – a process that constitutes a veritable paradigm shift. In Germany, waste management now aims to conserve natural resources and manage waste in an environmentally sound manner, whereby sustainable strengthening of environmental and climate protection measures, as well as resource efficiency, play a key role.

The centerpiece of Germany’s Waste Management Act is a five-level waste hierarchy that lays down a fundamental series of steps comprising waste prevention, reuse, recycling, and other elements besides, including energy recovery, and finally waste disposal. In any given instance, the best option from an environmental protection standpoint always takes precedence, whereby ecological, technical, economic and social effects are to be taken into account as well. Thus waste management practices in Germany systematically aim to minimize waste generation and maximize recycling, while at the same time ensuring that the remaining waste is disposed of in a manner consistent with the common welfare.

The various types of waste have to be collected separately at source (source separation at the collection point by depositing the various types of waste in separate containers designated for this purpose) so as to maximize the recycling potential of the various waste streams.
The instrument of product responsibility promulgated by the Waste Management Act defines responsibilities along the product life cycle, as well as incentives for manufacturers to make durable products that generate a minimum amount of waste. The principle of product responsibility is also intended to ensure environmentally sound recovery and disposal of end-of-life goods.

Between 325 and 350 million tons (net) of waste are produced in Germany each year, with construction and demolition waste (including road construction) accounting for 60 percent of this waste, while municipal waste accounts for 14 percent, and hazardous waste for 5 percent. For further information see under Waste Statistics.

In 1994, the Focal Point to the Basel Convention was established in the UBA Basel. The focal point’s main task is to issue permits for trans frontier shipment of waste through Germany, respond to queries, and advise businesses and government agencies. It is also the point of contact for other focal points and correspondents, as well as for the UNEP secretariat and the European Commission.
2.1.3 Urban Waste Classification in the US

As a country, Americans generate more waste than any other country in the world. Officially, each person generates 4.4 pounds (2.0 kg) of municipal solid waste (MSW) per day. Another study estimated that 7.1 per person per day. Pounds (3.2 kg) per person per day. Fifty-five percent of this waste is residential waste, while the remaining 45 percent of the US "waste stream" comes from manufacturing, retail, and commercial trade in the US economy.

In the United States, e-waste has become a growing problem. In the United States, nearly 20% of waste is incinerated, and the rest is landfilled. In this way, almost 80% of the waste consumed in the United States is thrown into landfills. Among the 80% of waste, most of the waste is mainly electronic. Every year, more than 3.2 million tons of e-waste is shipped to landfills in the United States. The United States processes more than 100 million computers, monitors, and televisions every year. Although the United States has a large amount of e-waste

The Environmental Protection Agency found that in 2009, only about 25% of e-waste was discarded. Recycled in the United States. About 70% of the metals found in landfills in the United States come from electronic equipment. The disposal of all these e-wastes will adversely affect the environment and the global economy. The various types of waste have to be collected separately at source (source separation at the collection point by depositing the various types of waste in separate containers designated for this purpose) so as to maximize the recycling potential of the various waste streams.

In 2017, the output of plastic products was 35.4 million tons, accounting for 13.2% of the total output. From 2010 to 2017, this increased by 4 million tons, from the durable goods, containers and packaging categories. Electricity generation from plastics has grown from 8.2% in 1990 to 13.2% in 2017. In the past five years, plastic power generation as a percentage of total power generation has increased slightly
The total generation of municipal solid waste in 2017 was 267.8 million tons of MSW, approximately 5.7 million tons more than the amount generated in 2015. MSW generated in 2017 increased to 4.51 pounds per person per day. This is an increase from the 262.1 million tons generated in 2015 and the 208.3 million tons in 1990.

Paper and cardboard products account for the largest proportion of all materials in municipal solid waste, accounting for 25% of the total power generation. The output of paper and cardboard products dropped from 84.8 million tons in 2005 to 67 million tons in 2017.

The output of newspapers has been declining since 2000, and this trend is expected to continue, partly due to the reduction in page size, but mainly due to the increase in the number of pages and news digitization. Since 2005, the use of paper and cardboard products has accounted for 33% to 28% of the total production.

The per capita MSW production increased from 4.48 pounds per person per day in 2015 to 4.51 pounds per person per day in 2017, which is the lowest estimate since 1990. The average daily MSW production per capita reached its peak in 2000.

Figure 2.3  Total MSW Generated by Material, 2017
In terms of tons, the most recycled or composted products and materials in 2017 were corrugated boxes (28.8 million tons), yard decorations (24.4 million tons), mixed non-durable paper products (9.9 million tons), newspapers/machinery Paper (4.2 million tons), lead-acid batteries (3.2 million tons), main electrical appliances (3.1 million tons), glass containers (3 million tons), wooden packaging (3 million tons), tires (2.6 million tons), food (2.6 million tons), mixed paper containers and packaging (1.3 million tons) and selected consumer electronics products (1 million tons).

In 2017, selected consumer electronics products generated 2.8 million tons, accounting for less than 2% of MSW production. The selected consumer electronics products include TVs, VCRs, DVD players, cameras, stereo systems, telephones, and computer equipment.

Every resident throws away more than 14 pounds of unrecycled and unused items every day, and often ends up in landfills and incinerators, which is 8 pounds higher than the national average daily discard.
Japan has the most detailed and complex garbage classification method. For example, kitchen waste must be drained before it can be thrown into the trash can. The spray can must be deflated and opened. Milk bottles must also be cleaned, drained, flattened and recycled. Newspapers, cartons, etc. must also be neatly coded and tied up with ropes before they can be recycled. Even take-out lunch boxes need to be cleaned before they can be recycled. Ordinary beverage bottles need to remove the cap and label, because they are different from the bottle body, and the bottle body needs to be cleaned and kept in its original condition. Bottle caps, labels and bottle bodies are packed in different garbage bags.

Each type of garbage has a designated garbage bag classification, which cannot be disorderly. Garbage bags are purchased, not free. You cannot throw garbage into free plastic bags. Each type of garbage bag has a prescribed size. Large garbage must be handled in the same way as large garbage. You also need to purchase large garbage tickets to deal with large pieces of garbage.

Figure 2.5 Urban waste classification situation, Japan
Generally speaking, kitchen waste is only collected twice a week. Resource waste is collected only once a week, but in some areas only twice a month. Before the stipulated date, garbage can only be collected in your own home. As for “bulky garbage”, we need to make an appointment with the government, and the government will provide one day a week recycling service. However, not all large garbage can be counted as “big garbage.” Some garbage that the government refuses to directly handle can only be found with the help of professional enterprises, and the expenses are self-care.

There are almost no trash cans on the streets of Japan. There are many different kinds of metal trash bins in schools, such as galvanized bins with lids, galvanized trash bins, galvanized steel bins, etc. If you throw rubbish at will, you will be fined more than 10,000 yuan and fined. For example, according to Article 25, paragraph 14 of the “Waste Disposal Law”: Those who discard waste indiscriminately will be punished with imprisonment of up to 5 years and a fine of 10 million yen. If a company or legal person discards it, a heavy fine of 300 million yen will be imposed.

Figure 2.6 Paper waste classification situation, Japan
### 2.1.5 Classification of Medical Waste in Europe

Waste classification, as shown in the following table:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious waste</td>
<td>Waste contaminated with blood and other body fluids (for example, waste from discarded diagnostic samples), cultures of laboratory work and stocks of infectious agents (for example, autopsy and waste from infected animals in the laboratory) ) Or infected patients' waste (such as swabs, bandages and disposable medical devices);</td>
</tr>
<tr>
<td>Pathological waste</td>
<td>Human tissues, organs or body fluids, body parts and contaminated animal carcasses;</td>
</tr>
<tr>
<td>Sharp waste</td>
<td>Syringes, needles, disposable scalpels and blades, etc.;</td>
</tr>
<tr>
<td>Chemical waste</td>
<td>Such as solvents and reagents used in laboratory preparations, disinfectants, sterilants, and heavy metals contained in medical devices (such as mercury from broken thermometers) and batteries;</td>
</tr>
<tr>
<td>Drug waste</td>
<td>Expired, unused and contaminated drugs and vaccines;</td>
</tr>
<tr>
<td>Cytotoxic waste</td>
<td>Wastes containing genotoxic substances (that is, highly dangerous substances that are mutagenic, teratogenic or carcinogenic), such as cytotoxic drugs and their metabolites used in cancer treatment;</td>
</tr>
<tr>
<td>Radioactive waste</td>
<td>Such as products contaminated with radionuclides, including radioactive diagnostic materials or radiotherapy materials;</td>
</tr>
<tr>
<td>Non-hazardous</td>
<td>Waste that does not constitute any specific biological, chemical, radiological or physical hazard.</td>
</tr>
</tbody>
</table>

*Figure 2.7 Waste classification*
The medical waste treatment technology used in Europe-combined incineration, high temperature steam sterilization, incineration-high temperature steam sterilization, mechanical-chemical disinfection, microwave radiation, pointed out that the incineration method is currently the first choice for the treatment of hazardous waste. Method, the new treatment technology combining incineration and steam sterilization is the most effective way to manage and treat hazardous medical waste. In view of the particularity of medical waste, the pre-combustion control must be carried out when it is incinerated together with urban waste. A combined incineration system for urban waste and medical waste is proposed.

Figure 2.8 medical waste classification

Figure 2.9 medical waste box

Figure 2.10 medical waste packaging
Generally, there are four main types of medical waste. What are they and how to deal with them?

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>General medical waste</td>
<td>General medical waste is the vast majority of medical waste in facilities and is not generally considered hazardous. These include paper, plastic and office waste. These can be processed on a regular basis without any special treatment.</td>
</tr>
<tr>
<td>Infectious medical waste</td>
<td>As the name suggests, infectious wastes are wastes: wastes that may pose a risk of infection to humans, animals, and the entire environment. This includes blood-stained bandages, sharp waste, surgical waste, human body or body parts, cultures and swabs. Each state has comprehensive rules for infectious disease management, including requirements for storage, transportation, disposal, permits and processing.</td>
</tr>
<tr>
<td>Hazardous medical waste</td>
<td>Hazardous waste is hazardous waste, but it is not infectious to humans. Believe it or not, sharp pens also fall into this category. At least sharp pens that have not been used are because they have the ability to pierce or harm the user. Chemotherapeutics and chemicals (such as solvents, mercury in thermometers, and lead in paint) fall into this category.</td>
</tr>
<tr>
<td>Radioactive medical waste</td>
<td>In short, radioactive waste is waste that contains radioactive materials. In the medical setting, this includes radiotherapy used for radiation therapy (such as th stress testing) and other nuclear medicine therapies used to treat certain cancers. Nuclear medicine uses radiation to provide diagnostic information about the function of specific human organs or to treat them.</td>
</tr>
</tbody>
</table>
• Medical waste must be collected by a licensed medical waste transporter, because waste disposal is strictly monitored and regulated in most states. The waste must be treated and made harmless before recycling or discarding it.

**Incineration of medical waste**

Before 1997, more than 90% of potentially infectious medical waste was incinerated. In August 1997, due to serious concerns about the harmful air quality that affects human health, the EPA issued regulations that set strict emission standards for medical waste incinerators. The EPA’s Air Quality Program and Standards Office continues to review and revise the hospital’s medical infectious waste incinerator (HMIWI) standards in accordance with the latest requirements in May 2013.

**Potential alternatives to incineration of medical waste include:**

• Heat treatment, such as microwave technology;
• Steam sterilization, such as autoclaving;
• Electropyrolysis; and
• Chemical mechanical systems, etc.

It is important to note that not all medical waste can be packaged together, so medical waste must be separated into containers for compliance reasons.

**The World Health Organization (WHO) divides biomedical waste into eight categories, including:**

• General waste
• Infectious or hazardous waste
• Radioactive
• Chemicals
• Pathological
• Pressurized container
• Medicines

OSHA requires that when classifying medical waste, the following items must be marked and clearly marked:

• Contaminated sharp objects must be placed in puncture-proof, sealable, leak-proof, labeled or color-coded containers;

• Specimens of blood or other biohazardous materials must be placed in labeled, color-coded and airtight containers before they are stored, transported or transported.

• The label must contain a biohazard symbol, fluorescent orange or orange-red, with letters and symbols in contrasting colors, and be attached to the container as closely as possible with adhesive or wire to prevent loss or removal.
In Japan, waste management practices are carried out in accordance with the Waste Disposal Act of 1970. In 1992, the first rule of infectious waste management was stipulated, and infectious waste was defined as waste generated by medical institutions in medical institutions. Care or research involving pathogens that may spread infectious diseases. The Ministry of Environment issued revised infectious waste management standards in 2004. The place where the waste is generated; the type of infectious disease. It is expected to reduce infectious waste.

Waste from medical institutions is divided into infectious and non-infectious. The characteristics of infectious waste are divided into the form of waste, the place where the waste is generated and the type of infectious disease. The revised guidelines define infectious waste as follows:

The form of waste. The following waste materials are defined as infectious waste:
- Blood and body fluids.
- Tissues, organs and body parts.
- Sharp objects are contaminated by blood and body fluids.
- Testing equipment and cultivation of infectious agents.

Infectious waste includes infectious pathogens produced by laboratory work. Waste from veterinary clinics is also included in infectious waste.

Regarding the disposal methods of medical institutions, medical institutions sign contracts with specific businesses authorized by the county government to collect, transport and incinerate infectious waste. All infectious waste must be separated from other waste. The waste disposal staff of medical institutions collect all infectious wastes from special storage locations and transport them to restricted areas. The special infectious waste business (contractor) collects these wastes. Waste workers wear gloves and masks at work. The contractor transports the infectious waste directly to the incinerator authorized by the county government, and the waste is burned above 800 degrees Celsius immediately after collection.
Figure 2.12 Flow chart for identifying infectious waste
Various incinerators that control the production of dioxins
In addition to harmful bacteria and viruses, medical waste also contains vinyl chloride and organochlorine chemicals. Simple incineration may generate hydrogen chloride and dioxins. Japan has strict regulations on the production of dioxin, and has adopted measures to reduce dioxin through the structure, operation method and dioxin elimination system of the incinerator, and use an incinerator specifically for medical waste to reduce gas Dioxin content in emissions.

Furnaces used as medical waste incinerators to control dioxin emissions include gasifiers, kilns and vertical furnaces that can safely and completely burn waste.

According to the "Waste Disposal and Public Cleaning Law", infectious waste is designated as specially controlled waste and must be disposed of as shown in the figure on the right.

The law stipulates that the treatment of infectious waste is as follows:
In measures 3 to 5, waste must be decomposed and fully disinfected so that infectious pathogens cannot spread in the air. In Measure 1 or 2, the gas temperature in the incinerator must be maintained at 800°C or higher, and when the incinerator's processing capacity is less than 2t/hour, the dioxin should be 5ng-TEQ/m3 or lower.

- Burn in an incinerator
- Melting in melting equipment
- Autoclave sterilization
- Sterilize with dry heat sterilizer
- Disinfection method

Figure 2.13 Dry distillation gasification compact incinerator, Japan
Conclusion
1. For macro classification, China, the European Union, Japan, and the United States all classify waste according to the source of generation and/or hazardous characteristics. The advantage is that it is easy to distinguish the corresponding responsibilities and focus on the importance of management by environmental authorities.

2. For the micro-level waste classification, there are various classification methods, and the material-oriented and process-oriented classification systems are widely used. A process-oriented classification system can help waste generators to judge the nature of waste very easily, and make the management process simpler and more feasible.

For EWC, it is easy to identify or identify the relevant waste codes to be used, as there are approximately 850 different entries in the catalog. In this way, registration can provide very detailed information. The disadvantage is that the production process will continue to change, some typical processes will disappear, and new processes will appear.

This requires corresponding adjustments to the list.
For a substance-oriented classification system, it is very simple and efficient for generators or managers who have a solid knowledge and understanding of all regulations and production processes. The multi-directional classification method of parallel layers may overlap with different waste categories and should be used with caution.

3. In the waste treatment process, all countries and regions adopt similar classification methods, such as recycling and disposal. However, the European Union and the United States have classified treatment methods in more detail.

We analyzed the waste classification in the European Union, Japan and the United States, and listed the imaginable pros and cons in the table. They may need further comparison. From a systematic point of view, Japan's waste classification system is more integrated not only at the macro level, but also at the micro level.

From the perspective of hierarchical structure, the European Union has a clear multilayer structure, while
Japan has a clear secondary structure. From the perspective of practical operability, the European Union's waste classification system is easier to use, while the Japanese waste classification system requires a certain degree of expertise in the chemical and physical characteristics of waste. From the perspective of scalability, the EU classification system is superior to the other two systems.

**Environmental impact**

The treatment and disposal of medical waste may indirectly cause health risks by releasing pathogens and toxic pollutants into the environment.

- If the landfill is not constructed properly, disposing of untreated medical waste in the landfill will cause contamination of drinking water, surface water and groundwater.

- If chemicals are not handled, stored, and disposed of in an environmentally sound manner, the use of chemical disinfectants to treat healthcare waste can result in the release of chemicals into the environment.

- Waste incineration is widely practiced, but insufficient incineration or incineration of inappropriate materials can cause pollutants to be released into the air and produce ash. Incineration materials containing chlorine or treated with chlorine will produce dioxins and furans, which are human carcinogens and are associated with a series of adverse health effects. The incineration of heavy metals or materials with high metal content (especially lead, mercury and cadmium) can cause toxic metals to diffuse in the environment.

- Only modern incinerators that operate at temperatures of 850-1100°C and equipped with special gas cleaning equipment can meet the international emission standards for dioxins and furans.

- When there are sufficient resources in the environment to operate and maintain the system and dispose of the treated waste, alternative methods of incineration, such as autoclaving, microwave treatment, and steam treatment combined with internal mixing, should be considered to maximize the reduction of formation and release of chemical substances or harmful emissions.
The way forward

The management of health waste requires more attention and effort to avoid the adverse health consequences associated with bad practices, including exposure to infectious and toxic substances. The key elements to improve medical waste management are:

- Promote the reduction of waste generation and ensure the proposer's waste separation practices;

- Develop strategies and systems, and carry out strong supervision and supervision to gradually improve waste classification, destruction and disposal practices, with the ultimate goal of reaching national and international standards;

- Where feasible, instead of incineration of medical waste, the safe and environmentally sound treatment of hazardous medical waste is advocated (for example, through autoclaving, microwave treatment, steam treatment combined with internal mixing, and chemical treatment)

- Establish a comprehensive system for handling responsibilities, resource allocation, processing and disposal. This is a long-term process and needs to be improved gradually.

- Raise awareness of the risks and safety practices associated with medical waste;

- Choose a safe and environmentally friendly management plan to protect people from hazards when collecting, processing, storing, transporting, processing or disposing of waste.

WHO's response

The WHO has developed the first global comprehensive guidance document, "Safe Management of Wastes from Health Care Activities", which is currently published in its second edition, and recently is a short guide that outlines the key elements.

- Safely manage waste from healthcare activities

The guide covers the regulatory framework, planning issues, waste minimization and recycling, treatment, storage and transportation, treatment and disposal options, and training. This document is aimed at managers, decision makers, public health professionals and managers involved in waste management in hospitals and other medical institutions. In addition, as part of the monitoring of Sustainable Development Goal 6 on the safe management of water and sanitation facilities, the World Health Organization/UNICEF joint monitoring
program will regularly report on the safe management of medical waste as part of the safety management of water and sanitation in health care facilities. The facility is part of a broader monitoring.

In collaboration with other partners, WHO has also developed a series of training modules on good practices in health waste management, covering all aspects of waste management activities, from the identification and classification of waste to guiding the use of non-incineration or incineration strategies for safe disposal considerations factor. It also provides WHO guidance documents on medical waste, including:

- Monitoring tools;
- Cost assessment tools;
- Quick assessment tool;
- Policy documents;
- Guide the formulation of national plans;
- Manage waste from injection activities;
- Waste management in primary health care centers;
- Manage waste from mass immunization activities; and
- Waste management in emergency situations.

In addition, WHO and UNICEF launched a global initiative with partners in 2015 to ensure that all health care facilities have adequate water, sanitation and sanitation services. This includes addressing medical and health waste.

Figure 2.14 The six administrative regions of WHO
References


In this chapter, a total of 12 cases were studied, including machines, new technologies, Internet management systems, Internet of Things management systems, smart trash cans, etc. If these technologies can be combined reasonably and effectively, it will be an expected new system design.
CHAPTER 3
The role of innovation in the waste world
3.1 Case study

Main types of case studies conducted basic types of alternative treatment technologies and operations management solution.

3.1.1 Basic types of alternative treatment technologies

A wide range of alternative technologies are now commercially available. Steam sterilization in autoclaves is autoclaves the most common alternative treatment method. Since autoclaves have been used in the treatment of infectious waste for many decades, their operation is well established. Several types of steam sterilizers or autoclaves are available: gravity-fed, pre-vacuum and pulse or multivacuum cycle autoclaves. Unlike incinerators, autoclaves heat the waste to temperatures high enough to disinfect but not hot enough to burn and create air pollutants such as dioxins and furans.

Autoclaves specifically designed for waste are generally much larger and have a horizontal configuration to make it easier to load and remove waste. A major difference is the container used for autoclaving. Autoclaves for medical devices often use trays or stainless steel baskets, while waste autoclave use autoclavable carts or bucket-shaped open containers into which the plastic waste bags are stacked. Depending on the type of plastic bags used, some bags may melt and stick to the surfaces of the cart or container. Use of autoclavable plastic bags or liners that prevent sticking is an option.

A post-treatment shredder or grinder could be used if the waste is to be rendered unrecognizable and if reduction of waste volume is desired. Advanced single- or multiple-shaft shredders specially made for medical waste are capable of reducing waste volume by about 80%. The advanced
shredders are typically low-speed, The advanced shredders are typically low-speed, high-torque, single-pass shredders with easily replaceable cutters and with discharge screens to control the size of shredded waste. In the last few decades, a second generation of advanced steam based systems has been developed for the purposes of improving heat transfer, decreasing the processing time, achieving more uniform heating of the waste and eliminating cold spots, rendering the waste unrecognizable, reducing waste volume significantly, making most of the operation automatic, and/or making the treatment system a continuous process. These advanced treatment technologies combine steam treatment with vacuuming, internal mixing or fragmentation, internal shredding, post-treatment drying, and compaction.

Microwave treatment is another type of alternative technology. For years, the most common microwave device has been a medium- to large-scale, semi-continuous system using an internal shredder, rotating internal screw, and industrial magnetrons to generate microwave energy. The semi-continuous microwave unit has the advantage of low operating costs and no liquid effluent but the treated and shredded waste comes out moist. The semi-continuous system has its own steel enclosure and can be installed outside a building. Small batch microwave units are now also available and can be used in small hospitals, clinics or in departments of a large hospital. Microwave units generally have higher capital costs than standard autoclaves.

In this type of research, we mainly study the machines and new technologies used in modern hospitals, analyze the advantages and disadvantages of various types of machines, the types of waste processed, the time and weight of medical waste processing of a machine, and the input and output of the machine. The temperature required by the machine to process waste, that is, the heat generated by a machine, if the conversion produced meets the requirements of cogeneration, we can also carry out heat recycling on this basis.
NAME 125 - 1400 Litre square Chamber autoclaves
COMPANY Astell Scientific Ltd
TYPE Steam sterilization
BRIEF DESCRIPTION
Autoclaves provide a physical method for disinfection and sterilization. They work with a combination of steam, pressure and time. Autoclaves operate at high temperature and pressure in order to kill microorganisms and spores.
COUNTRY England, Algeria, Argentina, Brazil, Cyprus, Denmark, Egypt, France, Guyana, Honduras, Hungary, Japan, Lebanon, Mexico, Morocco, New Caledonia, Poland, Reunion Island, Russia, Saint Lucia, Spain, Tunisia, Uk

DURATION(MINUTES) 15-35(8100kg)
TEMPERATURE 134°
DISPOSABLE WASTE TYPES
• Liquids (e.g. Culture Media, Reagents, etc)
• Laboratory Waste (e.g. Discard)
• Glassware and Unwrapped Instruments
• Wrapped Instruments and Fabrics
• Hazardous Waste (e.g. BSL3)
INPUT
• Medical waste
• Electricity
• External steam supply
OUTPUT
• Exhaust gas
• Wastewater
• Sterile and non-toxic medical waste

Figure 3.1 125 - 1400 litre square chamber autoclaves
**ADVANTAGE**

1. Integrated steam generator
   By introducing steam between vacuum pulses, air is forced out of the autoclave chamber under pressure; the best method for removing air from porous type loads and discard waste. Following the sterilization stage, a post vacuum removes the steam from the chamber.

2. Energy saving
   ‘Heaters in chamber’ models have ‘media holdwarm’, a feature that uses the heaters to hold sterilized media at a set temperature until it is to be used.

3. Easy to operate and monitor
   5.7” colour touchscreen controller with USB connectivity; allows users to edit cycle parameters, store and recover historic cycle data, add security levels with user passwords and more.

4. Safe for operators
   Industry-standard safety features to ensure the well-being of both the sterilizer and its operators; including external pressure gauge, over pressure and over temperature protection, a safety-linked door mechanism and thermally insulated doors.

5. Advanced water cooling
   Advanced Water Cooling offers substantial sterilization cycle time savings.

**DISADVANTAGE**

1. Need a lot of water
   The machine running process requires a lot of water for pressurization and heating. The output of harmful wastewater requires additional treatment.

2. Output of harmful exhaust gas
   An effluent retention system would also be a requirement, which would include a bacteriological HEPA filter on the exhaust, preventing dangerous pathogens from entering the atmosphere.

Figure 3.2 Square MAX autoclaves
NAME  Ininnovative solution for biomedical waste management
COMPANY  Bertin medical waste technologies s.A.S
TYPE  A post-treatment shredder
BRIEF DESCRIPTION  Its innovative concept uses a suspended vessel and rotating grinder blades to grind down all types of waste. Biohazardous waste is sterilised using microwaves and converted into inert municipal waste. The end product is similar to municipal waste and can then be fed into standard urban waste systems.
COUNTRY  France
DURATION(MINUTES)  32-35(1400kg)
TEMPERATURE  110°

DISPOSABLE WASTE TYPES
Adapted to any type of medical waste
• Hospital and laboratory waste
• Solid and liquid medical waste
• Human and animal pathological waste
• Sharps and prickly hospital waste with their containers
• Cultures and stocks
• Any other waste listed in state and federal regulations as medical waste.

INPUT
• Medical waste
• Electricity

OUTPUT
• Compact, inert & dry waste
Combustible material (Refuse-Derived Fuel)

Figure 3.3  Ininnovative solution for biomedical waste management
THE ROLE OF INNOVATION IN THE WASTE WORLD

**ADVANTAGE**

1. **Full decontamination**
   Biohazardous waste is sterilised with microwaves (heat it up to 110°C for 20 minutes) and allows microbial inactivation of up to 8log10.

2. **No liquid effluent**
   The treatment process does not produce any steam or liquid effluent, which means no consumption of water and no need to include an effluent drainage system in its installation.

3. **Easy maintenance**
   The equipment is built using robust technology. IP connection for diagnostics. Preventive maintenance plan/calendar with alarm.

4. **Safe processing**
   Microwave sterilisation technology does not require pressurisation, and this removes any risk of explosion. Moreover, the microwaves are confined to the inside of the vessel to avoid operator exposure to radiation.

5. **No segregation**
   The Sterilwave is suitable for all types of biomedical waste (needles, glass, solids, liquids, etc.)

6. **Reduces weight by 25% and volume by 80%**
   Biomedical waste is converted to inert waste similar to municipal waste. The dry ground-up waste can also be used as secondary fuel.

---

**DISADVANTAGE**

1. **Treated waste still needs to be transported to a waste**

---

*Figure 3.4 Process description*

*Figure 3.5 Actual operation*
NAME Meteka hygiene and infection prevention system

COMPANY METEKA GmbH

TYPE Microwave treatment

BRIEF DESCRIPTION
Safe disinfection with microwaves, waste treatment is done by heating the waste in the collection / transport container "from the inside" without contact by the microwave radiation. This special, patented technology is used in all medister waste decontamination devices.

COUNTRY Austria

DURATION(MINUTES) 45(350kg)

TEMPERATURE -

DISPOSABLE WASTE TYPES
• Infectious waste

INPUT
• Infectious waste
• Electricity
• Water

OUTPUT
• Harmless waste assimilated with municipal waste
• Harmless wastewater
• Carbon dioxide

Figure 3.6 Medister®160
THE ROLE OF INNOVATION IN THE WASTE WORLD

**ADVANTAGE**

1. **Safety**
   Infection can be prevented by collecting and decontaminating the infectious waste in the collection and transport container directly at the point of origin. Both hospital and waste disposal personnel and patients are protected from injuries and infections.

2. **Economical & environmentally friendly**
   Low energy and water consumption. The volume of waste can be reduced by 30-50%. No chemicals necessary. No air pollution.

3. **Maximum reliability of waste treatment**
   The special microwave technology ensures that the waste is heated evenly, even if the waste material is inhomogeneous.

4. **Easy and comfortable operation**
   Safe and ergonomic front loading system, easy installation, fully automatic program execution, short cycle times, low noise, simple operation.

5. **Easy and comfortable operation**
   Perform cycle recording on internal memory, read cycle data through USB interface, built-in printer, statistical analysis, QR code recognition with scanner.

**DISADVANTAGE**

1. **Single type of medical waste that can be treated**
2. **Produce carbon dioxide**
3. **Produce wastewater**

![Figure 3.7 System use process](image)
NAME Resomator - the alkaline hydrolysis machine
COMPANY Bio-Response Solutions
TYPE Alkaline hydrolysis technology
BRIEF DESCRIPTION
Technology which combines steam sterilization with tissue digestion using sodium or potassium hydroxide. These technologies are designed to destroy anatomical parts, organs, tissues and animal carcasses, and leaving behind a “bone shadow” of calcium. Alkaline hydrolysis can also destroy many chemotherapeutic or cytotoxic agents, and aldehydes (such as formaldehyde and glutaraldehyde) commonly used in hospitals.
COUNTRY United States
DURATION (MINUTES) 90
TEMPERATURE 52°
DISPOSABLE WASTE TYPES
Pathological waste, Chemical waste

- Anatomical parts
- Organs
- Tissues
- Animal carcasses
- Many chemotherapeutic
- Cytotoxic agents
- Aldehydes (such as formaldehyde and glutaraldehyde)

INPUT
- Pathological waste
- Chemical waste
- Potassium hydroxide / sodium hydroxide
- Water
- Electricity

OUTPUT
- Green-brown tinted liquid (containing amino acids, peptides, sugars and salts)
- Soft, porous white bone remains (calcium phosphate)

Figure 3.8 Resomator - the alkaline hydrolysis machine
**ADVANTAGE**

1. Environmentally friendly
   This is a "green cremation" that does not produce harmful gases.

2. Easy to operate
   Pathological waste does not require pretreatment, just put it in the machine and press the switch.

3. Non-toxic and sterile
   Pathological waste does not require pretreatment.

**DISADVANTAGE**

1. Use a lot of chemicals
2. Use large amounts of water
NAME GM1300 medical incinerator
COMPANY Addfield Environmental Systems Ltd.
TYPE Dry heat treatment technologies
BRIEF DESCRIPTION
The GM1300 medical incinerator is a highly powerful, robust, incineration system. It’s top loading design is sized to ensure large waste loads of medical, biological, pathological and clinical waste are treated in a fast efficient manner.
COUNTRY United Kingdom
DURATION(MINUTES) -(1300kg)
TEMPERATURE 1100°
DISPOSABLE WASTE TYPES
• Clinical waste
• Treated waste
• Anatomical waste
• Cytotoxic & cytostatic waste
• Off ensive/hygiene waste
• Medicinal waste
• Domestic (municipal) waste
INPUT
• Medical waste

• Electricity
• Diesel/LPG/ Natural Gas,/Bio Fuel
OUTPUT
• Fly ash
• Exhaust gas

ADVANTAGE
1. Efficient
GM range of incinerators are up to 40% more efficient than other machines, saving fuel and money. Pulse firing burners save fuel, ramp burners allow for a controlled burn, class leading 180MM refractory lining, Excess air system aids combustion with additional oxygen.
2. Robust
Manufactured from 8mm &10mm steel, front protection ram guard, impact/abrasion resistant loading zone.
3. Many types of applicable waste

DISADVANTAGE
1. Produces harmful exhaust gas
2. Need to use a lot of fuel

Figure 3.12 Use scene of incinerator
Figure 3.13 High Capacity Clinical Waste incinerator machine Addfield C200.
3.1.2 Operations management solution

In this type of research, we mainly study the medical waste management system used in some hospitals in China, which includes the use of network systems, the use of real-time monitoring systems, and the use of traceability systems.

NAME Medical waste management system
COMPANY EWELL-China Medical Technology Co., Ltd.
USE HOSPITAL China’s Yifu Hospital, People’s Hospital of Zhejiang Province, China, Third People’s Hospital of Hangzhou, China, Beilun Hospital of Traditional Chinese Medicine, Ningbo Sixth Hospital of China, Kecheng People’s Hospital of Quzhou, China, Shandong Provincial Hospital, China
BRIEF DESCRIPTION Based on the Internet of Things and cloud technology, the medical waste management system truly pays attention to the effective traceability management and bar code management of the life cycle of medical waste classification, packaging, temporary storage, transportation, transit, processing, etc.

✔ ADVANTAGE
1. Reduce environmental impact
Reduce environmental damage caused by losses in the waste recycling process.
2. Improve employee and patient safety
3. Protect confidentiality
Prevent sensitive waste from being mishandled or misused. Standardize the waste recycling process and information management of the entire waste management process.
4. Reduce operating costs
Waste weighing, handover process traceability, fine-grained management of classification, automatic generation of cloud reports. Using mobile terminals such as PDAs, with intelligent identification, mobile computing technology, easy to operate, only need to scan, confirm, and truly achieve zero input.

⚠️ DISADVANTAGE
1. Still harmful to the environment
The pre-cleaning of some medical wastes still uses a lot of chemical products, and the pollution of water has not changed.
2. The output rate has not changed
This method does not reduce the generation of medical waste, and still requires a large number of vehicles for transportation and treatment.
Figure 3.14 EWELL-Flow chart of medical waste management system
NAME Medical waste management system
COMPANY SUPERSENSE-China Technology Co., Ltd.
USE HOSPITAL The “Internet Plus” medical waste real-time tracing cloud platform based on IoT technology can track the entire life cycle of waste. Achieve the whole process positioning and monitoring of medical waste disposal, thereby greatly enhancing medical safety management.

BRIEF DESCRIPTION
Its innovative concept uses a suspended vessel and rotating grinder blades to grind down all types of waste. Biohazardous waste is sterilised using microwaves and converted into inert municipal waste. The end product is similar to municipal waste and can then be fed into standard urban waste systems.

ADVANTAGE
1. Reduce environmental impact
Reduce environmental damage caused by losses in the waste recycling process. The system uses barcode identification technology, satellite positioning technology, and EDI (electronic data interchange technology) to effectively and real-time monitor the entire life cycle of medical waste from "cradle to grave".

2. Improve employee and patient safety

3. Protect confidentiality

4. Reduce operating costs
Waste weighing, handover process traceability, fine-grained management of classification, automatic generation of cloud reports. Using mobile terminals such as PDAs, with intelligent identification, mobile computing technology, easy to operate, only need to scan, confirm, and truly achieve zero input.

DISADVANTAGE
1. Still harmful to the environment
The pre-cleaning of some medical wastes still uses a lot of chemical products, and the pollution of water has not changed.

2. The output rate of waste has not changed
This method does not reduce the generation of medical waste, and still requires a large number of vehicles for transportation and treatment.
Figure 3.15  SUPERSENSE-Flow chart of medical waste management system
A university study out of India titled "Waste Management in IoT-Enabled Smart Cities: A Survey" contends that "The new era of Web and Internet of Things (IoT) paradigm is being enabled by the proliferation of various devices like RFIDs, sensors, and actuators. Smart devices (devices having significant computational capabilities, transforming them into ‘smart things’) are embedded in the environment to monitor and collect ambient information. In a city, this leads to Smart City frameworks.”

Smart cities are defined by three characteristics:
- They increase their operational efficiency through information and communication technology.
- They use that technology to share information with the public.
- They improve their residents’ welfare using data and technology.
Globally, the number of smart cities is on the rise. In 2013, the world hosted 21 smart cities. By 2025, futurists that number to hit 88. Rising human populations in urban areas are necessitating the adoption of IoT technology for processes like waste management. Smart cities are emerging not only for waste economic but also for environmental reasons. The world relies on technology. The links between smart technology and sustainable development are not impractical theories of the future. They are immediate economic realities, and these links are leading to a greater demand for the Internet of Things (IoT) and more efficient, technology-directed waste management. Examples of smart city waste management tools include sensors for capacity and weight, RFIDs, and WSNs.

Smart City technology evolved together with the developments in wireless sensor networks (WSN) and the Internet of Things (IoT). Smart cities essentially combine the use of ICT to provide services for better living conditions inside cities. The current state of technology in the field of smart waste management involves the use of sensors that measure the fill level of the trash bin. Measured data is sent to the Cloud for further processing and analysis. By exploiting this data, trash collection can be planned as well as truck routes can be optimized. The improvement of the urban waste collection service and, in general, the achievement of a more efficient management of the waste, is one of the main challenges that the cities face, especially due to the population growth. Thus, smart waste management is a key factor of smartcities.
3.2.1 5 smart cities and their smart trash cans that use IoT to achieve efficient waste management

CITY Singapore
CITY SITUATION
Singapore ranked first in the Global Smart City Performance Index 2017. The index graded cities on how well technology improved citizen life in four areas – mobility, health, safety and productivity.
2016, Singapore began experimenting with smart, solar-powered rubbish bins that served as internet hotspots and came equipped with fill-level sensors. At the same time Singapore was the first smart city to implement the intelligent rubbish bin concept. 2018, Singapore hosts 7,000 public waste bins.
NAME The solar-powered smart compacting BigBelly bin
TIME 2016
DESCRIPTION
Bigbelly bins have an internal compactor to crunch rubbish and can handle about five times more trash than another of a similar size. They have an enclosed design that prevents scavengers, pests and odours, and are connected wirelessly for easy monitoring and management.

Once the bin is full, its sensors will detect and send, via 3G, email or text message alerts to the mobile phones of cleaners. Because they work on solar energy, the bins have no cabling. The solar panels power an internal battery that drives the compaction mechanism, internal sensors and the communication module. A fully charged battery can power the bin for about three months without sunlight.

Figure 3.18 The solar-powered smart compacting
CITY Barcelona

CITY SITUATION
Perhaps best recognized for its globally renowned soccer team, Barcelona was also one of the earliest cities to adopt the smart approach to urban development. According to the Financial Times, “The Spanish metropolis has long had a reputation for being at the forefront of urban technological innovation. With a municipal network of 500 km of optical fibre, free WiFi routed via street lighting, and sensors to monitor air quality, parking spaces and even waste bins, Barcelona has been at the cutting edge of testing the Internet of Things (IoT).”

Prior to its smart commitment, Barcelona spent 1.5 billion Euros over four years to manage waste and recycling. 2018, however, the city has committed itself to reducing these costs through home-based recycling and fill-level sensors in waste bins. The city now hosts 7,000 public waste bins.

NAME Smart pneumatic waste containers

TIME 2016

DESCRIPTION
The citizens of Barcelona deposit their residential waste into smart bins with the help of smart waste disposal system. These smart bins use a vacuum and suck the waste into underground storage. This reduces the smell of trash waiting to be fetched and the noise pollution from collection vehicles. Through radio frequency and WiFi, the sensor gives data to a central system, detecting the trash level. Sanitation workers can then plan the optimal route and times to collect it. It also enables the city to detect the level of waste that comes from different places and optimize the collection of waste, which decreases both the resources and time needed for this service. The incineration of waste is used later to produce energy for heating systems.
CITY Seoul

CITY SITUATION
Seoul, the capital city of South Korea, is the world’s second largest metropolitan area by population. As a rising global city, it is home to more than half of South Koreans and 632,000 international residents. Seoul boasts 7 UNESCO World Heritage Sites as well as numerous shopping centers and cultural attractions which draw a lot of international tourists. Already home to more than 10 million residents, Seoul proudly calls itself the “Soul of Asia.” It’s a smart soul, too, with one publication saying, “In many ways, the city of Seoul is both a blueprint ‘how-to’ guide for smart city development and a petri-dish for technological experiments.”

The local government was facing a challenge with frequent waste management, collection and overflow issues. With an inadequate number of public waste bins and with four to five daily waste collections proving to be insufficient, the Seoul metropolitan government had a serious challenge regarding waste management and collection. Furthermore, because the waste collection planners did not know how full or how quickly the bins became full, Seoul’s waste collection staff had to deal with plastic bottles and paper cups that continuously piled up on top of recycling bins.

NAME Clean Cube bins
TIME 2014
DESCRIPTION
Clean Cubes bin for general waste and recyclables. The managers of the public cleanliness department utilized Clean City Networks (CCN) to monitor the status and fill-level of Ecube Labs’ Clean Cubes and observe the collection efficiency throughout Seoul. Clean City Networks (CCN) is an integrated waste management platform designed to optimize the efficiency of waste collection. CCN provides a comprehensive collection of historical data and analytics reports. It also allows users to monitor Clean Cubes in real-time.

The city introduced smart waste solutions by installing Clean Cubes, a solar-powered waste compaction bin with embedded sensors. This solution has reduced Seoul’s waste collection costs by about 85%.

Figure 3.20 Clean Cube bins in Seoul
CITY Seattle

CITY SITUATION
PHome to tech giants like Microsoft and Amazon, Seattle gives off a geeky, techno-future vibe, and it has, in fact, established a plan to become a smart city. Seattle’s smart city waste management strategies include recycling initiatives, a stable rate path, and a revamped transfer station.

NAME In IoT-based waste management technology

TIME 2018

DESCRIPTION
Sensa Networks utilizes machine-to-machine (M2M) wireless communications to allow for the automation and optimization of these waste management operations. This, in turn, enables organizations to achieve significant cost savings and operational efficiency. Sensa can automatically schedule pick-ups and issue purchase orders to haulers only when compactors reach a specified fullness level, eliminating the cost of unnecessary collections while at the same time reducing your organization’s carbon footprint. All of this is managed through an innovative web-based remote monitoring platform that can be accessed by multiple stakeholders throughout your organization. All data is in real time and accessible 24/7.

Figure 3.21 Smart trash can in Seattle

Figure 3.22 Smart pneumatic waste containers in Barcelona
Global Zero Waste initiatives and challenging environmental issues resulted in national waste separation, reuse & recycle programs. Considering modern day market requests, Binology introduces smart IoT solution for efficient urban waste separate collection – SmartCity Separation Station 3.

It is a self-sustainable solar paneled urban rubbish separation station, which consists of two and up to ten allied trash containers for manual separation of such valuable recyclables as: paper and cardboard, recyclable plastic, metal, glass etc. The central element of the station is the container for landfill waste, with compaction feature, while satellite containers are non-compacting, but all equipped with own fullness level advanced sensor system. Using SmartCity Management software, becomes simple to recognize the amount of each type collected waste.

Integrated press feature, allows reducing waste volume by up to 8 times for the landfill waste container.

Clean recyclable materials. As the result of SmartCity Separation Station implementation helps to collect and store sorted waste to essentially reduce the manual work on waste sorting facilities. Due to the simple manual sorting of the rubbish, generated from intensive pedestrian traffic, the accumulated recyclable materials are clean and won’t require additional washing and high amount of cleaning chemicals.

Online monitoring. As a key feature of SmartCity Management Cloud App allows a real-time data collection just as for all installed smart bins and stations, so for each satellite container. Fill-level data for each satellite container of Separation Station is separately collected indicated by color on the dashboard. The task management feature allows considering types of the collected waste for smart routing.

Figure 3.23 Binology smartcity bin
THE ROLE OF INNOVATION IN THE WASTE WORLD

Build-in vertical press allows up to 8 times waste compaction. Used only for landfill trash in the first section of SCST 2.

Build-in vertical press allows up to 8 times waste compaction. Used only for landfill trash in the first section of SCST 2.

Binology software designed for separation tasks, identifies and marks each satellite container collected type of waste.

Each container in SCST 2 equipped with own sensor system enable fill-level tracking for each waste type.
3.3 Analyze the advantages after innovation

Through the analysis of case studies, the most innovative and functional products can be extracted from the determined technologies.

It can be inferred from the comparison that the high-value projects in different categories are also the most innovative, and their advantages are more obvious, because they present more innovative technologies, and the final result with less innovation is also worse. The disadvantage will be more obvious.

This chapter combined with the analysis of China’s national conditions in Chapter 1 shows that the post-processing shredder mentioned in 3.1.1 is suitable for use in Xinhua Hospital, and it complies with China’s medical waste treatment regulations, which can effectively reduce waste transportation. Therefore reducing the use of oil and reducing carbon footprint emissions. The medical waste management system mentioned in 3.1.2 uses the technology of the Internet of Things to achieve effective management of medical waste, but it also has certain limitations, that is, the number of medical supplies entering the hospital and the final amount of medical waste generated There is no intuitive management system. Therefore, our future projects will consider solving this problem. The smart trash can mentioned in 3.2 is a foundation of our medical waste management system based on the Internet of Things. Therefore, we plan to select an appropriate one to carry out the renovation of the medical waste trash can of Xinhua Hospital in the future.
Summary

In this chapter, a total of 12 cases were studied, including machines, new technologies, Internet management systems, Internet of Things management systems, smart trash cans, etc. If these technologies can be combined reasonably and effectively, it will be an expected new system design.
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Xinhua Hospital currently uses the centralized treatment method of waste disposal. The disadvantage is that infectious waste must be transported through public roads and increase transportation costs, such as fuel costs. However, it has the advantages of economies of scale and is the method of choice in many industrialized countries. Of course, this is also a relatively traditional old-fashioned treatment method, which is still relatively harmful to energy and the environment. China now also attaches great importance to the treatment of medical waste. China also has a big advantage in the rapid development of the Internet, and its penetration rate is high. So it can be managed through the Internet of Things.
CHAPTER 4

Xinhua Hospital
4.1 Reasons why we choose Xinhua Hospital

Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine was founded in 1958. It is the first comprehensive hospital designed and constructed in Shanghai since the founding of New China. It is a tertiary first-class hospital with complete disciplines and distinctive features, and the number of outpatient and emergency services ranks among the best in Shanghai hospitals. Xinhua Hospital has successively won the honorary titles of National Advanced Group, National Health System Advanced Unit, National Health System Hygienic Culture Construction Advanced Unit, Shanghai Civilized Unit and Shanghai May 1st Labor Award.

Xinhua Hospital covers an area of 109 acres, with a total construction area of 192,000 square meters. It has a complete set of disciplines and distinctive features. It has 60 clinical, medical and technical departments and diagnosis and treatment platforms for internal, external, women's and children's, and more than 2090 open beds. There are more than 2500 staff in the staff. It is the only general hospital in the city's tertiary hospitals that has both perinatal and complete pediatric subspecialties, and is the first batch of national early childhood development demonstration bases.

Xinhua Hospital has a well-equipped

Figure 4.1 Panorama of Xinhua Hospital
emergency building, outpatient and internal medicine building, surgery building, medical care complex, pediatric surgery building, women’s and children’s building, oral dermatology building and medical technology building to provide patients with a comfortable medical environment. The pediatric complex under construction will be TOMO, PET-CT, DSCT (dual-source CT), SPECT, LA, DSA, MRI, integrated laser ultrasound intervention system, argon-helium cryogenic surgery system, mobile intraoperative magnetic resonance imaging system, Medical equipment such as high-pressure (low-pressure) oxygen therapy chamber and excimer laser ensure the quality of diagnosis and treatment.

10 disciplines including General Surgery, Cardiovascular Surgery, Pediatric Surgery, Emergency Medicine Department, Otorhinolaryngology Head and Neck Surgery, Dermatology, Pediatrics Pediatric Respiratory Specialty, Pediatrics of Traditional Chinese Medicine, Laboratory Medicine and Clinical Pharmacy are among the national key clinical specialty construction projects.

Department of Newborn Screening and Genetic Metabolic Diseases, Chinese Genetic Medicine Center, Ministry of Health, Shanghai Pediatric Surgery Clinical Medicine Center, Shanghai Critical Maternal Consultation and Rescue Center, Shanghai Critical Newborn Consultation and Rescue Center, Shanghai Prenatal Diagnosis Center, Shanghai City Children’s Hearing Impairment Diagnosis and Treatment Center, Shanghai Neonatal Congenital Heart Disease Screening, Diagnosis and Treatment Center, Shanghai Rare Disease Diagnosis and Treatment Center, Shanghai Children Rare Disease Diagnosis and Treatment Center, 9 provincial and ministerial diagnosis and treatment centers, and 8 Shanghai Transportation Centers.

Xinhua Hospital has a total of 12 national and Shanghai key disciplines or research bases, including the Ministry of Environment and Child Health Education, Shanghai Key Laboratory, Shanghai Key Laboratory of Pediatric Digestion and Nutrition, and Shanghai Institute of Pediatric Medicine. In recent years, it has won 2 National Science and Technology Progress Awards and 35 provincial and ministerial-level Science and Technology Progress Awards; talent projects above the municipal level, such as the National Ten Million Talent
Project, the Ministry of Education New Century Talents, Shanghai Leading Talents, and Shanghai Excellent Academic Leaders 107 items; 1,218 items of various scientific research topics at all levels; 2062 SCI articles published. There are four medical education departments: Xinhua School of Medicine and Shanghai Jiao Tong University School of Medicine, Department of Clinical Medicine, Department of Clinical Nutrition, Department of Pediatrics, and Department of Otorhinolaryngology. There are 84 doctoral supervisors and 141 master supervisors. The professional academic journals "Journal of Clinical Pediatrics" and "Journal of Educational Biology" sponsored by the hospital are included in many international search databases.

In 2015, Xinhua Hospital formally established a clinical research center, which is the first hospital-based clinical research system in Shanghai to support innovative platform institutions. It has in-depth cooperation with the University of Ottawa School of Medicine in Canada and Harvard Medical School in the United States to gather doctors and clinical trends. Pathologists, clinical pharmacists, and statisticians follow the international scientific level and ethical standards, build a collaborative network of clinical research, promote the quality improvement of clinical research projects, and provide standardized ways for the transformation of clinical medical research results to enrich the clinical research talent pool.

The hospital maintains long-term friendly exchanges and cooperation with top hospitals and scientific research institutions in developed countries such as the United States, France, Canada, etc., strengthens personnel exchanges and academic cooperation in key medical fields, deepens international exchanges and cooperation with projects, and supports and assists Xinhua - The international clinical research cooperation project of the University of Ottawa School of Medicine, the Xinhua-Harvard multidisciplinary cooperation project, the children's solid tumor team and the Australian clinical research cooperation project have entered a new stage. Always guided by the concept of "sharing, win-win, and common development", we will strive to strengthen communication, exchanges and cooperation, consolidate and expand practical collaboration areas, and form a grid-based international academic exchange layout that combines points and faces to internationalize Vision boosts.
boosts the overall development of hospital medicine, teaching, and research.

Xinhua has always adhered to the direction of non-profit medical services, actively promoted the homogeneous development of regional pediatric medical care, and promoted the initial establishment of a pediatric graded diagnosis and treatment system. The construction of Xinhua-Shidong Medical Consortium was awarded the "Innovative Medical Service Brand" in Shanghai. Since its establishment, the Xinhua Hospital Alliance has 28 member units, and has gradually moved from loose cooperation to a model of in-depth and key cooperation. The achievements of the "Thousand-Day Plan" based on the alliance platform have been increasing, and it will continue to try to transform to the Internet to make the Xinhua brand further spread on the Internet.

In summary, the geographic location and medical technology of Xinhua Hospital are all worthy of in-depth study. Moreover, relying on Shanghai Jiaotong University, it has its own corresponding medical scientific research institution, which has more innovative possibilities.
4.2 Some basic data of the hospital

**FULL NAME**  Xinhua Hospital  
Affiliated to Shanghai Jiaotong University School of Medicine  

**ESTABLISHED**  1958  

**ADDRESS**  Xinhua hospital affiliated to shanghai jiaotong university  

**HOSPITAL LEVEL**  Class III  

**COMPETENT AUTHORITY**  Shanghai municipal health and family planning commission  

**HOSPITAL DEAN**  Sun Kun  

**GIURIDIC STATUS**  Non-profit hospital  

**XINHUA HOSPITAL ORGANIZATIONAL STRUCTURE**  
Xinhua Hospital is a large-scale comprehensive hospital with 17 departments, and the Door and emergence department has 54 departments. See Image 4.4 for details.  

**MEDICAL FACILITIES**  
The hospital has more than 2,000 open beds, with TOMO, PET-CT, DSCT (dual-source CT), SPECT, LA, DSA, MRI, integrated laser ultrasound intervention system, argon helium cryogenic surgery system, and mobile intraoperative magnetic resonance imaging system, High-pressure (low-pressure) oxygen therapy cabin, excimer laser and other medical equipment.  

**DIVISION OF DEPARTMENTS**  
A total of 56 departments are divided into five major categories, of which five major categories include surgery, internal medicine, medical technology, pediatrics and other clinical departments.
Figure 4.4 Xinhua hospital organizational structure
We surveyed that Xinhua Hospital in China divided medical waste into seven categories.

Include waste assimilated to urban waste, pathological waste, infections waste, pharmaceutical waste, pharmaceutical waste, damaging waste and chemical waste.

In the first system flow chart, This part is not the responsibility of the logistics department within the hospital, but the regional sanitation.

The amount of pathological waste generated is 13556kg per year, and finally it is transported to Shanghai Longhua Funeral parlor for incineration. Pathological waste includes human waste generated during diagnosis and treatment and medical laboratory animal carcasses. Including discarded human tissues and organs generated during surgery and other diagnosis and treatment; tissues of medical laboratory animals; pathological cuts.

The hospital’s infectious waste and pharmaceutical waste are treated together. The annual waste volume is 836400kg, which is basically delivered to Shanghai Solid Waste Disposal Co., Ltd. for incineration. Infected bed linen set & clothes are transported to Xinhua Hospital Central Office for cleaning, disinfection and sterilization, and reuse. This part is 76290 sets per year, and of course damaging waste is also sent to Xinhua Hospital Central Office for cleaning, disinfection and sterilization, and repeated use. The annual quantity of this part is 80210kg. The hospital has its own sewage treatment system, which treats the sewage from various clinics to meet the standards of domestic sewage, and then reaches the Shanghai Jiading Xincheng sewage treatment plant along the urban sewage pipeline for treatment, and then discharges it into the river for natural reduction.

Pharmaceutical waste includes expired, obsolete, spoiled or contaminated waste drugs. Including: General drugs discarded in batches, such as antibiotics, over-the-counter drugs, etc. Obsolete cytotoxic drugs and genotoxic drugs, including: carcinogenic drugs, suspected carcinogenic drugs, immunosuppressants.
immunosuppressants. Discarded vaccines, blood products, etc.

Infectious waste includes medical waste that carries pathogenic microorganisms and has the risk of spreading infectious diseases. It mainly includes: cotton swabs, drainage slivers, gauze and various dressings; disposable sanitary items, disposable medical supplies and disposable medical equipment; discarded bedclothes; other items contaminated by patients' blood, body fluids and excrement.

Harmful waste includes discarded medical sharp instruments that can stab or cut the human body. Including medical needles, suture needles; various medical sharps, such as: scalpels, scalpels, skin preparation knives, surgical saws, etc.; glass slides, glass test tubes, glass ampoules, etc. The annual amount of chemical waste is 5316kg, and finally it is transported to China State Food and Drug Administration-Shanghai branch for processing.

Chemical waste includes waste chemicals that are toxic, corrosive, flammable and explosive. Including discarded chemical reagents in medical imaging rooms and laboratories; discarded chemical disinfectants such as peracetic acid and glutaraldehyde; discarded mercurysphygmomanometers and mercury thermometers. Medical waste entrusted treatment costs is 195060 euros per year, paid to various medical waste treatment companies.

Office for cleaning, disinfection and sterilization, and repeated use. The annual quantity of this part is 80210kg. The hospital has its own sewage treatment system, which treats the sewage from various clinics to meet the standards of domestic sewage, and then reaches the Shanghai Jiading Xincheng sewage treatment plant along the urban sewage pipeline for treatment, and then discharges it into the river for natural reduction.

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LINEAR PROCRESS - Total analysis current

WASTE ASSIMILATED TO URBAN WASTE

INFECTION WASTE & PHARMACEUTICAL WASTE 836,400kg/year

PHARMACEUTICAL WASTE

DAMAGING WASTE 80,210kg/year

30min/T 121°C

INPUT OUTPUT
Figure 4.5 Xinhua hospital linear process - total analysis current situation
### 2018 Medical Waste Disposal Fees in Shanghai, China

<table>
<thead>
<tr>
<th>Categories</th>
<th>Charge standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medical and health institutions with beds</strong></td>
<td></td>
</tr>
<tr>
<td>Calculated by bed</td>
<td>0.48 €/bed/ day</td>
</tr>
<tr>
<td>Calculated by the weight of medical waste</td>
<td>0.41 €/kg</td>
</tr>
<tr>
<td><strong>Medical and health institutions without beds</strong></td>
<td></td>
</tr>
<tr>
<td>Monthly medical waste weighs more than 100kg</td>
<td>0.41 €/kg</td>
</tr>
<tr>
<td>Monthly weight of medical waste 30-100kg</td>
<td>31.94 €/month</td>
</tr>
<tr>
<td>Monthly weight of medical waste 10-30kg</td>
<td>17.81 €/month</td>
</tr>
<tr>
<td>Monthly medical waste weighs less than 10kg</td>
<td>11.06 €/month</td>
</tr>
</tbody>
</table>

Price linkage mechanism charged by bed:

\[ N = 0.48 \times \frac{M}{1.25} \]

- \( N \) is the bed-based charging standard for subsequent years.
- \( M \) is the average annual weight of medical waste generated per bed per day in medical and health institutions that are billed by bed.
- 1.25 is the average weight of medical waste generated per bed per day in Shanghai in 2016.
- 2018 Standard price based on bed charges.
### Medical Waste Disposal Fees in Shanghai, China

<table>
<thead>
<tr>
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<tr>
<td>Medical and health institutions without beds</td>
<td>0.41 €/kg</td>
</tr>
</tbody>
</table>

- **Converted to 1.25 kg/bed/day**
- **Monthly medical waste weighs more than 100 kg**
- **Monthly weight of medical waste 30-100 kg**
- **Monthly weight of medical waste 10-30 kg**
- **Monthly medical waste weighs less than 10 kg**

**Price linkage mechanism charged by bed:**

\[
N \times \frac{M}{1.25} 
\]

- \( N \) is the bed-based charging standard for subsequent years
- \( M \) is the average annual weight of medical waste generated per bed per day in medical and health institutions that are billed by bed
- 1.25 is the average weight of medical waste generated per bed per day in Shanghai in 2016, and 0.41 is the 2018 standard price based on bed charges.

---

**Figure 4.6** Analysis of the cost of treatment of medical waste in Xinhua Hospital

- **195060 €/year**
- **2090 Beds**

- **Labor costs (salaries, office expenses, etc.)** 33%
- **Raw materials required for incineration** 20%
- **Transportation costs (diesel)** 10%
- **Equipment and vehicle maintenance costs** 5%
- **Depreciation of fixed assets** 5%
- **Utility bill** 10%
- **Communication fee** 5%
- **Sewage treatment plant** 2%
- **Tax** 10%
4.4 Analysis of the cost of treatment of medical waste in Xinhua Hospital

The medical waste disposal fee is a service fee in China, and the government-guided price management is implemented.

The medical waste disposal fee shall be collected by the medical waste centralized disposal unit from the medical and health institutions and related units. The left part of the figure shows some charging methods for medical waste disposal fees in Shanghai, China in 2018.

Currently, Xinhua Hospital chooses to charge by weight (kg). Behind is the percentage of medical waste treatment expenses that Xinhua Hospital needs to pay in one year.

Among them, labor cost is the largest proportion, with 33%, including wages, office freight and so on. Next is the raw materials (fly ash, etc.) required for incineration operations, 20%. Transportation costs (diesel), utilities and taxes are 10%; equipment and vehicle maintenance fees, fixed asset depreciation fees, communication fees, etc. are 5% respectively; at the same time, China Shanghai Solid Waste Disposal Co., Ltd. also needs to pay the sewage treatment plant The cost of sewage treatment. (See the figure on the next page for details)

4.5 Why we choose to study infectious waste

In the treatment process of infectious waste in various countries, it is an urgent need to solve and pay attention. Because infectious waste is not ordinary waste, but bacteria and viruses with various diseases. If infectious waste cannot be handled well, it is easy to cause various
problems. For the treatment of this part of waste, hospitals in various countries and regions have different treatment methods, but the ones used in China are relatively primitive and fast. The method of incineration is incineration, and the environmental problems caused by incineration need to be solved urgently.

In the past two decades of development, China has slowly begun to pay attention to this aspect of the problem, but it is still at the initial stage. Therefore, we focus on this part of the study, which is of more research significance, and combines various excellent solutions. The case is that it is hoped to combine the technology of the Internet of Things to carry out an effective management, and then conduct big data analysis based on the big data behind the Internet of Things, and then formulate more reasonable recommendations for the use of medical supplies.

As shown in Figure 4.7 Overall results of the 2014 MUD data analysis (2013 data)-Quantity produced (t), the medical waste generated by the hospital accounts for 78.53% of the total medical waste.

Shown in Figure 4.3 Percentage breakdown of waste considered-year 2013: Most of the waste considered is belonging to CER 180103 (79.7%), ie waste requiring precautions in
collection and management phase, as they can be infectious. 12.8% of waste produced consists of substances dangerous, while the other types of waste such as those from activities radiodiagnostics, waste medicines and other non-hazardous substances they represent approximately 7.5% of the total.

Shown in Figure 4.9 Percentage breakdown of total waste production considered among the different types of producers - year 2013: Hospitals produce over 78% of all waste taken into consideration, and others health facilities dependent on the ASL a additional 5%; the activities belonging to Istat classes of health care e social (medical, dental and veterinarians, etc.) produce 10%, while the other commercial activities such as pharmacies and beauty centers 7%.

According to the above data, infectious wastes are more dangerous than other wastes, so it is an urgent matter to solve more dangerous wastes.

4.6 Waste treatment process in hospita

This is Infectious waste treatment process (specific process from Xinhua Hospital to Shanghai Solid Waste Disposal Co., Ltd.) (See the figure on the next page for details)

Among them, Xinhua Hospital has three temporary storage rooms, each about 30 square meters. When infectious waste is generated, it divided into four categories for packaging and transshipment, and the
Medical waste transported once a day, usually transported in the afternoon.

Medical waste disposal company provides hospitals with a total of two sizes transport box is 660 liter and 171 liter. The company has a total of 90 vans for transport medical waste in shanghai. The company has a temporary waste storage room and two cold storage rooms, respectively. Usually the medical waste arrives in the temporary storage room and waits for treatment; then the waste is transported to the rotary kiln incinerator for high temperature incineration treatment (the company has three production lines, which can process a total of 1220000 kilogram per day); After passing through the enterprise's sewage treatment system, the generated sewage is discharged to Jiading Xincheng Sewage Treatment Plant, and the exhaust gas is directly discharged into the air through the 50-meter-high exhaust pipe; the fly ash generated by incineration is transported to the landfill site of the enterprise Landfill treatment.

Figure 4.10 Operation of medical waste in incinerator
THE TRANSFORMATION TECHNOLOGIES

Cerebrospinal fluid, patient's peritoneum, patient's urine, etc. are processed by the sewage treatment system in the hospital.

Discarded blood, serum, fecal specimens, and other infectious waste are placed in medical garbage bags and medical garbage cans with lids.

Blood transfusion bags should be collected separately in yellow medical garbage bags 24 hours after blood transfusion.

The wastes (including domestic wastes) generated by isolated infectious patients or suspected infectious patients should be sealed in double-layer yellow medical garbage bags.

Pathogen culture media, specimens, strains, and poisonous species preservation solutions in the microbiology laboratory are sterilized with pressure steam at the place of production and then collected as infectious waste.

JIADING XINCHENG SEWAGE TREATMENT PLANT

SEWAGE TREATMENT

THE TRANSFORMATION TECHNOLOGIES

3 temporary storage room (36 square)
THE TRANSFORMATION TECHNOLOGIES

Cerebrospinal fluid, patient's peritoneum, patient's urine, etc. are processed by the sewage treatment system in the hospital.

Discarded blood, serum, fecal specimens, and other infectious waste are placed in medical garbage bags and medical garbage cans with lids.

Blood transfusion bags should be collected separately in yellow medical garbage bags 24 hours after blood transfusion.

Pathogen culture media, specimens, strains, and poisonous species preservation solutions in the microbiology laboratory are sterilized with pressure steam at the place of production and then collected as infectious waste.

The wastes (including domestic wastes) generated by isolated infectious patients or suspected infectious patients should be sealed in double-layer yellow medical garbage bags.

QUANTITY OF VANS: 90
(15 vehicles serve Xinhua Hospital)

CAPACITY OF MEDICAL WASTE CONTAINER
648 Container serving Xinhua Hospital

1
STERILIZE THE TEMPORARY STORAGE OF MEDICAL WASTE
- 1 temporary storage room (780 square)
- 2 cold storage (192 square and 514 square)

2
ROTARY KILN INCINERATOR FOR INCINERATION
- Line 1 + 2 (incineration capacity 500000kg / day)
- Line 3 (incineration capacity 720000kg / day)

WASTEWATER ENTERS SEWAGE TREATMENT
- Jiading Xincheng Sewage Treatment Plant

EXHAUST GAS IS DISCHARGED THROUGH A 50-METER-HIGH EXHAUST CYLINDER

HAZARDOUS WASTES SUCH AS SLUDGE AND FLY ASH SENT TO QUALIFIED UNITS FOR DISPOSAL.
- Landfill
4.7 Basic information and data of Shanghai Waste Treatment Plant

**FULL NAME**  Shanghai solid waste disposal co. LTD, CHINA.

**ESTABLISHED** 2001

**ADDRESS** 2491 jiazhu road, jiading district, Shanghai, China

**HOSPITAL LEVEL**  Class III

**COMPETENT AUTHORITY** Shanghai Municipal Bureau of Ecological Environment

**HOSPITAL DEAN** Li ChuanHua

**GIURIDIC STATUS** Non-profit hospital

**BUSINESS SCOPE**
- Waste assimilated to urban waste/
- Infectious waste
- Damaged waste
- Pathological waste
- Chemical waste
- Drug waste
- Waste that needs to be collected and disposed of to prevent zoonotic diseases
- Waste generated by chemical and biological laboratories in research, development and teaching activities

**DESCRIPTION**
It is a major environmental protection enterprise invested and constructed by the Shanghai Municipal Government and market-oriented operation. It is a professional environmental protection enterprise under Shanghai Urban Investment (Group) Co., Ltd. and is currently managed by Shanghai Environment Group Co., Ltd. (listed company: 601200). The company has assets of over 500 million yuan and employs more than 580 people. It is the only environmental protection enterprise in Shanghai that integrates medical waste, hazardous waste and general industrial solid waste.

It has successively won the key enterprise of China's environmental protection industry, the 3A credit enterprise of China's environmental protection industry, the training base of medical and hazardous waste incineration treatment and disposal of China Environmental Protection Industry Association, the winner of the national "Ankang Cup" competition, Shanghai high-tech enterprise, and Shanghai A number of qualifications and honors such as a civilized unit, a
second-level enterprise of Shanghai safety production standardization, and a designated unit for emergency disposal of hazardous waste in Shanghai. Relying on the existing technological achievements, construction experience and operating standards, the company can provide customers with professional services for the entire industrial chain of medical waste, hazardous waste and general industrial solid waste pollution treatment facilities from design consultation, engineering construction to operation management. As a world-class and domestic leader in the industry, the company has always firmly believed that people-oriented is the key to success. It advocates "the company as a platform for the growth of the wealth of outstanding employees" and enhances the personal value of employees through a multi-level talent training mechanism. While the company is developing rapidly, it has provided employees with a broad space for growth. The dual-channel employee development system has also created a group of outstanding managers and technical innovators.
4.8 Treatment Approaches

There are four basic treatment approaches to consider: a centralized treatment system, decentralized (on-site) treatment, mobile treatment system, and treatment within clusters.

The centralized treatment approach entails the use of one or more large-scale treatment units each located at a central treatment plant. A centralized approach requires a good infrastructure of collection and transportation of untreated waste using specialized vehicles. If the central facility is not located adjacent to a landfill or dumpsite, regular waste transport vehicles will be needed to bring the treated waste to the landfill or dumpsite for final disposal as domestic waste. The centralized approach has the disadvantages of having to transport infectious waste through public roads and the added cost of transport, such as fuel costs. However, it has the advantage of the economy of scale and is the preferred approach in many industrialized countries.

The opposite approach is a decentralized treatment system wherein all health facilities operate their own on-site treatment unit. This approach would require that each facility prepare an adequate space for a treatment system including utilities, ventilation, and sewer drains. The location of the treatment area should be away from public areas but easily accessible to the health workers responsible for collecting infectious waste. Each facility would be required to maintain their equipment, document the treatment process, train workers on the proper operation and safety procedures, and provide workers with personal protection equipment. After the waste is treated, it can be mixed with domestic waste for pickup and disposal. The decentralized approach has the advantage of disinfecting infectious waste close to the source of generation. By avoiding the problem of transporting infectious waste through public roads, the potential for accidental release of infectious materials is reduced.

A relatively new approach is a mobile treatment system. In this treatment system approach, the
treatment units are mounted on trucks and are brought to different health facilities where they treat the waste.

After the waste is treated, it becomes domestic waste for regular pickup and disposal. The mobile unit is then transported to the next health facility to treat their waste. Only a few vendors offer a mobile treatment system, and the capital and operating costs of mobile systems are high.

A fourth approach is a combination of the centralized and decentralized system, namely, the treatment within clusters of health facilities. In this approach, a major hospital or health facility is designated as a central hub for the treatment of infectious waste within an area or district.

Infectious waste from the hospital itself plus waste from nearby hospitals, clinics and health centers are treated at the central hub. The central hub has to maintain one or more transport vehicles to collect waste from all the nearby health facilities. The treated waste then becomes part of the domestic waste of the major hospital and is picked up and disposed of as domestic waste. In a cluster treatment approach, a cost sharing arrangement could be set up between the major facility (the hub) and other hospitals and health facilities within the cluster.

Xinhua Hospital currently uses the centralized treatment method of waste disposal. The disadvantage is that infectious waste must be transported through public roads and increase transportation costs, such as fuel costs. However, it has the advantages of economies of scale and is the method of choice in many industrialized countries. Of course, this is also a relatively traditional old-fashioned treatment method, which is still relatively harmful to energy and the environment. China now also attaches great importance to the treatment of medical waste. China also has a big advantage in the rapid development of the Internet, and its penetration rate is high. So it can be managed through the Internet of Things.
References

Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine, www.xinhuamed.com.cn/.


In the system diagram of infectious waste, we found some problems in the supply chain. These problems directly or indirectly caused the hospital to have certain difficulties in the management of medical supplies or the disposal and recycling of waste, and may cause problems. The pollution to the environment and the human body have a lot of health effects.
CHAPTER 5

Problems found in the processing line of infectious waste
5.1 Problem 1: plastic packaging

The first is the problem of plastic packaging. The current disposable medical product packaging is PET plastic and two-layer carton. PET plastic is a raw material that can be reused as carpet fiber and other products, but only 0% of the hospital collects it, but directly throws it into infectious waste for disposal. This will affect the food chain, even groundwater, land and air pollution, and it is also difficult to biodegrade.

Figure 5.1 The process of plastic packaging for medical supplies from production to waste
In the sustainable medical care in Northern Europe, Aarhus University Hospital is conducting related research on the EU circular economy, plastics and recycling.

In the EU, nearly a third of municipal waste is landfilled, with a limited share of the total being recycled. The waste package proposals establish binding waste reduction targets and updated rules to decrease waste generation, ensure a better control of waste management, encourage the reuse of products and improve recycling in all EU countries. These new targets and rules will promote a more circular economy. EU2017.EE Project aims at AUH

- To increase recycling and circular economy of hospital plastic packaging waste
- To develop and test a value chain model for creation of commercial and other kinds of value out of hospital plastic packaging waste in cooperation with stakeholders.

For Xinhua Hospital, the amount of plastic packaging for medical supplies produced every day is very large, which has the value and significance of
recycling. Like the current situation, the plastic packaging of medical supplies is directly discarded as infectious waste. Therefore, we decided to conduct certain questions on various types of plastic packaging based on the following research list.

As shown in Figure 5.3 Results at AUH-clinical sorting, November 2016, plastics accounted for 25% of solid waste. Xinhua Hospital removes waste assimilated to urban waste and the total amount of other medical waste is 935,482 kg/year. It is estimated that the amount of waste is 23,3870.5 kg/year.

In Figure 5.4 Plastic packaging—a complex fraction and Figure 5.5 Clinical sorting-by type of packaging, there are about 17 types of waste plastics used in medical product packaging. Tyvek® mentioned in the picture is a 100% synthetic material made of high-density spunbond polyethylene fibers. Tyvek® (Tyvek®) is lightweight, durable, breathable, but resistant to water, abrasion, bacterial penetration and aging. It is an amazing material that can be used to improve various applications in multiple industries.

<table>
<thead>
<tr>
<th></th>
<th>Plastic (kg) 1</th>
<th>Solid waste/day including plastic (kg.)</th>
<th>Plastic part of solid waste (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient ward -child</td>
<td>2.0</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Patient ward -heart</td>
<td>0.5</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Patient ward -lung</td>
<td>0.7</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td><strong>Patient wards total</strong></td>
<td><strong>4.2</strong></td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Operations Dep. 1</td>
<td>10</td>
<td>64</td>
<td>15%</td>
</tr>
<tr>
<td>Operations Dep. 2</td>
<td>30</td>
<td>197</td>
<td>15%</td>
</tr>
<tr>
<td>Operations Dep. 3</td>
<td>20</td>
<td>131</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Operations Dept.</strong></td>
<td><strong>59</strong></td>
<td>392</td>
<td><strong>15%</strong></td>
</tr>
<tr>
<td>Pharmacy</td>
<td>7</td>
<td>19</td>
<td>34%</td>
</tr>
<tr>
<td>Intensive preperations</td>
<td>17</td>
<td>54</td>
<td>32%</td>
</tr>
<tr>
<td>Radiology</td>
<td>3</td>
<td>32</td>
<td>9%</td>
</tr>
<tr>
<td><strong>Auxilliary total</strong></td>
<td><strong>27</strong></td>
<td><strong>105</strong></td>
<td><strong>25%</strong></td>
</tr>
</tbody>
</table>

Figure 5.3  Results at AUH - clinical sorting, November 2016
Figure 5.4 Plastic packaging – a complex fraction

Figure 5.5 Clinical sorting - by type of packaging
There are 17 departments in Xinhua Hospital, of which the Logistics Department is responsible for the collection and transportation of medical waste. There are three loopholes in data management:

1. The amount of medical supplies used is not managed. The amount of medical supplies used by various doctors and nurses in the hospital is not effectively managed. When the amount of disposable medical supplies cannot be effectively managed, it is easy to cause waste.

2. No data exchange between departments. The procurement of medical supplies is carried out uniformly by the purchasing department; the departments used are various clinics, etc.; the waste management is carried out by the logistics service department, and there is no data exchange between the departments. This is easy to cause waste and excessive use of medical supplies.

3. There is no waste data in each department. Each department does not collect waste data, but the logistics service department collects all types of waste on the same floor. When plastic is burned in the open air, it releases large amounts of toxins, which pollutes the air. If the toxins are inhaled for a long period of time, it can lead to respiratory problems.
Figure 5.7  Xinhua hospital organizational structure
5.3 Problem 3 incineration gas emissions

The waste treatment plant discharges the incinerated gas directly into the atmosphere through a 50-meter flue. Often, harmful gases and particles in the air may directly cause air pollution, and soil pollution and water pollution may even seriously endanger human health.

Among them, through investigation, we found that the substance dioxin has always been a toxic substance produced after incineration in the world, which is extremely harmful to the human body.

**THE MOST SEVERE HIGHLY TOXIC POLLUTANTS FROM INCINERATION - DIOXIN**

Among the toxic substances produced during the incineration process, this substance is the most harmful to the human body. Its predecessor is present in many plastic wastes. The temperature of incineration wastes needs to be above 850 °C to degrade it. How to degrade this substance Elimination is also a problem that the world is paying great attention to.

The soot generated by the incineration of medical waste is the starting point of the dioxin generation pathway. The structure of soot is a collection of various ring-shaped substances, which is very similar to the structure of dioxin and can easily become a dioxin structure.

Dioxins are persistent organic pollutants, which are not easily degraded in the environment and have a long residence time. They can affect the environment through the transportation of the atmosphere and water, and can be enriched through the food chain, and finally can enter the human body.

It can cause disturbance of the human endocrine system, damage to the reproductive and immune systems, and induce cancer and neurological diseases, seriously affecting human health. These are only for human beings, but for the natural environment, they will seriously pollute the atmosphere, causing atmospheric pollution and groundwater pollution.

*Figure 5.8 Three problems with incineration gas emissions*
PROBLEMS FOUND IN THE PROCESSING LINE OF INFECTIOUS WASTE

- CARBON OXIDES
- NITROGEN OXIDES
- BENZENE, FURAN
- IOXINS, SULFUR DIOXIDE
- ORGANIC CHLORINE
- HEAVY METALS
- HYDROGEN CHLORIDE
- FLY ASH
- VOLATILE ORGANIC COM-
- CHLORINATED DIBENZOOXIN
- CHLORINATED DIBENZOFU-
- HIGHLY TOXIC SUBSTANCES

Figure 5.9 Three problems with incineration gas emissions
5.4 Problem 4 Disinfection water

In hospitals, public facilities or medical devices that can be reused are subject to strict disinfection procedures, so the hospital consumes a lot of disinfection water every day. These disinfection waters may be pollute the water and the environment. Among them, we found chlorine-containing disinfection water It is the most frequently used in daily disinfection, but it actually causes great harm to the human body.

**Figure 5.10 Disinfection water**

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**MEDICAL APPLIANCES REQUIRING DISINFECTION**

- **AUXILIARY BREATHING APPARATUS, SOFT ENDSCOPE, GLASS, ENAMEL, PLASTIC AND RUBBER PRODUCTS**
  - The disinfection of instruments and articles includes 0.5%-0.2% peracetic acid, 84 disinfectant, 2% glutaraldehyde and so on.

- **THE SKIN AND MUCOUS MEMBRANES**
  - The skin and mucous membranes are disinfected with 2% iodine, 75% alcohol, 0.5% iodophor, hydrogen peroxide, etc.

- **SURGERY SITE, INJECTION SITE, ORAL MUCOSA PERINEAL AND VAGINAL SURGERY SITE**
  - Various instrument surfaces, incubators, neonatal radiation tables, biological safety cabinets, clean operation tables, clean area walls, patient contact appliances and floors
    - There are 37%-40% formaldehyde, lactic acid, peracetic acid, 84 disinfectant etc.
PROBLEMS FOUND IN THE PROCESSING LINE OF INFECTIONOUS WASTE

LAND POLLUTION
The presence of large amounts of chlorine and residual chloride ions can cause the soil to become acidic, destroy the soil structure, and cause compaction. There are huge numbers of microorganisms living in the soil, some of them are ‘scavengers’ that are very good for the environment. When excessive disinfectant kills harmful bacteria, it may kill these beneficial bacteria at the same time, causing damage to the biological network chain of urban green space.

GROUNDWATE AND AIR POLLUTION
Due to over-disinfection, a large amount of bleach was poured into the Tamsui River and its tributaries in Taiwan, resulting in excessively high chlorine content and a large number of fish killing. It did not return to normal until half a year later, which had a significant impact on the ecology of the river. When plastic is burned in the open air, it releases large amounts of toxins, which pollutes the air. If the toxins are inhaled for a long period of time, it can lead to respiratory problems.

HUGE DAMAGE TO THE HUMAN BODY
Plastic can hurt tiny organisms like plankton, which larger animals rely on for food. If small organisms are poisoned from ingesting plastic, the animals that eat them will also consume toxins.

CHLORINE-CONTAINING DISINFECTANT
After inhaling a large amount of high-concentration disinfectant, obvious respiratory irritation symptoms may occur, such as cough, shortness of breath, and difficulty in breathing. In severe cases, chemical bronchitis, chemical pneumonia, and even chemical pulmonary edema may occur.

HYDROGEN PEROXIDE
Hydrogen peroxide can cause poisoning in contact with the respiratory tract, digestive tract and skin and mucous membranes. Hydrogen peroxide with a concentration greater than 10% is highly oxidative and corrosive, and can cause chemical burns to the skin, eyes, respiratory tract, and digestive tract.

PERACETIC ACID
High concentration of peracetic acid can cause explosion due to violent collision or high heat. Peracetic acid can invade the body through the digestive tract, respiratory tract and skin and mucous membranes, and it is obviously irritating and corrosive to the eyes, respiratory tract, digestive tract and skin and mucous membranes.

Figure 5.11  Five problems with Disinfection water
References


Commonly used items disinfection method-Nanjing Tongren Hospital, www.njtrh.com/yiliaoxiangguan/zhikongguanli/2018-08-03/89.html.

PROBLEMS FOUND IN THE PROCESSING LINE OF INFECTIOUS WASTE
Many toxins were produced during waste incineration, especially plastic products that do not meet certain incineration conditions will release toxins. Therefore, if we can sort and collect and recycle waste from the source, we can avoid a large amount of hazardous waste being incinerated every day, thereby reducing The production of DIOXIN.
CHAPTER 6

Opportunities in infectious waste
6.1 Focus on Plastic waste

After we further analyzed the problem of the system diagram, we also found several opportunities to solve the problem:

**Problem 1** A management system with medical reminders: a complete automated management system, which enters the hospital for computer self-recording from the product. When each department needs to pick up the goods, Scan out the warehouse and use it in the ward. It has been electronically managed to waste output.

At the same time, this management system has become the main research direction of our subsequent projects. We believe that if the hospital has a more complete management system, all data can be properly entered and shared, and the product packaging materials and the degree of recyclability can be calculated more accurately. Not only can remind medical staff managers of the importance of waste recycling, but also save a lot of human time to sort and calculate.

**Problem 2** We consider whether we can reduce the use of disposable medical supplies and increase the recycling of plastic packaging. Then consider whether it is shipped to the carpet or recycled by another factory for secondary use.

At present, according to our data collection, China’s recycling of medical waste is 0%. All medical waste is sent to the treatment plant for incineration and landfill. It also contains a large amount of recyclable waste, such as packaging paper for medicines. According to Chinese laws, the used infectious waste cannot be recycled. However, the materials used in the packaging of those medical devices are almost recyclable. If they can be recycled, they can be Reduce the possibility of a large amount of environmental pollution, while also saving hospitals and treatment plants.

**Problem 3** We can improve the extended burning conditions in the incinerator to suppress the production of dioxins, or directly increase the flue gas treatment to minimize the flue gas generated by incineration.
According to our research, the dioxins produced by incineration have become a headache for the whole world, and the production of dioxins is mainly due to the incineration of medical waste, and the most toxic gas is released by incineration of plastics. China’s non-recycling of plastic products results in a large amount of medical plastics being directly incinerated every day to produce a large amount of toxic gases. Therefore, we believe that if the recycling of plastic products in hospitals can be increased, some of the toxic gases generated by incineration of plastics can be reduced.

**Problem 4** Many new organic disinfection waters or more environmentally friendly disinfection methods have also been launched on the market. You can try to use some organic disinfection water instead of a large amount of chlorine disinfection water.

After we have fully analyzed the problems in the system and the opportunities to improve them, we believe that the recycling of plastics is actually the key to the entire project, and how to make the hospital raise awareness of the recycling of medical waste has become our main goal.

Next, we will conduct a more in-depth analysis on the materials used in medical supplies, especially the plastic components, to analyze whether the plastic used for packaging is recyclable, what can be made into it after it is recycled, and the current society on the production and processing of these plastic materials, and whether they are degradable.

At the same time, we will continue to investigate the causes of dioxins and what kind of harm it can cause to the human body, and at the same time how can we try to suppress the occurrence of dioxins. Hope that we can get a clearer project direction and goal through our deeper investigation.
6.1.1 PET

Polyethylene terephthalate (sometimes written poly(ethylene terephthalate)), commonly abbreviated PET, PETE, or the obsolete PETP or PET-P, is the most common thermoplastic polymer resin of the polyester family and is used in fibres for clothing, containers for liquids and foods, thermoforming for manufacturing, and in combination with glass fibre for engineering resins.

Physical properties
Sailcloth is typically made from PET fibers also known as polyester or under the brand name Dacron; colorful lightweight spinnakers are usually made of nylon.

PET in its natural state is a colorless, semi-crystalline resin. Based on how it is processed, PET can be semi-rigid to rigid, and it is very lightweight. It makes a good gas and fair moisture barrier, as well as a good barrier to alcohol (requires additional "barrier" treatment) and solvents. It is strong and impact-resistant. PET becomes white when exposed to chloroform and also certain other chemicals such as toluene.
Polyester recycling industry
In 2016, it was estimated that 56 million tons of PET are produced each year. While most thermoplastics can, in principle, be recycled, PET bottle recycling is more practical than many other plastic applications because of the high value of the resin and the almost exclusive use of PET for widely used water and carbonated soft drink bottling. PET has a resin identification code of 1. The prime uses for recycled PET are polyester fiber, strapping, and non-food containers.

When recycling polyethylene terephthalate or PET or polyester, in general three ways have to be differentiated:

The chemical recycling back to the initial raw materials purified terephthalic acid (PTA) or dimethyl terephthalate (DMT) and ethylene glycol (EG) where the polymer structure is destroyed completely, or in process intermediates like bis(2-hydroxyethyl) terephthalate

The mechanical recycling where the original polymer properties are being maintained or reconstituted.

The chemical recycling where transesterification takes place and other glycols/polyols or glycerol are added to make a polylol which may be used in other ways such as polyurethane production or PU foam

there are processes that are sharing most of these principles. Depending on composition and impurity level of input material, the general following process steps are applied.

- Bale opening, briquette opening
- Sorting and selection for different colors, foreign polymers especially PVC, foreign matter, removal of film, paper, glass, sand, soil, stones, and metals
- Pre-washing without cutting
- Coarse cutting dry or combined to pre-washing
- Removal of stones, glass, and metal
- Air sifting to remove film, paper, and labels
- Grinding, dry and / or wet
- Removal of low-density polymers (cups) by density differences
- Hot-wash
- Caustic wash, and surface etching, maintaining intrinsic viscosity and decontamination
- Rinsing
- Clean water rinsing
- Drying
- Air-sifting of flakes
- Automatic flake sorting
- Water circuit and water treatment technology
- Flake quality control

Figure 6.3 number “5” as its resin identification
6.1.2 PE

Polyethylene or polythene (abbreviated PE; IUPAC name polyethene or poly(methylene)) is the most common plastic in use today. It is a linear, man-made, addition, homo-polymer, primarily used for packaging (plastic bags, plastic films, geomembranes, containers including bottles, etc.). As of 2017, over 100 million tonnes of polyethylene resins are being produced annually, accounting for 34% of the total plastics market.

Figure 6.4 Polyethylene

Mechanical properties of polyethylene
Polyethylene is of low strength, hardness and rigidity, but has a high ductility and impact strength as well as low friction. It shows strong creep under persistent force, which can be reduced by addition of short fibers. It feels waxy when touched.

Chemical properties
Polyethylene consists of nonpolar, saturated, high molecular weight hydrocarbons. Therefore, its chemical
behavior is similar to paraffin. The individual macromolecules are not covalently linked. Because of their symmetric molecular structure, they tend to crystallize; overall polyethylene is partially crystalline. Higher crystallinity increases density and mechanical and chemical stability.

**Environmental issues**
Polyethylene is produced from ethylene, and although ethylene can be produced from renewable resources, it is mainly obtained from petroleum or natural gas.

Moreover, the widespread usage of polyethylene poses difficulties for waste management if it is not recycled. Polyethylene, like other synthetic plastics, is not readily biodegradable, and thus accumulates in landfills.

**Climate change**
When exposed to ambient solar radiation the plastic produces two greenhouse gases, methane and ethylene. Of particular concern is the plastic type which releases gases at the highest rate: low-density polyethylene (or LDPE). Due to its low density properties it breaks down more easily over time, leading to higher surface areas.

**Recycle**
Material recycling is often called degraded recycling. There is no strict classification of PE according to the type, and it is processed into new PE products directly or after granulation. For these products, low-quality PE is sufficient. Materials from households are usually sent to this process. If particles are added to the road surface, this method can reduce road construction costs, for example. Sometimes unnecessary products are produced, and there are a lot of unnecessary or unnecessary products for these products.

In view of the simple chemical structure of PE, raw material recovery (ie chemical decomposition) is not worthwhile. This method is used for polyester (such as PET), polyamide, polyurethane and polycarbonate. Since it is not necessary to use this method to classify plastics, a small amount of PE can also be converted in this way. Pure PE is sent to material recycling instead of chemical decomposition. Since PE is decomposed into water and carbon dioxide during combustion, it is often burned in waste incineration plants. It is very expensive to burn with other contaminated plastics. Because PE is used, no complicated procedures are required.
6.1.3 PP

Polypropylene (PP) also known as polypropene, is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene.

Polypropylene belongs to the group of polyolefins and is partially crystalline and non-polar. Its properties are similar to polyethylene, but it is slightly harder and more heat resistant. It is a white, mechanically rugged material and has a high chemical resistance. [1 ] Polypropylene is the second-most widely produced commodity plastic (after polyethylene) and it is often used in packaging and labeling.

Chemical properties

Polypropylene at room temperature is resistant to fats and almost all organic solvents, apart from strong oxidants. Non-oxidizing acids and bases can be stored in containers made of PP. At elevated temperature, PP can be dissolved in nonpolar solvents such as xylene, tetralin and decalin.

There are three general types of polypropylene: homopolymer, random copolymer, and block copolymer. The comonomer is typically used with ethylene. Ethylene-propylene rubber or EPDM added to polypropylene homopolymer increases its low temperature impact strength.
Randomly polymerized ethylene monomer added to polypropylene homopolymer decreases the polymer crystallinity, lowers the melting point and makes the polymer more transparent.

**Clothing**
Various polypropylene yarns and textiles
Polypropylene is a major polymer used in nonwovens, with over 50% used[citation needed] for diapers or sanitary products where it is treated to absorb water (hydrophilic) rather than naturally repelling water (hydrophobic).

**Medical**
Its most common medical use is in the synthetic, nonabsorbable suture Prolene, manufactured by Ethicon Inc.

Polypropylene has been used in hernia and pelvic organ prolapse repair operations to protect the body from new hernias in the same location. A small patch of the material is placed over the spot of the hernia, below the skin, and is painless and rarely, if ever, rejected by the body. However, a polypropylene mesh will erode the tissue surrounding it over the uncertain period from days to years. A notable application was as a transvaginal mesh, used to treat vaginal prolapse and concurrent urinary incontinence.] Due to the above-mentioned propensity for polypropylene mesh to erode the tissue surrounding it, the FDA has issued several warnings on the use of polypropylene mesh medical kits for certain applications in pelvic organ prolapse, specifically when introduced in close proximity to the vaginal wall due to a continued increase in number of mesh-driven tissue erosions reported by patients over the past few years. On 3 January 2012, the FDA ordered 35 manufacturers of these mesh products to study the side effects of these devices. Due to the outbreak of the COVID-19 pandemic in 2020, the demand for PP has increased significantly because it's a vital raw material for producing meltblown fabric, which is in turn the raw material for producing facial masks.

**Recycling**
Polypropylene is recyclable and has the number "5" as its resin identification code.

Figure 6.8 Resin identification code
6.1.4 HDPE

High-density polyethylene (HDPE) polyethylene high-density (PEHD) is a thermoplastic polymer produced from the monomer ethylene. It is sometimes called "alkathene" or "polythene" when used for HDPE pipes. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geomembranes and plastic lumber. **HDPE is commonly recycled**, and has the number "2" as its resin identification code.

In 2007, the global HDPE market reached a volume of more than 30 million tons.

**HDPE is resistant to many different solvents.**

The physical properties of HDPE can vary depending on the molding process that is used to manufacture a specific sample; to some degree a determining factor are the international standardized testing methods employed to identify these properties for a specific process. For example, in Rotational Molding, to identify the environmental stress crack resistance of a sample, the Notched Constant Tensile Load Test (NCTL) is put to use.

Owing to these desirable properties, pipes constructed out of HDPE are ideally applicable for potable water, and waste water (storm and sewage).
A polyamide is a polymer with repeating units linked by amide bonds. The recycling code for polyamide is 07.

Polyamides occur both naturally and artificially. Examples of naturally occurring polyamides are proteins, such as wool and silk. Artificially made polyamides can be made through step-growth polymerization or solid-phase synthesis yielding materials such asnylons, aramids, and sodium poly(aspartate).

Synthetic polyamides are commonly used in textiles, automotive industry, carpets, kitchen utensils and sportswear due to their high durability and strength. The transportation manufacturing industry is the major consumer, accounting for 35% of polyamide (PA) consumption.

Due to its uniform smooth surface, polyamide is very suitable for sutures in surgical operations. Polyamide suture thread is characterized by excellent knotting performance and high tensile strength. It is a monofilament made of polyamide 6 and polyamide 6.6, a non-absorbable surgical material.

Most polyamide products are used as synthetic fibers for textiles. clothing Parachute, paraglider, balloon, sail Industrial fabrics (such as wire mesh fabrics used in papermaking) rope Fishing line Lawn mower cutting line Tennis racket stringing Stringed instruments and plucked instruments

It is also used to produce household goods and technical parts that must be very wear-resistant, such as pins, screws, housings, sliding bearings, insulators in the electrical engineering field, cable ties, adhesive base materials, knots for medical tents, kitchen utensils (trowels), Spoon), machine parts (cover), gears, bearings, rollers) and toothbrush bristles.

PA12 is used as an inexpensive standard material for 3D printing of parts and housings. The powder moistened with water is baked with a laser beam.

Figure 6.11 Resin identification code
Polystyrene (PS)

Polystyrene can be solid or foamed. General-purpose polystyrene is clear, hard, and rather brittle. It is an inexpensive resin per unit weight. It is a rather poor barrier to oxygen and water vapour and has a relatively low melting point. Polystyrene is one of the most widely used plastics, the scale of its production being several million tonnes per year. Polystyrene can be naturally transparent, but can be coloured with colourants. Uses include protective packaging (such as packing peanuts and in the jewel cases used for storage of optical discs such as CDs and occasionally DVDs), containers, lids, bottles, trays, tumblers, disposable cutlery and in the making of models.

Under ASTM standards, polystyrene is regarded as **not biodegradable**. It is accumulating as a form of litter in the outside environment, particularly along shores and waterways, especially in its foam form, and in the Pacific Ocean.

**Production**

Polystyrene foams are produced using blowing agents that form bubbles and expand the foam. In expanded polystyrene, these are usually hydrocarbons such as pentane, which may pose a flammability hazard in manufacturing or storage of newly manufactured material, but have relatively mild environmental impact.[citation needed] Extruded polystyrene is usually made with hydro-fluorocarbons (HFC-134a),[54] which have global warming potentials of approximately 1000–1300 times that of carbon dioxide.
Non-biodegradable
Waste polystyrene takes hundreds of years to biodegrade and is resistant to photo-oxidation.
Reducing
Restricting the use of foamed polystyrene takeout food packaging is a priority of many solid waste environmental organisations.[58] Efforts have been made to find alternatives to polystyrene, especially foam in restaurant settings. The original impetus was to eliminate chlorofluorocarbons (CFC), which was a former component of foam.

Recycling
In general, polystyrene is not accepted in curbside collection recycling programs and is not separated and recycled where it is accepted. In Germany, polystyrene is collected, as a consequence of the packaging law (Verpackungsverordnung) that requires manufacturers to take responsibility for recycling or disposing of any packaging material they sell.
If the waste material goes through an initial compaction process, the material changes density from typically 30 kg/m3 to 330 kg/m3 and becomes a recyclable commodity of high value for producers of recycled plastic pellets. Expanded polystyrene scrap can be easily added to products such as EPS insulation sheets and other EPS.

Expanded polystyrene (EPS)
Thermocol slabs made of expanded polystyrene (EPS) beads. The one on the left is from a packing box. The one on the right is used for crafts. It has a corky, papery texture and is used for stage decoration, exhibition models, and sometimes as a cheap alternative to Shola (Aeschynomene aspera) stems for artwork. Expanded polystyrene (EPS) is a rigid and tough, closed-cell foam with a normal density range of 11 to 32 kg/m3. It is usually white and made of pre-expanded polystyrene beads. EPS is used for food containers, molded sheets for building insulation, and packing material either as solid blocks formed to accommodate the item being protected or as loose-fill "peanuts" cushioning fragile items inside boxes. A significant portion of all EPS products are manufactured through injection molding. Mold tools tend to be manufactured from steels (which can be hardened and plated), and aluminum alloys.
6.2 Problems and opportunities related to dioxin emissions

Dioxins are many chemically similar substances, they come from organic matter, namely dibenzo-p-dioxin (PCDD) and dibenzofuran (PCDF). They have similar chemical and physical properties, and dioxins are not produced for specific purposes, but are mainly produced as by-products in the incineration process (for example, the burning of households and hazardous waste) (including forest fires and volcanic eruptions).

Dioxins will stay on dust particles and diffuse into the environment.

Dioxins are very persistent compounds and decompose very slowly in the body. In animal experiments, it has been observed that disturbances in reproductive function, immune system, nervous system and hormone balance are chronic effects of dioxins. It is believed that certain dioxins increase the risk of cancer.

Figure 6.13 how much dioxin the average American consumes per day.
Since dioxins can be seen everywhere in the environment, it is impossible to completely prevent them from entering the food chain. Humans mainly ingest dioxins through animal food. Agricultural animals are mainly replaced by soil particles. They are very common in the environment and have accumulated in the soil. Dioxins enter the soil mainly through air, but also enter the soil through cultivation, such as fertilization through sewage sludge or other auxiliary raw material fertilizers. An important source of local dioxin concentrations may also be the uncontrolled burning of paint or other waste. The half-life is decades, so the dioxins in the soil have a long lifespan and hardly migrate. Studies have shown that with a few exceptions (summer squash), dioxins are rarely found in vegetables, but adhere to the outside of vegetables or grasses through soil particles.

Dioxins from the soil enter the food chain mainly through these adhered soil particles. Therefore, if the soil is contaminated, using it as a pasture or chicken farm is particularly problematic. In animals and humans, dioxins are stored in fat for a long time and therefore accumulate in them. For decades, dioxins have entered the ocean in high concentrations through sewage and rivers. Dioxins accumulate here through the food chain, especially in the fat of fish, mammals and birds.

**Dioxins in humans**

Humans absorb 90% to 95% of dioxins through food. Nearly two-thirds of the intake comes from the consumption of meat and dairy products. Dioxins accumulate in living organisms, especially in fat tissues, and decompose slowly. Dioxin (2,3,7,8 TCDD), which is the most toxic in human fat, has a half-life of about 7 years, and the slowest degradation of 2,3,4,7,8 pentachlorodibenzofuran is nearly 20 years. Eliminate half of it later. The danger of dioxin is that it is stored in body fat, accumulates in the body and is only eliminated very slowly. 2,3,7,8 TCDD was classified as a human carcinogen (human carcinogen) by the World Health Organization (WHO) in February 1997.

DIOXIN is produced during waste incineration, especially plastic products that do not meet certain incineration conditions will release toxins. Therefore, if we can sort and collect and recycle waste from the source, we can avoid a large amount of hazardous waste being incinerated every day, thereby reducing The production of DIOXIN.
References


Bing, Microsoft, www.bing.com/search?q=PP.


Designing a complete automated medical waste management system can help hospitals effectively manage waste. It is based on artificial intelligence management, the artificial intelligence and real-time management of users, users only need the simplest operation, can completely record and manage all medical supplies data.
CHAPTER 7

Concept
7.1 Concept idea of our project

Designing a complete automated medical waste management system can help hospitals effectively manage waste.

From the product entering the hospital for intelligent scanning and recording, to the medical staff in each department when using medical items can automatically scan out of the library and put it into the hospital, electronic management until the waste is transported to the factory.

It is based on artificial intelligence management, the artificial intelligence and real-time management of users, users only need the simplest operation, can completely record and manage all medical supplies data.

Figure 7.1 Concept idea of our project
7.2 Our main goals

**HELP & EDUCATE**

The system helps hospitals to effectively manage waste, and also understands how medical staff use medical supplies for diagnosis and treatment.

**MONITORING**

Sensors can monitor the input and output of medical supplies in the hospital.

**MANAGEMENT**

The research interaction uses face recognition and voice to operate, easy to use and precise.

**EASILY INTERACTING**

The system collects accurate data from various departments to ensure convenient waste separation and recycling.
7.3 Personas

**Name:** Qian Wang  
**Age:** 25  
**Work occupation:** Nurse  
**Department:** Inpatient

Qian has come to Shanghai for his studies. He's always wanted to become a good nurse and his dream is almost fulfilled. She likes working to save people's lives, but because of the heavy work, she really wants to have some free time.

**Needs:**  
- Hope that working hours can be stable.  
- Hope to get the medical supplies needed by patients quickly and accurately.

**Habbits:**  
- Working in the hospital is very busy and has very little free time.  
- Often work day and night upside down, work pressure is high, often feel tired.

**Curiosity**  
**Patient**  
**Creativity**  
**Pressure**  
**Skill**  
**Passion**

*Figure 7.2 Picture of a Nurse in Xinhua hospital*

*Figure 7.3 Character chart of Qian Wang*
Doc. Li is a local person, and have a nice family, he has two beautiful daughters. He’s dream is to help people become better, and try his best to save people’s lives. He loves his job, but he always want to have more time to company his daughters.

**Needs:** The interactive interface of the management system can be easily operated.
Quickly view the patient's medical history and medication history.

**Habbits:** Need to work between outpatients and inpatients every day.
Need to communicate with many children and parents every day.

---

**Figure 7.4 picture of a Doctor in Xinhua hospital**

**Name:** Wei Li  
**Age:** 73  
**Work occupation:** Doctor  
**Department:** Pediatrics

Doc. Li is a local person, and have a nice family, he has two beautiful daughters. He’s dream is to help people become better, and try his best to save people’s lives. He loves his job, but he always want to have more time to company his daughters.

---

**Figure 7.5 Character chart of Wei Li**
Name: Guo Ai  
Age: 37  
Work occupation: Manager  
Department: Logistics Service  

Mr. Ai lives for his family. He’s very happy with his life and he feels very lucky. When he looks at his children, he always thinks about his family; when he came to Shanghai to work, he was only 25, now he has been in Shanghai for almost 20 years.

Needs:  
Hope to better manage medical waste.  
Hope to have an intelligent data entry system.

Habbits:  
Check a large amount of paper data and medical waste every day.  
Need to arrange staff to go to various departments for waste transfer.

<table>
<thead>
<tr>
<th>Curiosity</th>
<th>Patient</th>
<th>Creativity</th>
<th>Pressure</th>
<th>Skill</th>
<th>Passion</th>
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</table>

Figure 7.7 Character chart of Guo Ai
Han is a young mother of one lovely child, unluckily, Her 5-year-old son has a serious health problem. The family spends almost all the money to treat the child, and she has to come to the hospital for check-ups almost every week. She is worrying about her son all the time.

**Name:** Xiao Han  
**Age:** 32  
**Work:** Housewife

Han is a young mother of one lovely child, unluckily, Her 5-year-old son has a serious health problem. The family spends almost all the money to treat the child, and she has to come to the hospital for check-ups almost every week. She is worrying about her son all the time.

**Needs:** Hope to find a hospital can better take care of her son. Hope the doctor can come up with a better treatment plan.

**Habbits:** There are a lot of cases and medical lists at home. Go to the hospital almost every week to inquire about the latest situation and progress.

![Figure 7.8 picture of a Patient in Xinhua hospital](image)

Name: Xiao Han  
Age: 32  
Work: Housewife

Han is a young mother of one lovely child, unluckily, Her 5-year-old son has a serious health problem. The family spends almost all the money to treat the child, and she has to come to the hospital for check-ups almost every week. She is worrying about her son all the time.

**Needs:** Hope to find a hospital can better take care of her son. Hope the doctor can come up with a better treatment plan.

**Habbits:** There are a lot of cases and medical lists at home. Go to the hospital almost every week to inquire about the latest situation and progress.

![Figure 7.9 Character chart of Xiao Han](image)
7.4 The planning of the user process of the medical waste management system

First, when medical supplies arrive at the hospital, the pharmacy manager of the hospital can log in to the system through face recognition, and then use a sensor to scan and register the medical waste. At the same time, you can check whether it is the previously booked quantity. Followed by the use of medical waste, doctors/nurses can also trigger the system through voice/gesture, and then log in to the doctor/nurse’s home page through face recognition, and then use voice control to quickly understand the specific location and location of medical supplies. Packaging classification tips.

At present, Xinhua Hospital is divided into surgery, internal medicine, pediatrics, medical technology and other clinical departments. Then the corresponding department will have its own independent pharmacy stock. Then each doctor will have his own independent consulting room, equipped with independent computers and medical facilities. After the diagnosis and treatment, some patients will need to be hospitalized; some patients go to the hospital pharmacy to get medicine and go home for treatment. The data of patients who take medicine home for treatment is operated by the pharmacy.

After the medical supplies are used, the waste generated will be weighed according to the weight of the smart trash can in each office and recorded and reminded in real time through the medical waste management system. When the weight reminder is about to be full, the corresponding floor staff of the logistics service department will receive a message prompting the transfer of medical waste. Normally, the cleaning and transfer of medical waste is 24H/time. Then the medical waste will be sorted into the temporary storage room of the logistics service department. Then, non-recyclable infectious waste, chemical waste, pharmaceutical waste and pathological waste will undergo a pre-treatment, in order to reduce the volume of waste and facilitate transportation. The recyclable waste will be processed and reproduced by the corresponding receiving company.
**Medical Stuff**

- Quick reminder if medical packaging is recyclable
- Quickly remind the location of medical items
- Intelligent operating system

**Managers**

- A few click experience
- Clean design with attention to important information
- A simple and clear interaction system
- Organized list of medical products
- Clearly view the quantity inventory of medical items
- Quickly know the data generated by medical waste

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**Technical Specification**

- Medication database
- Medical waste classification
- Encrypted data
- Synchronizing
- Between users

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*Figure 7.10 the planning of the user process of the medical waste management system 1*

*Figure 7.11 the planning of the user process of the medical waste management system 2*
7.5 SWOT analysis about Xinhua Hospital

- When the new management system is successfully applied, it will guide most hospitals in China.
- It has a relatively detailed size sector classification.
- It has full-time drug procurement and management personnel.
- Shanghai, where the hospital is located, is the first city in China to classify waste.
- The hospital has high state funding support.
- Xinhua Hospital is a comprehensive large-scale hospital with advanced medical technology and equipment, so it may have a higher demand and acceptance for the new management system.
- When the waste can be better classified, the secondary utilization rate of recyclable waste will be greatly improved.
- Recycling plastic waste products can also reduce the generation of incinerated dioxins and reduce air pollution.
Analysis of Xinhua Hospital's strengths, weaknesses, opportunities, threats (Strengths, Weaknesses, Opportunities, Threats) The purpose of analysis is to determine development opportunities based on Xinhua Hospital's opportunity and risk framework.

The amount of waste generated by the hospital every day is huge, and the classified data is difficult to count

It has a large number of treatment rooms, so more intelligent sensing equipment is needed

Due to the huge number of medical staff, applying the data management system to Xinhua Hospital may cause confusion

Training of medical staff may consume more manpower and capital

Figure 7.12 SWOT analysis about Xinhua Hospital
Its innovative concept uses a suspended vessel and rotating grinder blades to grind down all types of waste. Biohazardous waste is sterilised using microwaves and converted into inert municipal waste, The end product is similar to municipal waste and can then be fed into standard urban waste systems.
CHAPTER 8

Project
8.1 The information architecture of the medical waste management system

First is the login interface, and then you can go directly to the corresponding page (pharmacy manager, doctor/nurse, and logistics service department) based on face recognition. For example, a doctor/nurse will go directly to the interface between the doctor and the nurse, but the doctor/nurse cannot see the interface between the pharmacy manager and the logistics service department, and they do not have the authority to view each other.

Pharmacy managers can self-scan and register medical supplies for self-checking and self-checking of the reserved quantity. At the same time, you can remind "today, the amount of medical supplies in storage", "today, the number of medical supplies used", and "today, the number of medical supplies in storage".

![Figure 8.1 Information architecture-Medical waste management system](image-url)
the remaining amount of medical supplies", "today, the amount of medical supplies used" and other related information.

The main page of the doctor/nurse can be operated by voice/keyboard, gestures, etc., and then the specific location and packaging classification information of medical supplies can be quickly provided. At the same time, it can remind the individual of "Today, how much of your medical supplies used", "Today, how many packages are recycled" and other information.

The logistics service department can also operate through voice/keyboard, gestures, etc., and medical waste can be autonomously weighed and recorded through the smart trash can. Then a data sheet of waste production will be compiled.
8.2 User flow-Medical waste management

User flow-Medical waste management system

Figure 8.2 User flow-Medical waste management system
When the weight reminder is almost full, the logistics service department receives the reminder and the floor staff carry out the transfer. Medical waste cleaning and transportation 24h/time.

**Logistics Service Department**

**Waste Temporary Storage Room**

- Not recyclable
- Recyclable

**Medical waste**

- Pretreatment (compression/powder)
- Shanghai solid waste disposal co. LTD., CHINA.
- Plastic
- Pretreatment (compression/powder)
- Plastic factory
- Carton
- Paper mill
- Quilt & Clothes
- Clean, disinfect and sterilize the central office
- Electronic waste
- Electronic waste treatment plant

Logistics Service Department receives the reminder and the floor staff carry out the transfer. Medical waste cleaning and transportation 24h/time.
8.3 Sketch/wireframe

In order to identify, use the logo of the hospital.

Voice/gesture activated login interface

Figure 8.3 login interface
Log in through facial recognition, freeing the hands of hospital workers.
Figure 8.4 Pharmacy Manager Home Page

Quick search bar. Can be operated by voice.

Main menu bar.

Help button. Provide help.

The photo and name of the registrant. The circle in the upper right corner is a new message reminder.

Self-scanning and storage of medical supplies.

Message reminder page.
List of medical supplies warehousing, provide name, medical department used, and quantity (the left side is the current warehousing quantity, the right side is the total amount).

Different circle colors show the type of recyclable waste contained in the product.

Provide specific data of Inbound quantity, Usage amount and Remaining amount according to date.
Self-scanning and storage of medical supplies.

List of medical supplies warehousing, provide name, medical department used, and quantity (the left side is the current warehousing quantity, the right side is the total amount).

Figure 8.5 Various functional interfaces for pharmacy managers
Message reminder page.

Voice interface.
Figure 8.6 Doctor/nurse Home Page

Quick search bar. Can be operated by voice.

Main menu bar.

Help button. Provide help.

The photo and name of the registrant. The circle in the upper right corner is a new message reminder.

Self-scanning and storage of medical supplies.

Message reminder page.
List of medical supplies warehousing, provide name, medical department used, and quantity (the left side is the current warehousing quantity, the right side is the total amount).

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Type of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

Different circle colors show the type of recyclable waste contained in the product.

Provide specific data of Inbound quantity, Usage amount and Remaining amount according to date.

<table>
<thead>
<tr>
<th>Date</th>
<th>Usage amount</th>
<th>Quantity of waste</th>
<th>Recyclable waste</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>
Figure 8.7 Various functional interfaces of doctors/nurses

Quickly provide the specific location of medical supplies in 3D mode.
Use the button to select the time of the line graph, you can choose days, a week, a month, a year.

Use a line chart to display the amount of medical supplies used by doctors/nurses and the amount of medical waste generated.
Quick search bar. Can be operated by voice.

Figure 8.8 Various functional interfaces for pharmacy managers
Voice interface.

Message reminder page.
Figure 8.9 Logistic Service Manager Home

- **Quick search bar.** Can be operated by voice.
- **Main menu bar.**
- **Help button.** Provide help.
- **The photo and name of the registrant.** The circle in the upper right corner is a new message reminder.
- **Self-scanning and storage of medical supplies.**
- **Message reminder page.**
The medical waste list provides the type of waste, the department that generates the medical waste (you can also select the corresponding department) and the amount of waste generated.

<table>
<thead>
<tr>
<th>Department</th>
<th>Type of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMMARY</td>
<td></td>
</tr>
<tr>
<td>50,000</td>
<td></td>
</tr>
<tr>
<td>80,000</td>
<td></td>
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<tr>
<td>80,000</td>
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<td>80,000</td>
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<tr>
<td>80,000</td>
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</tbody>
</table>

Different circle colors show the type of recyclable waste contained in the product.

Quickly display the amount of medical supplies used on the day, the amount of medical waste generated, the amount of medical waste pretreatment that day, the number of quilts & clothes used, the amount of quilts & clothes waste processed, and the amount of recyclable plastic produced.
Drop-down menu bar, you can choose to view surgical waste, internal medicine waste, pediatric waste, medical science waste, other waste and summary data.

Voice interface.

Figure 8.10 Various functional interfaces for pharmacy managers
Quick search bar. Can be operated by voice.

Message reminder page.
8.4 Moodboard

Color is the basic element, not only can convey visual information, but also more information. When choosing colors, consider the desire to give the image a futuristic and original appearance, so choose bright color with easy-to-recognize blue and lavender tones.

Blue represents both the sky and the sea, and is associated with open spaces, freedom, intuition, imagination, expansiveness, inspiration, and sensitivity. Blue also represents meanings of depth, trust, loyalty, sincerity, wisdom, confidence, stability, faith, heaven, and intelligence.

The color blue has positive affects on the mind and the body. As the color of the spirit, it invokes rest and can cause the body to produce chemicals that are calming and exude feelings of tranquility. Blue helps to slow human metabolism, is cooling in nature, and helps with balance and self-expression. Blue is also an appetite suppressant.

Purple is related to the spiritual sphere, it represents wisdom, magic, luxury and the future. It is a color often associated with the concept of beauty.
Figure 8.11  Mood board
8.5 Interactive Design

Figure 8.12 Login main interface—when the system is activated

Figure 8.13 Start face recognition
Figure 8.14  Recognition success

Figure 8.15  Login main interface-when the system is activated
Figure 8.16 Pharmacy manager main interface

Figure 8.17 Quick search interface
Medical supplies will be stored...

Figure 8.18  Self-service identification

Figure 8.19  Self-service scan succeeded
"Hey Xiaohua" is an AI voice recognition service for operating the medical waste management system.

Figure 8.20 Voice recognition interface

Figure 8.21 Doctor/nurse main interface 1
Figure 8.22  Doctor/nurse main interface 2

Figure 8.23  Various functional interfaces for pharmacy managers
Figure 8.24  Self-service identification

Figure 8.25  Self-service scan succeeded
Figure 8.26  Personal use of medical supplies data 1

Figure 8.27  Personal use of medical supplies data 2
Figure 8.28 Logistics service manager main interface 1

Figure 8.29 Logistics service manager main interface 2
Figure 8.30 Logistics service manager main interface 3

Figure 8.31 Logistics service manager main interface 4
Medical waste enters the temporary storage room

Figure 8.32  Self-service identification

Type of waste: Infectious Waste
Department: INTERNAL MEDICAL-Gastroenterology

Figure 8.33  Self-service scan succeeded
Figure 8.34 Data on cleaning medical supplies in the central office 1

Figure 8.35 Data on cleaning medical supplies in the central office 2
Figure 8.36 Medical waste data 1

Figure 8.37 Medical waste data 2
Figure 8.38 Smart trash can data

Figure 8.39 Medical waste data 4
8.6 Smart waste bin

The use of smart trash cans is a manifestation of smart cities. The smart waste bin is based on the Internet of Things technology and the use of the medical waste management system, which improves the efficiency of medical waste management. It is more convenient for managers to know the specific address, responsible person, quantity, and preparation of the waste to be transferred. How big is the transfer vehicle and the appropriate transfer route is planned; for doctors and patients, the medical waste is transferred in time, the quality of the medical environment is greatly improved, the probability of secondary infection of medical waste is reduced, and the The number of medical supplies used by a medical staff and the amount of medical waste generated; for hospital managers, according to the effective data after one year of use, the hospital’s treatment process can be planned and improved, and the use of medical supplies can be reduced. The same treatment effect as the original one strengthens the management of recyclable waste and enables them to be reused.

In the new system, based on the case study in Chapter 3, combined with the situation of Xinhua Hospital, we use Binology smartcity bin.

It is a self-sustainable solar paneled urban rubbish separation station, which consists of two and up to ten allied trash containers for manual separation of such valuable recyclables as: paper and cardboard, recyclable plastic, metal, glass etc. The central element of the station is the container for landfill waste, with compaction feature, while satellite containers are non-compacting, but all equipped with own fullness level advanced sensor system. Using SmartCity Management software, becomes simple to recognize the amount of each type collected waste.
Figure 8.40 Binology smart city bin

Figure 8.41 Cseparate tracking

Figure 8.42 Smart trash can data
8.7 Pretreatment of medical waste

In the early field investigation, it was found that Xinhua Hospital can produce about 2350kg of medical waste every day, which is transferred once a day. There are also many community clinics and various types of hospitals near Xinhua Hospital. In Shanghai, a medical waste treatment company is implemented in a city to transfer and dispose of waste. About 92 vans are used to transfer medical waste every day. Large hospitals can carry out pretreatment of medical waste, which can greatly reduce the volume of waste, and it is the initial disinfection and sterilization to prevent secondary infection during the transfer process. Then, the medical waste treatment company can rationally plan the transfer line, which is more efficient Medical waste transfer and reduction of non-reusable energy use. It is a good tool for environmental sustainability. sphere, it represents wisdom, magic, luxury and the future. It is a color often associated with the concept of beauty.

According to the case study comparison in Chapter 3, combined with the situation of Xinhua Hospital, our new system design will use Bertin medical waste technologies s.A.S’s Innovative solution for biomedical waste management.

According to the current Xinhua Hospital’s daily output of 2500kg of medical waste, in the new system, only one A post-treatment shredder needs to be purchased and run twice a day for approximately one hour to meet the medical waste treatment needs of Xinhua Hospital.

Its innovative concept uses a suspended vessel and rotating grinder blades to grind down all types of waste. Biohazardous waste is sterilised using microwaves and converted into inert municipal waste, The end product is similar to municipal waste and can then be fed into standard urban waste systems.
**ADVANTAGE**

1. **Full decontamination**  
   Biohazardous waste is sterilised with microwaves (heat it up to 110°C for 20 minutes) and allows microbial inactivation of up to 8log10.

2. **No liquid effluent**  
   The treatment process does not produce any steam or liquid effluent, which means no consumption of water and no need to include an effluent drainage system in its installation.

3. **Easy maintenance**  
   The equipment is built using robust technology. IP connection for diagnostics. Preventive maintenance plan/calendar with alarm.

4. **Safe processing**  
   Microwave sterilisation technology does not require pressurisation, and this removes any risk of explosion. Moreover, the microwaves are confined to the inside of the vessel to avoid operator exposure to radiation.

5. **No segregation**  
   The Sterilwave is suitable for all types of biomedical waste (needles, glass, solids, liquids, etc.)

6. **Reduces weight by 25% and volume by 80%**  
   Biomedical waste is converted to inert waste similar to municipal waste. The dry ground-up waste can also be used as secondary fuel.

**DISADVANTAGE**

1. **Treated waste still needs to be transported to a waste**

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**Figure 8.43 Process description**

**Figure 8.44 Innovative solution for biomedical waste management**
8.8 Project system
Figure 8.45 Diagram of the project system
1. Medical Supply Company
The raw materials of paper, plastic, glass, etc. output from the waste recycling plant can be reused by the medical supply company.

5. Temporary waste storage room

6. Logistics Service Department

Figure 8.46 Life cycle of medical supplies in Xinhua Hospital
2. Pharmacy and Supply storage of Xinhua Hospital

3. Pharmacy and Supply storage in various departments

4. Various medical offices

7. Central office
   - Used medical sharps, infected quilt & clothes are cleaned, disinfected and sterilized, and then reused.

8. Waste recyclable plant, waste treatment plant

   The output of the waste recycling plant is that some of the raw materials such as paper, plastic, and glass can be reused, and some will be used as raw materials for carpets. The waste treatment plant outputs raw materials such as compost and fly ash.
our research also found that Xinhua Hospital has a 0% recycling rate for uncontaminated plastics. Therefore, the new system design will intelligently remind doctors\nurses to recycle materials such as recyclable plastics and paper.
CHAPTER 9

Conclusion
9.1 Conclusion

After nearly eleven months of research, we successfully completed the field survey at Shanghai Xinhua Hospital ten days before the outbreak of the new coronavirus. Unfortunately, the Italian epidemic immediately followed the outbreak and there was no opportunity to conduct field surveys in Italian hospitals. But Professor Amina Pereno has provided us with a lot of help, allowing us to smoothly carry out our project to this point.

A year ago, Shanghai’s mandatory classification of municipal waste aroused our interest in research on the treatment of medical waste, because the rationalized classification of municipal waste has been implemented, and poorly managed medical waste has already had a certain impact on the environment and people. An urgent problem. Coupled with the menacing new coronary pneumonia epidemic, the reasonable and effective treatment of medical waste is of great significance to the sustainable development of the territory.

Therefore, after we conducted 11 months of research, we designed a new Xinhua Hospital system design. Based on the Internet of Things technology and smart city ideas, we designed a medical waste management system for the hospital’s pharmacy managers, Doctors/nurses and managers of the logistics service department conduct a systematic management of the whole life cycle of medical supplies to medical waste in the hospital.

The use of smart trash cans is a manifestation of smart cities. The smart waste bin is based on the Internet of Things technology and the use of the medical waste management system, which improves the efficiency of medical waste management. It is more convenient for managers to know the specific address, responsible person, quantity, and preparation of the waste to be transferred. How big is the transfer vehicle and the appropriate transfer route is planned; for doctors and patients, the medical waste is transferred in time, the quality of the medical environment is greatly improved, the probability of
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In the early field investigation, it was found that Xinhua Hospital can produce about 2350kg of medical waste every day, which is transferred once a day. There are also many community clinics and various types of hospitals near Xinhua Hospital. In Shanghai, a medical waste treatment company is implemented in a city to transfer and dispose of waste. About 92 vans are used to transfer medical waste every day. Large hospitals can carry out pretreatment of medical waste, which can greatly reduce the volume of waste, and it is the initial disinfection and sterilization to prevent secondary infection during the transfer process. Then, the medical waste treatment company can rationally plan the transfer line, which is more efficient Medical waste transfer and reduction of non-reusable energy use. It is a good tool for environmental sustainability.sphere, it represents wisdom, magic, luxury and the future. It is a color often associated with the concept of beauty.

Of course, our research also found that Xinhua Hospital has a 0% recycling rate for uncontaminated plastics. Therefore, the new system design will intelligently remind doctors\nurses to recycle materials such as recyclable plastics and paper.
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