

# The Echelon Pattern and Its Key Technologies of Urban Circle Solid Waste Disposal

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## Abstract

A systematic, global and integration concept is applied upon garbage disposal problem caused by the substantial increase of garbage in China's cities and towns to promote the coordinated development of garbage stations. A kind of echelon pattern of urban circle solid waste disposal is put forward as well as five key technologies which are essential to be used in the pattern. The echelon pattern can provide the technical foundation for urban-rural garbage treatment station construction and assessment and help policy makers to make sound decisions in improving the comprehensive efficiency of urban circle solid waste disposal.

**Keywords:** *Urban Circle; Solid Waste Disposal; Echelon Pattern; Key Technology.*

## 1. Introduction

With the growing urban population, the continuous improvement of the consumption level, significant increase in the amount of municipal solid waste (MSW), and the contradiction between the urban-rural waste site settings at different levels and people's living environment has become increasingly prominent. The existing MSW disposal can't meet the needs of the current and future development anymore, so there is an urgent need to seek a new solid waste disposal mode to crack this puzzle. With the goal of common development, Urban circle is a cooperative community, led by one central city, including small and medium-sized cities around, and covering towns in rural areas, Driven by "Rise of Central China" strategy, six major city groups of the central region – Hubei Wuhan Urban circle, Henan Central Plains City Group, Hunan Changzhutan city group, Anhui Wanjiang

City Group, Shanxi Taiyuan Metropolitan Area as well as in Jiangxi the Poyang Lake City Group came into being. The establishment of the urban circle provides a political and policy environment to the building of solid waste disposal system.

Solid waste collection and disposal problem, belonging to government behavior, is also a social action, because it's related to the social environment and people's health. At present, the theoretical study by the domestic and foreign experts and scholars are mainly concentrated in the MSW collection and disposal approach, the optimization of transportation route, the impact on environmental, economic evaluation, etc, all of which are unilateral-lacking of systematic, global and integration concept. Researchers considering the layout and planning issues for all of the urban-rural solid waste disposal point, stations and field is quite few.

In order to solve the current and the next period solid waste disposal problem, a kind of echelon pattern about urban circle solid waste disposal is proposed, which is designed to solve the integrated design problem of the solid waste disposal stations that occurs in the processing of urbanization systematically and scientifically.

## 2. Current Situation and Existing Problems of the Urban Circle Solid Waste Disposal Pattern

### 2.1 Lack of Systematic Concept

Urban circle solid waste processing usually contains operations of collection, initial processing, transit processing and final processing, etc. There exist association and mutual constraints in the series of the operations. For example, if the final processing uses incineration treatment, there is no need to compact in the transit processing. Therefore, planning and layout of the urban circle solid waste disposal must be based on systematic view.

There are mainly four kinds of final processing of the urban circle solid waste currently, which includes landfill, incineration, composting and sorting-recovery [1]. At present, the domestic final disposal of solid waste is mostly landfill, a variety of final treatment methods are independent of each other, out of touch with each other, or even contradictory. Such as, in order to save freight cost, the solid waste station blindly pursuing increased compression ratio in transit processing, regardless of the requirements of landfill, incineration, composting, sorting-recovery, resulting in stamp breaking of the compacted solid waste again in the middle and the end of the processing chain.

In addition, waste classification illustrates the wide gap between China and developed countries. Sorting-recovery system has not yet formed, currently depending on setting waste sorting bins to achieve junior garbage classification, but the mixed solid waste collection still dominates in transportation. Due to the limited separation efficiency, quality and market of the mixed MSW's recoveries are restricted.

## 2.2 Lack of Global Planning

The planning and construction of the garbage station belongs to the category of urban planning and environmental planning usually. The planning department sets refuse collection points and transfer stations at all levels in accordance with the specification and the service radius configuration, generally only considering the division of location, geographical environment, city size and population factors, regardless of the environmental, economic and social benefits analysis based on the principle of 3R-reduce, reuse, recycle. There is no global planning of all the environment, society, economics, and technology.

From the level of economic development situation, in the economically less developed areas, the phenomenon of "valuing cleaning, but belittling waste processing" is prevalent, which means sweeping, transiting, and transporting the untreated MSW to the yard or simple landfill directly, resulting in a very serious environmental pollution. In the not particularly developed areas, there is the phenomenon of "attaching importance to the end of garbage treatment, undervaluing reducing the waste source". In these areas, sanitary landfills with high investment and a large-scale are constructed in most areas, but the neglect of reducing the waste source, mixed collection and transportation, results in higher organic loading landfill, also, the defective methane collection and treatment measures causes security risks and the pollution of the atmosphere. In economically developed areas, limiting disposable supplies and excessive packaging in many

regions, implementing clean vegetables to urban, increasing the classification collection efforts, and other measures are taking to achieve "emphasizing both the reduction of the waste source and classification collection", but due to the lack of appropriate policies and regulations support, and the mixed garbage collection, as well as ineffective follow-up treatment facilities convergence supporting, garbage source reduction is not good [2].

Meanwhile, the planning and management of rural solid waste has also become an increasingly prominent problem. The rural garbage has no fixed stacking and disposal points, so residents can only randomly dump waste in the rural roads, ditches and river side in the open air, which affects the surrounding environment. What's more, in a rain season, the garbage in the ditches and river side is washed into rivers or lakes, which will not only seriously affect the safety of the people's production and living water in downstream areas, but also silt river estuary over time, planting a security risk for boating.

## 2.3 Lack of Integration Design

The integration design of urban circle solid waste disposal is the key to achieve optimum comprehensive effectiveness of environmental, social, economic benefits, which includes the whole process integration design of garbage primary processing method and collection, transfer processing method, mode of transportation, site layout, final disposal field construction, etc. Currently in either planning or enterprise product design process, no integrated design mentality has formed.

According to the survey of a large company located in Wuhan, Hubei, which is focused on environmental protection equipment R & D, manufacturing and sales, the company has assets of RMB ¥230 million, and its annual production of various kinds of environmental protection equipment is more than 1000 sets. Through the research of the firm's buried lifting type garbage compression station, transfer station, etc, it's found that the mentioned two kinds of products' design ignored the series matching problem of the compression cavity's section size, namely to put compressed garbage (compression ratio of 1:1.3) of the underground station into the transfer station to do the second compression (compression ratio of 1:3), the compacted trash also needs to be scattered and put into the discharge chute. That is to say, the products of the present large-scale domestic enterprises also hasn't formed an effective docking technique, ignoring the relationship between upstream and downstream, regardless of the series products conception, and produced tremendous waste. Direct consequence of that is all the garbage, compressed by the environmental protection mechanical,

can only achieve the single performance of collection and transfer level.

This is just an example of ignoring one part of integration design. In addition, the ineffective separating in the collection points, which leads to antinomy of compression and sorting, technical conflicts between small station and big station, cohesive link problems of transfer processing, final disposal and resource utilization, can all be attributed to the lack of integration design method in the whole process of garbage disposal.

### 3. Echelon Pattern of Urban Circle Solid Waste Disposal

This paper puts forward a kind of the echelon pattern of urban circle solid waste disposal to provide a comprehensively optimum and systematical integration design of urban circle solid waste disposal, and to solve the rural garbage disposal problems especially[3],[4],[5].

From the systematic and global perspective, urban circle solid waste disposal pattern has a category of urban circle

which contains rural areas, with the object of optimum comprehensive effectiveness –being highly efficient environmental friendly, economical and social favorable. The pattern is the integration design of garbage disposal process, which unifies the independent steps into a whole process, which includes garbage collection, intermediate processing, transfer, middle processing, and the final disposal[6],[7].

The echelon pattern of solid waste disposal divides the process from urban circle garbage's emergence to its harmless treatment into three stages- "pretreatment (Collection) -- intermediate processing (transit) -- final disposal", which constitute gradient levels, as shown in figure 1. According to the order processing (pretreatment -- intermediate processing -- final disposal) or reverse order processing (final disposal -- intermediate processing -- pretreatment), the integrated design (configuration) deals with the entire process of garbage disposal, considering the interactions among these factors and constraints of garbage disposal system, to achieve the goal of optimum comprehensive effectiveness.

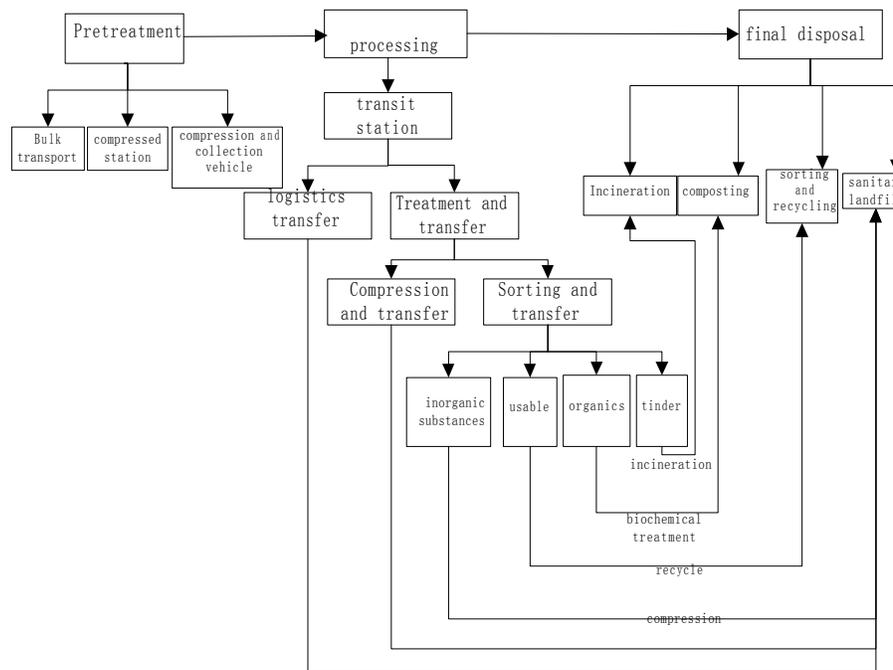


Fig.1 The systematic structure of echelon pattern of the urban circle solid waste disposal

As seen from Figure 1, echelon processing mode is the design of various types of domestic waste treatment process from the systematic view. Urban circle is a large cluster that contains more than one city, each subset has different features. Therefore, selection and establishment of the echelon processing mode must solve the relevant

issues of the whole process binding factors mainly, which include the policy, environment, economy, society, technology, properties of the waste, and so on [8],[9],[10],[11]. Taking one echelon mode as an example, in which landfill is the final processing, the article lists the constraints on collecting points, garbage station and

garbage fields of the urban circle garbage collection and transportation mode, considering the ash, residue produced

in incineration, biochemical treatment and recycling also needs sanitary landfill, as shown in table 1.

Table1 The constraints on collecting points, garbage station and garbage fields of urban circle garbage processing mode

In the echelon pattern of urban circle solid waste disposal, owing to too many factors in table 1, the paper selects some representative factors to illustrate the constraints and relationship between the three links of from the angle of technology, selection of echelon pattern between each, as

shown in figure 2. In order to achieve integrated design goal of collecting points, garbage station and garbage fields, the series optimization of waste production, development, and processing must be done. The process of optimization is to analyze the related factors of the key

<i>Processing steps</i>	<i>Collection points</i>	<i>Transfer stations</i>	<i>Landfills</i>
<i>Constraints</i>			
<i>Garbage characteristic</i>	physical properties (water content, bulk density, porosity, internal friction) chemical properties (volatility, ash, elemental composition, calorific value) biological characteristics (biological properties, biodegradability of waste)	garbage sorting garbage grinding garbage compression	compression density content of organic matter external load outline dimensions
<i>Political factors</i>	Technical specification for garbage collection station	Technical specification for city garbage Standard for transfer station design ; Technical specification for garbage transfer station	Standard for garbage sanitary landfill technology Control index of Garbage landfill pollution Technical requirements for environmental monitoring of landfills vegetation, landform, stone and soil conditions
<i>Environmental factors</i>	Urban-rural planning Professional planning in environmental sanitation	dusting and deodorization virescence requirements of fireproofing, sanitary and security	hydrology and geology precipitation amount of evaporation prevailing wind direction in summer
<i>Economic factors</i>	sanitation facilities residents' living level	transportation cost of collection vehicle transportation cost of transport vehicle transfer stations' operating cost	cost of land acquisition cost of sealing barrier system cost of geological barrier system cost of leachate collection and treatment system
<i>Social factors</i>	the residents living habits population density residents' support and participation	geographical environment Customs and habits Architectural style Traffic	overall planning of city Regional environmental planning Professional planning in cities' environmental sanitation
<i>Technical factors</i>	waste generation collection point distribution service radius collection mode collection devices	daily processing capacity garbage compression ratio collection vehicle loading transport vehicle loading process of technique	city scale service radius machinery and equipment the way of landfill total capacity of landfill

links and the building of key indicators. Taking the disposal manner of sanitary landfill as an example, the optimization is to develop the indicators for garbage compression ratios of various sites that are consistent with landfill requirements, to set the box body size indices for collection vehicles, compression vehicle, transport vehicle that are good for docking, and to develop the size indicators for the compression station, relay station and landfill feeding bin (heap) to meet the technical requirements, etc.

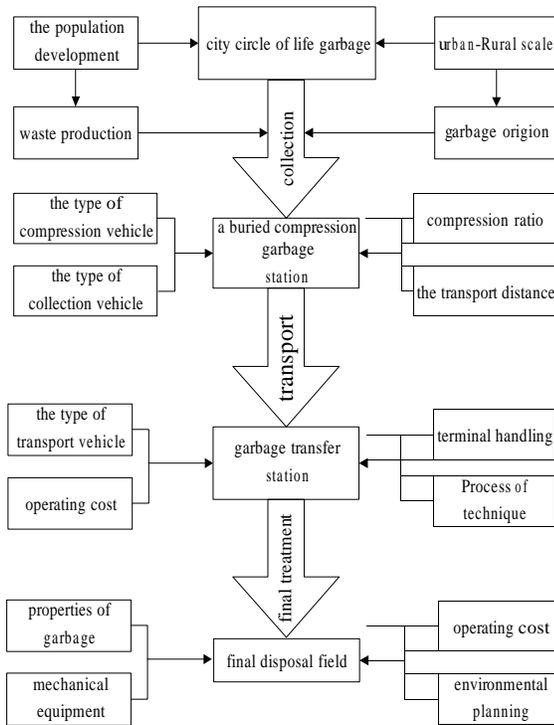


Fig.2 The graph of echelon pattern of the urban circle solid waste disposal

In addition, to ultimately realize the integrative design of echelon pattern of the urban circle solid waste disposal, it is necessary to explore the regularity of influence between relational links' constraint factors, to find the balance point of treatment effect and economic benefit, and to the realize some key techniques of this mode[12],[13].

#### 4. Key Technologies of Urban Circle Solid Waste Disposal

Based on a wide range of research and analysis, the key technologies are summed up in the following five aspects, which are necessary for the realization of echelon mode of urban circle solid waste disposal:

1) The technology for the prediction of the quality, location and classification of the urban circle garbage output, which includes towns and villages.

The technology is based on the residents' solid waste in urban circle, especially the rural areas included in which. Coincident with the development and long-term planning of urban circle, it's a joint prediction technology of the quality, location and classification of the urban circle garbage output.

2) The technology researching the relationship and constraint between elements of various processes in the echelon mode.

Grounded on the rule of law about garbage disposal and dividing the process of garbage disposal into stages of pre-treatment, treatment and final processing, the technology analyze influence elements of garbage disposal station (field), restricting factors of the construction of garbage disposal station (field) in the urban circle, technology characteristics of different garbage processing stages, and make the pattern of the systematically echelon pattern according to sequence and the reverse process.

3) The integrated design (configuration) technology for achieving optimum comprehensive effectiveness under the framework of urban circle.

Aimed at achieving optimum comprehensive effectiveness, the technology uses correlation algorithm, explores relationships and seeks integrated design of the whole process to optimize primary garbage processing, intermediate process, transportation mode, site layout, final disposal field construction and other links[14],[15]. It developed a comprehensive technology providing indices for different processing method, which includes garbage classification, collection and transportation route, technical planning, equipment improvement, and selection of locations.

4) Urban circle solid waste disposal station (field) layout optimization technique

Premised on low investment, small area and low operation cost[16], and the technology is to optimize the layout of urban circle garbage treatment station (field) for a proper echelon mode, which means the optimization of both the technical process and layout planning, with theories of facilities planning, logistics and plant design. What's more, by establishing the evaluation methods for layout optimization, an optimized project can come into being.

5) The software development technology for the garbage treatment station (field) planning and layout system

Based on the optimal layout method of urban circle garbage disposal station (field), programming with the target layer parameters, constraint conditions, and pattern calculation method, and inputting the known conditions, garbage disposal station (field) layout and equipment selection can be shown to us, by using computer aided design method. By developing the relevant planning software, combined with the engineering example, and using human-computer interaction, research can be done and technical rationality of the layout in engineering cases can be evaluated.

## 5. Functions and Significance of the Urban Circle Solid Waste Disposal Echelon Pattern

To establish an echelon pattern of urban circle garbage disposal, a series of theory is to be used comprehensively, which includes mathematical statistics, operations research, systems engineering, facilities planning and logistics, computational applications. The construction and implementation of urban circle garbage processing echelon mode can effectively solve the environmental protection problem in the development of win-win urban circle urban and the hierarchy problem of urban-rural garbage disposal station planning, providing the technical foundation and guidance for urban-rural garbage treatment station construction and assessment. At the same time, the research for core technology of the urban circle garbage echelon mode and its application technology can make a good use of land resources of available land for layout of intercity garbage stations, solving the problem of disordered garbage collection, resourceful disposal and industry application. Functions and significance of the urban circle solid waste disposal echelon pattern are as follows:

1) Integration of design (configuration) technology can effectively solve the collection and processing problems of urban circle, improving the situation of each city manages MSW severally. Comprehensively optimal efficiency pattern is conducive to the sustainable development of resources and environment, reducing the social waste greatly.

2) The corresponding theoretical pattern and computer aided design application, especially from the source of design, simplifies layout program, optimizes design method in engineering, and provides scientific theoretical basis for government management and city planning departments.

3) By constructing of the human-computer interactive key parameters calculation and equipment selection platform,

developing reasonable and systematic software for design process, and creating an effective business technology marketing pattern, technical support can be provided for many domestic sanitation enterprises, which is good for their sustainable development.

The research into echelon pattern of urban circle garbage disposal is a future-oriented and social commonweal activity. Comprehensive, systematic, and integrated research ideas will lead the trend of future development and turn over a new leaf for solving the MSW disposal problem.

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