



ECOLOGICAL TREATMENT OF URBAN ORGANIC WASTE IN THE CONTEXT OF CLIMATE CHANGE- A CHINESE PERSPECTIVE

Xiuhua Li¹

Mehran Idris

Khan²

Yen-Chiang Chang³⁺

^{1,2}Ph.D Candidate, School of Law, Shandong University, China.

¹Email: lixuhua@wincon.cn Tel: +86-15954220987

²Email: lfomd@hotmail.com Tel: +86-13065058671

³Professor of Law, Ph.D. Supervisor, School of Law, Dalian Maritime University, China.

³Email: ycchang@dlmu.edu.cn Tel: +86-15275197632



(+ Corresponding author)

ABSTRACT

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Climate change is a common challenge for human society. On December 12, 2015, as the Paris Agreement adopted, China's carbon emission reduction actions have been more determined to become a fundamental force in promoting global climate governance. China has to carry on the corresponding reform in terms of the policy, technology, market of climate control, and innovate the way of low carbon development and energy transformation with Chinese characteristics. It will indicate that urban organic waste is closely related to the emission of greenhouse gas, which resources and ecological treatment will be faced with a profound change. Based on the analysis of the present situation and the development direction of China's urban organic waste treatment, this paper will provide a way for the construction of the ecological treatment mechanism of urban organic waste in the context of climate change. To this end, this study adopts qualitative means of investigation, and takes a Beijing-based energy company as case study and draw lessons from its implications concerning the ecological treatment of urban organic wastes, for future considerations by various stakeholders including government agencies.

Contribution/Originality: It is suggested that from the legal level, the purpose of the *Law on Prevention and Control of Environmental Pollution Caused by Solid Wastes* should be re-defined, and the provisions about urban organic wastes treatment in the *Law of Promotion of Circular Economy* should be further detailed; from the technical level, attention should be paid to research and development of ecological treatment technology, and the construction and application of China's ecological treatment information database should be intensified; from the social consciousness level, efforts should be made to emphasize the consciousness of organic wastes classification and intensify the cultivation of the values of the public for organic wastes classification to cope with the oncoming risks of climate change with active actions.

1. INTRODUCTION

On April 22, 2016, China became one of the parties to the Paris Agreement that is the third milestone agreement responding to climate change in the history of humankind, which lays solid legal foundation for China to implement greenhouse gas (hereinafter GHG) emission reduction action after 2020. Since 2007, China has overtaken developed countries such as the United States and Japan, and became the largest GHG emitter in the world (United Nations, 2010). However, on the basis of the 'common but differentiated' principle, the Paris Agreement firstly put all developing countries, including China, into the list of countries with mandatory emission

reductions and clearly defined the important legal status of nationally determined contributions (Jiménez, 2013). The nationally-determined contribution document submitted by China on June 30, 2015, clearly stated the nationally-determined action target that “carbon dioxide emission per unit GDP in 2030 will decrease by 60% -65% as compared to the level in 2015 (Xinhua, 2015).” However, China’s carbon dioxide emission per unit GDP in 2014 decreased only by 33.8% over 2015 (Jiang, 2016) which means that China has to complete close to 1/2 emission reduction task within the coming 15 years. It is, undoubtedly, an enormous challenge for China since it is in the buffer period of emission reduction. Besides, due to the parallel operation of mandatory emission reduction and nationally-determined contribution action adopted by the Paris Agreement, China has drawn the attention from across the world. China has to make more efforts than ever in order to achieve the agreed targets. The carbon emission reduction action, therefore, must be initiated immediately (Chang and Wang, 2010).

In recent years, China paid more and more attention to control over carbon emission in the fields of buildings (Wang *et al.*, 2010) and traffic while relatively less attention being paid to the treatment of urban organic wastes. As early as 1994, the biogas produced by the treatment of urban solid wastes in China reached 2.03 million tons, and the carbon dioxide produced reached 42.63 million tons, close to 1/3 of GHG produced by nation-wide wastes treatments (Wang and Chang, 2014a). A report released by the EU namely the ‘*Waste Management Options and Climate Change: Final Report*’ pointed out that biogas emission of biomass wastes in an anaerobic environment imposes the largest impact on the global warming potential in the EU solid waste management, and about 1/3 of artificial biogas emission comes from solid waste landfilling (Jinxing, 2012). With the development of urbanization in China, the output of China’s urban solid wastes may reach close to 1/4 of the world’s gross output (Wang and Chang, 2014b). The GHG produced by wastes treatment is inestimable. This means that urban organic wastes, as a part closely relating to the GHG emission, have to go through a profound revolution in their resource-oriented or ecology-oriented treatments.

The study presents a thorough discussion and appropriate knowledge about the ecological treatment of urban organic wastes in China by adopting a method of content analysis for investigating environmental significance. The study takes Beijing Baishiqingyuan New Energy Technology Co., Ltd. (hereinafter Baishiqingyuan Company) as a case study and sketches its implications to the subject matter in a broader sense followed up with an abstract as suggestive measures for Chinese government to reconsideration, and amending relevant laws and policies in order to make progress in this domain. While considering data constituting the internal documents of Baishiqingyuan Company, official websites, as well as secondary sources including books and scholarly articles, have also been considered.

Table 1 presents the comparative advantages and disadvantages of traditional treatment manners. Table 2 provides the principal legal documents for urban organic waste treatment in China. Table 3 gives a comparison of ‘ecological treatment’ with that of ‘traditional treatment’ for urban organic wastes. Table 4 presents a comparison between the heat-pressing critical oxidation technology and the traditional treatment technology. Whereas, Figure 1 provides in-depth knowledge about marketization mode applied by the Baishiqingyuan Company, and Figure 2 deals with the ecological treatment mechanism of urban organic wastes.

By the same token, section two explains and discusses the current situation concerning the treatment of urban organic wastes in China coupled with its implementation, legislation and a call for climate change. It describes the new requirements of the climate change on the urban organic waste treatment in China, and explains the pertinent ecological concept in detail. Section three provides a case study of Baishiqingyuan Company concerning the development direction of ecological treatment of urban organic wastes. This section explains the characteristics of ecological treatment, current practices and some significant measures in which the said company has taken in this regard, and would benefit the relevant government agencies while considering or reconsidering the appropriate laws and policies. These observations are based on the analysis of the company’s operational mechanism and its own technology, i.e. ‘heat-pressing critical oxidation’. This section also compares ecological treatment with traditional

incineration, landfill and composting treatments, and the development of the treatment of urban organic waste in China, which should be characterized as carbon reduction technology with high efficiency and market-oriented multi-participation.

Section four will provide a discussion over ecological treatment mechanism for urban organic wastes in the context of climate change including its ideas and main contents. Ideas are 'Greenization' and 'Integration', together with the recommendation to establish appropriate ecological treatment mechanism at legal, technical, and social consciousness levels. Summed up in section five will provide recommendations and concluding remarks.

2. THE CURRENT SITUATION REGARDING TREATMENT OF URBAN ORGANIC WASTES IN CHINA

2.1. The Implementation of Treatment of Urban Organic Wastes in China

At present, the treatment of China's urban organic wastes follows the principle of harmless treatment. The pollutants can be decreased through harmless treatment as outlined in the national standards to achieve the goals of harmless treatment and resource recovery on the sphere of ecological treatment of organic waste (Tang and Xie, 2017). Therefore, the major treatment methods in China include landfilling, incineration and composting in sequence. The basic principle of treatment of China's urban organic wastes mainly carries forward the concept of circular economy of 'material reciprocity and recycling', that is, (1) reduction: all measures are taken from the production front end to the final end in order to minimize the produced wastes quantity, volume, and toxicity; (2) resource-oriented treatment: the wastes are transformed into precious materials by different technical approaches to restore the resource attribute of the wastes so that all usable materials and energy can be extracted from the wastes for reuse; (3) harmless treatment: the purpose of making the wastes harmless to human and environment can be achieved by a particular harmless treatment technology, thereby avoiding secondary pollution of the wastes (Fenyun, 2011; Mylan *et al.*, 2016; Ferronato *et al.*, 2019; Tseng *et al.*, 2019).

Table-1. Comparative advantages and disadvantages of traditional treatment manners.

Manner of treatment	Advantages	Disadvantages
Landfill	Low costs	severe waste of resources; occupation of a large quantity of land; production of a large quantity of carbon dioxide and biogas
Incineration	Noticeable reduction effect; thorough harmless treatment	high costs; a large quantity of pollutions and carbon emissions; difficult to select a site
Compost	Better resource effect	Soil pollution

In practice, as shown in Table 1, three different organic waste treatment manners have their respective advantages and disadvantages. From an economic perspective, the landfill is lowest in cost and easiest to operate, which, however, requires the occupation of a large quantity of land and cannot effectively extract resources from the wastes. The net result will be wasting a large quantity of resources and going against the basic principle of China's circular economy. From the perspective of resource availability, the compost is only applicable to the middle and western regions of China that are abundant in land resources. From the perspective of reduction, the incineration has the highest reduction level. However, the incineration is easy to result in severe environmental pollution and arouse contradictions and conflict of interests between different social groups (Jingwei, 2014).

In 2009, several group events protesting against waste incineration power generation project occurred in China. The waste incineration power generation projects that have been completed and are intended to be built in Wujiang, Jiangsu and Fanyu Guangdong, were canceled or postponed indefinitely due to strong protest from the public (Ke, 2014). Many local residents may still strongly oppose those waste incineration power generation plants that already pass environmental impact assessment and produce an extremely low level of pollutions. From the

perspective of the resources-oriented treatment, the effect of composting is remarkable. However, because the wastes in China contain higher bio-degradable content and more toxic and harmful substances (Wentao, 2015) soil pollution may be easily produced after a long time of compost, thereby harming human health. Thus, composting is seldom adopted in China (Runyuan, 2010).

From the perspective of climate change, the landfill is most frequently adopted in China to treat urban organic wastes with the main purpose of seeking harmless treatment rather than resource-oriented treatment. In this manner, the threat of climate change will be aggravated, and thus the effect of GHG will be intensified.¹ The wastes' landfilling rates in some developed countries are also high, for example, 67 % in the United States, 83% in the United Kingdom, and 68% in Germany. Japan's wastes' landfilling rate is still up to 23% despite the shortage of land in the country. Different from China's harmless treatment, the resource-oriented treatment in these countries occupied a big proportion (Jianming and Xingge, 2006). For example, the United States and Japan utilized the wastes landfill gases to generate power with mature technologies and supplied electric energy or heat energy to cities to achieve resource recycling. However, China utilized the backward landfilling approach to treat urban organic wastes, resulting in an extremely low rate of resource-oriented treatment and bringing about the structural imbalance of China's urban domestic waste treatment (Zhong and Fujian, 2015). The existing landfill and incineration manners of China will not only break through the local environmental capacity and waste inestimable useful resources but also trigger large-scale group events. With the passage of time, this even brings unfavorable impact to China's actions in responding to climate change.

2.2. The Legislation for China's Urban Organic Wastes Treatment

As shown in Table 2, the legislation in China regarding organic waste treatment mainly includes *Law on Environmental Protection (EPL, 1989)* *Law on Promotion of Circular Economy (CEPL, 2008)* *Law on Prevention and Control of Environmental Pollution Caused by Solid Wastes* in which indicated the basic principles for treatment of urban solid waste, reduction, resource-oriented and clean treatments of urban organic wastes (MOFCOM, 2007). The regulations relating this aspect mainly include *Administrative Regulations on Urban Domestic Wastes (NPC, 2004)* *Working Opinions about Further Intensifying Urban Domestic Wastes Treatment*, and so on.

Table-2. Major legal documents for urban organic waste treatment in China.

Major legal documents	Articles relating to urban organic wastes treatment	Main contents
Law on promotion of circular economy	Articles 41 and 46	Recycling and resource-oriented treatment of urban organic wastes and incentive measures
Law on prevention and control of environmental pollution caused by solid wastes	Articles 48-49	Competent authorities in charge of sweeping, gathering, transportation and treatment of urban domestic wastes and their responsibilities and obligations
Administrative provisions on urban domestic wastes	Articles 23-28	Qualification requirements for enterprises to treat urban organic wastes
Working opinions about further intensifying urban domestic wastes treatment	All	Strictly control the production of urban domestic wastes, comprehensively increase the capability to treat urban domestic wastes, intensify supervision and management, and increase policy supports and strengthen organization leadership

¹The landfill gases also contain a small amount of ammonia, carbon monoxide, hydrogen sulfide, and several volatile organic substances and so on, and produce odor and air pollution. Two major components of the landfill gas (methane and carbon dioxide) belong to greenhouse gases. According to IPCC, the carbon dioxide contained in the landfill gas that are not processed results from biomass decomposition and is deemed as a part of natural carbon circulation and not calculated in greenhouse gases. The methane in the landfill gas is put into the list of atmospheric greenhouse gases and has a greenhouse effect 21 times that of carbon dioxide of the same volume.

Section 3, Article 3 of *Law on Prevention and Control of Environmental Pollution Caused by Solid Wastes* states “prevention and control on environmental pollution caused by domestic wastes”, generally specify “sweeping, gathering, transportation and treatment of domestic wastes should be in compliance with the State rules relating to environmental protection and environmental health administration to prevent environmental pollution.” *Administration Regulations on Urban Domestic Wastes* is considered as a legal document that covers the largest range of urban organic wastes.

Articles 23-28 in the *Administration Regulations on Urban Domestic Wastes* state that wastes treatments are mainly covering qualification requirements for enterprises to treat solid wastes rather than providing for specific and quantifiable action targets geared to modern solid waste treatment development in addition to the basic obligations. For example, Article 23 states that “urban domestic wastes should be treated in urban domestic wastes transfer station or treatment plants or sites. Any unit or individual shall not treat urban domestic wastes arbitrarily without approval.” Article 24 states that “technologies, equipment, materials used for the treatment of urban domestic wastes should comply with the State technical standards relating to urban domestic wastes treatment to prevent environmental pollution.” These provisions are excessively formalized so that their applicability and practicability are essentially poor. Thus, the provisions cannot be well adapted to fulfill the requirements of China’s ecological development.

Working Opinions about Further Intensifying Urban Domestic Wastes Treatment suggested that applicable technologies should be selected according to specific situations and different regions should select different wastes treatment technologies based on respective land resources situations and waste management levels. However, since local economic development levels and wastes management capabilities differ significantly, the selection of respective wastes treatment methods by respective governments does not facilitate high-efficiency treatment and carbon emission reduction at a nation-wide level.

In China, urban organic wastes treatment is more likely to be regarded as a welfare undertaking. Therefore, compared with mandatory and punitive measures, more policy documents for guidance and incentives are released. For example, the outline of the 11th Five Year Plan 2006 ever pointed out that “efforts should be made to intensify construction of urban wastes treatment facilities and strengthen levy of urban wastes treatment fees to ensure harmless treatment rate of urban domestic wastes is no less than 60% by 2010 (11th FYP, 2006).” In 2013, *Opinions of State Council about Accelerating Development of Energy-Saving Environment-Friendly Industries* proposed that “efforts should be made to explore a new path for urban wastes treatment and implement exemplary projects for the collaborative resource-oriented treatment of urban wastes.”² These proposed policy provisions only focus on the problem of urban organic wastes treatment on one point, resulting in that the problem of resource-oriented treatment of urban organic wastes across regions or industries is still pending. The treatment level of China’s urban organic wastes is directly related to whether the target of climate governance can be achieved. Improper urban organic waste treatments may also slow down or delay the progress of climate governance. It is, therefore, needed a new urban organic wastes treatment mode to meet the requirements of climate governance.

2.3. Climate Change Calls for Ecological Treatment

‘Ecological treatment’ is to focus on the wide application of ecological and technical approaches with the circular economy as guidance and green ecology as a target to fully exert the functions of market and effectively coordinate the forces of governments, enterprises, and the public. The purpose is to ensure that the urban organic wastes treatment would meet China’s needs to respond to climate change under the precondition of regulating and supervising the conducts of authorities and enterprises involved in urban organic wastes treatments (Yin, 2016).

² Page 10, *Opinions of State Council about Accelerating Development of Energy-Saving and Environmental-Friendly Industries*, 2013.

'Ecological treatment' is an end-of-pipe control manner for organic wastes, which especially emphasizes the important functions of professional and efficient enterprises in the ecological treatment of urban organic wastes. However, ecological treatment is different from traditional end-of-pipe treatment. The traditional end-of-pipe treatment is subject to limitations of methods, technologies, and benefits in the aspects such as the elimination of environmental pollution and the achievement of the ecological civilization of industrial production (Bin, 2003). However, 'ecological treatment' can effectively compensate deficiencies of China in the 'front end work' of urban organic wastes treatment (for example, China cannot achieve wastes classification and recovery at present), and also eliminate the limitations of traditional end-of-pipe treatment so as to achieve environment-friendliness, high technical efficiency and high benefits (Bo *et al.*, 2016).

3. DEVELOPMENT DIRECTION OF ECOLOGICAL TREATMENT OF URBAN ORGANIC WASTES – A CASE STUDY FROM BEIJING BAISHIQINGYUAN NEW ENERGY TECHNOLOGY CO., LTD

3.1. Characteristics of 'Ecological Treatment'

Firstly, 'ecological treatment' comes up in response to climate change. We are living in a world of highly carbonized with high-energy-consumption as well as high-pollution. With increasing urbanization together with the urban population in China, urban organic wastes have been increased in quantity and scale (The World Bank, 2012). The traditional single treatment will not only produce a large quantity of carbon emissions that may impose an unfavorable impact on climate change but also bring significant environmental risks. 'Ecological treatment' conforms to the environmental or ecological law of material reciprocity and therefore can meet the needs for performing low-carbon climate governance across regions (Yanqing, 2016).

Secondly, 'ecological treatment' is different from the comprehensive treatment. The comprehensive treatment is one of the traditional organic waste treatments. In recent years, China has constructed comprehensive wastes treatment plants such as Fangshan Comprehensive Wastes Treatment Plant in Beijing, which mostly adopted the comprehensive treatment, that is, an organic combination of several treatment technologies such as landfilling, incineration and composting. Each treatment technology is only applied to corresponding domestic wastes so that a systematic and comprehensive treatment device is formed to improve the resource-oriented treatment level of wastes (Yusheng, 2008).

However, 'ecological treatment' emphasizes the application of new technical approaches and therefore has absolute advantages over the comprehensive treatment in terms of treatment costs, environmental effects, resource level, and so on. The ecological treatment can maximize the resource yield on the basis of maximizing carbon reduction. As shown in Table 3, ecological treatment greatly differs from traditional treatments in terms of association with climate change, technical contents, marketization, public participation, and so on. For public participation, public opinions are usually solicited to enhance the participation degree of the public for ecological treatment.³

Table-3. Comparison of the 'ecological treatment' with the 'traditional treatment' for urban organic wastes.

Description	Ecological treatment	Traditional treatment
Association with climate change	High	Low
Technical contents	High	Low
Marketization	High	Low
Produced environmental pollution	Small	Uncertain
Produced resource damages	Small	Uncertain
Public participation	High	Low
Requirements for wastes classification	Low	High

³ From internal documents of the Baishiqingyuan Company.

3.2. The Ecological Treatment Adopted by the Baishiqingyuan Company

The development of the ecological treatment concerning urban organic wastes depends on advanced technologies and well-designed market-oriented operation modes. The Baishiqingyuan Company sets an example regarding the ecological treatment of urban organic wastes in China. In 2015, the Baishiqingyuan Company obtained two core technology patents after many years of research and development. One is heat-pressing critical oxidation technology, and the other is supercritical water oxidation technology.

Table-4. A comparison between the heat-pressing critical oxidation technology and the traditional treatment technology.

Description	Landfilling technology	Incineration technology	Composting technology	Heat-pressing critical oxidation technology
Reduction (degree)	No	More	Less	Resourceful
Stabilization (degree)	Unstable	Stable	Unstable	Stable
Resource-oriented treatment (degree)	Unavailable	Unavailable	Organic fertilizer	Recycling of organic fertilizer
Sterilization and pest elimination	Breed	Extinct	breed	Extinct
Heavy metal control	Uncontrolled	Exist in residual ash	Uncontrolled	None
Odor	Yes	No	Yes	No
Treatment time	Long	Short	Long	Short
Treatment costs	High	High	High	Low

Compared with the traditional organic wastes' treatment technology, the heat-pressing critical oxidation technology can realize three-waste discharges; no secondary pollution, reuses of heat energy, and complete resource transformation. As shown in Table 4, the heat-pressing critical oxidation technology is strong in heavy metal control capability, short in a time of odor treatment and low in treatment costs. Relevant independent assessments indicated that, compared with the waste landfilling technology, the heat-pressing critical oxidation technology could reduce carbon dioxide by 40 thousand tons each year if 100 thousand tons of urban domestic wastes to be treated each year.

The heat-pressing critical oxidation technology can greatly reduce carbon dioxide emission in a way such as reducing wastes transportation, lowering biogas leakage of wastes landfill, restoring highly-embedded carbon materials recovery, and generating permanent fossil-fuels. At the same time, the generated methane may be reduced by 3.5 to 8 times and the generated biological gases such as biogases can be increased by 1.2 times.⁴In addition to the heat-pressing critical oxidation technology, the supercritical water oxidation technology also performs extremely effective in the treatment of organic substances contained in the solid wastes. According to the supercritical water oxidation technology, the wastes are formed into small molecular groups through a given chemical reaction so that the hydrocarbon chains of the small molecular groups are broken to generate a large quantity of heat energy for power generation.

Since an anaerobic fermentation technology is adopted, an extremely small quantity of carbon dioxide is generated, water can be recycled, and a small quantity of wastewater and sediments can be used as a liquefaction method and organic fertilizer or fillings. The heat-pressing critical oxidation technology and the supercritical water oxidation technology can be widely applied to maximize resource yield while greatly reducing GHG emissions, which is of revolutionary significance for China to cope with climate change, reduce GHG emissions and recycle resources.

⁴ From internal documents of the Baishiqingyuan Company.

3.3. The High-Benefit Operation Mechanism of the Baishiqingyuan Company

At present, the urban domestic wastes treatments in different countries are mainly market-oriented based on three modes: firstly, 'the mode of direct payment by consumers' in which the governments only perform the functions of service and supervision; secondly, 'the mode of centralized procurement by government' in which the governments serve as agent; and thirdly, 'the mode of respective procurements by the government' (Edwards *et al.*, 2018; Rada *et al.*, 2018; Gradus *et al.*, 2019). The mode of direct payment by consumers refers to a mode in which the consumers may directly purchase waste treatment services from enterprises without going through a governmental agency, which will greatly increase operational risks, costs and bring an extra burden on the enterprises. In this way, the enterprises will not exercise sufficient efforts and have ample resources for technical researches.

'The mode of centralized procurement' and 'the mode of respective procurements' by the government, both refer to modes in which the government directly purchases wastes treatment services from enterprises with a difference being that the natures of parties to service contracts are different. The former is a wastes treatment group providing a service package of gathering, transportation, and treatment, and the latter are dependent enterprises performing their respective duties.

As shown in Figure 1, the Baishiqingyuan Company adopted 'the mode of respective procurement by the government.' In this mode, the government signs an agreement of urban solid wastes treatment, by entrusting and authorization, with the Baishiqingyuan Company serving as a professional and independent waste treatment enterprise to directly purchase the urban solid waste treatment services from the Baishiqingyuan Company while collecting domestic waste treatment fees from residents enjoying the services. The responsibility of the government during the service provision is to supervise waste treatments of the Baishiqingyuan Company and grant corresponding financial subsidies to the company. In addition to its own assets and received governmental subsidies, the Baishiqingyuan Company also gained capital supports from the Shanghai Panlong Environmental Protection Technology Co., Ltd.

The implementation of 'the mode of respective procurement by government' may allow Baishiqingyuan Company to have sufficient capital sources for development and operation of the ecological treatment technology and coordinate interest relationships with the government and public. More importantly, this mode may provide a relatively fair, reasonable and competitive platform for enterprises with high and new technologies so that those enterprises with core market competitiveness can be selected as important public service providers and ecological environment protectors.

Observing from the successful experiences of Baishiqingyuan Company in the ecological treatment of urban organic wastes, high-efficiency carbon reduction technology and multi-participant marketization constitute a basic core of the ecological treatment, which indicates the first development direction that ecological treatment is widely carried out in China. The 'carbon reduction technology' is a basis for the ecological operation of the enterprises as well as an active path for China to actively cope with climate change. 'Marketization' is a precondition for high-benefit development and orderly operation of the enterprises as well as a basic guarantee for the development and implementation of the 'carbon reduction technology.' Both measures will penetrate through the entire process of widely applying the ecological treatment manner across regions or industries in the future.⁵

⁵ From internal documents of the Baishiqingyuan Company.

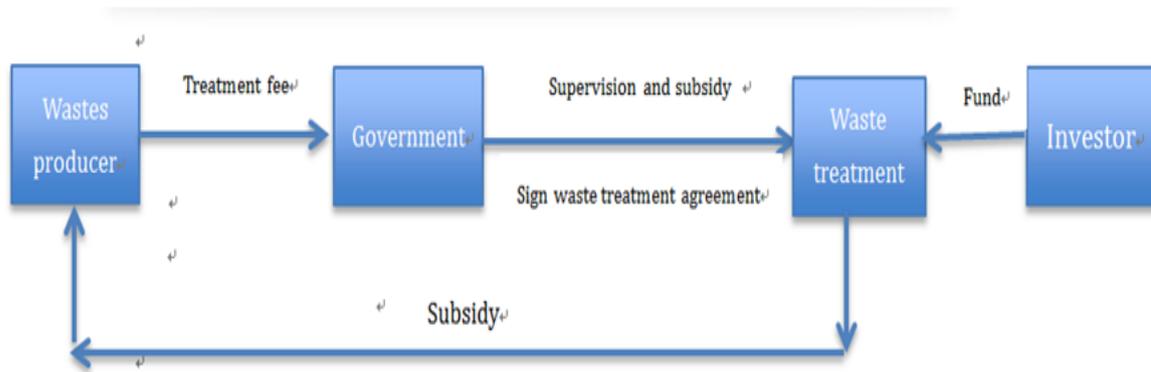


Figure-1. Marketization mode applied by the Baishiqingyuan Company.
Sources: Internal documents of the Baishiqingyuan Company.

4. ECOLOGICAL TREATMENT MECHANISM FOR URBAN ORGANIC WASTES IN THE CONTEXT OF CLIMATE CHANGE

At present, China’s urban organic wastes treatment industry is one important field relating to GHG emission and China’s carbon dioxide emission accounts for close to 1/4 of the total global emission (Li, 2015). Therefore, the implementation of ‘ecological treatment’ is a need for China to cope with climate change and develop a green economy. In general, ‘green’ and ‘economy’ are considered as mutually contradictory and exclusive factors. The first issue that China has to face is how to promote stable economic growth while controlling carbon emission reduction, inhibiting energy consumption and preventing environmental pollution; it merits putting a focus to achieve goals of sustainable development. The ‘ecological treatment’ will provide a new option going along with the latest development trend for concept and mechanism to achieve green development of organic waste treatment industry. Correspondingly, as shown in Figure 2, this paper seeks to construct an ecological treatment mechanism of urban organic wastes complying with China’s national conditions from legal, technical, and social consciousness level with ‘greenization’ and ‘integration’ as the basic concepts and aiming at the ‘ecological treatment’.

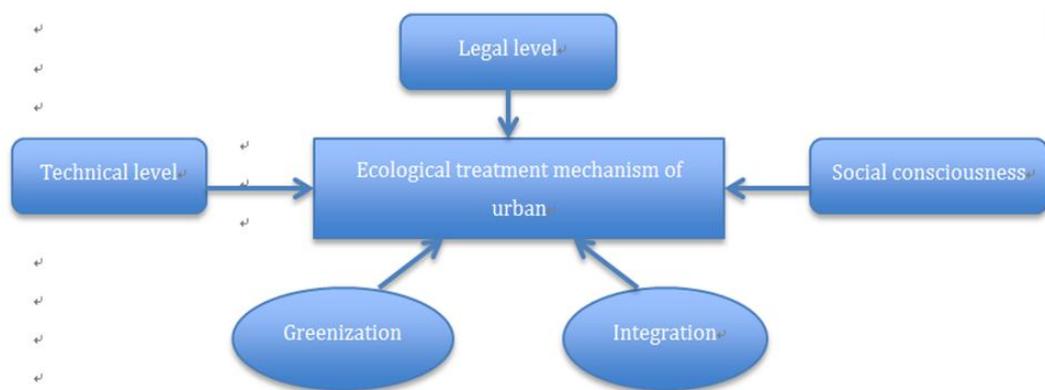


Figure-2. Ecological treatment mechanism of urban organic wastes.
Source: Created by this research.

4.1. Concept and Target of ‘Ecological Treatment

4.1.1. Greenization

Although China has made great progress in urban organic waste treatment, it still has a long way to go before satisfactorily coping with severe climate change and keeping pace with developed countries in implementations. The concept of greenization aims to innovate the existing traditional urban organic wastes treatment modes and requires that the urban organic wastes treatment should be based on green technology and follow development requirements of green economy, thereby realizing ‘minimum carbon emission’ and ‘maximum environmental and resource benefits’ of urban organic wastes in most regions of China (Zhong and Fujian, 2015).

'Ecological treatment' has to comply with the procedural development as required under the concept of a green economy. The green economy is not only realizing economic development with an eye on environmental protection but also performing 'greenization' or ecological restructuring on the original economy (Guang, 2010). 'Green economy' requires development and adoption of green technologies for the treatment of urban organic wastes. The green technology will not only help China to overcome its difficulty concerning urban organic wastes classification but also aid to achieve the aim of low carbon emission and maximum reuse of solid wastes resource. At the same time, the 'green economy' includes the concepts of 'circular economy' and 'low-carbon economy'. The 'greenization' of 'ecological treatment' fuses 'Three R' Principle namely; Reduction, Reuse and Recycle, of resource utilization in 'circular economy' and GHG emission reduction concept of 'low carbon economy' which is used in responding climate change. Therefore, the ecological treatment can be regarded as a green treatment manner of urban organic wastes combining climate friendliness, resource recycle and economic benefits (Ming, 2015).

Green economy presents appeals at the levels of value and implementation for urban organic waste treatments, which provides a theoretical path for wide implementation of 'ecological treatment.' From the value level, it is desired to transform the existing, extensive and unidirectional organic wastes treatment manners based on the nature of; green economy, transform the past basic principle of 'reduction' into the principles of 'resource' and 'low carbon', fully consider what impacts will be brought by different treatment manners of urban organic wastes to the environment and the humankind, and effectively utilize ecological-friendly approaches to minimize the unfavorable impacts.

During the development and application of ecological treatment technologies, the technical rationality should be followed to prevent single direction and simplification (Zhong and Fujian, 2015) thereby completely abandoning the value judgment of the past resource utilitarianism and taking the ecological treatment manner of urban organic wastes as an important mechanism for mitigating interest conflicts of waste treatments. From the implementation level, it is desired to pay more attention to the development of the local environmental protection enterprises engaged in wastes treatment and encourage more enterprises to be fused into ecological treatment services through economic incentives, such as increasing subsidies, thereby promoting the development of ecological treatment industries in different regions, especially in remote and poverty-stricken regions.

4.1.2. Integration

In the context of risk society, the pertinent consciousness or appropriate knowledge determines how we can cope with climate change and what technical approaches can be utilized to minimize the risks of urban organic waste treatment (Chang, 2017). The number of regions where the ecological treatment technology is popularized determines the depth of carbon emission reduction in China to some extent and thus produces a significant impact on the collaborative treatment of the urban organic wastes in different regions and at different levels (Wang *et al.*, 2018). In essence, the ecological treatment of urban organic wastes also focuses on carbon emission reduction and resources recycling in the whole society for the benefits of all people around rather than only on the problems of a single enterprise, region or a particular group of persons (Wang *et al.*, 2018). Based on the attributes of urban organic wastes, urban organic wastes belong to quasi-public goods. This attribute requires a transformation of governmental functions, regression of market values and rational and effective participation of the public. 'Ecological treatment' can also organically cause or harmonize the environmental benefits of governments, enterprises and the public to transform external problems into internal problems (Feng and Huailong, 2018).

The 'integration' concept emphasizes the coordination relationship of the flexible application of the market mechanism and the interests of governments, enterprises, and the public during the implementation of 'ecological treatment' (Wang and Chang, 2018). Firstly, the government should be fully conscious of the commercial feasibility of energy-oriented and resource-oriented transformations of urban organic wastes. To this end, different regions in China have different requirements and different potentials for 'ecological treatment.' The Chinese government

should provide supports of capital, technologies, and talents for the resource-oriented transformation of solid wastes based on fair distribution. At the same time, the government should delegate the power of urban organic waste treatment as possible to the qualified enterprises so that the government functionality may be transformed from a leader to a supervisor to resolve the issue of low efficiency in organic waste treatment (Khan and Chang, 2018).

Secondly, in addition to the smooth and timely communication of information about problems of wastes treatment between the government and the public, attention should also be paid to smoothen public-enterprises information sharing and device a fruitful communication system. Having insufficient information about 'ecological treatment,' public may not be able to cooperate, supervise and promote the ecological operation of the enterprises. Therefore, the enterprises should make the information transparently available to the public, and educate or let general public to know about the significance and imperative functionality of the 'ecological treatment,' thereby improving the behaviors of the public (Zhai and Chang, 2018). In this way, the public may become an external force for 'ecological treatment,' which will greatly assist the relevant agencies in achieving their goals of the sustainable environment (Yuchen and Xixian, 2018).

4.2. Establishing Appropriate Ecological Treatment Mechanism of Urban Organic Wastes for China

4.2.1. At Legal Level

Firstly, the legislative purpose of the *Law on Prevention and Control of Environmental Pollutions Caused by Solid Wastes* should be redefined, and the responsibilities of different government departments should be straightened. Article 1 of the *Law on Prevention and Control of Environmental Pollutions Caused by Solid Wastes* states that "this law is formulated in order to prevent environmental pollution caused by solid wastes, guarantee human health, maintain ecological security and promote sustainable development of economic society", and does not state the purpose of "protecting precious and rare fossil energy and raw materials, reducing wastes generation and effectively controlling GHG emission by resource-oriented and energy-oriented utilization of solid wastes (Hui, 2015)." The wastes are a resource that is placed in the wrong location. If the resource attributes of the solid wastes can be fully exerted by technical approaches, it will reduce not only environmental pollution caused by the solid wastes but also the precious fossil resources of China will be saved and protected.

Moreover, Article 10 of the *Law on Prevention and Control of Environmental Pollutions Caused by Solid Wastes* states that "the competent authorities of local people's governments at the county level or higher shall carry out uniform supervision and management over prevention and control work of environmental pollutions caused by solid wastes within their administrative regions. Relevant departments of local people's governments at the county level or higher should take charge of supervision and administration over the prevention and control of environmental pollution caused by solid wastes within their scopes of responsibility. The competent authority of construction under State Council and the competent authority of environment and health of local people's governments at the county level or higher take charge of supervision and management over sweeping, gathering, storage, transportation and treatment of domestic wastes." According to this Article, the competent authority of environmental protection and the competent authority of the environment and health, both are empowered to supervise and manage the treatments of urban organic wastes.

In practice, the case that two departments perform buck-passing and *ultra vires* management mutually due to unclear responsibilities may occasionally occur (Yong, 2011). Along with subsequent initial construction of a carbon emission database and gradual perfection of a carbon emission system, the ecological treatment system will be more systematic and complex, and more and more local governments will choose enterprises qualified to perform ecological treatment for urban organic wastes. Unclear responsibilities of governmental departments will lower the efficiency of the enterprises concerning ecological treatment, thereby bringing unfavorable impact to the operation of an urban organic wastes' treatment market. The urban organic wastes come from local regions, and therefore a local responsibility system should be strictly implemented. Vertically, the relationship of the central government

and the local governments regarding the ecological treatment of urban organic wastes should be defined so that the central government puts forward a target and an overall plan and the local governments implement them according to actual local situations respectively. Horizontally, the competent authority of environment and health should be empowered by legislation to take full responsibility for the ecological treatment of urban organic wastes to mitigate the low management efficiency caused by multi-department participation and dispersed responsibilities (Yingmin, 2011).

Secondly, the provisions regarding urban organic wastes treatment in the *Law on Promotion of Circular Economy* should be further detailed. The 'ecological treatment' is efficiently implemented on the precondition of the smooth operation of the circular economy in China. The circular economy is a kind of environmental protection economy in essence, which directs economic activities of human society through ecological and economic laws, and finally realizes sustainable development of human society and harmonious co-existence of human and nature through a feedback flow of 'resources – products – renewable resources.' The features of 'external,' 'public' and asymmetric information of the circular economy determine the development of the circular economy, and thus guidance and regulation must be provided by employing the legislation (Yongyou, 2013). However, the *Law on Promotion of Circular Economy* in China is simply based on the theoretical basis of the ecology and the thermodynamics with insufficient combination with the ecology (Ke and Yiwen, 2007).

The provisions about urban organic wastes treatment are excessively generalized, which leads to lack of operability. Only Articles 41 and 46 are related to urban organic wastes treatment in this law.⁶ The lack of specific provisions may bring insufficient binding and deterring power on the local governments. In this way, the driving force for widely implementing 'carbon reduction technology' in the local regions will be weak, and the resource-oriented ecological treatment of urban organic wastes cannot be committed to action from law papers. Therefore, specific provisions about urban organic wastes treatment, including guarantee measures and responsibility clauses for recycling urban organic wastes, should be added to the *Law on Promotion of Circular Economy* so that it may become powerful enough to meet the legal requirements of climate change.

4.2.2. At Technical Level

Firstly, the research and development of ecological treatment technology should be accelerated in China. The high and new technologies constitute a basic condition for wide implementation of 'ecological treatment.' According to present situation, the ecological treatment technology suitable for urban organic wastes in China should have few requirements for wastes classification, and almost not generate secondary pollution and GHG, and feature low investment costs, high treatment efficiency, and good economic benefits and therefore it is widely regarded as a climate-friendly as well as environment-friendly comprehensive technical approach (Lizhai, 2018). Also, China should integrate the forces of enterprises, public research institutes, education and training organizations, governmental agencies and financial institutions to accelerate and strengthen the development of ecological treatment technology. To this end, special attention should be paid to the decisive functions of the governments in research and development of ecological treatment technology. Although the ecological treatment technology can generate huge ecological benefits because the technology is characterized by a long research period, high research costs and large research risk, but technologies have been neglected for long in China. It is a fact that the social resources of technical innovation cannot be optimized simply by the market mechanism. Thus, the governments are

⁶ Article 41 of Law on Promotion of Circular Economy states that "the governments at the county level or higher should plan and construct facilities for classified collection and resource-oriented utilization of urban and rural domestic wastes in a unified way, establish and perfect the system of classified collection and resource-oriented utilization, and improve resource rate of domestic wastes" and Article 46 states that "the governments in provinces, autonomous regions and municipalities directly under Central Government may implement wastes discharge fee system based on the economic and social development situations in their respective regions. The fees collected shall not be used for the purposes other than wastes classification, collection, transportation, storage, utilization and treatment".

required to take corresponding responsibilities to regulate the market-oriented operation of 'ecological treatment technology' based on 'social rationality.'

Secondly, the construction of China's ecological treatment information database should also be accelerated because the 'ecological treatment' relates not only to the material conversion of organic wastes by carbon reduction technology but also to exchange and communication of technologies and practice information between different specialties, governments at different levels, enterprises, and the public as well. China should establish an ecological treatment information database covering the whole country with an organic connection to a carbon trade database. The ecological treatment information database should mainly include information of laws and regulations about urban organic wastes treatment from different regions of China, information of different enterprises and industries relating to ecological treatment and information of supervision and management conducted by governmental departments for different enterprises and industries, and so on. The system of ecological treatment should operate on the basis of the information integration and monitor carbon emission reduction situations of different regions through information database (Yanqing, 2016).

4.2.3. At Social Consciousness Level

Efforts should be made to strengthen the popularization and cultivation of classified knowledge and values about organic wastes among the public. The scientific rationality without social rationality is empty (Beck, 2012). The ecological treatment of urban organic wastes without public participation will lack internal momentum, and core values of the public may also, more or less, be harmed. Whether the classification work of urban organic wastes sources is implemented and whether the implementation effect is good or not, it will directly determine actual aspects such as the degree of ecological treatment. In China, the wastes classification is always a relatively difficult issue for urban organic wastes treatment since many resident districts usually stop the waste classification work after implementing it for several days. Although the ecological treatment relieves the pressure resulting from difficult implementation of China's wastes classification work to some extent, the ecological treatment of organic wastes will be more efficiently implemented in China if the problem of wastes classification can be effectively solved in such a way that the public participates in the wastes treatment process. In this case, the efficiency of China's ecological treatment will be substantially improved.

It will serve mainly in two ways. Firstly, the popularization of organic wastes classification knowledge should be carried out in China. For example, a responsibility system, as wastes classification implementers, managers, and relevant specific implementation management rules may be established, with people of residential districts, classification instructors, wastes collectors and wastes classification leader of residential districts (Ying *et al.*, 2015) including how the residents of each household should make classification, responsibilities, and duties of the classification instructors, and how the wastes collectors process the mixed wastes, and so on. Also, efforts should be made to disseminate wastes classification knowledge through many channels such as internet, television, and newspapers to change the attitudes and spread appropriate knowledge to the public for the waste's classification.

Secondly, the sense of social responsibility and the values of the public for the wastes' classification should be cultivated. Effective wastes classification will play an important role in slowing down global warming, recycling resources and saving limited energy. Therefore, the public should be cultivated to pay attention to the environmental ecology value, the energy protection value and the climate value of the wastes classification so that the residents may have a relatively stable intrinsic emotion for wastes classification and further form a long and stable habit of classification (Shaojun *et al.*, 2015). Consequently, it will layout a foundation for subsequent implementation of the ecological treatment of urban organic wastes.

5. CONCLUSION

In the context of climate change, urban organic wastes treatment faces a significant transformation challenge. The past traditional manners of the landfill, incineration, and compost that result in high costs and increased pollution, as well as emissions, will no longer be acceptable to China's social development needs. The concept of 'ecological treatment' comes up in response to fulfill these needs. The 'ecological treatment' emphasizes on the application of technical approaches and features of low processing cost and high resource degree. In this case, the emission of GHG can be greatly reduced, and resource yield can be maximized. The 'ecological treatment' is not only an important channel to protect the ecological environment but also a requirement for China to develop the green industry.

Correspondingly, the market-oriented operation of heat-pressing critical oxidation technology conducted by the Beijing Baishiyingyuan New Energy Co., Ltd. is a typical example of the industrial development of the 'ecological treatment.' This development merits that China should establish an 'ecological treatment mechanism of urban organic wastes' as suitable for China's national conditions with greenization and integration as a basic concept. It is therefore suggested that: from the legal level, the purpose of the *Law on Prevention and Control of Environmental Pollution Caused by Solid Wastes* should be re-defined, and the provisions about urban organic wastes treatment in the *Law of Promotion of Circular Economy* should be further detailed; from the technical level, attention should be paid to research and development of ecological treatment technology, and the construction and application of China's ecological treatment information database should be intensified; from the social consciousness level, efforts should be made to emphasize the consciousness of organic wastes classification and intensify the cultivation of the values of the public for organic wastes classification to cope with the oncoming risks of climate change with active actions. However, the future research may include a broader perspective, such as data from a whole city or province to apply these results and hypothesize a broader scenario to assist the government in legislation and devising pertinent policies or mechanisms for ecological treatment of urban organic wastes in China.

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