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WET WASTE RECYCLING

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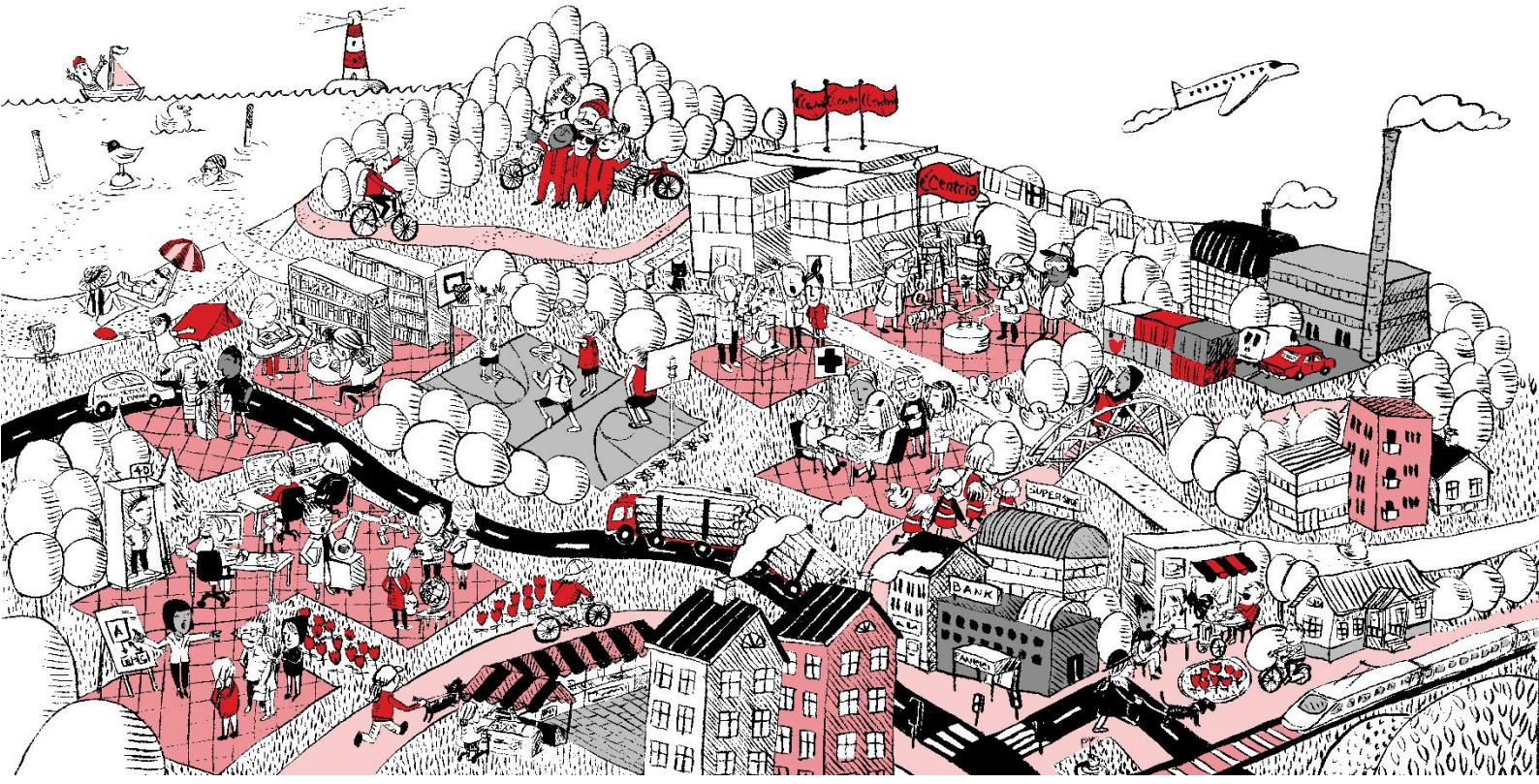

ABSTRACT

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A large amount of garbage is generated in the daily life of human beings, and if it is not treated and used, it will cause great harm to the human living environment and human health. Food waste (wet waste) accounts for a relatively large proportion of household waste. Compared with other waste, wet waste is more difficult to dispose of and is more harmful to the environment. How to recycle wet garbage and how to recycle wet garbage has always been the focus of mankind, but the recycling of wet garbage has great potential for development, which can effectively solve the problem of energy crisis and resource recycling.

Starting from the background and development of wet waste, the source and treatment methods of wet waste are described. Wet waste treatment methods mainly include mixed waste landfill, incineration, anaerobic fermentation, aerobic composting and livestock feed. The next article introduces the definition and energy application. In this part, to introduce the composting method of wet waste, the method of burning wet waste to generate energy, and the development prospect of wet waste recycling to generate energy.

Key words
Wet waste, compost, incineration, bio-diesel

CONCEPT DEFINITIONS

$C_6H_{12}O_6$	Fructose and glucose are isomers of each other
O_2	Oxygen
CO_2	Carbon dioxide
H_2O	Water
$Ca(OH)_2$	Calcium hydroxide
NaOH	Natrium hydroxide
KOH	Potassium hydroxide

ABSTRACT
CONCEPT DEFINITIONS
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1 BACKGROUND OF WET WASTE RECYCLING

With the continuous improvement of the level of science and technology, people's living standards have risen, and more various types of waste have been produced. In some cases untreated waste, waste residue and domestic garbage are stacked in the open air, occupying land and destroying the landscape. The harmful components in the waste enter the soil, rivers, oceans, and groundwater with rainwater. Plastic particles have been found even in the deepest Mariana Trench. (National Geographic 2018)

The development of science and technology and people's life activities have brought great harm to the environment. These waste are of various types and complex composition. If left untreated and left alone, it will cause great harm to the human living environment and human health. For example, the accumulation of garbage will indirectly pollute domestic water, and the harmful gas generated by the accumulation of garbage will pollute the air and indirectly affect people’s lives. Many countries in the world have seen the phenomenon of "garbage siege"(The economy continues to develop, the urban population is large, the total amount of garbage continues to rise, and land resources are limited, governance is relatively lagging, and the phenomenon of "garbage siege" appears.). However, mankind has gradually realized that these wastes are the resources with the most development potential, and they have begun a "circular economy" development model, and have driven the development of a series of industrial chains. The so-called " circular economy " refers to the rational classification of waste, decomposition and then making new products, or the collection of used products, cleaning, disposal and then selling. Compared with “traditional” waste disposal, recycling can save resources and reduce greenhouse gas emissions. Domestic waste accounts for a large proportion of waste in China (China neng yuan 2019), and with the continuous development of urbanization in China, the amount of domestic waste produced is increasing. Domestic waste is generally collected in a mixed manner, and the content and calorific value of recyclable materials are low, and the moisture content of the waste is low. The biodegradable organic content is high, the previous garbage disposal methods, such as sanitary landfill, incineration, are no longer suitable for the development process of urbanization. The Chinese government recognized the severity of this problem in 2011 and issued the project "Opinions on Further Strengthening the Treatment of Municipal Domestic Waste", but it was not until 2018 that some cities gradually implemented the classified collection, transportation, and disposal of domestic waste. There are four types of household garbage: recyclable garbage, food garbage, hazardous garbage and other garbage. The general treatment plan is: Recyclable garbage includes paper, metal, plastic, glass, textiles. Through comprehensive treatment and recycling,

pollution can be reduced and resources can be saved. For example, per ton of waste paper recycled can produce 850 kilograms of paper, saving 300 kilograms of wood, and reducing pollution about 74% compared with equivalent production, but toilet paper cannot be counted as recycled paper because it dissolves in water ; per ton of plastic beverage bottles can be recycled to obtain 0.7 ton of secondary raw materials; per ton of waste steel can be recycled. Smelting 0.9 tons of steel, saving 47% of the cost compared with ore smelting effectively improve the utilization effect. These steels will be used for industrial construction in China, and this process reducing air pollution by 75%, but there is still a problem of 3% water droplets and solid waste remaining that cannot be solved (CLW Group 2021) Food waste, including leftovers, bones, vegetable roots and leaves, and other food wastes, is composted by biotechnology, and 0.3 tons of organic fertilizer can be produced per ton. Hazardous waste includes waste batteries, waste fluorescent tubes, waste water silver thermometers, other heavy metal substances, and expired drugs. These wastes require special safe handling. Other waste includes bricks, ceramics, and clay, which can be classified as construction waste. Garbage such as toilet paper and cigarette cases is difficult to recycle. (Henan Electric Power Research Institute 2020). Sanitary landfill can effectively reduce the pollution of groundwater, surface water, soil and air. The sanitary landfill is usually located in a part of the land, and its function can be a natural buffer between the environment and the landfill. Asphalt made in the excavated soil forms an impervious liner before streaking.Therefore, the sanitary landfill can prevent harmful substances from escaping. (Chen et al. 2003)

China collected 215 million tonnes of urban household waste, according to the country's statistical yearbook. It is more increase 152 million than ten years ago. It is not clear what China's recycling rate is, as no figures have been released. China plans to recycle 35% of waste in major cities by the end of 2020, according to one government report. (BBC News.2019) With the growth of domestic garbage, the problem of urban and environmental problems has also begun to increase. In order to carry out reasonable waste recycling and solve the problem of energy consumption, this article will discuss the energy production from garbage recycling and the research on the way of garbage recycling.

2 DEFINITION

This part will mainly introduce several methods of recycling wet waste to produce energy,which are divided into compost incineration and bio-diesel production. Chinese composting method is very traditional. Chinese farmers widely use composting. Among them, strip composting is one of the main methods, and dynamic ventilation composting is now also used in China.Chinese waste incineration is also an important part of processing waste while achieving energy recovery, converting heat energy into electricity, but this also has the problem of environmental pollution. For example, acidic gases discharged into the air cause air pollution and cause acid rain. Bio-diesel technology is still in a groping stage in China. It is an emerging technology that needs continuous development and improvement. At present, China is the world's third largest ethanol producer, after the United States and Brazil.(Zhang et al. 2017).

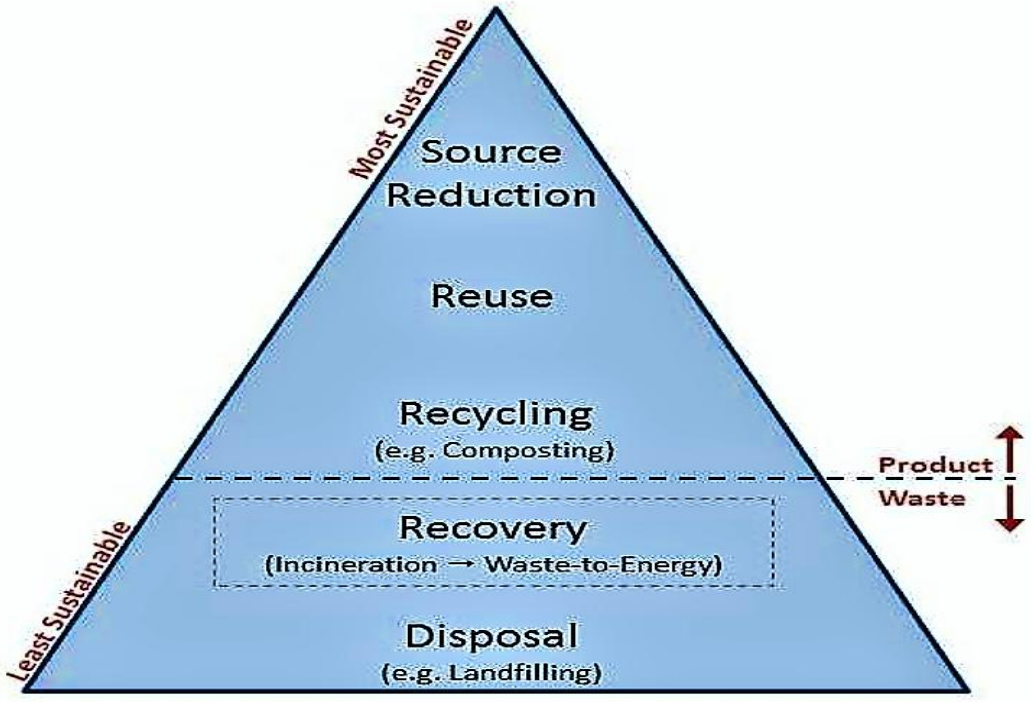
2.1 Composting

Composting refers to the method of decomposing, decomposing, and converting the organic matter in domestic waste into stable humus-like soil under manual control conditions under the biochemical action of microorganisms. The principle of composting treatment can be roughly divided into two types: aerobic composting and anaerobic digestion. Aerobic composting refers to the process of using aerobic microorganisms to decompose the organic matter in solid waste under the condition of sufficient oxygen supply. Anaerobic digestion refers to a biochemical process that uses the action of anaerobic microorganisms to convert biodegradable microorganisms in waste into methane, carbon dioxide and stable substances under anaerobic or anoxic conditions. （Technical Guidelines for Solid Waste Treatment and Disposal Engineering HJ2035-2013, 6）

In people's daily life, the problem of garbage disposal has become more . The solid content of garbage and the continuous increase of liquid waste have become importance issues. There are three methods to remove solid waste: sedimentation (78%), pyrolysis (20%) and compost (2%). Compost can effectively deal with it, killing pathogens or inactivating in the process of decay, and at the same time generating energy.（Küster & Schmitten 2004.）

2.2 Incineration

China use the incineration method to treat domestic garbage. The incineration method is a high-temperature heat treatment technology, that is, a certain amount of excess air is used to carry out an oxidation combustion reaction with the treated organic waste in an incinerator. The harmful and toxic substances in the waste are oxidized and pyrolyzed at a high temperature of 870°C to 1200°C (Shem et al, 2019) and being destroyed is a treatment technology that can simultaneously realize the harmlessness, reduction and recycling of waste. The purpose of incineration is to incinerate the waste as much as possible, make the burned material become harmless and minimize the volume, and minimize the production of new pollutants to avoid secondary pollution. The daily output of large-scale incinerators can reach 3,000 tons, with high technical content and high prices. There are mainly several types of large-scale incinerators: large-scale combustion incinerators, fluidized bed incinerators and calciners. Incineration is only applicable after the separation of reusable and recyclable materials (plastics, organic matter.) to the greatest extent. At the same time, Dahang Incineration Plant also needs special geographical conditions to make it obtain effective costs. (Stauffer& Spuhler 2012.)



PICTURE1:Hierarchy of integrated solid waste management (adapt from WASTE INCINERATION (2010) and AFRICAN DEVELOPMENT BANK 2002）

2.3 Bio-diesel

Bio-diesel refers to the clean fuel that is produced from renewable bio-logical resources such as animal oil and vegetable oil and can be used in compression ignition engines. The main component is fatty acid fat, which generally refers to the production of renewable fats such as rapeseed oil, soybean oil, recycled cooking oil, animal oil, and alcohols (methanol, ethanol) through lipidation reaction. Bio-diesel is also a renewable, biodegradable, non-toxic fuel, which has many advantages.This article introduces the catalytic property exchange method for biodiesel production. (Monteiro et al. 2018. 88, 109-122.)

3 ENERGY FROM WET WASTE COMPOSTING

In Italy, people compost the waste from olive factories to solve environmental problems related to the spread of waste on the land. In Italy, regulations (Italian Law No. 574,1996) restrict the spread of olive mill waste on land as a method of disposal. Among the solutions proposed for this problem, composting is considered to be one of the most promising methods. Efficient composting can convert organic waste into valuable by-products (Francesco et al,2018 1-3). For wet waste, composting technology can also be used to improve the environment.

3.1 Development of wet waste composting technology

The scientific research of wet waste composting technology began in the 1920s, and the high-temperature aerobic composting technology was adopted in the 1930s. In the 1970s and 1980s, many developed countries built a large number of highly mechanized waste composting plants, and many countries also formulated technical standards for waste composting products; in the late 1980s, the domestic waste composting technology in developed countries. The application has fallen into a low tide, and many large-scale and highly mechanized domestic waste composting plants in many countries have closed down one after another. Mainly because waste affects the environment and may have adverse effects on both humans and animals. These adverse effects may cause disease outbreaks and shorten life expectancy. For example, the generated exhaust gas contributes to the greenhouse effect. It also pollutes water and soil. At the same time, the olive oil produced by the European olive oil industry accounts for more than 75% of the global olive oil production. In the past ten years, two-stage centrifugal systems have been implemented in many production areas, especially in Spain (the country is the world's leading olive oil output). However, despite its environmental advantages, the olive factory waste disposal problem has not been solved. The semi-solid sludge produced above is called two-phase olive mill waste (TPOMW), which causes more disposal problems than the olive husks of the previous crude oil system, and requires new environmental and economically feasible management alternatives. The remaining oil is extracted a second time and then burned. Even so, there were still a large amount of organic matter and proprietary nutrients in the olive mill waste, making them a valuable resource that can be used beneficially in agricultural soils. Most of these olive trees are located in the Mediterranean. In the southern region, where the content of organic matter in the soil is extremely low, climatic conditions, intensive agricultural practices and erosion have led to serious

soil degradation in many areas. In order to improve the soil and solve the problem of olive fertilizer, people have proposed a composting method after research, which mixes TPOMW with other residues, such as the physical and chemical changes caused by the compost mixture made from sheep manure and olives. Leaves or grape stems can improve the quality of the final product and balance the soil. (Maria Luz Cayuela et al., 2009)

3.2 Wet waste composting technology

According to the process and operating conditions, high-temperature aerobic composting technology can be divided into two types: natural static composting technology and dynamic aeration composting technology. Dynamic anaerobic composting technology has been applied and popularized in some countries.（Misra, R. V.et al. 2003)

3.2.1 Natural static ventilation composting

Under a site, the pile is 2-3 meters high, the upper part is generally covered with soil, the bottom is hardened with concrete and drainage ditch is laid, and the decomposed garbage is produced by shovel loader, roller screen, belt conveyor and magnetic separator roller to produce compost products. Natural ventilation is the surface diffusion oxygen supply, which is caused by the difference in oxygen concentration between the surface of the garbage pile and the inside of the pile, so that the oxygen is in contact with the material to provide oxygen for the fermentation of the garbage. According to theoretical calculations, by supplying oxygen on the surface, oxygen can only be guaranteed within 22cm from the surface during a fermentation stage. Therefore, this kind of ventilation method is clearly insufficient for the internal oxygen supply of the waste pile, and the inside of the pile is prone to anaerobic state. The heating and cooling process of the composting process is slow, and the composting cycle is extended from the fertilizer. Although it saves energy, it is not suitable for actual production. (Li Yuhua&Liao Li 20-22） figure 1 shows the natural static ventilation composting process and structure.

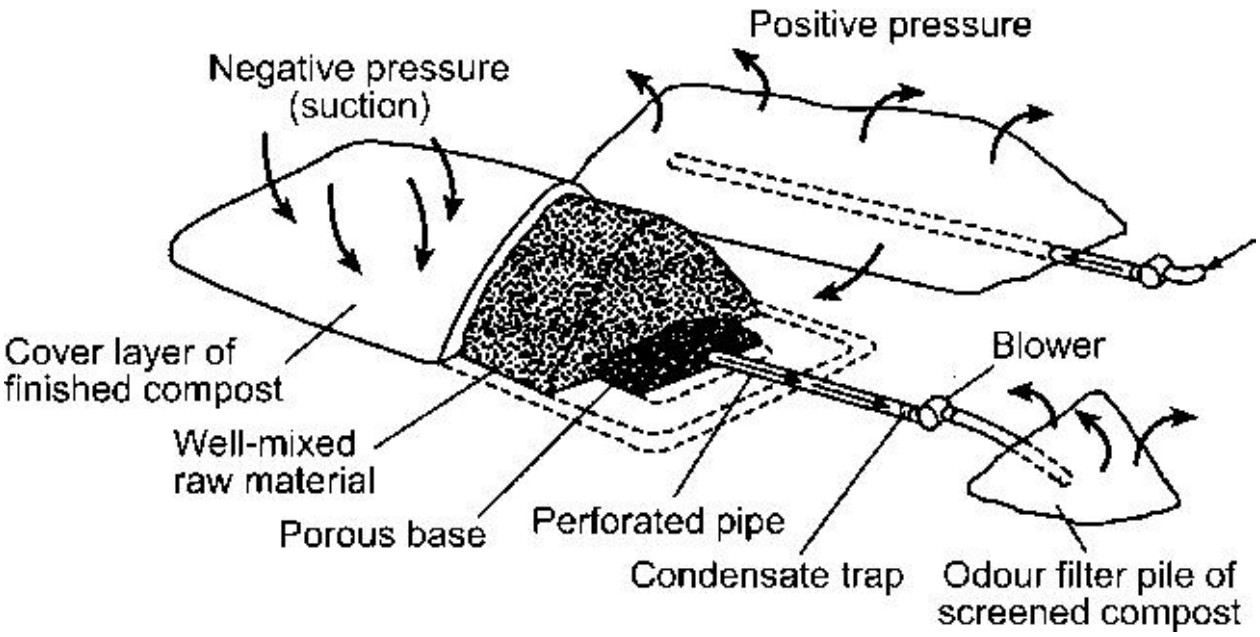


FIGURE 1: Aerated static pile layout (adapt from FIELD GUIDE TO ON-FARM COMPOSTING NRAES-114)

Because of the shortcomings of this method, its widespread use and efficiency are not very high. Disadvantages include pathogen detection, low nutrient levels, long composting time, long mineralization time, and odor generation, which make the composting process must use different countermeasures against various problems, so the productivity of composting is not very high and it is difficult to invest to actual production.（Modupe Stella Ayilara. et al）

3.2.2 Temporary dynamic ventilation composting

Temporary dynamic aerobic composting technology is a new technology developed between static composting and dynamic composting, based on static composting technology. This ventilation method can fully supply the oxygen required for the fermentation of the pile at the beginning of composting. In the high temperature stage, it can better control the temperature of the pile to keep the aerobic bacteria active. In the later stage, it can remove moisture and accelerate the accumulation speed to achieve the stacking cooling effect. Mechanism ventilation composting has a good oxygen supply effect, which speeds up the composting reaction rate, thereby shortening the composting cycle. Generally, a fermentation time of about 20 days can be completed. This kind of ventilation method is widely used in actual projects. (Li et al. Vol. 12 No. 1 20-22)

The main reaction equation is: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 2804KJ$

China has implemented the "Technical Specifications for Domestic Waste Composting Treatment" (CJJ 52-2014) on August 1, 2015, which stipulates the basic process of domestic waste composting: pretreatment, main fermentation, intermediate treatment, secondary fermentation and post-treatment. The treatment unit is divided into two types (dust removal and deodorization, leachate collection and treatment). Table 1 shows the following types of composting processes.（Li et al. 2011. Vol. 12 No. 1 20-22）

Table1.Composting composting deal with craft（LiYuhua & Li Liao . 2011 Vol. 12 No. 1 20-22）

Classification	Fermentation section	Material movement	The way of ventilation	Type of reactor
Type of crafts	First	Static state	Natural	Batten type
	Second	Intermittent dynamic	Enforce	Trough type
		Moving		Tower type
				Rotary equation

The "Technical Specification for Domestic Waste Compost Treatment" stipulates the characteristics of the materials entering the main fermentation unit of the composting treatment: for example, the moisture content should be 40-60%, the total organic content (calculated on a dry basis) should not be subtotal 25%, carbon and nitrogen a ratio (C/N) should be 20:1~30:1. The temperature of each test point of the main fermentation stack should be above 55℃, and the duration should not be less than 5d, or reach 65℃ or more, and the duration should not be less than 4d.(NDEP NRS 444.56)

The "Technical Specification for Domestic Waste Composting Treatment" requires that "the process air volume of forced ventilation is based on each cubic meter of waste, and should be 0.05m3/min~0.20m3/min. When the pile height is less than 3m, the wind pressure can be adjusted according to the pile height. Increasing of 1000pa~1500pa for every 1m of layer rise."(NDEP NRS 444.56)

Composting mainly uses the action of a variety of microorganisms to convert various complex organic nutrients into soluble nutrients and humus. At the same time, it uses the high temperature generated during stacking to kill germs, insect eggs and weed seeds in the raw materials. People in order to achieve the effect of preventing and reducing pollution hazards. Therefore, in order to obtain high-quality compost, creating good conditions for microbial life activities during the composting process the key is to speed up the compost maturity and improving fertilizer efficiency and controlling the air intake is the main control parameter of this process. (Chen et al. 2016 10-13)

The specific calculation formula of the air intake is: $G_1 = \frac{M\rho o}{24\eta\psi T_{\rho o1}}$

In the formula:

- G1 is the intake air volume of bio-logical drying (Kg/h);
- M is bio-logical drying (Kg);
- η is the utilization rate of oxygen in the intake air during the bio-logical drying process, η=8%~12%;
- ψ is the volume fraction of oxygen in the air, ψ=21%;
- T is the number of days (d) when the wind enters during the bio-logical drying process;
- ρo is the density of the air (the density at the temperature calculated outside the ventilated area of various places) (Kg/m3);
- Po_1 is the oxygen density (the density of oxygen at the temperature of the ventilation outdoor is used to calculate the density) (Kg/m3).（Chen et al. Vol. 24 No. 4 10-13）

3.2.3 Intermittent dynamic ventilation composting

Intermittent dynamic aerobic composting technology is a new technology developed between static composting and dynamic composting, based on static composting technology. The key to this processing technology is layered cutting and uniform discharging. It has the characteristics of short fermentation cycle, simple processing technology, small number of fermentation bins, and small investment (EPA). Advantages of intermittent dynamic aerobic composting adopt intermittent turning over or intermittent feeding and discharging methods to ferment the materials in batches. (Qian,1998 Vol. 6 No. 2 43-46)

The intermittent dynamic aerobic composting technology is to feed evenly one layer every day, the materials in the fermentation bin will be fermented and decomposed from bottom to top, and the most

decomposed bottom layer will be discharged every day. Due to the bottom-up heat transfer and the inoculation of microorganisms, the general static aerobic fermentation cycle can be greatly shortened. The actual measurement proves that under the effect of forced ventilation at the bottom layer, the new waste in the upper layer is affected by the high temperature of the lower layer (about 65°C) and the effect of microbial inoculation and reproduction, and reaches the temperature required for harmlessness (about 55°C) within 4 hours, which is only 72 hours the garbage reaches the harmlessness index within an hour, and the reduction is about 1/3. One fermentation cycle of 5 days is enough to meet the requirements of harmlessness and reduction. The "Technical Specification for Domestic Waste Composting Treatment" requires that mechanical turning of intermittent dynamic composting with forced ventilation facilities should not be less than 0.5 times per day. During the main fermentation process, the oxygen concentration is measured and the oxygen concentration at each point is measured. The oxygen concentration is exported greater than 5%. (Qian,1998 Vol. 6 No. 2 43-46)

3.2.4 Dynamic anaerobic composting

In order to solve the problems of low waste reduction, low composting efficiency, lack of sales market, and poor storage yard environment, after 2000, foreign countries applied anaerobic digestion technology to waste composting. Wet continuous single-stage anaerobic digestion process represented by the TBW company in Germany, and the wet continuous multi-stage anaerobic digestion process represented by the German TBW company. The technological process of the wet continuous single-stage anaerobic digestion process is: at 35℃, with the biogas generated in the digestion process as the power, the organic waste with a solid content concentration of 15% is fermented in the digestion tank for 15-20 days, and it is decomposed. The materials are sterilized at 70°C for 30 minutes to achieve the purpose of composting for agricultural use. The characteristic of the process is that the fermentation is completed in a tank, and the stirring power is the biogas produced during the fermentation process. This include anaerobic decomposition, which occurs in nature. For example, the organic mud at the bottom of the swamp and the decomposition of buried organic materials that cannot be contacted by oxygen. The strong reduction of organic matter by decay is usually accompanied by an unpleasant odor of hydrogen sulfide and reduced sulfur-containing organic compounds. The decomposition of organic materials occurs under anaerobic conditions. If the contaminated materials are used for composting, insufficient heat generated during the anaerobic destruction of organic materials is an disadvantage. High temperatures are needed to destroy pathogens and parasites. In anaerobic

decomposition, pathogenic organisms will eventually disappear in organic matter due to unfavorable environment and biological antagonism. However, the rate of disappearance is slow, and 6 months to 1 year to ensure the complete elimination of pathogens.(Earth-kind 2009)

The technological process of the wet continuous multi-stage anaerobic digestion process is: fermentation is carried out in two tanks, the fermentation temperature in the first tank is 35°C, the residence time is 2 weeks, and the fermentation temperature in the second tank is 55°C. The stay time is 2 weeks. The characteristics of this process are: anaerobic digestion is carried out in two stages, one is medium temperature digestion, and the other is high temperature digestion. (Dai et al. 2005. 1, 50-52)

3.3 Follow-up environmental treatment

The "Technical Specification for Domestic Waste Composting Treatment.2014" requires that "surplus garbage leachate, garbage truck cleaning water and workshop floor cleaning water and other production sewage can be connected to urban sewage management and treatment. When production sewage treatment facilities are installed in the plant, the discharge standard. The leachate treatment process can be divided into pretreatment, bio-logical treatment and advanced treatment. The treatment process of the leachate should be selected comprehensively according to the water quality, water volume and discharge requirements of the leachate. The figure 2 shows the combination process of "pretreatment + bio-logical treatment + advanced treatment" should be used. (CJJ150 2010)

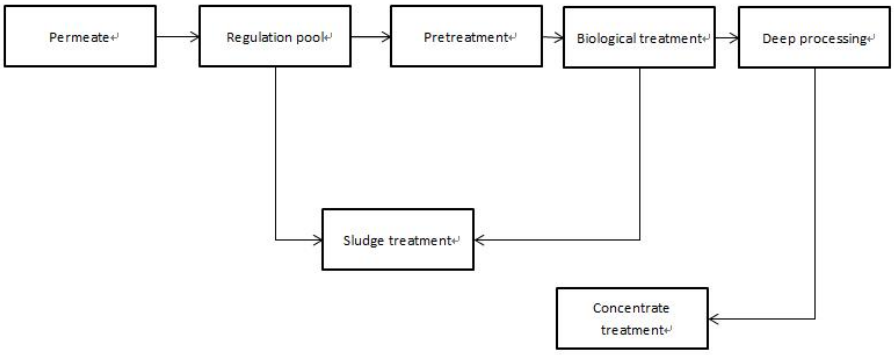


FIGURE2.The remaining garbage disposal process (adapt from Chinese "Technical Specification for Treatment of Domestic Garbage Leachate" CJJ150)

Bio-logical treatment can be divided into anaerobic bio-logical treatment and aerobic bio-logical treatment. Anaerobic bio-logical treatment can adopt up flow anaerobic sludge bed method (UASB) and its deformation improvement process. Generally, temperature and pH value are required. Aerobic bio-logical treatment should choose oxidation ditch, pure oxygen aeration reactor, membrane bioreactor, sequencing batch bioreactor, bio-logical filter, contact oxidation tank. Advanced treatment can choose nanofiltration and reverse osmosis processes. The concentrated liquid produced by nanofiltration and reverse osmosis processes should be treated separately, and incineration, evaporation or other suitable treatment methods can be used. (CJJ150 2010)

4 ENERGY FROM WET WASTE INCINERATION

This paragraph mainly introduces the process and types of burning wet waste to produce energy. Waste incineration power generation is neither clean nor renewable. But, with the gradual increase in people's needs and consumption, the types of waste are gradually increasing, of which household waste accounts for the main part.Garbage incineration is a method that can be quickly recycled and processed, and it can also produce harmful organisms in the garbage. At the same time, energy can be generated to solve the problem of insufficient energy. The waste incineration technology is still in the process of development. There are three types of waste incineration methods mainly introduced in this article, they are mechanical grate furnace type incinerator, fluidized bed type incinerator, rotary kiln type incinerator.

4.1 Development of wet waste incineration technology

In 1901, Sweden had achieved advanced technology in waste incineration and became the world's first waste incineration plant(A. U. Zaman. 2013) .Sweden handles approximately 4.66 million tons of domestic waste each year, and the national average annual waste generation per capita is 467 kilograms. In Sweden, almost all domestic waste is recycled, processed and treated, or used as energy.Among the domestic garbage in Sweden, 4.4 million tons of household waste are generated annually throughout the country, and 2.2 million tons of these wastes will be converted into energy through the process of waste. In 1975, Sweden only recycled 38% of household waste, but now Sweden's goal is to achieve zero waste by 2020. （Garima Bakshi,2016） In 2016, the energy produced by incinerators can meet the heating needs of 20% of Swedish urban households, while providing cheap electricity for 5% of households. However, the latest data show that Sweden's waste incineration data has undergone new changes. From 2002 to 2005, Sweden banned the disposal of organic and combustible waste in landfills. Compared with 40 years ago, in 1975, Sweden reclaimed an average of 18 kilograms of garbage per person, while in 2016 it was about 357 pounds. At that time, each resident also produced about 430 pounds of garbage, which was transported to landfills, and the amount of garbage collected from the incinerator was about 6.6 pounds. According to data, the weight in 2016 was 10 pounds. (Amy Yee. 2018)

According to Eurostat data from 2005 to 2019, the amount of domestic waste processed in the 28 EU member states dropped from 257 million tons in 2006 to 249 million tons in 2017, with a per capita processing volume of 487kg/person·year (2017), and the amount of incineration from 51 million tons (2006) to 6.8 million tons (2017), the per capita incineration increased from 104.1kg/person·year in 2006 to 133kg/person·year in 2017, and 27.3 % of domestic waste is processed by incineration. In 2016, a total of 475 incineration facilities were built. Compared with the EU, China's overall per capita incineration has a large gap, but the proportion of incineration processes has exceeded that of the EU by 7 percentage points. There are 6 provinces and cities in Jiangsu, Zhejiang, Hainan, Beijing, Shanghai, and Fujian. The per capita incineration volume exceeds the overall level of the 28 EU countries, and 16 provinces, autonomous regions and municipalities including Jiangsu, Hainan, Fujian, Zhejiang, and Shandong account for more incineration processes than the EU.（EU ROSTAT 2019）
The picture2 shows The situation at the garbage dump.

PICTURE2: Insects fly around labourers sorting and collecting rubbish for recycling at a dump in Hefei, Anhui province, May 18, 2011. REUTERS/Stringer/File Photo

Combustion is a management strategy for burning and treating non-recyclable combustible urban clean waste. While recovering the dissipated energy, the waste heat is greatly reduced. Incinerators usually operate at an average temperature of 850-1000° C. The specific furnace design and the time the waste is in the incinerator varies from 45 to 90 minutes.（Jeannet A. Meima, &Rob N.J. Comans.1997) In incineration applications, the fuel is mainly waste combustion to produce many of the same stable end products, regardless of whether the burning material is natural gas, coal, wood, gasoline, municipal solid waste, hazardous waste or medical waste. The flame area of a well-designed incinerator is hot enough to decompose all organic molecules and many inorganic molecules, causing most of the volatile components in the waste to react with oxygen and nitrogen (N2) in the air. In the process of incomplete combustion, some carbon monoxide (CO) and carbon-containing particles are produced. Hydrogen also reacts with organically bound chlorine to produce hydrogen chloride (HCl). In addition, many other reactions occur, from sulfur-containing compounds to sulfur oxides (SOx), from nitrogen-containing compounds (and a small amount of nitrogen in the air) to nitrogen oxides (NOx) and other harmful components.（Washington, DC 2000 17）

4.2 Wet waste incineration technology

The calorific value, composition and dimensions of domestic waste are the main factors that affect the incineration of domestic waste. The higher the calorific value, the easier the combustion process will be, and the better the incineration effect will be. The smaller the size of the components of the domestic waste, the better the effect per unit mass or volume of domestic waste, and the more complete the combustion; on the contrary, the poorer the mass and heat transfer effects are, and incomplete combustion is likely to occur. The waste entering the factory stays in the storage pit for a certain period of time, through natural compression and partial fermentation, to increase the calorific value of the waste entering the furnace, that improve the incineration effect of the waste, and it is also the key to the quality of waste incineration.In the United States in 1997, almost 40% of the urban waste stream consisted of paper and cardboard, about 10% of plastic, about 13% of metal and glass, and about 13% of courtyard decoration. The rest is composed of various materials (wood, rubber, textiles). Municipal domestic waste does not include quarantined medical waste, but includes some mixed medical waste. The calorific value of different waste burning is also different, and the effect of waste incineration needs to be improved. (Washington, DC. 2000 17)

Reasonable storage allows the waste to be fully fermented and dried into the factory. Domestic waste is not sent directly to the waste incinerator, but must go through the process of storage. To set up garbage storage pits, one is to store the garbage into the factory to adjust the amount of garbage; the other is to mix, mix, and dehydrate the garbage to adjust the nature of the garbage. In addition, the waste entering the plant stays in the storage pit for a certain period of time. Through natural compression and partial fermentation, the moisture content of the waste can be reduced, so as to increase the calorific value of the waste entering the furnace and improve the incineration effect of the waste. It is more suitable for domestic garbage to stay in the storage pit for 3 to 5 days. If the temperature is low and the humidity is high, the residence time can be appropriately extended. The general process of storage of domestic garbage is as follows The auxiliary fuel needs to be filtered and injected into the oil storage tank, and then the fuel is filtered through the filter, injected into the incinerator, and burned twice. Waste incineration technology is a relatively mature waste treatment technology. The more mature furnace types include mechanical grate furnace incinerators, fluidized bed incinerators, and rotary kiln incinerators. (Zhao &Li , Vol. 35 No. 9 135-140)

4.2.1 Mechanical grate furnace type incineration

The mechanical grate incineration technology originated in Europe and the United States, and has been widely used in the field of waste incineration. It has become the main type of waste incineration. Through years of accumulation, the maximum processing capacity of a single unit has reached 1200t/d. Germany's Martin, Japan's Mitsubishi Corporation, Hitachi Shipbuilding, Germany's Stan Miller Corporation, and Belgian Siggs Incineration Power Generation Equipment are at the forefront of technology in the world, and their products have the characteristics of stable combustion, high degree of automation, and full decomposition. (Zhao et al, Vol. 35 No. 9 135-140)

The mechanical grate incinerator adopted stratified combustion technology. The hearth is formed by mechanical grate blocks to directly burn the garbage. The relative movement between the grate and the gravity of the garbage itself make the garbage continue to turn, stir and push forward. The entire combustion process is carried out in a furnace. The garbage first enters the drying section. In order to ensure that the garbage can be quickly dried and dewatered, the heated air is used to dry the garbage from the bottom of the grate. At the same time, burning garbage in the furnace can also bake the garbage in the drying section; when the garbage enters the combustion section. After that, the garbage is burned at a high temperature about 900℃, which can completely decompose the combustible and

harmful components. At the same time, the furnace bottom enters the air to cool the grate, so as to prevent the high temperature from damaging the grate, when the waste enters the burning section. And then, the garbage is in the cooling process and completely burned out, completely turning into ash, and the whole process of garbage burning is completed. At present, the commonly used mechanical grate type incinerators mainly include inclined reverse push reciprocating grate, inclined forward push reciprocating grate, inclined forward push reciprocating grate, horizontal forward push reciprocating grate, and inclined multi-stage grate. （Zhao et al, Vol. 35 No. 9 135-140）

4.2.2 Fluidizde bed incineration

The fluidized bed incinerator body is usually lined with refractory materials, arranged vertically, with a porous distribution plate at the bottom of the furnace, and domestic waste is fed into the furnace from the upper or side of the fluidized bed, accompanied by inert particles (usually silica sand can be used). As a fluidized carrier, it enters the furnace body at a certain proportion at the same time. Air enters the furnace from the ventilation device at the bottom of the incinerator. The vertically rising airflow blows the mixed particles in the furnace, causing intense tumbling combustion and continuous circulation. Since the pores provided between the media are narrow and cannot accept larger particles, if solid waste is processed, it must be broken into small particles to facilitate the reaction. The upward air flow rate controls the degree of particle fluidization. If the air flow rate is too high, the medium will be brought into the air pollution control system by the updraft. A cyclone dust collector can be installed to capture the large particles of the medium and return it to the furnace. Generally, the temperature range of incineration is kept at 400~980℃, and the apparent gas flow rate of the bubble bed is about 1~3m/S. The medium in the fluidized bed is in a suspended state, and the gas and solid are fully mixed and contacted. The temperature of the combustion section of the entire hearth is quite uniform. There are no moving parts inside the fluidized bed furnace, so the friction is low. (Wu Vol. 36 No. 5 22-26 2020). At present, the commonly used furnace types include bubble fluidized bed incinerators and circulating fluidized bed incinerators. (Wu Vol. 36 No. 5 22-26 2020)

4.2.3 Rotary kiln incineration

Rotary kiln incinerator refers to an incinerator in which a refractory lining furnace is installed inside a cylindrical body made of steel plate. From the front to the back, the structure usually includes the domestic garbage stacking area, the garbage inlet, the incinerator body, the heat recovery device, the

secondary calcining chamber, the waste recovery and pollution control. The kiln body is installed slightly slanted from the horizontal. After the waste enters, it rotates slowly while transferring the waste supplied from the upper part to the lower part, and the air is supplied from the front or the rear to burn it. Usually, a secondary combustion chamber is installed after the rotary kiln, so that the toxic and harmful gases that have not been completely burned by the previous pyrolysis can be completely burned in a higher temperature oxidation state. (Wu Vol. 36 No. 5 22-26 2020)

Table 2. Comparison of technical characteristics of three incinerators (adapt from Chen 2021 No.2 5-6)

Project	Mechanical grate furnace	Fluidized bed incinerator	Indirect kiln incinerator
Structural features	Mechanical movement grate, the area of the grate and the volume of the furnace are large	Fixed grate, the area of the grate and the volume of the furnace are small	No grate, relying on the rotation of the furnace body to drive the garbage to move
Equipment area	Big	Small	Medium
Garbage pretreatment	Not need	Need	Not need
Garbage adaptability	Good	Good	poor
Combustion condition control	Easier	Not easy	Not easy
Operating expenses	Low	Low	Higher
Fly ash production	Less	More	Less
Maintenance workload	general	More	less
Operating performance	Most	More	Deal with more industrial waste
Overview	Strong adaptability to garbage, no need to deal with, high combustion efficiency, reliable operation	Face the garbage for sorting and crushing, which can be combined with coal for incineration	Requires higher calorific value and higher operating cost of waste, and is mostly used for industrial waste incineration

4.3 Follow-up environmental treatment

The pollutants in the waste gas generated by the incineration of domestic garbage can be particulate matter, acid gases such as sulfur dioxide, nitrogen oxides, heavy metals, and dioxins, which are harmful to the human body and the environment. The "Household Waste Incineration Technology" edited by Zhang Yi and Zhao Youcai introduced in detail the purification measures for the flue gas of domestic refuse incineration. Factories generally adopt "low temperature control" and "high-efficiency particulate matter" trapping measures. Particulate matter is mainly completed in electrostatic precipitator or bag dust removal. Sulfur dioxide mainly does not chemically react with Ca(OH)2 powder, generating gypsum and removing it. Nitrogen oxides mainly adopt selective catalytic oxidation reduction (SCR), which is reduced by ammonia to N2, which is not harmful to the

environment. Heavy metals and dioxins are usually removed by activated carbon adsorption. (Zhang Yi, &Zhao Youcai 2000)

5 BIO-DIESEL FROM WET WASTE

The research on bio-diesel and its production technology started in the late 1950s and early 1960s and developed in the 1970s. In 1980, the United States began to study the use of soybean oil to replace diesel as fuel, but ordinary soybean oil is not compatible with diesel prepared from petroleum, and the glycerin in triglycerides contained in ordinary animal and vegetable fats and oils burns incompletely and is easy to coke. Result in ordinary diesel engines can not use animal and vegetable oils as fuel. Scientists at the Illinois Agricultural Research Service have discovered that hydraulic fluid can be extracted from oil seeds. This fluid can transmit force under pressure and can be used in cars, bulldozers, tractors, and most large devices used to build roads and buildings. The torque, power and kilometers per liter of combustion transmitted by an engine using it as fuel are similar to those of a petroleum engine. However, it cannot withstand low temperatures and is very expensive. In fact raw materials with high oleic acid content are better, such as sunflower, safflower and some soybean oil. In 1983, American scientist Craham Quick first used the methyl ester of linseed oil in an engine, burned it for 1,000 hours, and defined it as a "Bio-diesel" as a renewable fatty acid methyl ester. In 1984, scientists in Germany and other countries studied the use of fatty acid methyl ester instead of diesel as fuel, forming a broad definition of bio-diesel, and countries around the world have successively carried out related research. China started bio-diesel research in 1985 and built a bio-diesel pilot plant with an annual output of 10,000 tons in Handan, Hebei in September 2001. (Jia et al. 2017)

In 2003, Europe began to approve the development and use of bio-fuels. According to the European Union’s "Renewable Energy Directive" and its revised version, it requires that the proportion of renewable energy consumption in 2020 and 2030 reach 20% and 32%, respectively. The proportion of the transportation sector needs to reach 10% and 14%, and bio-diesel is gradually being promoted as a renewable energy source. (EU publications 2021) According to European commission statistics, 20-80Kg of waste grease can be extracted from per ton of wet garbage. After centralized processing, it can be made into fatty acid methyl ester and other low-carbon ester substances. Pretreatment and transesterification, as well as the recovery of fatty acid methyl ester and glycerin, constitute the main stages of the bio-diesel production process from wet waste. Pretreatment includes precipitation and removal of impurities, acidification and degumming, steam cooking and deodorization, vacuum dehydration.

5.1 Development of bio-diesel technology from wet waste

The research on bio-diesel and its production technology started in the late 1950s and early 1960s and developed in the 1970s. In 1980, the United States began to study the use of soybean oil to replace diesel as fuel, but ordinary soybean oil is not compatible with diesel prepared from petroleum, and the glycerin in triglycerides contained in ordinary animal and vegetable fats and oils burns incompletely and is easy to coke. , Resulting in ordinary diesel engines can not use animal and vegetable oils as fuel. Scientists at the Illinois Agricultural Research Service have discovered that hydraulic fluid can be extracted from oil seeds. This fluid can transmit force under pressure and can be used in cars, bulldozers, tractors, and most large devices used to build roads and buildings. , And the torque, power and kilometers per liter of combustion transmitted by an engine using it as fuel are similar to those of a petroleum engine. But it cannot withstand low temperatures and is very expensive. Later, they found that raw materials with high oleic acid content were better, such as sunflower, safflower, and certain soybean oils. In 1983, American scientist Craham Quick first used the methyl ester of linseed oil in an engine, burned it for 1,000 hours, and defined it as a biodiesel "Bio-diesel" as a renewable fatty acid methyl ester. In 1984, scientists in Germany and other countries studied the use of fatty acid methyl ester instead of diesel as fuel, forming a broad definition of bio-diesel, and countries around the world have successively carried out related research. China started bio-diesel research in 1985 and built a bio-diesel pilot plant with an annual output of 10,000 tons in Handan, Hebei in September 2001. (Jia et al. 2017)

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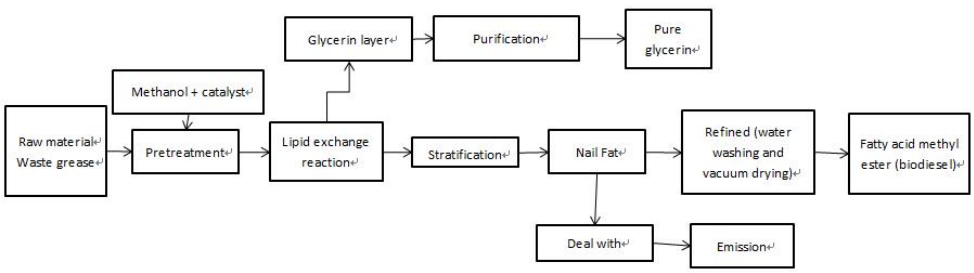
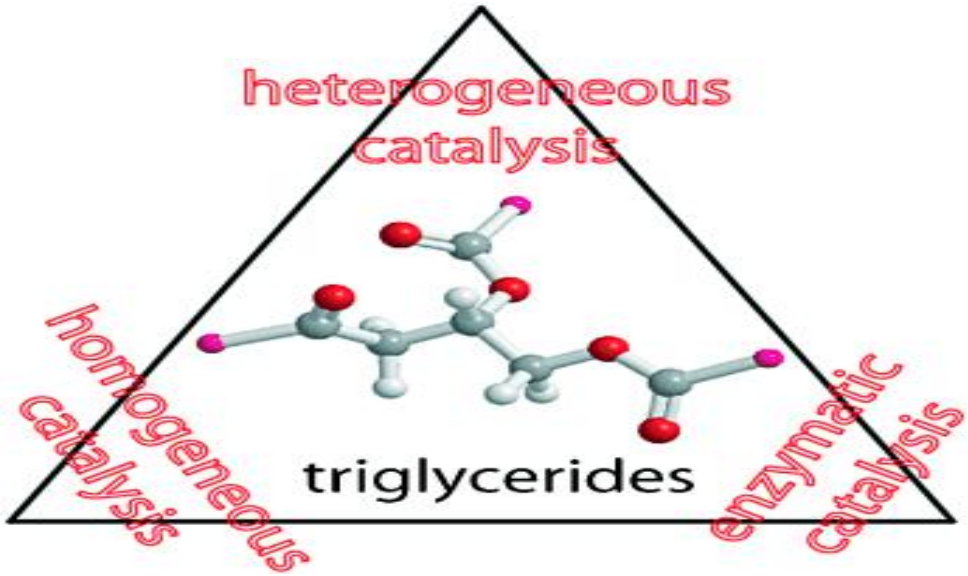


FIGURE 3. Bio-diesel from waste oil general process (adapt from Xie et al. 2019 Vol. 16 No. 2 43-4)

5.2 Bio-diesel from wet waste

The method of preparing bio-diesel mainly uses animal and vegetable oils as raw materials. Under the action of a catalyst, it undergoes an acid exchange reaction with low-carbon alcohols, and the products are bio-diesel and glycerin. The process of this reaction is actually a three-step continuous reaction. If the alcohol involved in the reaction is methanol, each step of the reaction will generate diglycerides, monoglycerides and glycerol in sequence in addition to the formation of fatty acid methyl esters. (Hu&Lin.2020. Vol. 22 No. 246 35-39)

Since the transesterification reaction is a reversible reaction, in order to promote the formation of fatty acid methyl esters, an excessive amount of alcohol is often added during the actual reaction. The commonly used alcohol for transesterification to synthesize bio-diesel is methanol or ethanol. Studies have found that under the same conditions, the shorter the carbon chain of the alcohol, the faster the methyl esterification rate of triglycerides, and the higher the conversion rate. In addition, fatty acid methyl esters and fatty acid ethyl esters are also very close in nature, but the price of methanol is lower, so it is more popular. (Hu et al.2020. Vol. 22 No. 246 35-39) The picture 3 shows simple lipid exchange reaction process.



PICTURE 3.Lipid exchange reaction(sivasamy, A., Cheah, K., Fornasiero, P., Kemausuor, F., Zinoviev, S., & Miertus, S. (2009). Catalytic applications in the production of biodiesel from vegetable oils. ChemSusChem, 2 4, 278-300 .)

5.2.1 Chemical catalysis

The property exchange method is to make the waste oil and the rose undergo an exchange reaction under the action. The property exchange of vegetable oil, animal fat or waste edible oil is the process of traditional bio-diesel. Catalyst with alcohol (usually methanol or ethanol), plant properties and alcohol. Food waste bio-biology is a excellent technology. In most cities and towns, the waste cooking oil is simply dumped, which has caused serious environmental, social, economic and health problems to the society. At the same time, the influence of oil treatment on the harmful environment and other biological influences has been increased. In 2019 , the use of heterogeneous catalysts in biological production has attracted great attention. The new catalyst is separated from the product, reusable and environmentally friendly. Synthesis can more effectively solve the problem of kitchen waste oil. (Degfie, T.A. et al. 2019)

The catalyst used in the acid catalysis method is an acid catalyst, mainly sulfuric acid, hydrochloric acid and phosphoric acid. Under the condition of acid catalysis method, free fatty acid will undergo esterification reaction, and the esterification reaction rate is much faster than the transesterification rate. Therefore, this method is suitable for the preparation of bio-diesel from oils with high moisture content and free fatty acids, and its yield is high. However, the reaction temperature and pressure are high, the amount of methanol is large, the reaction speed is slow, and the reaction equipment needs stainless steel materials. In industry, acid catalysis has received much less attention than alkali catalysis. The production of bio-diesel from microalgae culture is environmentally friendly and sustainable. Algae have several advantages over bioenergy, including their good photosynthetic capacity and faster growth rate. The productivity area of microalgae per unit of land is also significantly higher than that of terrestrial plants. The microalgal biomass produced is rich in high-quality lipids, which can be converted into biodiesel through a transesterification reaction. The transesterification of solid acid-base catalysts can provide new progress for biodiesel production. (Faruque, M. et al .2020)

The catalyst used in the alkali catalysis method is a basic catalyst, generally NaOH, KOH, NaOH, and organic amines. In the absence of water, the transesterification activity of basic catalysts is generally higher than that of acidic catalysts. The traditional production process uses alkali metal hydroxides with greater solubility in methanol as homogeneous catalysts, and their catalytic activity is related to their alkalinity. Among alkali metal hydroxides, KOH has higher activity than NaOH. The typical

conditions for the transesterification reaction with KOH as a catalyst are: the amount of methanol is 5%-21%, the amount of KOH is 0.1%-1%, the reaction temperature is 25-60°C, and the NaOH catalyst usually needs to be reacted at 60°C. The alkali catalysis method can obtain higher yields at low temperatures, but it has higher requirements for the free fatty acid and water content in the raw materials. During the reaction process, free fatty acids will undergo saponification reaction with alkali to produce emulsification, and the water content can cause ester hydrolysis, and then saponification reaction. At the same time, it can also weaken the catalyst activity, as a result, the glycerin phase and the methyl ester phase will become difficult to separate, which makes the post-reaction treatment process complicated. Therefore, when using alkaline catalysts such as potassium hydroxide, sodium hydroxide, potassium methoxide, it is often required that the acid value of the oil is <1 and the moisture content is <0.06%. However, almost all oils usually contain relatively high amounts of fatty acids and moisture. For this reason, the industry generally requires dehydration, deacidification, or pre-esterification of raw materials. (Li et al .2005)

5.2.2 Enzymatic method

Lipase is used to catalyze the esterification reaction between animal and vegetable oils and low-carbon alcohols to generate corresponding fatty acid esters. Lipase has a wide range of sources, with selectivity, substrate and functional group specificity. It can catalyze hydrolysis, ester synthesis, transesterification and other reactions in the non-aqueous phase, and the reaction conditions are mild, no auxiliary factors are required, and fat is used. Enzymes can further synthesize other high-value products, including biodegradable lubricants and additives for fuels and lubricants. These advantages make lipase a suitable catalyst for biodiesel production. (Li et al .2005)

5.3 Follow-up environmental treatment

In the process of preparing bio-diesel, wastewater is generated from catalytic reactions, raw material dehydration, refined products. The main reason is that the content of COD is relatively high, reaching 150,000 to 20,000 mg/l, the suspended matter is relatively high, the composition of wastewater is complex, and there are residual reactions. For products, catalysts. China has studied that the wastewater mainly adopts a combination of contact oxidation, UASB anaerobic reaction, and MBR technology, and has achieved good treatment results. (Yang & Wu .2019. Vol. 46 Total No. 409 57-58)

6 THE DEVELOPEMENT OF FUTURE

Food waste recycling has attracted worldwide attention. Every year, the amount of waste food is estimated to account for the increase in global food production each year. According to research in Beijing, the anaerobic treatment of 200 tons of kitchen waste can generate a profit of 66,888 yuan, generate 4,350 kW·h of electricity, and reduce carbon dioxide emissions by 1,087 kg. Generally, the economic and environmental benefits of anaerobic treatment of food waste are considerable. However, the economic benefits mainly come from government subsidies. There are many impurities in food waste, which indicates that there are some problems in food waste disposal. Reducing waste is the best way to use resources and deal with waste. Garbage collection needs to be supported, and those who pay attention to it will not develop in the future.(Guo&Yang, 2019）

6.1 Production of reducing sugar from wet waste

Compared with the methane, alcohol. produced by fermentation, the polysaccharide components rich in meal waste can be produced through enzymatic, acid hydrolysis, and hydrothermal technology. The mechanism is simpler and the product can be used in a wide range. In addition, enzymatic hydrolysis technology and hydrothermal technology are still more promising treatment methods for the resource utilization of kitchen waste, so this technology has attracted more and more attention. (Wei et al.2016)

6.2 Wet waste production acetic acid

The hydrothermal process is one of the most promising processes, and one of the most important for the conversion of biomass. Converting renewable resources into chemicals at high temperatures. High-pressure water has excellent performance as a reaction medium. Because wet garbage contains a large amount of mailing components and food fiber, this is a favorable condition for the manufacture of acetic acid. Almost all organic waste are recyclable intermediate products in wet oxidation. It is hoped that waste will be converted into acetic acid through a hydrothermal reaction process in the future.(Zhou et al,2006)

7 CONCLUSIONS

The most fundamental purpose of wet waste recycling energy is to recycle organic waste into renewable energy opportunities while offsetting disposal and environmental costs.The scheme of recycling energy from wet waste ensure economic circulation and environmental feasibility. Waste is a valuable secondary carbon resource, but these treatment methods will be accompanied by the loss of carbon resources. China is at the beginning of the transition from a linear carbon economy to a circular carbon economy. Therefore, it can learn from the waste management experience of other economies and evaluate transfer opportunities to support the development of its "zero waste city". At the invitation of US President Biden, Chinese Premier Xi Jinping will attend the leaders climate summit on April 22, 2021 and Xi Jinping stated that China will strive to achieve carbon peaks by 2030 and carbon neutrality by 2060. In the future, China's wet garbage recycling will receive attention and develop rapidly.（Business News.2021）

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