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Review Article

Organic waste utilization and urban food waste composting strategies in China - A review

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Abstract

Food loss may occur in production, storage, transport, and processing, which are the stages of the value chain with the lowest returns. The current searching was done by the keywords in main indexing systems including PubMed/MEDLINE, Scopus, and Institute for Scientific Information Web of Science as well as the search engine of Google Scholar. The most important points challenging areas that represent opportunities for stakeholders to look into in China are, put in place suitable economic incentives to encourage restaurants to get more involved in the formal system, create a comprehensive regulation system to benefit all relevant stakeholders by clearly defining their respective roles and responsibilities, which is necessary for the proper functioning of the whole system. In China, the most important regulations, policies and plans are regulations on safety issues of food waste treatment, detailed countermeasures on organizing, educating, supervising, and inspecting the work on food waste reduction in China, and detailed plant for household waste collection and treatment, issued by Chinese government, state council, and ministry of environmental protection. Setting national goals, awareness-raising campaigns, strict and appropriate regulation, stakeholder engagement, biorefinery and food waste recycling to animal feed are important strategies for better waste management. The most important food waste management practices in China are source separation, animal feed, rendering, composting, co-digestion, anaerobic digestion, incineration, landfill, and etc. Understanding social factors influencing household behavior is utmost importance; public education and specific communication highly contribute to improve recycling.

Keywords: animal nutrition; food composting; food waste; organic waste

Introduction

Wastes fall in to five groups, ordinary wastes, medical (health care) wastes, special wastes, industrial wastes, and agricultural wastes. Clean technology can be implemented to minimize waste, and increasing productivity and reducing the unit cost of the products. One third of the food produced globally for human consumption is either lost or wasted every year which has a high potential of energy recovery (Jeevahan *et al.*, 2018; Shahrajabian *et al.*, 2019; Ilakovac *et al.*, 2020). Inappropriate management of organic waste is the main

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cause of environmental pollution and nutrient loss in many countries, especially developing countries (Soleymani *et al.*, 2016; Soleymani and Shahrajabian, 2017; Shahrajabian *et al.*, 2017; Bekchanov and Mirzabaev, 2018; Shahrajabian *et al.*, 2020; Sun *et al.*, 2021a, b). Food loss means decrease in weight (dry matter) or quality (nutritional value) of food that was originally produced for human consumption, while food waste means food appropriate for human consumption being discarded, whether after it is left to spoil or kept beyond its expiry date. The loss of edible food and inedible food parts at the point of retail or consumer use is typically considered food waste, food that is lost in the stages between production and distribution, where, food may have spoiled as a result of production and processing technologies, is considered food loss. Three main objectives are preventing food waste from occurring in the first place, recover safe and nutritious food for people and food scraps for animals, and recycle energy and nutrients from the remaining, unavoidable food waste. The most important factors which may cause food loss and waste are human behavior and the incentives behind it such as consumer, employee and management decisions, time-limited biological reality of food-particularly fresh and unpackaged food, limited or lack of advanced technology, equipment, packaging, etc; risk perception and risk avoidance among businesses and consumers; and unintended consequences of regulation. Compost products application has a potential in the suppression of plant pathogens and green waste composting represents a promising approach in sustainable agriculture (Milinkovic *et al.*, 2019). Composting is a natural process that stems through microbial succession, marking the degradation and stabilization of organic matter present in waste (Rastogi *et al.*, 2020). Most municipal solid waste consists of biodegradable components, and the most abundant biological component is cellulose, followed by hemicelluloses and lignin (Donovan *et al.*, 2010). The most important reasons for improving the recycling of municipal and industrial organic waste on agricultural land are benefits to crop production due to the recycling of organic matter and mineral nutrients and possible suppression of soil-borne pathogens, conservation of naturally available but limited supplies of nutrient resources and avoidance of alternative disposal methods which are environmentally damaging, expensive or limited by space (Schulz and Romheld, 1997). Composts are safer from an agricultural point of view than fresh wastes, because they contain a smaller amount of phytotoxic substances and organic matter is more stabilized than in fresh residues (Ayuso *et al.*, 1996). Factors affecting the composting process are C/N ratio, pH, moisture content, aeration/O_2 supply, temperature, particle size, and bulking agents. Various methods are available for composting process, rotary drum is an efficient and decentralized composting technique which helps in proper mixing, aeration and produces stable and matured compost, while analytical hierarchy process is very popular and widely used decision-making method to solve the problems of various fields (Sharma and Yadav, 2018). As China has experienced double-digit economic growth in recent 30 years, more than 300 million people have moved into big cities, and the relationship between people and food, and food waste has changed. A significant portion of food waste ends up in landfills or incinerators without undergoing proper treatment or is illegally diverted into the informal system to feed livestock or produce cooking oil through practices that have resulted in serious food safety problems. China is currently trying to facilitate food waste harmless disposal and resource utilization by urban food waste management, but it is critical for government departments to take advantage of the informal regulation of the public and NGO, gradually reduce food waste treatment fee and maintain a reasonable regulation cost to increase urban food waste management and promoting food waste harmless disposal and resource utilization (Zhu *et al.*, 2020). Factors contributing to food waste, effective cost/benefit food waste utilization methods, sustainability and environment considerations, and public acceptance are recognized as hurdles in preventing large-scale food waste processing (Ghosh *et al.*, 2016). Food waste has not only incurred economic losses and negative environmental impact, but it also threatens China's agricultural capacity to deliver fresh, safe and affordable produce to its rising middle class and urbanites. Tremendous food waste also equates to a loss of resources such as water, seed, and labor, which are already considered scarce in China. Composting is divided into two categories, earthworm composting and microorganism composting. Through earthworm composting, food waste is utilized as earthworm feed for worm cultivation; both worms and worm castings being used as the soil conditioners or organic compost in agricultural activities. Through microorganism composting, food waste is decomposed and converted into microbial fertilizers rich in diverse nutrients that can improve soil quality and productivity. The aim of this mini-review is survey on organic waste, organic waste utilization in animal nutrition, urban food waste composting, and public awareness, especially in China.

Organic Waste

Organic wastes are increasingly becoming a valuable resource and have the potential to significantly spur the transition towards a sustainable and circular bioeconomy (Mahjoub and Domscheit, 2020). Organic waste diversion program participants are motivated by environmental concern (Pickering *et al.*, 2020). Different types and sources of organic wastes are domestic or household waste, commercially produced organic waste, animal and human waste, and agricultural residue. Food waste most commonly refers to edible food products, which are intended for the purposes of human consumption, but have instead been discarded, lost, degraded or consumed by pests, and does not include the inedible or undesirable portions of foodstuffs. Food waste is considered as an obstacle to achieving food and nutrition security for the millions of undernourished around the world, and most societies attach an ethical and moral dimension to food waste. Food loss occurs in production, storage, transport, and processing, which are the stages of the value chain with the lowest returns. Organic waste biorefinery is a concept for waste management which can extract high value products from organic waste and technological, strategic and market constrains may affect implementation (Alibardi *et al.*, 2020). Organic waste fertilization which might be an alternative for mineral fertilizers, promoted soil biochemical and microbial properties (Gryta *et al.*, 2019). Composted organic waste has been proved to be a good amendment for soil productivity and agricultural sustainability while reducing nitrate leachate (Galsim *et al.*, 2020). The objectives of composting can be stabilization, volume and mass reduction, drying, elimination of phytotoxic substances and undesired seed and plant parts, and sanitation. Some important wastes for composting are kitchen waste, biowaste, garden and green waste, garbage, feces of human, wastewater sludge (raw), wastewater sludge (anaerobic stabilized), dung of cattle, horses, sheep, pigs, liquid manure of cattle, pigs and chickens, beet leaves, straw, fresh bark, bark mulch, wood chips, leaves, reed, peat, paunch manure, grape marc, fruit marc, tobacco and paper, Organic waste management and bioenergy production are complementary to each other; while social, economic and environmental development are key indicators for sustainable waste management, nanotechnological based implications play a profound role in increasing bioenergy production (Dhanya *et al.*, 2020). Solar composers offer a viable solution in rural areas lacking connection to municipal power supplies, and solar composting greenhouse has a high potentiality to transform organic waste into organic fertilizer (Lin *et al.*, 2020). Sustainable energy from waste organic matters may mitigate climate changes, toxic gases and particle generation (Srivastava *et al.*, 2020). The absence of source separation of organic municipal solid waste and the farmers' lack of awareness of compost's advantages as a substitute for conventional fertilizers are main reasons of the efficiency of composting organic wastes (Kan *et al.*, 2010). Guo *et al.* (2021) reported that conventional treatment and recycling methods of organic solid waste contain inherent flaws, such as low efficiency, low accuracy, high cost, and potential environmental risks, and most studies have been focused on municipal solid waste management, followed by anaerobic digestion, thermal treatment, composting and landfill. Moldagulova *et al.* (2020) reported that thermotolerant microorganisms play an important role in the composting process of organic waste which are responsible for the degradation process of organic compounds owing to their enzymatic activity in the high-temperature phase of composting. Duan *et al.* (2020) found that biorefinery facing a big challenge in technical, financial and social awareness, and circular bioeconomy requires coordinated policy intervention in socioeconomic. Both aerobic and anaerobic digestion technology is sustainable approach for biorefinery (Wainaina *et al.*, 2020). The adoption of anaerobic membrane bioreactors for organic solid waste management is important for the recovery of energy and high-quality treated water (Inaba *et al.*, 2020). Anaerobic digestion can represent a simple biorefinery producing both energy and polyhydroxyalkanoates (Papa *et al.*, 2020). Composting of organic waste helps to ensure environmental sustainability, reduce greenhouse effects by mitigating the production of gases like methane, reduce the volume of wastes drastically and recalcitrant substances (Ayilara *et al.*, 2020). The most important factors which influence the decomposition process of organic wastes are carbon to nitrogen (C:N) ratio, moisture content, temperature and oxygen (Salah and Hala, 2017). Fundamental types of composting aerobic and anaerobic are presented in Table 1.

Table 1. Fundamental types of composting aerobic and anaerobic

Type	Key points
Aerobic composting	Composting is the decomposition of organic waste in the presence of oxygen (air); the process includes CO_2, NH_3, water and heat. Composting requires the moisture contents around 60-70% and carbon to nitrogen ratios of 30/1. Wood and paper provide an important source of carbon, while sewage sludge and food waste provide to nitrogen to ensure and adequate supply of oxygen at all times. Ventilation of waste is important.
Anaerobic composting	It is the decomposition of organic wastes in the absence of O2, the products being methane (CH_4), CO_2, NH_3, and trace amounts of other gases and organic acids. It was traditionally used to compost animal manure and human sewage sludge which can be used for some municipal solid waste and green waste.

Urban Food Waste Composting

Food waste has emerged as a key governance challenge in many countries (Brink, 1994; Warshawsky, 2020). It is considered as inherent part of the global food system, with significant environmental social and economic impacts (Boulet *et al.*, 2019). Food waste serves as a valuable and sustainable resource, which can alleviate the environmental and health problems associated with organics in landfills. Cooperative solid waste composting may reduce environmental health concerns associated with agricultural wastes, while generating a value-assed soil amendment and reducing solid waste volume (Kelley *et al.*, 1999). The overall benefits of \$100/Mg for the Chicago case study suggest the financial feasibility of pursuing a city-wide decentralized composting strategy (Pai *et al.*, 2019). The complexities in choosing appropriate assumptions, factors and datasets are important parameters for calculating food waste baseline amounts (Davies and Legg, 2018; Dusoruth *et al.*, 2018). Anaerobic digestion is the main means of energy utilization which has the advantages of high benefit, and can be used for recycling clean energy. Anaerobic digestion includes batch system, continuous flow single-phase digestion system and continuous flow two-phase system. Composting is an effective fertilizer treatment technology for organic waste; aerobic composting has a high temperature, generally 50 °C-65 °C, so it is also called high temperature composting, and this method can kill pathogenic bacteria to maximum extent and degrade organic matter rapidly; moreover, aerobic composting includes direct composting of fruit and vegetable waste and mixed landfill of fruit and vegetable wastes and feces. On-farm composting is viable option because of its tremendous benefits on soil quality and plant health which valorize underused biomass (Corato, 2020). Also, focusing of food packaging performance in food waste minimization is critical (Kakadellis and Harris, 2020). The most environmentally friend food waste conversion technology is composting after pre-treatment of high temperature, and the next most one is direct composting treatment which is followed by anaerobic co-digestion with sewage sludge, and the worst one is transforming food waste into bio-ethanol (Tseng and Chiueh, 2015).

Composting of food waste encounters a number of technical challenges, arising weak physical structure of food waste with weak porosity, high content of water, low carbon-to-nitrogen relation and fast hydrolysis and accumulation of organic acids during composting (Voberkova *et al.*, 2020). Anaerobic digestion coupled with effective nutrient and energy recovery appears to be the preferred option to improve the overall sustainability of household food waste management in Amsterdam (Tonini *et al.*, 2020). Kucbel *et al.* (2019) reported that composts household food waste has low stabilization of organic components. Nigussie *et al.*

(2015) concluded that education, landownership, experience with compost and access to extension services may explain variation in compost demand. Improvement of separate collections of food market and municipal gardening wastes can provide specific clean waste streams of degradable materials to be managed separately from not separately collected municipal solid waste (Jara-Samaniego *et al.*, 2015). The slow release nitrogen supplied by food waste composts is ideally suited for urban landscapes, where a moderate, consistent rate of plant growth is highly desirable (Sullivan *et al.*, 1998). Slorach *et al.* (2020) concluded that anaerobic digestion is environmentally the most sustainable option with the lowest overall impact on the nexus, and incineration is the second-best option but has a greater impact on the health aspect than landfilling; moreover, landfilling has the greatest influence on the water aspect and the second highest overall impact on the nexus. Sullivan *et al.* (2003) reported that after 7 year, increased soil organic matter (both total soil C and N) in the compost amended soil accounted for nearly 18% of compost-C and 33% of compost-N applied. Tucker and Farrelly (2016) concluded that individual or household-level changes of food waste are important and should be supported by both local body and state level legislation and initiatives. Mansfield and Mendes (2013) also emphasized on roles of local of government in food production, food processing, food distribution, food access and food waste management. The use of wood chips in composting increases the efficiency nutrient retention from food waste and in turn increases nutrient recycling in urban environments (Small *et al.*, 2017). Sun *et al.* (2020) also concluded that food waste compost and wood waste biochar were effective bioretention filters for metal removal. The use of zeolite and perlite regulates the concentrations of ammonia and consequently the nitrate in the substrate of home composting of kitchen waste (Margaritis *et al.*, 2018). Reasonable temperature, pH, good mixing and small particle sizes are important factors for successful and productive anaerobic digestion process of food wastes (Leung and Wang 2016). Kaudal and Weatherley (2018) reported that addition of 10% urban biochar to food waste accelerated the composting process. Mandpe *et al.* (2019) observed that combination of 80% organic waste and 20% fly ash showed better enzymatic activity. Pereira *et al.* (2018) that CH_4 emissions are the major environmental aspects during organic urban waste composting, and composting stabilizes about 50% of the initial total C content.

Compost can be utilized as fertilizer and energy fuel, promoting circular economy, and optimizing composting process and composter can mitigate the environmental impacts (Liu *et al.*, 2018; Chia *et al.*, 2020). *Paecilomyces lilacinus* has protease activity and nematocidal ability which can convert food waste into nematocidal biofertilizer (Yu *et al.*, 2015). Zhao *et al.* (2019) highlighted the necessity of location-suitable and urban-rural recycling nitrogen management strategies for reducing the risk of nitrogen emission from household food consumption in China. Guo *et al.* (2018) proposed the source-separation composting in situ with complete equipment, which may lead to obtaining high quality compost, and the odor (H_2S and NH_3) could be effectively controlled in the composting process. Lime addition as well as formation of struvite through the addition of magnesium and phosphorus salts may provide good pH buffering and reduce odor emission (Wang *et al.*, 2018). It has reported that Chinese medicinal herbal residues are a good bulking agent of composting, and longer thermophilic phase was found in treatment 1:1:1 (Food waste: sawdust: Chinese medicinal herbal residues) (Zhou *et al.*, 2018). Chinese medicinal herbal residue can be a potential bulking agent/co-substrate, and Chinese medicinal herbal residue-born active ingredients are the main cause of inhibition (Zhou *et al.*, 2016). Chen *et al.* (2015) reported that heat treatment process did not significantly reduce the concentration of hazardous trace elements in food waste, but the separation process for solid and aqueous components, such as centrifugal dehydration, could reduce the risk considerably; they have concluded that combined with the separation technology for solid and liquid components, dry-heat treatment is superior to moist-heat treatment on the removal of external water-soluble ionic hazardous trace elements. The most important points challenging areas that represent opportunities for stakeholders to look into in China are, put in place suitable economic incentives to encourage restaurants to get more involved in the formal system, create a comprehensive regulation system to benefit all relevant stakeholders by clearly defining their respective roles and responsibilities, which is necessary for the proper functioning of the whole system, foster the development of companies specializing in different waste treatment technologies, which is a growing trend that will help achieve higher treatment efficiency at a lower cost, support and incentivize the development of a market which closes the loop and redeploys these wastes as new resources. In China, the most important regulations, policies and plans are regulations on safety issues of food waste treatment, detailed countermeasures on organizing, educating, supervising, and inspecting the work on food waste reduction in China, and detailed plant for household waste collection and treatment (a safe treatment rate of 80% in urban areas by 2015), issued by Chinese government, state council, and ministry of environmental protection (Li *et al.*, 2016). Guo *et al.* (2018) reported that during 10 days drum composting, the temperature of food waste experienced three classic phases including heating phase, thermophilic phase, and cooling phase, and the concentration of H_2S and NH_3 in the effluent were as low as 0.0001 and 0.025 mg/m^3 after biofiltering treatment, and after 20 days subsequent post-maturity, total content of N, P and K in the food waste compost was as high as 11.66%, and as for economical consideration, the average investment and energy consumption of the CPRM were as low as US$ 61.5 and 50.0 kWh/t. They have concluded that the successful case of the pilot scale plant showed the mode of source separation-composting in situ with composting in situ with complete equipment (CPEM) was feasible to realize the recycling of food waste. Possible strategies to prevent the food loss and waste (FLW) at different stages of food supply chains (FSC) were presented in Table 2.

Toledo *et al.* (2019) reported that co-composting of eggplant waste and sewage sludge had an important impact on odor concentration reduction. Palm waste can be managed by co-composting with sewage and agri-food sludge, but the use of date palm waste may increase the salt contents in the final composts (Vico *et al.*, 2018; Doctor *et al.*, 2020). The most important responsibilities of waste management in China are cleaning of streets, collection, transport, transfer, recycling, treatment, disposal, supervision, training, legislation and issuing of technical standards on pollution control, supervision, pollution control, enforcement, solid waste import/export, administration, legislation, planning and construction, technical standards, research, training, supervision, information collection, regulations on material recovery and material recovery (Wang and Nie, 2001).

Organic Waste Utilization in Animal and Poultry Nutrition

Not only in rural areas, but also in urban regions, China lacks advanced waste management facilities, waste management firms, and other institutions-effective, high-quality management systems like those in other developed countries (Rada *et al.*, 2014; Ferreira *et al.*, 2017; Ranieri *et al.*, 2017). The most important food waste resources which have potential to convert to food waste to animal feed are household and catering food waste, kitchen and food factory waste, household and catering food waste, manufacturing food waste, retail food waste, compared banana chicken, lettuce, beef, bread waste (Takata *et al.*, 2012; Tufvesson *et al.*, 2013; Vandermeersch *et al.*, 2014; Salemdeeb *et al.*, 2017). Kazemi-Bonchenari *et al.* (2017) concluded that poultry slaughterhouse waste has a considerable amount of essential amino acids, which can be used in ruminant nutrition has a huge potential as a cleaner product of animal feeding and prevention environmental pollution. Alternative feeding method may be helpful to utilize the innovative feeds and alternative protein feeds can contribute to ecological poultry production which has important function under certified organic standards (Fanatico *et al.*, 2018). Also, nutrient strategies should be integrated into total production systems so that animal production systems are environmentally safe as well as economically viable (Lu *et al.*, 2017).

Table 2. Possible strategies to prevent the food loss and waste (FLW) at different stages of food supply chain (FSC) (Ishangulyyev *et al.*, 2019)

Stage	Strategy
Production stage	Government investments in infrastructure
	Improve harvesting techniques
	Improve market access
	Organize extension services and educate farmers
	Increase tax incentives for donating unsellable edible foods
Handling and Storage Stage	Improve transportation facilities
	Provide access to cheap handling and storage technologies
	Invest in storage facilities (warehouse, cold storage, etc.)
	Improve the ability and knowledge of workers to employ safe food handling practice
	Use of appropriate and clean containers for the products
Processing and Packaging Stage	Improve capacity of process line
	Improve packaging to keep food fresher for longer
	Standardize date labels to prevent consumer confusion
	Establish other ways to use peels and trimmings
	Improve the knowledge and ability of workers
	Facilitate sanitary and cleaning inspections
	Improve inventory systems
	Establish online marketplaces to facilitate sale (donation) of perishable products
	Change food date labeling practices and in-store promotions
Distribution and Marketing Stage	Improve institutions related to this stage
	Improve transportation vehicles
	Provide guidance on storage and preparation of food to consumers
	Improve the knowledge and ability of workers
	Improve market places (storage, covered areas)
	Interlink with research institutions to predict consumer demand changes
Consumption Stage	Facilitate increased donation of unsold foods from cafeterias and restaurants
	Implement consumer education and campaigns, both nationally and regionally
	Reduced portion sizes
	Provide education about hone economics in education institutions and communities
	Involve women in food safe campaigns
	Effective use of leftovers
	Training for restaurant, cafeteria, and supermarket management to forecast customer demand and reflect demand in food purchasing to avoid bulk purchases
	Implement good storage practices
	Correctly interpret label dates
	Distribution of excess food to charitable groups

Increased information is required to remedy the public's lack of awareness and concern regarding waste issues (Minghua *et al.*, 2009). The barriers such as consumer and industry support, policy change and investment in food waste collection infrastructure should be overcome to use food waste in animal feed industry which may lead to substantial environmental and health benefits (Salemdeeb *et al.*, 2017). Truong et al. (2019) proposed that food waste, occurring in all sectors of the food supply chain, could become a partial substitute for corn and soy in broiler diets. Akankali and Nwafili (2015) reported that the use of organic waste provide not only cheap alternative source of fish feed but also eliminates the problems associated with indiscriminate dumping of organic waste in the environment because of the associated air, water and soil pollution, and proper utilization of organic waste can contribute significantly to increasing fish productivity by reducing feed cost; protect the environment and reduction of greenhouse gas emissions. Shurson (2020) concluded that the tremendous opportunity for nitrogen and phosphorus resource recovery along with several other environmental benefits from recycling food waste streams and rendered animal by-products into animal feed have not been fully appreciated for their substantial contribution toward solving the climate crisis. Poultry industry itself generates large amounts of waste, and three primary waste products are dissolved air flotation sludge, compost from dead birds and hatchery waste, and litter and manure from production facilities which can be converted to feed and fertilizers (Brandelli *et al.* 2015). Pourbayramian *et al.* (2021) identified potential applications of both potato wastes and rumen fluids; they have reported up to 78.8% digestion rates for potato waste and found that the solid parts of the fermentation mixture had the higher protein content. Tropical by-products proposed for silage for pig feedstuff are spent grain, banana stems, banana skin (ripe), rejected banana (ripe), cassava leaves, cassava roots, molasses, breadfruit (ripe fruit), taro leaves, taro roots, sweet potato (leaves), sweet potato (tuber), yam (leaves), yam (root, olive cake, olive leaves, grape marc, sugar beet pulp, tomato pulp, wheat bran, date palm fruit and citrus pulp. In 2016, the amount of waste agricultural and forestry fibers is 2.02 billion tons in China; among them, 1.078 billion tons belong to waste agricultural fibers and 0.924 billion tons belongs to waste forestry fibers, and the main five utilization of waste agricultural and forestry fiber are energy utilization mode, the second one is material utilization mode, the third one is fertilizer utilization mode, the fourth one is feed utilization mode, and the fifth one is the cultivation-based utilization mode (Yunjuan *et al.*, 2018). Wang *et al.* (2017) on the basis of primary data collected in 2016 from 100 villages across five provinces in China, reported that the proportion of villages with waste collection, waste transportation, and waste disposal services in 2015 is 80%, 55%, and 22%, respectively; and the differences in shares of villages with these services across provinces were statistically significant. They have proposed increase investments in waste collection facilities and worker services, encouraging local residents to classify and recycle waste; designing optimal waste transportation networks and routes; and improving on-site waste disposal technology. Zhou *et al.* (2017) reported that the adoption of resources use policy, industrial SO_2 emission, local environmental regulation, GDP per capita, population density and educational level also affect industrial solid waste disposal, and it is important for China to continue implementing solid waste disposal policies, upgrade current industrial systems, push forward economic and social reform and increase environmental education to boost the effectiveness of solid waste disposal for long-term sustainable development. National environmental protection plant is indicated in Table 3.

Table 3. National environmental protection plants (Zhou *et al.*, 2017)

Year	Solid Waste Policies and Plants
2003	The 11th Five-Year Plan (11th FYP)
2009	The 12th Five-Year Plan (12th FYP)
2009	National Total Emission Control (NTEC)
2011	National Environmental Protection "12th Five-Year Plan"
2015	Solid Waste Pollution Preventing and Control Law (Revised Version)

Public Awareness

The amount of agricultural organic and urban waste has increased steadily in China. Waste management also addresses the use of multidisciplinary approaches ranging from engineering, humanities, sociology and biology. Almasi *et al.* (2019) stated that females with academic education and public employment as well as young females with academic education and public employment as well as young females had a great knowledge and practice, while they had less satisfaction with the waste collection systems. Almasi *et al.* (2019) concluded that with more emphasis on educational aspects, especially through municipalities and by creating participatory and encouraging programs among the families and the municipality, it is possible to improve the practice of citizens by improving their knowledge, while taking effective steps for promoting the environmental activity.

Knickmeyer (2020) concluded that understanding social factors influencing household behavior is utmost importance; public education and specific communication highly contribute to improve recycling. Joshi and Visvanthan (2019) found that policies rather than technologies are driving food waste management efforts in Asia. Lang *et al.* (2020) reported that in Gansu province in China, 37.33% of respondents has a high awareness and 62.67% of them has a low awareness of food waste recycling, which shows owners have a low level of overall awareness, and compared with the male restaurant owner, the female one has a lower awareness, and the younger restaurant owner has a higher awareness than the older one. Lang *et al.* (2020) found that factors, including the educational level of restaurant owner, restaurant scale, amount of daily restaurant food waste, the way of food waste treatment, and the macroeconomic development of Gansu city where restaurants located, have positive impacts on the awareness.

Conclusions

The main agriculture productions of China are rice, wheat, corn, beans and potatoes, there are some livestock- sheep, pork and cattle and so on. The occurrence of agricultural wastes was incredible in different regions with various climatic conditions. The agricultural straw and livestock excrement are considered to be potential resources. Improper disposition of agricultural wastes not only result in environmental pollution, but also waste a lot of valuable biomass resources in different areas. The recycling and utilization of agricultural wastes are categorized as the important step in environmental protection, agricultural development and energy structure. But, the most important problem in recycling agricultural section in China impeded the achievement of scale ecological functions. China is a traditional agricultural country with notable amounts of poultry farms, crops and etc. With the development of agriculture in China, the productions of straw and livestock manure grow significantly. It lacks laws and regulations of agricultural wastes recycling. The agricultural wastes from rapid expansion of animal farms and mushroom industries as well as other agricultural industries enter the environment. Improper disposition of agricultural wastes both result in environmental pollution and also waste a lot of valuable biomass resources. However, the crucial resources characteristics, utilization technologies, influence factors and socio-economic assessment on agricultural waste utilization still remain unclear. The development mode and operation mechanism of agricultural waste recycling can be discussed and elaborated systematically. Meanwhile, the perspective of collaborative innovation can also be explored via farmers, technical departments, professional associations and property management. In modern agronomic process, the small-scale recycling utilization could not afford the amounts of agricultural waste produced rapidly. They have suggested building economy incentive standard, improving laws and regulations, and creating rural market strengthening medium and long-term plans of agricultural waste recycling. Also, the influencing factors on the recycling and utilization of agricultural wastes have become the difficult problem in most countries, and the recycling and utilization policy of agricultural wastes should be considered via government attention and investment. There are some treatment methods for straw waste: fertilize; solid befouls; feeding the livestock; building or paper material and straw ethanol or diesel.

When it comes to organic waste, the mainly agricultural organic waste is the animal manure; spoiled feed; fodder vegetable etc., agricultural organic waste cannot be used as fertilizer directly, and they also can pollute the air, soil and water if they do not be treated. But, if loading organic waste into special containers and overlaps the access of air, they can produce a valuable energy raw material biogas. The gas is discharged into the gas storage and can be used as fuel. The biogas slurry and biogas residue are high quality fertile for the soil, and they also contribute to the increase in yield of some crops. The technology and the special containers need a little higher cost and the fuel are cheaper for farmers and companies, so the biogas just be used in some region in China. The plastic waste is the most difficult for China. Every year, there are millions of plastic bottle, plastic bag and plastic film be used in agriculture industry, but there are very few recycle places and recycle companies for them.

As a result of rapid economic development coupled with the increasing urbanization and labor costs, the recycling rate of organic materials in Chinese agriculture has dramatically declined during the last two decades, in particular in the more developed eastern and southeastern provinces of China. Improper managing and storage of the organic wastes lead to severe air and water pollution. China has set goals for recycling farm waste such as crop stalks and plastic film, according to a policy document jointly released by the National Development and Reform Commission, Ministry of Agriculture. Biogas technology, which can help save on electrical costs, is too expensive for many farmers unless the government helps. Getting rid of animal waste is a major problem for livestock producers worldwide, especially because of the strong odor and damage caused to the atmosphere by the release of harmful gases. Another problem is run-off containing animal wastes can also seep into the water table, rivers and lakes. In China, how to better dispose of animal waste has become a particular problem due to the fast growth of poultry and hog farming over the past decade to meet demand for higher quality meat. China meets increasingly serious solid waste problems and has adopted various policies in response in recent years; meanwhile, few studies have investigated the performance of solid waste disposal through statistical analysis with empirical data. Composting is an aerobic proves under the thermophilic condition for transforming organic matter into nutrient-enriched compost; aeration and moisture content play a significant role in maintaining the thermophilic compost. Important factors that need to be considered for successful utilization of a food waste-based products are governmental framework, public participation, utilization of waste products, cost to process wastes, assessment of waste sources, and processing facilities. Setting national goals, awareness-raising campaigns, strict and appropriate regulation, stakeholder engagement, biorefinery and food waste recycling to animal feed are important strategies for better waste management. The most important food waste management practices in China are source separation, animal feed, rendering, composting, co-digestion, anaerobic digestion, incineration, landfill, and etc. Increase attitude towards food waste, awareness of food waste, and improve social norm on food waste, may lead to increase motivation to reduce and avoid food waste.

Authors' Contributions

All authors read and approved the final manuscript.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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