Original Research

Analysis of Total Organic Waste and Potential for Replacing Chemical Fertilizers in China

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Abstract

The quantity of organic waste produced in China is enormous, and knowing the present situation of the country's total amount of organic waste and its nutritional supplies is important for both resource use and environmental safety. In order to analyze the potential for the utilization of organic wastes and the carrying capacity of the land, the current total amount of organic waste and its nutrient resources in China were estimated by reviewing Chinese statistical data and published literature. The study's objective was the production of major organic wastes (straw, livestock and poultry manure, rural human waste, sludge, and domestic organic waste) in China in 2021. The findings indicated that in 2021, its total resource would be 11.61×10^8 t, and its nutritional content would be 4075.24×10^4 t. In 2021, the nutrient contents of N, P_2O_5 and K_2O in the total nutrient content of organic waste in China were 1571.43×10^4 t, 733.52×10^4 t and 1770.29×10^4 t, respectively. In 2021, the N nutrient content of China's organic waste accounted for 67.48% of the recommended N application, the P_2O_5 nutrient content accounted for 69.30% of the recommended phosphorus application, and the K_2O nutrient content accounted for 131.09% of the recommended potassium application. From the perspective of China's overall scale, China has a large space for carrying and consuming livestock and poultry manure. When calculating the land carrying capacity based on nitrogen, the land carrying capacity index of China was 0.23, and when calculating the land carrying capacity based on phosphorus, the land carrying capacity index of China was 0.54. In general, China has a massive amount of organic waste materials and nutrients, with plenty of room for use. The current magnitude of farming places a minor strain on the land carrying capacity of animal manure. If the nutrient resource structure of China's organic waste remains unchanged and the entire amount is returned to the field, the nitrogen, phosphorus, and potassium nutrients in organic waste can satisfy 67.48%, 69.30%, and 100% of the nutrient requirements of various types of crops, respectively.

Keywords: organic waste, nutrient resources, land carrying capacity

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Introduction

Organic waste is a category of organic materials that humans abandon throughout their daily living and producing activities [1]. The productivity of all sorts of organic waste in China is rising at a 5 to 10% yearly pace due to the ongoing improvement of people's living conditions and the steady expansion of industry and agriculture [2]. The amount of organic waste created in China is enormous; in 2009, the amount of straw generated from main crops in China was over 700×10^6 t [3]. In 2015, China created around 3.16×10^7 t of animal and poultry waste [4]. Furthermore, China generates around 9.00×10^8 tons of kitchen waste and 6.00×10^8 tons of sludge per year [5]. According to statistics, the globe presently generates roughly 2.01×10^7 t of residential garbage per year, and if current trends continue, the world will create about 3.40×10^7 t of domestic waste yearly by 2050 [6]. It has been demonstrated that agricultural surface pollution in the Yangtze River Basin accounts for more than 50% of nitrogen and phosphorus imports into Yangtze River waters [7]. Failure to properly dispose of the massive quantity of waste produced can substantially harm the environment, producing eutrophication of water bodies and acidification of soil [8], both of which have a negative impact on human health [9]. Among them, the complete management of straw and animal waste has emerged as a critical challenge for China's agricultural growth. The output of livestock and poultry manure has grown year by year, particularly with the large-scale expansion of the farming sector, and the land carrying capacity index in local regions has exceeded the environmental danger threshold. Organic waste resource treatment can not only successfully avoid environmental pollution, but also achieve the recycling of nutritional resources in organic waste, which is critical to China's agricultural green growth.

Because of expanding human food consumption, the usage of chemical fertilizers has increased significantly in recent years, and the phenomena of declining returns has been seen in some areas with high levels of fertilizer application [10, 11]. Excessive use of chemical fertilizers might add damage to environment [12]. Although China has decreased the use of chemical fertilizer by 10% as of 2019, the fertilizer situation remains stressful at this time due to the rapid growth in the price of chemical fertilizer and the expense of growing food in China [13]. It is critical to continue to promote the coordinated application of organic and inorganic fertilizers in order to reduce chemical fertilizer application by using organic fertilizers to nourish low and medium yielding fields and to improve fertilizer utilization efficiency [14]. Global research has proven that the resourceful use and harmless treatment of organic waste is an effective way to reduce the application of chemical fertilizers, improve the utilization rate of chemical fertilizers, control agricultural environmental pollution, and thus achieve agricultural sustainability [15]. Clarifying the potential of China's organic waste resource utilization promotes further rational allocation and use of various types of organic waste resources in China, while also providing theoretical data for the formulation of scientific and standardized development planning and a sound development system [15, 16]. In order to promote the use of organic waste resources, the amount of typical organic waste (straw, livestock and poultry manure, rural human urine, sludge, and domestic organic waste) generated in China in 2021 was estimated, and its potential for use and land carrying capacity were assessed.

Research Methods and Data Sources

Research Target

The production of straw, livestock and poultry manure, rural human faces and urine, sludge and domestic organic waste in China in 2021 was studied. Based on the China Statistical Yearbook, rice, wheat, maize, beans, potatoes, cotton, peanuts, oilseed rape, and sugarcane were selected as straw crops, and cattle (beef, dairy, and service cattle), horses, donkeys, mules, sheep, pigs, poultry, and rabbits were selected as livestock species. Crop straw coefficient, livestock and poultry rearing period, single head daily excretion, domestic sludge yield coefficient, average annual human excretion, rural per capita daily rubbish production, rural domestic waste organic ratio, urban per capita daily rubbish production, urban domestic waste organic ratio, organic waste nutrient content, water content, and other parameters were determined with reference to domestic and international research results [17-19], as shown in Table 1, Table 2 and Table 3.

Methods for Estimating Total Organic Waste Generation and Crop Nutrient Requirements

Straw from Major Crops in China

Straw yield is computed by dividing economic crop yield by straw yield (grain-to-straw ratio). Straw nutrient resources are determined using the following method based on the link between straw yield and straw nutrient content:

$$F_{t-dry} = \sum_i^n (C_i \times R_i)$$

$$F_{tN} = F_{t-dry} \times N_i$$

$$F_{tP_2O_5} = F_{t-dry} \times P_i \times 2.29$$

$$F_{tK_2O} = F_{t-dry} \times K_i \times 1.2$$

Where F_{t-dry} is the straw yield (t) (dry basis); C_i is the economic yield of the ith crop (t); R_i is the straw

Table 1. Straw coefficients and nutrient contents of major crops in China (dry basis).

Crop species	Straw coefficient	N/%	P/%	K/%
Rice	1.01	0.91	0.13	1.89
Wheat	1.37	0.65	0.08	1.05
Maize	1.10	0.92	0.15	1.18
Soybean	1.44	1.81	0.20	1.17
Potato	0.77	1.25	0.15	1.42
Cotton	3.10	1.24	0.15	1.02
Peanut	1.26	1.82	0.16	1.09
Rape	2.71	0.87	0.14	1.94
Sugarcane	0.10	1.10	0.14	1.10

Table 2 Feeding cycle, daily excretion of manure, nutrient content (fresh basis) and moisture content of various types of livestock and poultry [17, 18, 20].

Species	Feeding period/d	Excretion/(kg·d⁻¹)	N/%	P/%	K/%	Moisture content/%
Cow	365	36.56	0.38	0.10	0.23	75.0
Horse	365	10.20	0.44	0.13	0.38	68.5
Donkey	365	8.56	0.49	0.19	0.54	61.5
Mule	365	8.56	0.31	0.16	0.23	62.9
Sheep	365	2.00	1.01	0.22	0.53	50.7
Pig	180	2.44	0.55	0.25	0.30	68.7
Poultry	55	0.12	1.03	0.37	0.72	52.3
Rabbit	90	0.15	0.87	0.30	0.64	57.4

Table 3. Nutrient content (fresh basis) and water content of rural human farces, sludge and domestic organic waste [18].

Waste species	N/%	P/%	K/%	Water content/%
Human manure	0.64	0.11	0.19	90.3
Sludge	0.13	0.05	0.02	96.2
Domestic organic waste	0.28	0.12	1.07	28.9

coefficient of the ith crop (Table 1); F_{tN}, F_{tP2O5}, and F_{tK2O} denote the N, P, and K nutrient resources of the crop straws (t), respectively; and N_i, P_i, and K_i denote the ith straw N, P, and K nutrient contents (dry basis), respectively; 2.29 is the coefficient for the conversion of monomorphic phosphorus to P_2O_5, and 1.2 is the coefficient for the conversion of monomorphic potassium to K_2O.

Livestock and Poultry Manure

Livestock and poultry manure production and its nutrient resources are calculated with reference to the following formulae:

$$F_{m-fresh} = \sum_{i}^{n} Cd_i \times d_i \times h_i$$

$$F_{m-dry} = \sum_{i}^{n} Cd_i \times d_i \times h_i \times (1 - W_i)$$

$$F_{mN} = F_{m-fresh} \times N_i$$

$$F_{mP_2O_5} = F_{m-fresh} \times P_i \times 2.29$$

$$F_{mK_2O} = F_{m-fresh} \times K_i \times 1.2$$

Where, $F_{m-fresh}$ is the livestock and poultry manure production (t) (fresh basis); F_{m-dry} is the livestock

and poultry manure production (t) (dry basis); Cd_i is the number of livestock and poultry of the ith species (10×10^3); d_i is the daily excretion of livestock and poultry manure in the ith (kg/d); h_i is the feeding cycle of the ith species (d); W_i is the water content of the ith species of livestock and poultry manure; M_{mN}, M_{mP2O5}, M_{mK2O} denote the amount of N, P and K nutrient resources of livestock and poultry manure (t), respectively; N_i, P_i and K_i denote the N, P and K nutrient content of the ith species of livestock and poultry manure (fresh basis), respectively; 2.29 is the coefficient of conversion of monomorphic phosphorus to P_2O_5, and 1.2 is the coefficient of conversion of monomorphic potassium to K_2O.

Rural Human Farces and Urine

The volume of rural human farces and urine and its nutrient resources are calculated with reference to the following formula:

$$F_{u-fresh} = Y \times A$$

$$F_{u-dry} = F_{u-fresh} \times (1 - W)$$

$$F_{uN} = F_{u-fresh} \times N$$

$$F_{uP_2O_5} = F_{u-fresh} \times P_i \times 2.29$$

$$F_{uK_2O=}F_{u-fresh} \times K_i \times 1.2$$

Where $F_{u-fresh}$ is the volume of human farces and urine (t) (fresh basis); F_{u-dry} is the volume of human farces and urine (t) (dry basis); Y is the size of the rural population aged 14 years or older; A is the annual faucal and urinary excretion of adults (in terms of age greater than 14 years); W is the water content of rural human farces and urine; and F_{uN}, F_{uP2O5}, and F_{uK2O} denote the volume of the N, P, and K nutrient resources of human farces and urine (t), respectively; 2.29 is the coefficient of conversion of monomorphic phosphorus to P_2O_5, and 1.2 is the coefficient of conversion of monomorphic potassium to K_2O.

Sludge

Sludge production is in a proportional relationship with sewage treatment volume. Therefore, the empirical coefficient method was used in this study to estimate the domestic sludge production. The formula for calculating sludge production and its nutrient resources is as follows:

$$F_{s-fresh} = Z \times J \times 0.02\%$$

$$F_{s-dry} = F_{s-fresh} \times (1 - W)$$

$$F_{sN} = F_{s-fresh} \times N$$

$$F_{sP_2O_5} = F_{s-fresh} \times P_i \times 2.29$$

$$F_{sK_2O=}F_{s-fresh} \times K_i \times 1.2$$

Where $F_{s-fresh}$ is the amount of urban sludge generated (t, fresh basis); F_{s-dry} is the amount of urban sludge generated (t, dry basis); Z is the amount of urban domestic wastewater discharged; J is the urban domestic wastewater treatment rate (%); 0.02% is the coefficient of the domestic sludge generation rate; W is the sludge moisture content; F_{sN}, F_{sP2O5}, and F_{sK2O} denote the sludge's N, P, and K nutrient resources (t); 2.29 is the coefficient of conversion of monomorphic phosphorus to P_2O_5, and 1.2 is the coefficient of conversion of monomorphic potassium to K_2O.

Domestic Organic Waste

Domestic organic waste mainly consists of food waste, fruit peels, grasses and other easily decayed organic matter in the physical composition of domestic waste. In this study, the amount of organic waste and its nutrient content were estimated by the following equations:

$$F_{g-fresh} = 365 \times (P_T \times 1.03 \times 0.41\% + P_v \times 0.3 \times 0.15\%)$$

$$F_{g-dry} = F_{g-fresh} \times (1 - W)$$

$$F_{gN} = F_{g-fresh} \times N$$

$$F_{gP_2O_5} = F_{g-fresh} \times P_i \times 2.29$$

$$F_{gK_2O=}F_{g-fresh} \times K_i \times 1.2$$

Where $F_{g-fresh}$ is the amount of domestic organic waste generated (t, fresh basis); F_{g-dry} is the amount of domestic organic waste generated (t, dry basis); P_T is the number of people in the city (person), 1.03 is the urban per capita waste production rate [kg/(person·d)], and 0.41% is the organic content in urban waste (%); P_v is the number of people in the countryside (person), 0.3 is the rural per capita P_v is the rural population (people), 0.3 is the rural per capita waste production rate [kg/(person·d)], and 0.15% is the organic matter content in rural waste (%); W is the water content of domestic waste; F_{gN}, F_{gP2O5}, and F_{gK2O} denote the amount of N, P, and K nutrient resources in domestic waste (t), respectively; 2.29 is the coefficient of conversion of monomorphic phosphorus to P_2O_5, and

Table 4. Total organic waste resources (dry basis) and their total nutrient resources (×104 t⁴).

Species	Total resources	Total nutrients	Total N	Total P	Total K
Straw	75885.86	2171.97	697.25	227.26	1247.47
Livestock and poultry manure	35305.96	1457.44	620.49	405.69	431.26
Rural human farces	3816.92	440.68	251.84	99.12	89.72
Sludge	42.34	2.99	1.45	1.28	0.27
Domestic organic waste	1048.05	2.17	0.41	0.18	1.58
Total	116099.14	4075.24	1571.43	733.52	1770.292

1.2 is the coefficient of conversion of monomorphic potassium to K_2O.

Crop Nutrient Requirements

The formula is as follows:

$$F_{nN} = Q \times N_{iN}$$

$$F_{nP_2O_5} = Q \times N_{iP_2O_5}$$

$$F_{nK_2O} = Q \times N_{iK_2O}$$

Where F_{gN}, F_{gP2O5}, and F_{gK2O} are the crop N, P, K nutrient requirements (10×10^3 t); Q is the sown area of the crop ($\times10^3$ hm²); N_{iN}, N_{iP2O5}, N_{iK2O} are the recommended application of N, P, K for the crop (kg/hm²).

Estimation of Land Carrying Capacity for Livestock and Poultry Manure

Land carrying capacity is the maximum amount of livestock and poultry raised in the region based on crop nutrient demand, which is calculated from the maximum amount of livestock and poultry raised per unit area of different crops in relation to the planted area. Livestock and poultry manure nutrient requirements for different crops and maximum livestock and poultry farming per unit area for different crops were calculated as follows:

$$F_f = \frac{(F_i \times FP \times MP)}{MR}$$

$$R_i = \frac{F_f}{q}$$

Where F_f is the nutrient demand for livestock and poultry manure compost for different crops (t); R_i is the maximum amount of livestock and poultry breeding per unit area for different crops (pig equivalent/hm²), i.e., the total amount of various types of livestock and poultry reared per unit area converted into pig equivalent. Pig equivalent: 100 pigs are equivalent to 15 dairy cows, 30 beef cows, 250 sheep and 2500 poultry. q is the nutrient supply per unit of pig equivalent (nitrogen nutrient supply of 7.0 kg and phosphorus supply of 1.2 kg) in the case that all manure produced by livestock and poultry is utilized on-site; F_i is the nitrogen and phosphorus nutrient requirement of different crops (t); FP is the proportion of nutrients supplied by fertilizer to the total nutrient requirement of the crop (%). The proportion of nutrients supplied by fertilizer varies according to soil geography and was set at 45%; MP is the proportion of nutrients supplied by livestock and poultry manure to the total amount of fertilizer applied (%), which was calculated at 50%; MR is the seasonal utilization efficiency of livestock and poultry manure (%), and the seasonal utilization rate of nitrogen and phosphorus from livestock and poultry manure was calculated at 25% and 30%, respectively.

Data Sources

Data on crop production, sown area, rural population size, and urban population size were obtained from China Statistical Yearbook 2022 [21]; data on livestock and poultry output and stock were obtained from China Rural Statistical Yearbook 2022 [22]; data on wastewater discharge were obtained from China Environmental Statistical Yearbook 2022 [23]; and fertilizer application was obtained from China Statistical Yearbook 2023 [21].

Results

Total Organic Waste and Nutrient Resources

After removing the water from various organic wastes, it can be seen that straw and livestock and poultry manure are still the main components of organic waste in China at present, accounting for 65.36% and 30.41% of the total organic waste resources, respectively. Correspondingly, their total nutrients are also higher among all organic wastes, accounting for 53.30% and 35.76%, respectively. In terms of the content of different nutrients, the total amount of N and K of straw were among the highest values of all types of organic wastes. Especially, the total K of straw was as high as 1247.47×10^4 t, which was nearly three times of the total K of livestock and poultry manure. The total P

Table 5. Planted area, optimal fertilizer application and nutrient requirement [24] of major crops in China in 2021.

| Species	Planted area (×10⁹/hm²)	Optimal fertilizer application (kg/hm²)			Nutrient requirement (×10⁴t)		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
Rice	29.45	180.2	67.9	109.9	530.69	199.97	323.66
Wheat	23.52	162.9	79.4	86.5	383.14	186.75	203.45
Maize	43.07	213.7	83	103.1	920.41	357.48	444.05
Soybean	10.12	75.5	74	59.9	76.41	74.89	60.62
Potato	7.33	169	95	174.8	123.93	69.67	128.19
Cotton	3.00	259.5	164	120	77.85	49.20	3.60
Peanut	4.81	124.6	94.7	118.5	59.87	45.51	56.94
Rape	6.99	175.4	88.7	98.2	122.63	62.02	68.66
Sugarcane	1.32	258.2	98.7	219.8	33.98	12.99	28.93
Total	129.61	-	-	-	2328.92	1058.47	1350.49
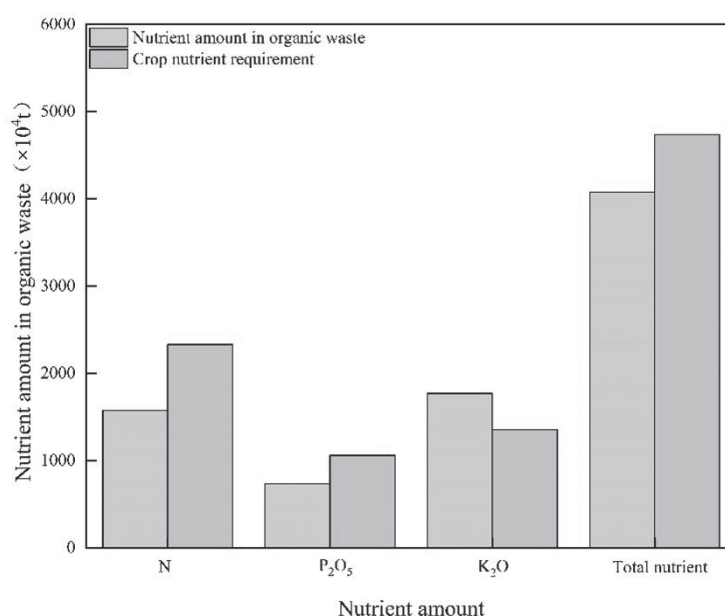
Fig. 1. Comparison of nutrient content of organic waste with crop nutrient requirement.

of livestock and poultry manure was higher than that of straw, reaching $405.69×10^4$ t. In terms of the ratio of total nutrients to total resources, straw is 2.86%, livestock and poultry manure is 4.13%, rural human urine is 11.55%, municipal sludge is 7.06% and domestic organic waste is 0.21%. It is clear that rural human farces and urine and municipal sludge have the highest percentage of nutrients available in them, although the total amount of resources is relatively small.

Potential for Organic Waste to Replace Chemical Fertilizers

Table 5 lists the planted area, optimal fertilizer application and nutrient requirement for major crops in China in 2021. It can be seen that the current demand for nitrogen fertilizer for major crops in China is still the highest, followed by potash and phosphate fertilizers. The relationship between the total amount of nutrients provided by organic waste and the total crop nutrient requirement in China can be seen more directly in Fig. 1. In general, the total amount of nutrients that can be provided by organic waste in China is $4075.24×10^4$t, which is lower than the nutrient requirement of China's major crops, which is $4737.88×10^4$t, and there is still a 113.99% shortfall in relation to the requirement. In terms of specific nutrients, the N content and P content available from organic waste in China are both significantly lower than the N and P requirements of major crops, but are sufficient to meet the K requirement.

Table 6. Nitrogen and phosphorus land carrying capacity of poultry and livestock manure and land carrying capacity index in China.

Nutrient	Ff	Q	R	I
N	11.82	2.42	48.92	0.23
P	2.29	1.10	20.84	0.54

Land Carrying Capacity for Livestock and Poultry Manure

The current amount of livestock and poultry breeding in China converted to pig equivalent is 11.19×10^8 pig equivalent. When calculating the land carrying capacity based on nitrogen, the scale of livestock and poultry breeding that China can accommodate is 48.92×10^8 t pig equivalent. When calculating the land carrying capacity based on phosphorus, the scale of livestock and poultry breeding that can be accommodated in China is 20.84×10^8 t pig equivalent. At the regional scale, China has a large space for carrying and consuming livestock and poultry manure. When calculating land carrying capacity based on nitrogen, China's land carrying capacity index is 0.23, while when calculating land carrying capacity based on phosphorus, China's land carrying capacity index is 0.54.

Discussion

At present, there have been more studies on the estimation of the amount of organic waste generated and nutrients in China, but there are some gaps in the calculation results between different researchers. However, all of them proved that the amount of organic waste production and nutrients in China is huge. The main reason for the difference is the different forms of dry and wet weight presentation of the total amount of waste in the estimation of each researcher, as well as the different scope of the selected research object and the difference in the selection of coefficients, such as: the coefficient of straw, the coefficient of livestock and poultry excreta, the feeding cycle, the content of nutrients, etc., which led to the large differences in the estimation of the amount of straw, livestock and poultry farces, and other organic wastes and nutrients produced by the researcher.

Organic waste is rich in nitrogen, phosphorus, potassium and other nutrient resources, if it can be reasonably returned to the field for resource use, it will greatly reduce the application of chemical fertilizer. If livestock and poultry manure can completely achieve fertilizer use, the fertilizer replacement rate of nutrients in livestock and poultry manure will be more than 60% [25]. At present, different types of organic waste in China have different potential and contribution to return to the field [26]. The fertilization of straw is divided into two forms: direct return to the field and processing of commercial organic fertilizer [27, 28]. According to

data, the rate of direct straw return to the field in China in 2016 was 61.27%, with the nutrient amounts of straw directly returned to the field being 7.06×10^7 t of N, 8.70×10^5 t of P_2O_5, and 9.09×10^7 t of K_2O [24]. Methods of fertilizing livestock and poultry manure mostly include direct return to the field, composting return to the field, manufacturing of bio-organic fertilizers, and ash return to the field following burning [29]. The return of livestock and poultry dung to the field delivers a significant amount of nitrogen, phosphorous, and potassium nutrients to the agriculture [29, 30]. The amount of sludge created in China's sewage treatment sector is increasing year by year, yet the current state of sludge use is concerning [31]. According to statistics, the land utilization rate of sludge in China is only 44.8%, and there is still a lot of sludge being piled up randomly, resulting in resource waste, and due to the high content of heavy metals in the sludge itself, it is currently primarily used for gardening and greening applications [24]. Prior to 1980, the combination of farming and raising was relatively close in China, and most rural human feces and urine were returned to the field for use, but as urbanization and population transfer to cities and towns accelerated, the amount of human feces and urine returned to the field gradually decreased. The Measures for the Management of Rural Toilet Conversion (Trial) improved the amount of human feces and urine collected, the degree of harmlessness, and the possibility for returning human feces and urine to the field. The total amount of nitrogen, phosphorus, and potassium nutrients in organic waste can satisfy 71.8% of the N, 75.9% of the P_2O_5, and 100% of the K_2O for each type of nutrient requirement of the crop, according to this study, if the nutrient resource structure of organic waste in China remains unchanged and the full amount of organic waste is returned to the field. Although organic waste has a high nutritional potential, the nitrogen, phosphorus, and potassium nutrients in organic waste cannot be entirely absorbed by crops. At the same time, some nutrient losses (such as NH_3 volatilization, etc.) will occur during the process of organic waste fertilizer treatment, and it is still not possible to achieve the complete cycle of nutrients between organic waste and crops by relying solely on the return of organic waste to the field. As a result, as long as the soil nutrient level remains constant, chemical fertilizers must be used in conjunction with organic fertilizers. Only 38% of the nutrients in our farmland are now derived from organic fertilizers [32], and when compared to Denmark, where 70% of the nitrogen nutrients in farmland are derived from organic fertilizers [33], China's level of organic

waste utilization remains low. Ji et al. [34] shown that composting organic waste into organic fertilizer reduces the global warming potential, eutrophication potential, and environmental acidification potential by 17.5%, 52.9%, and 62.6%, respectively. Furthermore, increasing the use of organic fertilizer can indirectly reduce carbon emissions caused by the production and application of chemical fertilizers. It is estimated that the average carbon emission coefficients of Nitrogen, Phosphorus, and Potassium fertilizers in China are 2.116 t CE/t (N), 0.636 t CE/t (P_2O_5), and 0.180 t CE/t (K_2O), which are 1.6 times the average level of foreign countries (N), 3.2 times the average level of P_2O_5, and 1.2 times the average level of K_2O [35]. Furthermore, long-term organic fertilizer application not only sustains crop yields, but also enhances soil carbon sequestration and increases soil organic carbon content [36]. As a result, increasing the rate of organic waste utilization and minimizing fertilizer application are significant implementation pathways to attain carbon peak and carbon neutrality. However, China currently lacks scientific guidance on the structure and quantity of fertilizer applied to farmland, chemical and organic fertilizer application is disjointed, and in some areas, problems such as high fertilizer application, low fertilizer efficiency, improper fertilizer rationing and layout limit the efficient use of nutrient resources [32]. Simultaneously, issues such as long-distance shipping raise the expense of applying organic fertilizer and diminish the incentive to use organic fertilizer in the plantation business. To address the issue of increased organic fertilizer application costs owing to disparities in geographical and temporal dispersion of commercial organic fertilizer, the industrial layout should be optimized to support the process of resourceful use of organic waste.

Conclusions

The overall amount of organic waste materials and nutrients available in China is enormous, with ample room for usage, and the current size of farming places less strain on the soil carrying capacity of animal manure. If the nutrient resource structure of China's organic waste remains unchanged and the entire amount is returned to the field, the N, P_2O_5, and K_2O nutrients in organic waste can satisfy 67.48%, 69.30%, and 100% of the nutrient requirements of various types of crops, respectively.

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Conflict of Interest

The authors declare no conflict of interest.

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