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The Demand & Supply Balance Analysis for Organic Matter of the Agricultural Waste in Yongcheng City

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Taking the 6 townships and 23 towns in the administrative areas of Yongcheng as objects of study, this paper evaluates the resources quantity of organic matter (OM) in the agricultural wastes (straws and livestock/poultry excrements) and the OM demands for the arable soil in the studies area respectively, and also make discussion of the demand-supply ratio of OM for every object of study. The study result shows that the demand-supply ratio for every object is lower than 1.0. In 2013, the OM resources of the total straws in Yongcheng city reached about 1,007,600 tons, and the OM resources of livestock excrements was about 407,500 tons, both added together to 1,415,100 tons of OM in total; the OM demands of for the whole arable soil in these areas were about 1,146,600 tons; therefore, the demand-supply ratio was about 0.81. With demands below supply, in theory, the agricultural organic wastes cannot be fully utilized into the arable soil in these areas.

1. Introduction

China is a big agricultural country, and also has the most agricultural wastes in the world, mainly including straws and livestock/poultry excrements etc. The preliminary estimates show that the annual outputs of agricultural wastes in China reaches 3.9 billion tons: livestock excrement 2.6 billion tons, crop straws 0.7 billion tons, vegetable wastes 0.1 billion tons, household wastes 0.25 billon tons and others 0.25 billion tons (Qin and Liu, 2015). The agricultural waste is the inevitable by-product with the agricultural development. Recently, following the constant development of Chinese agriculture, the agricultural wastes have also been increasing, also leading to resources waste and producing serious negative effects on the environment, with undeveloped disposal technology and lower efficiency/utilization etc (Jiang, 2013; Zhang and Gao, 2004). Henan Province was the main agricultural production area in China (Zhang et al., 2013) with huge outputs of agricultural organic wastes. The straws output of different crops in Henan made up about 11% in China (Yuan, 2013), while the annual yield of all livestock excrements occupied about 17.5% in China (Lin et al., 2012), respectively ranking the first among the Chinese provinces and cities (Zhu et al.,2015). However, the agricultural organic waste compost in Henan province hasn't been utilized effectively (Shen et al., 2007). The land restoration of agricultural organic wastes can not only release the environment pressure, but also promote the resource recycling (Mouri and Aisaki; Liu et al., 2015). Then with the territorial area as unit, the demand-supply balance analysis for agricultural organic waste resources shall be the basis for improving the effective utilization (Zhou, 2011), therefore, it is very necessary to study how much organic matter (OM) can be provided in this studied area and whether the organic matter can be utilized into the arable soils in this area etc.

2. Study method

In this study, it was supposed that the OM in agricultural organic wastes (straws and livestock excrements) would be utilized in the arable soils in Yongcheng. Take the 6 townships and 23 town as the objects of study in Yongcheng administrative areas, including the townships: Huangkou, Xinqiao, Shuangqiao, Tiaohe, Chengxiang and Chenguanzhuang, and the towns: Chengguan, Houling, Zanyang, Mamu, Wangji, Liuhe, Mangshan, Gaozhuang, Shibali, Xuehu, Maqiao, Peiqiao, Chenji, Jiangkou, Zancheng, Shunhe, Wolong, Taiqiu, Lizhai, Longgang, Miaoqiao, Huicun, and Yanji. In every studied area, the OM resource quantity in the agricultural wastes was calculated respectively, the evaluation was made for the OM demands for the arable soil, and the quantitative analysis was conducted for the demand-supply balance of organic matters and its agricultural availability, which could provide scientific basis for the resource utilization of agricultural organic wastes in these areas.

3. Organic matter resources and demands calculation

3.1 Organic matter resources calculation

3.1.1 Resources calculation for organic matters in crop straws

Based on formula (1) and (2), calculate the OM resource quantity in crop straws. In formula (1), multiply the harvest yield Uij by the genetic coefficient of crop straws Sj (output of straws/harvest yield), to get the straw outputs Wij. In formula (2), multiply the straw outputs Wij by the OM percentage in all kinds of crop straws (organic matter weight/straw weight), to obtain the OM resource quantity in straws:

$$W_{ij} = U_{ij} \times S_j \tag{1}$$

Where:
W_{ij}: Straw output (t/year)
U_{ij}: Harvest yield of all kinds of crops (t/year)
S_j: Genetic coefficient of all straws
J: All kinds of crops
I: Every object of study

$$B_{ij} = W_{ij} \times V_j \tag{2}$$

Where:
Bij: OM resource quantity in straws (t/year)
Wij: Straw outputs (t/year)
V_j: OM percentage in all straws
J: All kinds of crops
I: Every object of study

The harvest yields of all kinds of crops in the studied area were based on the Statistical Yearbook of Kaifeng City (Yongcheng is subordinate to Kaifeng, Henan province). Based on the literature (Guo, 2013; Gao et al., 2009; Cui et al., 2008), the calculation for the straw genetic coefficient and OM percentage of all straws was made as shown in Table 1:

Table 1: Genetic coefficient and OM percentage in all crop straws

Crop	Wheat	Corn	Beans	Sweet potato	Peanut	Cotton	Sesame	Rape
Straw genetic coefficient	1.1	1.2	1.6	0.5	0.8	3	2	1.5
Percentage of organic matter (%)	64.24	70.25	71.43	56.53	67.1	50	50	69.59

3.1.2 Resource calculation for organic matter in livestock excrement

Based on formula (3), calculate the OM resource quantity in livestock excrements. Multiply the number of livestock in the areas *Tij* by the daily excrements of every livestock *H_j* of all livestock excrements, and then multiply by the number of breeding days, to obtain the excrement quantity; multiply the excrement quantity by the OM percentage *E_j* in excrements (organic matter weight/livestock excrements weight), to gain the OM resource quantity in excrements *Dij.*

$$D_{ij} = (T_{ij} \times H_j \times 365) E_{ij} \tag{3}$$

Where:
Dij: OM resource quantity in livestock excrements (t/year)
Tij: Number of all livestock in every area
H_j: Daily excrements for every livestock (kg/day)
E_j: OM percentage in the livestock excrements
J: All kinds of livestock and poultry
I: All objects of study

The number of all livestock and poultry in the studied areas were based on the Statistical Yearbook of Kaifeng City (Yongcheng is subordinate to Kaifeng, Henan province). Based on the literature (Bai and Ma, 2010; Peng and Wang, 2004), the calculation for the daily excrement of every livestock (Wang et al.,2006; Zhang et al., 2007) and the OM percentage in all livestock and poultry has been made as shown in Table 2:

Table 2: Daily excrement of every livestock and the OM percentage in all livestock and poultry

Species	Beef	Cow	Horse	Donkey	Mule	pig	Sheep	Poultry	Rabbit
Daily excrement of every livestock (kg/day)	18.0	45.5	9.47	5.59	5.59	3.3	2.1	0.13	0.16
OM percentage (%)	17.95	17.95	20.63	22.85	14.14	23.72	32.51	28.47	26.31

3.2 Organic matter demands for arable soils

Based on Formula (4) and (5), calculate the OM demands for arable soils. Suppose C as the OM quantity of soil, M as the application amount of organic matter (Kg/mu per year) (mu, a unit of area, =0.0667 hectares), t as time (year), and b as the mineralization rate, and then the OM in soil can be indicated in formula (4); make integrals for formula 4 to obtain the OM quantity of soil C as shown in Figure 5:

$$\frac{dc}{dt} = M \quad bc \tag{4}$$

$$C = \frac{M}{b} \quad \frac{M}{b} \quad C_0 \, e^{\;bt} \tag{5}$$

Where C_0 means the initial OM quantity of soil, and 150,000 Kg/mu is OM quantity of soil of the 20cm arable layer(An and Wang, 2010):

C_0= soil OM content (%)×150000Kg/mu

Yongcheng is mainly covered with the moisture soil and Shajiang black soil. The literature showed that the average of the OM content in these two types of soil was 1.1%, with lower OM content of soil and lower soil mineralization rate; the calculation in this literature was based on the average value 1.5%(Zhang, 2014). Supposing that it needs ten years to increase the average OM content of soil from 1.1% to about 4.0%, based on formula (5), it can be calculated that about 493.2kg OM quantity of soil per mu every year is needed, and in ten years, the average OM content in soil could increase from 1.1% to 4.0%.

4. Demand-supply balance analysis of organic matter

The analysis was based on the formula of OM resource quantity in the agricultural organic wastes and the formula of OM demands for arable soil. In 2013, the OM resources of the total straws in Yongcheng reached about 1,007,600 tons, and the OM resources of livestock excrements was about 407,500 tons, both added together to 1,415,100 tons of organic matter in total; the OM demands for the whole arable soil in these areas was about 1,146,600 tons; therefore, the demand-supply ratio was about 0.81. With demands below supply quantity, in theory, the agricultural organic wastes cannot be fully utilized into the arable soil in these areas. For the OM demands for soil and OM resources quantity for the 6 townships and 23 towns as the objects of study, refer to the calculation results in Figure 1.

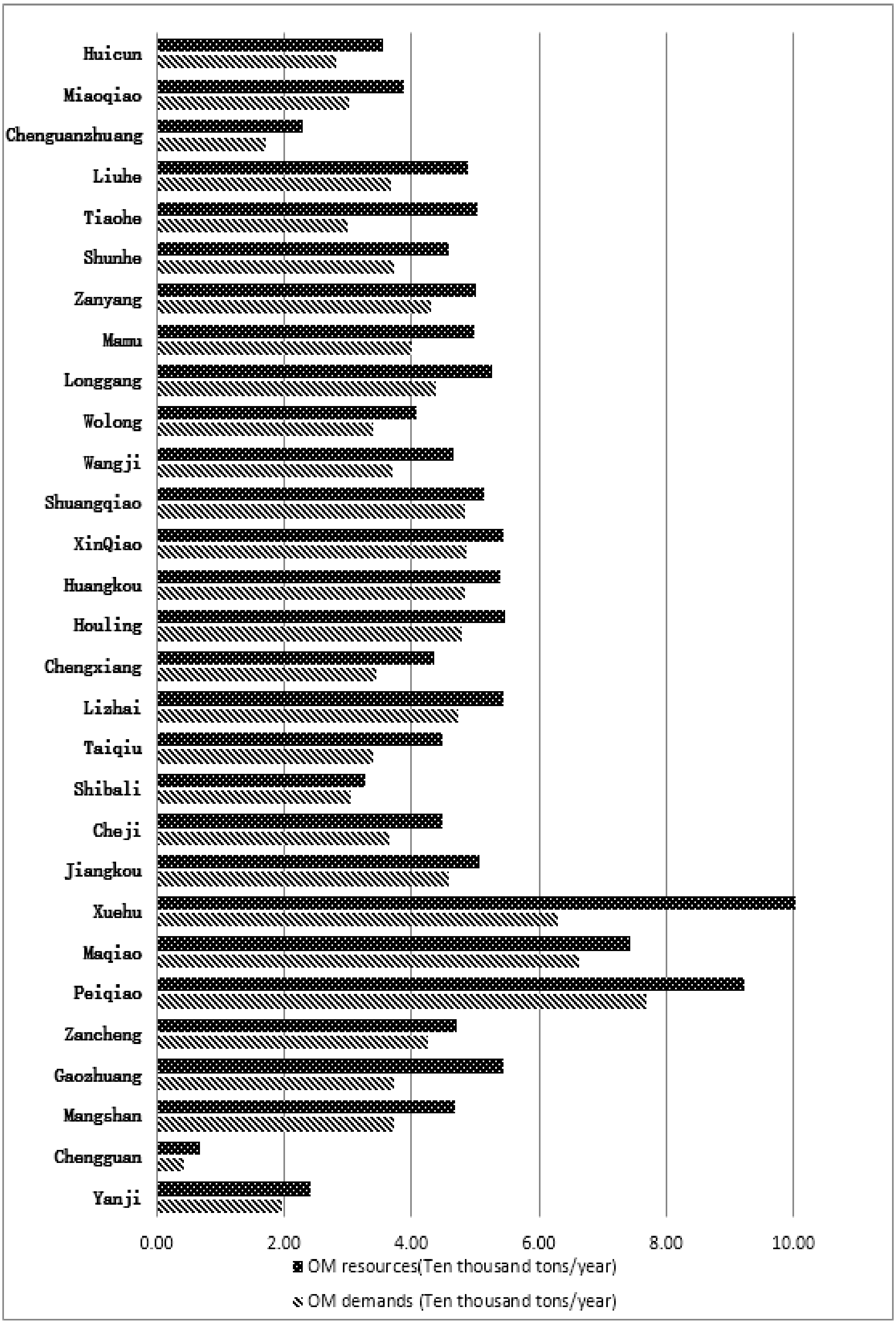

Figure 1: OM demands in soils and OM resources in the studies areas (Ten thousand tons/year) (2013)

Figure 1 shows, the OM demands for soil is less than the OM resources quantity in the studied areas, all presenting the supply over demand. In Shuangqiao town, with the highest demand-supply ratio about 0.95, the breeding industry and crop production in this area developed in the relatively balanced trend, which achieved the result that the OM resources produced by the agricultural organic wastes were slightly higher than demands. In Chengguan town, with the lowest demand-supply ratio about 0.62, close to the city, the industry played a key role with more density of population and less arable soil, therefore, there were less OM demands in this area. The study indicates that due to the difference in geographical location and industrial structure, the demand-supply ratio of organic matter in the studied areas vary to some extent.

5. Conclusion

This paper aims to promote the resource utilization of organic matters in the agricultural organic wastes, calculate the OM demands for the arable soil and the OM resources quantity by the agricultural organic wastes in every studied area, and analyse the demand-supply balance of OM resources in the local wastes. Suppose that the OM resource utilization of the agricultural organic wastes in Yongcheng is made: taking the 6 townships and 23 towns in the administrative areas of Yongcheng as objects of study, the calculation has been made for the OM demands for soil and the OM resources by the agricultural organic waste, and the quantitative analysis of demand-supply ratio also has been conducted. Refer to the study results as follows:

1) In 2013, the OM resources of the total straws in Yongcheng city reached about 1,007,600 tons, and the OM resources of livestock excrements was about 407,500 tons, both added together to 1,415,100 tons of OM in total; the OM demands of for the whole arable soil in these areas were about 1,146,600 tons; therefore, the demand-supply ratio was about 0.81. With demands below supply, in theory, the agricultural organic wastes cannot be fully utilized into the arable soil in these areas.

2) The OM demands for soil is below the OM resources in the studied areas, all presenting the status of supply over demand.

3) The demand-supply ratios in all the studied areas are less than 1.0 inordinately. Due to the difference in geographical location and industrial structure, the demand-supply ratio of organic matter in the studied areas vary to some extent.

This study shall provide scientific basis for the OM resource utilization of the agricultural organic wastes in the studied areas, and also become the foundation for improving wide-area effective utilization of agricultural organic waste in future. Therefore, for improving the resource utilization of agricultural organic waste, it will be important to study the effective utilization etc. by transferring the excessive OM resources to the insufficient areas.

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