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Analysis on Supply-demand Balance of Compost from Agricultural Organic Wastes in Henan Province, China

Qingsheng Zhou*[a], Yao Wang [b], Yichuan Zhang [b], Xinzheng Li [b]

[a]School of Resource and Environment, Henan Institute of Science and Technology, Xinxiang 453003, China
[b] School of Horticulture and Landscape Architecture, Henan Institute of Science and Technology, Xinxiang 453003, China
aid1166zhou@163.com

In this study, eighteen prefecture-level cities in China's Henan province are divided into 5 compost utilization regions based on geographical adjacency and similarity in agricultural production. Then, the author calculated the potential demand of compost in agriculture and the potential compost supply from agricultural organic wastes (straw and livestock manure), and carried out an in-depth supply and demand analysis. The results show that the overall compost demand-supply ratio in Henan is around 1.21, indicating that the supply falls short of demand. This means all the organic wastes of Henan are utilized in agriculture of this region. In addition, the livestock mature-based compost differs greatly from straw-based compost in the ratio of potential supply, owing to the differences in geographical location and agricultural production. There are also large fluctuations in the supply-demand ratio in compost utilization region.

1. Introduction

Resourcization of organic wastes is an important strategy in cyclic agriculture (Zhu et al. 2015, Xing 2016). The returning of farmland to organic wastes composting both alleviates environmental pressure, and promotes cyclic use of resources (Mouri and Aisaki 2015, Liu et al. 2015, Zhang et al., 2016). Despite being the largest producer of agricultural organic wastes in China (Yuan 2013, Lin et al., 2012), Henan Province fails to achieve scientific use of compost produced from organic wastes (Shen et al., 2007, Zhang et al., 2016). For better use of organic waste-based compost, it is necessary to adopt state-of-art composting techniques, and investigate compost supply and demand and its economic use (Aramaki et al., 2001, Guo et al., 2016). In recent years, studies on composting techniques (Ye et al., 2014, Yang et al., 2016, Yang et al., 2015) and pollution treatment (Zhang and Gao 2004, Mahar et al. 2016) for organic wastes in China have entered international frontiers. In view of the high labour-cost of organic wastes composting and the constraints of moving range and local conditions (Tanikawa et al., 2006, Archambault et al., 2016), the potential supply and demand of organic waste-based compost in a certain region should be analysed to ensure the scientific utilization of resources. It is particularly important to discuss the supply-demand balance of organic waste-based compost and examine the utilization strategies, because no research has been conducted on this issue in Henan Province.

2. Methodology

It is assumed that the resourcization of compost mainly relies on agricultural organic wastes like straw and livestock manure. The 18 prefecture-level cities in Henan were grouped into 5 compost utilization regions based on geographical adjacency and similarity in agricultural production. The 5 regions are respectively called eastern, western, southern, northern, and central Henan.
The author calculated the theoretical maximum demand of compost for agricultural production (i.e. the potential demand) in each region, estimated the organic waste output of straw and livestock manure through investigation, and converted the estimated output to the theoretical maximum supply of compost (i.e. the potential supply). Based on these data, the supply-demand balance of compost was quantitatively analysed on three levels: Henan province, utilization region, and prefecture-level city. The possibility of agricultural

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utilization was also discussed. The purpose is to provide a scientific reference for the use of organic waste-based compost in each region. The research flow is shown in Figure 1.

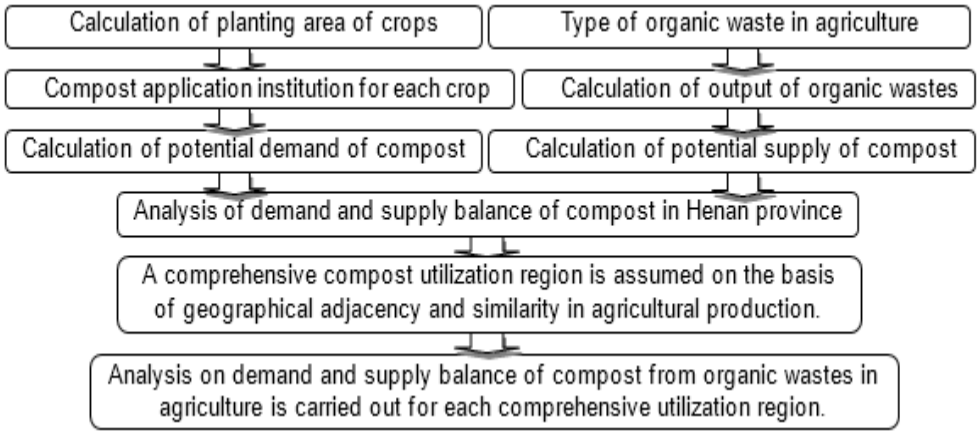

Figure 1: Flow of analysis on supply and demand balance of compost from organic wastes in agriculture of Henan

3. Reckoning of potential demand and potential compost supply in the utilization regions

3.1 Potential compost demand

The potential compost demand of crops was calculated based on the cultivated area of crops and the application standards (i.e. the original fertilization unit) of compost. The potential compost demand of the utilization regions is calculated by formula (1):

$$D_i = A_i \times B_n \quad (1)$$

Where:

D_i: potential compost demand (t/year); A_i: cultivated area of crops (ha); B_n: original fertilization unit of crops (t/ha) Genetic coefficient of all straws; n: crops; i: regions.

The cultivated area of crops A in the utilization regions was extracted from The Statistical Yearbook of Henan Province (NBS Henan Survey Team, 2013). The compost demand varies from crop to crop. The original fertilization unit of crops B was obtained from Zhou's research (2011), as shown in Table 1

Table 1: Original fertilization unit of crops (wet basis) (t/ha)

Crop Species	The Summer Crops	The Autumn Crops	Oil Crops	Fruit Trees	Vegetables	Cotton	Chinese herbs	Others
Application Unit	10	10	15	20	20	15	20	20

3.2 Potential supply of livestock manure-based compost

The annual occurrence quantity of fresh livestock manure is the product of the number of livestocks in each region Tij, the daily occurrence quantity of livestock manure Sj (i.e. the original unit), and the annual number of raising days. In accordance with national standards, the fresh manure should be transformed into compost via fermenting and drying. The transformation is a weight loss process. Here, the weight ratio of compost to fresh manure is defined as the composting rate. The composting rate is different from one livestock to another, as the water content varies in fresh manure. The potential supply of livestock manure-based compost in a utilization region Hij can be obtained by multiplying the annual occurrence quantity of fresh livestock manure by the composting rate of livestock manure Ej:

$$H_{ij} = (T_{ij} \times S_j \times 365) E_j \quad (2)$$

Where:

H_{ij}: the potential supply of livestock manure-based compost (t/year); T_{ij}: the number of livestock in the utilization region; S_j: the original occurrence unit of livestock manure (kg/day); E_j: the composting rate of livestock manure; j: livestock; i: regions.

The number of different livestock in the utilization regions was obtained from The Statistical Yearbook of Henan Province (NBS Henan Survey Team 2013), the original occurrence unit of livestock manure was acquired from the research of Bai and Ma (2010), the composting rate of livestock manure was calculated based on the findings of Zhou et al., (2010). Table 2 shows the original occurrence unit and the composting rate of livestock manure.

Table 2: The original occurrence unit and the composting rate of livestock manures

Livestock Species	Dairy Cattle	Beef Cattle	Horse, Donkey and Mule	Pig	Sheep	Rabbit	Chicken
Original Occurrence (kg/day)	45	20	14	3	1.7	0.15	0.14
Composting Rate (%)	40	40	40	40	60	60	60

*Composting Rate: the rate of converting fresh livestock manures into composts (the weight of livestock manure composts/the weight of fresh livestock manures)*100%

3.3 Potential supply of straw-based compost

During the harvest season, the water content of straw is so low as to meet the standard of compost. Hence, the straw can be directly used as compost. The potential supply of straw-based compost Pij can be obtained by multiplying the harvest yield of crop Uij with the occurrence coefficient of crop straw Vj (the occurrence quantity of straw/the harvest yield of crop):

$$P_{ij}:=U_{ij}\times V_j \quad (3)$$

Where:
P_{ij}: the potential supply of straw compost (t/year); U_{ij}: the harvest yield of crop (t/year); V_j: the occurrence coefficient of straw; j: crops; i: regions.
The harvest yield of crop in the utilization regions was obtained from The Statistical Yearbook of Henan Province (NBS Henan Survey Team 2013). The occurrence coefficient of crop straw was calculated based on Guo's research (2013), as shown in Table 3.

Table 3: The occurrence coefficient of crop straws

Unit	Barley Wheat	Rice	Corn	Bean	Oil	Cotton
t/t	1.0	1.0	1.5	3.0	2.0	4.0

4. Analysis of Demand-Supply Balance of Compost in Each Utilization region

4.1 Eastern Henan

Eastern Henan: Figure 2 illustrates the potential demand and supply of organic waste-based compost in eastern Henan, and the demand-supply ratio of compost of each prefecture-level city in this region (including county-level administrative unit). The potential compost demand is around 61,577,100 ton/year; the potential compost supply is around 41,439,400 ton/year; the overall compost demand-supply ratio in the eastern Henan region is about 1.49. In this region, compost supply is 20,137,700 ton/year less than the compost demand. The results reflect a severe short supply of organic waste-based compost across the region. Within this region,
the compost demand-supply ratio is around 1.95 in Shangqiu, 1.14 in Zhoukou and 1.3 in Kaifeng, all exceeding 1.0. The city-level demand-supply ratios also demonstrate the severe imbalance of compos supply and demand in this region.

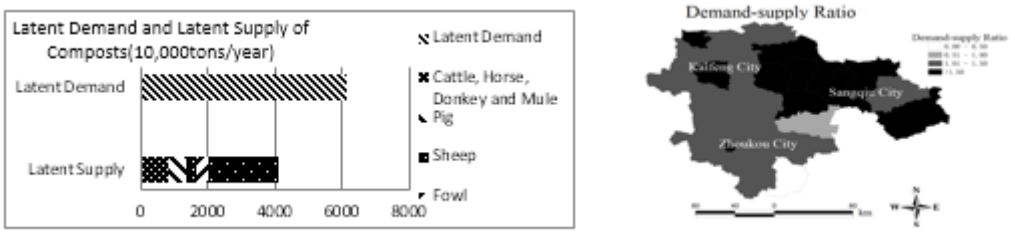

Figure 2: Potential demand and supply of compost in east Henan region, as well as demand to supply ratio of each prefecture-level city in this region

4.2 Western Henan

Western Henan: Figure 3 illustrates the potential demand and supply of organic waste-based compost in western Henan, and the demand-supply ratio of compost of each prefecture-level city in this region (including county-level administrative unit). The potential compost demand is around 16,166,500 ton/year; the potential compost supply is around 14,220,800 ton/year; the overall compost demand-supply ratio in the western Henan region is about 1.14. In this region, the potential compost demand is slightly higher than the potential compost supply, indicating that the organic wastes can be fully utilized in agricultural production of this region. The gap between supply and demand stands at 1,945,700 ton/year. Within this region, the compost demand-supply ratio is around 1.26 in Pingdingshan, 1.09 in Sanmenxia and 1.08 in Luoyang, all exceeding 1.0. These data reveal a basic balance of demand and supply in western Henan. Thus, the region boasts a comparative advantage in efficient utilization of compost from agricultural organic wastes.

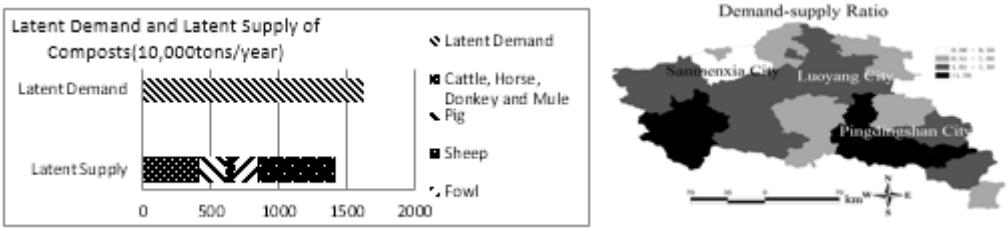

Figure 3: Potential demand and supply of compost in west Henan region, as well as demand to supply ratio of each prefecture-level city in this region

4.3 Southern Henan

Southern Henan: Figure 4 illustrates the potential demand and supply of organic waste-based compost in eastern Henan, and the demand-supply ratio of compost of each prefecture-level city in this region (including county-level administrative unit). The potential compost demand is around 55,207,900 ton/year; the potential compost supply is around 48,535,300 ton/year; the overall compost demand-supply ratio in southern Henan region is about 1.14. In this region, the potential compost demand is slightly higher than the potential compost supply, indicating that the organic wastes can be fully utilized in agricultural production of this region. The gap between supply and demand amounts to 6,672,600 ton/year. Within this region, the compost demand-supply ratio is around 1.08 in Zhumadian, 0.98 in Xinyang and 1.31 in Nanyang. The city-level demand-supply ratios evidence a basic balance of demand and supply in southern Henan. Similar to western Henan, this region also enjoys a comparative advantage in efficient utilization of compost from agricultural organic wastes.

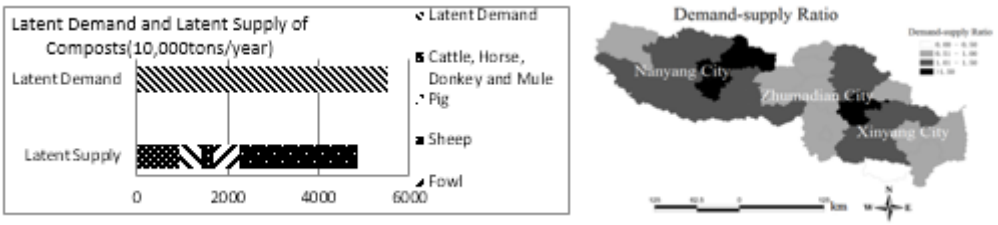

Figure 4: Potential demand and supply of compost in south Henan region, as well as demand to supply ratio of each prefecture-level city in this region

4.4 Northern Henan

Northern Henan: Figure 5 illustrates the potential demand and supply of organic waste-based compost in northern Henan, and the demand-supply ratio of compost of each prefecture-level city in this region (including county-level administrative unit). The potential compost demand is around 37,573,800 ton/year; the potential compost supply is around 31,000,700 ton/year; the overall compost demand-supply ratio in northern Henan region is about 1.21. In this region, the potential compost demand is slightly higher than the potential compost supply, indicating that the organic wastes can be fully utilized in agricultural production of this region. The gap between supply and demand amounts to 6,573,100 ton/year. Within this region, the compost demand-supply ratio is around 0.59 in Hebi, 0.99 in Puyang, 1.2 in Anyang, 0.81 in Jiaozuo, 1.61 in Jiyuan, and 1.03 in Xinxiang. These data disclose the huge difference in compost demand-supply ratio among all prefecture-level cities of northern Henan.

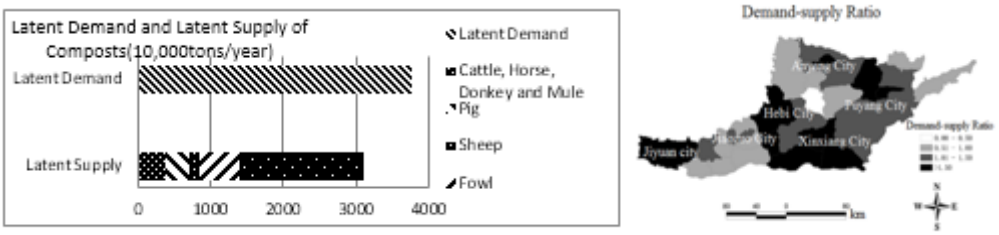

Figure 5: Potential demand and supply of compost in north Henan region, as well as demand to supply ratio of each prefecture-level city in this region

4.5 Central Henan

Central Henan: Figure 6 illustrates the potential demand and supply of organic waste-based compost in central Henan, and the demand-supply ratio of compost of each prefecture-level city in this region (including county-level administrative unit). The potential compost demand is around 16,736,400 ton/year; the potential compost supply is around 18,971,000 ton/year; the overall compost demand-supply ratio in central Henan region is about 0.88. In this region, the potential compost demand is slightly lower than the potential compost supply, indicating that the organic wastes cannot be fully utilized in agricultural production of this region. Around 2,234,600 ton/year of potential compost supply is left unused. Within this region, the demand-supply ratio is around 0.7 in Xuchang, 0.87 in Luohe, and 1.25 in Zhengzhou. The demand and supply is highly unbalanced: the two lower central cities Xuchang and Luohe have a lower demand-supply ratio than the upper central city Zhengzhou.

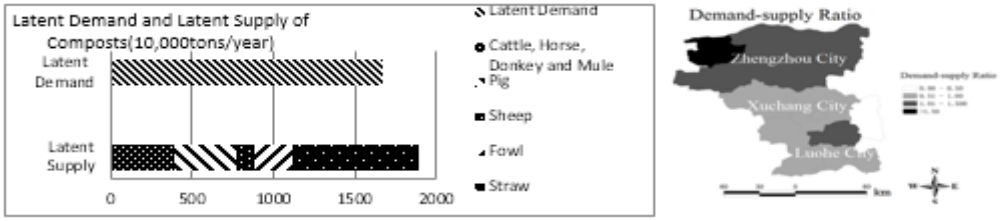

Figure 6: Potential demand and supply of compost in central Henan region, as well as demand to supply ratio of each prefecture-level city in this region

5. Conclusion

Assuming that the resourcelization of compost mainly relies on agricultural organic wastes like straw and livestock manure, this paper quantitatively analyses the compost supply-demand balance at three levels: Henan province, utilization region, and prefecture-level city. The possibility of agricultural utilization was also discussed. Through the analysis and discussion, the following conclusions are drawn:

On the provincial level, the potential demand, the potential supply and the overall demand-supply ratio of organic waste-based compost are around 186,960,000 ton/year, 154,166,200 ton/year, and 1.21, respectively. This means the organic wastes can be fully utilized in agricultural production of the province.

Owing to the different geographical locations and agricultural production conditions, the ratio of mature-based compost to straw-based compost varies greatly from one prefecture-level city to another.

The five compost utilization regions also differ greatly in demand-supply ratio. The potential demands in eastern, western, southern, and northern Henan are higher than their respective potential supply, resulting in an insufficient compost supply of around 35,329,100 ton/year. Only central Henan region has less potential demand than potential supply, indicating that the organic wastes cannot be fully utilized in agricultural production of this region. Around 2,234,600 ton/year of potential compost supply is left unused.

This research lays a scientific basis for utilization of organic waste-based compost in Henan province, and sheds new light on efficient utilization of compost from agricultural organic wastes. To further promote the efficiency of compost use, the future research will focus on the long distance relocation of organic waste-based compost, and the reduction of compost application cost.

Reference

Aramaki T., Suzuki E. Hanaki K., 2001, Supply and demand analysis of compost for effective use of various organic wastes in Aichi Prefecture, Journal of Environmental Science (Japan),14(4), 367-371.

Archambault D., Carpio M., Corre F., 2016, Developing a culture of digital accessibility in the academic context –a guide to good practices, Modelling, Measurement and Control C, 77(2), 60-72.

Bai, M.G. and Ma, C.H., 2010, Analysis on present conditions and strategies of livestock excrement and urine pollution in Hebei province, Guangdong Agricultural Sciences, 37(2),162.

Guo Q.J., Qi X.N., Wei Z., Yang B.B., Sun P., 2016, Experimental study on hydrodynamic performance and heat transfer mechanism of vapor-liquid-solid three-phase fluidized bed, International Journal of Heat and Technology, 34(3), 537-544.

Guo Y.Q., 2013, Quantitative appraisal of biomass energy of main crop straw resources and its geographical distribution in Henan Province, Research of Agricultural Modernization, 34(1),115.

Lin Y., Ma J. Qin F., 2012, The structure distribution and prospect of china manure resource, Chinese Agricultural Science Bulletin, 28(32), 1-5.

Liu L., Kong H.M., Lu B.B, Wang J.B., Xie Y. Fang P., 2015, The use of concentrated monosodium glutamate wastewater as a conditioning agent for adjusting acidity and minimizing ammonia volatilization in livestock manure composting, Journal of Environmental Management, 161, 131-136.

Mahar H.D., Agrawal A.M., Mahar D., Mahar D., 2016, Cultivation and biomedical application of Cissus quadrangularis L. in bone fracture, Modelling, Measurement and Control C, 77(1), 1-14.

Mouri G.R. and Aisaki N.K., 2015, Using land-use management policies to reduce the environmental impacts of livestock farming, Ecological Complexity, 22, 169-177.

NBS Henan Survey Team 2013, Henan Statistical Yearbook, China Statistics Press, Beijing.

Shen T., Qiao Y., Zhao X.L., 2007, The status quo and problems of organic fertilizer resources utilization in Henan Province, China Earth Press & National Agricultural Technology Spreading Center & MOA, Department of Plantation Management (jointly published), Beijing, 78-81.

Tanikawa N., Furuichi T., Tokai A., Ishii, K., Ohta Y., 2006, Factors determining use of compost in suburban areas by farmers, Waste Management Research (Japan), 17(2),153-161.

Xing L., 2016, Research on cooperation innovation among enterprises in the strategic emerging industrial cluster, Advances in Modelling and Analysis A, 53(2), 93-107.

Yang B.S., Xiong W.J., Zhu Q.Y., 2016, A research on aerobic composting technology, Modern Agriculture, 7, 57-58.

Yang T.X., Li, Y.J., Gao J.X., Huang C.H., Chen B., Zhang L.Y., Wang X.W., Zhao Y., Xi B.D., Li X., 2015, Performance of dry anaerobic technology in the co-digestion of rural organic solid wastes in China, Energy, 93, 2497-2502.

Ye M.F., Wu F.L., Lin D.Y., 2014, The Progress of research on composting technology of agricultural solid wastes, Energy and Environment, 6, 57-58.

Yuan M., 2013, Research on the ways and countermeasures of straw comprehensive utilization in Henan Province. Areal Research and Development, 32(6), 145.

Zhang H.T., Wei J.P., Wang Y.G., Wen Z.H., Yao B.H., 2016, Experimental study on the parameters effect on the sampling method based on negative pneumatic conveying, International Journal of Heat and Technology, 34(1), 51-56.

Zhang K.Q., Gao H.Y., 2004, Disposal of pollutants in livestock and poultry industry, Chemical Industry Press, Beijing, 120-121.

Zhang Z.J., Pan H.L., Xu G.W., 2016, Research on personalized tourism attractions recommendation model based on user social influence, Advances in Modelling and Analysis B, 59(1), 62-75.

Zhou Q.S., 2011, A research on the efficiency of organic waste wide-area movement—centering on the demand-supply balance in administrative region of Zhengzhou City, Henan Province, China. Toyo University, Tokyo, Japan, 101-125.

Zhou Q.S., Kitawaki H. Aramaki T., 2010, A study on the transportation and agricultural recycling of organic wastes in Zhengzhou City, China. The 38th Symposium of Research on Environmental System of Japan Society of Civil Engineers (Japan), 38, 341-347.

Zhu J.G., Chen W.C., Wang Y.J., 2015, Management of comprehensive resourcized utilization of organic wastes in agriculture, Chemical Industry Press, Beijing, 13-20.