Thoughts on the Present Conditions of Domestic Straw Utilization

Liang ZHOU *

Zhenjiang Environmental Monitoring Central Station, Zhenjiang 212004, China

Abstract According to the diverse studies on domestic straw utilization, the causes to the present situation of domestic straw utilization were analyzed and related solutions were proposed. It was pointed out that only by taking suitable measures can the problems of environment pollution and resources waste caused by straw burning be radically solved.

Key words Straw, Biomass, Comprehensive utilization

China has large grain production, and its grain output, promoted by the national agricultural policies, is gradually increasing. The present yield of straws in China accounts for 20% of that in whole world[1]. The straw is not only a type of precious bio-resources, but also a type of sustainable green resources. However, only about 50% of the straws in China is utilized, and most of straws are wasted or burned, which not only causes serious environmental pollution, but also is a great waste of resources[2-4].

In recent years, the government at all levels is paying high attention to the comprehensive utilization of straws. In 2008, the state council issued the *Suggestions on Promoting the Comprehensive Utilization of Straws*, and the National Development and Reform Commission and the Ministry of Agriculture jointly released the *Notice on Publishing the Suggestions on the Comprehensive Utilization of Straws* in 2009. In 2012, the National Development and Reform Commission, the Ministry of Agriculture and the Ministry of Finance jointly released the *Implementation of the Comprehensive Straw Utilization in the "Twelfth-Five Year" Plan*, all these papers aim at promoting the comprehensive utilization of straws and reducing the resources waste and environmental pollution.

1 Present situation of straw utilization

1.1 Use of straw as fertilizer The crop straw itself is a type of fertilizer, and its various nutrients, such as OM, N, P, K, Ca, Mg, *etc.*, can be well absorbed by the soil after being returned to the farmlands, so as to effectively promote the biological cycle in soil and improve the soil fertility. The humus residue in soil can also effectively reduce soil capacity, increase soil porosity and improve its water-holding capacity[5]. Thus, the returning of straws as fertilizer is an effective method to both save the costs and increase the soil fertility.

1.1.1 *The direct returning of straws to farmlands.* The direct returning of straws means to return the straws in the forms of straw granules, high stubble and whole plant. The returning of straw granules is to plough the ground straws into soil, accelerate their degradation and promote their adsorption by the soil, which can improve the granular structure and physiochemical properties of soil as well as the soil fertility[6]; the returning of high straw stubble is to intentionally reserve the high stubble when harvesting and let the stubble rot and degrade on field[7]; the returning of whole plants is to mulch the straws directly after harvesting, which can improve the OM content in soil, decrease the fertilizer use, improve the soil properties, regulate soil temperature and water, and effectively prevent field flood, grass and diseases, so as to realize the costs saving and sustainable development of agricultural production[8-12].

1.1.2 *The indirect returning of straws to farmlands.* The indirect returning of straws to farmlands includes the returning of stack retting and pass-rumen returning. The stack retting returning is to ferment the straws under high temperature into compost and then fertilize the compost to the soil. During the composting of straw stack retting, the nutrients are released, and some harmful components, such as organic acid, polyphenols, *etc.*, are degraded, and some parasite eggs, pathogens and weed seeds are killed. The pass-rumen returning is to feed the straws to the animals and turn the straws into excrement to fertilize the soil, which can not only improve the fertility without causing side effect, but also create equivalent economic benefits. The straw nutrients absorbed by the animals are turned into meat and milk, which improves economic benefits and realizes resources cycle[13-14].

1.2 Resourceful utilization of straws

1.2.1 *Use of straws as fuel.* The straws are traditionally used as fuel, which is costless and easy to be popularized. 30% of the straws in China are directly used as fuel, however, the burning efficiency of general kitchen stove is only about 18%, which means that most of the straw energy is wasted. Nowadays, a new technique of biomass solidification has emerged in China, which will condense the ground straws into high-dense fuel rods or granules with 11.93 - 18.84 MJ, improve the combustive efficiency to 90%, four times as high as the traditional efficiency, and turn the straws into clean fuel with the same combustive means and thermal value as coal[15].

1.2.2 *Straw gasification.* Straw gasification means to heat the

Received: August 22, 2012 Accepted: December 24, 2012
Supported by Zhenjiang Social Development Science and Technology Program (SH2011007).
* Corresponding author. E-mail: zjhbzl@qq.com

crop straws under anaerobic conditions and turn the elements of C, H and O in straws into CO, hydrogen, methane and other combustible gases, which can be directly provided for daily and industrial uses. The straw gasification is one of the high-efficient bio-energy transformation technique in straw utilization. The straw gasification are economical and healthy, but its large-scale promotion still faces several problems, such as the high price of gasification equipments, the low thermal value of gas and the high content of tar and oxygen in the gas[16].

1.2.3 *Use of straws for producing biogas.* The use of straws for producing biogas refers to the process of degrading the straws into biogas by various microorganism under the anaerobic conditions, and producing other byproduct biogas slurry and residue. Composed of 50% – 70% methane, the biogas belongs to high-grade clean fuel, which can be used for cooking, lightening and fruits preservation, *etc.*. The straws can be made into biogas directly or after being used as feeds for animals and then transformed into excrement. The use of straws for producing biogas can not only optimize rural energy structure and reduce the utilization of pesticides and fertilizer, but also effectively solve the problems of rural non-point source pollution, which has good economic, environmental and ecological benefits[17-20].

1.2.4 *Use of straws for producing ethanol.* Containing cellulose and hemicellulose, the straws can be degraded into fermentable glucose and xylose, which can be used for preparing ethanol. Ruan Qicheng firstly pretreated the red ramie straws with hot water, 3% H_2SO_4 and 1.5% soda solution, and then hydrolyzed the straws by cellulase. The average transformation rate of cellulose in red ramie was 12.23%, 25.62% and 85.34%. According to the simultaneous saccharification fermentation test with the red ramie treated by 10 g alkali as substrate, the ethanol concentration reached 26.06 mg/ml after 168 h of fermentation, and the ethanol yield accounted for about 76.71% of the theoretical yield[21]. Lingfeng Zhu degraded the straws into biogas by the thermochemical method, and then optimized the biogas, and transformed the industrial material of methanol, which realized the industrial use of agricultural wastes, greatly reduced the environmental pollution caused by straw burning, and achieved great environmental and social benefits[22].

1.3 Use of straws as feeds

1.3.1 *Physical method.* The physical method means to treat the straws through a series of process, including cutting, grinding, boiling, steaming, thermospray, and irradiation. The physical traits of straws are changed through the series of process, and the palatability of the straws processed will be greatly improved, which will increase the animals' intake of straw feeds, reduce their chewing time, help the rumen microorganism to degrade lignin and sugars, improve the animals' digestive rate of feeds and thus improve the utilization rate of per unit straw feeds[23-24].

1.3.2 *Chemical method.* The chemical method is to process the straws by chemical constituents so as to change the straw properties. Duowen Shi, with liquid ammonia, urea and NH_4HCO_3 as the ammonia sources, processed the straws of corn, rice and wheat, which radically changed the properties of lignin in straws, improved the nutrients, made the straws easier to digest and improved the animals' digestive rate of the straws[25]. Huaming Mao processed the straws with 40% water content by $Ca(OH)_2$ under sealed environment for 60 d, and improved the degradation rate of straws in bovine rumen by 30% within 48 h[26]; Hongli Wang treated the straws by SO_2, H_2O_2 and ozone, and the cellulose in the processed wheat straws was improved by 63%, the feed intake of sheep was also improved magnificently, and the degradation rate of neutral detergent fiber and cellulose in sheep rumen was significantly increased[27].

1.3.3 *Microbial fermentation.* The microbial fermentation is to add beneficial microorganism in the straw feeds, and then ferment the straws to soften them and reduce their volume. Some components in the straws can be further synthesized into the substances with high nutrients and palatability. Qingsen Chen, fermented the straws by multiple microorganisms and the cellulose utilization rate of corn straws reached 70%, and the yield of crude protein was above 23%, which greatly improved the nutritional value of corn straws[28]; Honglian Zhang fermented the corn maize by the staged treatment and multiple microorganisms, and inoculated the corn straws with *Trichoderma koningii*, *Aspergillus niger*, rumen bacteria and yeast, the content of crude protein after fermentation was 24.61% and the degradation rate of crude fiber was 48.37%[29]; Xueyi Liao used the mixture of *Trichoderma koningii*, *Aspergillus niger* and yeast as the best medium to ferment the straws, which improved the crude protein content in the fermented products from 2.2% to 24.6%, while reduced the crude fiber content from 36.2% to 18.5%[30]; Jianhong Hu fermented the corn straw for 30 d, improving the crude protein content from 3.33% to 7.96%, improving the crude fat content from 0.71% to 1.85%, increasing the content of total amino acids from 22.82% to 58.90%, and reducing the crude fuber content from 33.90% to 27.63%[31]; Tianhai Li processed the straws by microbial fermentation into granulated feeds to feed the cattle, whose palatability, compared with that of the cattles without being fed with the granulated straws, was greatly improved. The feed intake amount and rate per day of the cattles were improved by 36.8% and 27.1%, and the daily weight increase was improved by 77.69%[32].

1.4 Use of straws to cultivate edible fungi With rich organic substances of cellulose and lignin, the straws are good materials to cultivate edible fungi. To use straws to select good fungi can improve the transformation rate of straws as well as the quality and yield of edible fungi. The yield of mushroom and *Coprinus* cultivated with straws is greatly improved[33-34]. The scraps of edible fungi cultivation can also be used as quality fertilizer whose OM content is more than 30%, three times as much as that by the direct returning of straws and excrement to the farmlands. The direct returning can not only improve the soil, but also process the straws into organic fertilizer, inorganic fertilizer and seedling stroma, forming an ecological industrial chain of straws – edible fungi –

fungal residue – feeds(organic fertilizer)[35].

1.5 Other uses of straws In addition to the above uses, the straws can also be used to make papers, produce degradable materials and board. Among the raw materials of paper-making, around 30% are from straws, the use of straws for paper-making is cheap, and the produced papers are smooth and easy to be applied with glue; The straws are also used to produce some disposable tableware and construction materials. The disposable tableware is consumed in large amount in China, and the disposable tableware produced with straws have great market potential due to its cheapness, good properties and non-pollution. The boards made from rice and wheat straws are mainly used for the outer wall, inner wall, internal parting wall and the decking without producing pollutant and contaminants. Since the boards are pollutionless, they can be returned to the nature in their original forms as rice and wheat straws[36].

2 Problems and countermeasures in straw utilization

At present, the straws in China can be comprehensively used in diverse ways, which, however, are still at the stage of research and haven't be practically used. For example, the microbial fermentation technique of straws for feeds needs great capital and technical input, but still faces some difficulties; the straw gasification needs great input of capitals and equipments in the primary stage, but still brings about some problems; the direct returning of straws to farmlands has also brought some negative influence. All above restricts the comprehensive utilization of straws and directly influence the farmers' enthusiasm of reusing straws. Moreover, many young people in rural areas choose to work out, and there are no enough young labors to collect the straws; and the farmers in some places begin to use coal and biogas instead of the straws as the main fuel , and they feel it unnecessary to collect the straws.

Due to the above reasons, the farmers in lots of places choose to burn the straws. According to an investigation conducted by Dawei Zhu, more than sixty percent of farmers disapprove of straw burning, and their approual of straw burning ban is positively correlated with their recognition of the harms brought by straw burning and number of their family members, while negatively correlated with their cultural education, non-agricultural income and planting scale, the willingness of straw burning of cadres is higher than that of the mass[37]. Thus, the comprehensive utilization of straws, on the one hand, needs to improve the studies on related techniques, on the other hand, requires local government to enhance the propagation, education and management of farmers. The collection of straws can be collected by taking suitable measures, increasing the straw collection subsidies, improving the farmers' enthusiasm of collecting straws, and constructing a straw logistics system[38].

3 Conclusion

At present, there are a large quantity of straws produced in China every year and there are also various studies on their comprehensive utilization techniques, but the practical utilization rate of straws are still very low due to some objective reasons, resulting in a great loss of straw resources in many places. Thus, local government should promote the suitable model of straw utilization, improve the related money and technical input, and enhance the management of straw collection and utilization, so as to reduce the environmental pollution and resources waste caused by straw burning, finally forming an ecological agricultural model with virtuous cycle.

References

[1] SU Y, HUANG LG, WANG XM. Analysis on present condition and countermeasures of straw burning[J]. Ningxia Journal of Agriculture and Forestry Science and technology, 2012, 53(3): 113 – 114. (in Chinese).

[2] HU DZ. The utilization status and prospect of agricultural crops straw resource in China[J]. Resource Development and Market, 2000, 16(1): 19 – 20. (in Chinese).

[3] HANG WQ, CHEN JJ. Effects of field burning straw on environment quality and control [J]. Environment Monitoring Management and Technology, 2000, 12(2): 36 – 37. (in Chinese).

[4] DUAN FK, LU YQ, DI YA, *et al*. Influence of straw burning on the air quality in Beijing[J]. Environmental Monitoring in China, 2001, 17(3): 8 – 11. (in Chinese).

[5] LI YJ, XU JY, LI Y, *et al*. Study on technology of total wheat straw returning under different rice planting patterns[J]. Jiangsu Agricultural Sciences, 2010(5): 141 – 143. (in Chinese).

[6] LV XR, NU'ERXIATI? ZHUMAXI, LV XL. The status and development prospect of agricultural crops returning straw to field in China[J]. Modernizing Agriculture, 2004(9): 41 – 42. (in Chinese).

[7] LI WG, LI Q, HE XX. Research progress of returning straw to field[J]. Journal of Hubei Agricultural Sciences, 2006(1): 46 – 48. (in Chinese).

[8] LIAO HJ, DONG L, JIANG Q, *et al*. Research on straw mulching mode of potato in Anhui Province[J]. Journal of Anhui Agricultural Sciences, 2009, 37(35): 17599 – 17601. (in Chinese).

[9] GONG DR. Preliminary report on cultivation technique for rice stubble no tillage straw coverage[J]. Anhui Agriucltural Science Bulletin, 2010, 16 (14): 99 – 101. (in Chinese).

[10] QING GL. Effects of straw mulching on rice stubble and no – tillage autumn maize physiological characteristics and yield[J]. Journal of Guizhou Agricultural Sciences, 2009, 37(11): 38 – 40. (in Chinese).

[11] LI YY, WANG D, JIAN HZ, *et al*. Straw cover techniqus over wheat or rip crop after rice[J]. Shaanxi Journal of Agricultural Sciences, 2009, 55 (2): 181 – 182. (in Chinese).

[12] PU XW, ZUO WZ. Primary study on cultivation of watermelon under barley straw – covering and no – tillage cultivation[J]. Jiangsu Agricultural Sciences, 2010(1): 170 – 171. (in Chinese).

[13] YANG LJ. Way for agricultural crops returning straw to field and technique demands[J]. Modern Agriculture, 2011(5): 165. (in Chinese).

[14] LIU CY. Advantages and disadvantages of returning straw to field[J]. Agriculture Environment and Development, 2004(5): 37 – 38. (in Chinese).

[15] SHA WF, LI SJ, ZHU J. Research progress of development utilization technology in crop straw[J]. Journal of Jinling Institute of Technology, 2005, 21(4): 73 – 76. (in Chinese).

[16] CHEN LS. Problems about straw gasification and suggestions[J]. Jiangxi Energy, 2001(1): 46 – 47. (in Chinese).

[17] XIONG ZM. Several problems in promotion of current rural methane[J]. Jiangxi Energy, 2004(4): 45 – 46. (in Chinese).

[18] LI QM. A sustainable developing way of ecological balance and ecological protection[J]. Jiangxi Energy, 2005(1): 45 – 48. (in Chinese).

[19] QUAN GX, CHANG ZZ, YE XM, *et al*. Research on influencing factors and set-upquickly of rice straw dry anaerobic digestion[J]. Jiangsu Agricultural Sciences, 2009(3): 366 – 368. (in Chinese).

[20] NI SY, ZANG YP, DENG Y, *et al*. Application prospect of biogas tech-

nology[J]. Jiangsu Agricultural Sciences, 2009(3): 366 -368. (in Chinese).
[21] RUAN QC, QI JM, HU KH, *et al*. Bioconversion of fuel ethanol from kenaf stalk[J]. Journal of Fujian Agriculture and Forestry University: Natural Science Edition, 2012, 41(1): 78 -82. (in Chinese).
[22] ZHU LF, ZHANG BL, LIANG GB, *et al*. Study on methanol synthesis from cornstalk by the thermochemical method[J]. Journal of Henan Agricultural University: Natural Science Edition, 2003, 37(4): 400 -405. (in Chinese).
[23] YAN XH, QU MR, LI GH, *et al*. The research progress of development and application of straw resource [J]. Cereal & Feed Industry, 2000(5): 22 -25. (in Chinese).
[24] ZHU DW. Analysis on feasibility and limiting factors for straw as animal feed[J]. Feed Research, 2003(2): 34 -36. (in Chinese).
[25] SHI DW. Straw ammoniation technique[J]. Feed World, 2008(10): 63. (in Chinese).
[26] MAO HM, FENG YL. Treatment of urea and calcium hydroxide to improve the nutritional value of crop straw[J]. Chinese Journal of Animal Science, 1991, 27(5): 3 -6. (in Chinese).
[27] WANG HL, ZHANG ZL, BAI XH. Exploitation and utilization of crop straw feed resource[J]. Journal of Shenyang Agricultural University, 2003, 34(3): 228 -231. (in Chinese).
[28] CHEN QS, LIU JH, PAN JY, *et al*. Studies on utilizing the multi-strains co-fermentation for biotransformation of corn straw[J]. Journal of Microbiology, 1999, 9(4): 15 -19. (in Chinese).
[29] ZHANG HL, GUO AL, HE J. A study on utilizing stage process and the multi-strains solid state fermentation for corn straw[J]. Journal of Northwest University: Natural Science Edition, 2004, 34(6): 691 -694. (in Chinese).
[30] LIAO XY, DAI Q, YU HZ. Study on protein feed production by mixed strains fermenting straw[J]. China Feed, 2009(16): 8 -10. (in Chinese).
[31] HU JH, LI QW, JIA ZK. Study on the effect of feeding pigs with new microbial straw silage[J]. Agricultural Research in the Arid Areas, 2001, 19(1): 97 -101. (in Chinese).
[32] LI TH. Straw biochemical granulated feed beef cattle fattening test report [J]. Sichuan Animal & Veterinary Sciences, 2009, 84(6): 41 -42. (in Chinese).
[33] ZHAO C, GAO ZY, HE LL. Study on planting Lentinus edodes with crops straw stalk[J]. Guangdong Agricultural Sciences, 2007(9): 38 -41. (in Chinese).
[34] DENG GC, CHEN JT, GAO LA. High-yielding cultivation techniques for Coprinus conmatus used no - fermented straw[J]. Joangsu Agricultural Sciences, 2007(4): 178 -179. (in Chinese).
[35] SHI QS, YANG GJ, ZHU HB. Developing edible fungus industry to promote straw recycling utilization[J]. Shanghai Agricultural Science and Technology, 2004(5): 17 -18. (in Chinese).
[36] PAN JH. Do not let the valuable biological resources polluted ecological environment]J]. Jiangsu Science and Technology Information, 2004(2): 50 -52. (in Chinese).
[37] ZHU DW, CHANG ZZ, YANG SJ, *et al*. Analysis on farmers'willing of inhibiting straw burning based on Logit model[J]. Jiangsu Agricultural Sciences, 2011, 39(4): 497 -499. (in Chinese).
[38] ZHOU LY, LUO JF, ZHAO G, *et al*. Network planning of recycle materials of crop straw resources[J]. Jiangsu Agricultural Sciences, 2011(1): 474 -476, 481. (in Chinese).
[39] DU X, ZHANG HM, TIAN Q, *et al*. The impacts of agricultural machinery purchase subsidies on mechanized crop residue recycling[J]. Asian Agricultural Research, 2011, 3(5): 38 -40, 51.
[40] MA CH, LIU X, LI YC, *et al*. Research and utilization on straw transformation to biomass energy[J]. Journal of Anhui Agricultural Sciences, 2011, 39(7): 4146 -4147, 4150. (in Chinese).
[41] FENG W, ZHANG LQ, HE LJ, *et al*. A mode research of straw recycling based on circular agriculture theory[J]. Agricultural Science & Technology, 2011, 12(12): 1921 -1924.

(From page 67)

4 Conclusions

This paper initially establishes the evaluation indicator system of garden plant landscape in residential areas, and analyzes the indicators in criteria layer, using analytic hierarchy process and cluster analysis, in order to lay foundation for the scientific evaluation of garden plant landscape in residential areas. In specific use, it is necessary to select and complement the indicators proposed in this paper, according to the specific circumstances of residential areas in different cities.

At the same time, there are many indicators for evaluation of garden plant landscape in residential areas, but some indicators are still difficult to be quantified at present. When determining the evaluation indicator system, there are also some human propensities factors influencing the weight. Therefore, how to scientifically select evaluation factors and determine the scale of importance needs to be further researched when conducting mutual comparison between various elements.

References

[1] DONG T. Evaluation of Xi'an commodity residential building and living environment quality [D]. Xi'an: Northwest University, 2004. (in Chinese).
[2] XU YY, ZHUO LH. Plant landscape evaluation on Harbin residential community[J]. Journal of Tianjin Institute of Urban Construction, 2008, 14(1): 11 -14. (in Chinese).
[3] LIU BY, JIANG YF. The inclined errors and countermeasures of urban green space system planning in China: The research on indices system of the urban green space system planning[J]. Urban Planning Forum, 2002(2): 27 -29. (in Chinese).
[4] XIE HL, LIU LM, LI ZP. Study on the method of rural landscape evaluation in urban fringe[J]. Geography and Geo-information Science, 2003, 19(3): 101 -104. (in Chinese).
[5] TANG DQ, YANG XJ, XU DX. Study on the method applied in garden plant landscape evaluation[J]. Journal of Zhejiang Forestry College, 2001, 18(4): 394 -397. (in Chinese).
[6] WU BJ. Fuzzy mathematics and economic analysis[M]. Beijing: China Standard Press, 1994. (in Chinese).