THE UTILIZATION OF HUMAN EXCRETA IN CHINESE AGRICULTURE AND THE CHALLENGE FACED

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1. Chinese tradition of utilizing human excreta

According to the inscriptions on bones or tortoise shells in the Shang Dynasty about three thousand years ago, the use of human excreta may already have begun in China. During the Warring States Period (475-221 BC), the use of farm manure became quite popular when cropping system changed from crop/ fallow rotation to crop/crop rotation. In many articles written by famous persons in early Qin Dynasty (221-207 BC), there were words about "using excreta to field". In "Lao Jie" written by Han Feizi, he wrote "in order to increase fertility of soil, human excreta must be used." During Qin and Han Dynasty(221-220 AC), there was inscription about the link of toilet and pigsty in one place, also about the compost using human excreta. The method of using human excreta included basal fertilization, top application, and seed coating. In Ming and Qing Dynasty (1368-1911), Xu Guangqi described the method to cook human waste with human hair and cattle dung with cattle bone. He also described the distillation method for human excreta just as distillation method for wine. A formula for making compound fertilizer included black bean, hemp seed, pigeon waste, human excreta, manure from goats, dogs etc. He suggested that the right method of using fertilizer was according to season. To apply human and animal waste in spring, compost and green manure in summer, plant ash in fall and bone meal , hair and skin in winter. He also suggested that to apply fertilizer according to different soil type just as using medicine for different diseases. He recommended that to use black bean compost for millet, to use human excreta and bean cake for vegetable. In "Zhi Ben Ti Gang. Nong Ce Geng Jia", organic fertilizers were divided into ten categories. They were human excreta, animal waste, river mud, shell and bone ash, green manure, home waste, bean cake compost, feather and hair compost."

Under the influence of our long tradition, human excreta is always used as fertilizer for crops in China. The main application methods are (1) direct usage for crops and fruits as basal or top application after fermentation in a ditch for a certain period, (2) compost with crop stalk for basal application, (3) direct usage as feed for fish in pond.

Even human waste generated in the cities and towns were very dear for farmers and were brought back to rural areas for production purposes. Before 1949, there were firms in Wuhan, Beijing, and other cities to control the commercial selling of human excreta. In Guangzhou city, farmers sent some yam or sweet potato to house wives to show their gratefulness. This situation lasted until the end of 1970's and early 1980's.

2. The Challenge Facing China for Agricultural Usage of Human Excreta

Before the 1960's fertilization methods mainly relied on farm yard manure and organic fertilizer. In the mid-1960's, the wide use of semi dwarf rice variety promoted the growth of green manure in winter. At that time, the chemical fertilizer industry was on the eve of quick development in China. The maximum area of green manure reached 1.2 billion hectare in China and 8.7 million hectare in south China. From 1980 on, the amount of chemical fertilizer was more than organic fertilizer. Now organic fertilizer is only about 35% of the total fertilizer used.

Although the tradition of using human waste has been carried on, the percentage of human excreta used is decreasing. In part of the developed area in China, farmers

prefer to buy chemical fertilizer rather than using human and animal waste. According to estimates, the utilization rate of human excreta is now less than 30%. There are also sanitation problems in traditional methods. For example, in the single ditch toilet fresh and fermented excreta are mixed. This may lead to transmission of disease. According to an investigation in early 1980's, the infection rate for roundworm, hookworm, and whipworm were 94%, 65%, and 93% respectively.

The human waste generated in cities and towns is more and more difficult to absorb by surrounding rural areas because cities are becoming bigger, the quantity of wastes is increasing, and transportation distances extended. The whole process becomes more complicated. It includes the generation of waste—long distance transportation —treatment—local transportation —field application. The limited capacity of suburban areas results in longer transportation distances and higher cost. The absolute amount of human excreta to be transported from cities and towns increased from 2 billion tons in 1979 to 3.3 billion tons in 1994. Ranging from 10% to 48%, the average returning rate was only 31% according to investigations in Beijing, Xian, Shanghai, and Changchun.

3. Development of agricultural use of human excreta in China

This is a system engineering issue. It relates to material cycling within ecosystem, technical design, economic viability, and social acceptability. In the foreseeable future, the end user of human excreta in China still relies on agriculture that includes crops, forestry, animal husbandry and fishery. The system design is quite different in urban and rural areas. However, we can tackle this issue from the aspects of toilet structure, transportation method, treatment method and application approach.

(1) Improvement of the toilet structure

In order to reduce the total weight of waste produced from toilets, methods like reducing water by using vacuum assisted devices or dry toilets can be used.

In order to reduce smell and to reduce pathogen transmitted, toilet using double ditches or linked with biogas tank can be adopted. According to an investigation in Luo Yang, Henan Province, the contamination rate by pathogen was reduced in vegetable production, and cases of intestinal diseases were also 20% to 26% reduced by using double ditches toilet. In Mian Yang, ammonia concentration in the air of public toilet using biogas tank was 57.9% reduced, number of flies was reduced 90%. In rural areas, soil contaminated by whipwarm was reduced 58.3% and roundwarm 45.8%.

(2) Methods for long distance transportation

Transportation methods for human waste are mainly animal or human drawn cart, motor vehicle and pipelines. Machine and motor vehicle increased quickly. In mid- 1990's, 80% of collected human waste was moved by machine and motor vehicles. This figure is over 90% in eastern cities. Pipelines are developing quickly in recent years. About 70% of the households can connect to pinelines and only 20% of the waste water was treated before discharge.

These three methods will co-exist in the near future. While the percentage collected by cart will be reduced, the percentage carried by pipeline will be increased. In order to reduce the total volume, heavy metal, and pathogen, and to increase the recycling rate for nutrients and water, it is necessary to

separate rainfall, industrial waste, and hospital waste from human wastes in future pipeline systems. Technology to change from liquid to solid management should be encouraged.

(3) Centralized treatment methods in cities and towns

In wastewater treatment plants, procedures like physical separation, chemical adjustment, and biological oxidization are used. Water can be further treated through artificial wetland, or discharged to agricultural land systems if it meets the standards. Sludge generated from wastewater treatment plant can be used for agricultural purpose or as energy resources. Since 1980's, many methods were tested and tried in China for low cost and high efficiency approach. An airtight container system was tried in the suburban areas of Shanghai. Strip high temperature compost using human waste and garbage was tested in Hesi Tianjing. Treatment plant using high temperature biogas fermentation method was successful in Qingdao. Biogas method was successfully used in Yantai for all collected human waste. Dehydration facilitate was introduced in Foshan for human waste treatment.

(4) Decentralized treatment methods in rural areas

Decentralized treatment methods can be divided into dry and wet methods. Wet methods include improved sewage pool and biogas tank. Dry methods include normal compost, high temperature compost, inoculated compost and ventilated compost.

Various ecosystem models for human waste utilization are formed to link crop, soil, animal and human together, and promote the recycling process. In south China, human, animal—biogas—fruit tree models are quite popular. In north China, animal and human—biogas—vegetable—green house models are quite common. The animal, human—fish—crop models were used a lot in pond—dike systems in the Pearl River Delta. However the number of systems using this model is decreasing for public health reasons.

(5) Application of treatment products in agriculture

The nutrients contained in the liquid produced from biogas tanks and toilets are used directly as basal application and top dressing for crops. The liquid from biogas fermentation can also be used in seed treatment, leaf application, fish production and pig production. The gas from biogas fermentation can be used for cooking, temperature control in greenhouses and animal houses. It can also be used for preservation of agricultural products. The solid part from biogas tanks can be used for basal or top application, and for edible mushroom or earthworm production.

Water discharged from treatment plant can be used directly for field irrigation, if it meets the standard. Sludge from treatment plant can be used to make compound fertilization, if heavy metal contains meets the standard.

The method for field application of human waste in China mainly relies on manual labour. It has a high labour cost, requires a lot of hard work and provides poor sanitation conditions. Injection machines, which are already used in developed countries for liquid application in fields, can reduce evaporation and increase utilization rate. Spreading machines can reduce hard work in fields for solid form application. These machines can be modified and gradually be adopted in developed region in China.

Conclusions

- Considering the external cost caused by contamination of human excreta, economic policy, which benefits the human excreta treatment systems, should be made and implemented. Related educational and extensional programs should be carried out.

- Natural, social and cultural conditions should be considered before the design of a specific treatment system. Different steps from toilet to field of a system should adapt from one to another to maximize the social, economic and ecological effect of that system, not its components.

- Centralized and decentralized methods, which complement each other, should be co-existing in one region to reach the goal of regional optimization.

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