VERMICULTURE INDUSTRY IN CIRCULAR ECONOMY

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Summary

Vermiculture is an important component of agriculture. Earthworms can treat large amounts of organic waste, livestock manure and poultry droppings and turn them into premium organic fertilizers. On one hand, earthworms can greatly improve the ecological environment in rural areas; on the other hand it can restore the fertility of the soil because earthworm feces and castings consist only of humus compared with other fertilizers. Earthworms can supply quality animal protein as feed and even for human consumption, and offer the best raw materials for biochemical and pharmaceutical industries. Since industries and agriculture develop and urban construction is booming, the discharge of wastewater and sewage soars. Wastewater treatment plants are set up everywhere around cities; stabilizing the sludge [see also – *Socio-economic strategies for sustainability*] presents a big challenge and earthworms could play an important role in facing this challenge. Vermiculture should be oriented towards stabilizing sludge and organic wastes in a circular economy, for it is an approach to sustainable agriculture and a measure in promoting organic farming [see also – *Conventional Plant Breeding for Higher Yields and Pest Resistance*]. It should be supported by policies under the guidance of scientific development and be put into whole circular economy as a means of protecting the environment, maintaining ecological balance, and fully utilizing resources. However, it should be combined with other technologies such as EC (electro-coagulation), EH (energized hydrolyser), and especially EM (effective microorganisms). We should promote courtyard earthworm composting as well as large-scale

vermiculture, which should be mechanized and automated.

1. Introduction

During the Warring States Period (475-221 BC) of the Eastern Zhou Dynasty Xun Zi (313-238 BC)earthworms were described in "Encouraging Learning" to be "*with neither sharp claws and teeth, nor strong muscles and bones, could feast on dust at the upper layer and drink from netherworld at the lower. This is because they keep their minds on one thing.*". Earthworms were used as Chinese medicine as shown in Shennong's Classic of *Materia Medica*, which was compiled during the late Western Han Dynasty and early Eastern Han Dynasty (25-220 BC). In the West, the Greek philosopher Aristotle (384-322 BC) called earthworms the intestines of the earth. He believed that soil was an organic entity and he understood that earthworms played an important role in maintaining the life of soil. But even at the end of the 19th Century, some countries outside China still thought that earthworms would eat the roots of plants and so hinder the growth of plants and destroy crops, and thus they suggested to kill earthworms. The reputation of earthworms was not rehabilitated until Darwin published his works on *"Talking about the formation of cultivated soil from the observation of earthworm activities and their living habits"* in 1881. These documents indicated that the understanding of earthworms in ancient China was earlier than in Western countries, whereas vermiculture (the scientific name for worm farming) in China now lags behind these countries.

Since adopting economic reform and open policies China has started to throw away narrow-minded agricultural concepts with grains as its core sector, while promoting the diversification of macro-agriculture to develop crop planting, forestry, animal husbandry, side occupation and fisheries simultaneously [see also Topic 7 – *Agricultural Biotechnology*]. The well-known scientist Qian Xuesen pointed out in the early 1980s that the above mentioned five sectors were not enough for macro-agriculture and we should concurrently develop ten sectors, adding to the five above, apiculture, vermiculture, snail culture, edible fungi, and fodder grass. Furthermore he put forth his concept of the 6th Industrial Revolution in 1984. He thought that the 6th Industrial Revolution would appear in human society to establish five knowledge intensive type industries. He observed that *"industrial revolution absolutely does not mean whatever the partial change is; not the leaps caused by whatever aspect the production technologies are applied to, but the leaps caused by the changes in the whole production systems; not only in industries, but also agriculture, transportation and the changes of economic relationship. In short it can be defined as the leaps of social formation on the economic aspect."* He pointed out that this would be caused by the great development of modern biological sciences and technologies, revolution of knowledge intensive type agriculture, prataculture, forestry, sand-culture and mariculture. He estimated that the 6th Industrial revolution would be launched in China not later than the 2030s and *"Once the theory of grand-agriculture is put into effect it is the beginning of the 6th Industrial Revolution in the world."* There might be some basic characteristics of the 6th Industrial Revolution:

a) All sciences and technologies are applied to grand-agriculture so as to realize modernization of grand agriculture production technologies.

b) Solar energy would directly be used as energy for highly effective integrated production by using a variety of organisms.
c) The processes are strictly organized with various working procedures ecologically linked for factory production in streamlining plants, animals, and microorganisms as well as processing.
d) The three distinctions between town and country, industry and agriculture and mental and manual labor are eliminated.

As the economy grows rapidly China is facing great challenges of serious pollutions and consumption of resources. In order to promote circular economy, saving energy, reducing consumption of resources, protecting the environment and realizing sustainable development, the Peoples' Republic of China Circular Economy Promotion Act was approved by the NPC on August 28, 2008 and implemented from Jan 1, 2009. The so called circular economy refers to the general term of 3R (reduction, reuse and recycle) activities in production, circulation and consumption processes. Li Yutang wrote in 2004 that Qian Xuesen predicted some measures would be adopted in the 6th Industrial Revolution among which vermiculture could continuously be produced.

2. Necessity to develop a vermiculture industry

As agriculture modernization speeds up, the livestock, poultry and fishery sectors are marching on the road of expansion of intensive production in scale to meet human demand. Since 1988 when China put "Vegetable Basket Engineering" into effect, million-broiler farms, thousand-pig farms, hundred-cow farms and large-sized aquaculture farms have been set up everywhere. Intensive production sites are approaching the suburbs of cities and densely populated areas. On the one hand it greatly improves the living standards of the inhabitants of cities and towns; on the other hand large areas of land is becoming scarce to utilize the livestock manure and poultry droppings produced from animal husbandry and poultry. Furthermore, no clean and good water nearby to self-purify the effluent from aquaculture ponds, result in serious pollution of soil, air and water. Traditional manure looks dirty, smells, and is full of pathogenic bacteria while chemical fertilizers seem to be labor-saving and easy to use. This might be one of the reasons which promoted the application in large amounts for years. As a result soil fertility was degraded, soil hardened and impervious. This fossil fuel-based agriculture neglected the effects of manure and top-dressing. It caused serious wind erosion and water erosion. It destroyed large areas of croplands. It was reported that within 40 years, 8,000 ha of cropland had been destroyed to a certain extent by soil erosion in the States. In developing countries, many are affected by fossil fuel-based agriculture. Some pursue single-sided high yield, especially grain yield, and emphasize single sided energy input, and apply too much chemicals. Large amount of chemical fertilizers, pesticides and germicides not only caused energy stress but also serious pollution. The problem fossil agriculture brought about can only be solved by eco agriculture. The term of eco-agriculture appeared in the First Agricultural Eco Economy Symposium held in Yinchuan Ningxua Autonomous Region in 1980. It emphasized that we must integrate economic benefits with ecological benefits for agriculture to develop sustainably in China. In 1983 the UN passed the resolution about sustainable development. In 1995 the United Nations University organized the first Internet conference on "Zero Emissions". No matter what someone suggests as a new

concept to implement sustainable development, vermiculture should be an important part of agriculture or agricultural circular economy. In the book *"The Treatment and Reutilization of Wastes in Ecological Agriculture"* there are only two pages mentioning earthworms. Earthworms seem to be the missing link of eco agriculture in China. However, earthworms can treat organic wastes, livestock manure, and poultry droppings, and turn them into quality organic manure and greatly improve the ecological environment in rural areas. Earthworms are also a very good food source, with crude protein in dry weight reaching about 70%, as well as an excellent industrial raw material. Many enzymes and active matter can be extracted from earthworms for pharmaceutical, food, cosmetics and environmental protection. Owing to the development of industry and agriculture and the boom in urbanization, the discharge of industrial and agricultural wastewater and sewage effluents has rapidly increased. Thus many wastewater treatment plants have been established around cities. How to stabilize the sludge from those plants is an urgent challenge, and earthworms can play a unique role to stabilize sludge in the circular economy as a whole.

3. Status of the vermiculture industry

In the late 1970s, thousands of Americans were victimized by hucksters claiming that backyard worm breeders could easily earn over $14,000 a year by tapping the wrigglers' potential as bait, soil enrichers, and even food. Vermiculture collapsed at the end of the 1970s. Up to the environment-friendly 90s, the feeding habits of earthworms, which consume large amounts of rotten food, made them a viable waste-disposal alternative. The tiny creatures' ability to devour virtually any organic waste--livestock manure, rotten food, even ratty T-shirts--and excrete it as premium organic fertilizer (dubbed "black gold" by organic farmers for its nitrogen richness) is proving profitable for a host of non-squeamish entrepreneurs. Earthworms are the missing link that makes sustainable agriculture a reality. Vermiculture is booming thanks to environmentalism and the demand for organic foods. Vermiculture ventures in America, the biggest of which involve 50 million worms chewing down almost 90 tons of waste per week. Nearly 300 large-scale vermiculturalists formed the International Worm Growers Association in 1997 to help promote the trade. Many outfits are prospering thanks in part to the growing popularity of organic foods, which became a $6.5 billion-a-year business by 2000. With the U.S. Department of Agriculture estimating that 25 percent of Americans purchase organically grown foods at least once a week, organic farmers' demand for worm feces far outstrips supply.

Vermicycle Organics, which harvests worm droppings in high-tech greenhouses, produces 7.5 million pounds of a natural fertilizer a year. The company expects sales of the fertilizer to grow by 500 percent this year. Vermitechnology Unlimited has doubled its business every year since 1991, despite prices that can run twice as high as those of synthetic fertilizers. Vermitechnology founder Larry Martin predicts, *"In 5 to 10 years, every commercial fertilizer company will be selling worm castings."* With many local and state governments trying to divert waste from clogged landfills, forward-thinking cities are promoting "backyard vermin-composting." Traditional compost piles can take weeks to produce low-quality humus [see also – *Composting Agricultural and Industrial Wastes*]; a pound of worms, on the other hand, needs only 48 hours to convert a pound of waste into nutrient-rich castings. In San Jose, California, where state law has

mandated that the amount of waste going to landfills be cut in half by the year 2000, about 1,200 residents used city-distributed discount vouchers to purchase waste-eating worms from Chambers's Worm Farms. This small operation sells 4,000 pounds of worms a year--about 4 million of the critters--at around $20 per pound.

In the 1970s several species of earthworms were cultured in simulated natural ecological conditions in China, the same as in North America. On the one hand it met the market's demand for aquaculture, livestock and animal husbandry as quality protein feeds with high performance-to-price ratio, and also the pharmaceutical industry's demand for raw materials; on the other hand it was somewhat a profiteering activity as well. Especially after the Japanese premier presented the hybrid of red wiggler and local earthworm as a gift to China, it created a small boom in vermiculture in many places, but in a small and scattered scale with low technology, low unit yield (about 3 tons/mu/year), and competitive for land with crop planting. The direction of rearing earthworms fell wrongly on selling earthworm breeding stock to farmers for profit only, not for waste disposal on a large scale and selling earthworm feces and castings to improve the soil. In recent decades vermiculture has experienced ups and downs owing to the fluctuation of market requirements, narrow developmental concepts, and a lack of science and technology support or integrated development capability. In some places there is almost no vermiculture industry except scattered and sporadic farms.

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Biographical Sketch

Li Kangmin, Male, Nationality: Chinese, Birth: Dec 3, 1934 at Wuxi, Jiangsu Province China. Occupation: Freshwater Fisheries Research Center, Chinese Academy of Fisheries Sciences Senior Researcher; China National Rice Research Institute, visiting researcher; Zero Emissions Research Initiative Resources Personnel (1997-1999) and the Planning committee member of Internet Conference of IBS in 2000.

Graduated from CMC Engineering College in early 1950s, post graduated from Luoyang Foreign Language Institute and engaged in GSH of the PLA. Transferred to the Ministry of Agriculture in 1983. Deputy Director of Asian Pacific Regional Research and Training Center For Integrated Fish Farming NACA/FAO in charge of International Training Course of Integrated Fish Farming for three and half years. Engaged in IFS Deep Water Rice Fish Research, IRRI Deep Water Rice Screening, Eutrophication Control of Lake Taihu, IDRC extracting phycocyanin from blue-green algae *Microcystis aeruginosa* and Surface Aquaponics early or later.

Li Kangmin has been involved in rice fish farming research since 1986, when he published his first paper on rice fish farming and later published in the International Journal of Aquaculture in 1988. He published several papers later on the same topic e.g. Rice fields as Fish Nurseries and Grow-out systems in China.

According to the characteristics of agricultural climate and fishery resources, he has realized that there are three principal paddy areas in China suitable for rice fish farming. China has 20 million ha of paddy fields, 97% of which are under irrigation. In 1988, there were 1 million ha of rice fish fields, which accounted for 5% of the total rice fields. Practices prove that rice fish farming can function to eradicate weeds, to eliminate pests, to loosen the soil, to increase dissolved oxygen and improve the fertility and eventually increase the rice yield by 10%. Each ha of rice field can produce 150 kg of fish on average. In 1998 he and Li Peizhen published the paper of Rice Aquaculture System in China on the Internet Conference, describing that rice fish farming system is now developing to be rice aquaculture system under the transformation process from protein crop to cash crop. By quoting Jiangsu Province as a case, it describes the present status of rice fish farming and crab culture, shrimp culture and special aquatic product culture in rice fields as well. It indicates why rice fish culture can achieve sustainable development in China while rice fish culture is declining in the world. It is due to social, economic and cultural factors in China and all those factors represent the philosophy of the Chinese people.