Pollution of Solid Waste to Agricultural Environment and Preventive Countermeasures

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Abstract This paper elaborated the pollution and hazards caused by different kinds of agricultural solid wastes to the agro-ecological environment from the aspects of the types of solid wastes and the way they are produced. Besides, it came up with some countermeasures for preventing and controlling solid waste pollution and hazards.

Key words Solid waste, Agro-ecological environment, Preventive countermeasures

1 Introduction

Solid waste can be defined as the useless and unwanted products in the solid state derived from the activities of and discarded by society. It is produced either by-product of production processes or arise form the domestic or commercial sector when objects or materials are discarded after use. During the development and utilization of natural resources to carry out production and living activities, people often discard some of the resources as wastes due to the actual demand and technical limitations. On the other hand, each product has a different lifespan. Once a certain time limit is exceeded, some products will become wastes. Those solid-state materials and goods discarded are called solid wastes. As different raw materials, production processes and technical levels are applied in the production process, the solid wastes produced are also different. From the point of multi-level utilization of raw materials, the problem of solid waste is not only a problem of ecological environment, but also a problem of rational use of resources[1].

2 Types of solid waste

Solid waste can be divided into organic waste and inorganic waste by compositions; solid waste (lumpy, granular and powdery) and earthy waste (sludge) by forms; industrial waste, mining waste, domestic waste, agricultural waste and radioactive waste by sources; and hazardous waste and general waste by hazard ratings. The most common one is the classification of solid wastes according to the sources.

2.1 Solid waste from industries Solid waste from industries refers to the unused by-product discharged in the process of industrial and agricultural production. It can be divided into the following categories.

2.1.1 Industrial solid waste. Industrial solid waste refers to the residue, dust, chippings and sludge *etc.* produced in the process of industrial production and processing, mainly including metallurgical solid wastes, fuel residues, solid wastes from chemical industry, wastes from petroleum industry and solid wastes from food industry.

2.1.2 Agricultural solid waste. The solid wastes produced in the production activities of farming, forestry, animal husbandry, sideline production and fishery are collectively called agricultural solid wastes, which mainly comprise the components of crop stalks and the other dry branches and fallen leaves, animal bodies and bones, poultry excrements from factorial livestock farms and fungus dregs. Besides, wood and the solid wastes discharged by the other processing enterprises of agricultural and sideline products can also be classified as the agricultural solid wastes in a broad sense.

2.2 Domestic waste Domestic waste refers to the solid waste produced in the lives of residents, commercial activities, municipal construction and official business *etc.* The quantity, composition and property of domestic waste are changing constantly with urban-rural construction and development and the improvement of living standards. For example, if coal is used as the domestic fuel of a region, the waste discharged will mainly consist of inorganic matters. But for the community with central heating and gas supply, the waste produced will mainly consist of organic matters. At present, only some large and medium-sized cities have taken the disposal measures of waste emission in bags and classified collection & processing for wastes. It is really difficult to collect, transport, dispose and recycle the mixed wastes. Having the largest population in the world, China has more than 350 cities with an urban population of over 200 000 000. The annual output of domestic garbage is over 50 000 000 t, and this number is growing at a rate of 10% every year. In 2002, the transportation amount of domestic wastes in China is 136 380 000 t, among which the volume of harmless disposal is 74 040 000 t, resulting in a rate of harmless disposal of 54.3%.

2.3 Harmful solid waste and radioactive solid waste Harmful solid waste is also called hazardous solid waste. This kind of waste contains toxic, flammable, reactive, corrosive, explosive and infectious substances, thus may cause harm to the living environment of human beings. Therefore, the United Nations Environ-

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ment Programme (UNEP) has listed harmful solid waste as a major global environmental problem for focused management in 1983. This kind of solid waste is usually less in volume, and half of this kind of solid waste comes from the chemical industry. According to statistics, the amount of hazardous solid wastes generated has reached 10 000 000 t in 2002.

Radioactive solid waste comes mainly from nuclear fuel emissions in nuclear power stations, isotope applications research institutes and the disposal of radioactive wastes in medical organizations *etc*.

Among the four types of solid wastes, namely domestic waste, general industrial solid waste, harmful solid waste and radioactive solid waste, the radioactive solid waste and harmful solid waste are classified as substances under special management because of the great hazards they cause to the environment.

3 Pollution hazards of agricultural solid waste

The amount of solid waste discharged is very large, and the distribution of solid waste is scattered. Especially, some solid wastes contain a fair amount of organic substances or plant nutrients including nitrogen, phosphorus and potassium *etc*. The agricultural application of solid wastes has become one of the important ways to solve the problem of solid waste. However, unreasonable agricultural utilization of solid wastes can also cause harm to the agricultural environment to varying degrees.

3.1 Possible hazards of general agricultural solid wastes

Domestic wastes contain a fair amount of organic substances and plant nutrients, which can be applied in farmland so as to reclaim soil, improve soil fertility and increase crop yield. Therefore, extensive attention has been paid to the superiority of the agricultural utilization and resourceful treatment of wastes in recent years. On the other hand, improper waste disposal may cause different levels of environmental pollution and hazards due to the complex components and varying particle sizes of the wastes as well as the high content of heavy metal, worm eggs and pathogenic microorganisms. Firstly, a negative impact may be produced to the physical and chemical properties of soil. Results of the tests conducted by the Soil and Fertilizer Institute, Chinese Academy of Agricultural Sciences have shown that the gravel (grain size >2 mm) and sand – grain (grain size >0.01 mm) content in the soil layer of 0 – 20 cm will increase and the clay (grain size <0.005 mm) and silt (grain size of 0.01 – 0.005 mm) content in the soil will be reduced when 150t of wastes without strict treatment are applied in a hectare of land. This will give rise to a reduction in water and fertility retention of soil and reduce the cation exchange capacity of soil by 13% – 22%. In this way, a serious loss of nitrogen and potassium will be caused. Secondly, long-term application of wastes may cause the accumulation of heavy metals in farmland soil. After the cornfield test for two consecutive years, the Soil and Fertilizer Institute of Chinese Academy of Agricultural Sciences has found that the heavy metal content in the wheat grains produced from the farmland with waste application of 7.5t per hectare each year is significantly higher than the wheat grains produced from the farmland without waste application. Thirdly, more and more organic synthetic materials and their products will enter the farmland with the wastes, thus leading to environmental pollution. Organic chemical products such as broken plastic films enter the farmland with the wastes, which will impede the moisture transport of soil and the elongation of plant roots. Beside, these organic chemical products will release toxic and harmful substances slowly, resulting in soil and water pollution[2]. The fourth, the application of wastes without strict hazard-free treatment in the farmland will bring a large amount of pathogenic bacteria, viruses and parasitic ova into the soil. These harmful substances will become the propagating source of various diseases. Therefore, the wastes for agricultural application must be screened carefully and treated strictly so as to protect the farmland soil and ecological environment from being polluted. Only under this premise can the wastes be used as the soil conditioner or fertilizer of soil.

3.2 Harm of sludge Sludge is the solid part precipitated in the sewage treatment tank during the sewage treatment in the sewage disposal plant. After dewatering, the organic content of sludge is generally 45% – 80%, and the ash content is 20% – 50%. In addition, sludge is rich in nitrogen, phosphorus, potassium and other trace elements. Therefore, dewatered sludge is often applied in the farmland as soil conditioner or fertilizer. However, sludge has complex compositions. It often contains heavy metals, pathogenic microorganisms, organic compounds and some other toxic components. For example, the heavy metal content in sludge is often several times or even dozens of times higher than the waste water. Improper application of sludge will affect crop growth and cause soil pollution. In addition, the pollutant content in agricultural products will be increased. After entering the food chain, these pollutants will further cause harm to the health of people and livestock. At present, there is no effective hazard-free treatment method for the heavy metals and some other pollutants in sludge. In addition to the heavy metals, there are also the problems of extreme pH value and high salinity content *etc*. in the sludge. The long-term application of large amount of sludge in soil will give rise to a deterioration of its physical and chemical properties, soil hardening and secondary salinization *etc*. Moreover, the organic substances contained in the sludge are often in the reducing condition, especially after the application in the paddy field. These substances often cause a reduction in the soil redox potential and place the soil in strong reducing conditions, which will lead to a poor root development or even rotting. The bacteria and parasitic ova contained in the sludge may also cause harm to the growth of crops including grass and vegetables, and facilitate disease transmission.

3.3 Harm of coal ash Coal ash is the waste discharged by coal-fired power plant or coal burning power house after coal burning. Its compositions mainly include the superfine spongy hollow glass spheres, crystalline substances and some unburned carbon.

The physical and chemical properties of coal ash depend on coal category, place of origin, crushing fineness, combustion mode and ash collection method (precipitation after water flushing or direct emission in the dry state). Containing trace elements including Al, Si, Fe, Ca, S, B and Zn, coal ash is usually slightly alkaline with a pH value of 8 – 9. As coal ash is rich in Si, Ca and some other trace elements, is can be used as raw materials to produce silicon-calcium fertilizer. Besides, coal ash can be added to organic compound fertilizer as an additive so as to increase the pelletizing intensity of organic compound fertilizer and improve the physical and chemical properties of the fertilizer. Moreover, coal ash can be mixed with the other organic wastes to produce soil improvement agent and artificial nutrient soil so as to reclaim soil and promote the growth of special crops including ornamental plants. Obviously, excessive coal ash application will lead to an increase in pH value of farmland soil, soil desertification and heavy metal pollution of soil[3].

4 Prevention of solid waste pollution

As compared with wastewater, exhaust gas and noise pollutions, solid waste has the characteristics of high mobility, non – diffusion and long duration. In addition, the effects of pollution may be shown after a long period. That is to say, solid wastes can be the secondary pollution source for the other environmental elements. Therefore, new technologies and new processes such as Cleaner Production should be applied to minimize solid waste emissions. Besides, the management of solid wastes should be strengthened to turn the harm into a benefit by recycling the solid wastes and reducing the pollution load of the environment through comprehensive development and utilization of solid wastes.

4.1 Technical policy to control solid waste pollution Since the 1970s, many developed countries have put forward the concept of "Resources Recycling" due to a lack of disposal sites for solid wastes, high disposal cost and resource shortage. Comprehensive treatment for solid wastes has been promoted to recycle solid wastes. Our country began to promote the recycling technologies for solid wastes from the early 1980s and has put forward the technical policy of "Recycling, Harmless and Reducing" to control solid waste pollution. Later, the concept of "Circular Economy" has been proposed. Due to reasons such as funding and technology, the solid waste disposal and utilization in our country is carried out according to the principles of reducing, harmless and recycling.

The above mentioned "Reducing" is the treatment of reducing solid waste emissions during the production process through technical progress and technological innovation. For the solid wastes already discharged, reduce the amount or volume of them through appropriate reducing measures such as composting and incineration. In this way, the amount and volume of solid wastes discharged can be greatly reduced.

Harmless treatment refers to solid waste disposal in the ways of sanitary landfill, high-temperature composting, methane fermentation, incineration and pyrogenic decomposition *etc.* to protect human health and ambient environment from being damaged or polluted. There are many harmless treatment methods. Appropriate treatment methods should be chosen according to the type and characteristics of solid wastes as well as the costs required for treatment. Recycling refers to material and energy recovery from solid wastes by taking technological measures or the reuse of solid materials. For example, coal ash can be used to produce silicon-calcium fertilizer, and steel slag can be used as the raw materials of cement.

4.2 Control approaches of solid waste pollution

4.2.1 Improving and transforming the production process. The amount and types of solid wastes produced are directly determined by the production processes applied. At present, the technologies, equipments and production processes applied in many enterprises of our country lag behind the developed countries. There are also the problems of unreasonable resource and energy utilizations, low production, poor quality, huge material waste and high energy consumption during the production process. In this way, a large amount of solid wastes have been produced. Therefore, in order to solve the problem of large amount of solid waste emissions, the first priority should be given to the upgrading of old equipments and improvement of manufacturing techniques, thus to reduce energy consumption, increase the utilization efficiency of raw materials and realize "Cleaner Production".

4.2.2 Promoting multi-stage utilization process of raw materials. In view of the production process of different products, the wastes discharged in producing a product can be used as the raw materials of the next product. Therefore, the multi-stage utilization process is promoted to utilize the wastes produced from the first product as the raw materials of the next product. In the same manner, the wastes produced from the second product can be used as the raw materials of the third product. In such a way, the multi-stage utilization of a raw material can minimize the amount of wastes emitted to the environment while optimizing the comprehensive benefits in terms of the economy, environment and society.

4.2.3 Comprehensive utilization of solid wastes. The comprehensive utilization of solid wastes by taking appropriate measures and processing technologies can serve to solve the environmental problems brought by solid waste emissions very effectively. For example, the municipal solid wastes can be recycled by sorting out the iron, glass and plastics in them. After that, high-temperature composting can be performed for the remaining part to produce organic fertilizer. This is just one example for the comprehensive utilization of solid wastes.

4.2.4 Harmless treatment and disposal of solid wastes. According to the types and compositions of solid wastes, thermal treatment, solidified treatment, composting fermentation and other relevant treatment methods can be applied to dispose solid wastes, thus ensuring that the wastes meet relevant emission standards and making solid wastes harmless.

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general, (1) *Caragana microphylla* community has an obvious wind-breaking effect near ground surface. Compared with shifting dunes, the wind velocity in the 6-year-old and 11-year-old C. microphylla shrubs at the height of 30 cm separately decreases by 71.86% and 75.96%. (2) After restoration of artificial vegetation, the mean daily temperature in the 6-year-old and 11-year-old C. microphylla communities is significantly lower than in shifting dunes, the relative humidity of air is significantly increased, while daily changes of temperature of surface soil decrease.

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4.3 Strict enforcement of control standards for agricultural utilization of solid wastes As mentioned, agricultural utilization of solid wastes is one of the effective ways of recycling. For example, steel slag can be processed into silicon fertilizer, and coal ash can be processed into silicon-calcium fertilizer. In addition, many industrial residues can be applied directly in farmland soil as soil improvement agent. For instance, the by-product of phosphate fertilizer production is phosphogypsum, which can be used for improving alkaline soil. After appropriate crushing process, blast furnace slag can be used as soil improvement agent to improve the soil with heavy texture and poor permeability. Improper use of these solid wastes will result in serious consequences including soil contamination and land degradation *etc*. After soaking into the soil, heavy metals and the poisonous and harmful organic compounds will affect crop growth and will enter the food chain after being absorbed by crops. Ultimately, human health will suffer serious hazards. Excessive application of solid wastes could also result in secondary salinization, acidification or alkalinization of soil as well as soil texture deterioration due to the mixing of impurities including glass fragments. And of course, those heavy metals and organic pollutants soaking into the soil will continue to move in the soil mass and even reach the underground water under the action of rainfall or irrigation water. In this way, a greater range of environmental pollution will be caused. Therefore, the agricultural utilization of solid wastes should be conducted very carefully in strict accordance with national control standards on agricultural utilization of solid wastes. Besides, through discussion and demonstration should be carried out. When necessary, field trial can be performed on a small scale. And then extend the scope of application with reliable data obtained[4].

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