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Study on main problems and countermeasures of soil pollution control in China

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Abstract: *Soil pollution prevention and control provides an important guarantee for the safety of human production life and the sustainability of ecological development. This study systematically describes the types and characteristics of soil pollution, causes and hazards of environmental pollution, pointing out the exist soil environment and analyzing the problems and the corresponding control measures, and putting forward the future main direction of soil pollution control and suggestions, hoping for the soil environmental pollution prevention and control work throughout the country putting forward the corresponding suggestions for reference.*

Keywords: *soil pollution; pollution prevention; soil monitoring; pollution control*

Soil pollution control is related to food production, groundwater safety and a series of issues, and through the food chain involved in the cycle, closely related to human life. Therefore, soil pollution control is very important for people's production and life. In recent years, soil pollution has become more and more serious in China due to the accelerated pace of industrialization and urbanization. Studies have shown that the overall situation of soil environmental quality in China is declining[1-2], largely due to the diversity of pollutant types, the coexistence of old and new pollutants and the combination of pollution[3]. In addition, soil pollution control itself has the inherent characteristics of long time cycle and difficulty, which furtherly increases the difficulty of soil pollution control.

China's research on soil pollution was launched in 2005, focusing on the study of China's land status and pollution prevention and control. With the progress of science and technology, the research gradually extends to develop water fertilizer regulation and remediation technology[4-7]. At present, domestic and overseas focus on soil remediation, and strive to promote the development of soil pollution prevention and restoration technology[8-11], some researches on soil remediation are guiding and promoting the development of soil pollution prevention and control. However, systematic overview of soil remediation theory and technology is still relatively lacking[7, 12-13]. In this study, the types and characteristics of soil pollution, the causes and hazards of soil pollution, the existing problems and corresponding prevention and control countermeasures were comprehensively sorted out, aiming to furtherly clarify the development direction of soil pollution control in the future.

1. Overview of soil pollution

Soil pollution is a process formed in human activities, flowing into the land through different channels and its total amount greater than the capacity and absorption capacity of the land, resulting in changes of the physical properties and structural characteristics of the land, decline of the natural function and quality of the land.

1.1 Types and characteristics of soil pollutants

In a broad sense, soil pollutants mainly include inorganic pollutants, organic pollutants and radioactive pollutants, of which the sources of radioactive pollutants are relatively stable and easy to identify, but due to the complex sources of inorganic pollutants and organic pollutants leading it difficult to identify. At present, there are about 40 kinds of inorganic pollutants involved in the analysis of soil pollution sources such as lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn), chromium (Cr), arsenic (As), mercury (Hg), nickel (Ni) and other elements more concerned. Organic pollutants are mostly polycyclic aromatic hydrocarbons (PAHs) and oxygen-containing derivatives[11, 14]; radioactive pollutants are mainly radioactive elements such as strontium (Sr) and cesium (Cs) with long half-life in

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soil. See Table 1 for details.

Table 1: Soil pollutant types, source characteristics and corresponding typical pollutants

Types of soil pollutants	Source characteristics	Typical pollutant
Inorganic pollutant	more fixed generally and easy to identify	Pb, Cd, Cu, etc
Organic pollutant	complex and difficult to identify	PAHs and its oxygen-containing derivatives
Radioactive contaminant		Sr, Cs, etc

1.2 Soil pollution hazards

The harm brought by soil pollution is imperceptible, difficult to reverse and involve a wide range. On one hand, pollutants directly or without proper treatment into the soil will produce "soil-plant" accumulation effect, especially heavy metals, which will seriously damage the physical and chemical properties of the soil and the oxidative decomposition function, thus causing a major impact on food security and the food chain of the ecosystem, and easily cause health and safety problems. On the other hand, due to the strong dependence of agricultural modernization on industrial production of organic substances, a large number of organic substances such as pesticides, mechanized use of petroleum, plastic products and organic compounds in the process of farming into the soil will cause soil pollution. This will not only lead to the decline of food quality and yield, but more seriously, DDT and BHC and other chemicals will be transformed and enriched at different nutrient levels through the ecosystem, which will eventually lead to sustained spatio-temporal damage to the soil[15].

1.3 Causes of soil pollution

There are many reasons for soil pollution. At present, part of soil pollution comes from the random stacking or landfill of all kinds of household garbage. Many chemical substances cannot be degraded, which lead to soil pollution. At the same time, the negative impact of industrial activities on the local soil environment is also very prominent, the waste liquid and residue of industrial production is permanent pollution to the soil. Secondly, the development of technology related to agricultural activities that brings efficient benefits to local people often causes soil pollution. Unreasonable operation such as excessive use of organic fertilizers and random discarding of plastic films can easily lead to direct inflow of heavy metals from chemical fertilizers into the soil, thus affecting soil quality and pH. In addition, air pollutants such as SO_2 and automobile exhaust will form acid rain and other pollutants in the process of precipitation and re-enter the soil to produce secondary pollution.

2. Current problems of soil pollution prevention and control

2.1 Prevalence of soil pollution in China

The present data show that soil pollution is universal in China. At present, 48% of China's soil is severely polluted, 23% is considered to be unusable, and 34% of the non-severely polluted soil is mildly polluted[16]. From the perspective of soil pollution distribution, soil pollution in southern China is more serious than that in northern China. The main problems of soil pollution were obvious in the Yellow River Delta, Pearl River Delta and the old industrial base in northeast China. The area of soil organic heavy metals exceeding standard is large in southwest and central south region. The concentrations of cadmium, mercury, arsenic and lead increased gradually from northwest to southeast and from northeast to southwest, respectively[17-22].

2.2 Typical events of soil pollution in China

In recent years, the frequency of typical soil pollution events has gradually increased, especially heavy metal pollution. As the surrounding industrial factories and mines discharge a large amount of sewage into the river, and the sewage is used for irrigation of rice fields, thus causing the occurrence of "cadmium rice" accidents in many places in China. For example, in 1997, Jiangxi Nonferrous Metal 4 geology teams found in Dayu County of Jiangxi Province that cadmium exceeded the standard of rice

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in tungsten mine area. In 2008, researchers from the Institute of Geology, Chinese Academy of Sciences found serious lead and cadmium pollution in rice in Fenghuang lead-zinc mining area, west Hunan. In 2013, media visited Guangzhou and Hunan production area of cadmium rice and found that cadmium exceeded 50% in rice factory self-inspection. In addition, some serious site soil pollution accidents will cause great damage to human health. At the end of 2015, a school of Jiangsu Province were found to "toxic land", the plot of soil contamination caused hundreds of students physical abnormal reaction, final investigation study found that the site is rooted in the school in a chemical plant, the plot has long-term soil contamination in land restoration, and groundwater security threat to school[23]. Therefore, attention should be paid to the prevention and disposal of large-scale soil pollution events.

3. Study on countermeasures of soil pollution control

There are many laws on soil pollution prevention and control in China, such as The Constitution, Environmental Protection Law, Agriculture Law, Land Management Law and Regulations on Protection of Basic Farmland, etc., which have laid a framework foundation for the protection of soil environment. In 2016, the Action Plan for the Prevention and Control of Soil Pollution was issued, furtherly clarifying rights, responsibilities and relevant rules. With the gradual deepening of understanding, soil pollution prevention and control measures tend to be more comprehensive, systematic and professional, not only issue the corresponding policies and regulations to improve the soil pollution supervision and punishment mechanism, but also make full use of new technologies and new means to improve the monitoring, prevention and treatment of soil pollution.

3.1 Macro policy for prevention and control of soil pollution

In the face of severe soil pollution situation, China promulgated the Soil Pollution Prevention and Control Action Plan in 2016, and formulated control standards for 85 pollutants through the Soil Environmental Quality Construction Land Soil Pollution Risk Control Standards (Trial), which largely promoted soil environmental protection. However, the basic research on soil pollution source analysis, source tracing, management and prevention and control is still weak, needing to be further strengthened. In 2018, China launched the Soil Pollution Prevention and Control Law, which provides professional regulations on soil pollution and clarifies detailed rules for soil pollution risk control and remediation, including soil pollution status investigation, risk assessment, risk control and effect assessment, remediation and effect assessment, and post-management[23-24], the scope of soil pollution risk control and remediation system was further defined. On February 16, 2022, The State Council issued the Notice on carrying out the Third National Soil Survey, aiming to have a comprehensive understanding of soil types and distribution patterns, as well as the current situation and changing trend of soil resources in China within four years, and grasp accurate data on soil quality and utilization, so as to improve the protection and utilization of soil resources. This will also provide strong support for soil pollution control in China in the future.

3.2 Technical means for monitoring soil pollution prevention and control

Traditionally, it can be inferred that the soil may have been seriously polluted by observing whether the plot gives off peculiar smell, changes in color, hardening, diseased or dead plants, crop yield, etc., or whether there are long-term piles of domestic, construction and industrial wastes or sewage discharge around the plot[25]. This method is intuitive, but lacks quantitative experimental data measurement, so the results are difficult to determine the pollution degree, especially for heavy metal contaminated plots or slightly polluted plots.

With the rapid development of information technology, computer technology and electronic monitoring equipment have been gradually applied to land pollution monitoring. Using these information technology means soil monitoring, and further analysis of monitoring data to judge soil quality. At present, the soil environmental monitoring technology mainly includes 3S technology, biological technology, information technology and physical and chemical technology. 3S technology includes GIS, RS and GPS, which can be combined with computer technology to obtain soil information. Biotechnology is based on biosensors, nucleic acid probes and other technical means to monitor and evaluate the soil environment. Information technology such as wireless sensor technology realizes soil environment monitoring and control through computer and network service. Physicochemical technology obtains environmental monitoring data through physicochemical reaction,

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which has higher accuracy[25-26]. It should be noted that the advances and universality of current soil monitoring techniques and methods are not well balanced, and further improvement is needed.

3.3 Evaluation of soil pollution

The severity of land pollution can be expressed by soil pollution index. Soil pollution index, also known as soil environmental quality index, is a measurement standard to measure the status of land pollution and a quantitative evaluation method of soil quality. Currently, as a key indicator of soil pollution control and rational land use management, it has been widely used. According to the properties of soil pollution sources and the importance of soil evaluation, the basic evaluation parameters usually choose soil acidity, organic toxicants, heavy metals and other non-metallic toxicants, and then choose the background value of soil in the study area as the background value for further judgment. At present, single pollution index (Pi) and compound pollution index (P) are commonly used to evaluate soil pollution indexes, and their calculation formula is as followed[27-28]:

$$P_i = C_i / S_i \quad (1)$$

$$P = \frac{1}{n}\sum_{i=1}^{n} C_i / P_i \quad (2)$$

Where: P_i is the pollution index of a single pollutant; P is the comprehensive pollution index of various pollutants; C_i is the measured concentration of soil pollutant i; S_i is the evaluation standard of pollutant i; n is the number of polluted species.

P_i and P directly reflect the overshoot rate and pollution degree. When $P_i \leq 1$, the soil is not polluted. Conversely; when $P_i > 1$, it indicates that there is soil pollution. P value directly reflects the degree of soil pollution.

3.4 Methods for prevention and control of soil pollution

Table 2: Soil pollution control methods

Soil pollution control methods	Advantages	Disadvantages
Foreshadowing the guest earth method	The loam texture can be achieved by gradual improvement year by year.	Large amount of engineering, high cost, suitable for small site
Mixed layer method	The improvement effect is obvious in alluvial plain area.	For the upper and lower soil texture requirements, the underlying soil layer should be ≤50cm
Reverse method	It is suitable for areas with high level of topsoil pollution.	For the upper and lower soil texture requirements, the underlying soil layer should be ≤50cm
Flood diversion and sedimentation method	It can thicken soil layer and improve quality of a material, fertile soil.	Difficult to operate, sand and silt overflow ≤10cm each time
Soil improvement method	It can improve soil over sand or sticky bad properties, enhance soil water retention, fertilizer retention.	Large areas of sand or clay cannot effectively change texture in a short time

The traditional method of soil pollution control is to prevent waste water, waste residue, waste gas and agro-chemical substances from entering the soil. At present, the soil pollution prevention and control methods widely recognized are mainly bedding guest soil method, mixed layer method and inverted layer method, flood diversion channel silting method, soil improvement method and so on. Paving the guest soil method refers to the contaminated land on the spread of a layer of soil has not been polluted, or the contaminated soil removed to pave road subgrade and construction materials, the quality of the soil laid in the original place; the mixed layer method is to mix the contaminated soil on the surface and the clean soil at the bottom after ploughing. Once the contamination degree of surface soil is high, the upper and lower layers of soil are translocated by inverted layer method. Flood diversion and sedimentation method are to lead the Yellow River water or flood which is rich in silt, and speed up the flow rate by opening the field furrow mouth low, so that more sand is deposited, so as to achieve the effect of silt to improve the clay soil; on the other hand, raising the field border and slowing down the flood velocity can make more fine particles deposit to achieve sandy soil

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improvement. Soil improvement method refers to the screening of contaminated soil chemical components, and through the application of silicate, lime phosphate and so on to adjust the soil to the most suitable growth conditions for crops. See Table 2 for details.

4. Expect

Soil pollution has great potential risks and is difficult to manage, so the prevention and control of soil pollution will not be ignored in the future. In the future work, we should continue to improve the relevant laws and regulations, constantly optimize the supervision and management system, and improve the illegal cost of soil pollution. At the same time, expand the use and promotion of organic compound fertilizer in agricultural production; speed up technological upgrading and transformation, improve the utilization rate of "three wastes"; accelerating the development and utilization of clean energy; actively explore and develop new and more targeted remediation technologies for soil pollution.

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