Research on Contaminated Soil Remediation Based on the Present Situation of Soil Pollution in China

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Abstract: The problem of soil pollution in China is increasingly prominent, which seriously affects agricultural activities, even the health of the people, and hinders the smooth progress of sustainable development. Given that the problem of soil pollution needs to be solved urgently, this paper systematically introduces the overall situation of farmland soil pollution in China firstly, and then analyzes and compares the policies of soil remediation in China in recent years, to probe into the existing remediation technologies and the current research situation of domestic technologies. Finally, the Ten Articles of Soil is summarized, to put forward reasonable suggestions on the policies, technologies and management aspects of soil remediation.

1. Introduction

Soil is crucial and basic for social development. The distribution of soil pollution is obviously regional, and farmland, industrial sites, cities and other places are seriously polluted. Irrational and excessive use of chemical fertilizers, discharge of heavy metals and industrial wastes are the main sources of soil pollution. The National Soil Pollution Survey Communique released by the Ministry of Environmental Protection and the Ministry of Land and Resources in 2014 shows that the total over-standard rate of soil in the country is about 16.1%, of which the over-standard rate of farmland sites is as high as 19.4%, mainly due to heavy metal pollution such as cadmium, nickel, copper, arsenic, mercury, etc. Serious pollution accounts for 1.1% of the pollution sites, while cadmium, which can accumulate in organisms and cause chronic poisoning through the food chain, accounts for about 0.5% [1].

In terms of the distribution of soil pollution, the pollution in the southeast is obviously heavier than that in the northwest, and the pollution in the south is heavier than that in the north. The point distribution of soil pollution is obvious and regular. Soil pollution is serious in economically prosperous areas. Soil quality is obviously poor in Shanghai-Nanjing-Hangzhou area, northeast heavy industry base, Changsha Zhuzhou District, Guiyang and other places in the middle, and the pollution area is gradually increasing. Overall, the soil environment situation is grim and the prospect is worrying.

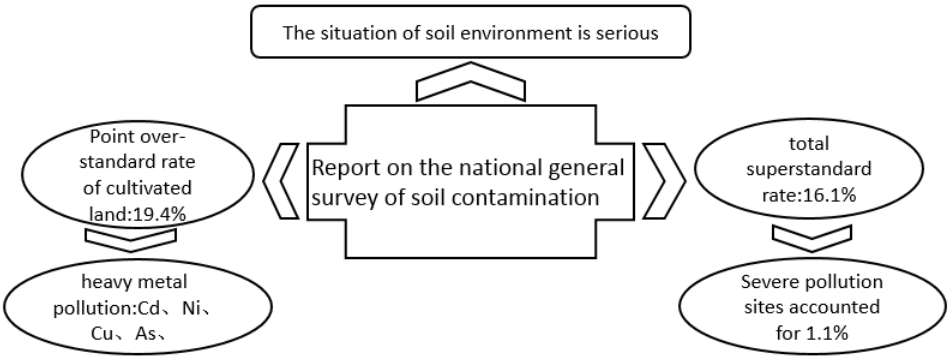

Fig.1 Data of National Soil Pollution

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2. Farmland Soil Pollution

2.1. Types of Farmland Soil Pollution in China

The types of cultivated land soil pollution in China can be roughly divided into two types: one is heavy metal soil pollution, and the other is organic pollution. Sources of heavy metal pollution in soil should be analyzed from two aspects: self-source and environment. The self-source is soil developed under natural conditions in different regions. The parent material and process of soil formation are different, and the content of heavy metal in soil itself is also different. For example, the content of heavy metal in soil itself in the central Yunnan-Guizhou Plateau region is not low. However, the environmental source is in the process of soil utilization. Heavy metal pollution in soil is also aggravated by sewage irrigation, mining and smelting, the use of phosphorus-containing fertilizers and organic manure, and atmospheric deposition [2]. For example, due to the long-term cultivation of crops with fertile soil, the use of chemical fertilizers and the discharge of industrial three wastes in the Yangtze River Delta Basin, cadmium pollution in the Yangtze River Delta Basin accounts for 40% of the heavy metal pollution [3]. Organic pollution includes pesticide, straw burning, dry and wet sedimentation process, etc. Chemical fertilizers and pesticides such as fungicides and pesticides, China produces about 500,000 tons of pesticides every year to meet the development needs of China's agriculture. Nearly 90% of them enter the soil environment, with Zhejiang being the most serious. With the accumulation of dosage and time, toxic residues of pesticides are increasingly enriched. More than 870,000 hectares of farmland in China are threatened by organic pollutants of pesticides [4].

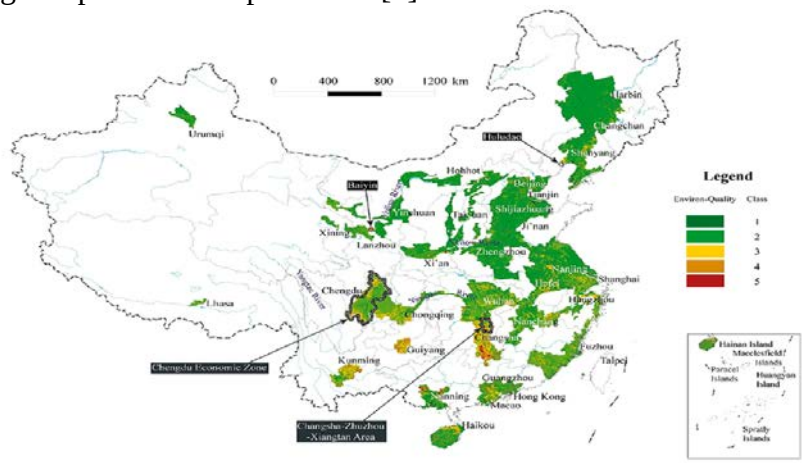

Fig.2 Spatial and Temporal Distribution of Farmland Soil Pollution in China

2.2. Hazards of Farmland Soil Pollution in China

Due to the low awareness of soil protection in China and the late implementation of practical actions, the coexistence of new and old pollutants causes long-term damage, which leads to the deterioration of soil quality. The impact is gradually expanding in scope and deepening in degree. At present, it can be roughly divided into four aspects.

(1) Effects on Plants. Soil with excessive heavy metal content will affect the absorption of nitrogen, phosphorus, potassium and other nutrient elements by plants or crops. At the same time, plants absorb some heavy metals and other toxic substances in the soil and produce substances that are not conducive to their physiological development, thus causing plants to have problems such as yellow leaves, high plant height, etc. Both the quality and output of crops have been reduced due to soil pollution. It is the deterioration of soil pollution that causes the output of agricultural products to fall below expectations and results in a loss of more than 20 billion yuan each year [5].

(2) Impact on Animals. Heavy metal and organic pollution in the soil have destroyed the ecological balance of the soil. The original habitat change of animals in the soil has reduced their communities and threatened their biodiversity.

(3) Effects on Soil Enzymes. Soil enzymes in soil are easy to be polluted by heavy metals, and the molecular structure is destroyed and decomposed, which changes the activity of soil enzymes to

a certain extent, thus affecting the normal chemical reaction. Moreover, different heavy metals also have different effects on different soil enzymes, temporarily and permanently damaging, and the content of heavy metals is usually proportional to the degree of destruction of soil enzymes [6].

(4) Harm to Human Health. Toxic substances in the soil enter the human body through crops, and the toxic substances are gradually enriched. As the top of the food chain, long-term intake of food containing toxic substances such as heavy metals is harmful to health and even life safety.

3. China's Soil Pollution Remediation Industry Situation and Development Trend

At present, the domestic soil remediation industry chain is divided into three steps. Step 1: The preliminary stage includes research and design, making relevant plans and budgets for the long-term strategy in the future, introducing advanced technologies to research and develop relevant equipment and devices, and testing the pollution level of soils with different textures in different regions. Step 2: In the medium term, it includes applying for funds from the government or attracting relevant enterprises and investment institutions, increasing financing and ensuring the source of funds for the restoration industry. Step 3: in the later stage, it is mainly to increase publicity and increase the proportion of soil pollution remediation in environmental remediation.

There is a huge development space for the soil pollution remediation industry. At present, the output value of soil pollution remediation is negligible in the total value of environmental protection, while countries such as the Netherlands and the United States, which started the soil pollution remediation industry earlier, have increased the proportion of the output value of soil pollution remediation to nearly one third. As a big country that is developing and exploring in this industry, China's soil pollution remediation market will have a great leap forward in the future with the gradual improvement of the national awareness of soil protection, the supplement and improvement of the policy and legal system year by year, the improvement of the relevant protection system, the expansion of market demand and the gradual increase of relevant enterprises and investment institutions.

Farmland soil remediation policy. Soil remediation started late in China, and the related environmental quality standard for soils was promulgated at the end of the 20th century, and environmental quality assessment standards for edible agricultural products and greenhouse vegetable producing areas were successively promulgated in 2006. Ten years later, the soil pollution prevention Action Plan was launched, aiming at effectively preventing soil pollution and improving soil environmental quality. In 2018, the "soil pollution prevention Law of the People's Republic of China" was promulgated, which is a great progress in China's exploration of soil pollution remediation.

4. China's Farmland Soil Remediation Policy System Characteristics

At present, China's farmland soil pollution remediation policy system has the following characteristics.

(1) Strengthening the foundation and consolidating the foundation. First of all, the soil environmental quality survey should be carried out in depth. Only by clarifying the current situation can the right remedy be found. In the information age, the advantages of the database should be fully utilized, the latest data on soil remediation should be acquired in real time and updated synchronously, and relevant management communication platforms should be established to facilitate the sharing of resources and the mutual exchange and supplement of experience technology [7].

(2) The rule of law thinking. In the decades of water pollution and air pollution control, the law has played an indispensable role and the rule of law has become the general trend. For the sustainable development of the land and the health of the citizens, the rule of law has been implemented and perfected year by year in our country.

(3) Classified management. Article 10 of the Soil distinguishes agricultural land from construction land and carries out soil pollution prevention respectively. It clearly stipulates the

classification of soil environmental quality of agricultural land. Those that are not polluted or with low degree of pollution are classified as priority protection, those with mild or moderate degree of pollution are classified as safe use, and those with serious pollution are classified as strict control.

(4) Risk Control. The control of soil pollution cannot be separated from proper risk control. Risk control has also been mentioned and emphasized many times in "Ten Articles of Soil", which can be summarized into four aspects: full implementation of strict control; strengthen the control of spatial layout; reducing pollution of rural life; governance and restoration will be carried out in an orderly manner.

(5) Prevention and protection. Measures for prevention and protection can be summarized as three strengthening and two establishing, namely, strengthening the protection, strengthening the environmental management of unused land, strengthening the prevention and control of pollution from livestock and poultry breeding, establishing comprehensive prevention and control advance zones, and establishing protection mechanisms and plans.

(6) Safe use. In agricultural production activities, the irrational application of chemical fertilizers and pesticides is an important cause of soil heavy metal and organic pollution, so the control of chemical fertilizers and pesticides is particularly important. Organic fertilizers have gradually become popular, encouraging farmers to use green organic fertilizers, promoting high efficiency, low toxicity, low residue pesticides and modern plant protection machinery.

(7) Clear responsibilities. According to the principle of "overall planning by the state, overall responsibility by the province and implementation by cities and counties", the enthusiasm of the people is mobilized, soil pollution prevention is vigorously publicized, and social supervision is strengthened.

(8) Industrial Development. Soil pollution remediation industry not only plays an important role in food security and agricultural development, but also plays a pivotal role in sustainable and green development of land resources. However, at present, China's relevant laws are not perfect, the public's awareness of environmental protection is low, social financing is insufficient, talents in the industry are scarce, and technology has not reached the advanced level. The remediation of soil pollution in Period is long, and the remediation speed is not as fast as the destruction speed [8].

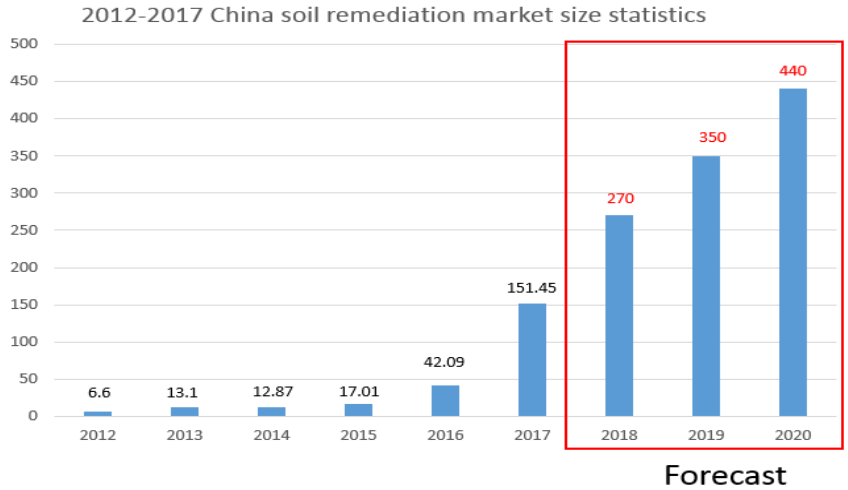

Fig.3 Soil Remediation Market Size Statistics in China

5. Discussion on Farmland Contaminated Soil Remediation

In terms of repair technology, it is mainly in situ and ex-situ remediation, and each has different branches in physical chemistry and biology.

In-situ remediation is carried out directly in contaminated soil areas without any remediation technology moving in space. In-situ remediation includes chemical oxidation/reduction method, soil leaching method, soil gas phase extraction method, enhanced soil vapor extraction, thermal desorption method, solidification and stabilization method at the physical/chemical level. Among them, soil vapor extraction is generally used in unsaturated zone to treat volatile pollutants in soil,

which has little effect on substances that are difficult to volatilize, and can be applied in combination with heating technology. However, it requires high ventilation of soil. In-situ biological treatment technology generally consists of plants, animals and microorganisms as the main body, and absorbs and degrades pollutants in the soil through certain functions of itself, so as to reach the required soil environment, and the absorption and degradation process of organisms can be artificially interfered.

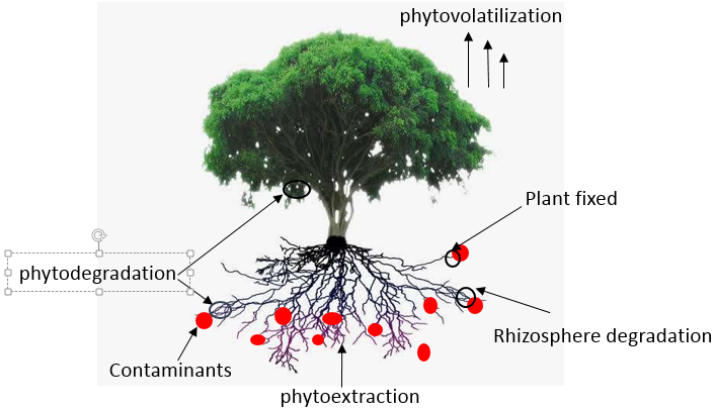

Fig.4 Schematic Diagram of Soil Pollution Plant Restoration Principle

In-situ soil leaching refers to injecting the leaching agent into the soil through the injection well according to the distribution position of pollutants. Under the influence of gravity or other forces, the leaching agent flows to remove soil pollution and form new migratable compounds through dissolution and other actions. Finally, the leaching agent can be reused or directly removed after being recycled through the extraction well. The method is easy to be influenced by soil physical and chemical properties, pollutant types and existing states. The soil texture is fine, viscous and permeable, leaching speed is slow, pollutant structure is stable, and leaching solution is difficult to repair due to poor degradability.

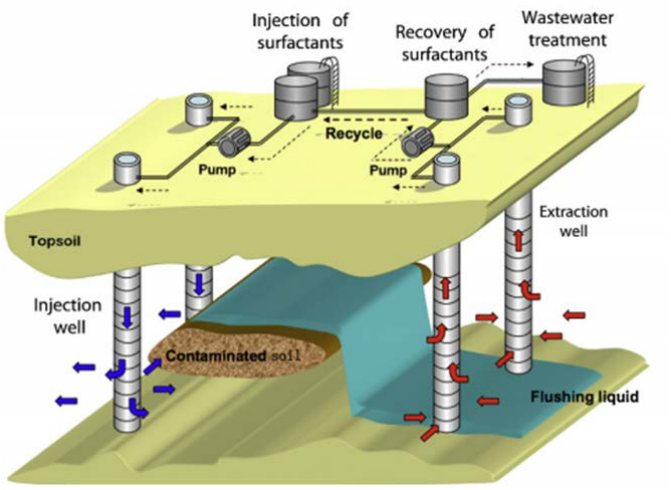

Fig.5 Schematic Diagram Of in Situ Soil Leaching

In-situ Stabilization is a simple, safe and effective method with low cost, so it is also widely used. Stabilization is mainly used to treat heavy metal pollution, including pH control technology and redox potential control technology, etc. The former uses alkaline substances such as lime and caustic soda to keep the pH within a range with the lowest dissolution value of heavy metal ions. The latter uses ferrous sulfate and sulfur dioxide to change redox potential and valence of heavy metal ions to reduce solubility. Soil stabilization materials come from a wide range of sources. Alkaline materials, materials containing phosphorus, iron and sulfur, clay minerals, organic mineral, redox agents and even activated carbon and zeolite can be used as materials to reduce pollutants. Among them, alkaline materials such as magnesium oxide and lime are widely used in China.

In-situ remediation is a method with low cost, little damage to the soil structure and the surrounding environment, but long and incomplete harmless treatment for repairing Period.

Thermal desorption method, soil vapor extraction and enhanced type will produce a large amount of industrial pollution. Biological ventilation method is still in the trial stage in China.

Tab.1 Several Common Stabilizing Substances and Effects

++: great; +: good; -: harmful

Stabilizer	As	Hg	Cr(VI)	Pb	Cd	Zn
Basic materials	-	+	-	++/-	++	++/-
Phosphorus materials	-	+	-	++	+	+
Iron compound	++			+	+	+
Sulfide	+	++	++	+	+	+
Clay mineral	+/-	+	+/-	+	+	+
Organics	+/-	+/-	+/-	+/-	+/-	+/-
Reducing agent	-		++			
Oxidizing agent	+					
Acticarbon /Zeolite	+	++	+	+	+	+

Ex-situ remediation is divided into on-site and off-site types, which is widely used in small areas or areas with serious pollution, especially brown areas or factory areas, due to its obvious engineering effect, short time consumption and strong flexibility. The physical and chemical technology in ex-situ remediation is not completely similar to that in situ. For example, the ectopic steam extraction technology is to use vacuum suction to dig out the contaminated soil placed on the air pipe network so that the organic matter volatilizes and then flows out, thus achieving the purpose of restoring the soil. In addition to physical, chemical and biological remediation similar to in-situ remediation, heat treatment is also included. Heat treatment methods include thermal desorption, incineration, or co-disposal in industrial kilns to reduce pollutant content. The pollutants are automatically separated or volatilized after the soil is directly or indirectly heated to a certain temperature to achieve the purpose.

Apart from the in-situ and ex-situ remediation technologies, the engineering control technology with in-situ soil barrier coverage and its reinforced and ectopic soil barrier landfill treatment is also a popular method. The principle of barrier technology is to separate contaminated and uncontaminated soil by setting a barrier layer to prevent pollutants from diffusing and migrating through groundwater flow and other forms to pollute more potatoes, which has good effects on heavy metal pollution, organic pollution and composite polluted soil.

6. Conclusion

Soil treatment and environmental restoration is a long-term and slow process. Future soil remediation in China should be focused on policies, technologies and management. Firstly, in terms of policy, the environmental quality standard and the soil pollution remediation effect requirement standard should be unified, and a reasonable soil remediation system and pollution prevention fund mechanism should be established. Besides, a good remediation external environment should be created, such as training specialized personnel, broadening financing channels, improving supporting industry chains, and realizing the transformation to a standard model based on risk control. Secondly, it is necessary to improve the technical level, adjust the proportion of components in different soil remediation technologies, and develop multi-method combined technology or "one technology for multiple purposes". For example, plants with super-enrichment function can be developed into new plants capable of enriching multiple heavy metal ions through genetic modification and recombination. Finally, in terms of management, supervision, inspection and punishment measures should be strengthened in the future to form a good pattern of polluters pay, beneficiaries share and owners compensate.

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