ISSN: 2710-0723

Chemical Technology and Development Trend of Contaminated Land Remediation

Tianqing Chen[1,2,3,4,5], Hang Zhou[2,3,4,5], Ying Wang[2,3,4,5]

[1] Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an,710075, China

[2] Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an,710075, China

[3] Key Laboratory of Degraded and Unused Land Consolidation Engineering, Ministry of Natural Resources, Xi'an,710075, China

[4] Shaanxi Engineering Research Center of Land Consolidation, Xi'an,710075, China

[5] Land Engineering Technology Innovation Center, Ministry of Natural Resources, Xi'an,710075, China

Abstract

In recent years, the rapid development of industry and agriculture in China has led to the destruction of soil environmental quality caused by pesticides, heavy metals and other pollutants entering the soil, and the decline of crop yield and quality. Therefore, soil pollution remediation is urgent, and it is urgent to explore the remediation technologies of polluted land with good remediation effect, low cost and popularization. This paper summarizes the relevant technologies in the literature, expounds several practical measures of chemical remediation technology of polluted land in detail, and discusses the development trend of contaminated land remediation technology in the future, in order to provide theoretical support for promoting the remediation technology of polluted land in China.

Keywords

Contaminated Land; Chemical Remediation; Technical Measures; Development Trends.

1. Introduction

As one of the most important components of the ecosystem, soil is inseparable from the survival and development of human beings, and soil health is directly related to the quality of crops. Safe soils are essential for the health of crops and people. With the rapid development of the country and the rise of cities and industrialization, a large number of heavy metals have been released into the environment of human existence, and heavy metal pollution has become a serious pollution problem[1]. The United Nations Environment Program has listed eight heavy metals including Pb, Cd, Cr, Hg, As, Cu, Zn, and Ni as priority pollutants for control[2]. According to the National Soil Pollution Survey Bulletin released in April 2014, the overall soil environment situation in China is not optimistic, and the pollution types are mainly inorganic pollution, and the number of inorganic pollutants exceeding the standard accounts for 82.8% of the total number of excess points. The heavy metal pollution in the soil around the non-ferrous metal mining area is serious[3]. A At the same time, surveys show that about 25 million hectares of agricultural land are polluted by heavy metals in the country, especially as many as 12 million tons of grain contaminated by heavy metals every year. The environmental protection monitoring system of the Ministry of Agriculture has investigated 82.23 million mu of soil in 320 seriously polluted areas in 24 provinces and municipalities across the country and found that the area of field agricultural products polluted exceeds the standard accounts for 20% of

ISSN: 2710-0723

the farmland area in the polluted area, of which heavy metals exceed the standard accounts for 80% of the polluted soil and crops, and the problem is very prominent[4].

Remediation of contaminated soil refers to the technical measures to reduce the concentration of soil pollutants and realize the harmlessness and stabilization of pollutants through physical, chemical, biological and ecological principles and artificial control measures, so as to achieve the desired detoxification effect. At present, theoretically feasible remediation technologies include phytoremediation, microbial remediation, chemical remediation, physical remediation, and comprehensive remediation[5]. Some restoration techniques have entered the field application stage and have achieved good results. The remediation of contaminated soil is of great significance to block the entry of pollutants into the food chain, prevent harm to human health, and promote the protection and sustainable development of land resources. At present, the research and development of this technology mainly focuses on the remediation of degradable organic pollutants and heavy metal contaminated soil. This paper summarizes the relevant technologies in the literature, expounds several practical measures of chemical remediation technology of polluted land in detail, and discusses the development trend of contaminated land remediation technology in the future, in order to provide theoretical support for promoting the remediation technology of polluted land in China.

2. Chemical Remediation Technology for Contaminated Land

2.1. Chemical Leaching Technology

Chemical leaching technology is a remediation technology that migrates or dissolves pollutants in the soil environment with the help of solvents or chemical additives, injects eluent into the contaminated soil through the action of hydraulic pressure or gravity, and finally extracts the liquid containing pollutants from the soil for separation and treatment. The key technical point is to improve the solubility of contaminants in contaminated soil and its migration in the liquid phase. Solvents or chemical additives should be substances that have a solubilizing or emulsifying effect or can change the chemical properties of the contaminant. This technology can be used to treat both organic and inorganic contaminants[6].

2.2. Chemical Oxidation/Reduction Technology

Chemical oxidation/reduction technology refers to the process of oxidizing/reducing pollutants in soil into low-toxicity products through the use of oxidation/reducing agents. Chemical oxidation/reduction technology is to drill wells at different depths in the contaminated area, and then inject the oxidation/reducing agent into the soil through a pump in the well, so that the oxidation/reduction agent is in full contact with the pollutants in the soil to undergo an oxidation/reduction reaction, so that the pollutants in the soil are decomposed into harmless substances [7]. This technique does not require the excavation of all contaminated soil.

Oxidation/reducing agents, injection wells, and extraction wells are the three elements of chemical oxidation/reduction technology. Before drilling wells, it is necessary to test soil and groundwater to study the characteristics of the underground soil layer and find out the area covered by the contaminated area and the actual location. Chemical oxidation/reduction technology is mainly suitable for the treatment of soils contaminated with oils, organic solvents, pesticides, non-aqueous chlorides and reduction-sensitive elements. After the remediation is completed using this technology, only harmless chemical reaction products such as water and carbon dioxide are generally available [8].

2.3. Solvent Leaching Technology

Solvent leaching technology is a technology that uses organic solvents to extract harmful chemicals from polluted soil, and then separates solvents and pollutants. The amount of time

ISSN: 2710-0723

the soil is soaked in solvents during separation depends on the characteristics of the soil and the nature of the contaminants. After leaching, the contaminants are either adsorbed in the medium or enriched at the bottom of the distillation section for further processing. Through the air heating device, the remaining solvent trapped in the soil can be transformed from liquid to gaseous state, escape from the soil, and then become liquid after cooling, so as to achieve the purpose of recycling [9]. Solvent leaching technology can make some resources (such as oil) be recycled, but this method has the problems of complex process, long process and high treatment cost, and is more suitable for soils with high oil concentration.

2.4. Applied Amendments or Inhibitors

The amendment or inhibitor method refers to the input of amendments or inhibitors into the soil to affect the redox, adsorption, antagonism or precipitation of pollutants in the soil, so as to reduce the remediation process of pollutants in the soil. The application of amendments or inhibitors to the soil is mainly for heavy metal contaminated soils, and some measures are also applicable to the remediation of organic contaminated soils. The application of amendments or inhibitors can reduce the diffusion, water solubility, and bioavailability of heavy metals in the soil environment, thereby reducing the content of heavy metals entering plants, microorganisms, and water, and reducing the harm of pollutants to the ecological environment [10]. The amendment or inhibitor method is suitable for moderately polluted areas, with good treatment effect and moderate cost, and is one of the economical and effective remediation technologies for contaminated soil. This method, if used in combination with agricultural measures and biological measures, will have a more significant treatment effect.

3. Development Trend of Contaminated Land Remediation Engineering Technology

3.1. Cultivated Land Pollution Remediation Engineering Technology

In view of the heavy metal pollution of cultivated land, combined with different soil physical and chemical properties, we developed efficient, rapid, economical, and universal passivation/stabilization remediation agents, built a professional pharmaceutical production line, determined and optimized engineering parameters such as the dosage ratio, passivation/stabilization time, and mixing mode, and developed supporting equipment for mixing pesticides and soil in combination with high-standard basic farmland fine leveling machinery [11,12].

In view of the organic pesticide pollution of cultivated land, the activation and degradation of indigenous microorganisms and the screening of engineering strains with stable expression were studied, and screening standards and methods were established, the preparation and addition of microbial agents and nutrients were developed, and the soil properties and microbial detection and monitoring methods in the remediation process were studied [13].

The above remediation technologies will help solve the shortcomings of soil structure destruction, high cost, and difficulty in the industrialization and promotion of technology in the current restoration process, greatly reduce the cost of remediation, promote the industrialization of passivation/stabilization remediation technology and microbial remediation technology with independent intellectual property rights, and open up a more cost-effective way of remediation of polluted cultivated land [14].

3.2. Mine Contaminated Land Remediation Engineering Technology

In view of the common characteristics of mine acid wastewater and mine tailings pollution in mine land, single remediation technologies such as neutralization and precipitation method, chemical redox method, and microbial remediation method and their enhanced technologies

ISSN: 2710-0723

were developed, and an efficient and stable continuous treatment system for acid mine wastewater was established, and technology integration and engineering demonstration were carried out [15].

The remediation technology of mine contaminated land will adopt passivation/stabilization remediation technology to reduce the migration and bioavailability of pollutants in the soil, screen new energy plants and their cultivation and afforestation methods, optimize the phytoremediation technology of tailings contaminated land [16], and develop complete sets of equipment suitable for mine tailings pretreatment, passivation/stabilization, and energy plant ecological restoration, and carry out pilot test and engineering demonstration.

3.3. Engineering Technology for Remediation of Industrial Contaminated Sites

In view of the problems of uneven distribution of pollutants, complex pollution, and relatively backward remediation technologies in industrial polluted sites after the relocation of township enterprises, the eluents, additives and proportions of different pollutants in heavy metal or organic polluted sites were developed, and key technologies such as soil pre-leaching treatment, recycling of leaching solution after leaching, and dewatering-stabilization of sludge and their modular integration were studied[17].

The industrial contaminated site remediation project will study the joint remediation technology integrating physical and chemical methods such as soil leaching and chemical oxidation and microbial remediation of the compound contaminated site, couple the key parameters of different remediation stages, study the material balance of each process unit, and develop a modular leaching equipment that can be disassembled and easily transported [18]. The research and development of this technology can solve the problems of small scale, low efficiency and low degree of equipment integration in China's contaminated soil leaching process, improve the current situation that a single remediation technology is widely used in industrial sites and the remediation cost is high, and effectively improve the level of technology industrialization and promotion.

3.4. Equipment for Remediation of Contaminated Land

The cultivated land contaminated land remediation project will develop in-situ microbial remediation equipment for cultivated land pollution, including microbial agent mixing and spraying equipment, and improved soil tillers; develop passivation/stabilization equipment for cultivated land pollution/mine tailings contaminated land, including soil/tailings pretreatment system, soil/tailings inlet and discharge system, chemical addition system, soil/tailings and chemical mixing system; Biological treatment and other units [19]. The industrial pollution remediation project will develop rapid soil leaching equipment for industrial polluted land, mainly including harmless treatment of leaching solution, soil leaching sludge dewatering-stabilization and other systems. The research and development of the above-mentioned remediation engineering equipment focuses on solving the modularization and integration problems of the main units, and plays a positive role in promoting the industrialization of cultivated land, mining and industrial pollution remediation engineering technology.

Acknowledgments

Intra-group Project "Ecological Environment and System Optimization Based on the Transformation of Market-oriented Major Scientific and Technological Projects" (DJNY-YB-2023-37), Intra-group Project "Integration of Agricultural Tourism Resources and its Spatial Effect under the Construction of Unmanned Farms"(DJNY2024-40).

ISSN: 2710-0723

References

[1] Cai Y.W., Chen X., Zhang P.Z. A study of ecological engineering methods for irrigation channel and its implementation procedures [J]. Journal of Chinese Agricultural Engineering (Taiwan), 2005, 51(3):78-84.

[2] Mitsch W.J., Jorgensen S.E. Ecological engineering: an introduction to ecotechnology[M]. New York: bWiley, 1989, 59.

[3] Gao Y.J. The study of quality evaluate and evolvement mechanism of soil sesertification betweet agriculture and husbandry interlace zone in north of Shannxi province[D]. Yangling, Shaanxi Province: Northwest University of Agriculture and Forestry Science and Technology, 2003.

[4] Wang J., Yan S., Guo Y., et a1. The effects of land consolidation on me ecological connectivity based on ecosystem service value: A case study of Da'an land consolidation proiect in Jilin province[J]. Joumal of Geographical Sciences, 2015, 25(5):603-616.

[5] Wang C F, Edwin D O. Transjurisdictional water pollution management: The Huai River example [J]. Water International, 2004,29(3):290-298.

[6] Li C.X., Wu K.N., Wu J.Y. Urban land use change and its socio-economic driving forces in China: a case study in Beijing, Tianjin and Hebei region[J]. Environment Development and Sustainability, 2018, 20: 1405-1419.

[7] Wang J., Zhong L.N. Problems and suggestion for developing ecological construction in land management work [J]. Transactions of the CSAE, 2017, 33(5): 308-314.

[8] Ye Y.M., Wu C.F., Yu J. Ecological design of irrigation and drainage ditches in agricultural land Consolidation[J]. Transactions of the CSAE, 2011,27(10):148-153.

[9] Zhang R.Z., Zhang X. The evolution of the ecological environment in Shaanxi part of Weihe River basin in recent 50 years [J]. Journal of Arid Land Resources and Environment, 2008, 22(2) :37-43.

[10] Luo M., Zhang H.Y. Land conso1idation and its ecological and environmental impacts[J]. Resources Science, 2002,24(2):60-63.

[11] Zenteno M.D.C, Freitas R.C.A., Fernandes R. B. A., et al.Sorption of cadmium in some soil amendments for in situ recovery of contaminated soils [J].Water, Air, & Soil Pollution, 2013, 224(2):1-9.

[12] LI J.Y. Analysis on the Main Environmental Problems in the Weihe River Basin in Shaanxi Province [J].Arid Zone Research, 2011,28(6):967-973.

[13] Li J.Y., Shi C.W., Fu Z.J., et al. Evaluation of potential of floodwater utilization in the middle and lower reaches of the Weihe River [J]. Geographical Research, 2008, 27(5) :1203-1 211.

[14] Wang J. Land consolidation calls for 1andscape ecological construction[J]. China Land Science, 2011, 25(6): 15-19.

[15] Zhu D.W., Xia L.F., Cai M. Soil nutrient and heavy metals contents in newly cultivated land of Qindong Town, Tongguan county[J]. Journal of Irrigation and Drainage, 2017,36:129-135.

[16] Chen Y.Z., Wang F., You Z.M., et al. Soil physical properties and infiltration capability with different tea plantation ages[J]. Mountain Research, 2016,34(1):38-45.

[17] Lambin E.F., Meyfroidt P. Global land use change, economic globalization, and the looming land scarcity[J]. Proceedings of the National Academy of Sciences, 2011, 108(9): 3465-3472.

[18] Hendriks A J, Ma W C, Brouns J J,et al. Modelling and monitoring organochlorine and heavy metal accumulation in soils, earchworms and shrews in Rhinedelta floodplains [J].Archives of Environmental. Contamination and. Toxicology,1995, 29(1):115-127.

[19] Edwards S C,Macleod C L, Lester J N. Bioavilibility of copper and mercury to the common nettle (Urtica dioica) and the earchworm Eisenia fetida from contaminated dredge spoil [J].Water Air &Soil Pollution,1998,102(1/2):75-90.