Discussion and Conception on Reducing the Total Amount of Soil Heavy Metal for Remediation Techniques

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Abstract. Through acknowledging the properties and the current remediation techniques of the soil heavy metals pollution, it is believed that the basic problem of pollution control is to reduce the total amount of heavy metals in the soil, and it is analyzed and summarized that the contribution of the current remediation techniques for reducing total amount of heavy metals in soil, and proposed that the general understanding and the application conception of removing heavy metals in the process of remediation.As for the improvement of remediation technology, we need to improve the process of enrichment, separation and treatment, which can enrich heavy metals in soil into target objects, remove objects and remove heavy metals from objects, which can fundamentally reduce the total amount of heavy metals in soil.

1. Introduction

With the development of the industrialization process of society, the problem of heavy metal pollution in soil becomes more and more serious, in which the common metal pollution about Arsenic, cadmium, copper, chromium, mercury, nickel, lead and zinc are included. It is common for heavy metal pollution that coal, oil and other fuel exploitation [1], mine surrounding [2], electroplating and other metal products factory surrounding [3], sewage irrigation area [4] and other soil. The heavy metals in soil has the features of non-degradability and accumulation, thus at present the remediation of heavy metals in soil is mainly based on Solidification/Stabilization technology [5-8]. It is way to add chemical or physical adsorbent to the soil, which reduces the harm to organisms by reducing the migration and bioavailability of metals. However, heavy metals in soil were not reduced or removed, when the environmental condition changes, such as soil pH volatility, this will cause heavy metals that has been solidified/stabilized release again and be harm for the animal and plant health and safety. The way to reduce the total amount of heavy metals in soil is to fundamentally solve the problem of heavy metal pollution. How to reduce the total amount of heavy metals in soil is a difficult problem for the researchers to try to solve. In this paper, aiming at the current treatment methods and remediation technologies, combining with the principle of reducing total amount of heavy metals in soil, the traditional and improved treatment methods and remediation technologies are analyzed and summarized. Furthermore ideas on how to reduce the total amount of heavy metals in the soil are put forward.

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2. Analysis and induction of soil heavy metal pollution remediation technology on the reduction of total amount

Aiming at polluted soil, researchers have proposed a number of methods and techniques for remediation of heavy metal pollution. From the angle of reducing total amount of heavy metals in soil, three different techniques were analyzed.

2.1. Analysis of physical, chemical or physical chemical remediation methods

2.1.1. Physical methods. The physical methods include soil replacement method, deep turning method, topsoil removal method. Such physical methods can not reduce the total amount of heavy metals in the soil. The physical and chemical methods include electric field migration, heat treatment, ventilation and leaching. The method of electric field migration is to remove soil that contains heavy metals after being enriched by anode or cathode under the action of electrolysis, migration, electroosmosis and electrophoresis. If the soil is not subsequent treated after removing, in fact the heavy metals are not removed from the soil. Heat treatment and ventilation are the treatment methods for mercury pollution in soil, so it is necessary to collect volatile mercury vapor for recovery or treatment.

2.1.2. Chemical methods. Leaching method is a way to use chemical liquid to wash soil containing heavy metals, resulting in a method of removing heavy metals in filtrate. The eluent can be divided into water, organic acid, surface active agent and surfactant, microbial extract *etc.* Microbial extraction is also a biological treatment method. Chen *et al.*[9]chose 11 mol L^{-1} citric acid and acetic acid solution to treat the soil containing Cu, Zn, Pb and Cd, its residue reaches the national soil environmental quality standard after treatment. Lv [10]pointed out that sodium chloride can promote the migration of heavy metal ion from ion exchangeable state to water soluble state, owing to the coordination ability between Cl^{-1} and heavy metal ions.

The use of fixed agent, passivating agent, modifier and other chemical agents can reduce the bioavailability of heavy metals according adsorption,precipitation and inhibition. This method can't reduce the content of heavy metals in soil. At present fixative materials widely used include: lime, pulverized coal ash and alkaline materials; apatite, hydroxyapatite, calcium phosphate phosphate material etc.; Natural or synthetic zeolite, bentonite and other clay mineral materials; Metal oxide materials, biological sludge, straw, farmyard manure, biochar and other organic materials as well as composite fixation agent[11-14].

The use of remediation agents for soil containing heavy metals can cause secondary pollution, Therefore, the use of eluent and fixative should be considered environment-friendly, biodegradable or renewable materials, the heavy metals in soil can be effectively removed if the eluent and fixative are recovered.

2.2. Analysis of bioremediation methods

2.2.1. Botanic methods. Phytoremediation techniques include plant extraction, plant stabilization, and plant volatilization. Plant stability is the use of plant root metabolic activities to precipitate soil active heavy metals in the soil or to absorb heavy metals to plant roots, with which heavy metals in soil can be reduced, reducing its environmental hazards. If you don't collect the roots, you can't remove heavy metals from the soil. Plants Volatilization is the key to uptake the volatile metals, mainly mercury. If the plastic film sealing device is not installed, the removal of mercury is not effective.

Plant extraction, can reduce the total amount of heavy metals in the soil, is planting heavy metal hyperaccumulator to absorb heavy metals to the above ground part of plants, then use agricultural means to collect for further processing. Study on the hyperaccumulator plants is much, having Sedum

alfredii plant with uptaking Zn and Cd, Alyssum murale plant with uptaking Ni *etc*. [15], India mustard[16] can absorb high concentrations of chromium, lead, zinc, nickel and so on.

2.2.2. Microbiological methods. Soil is made up of loose particles, filled with microporous. These pores contain dissolved solution (liquid) and air (gas). There are organic matter, nitrogen, phosphorus and other elements in the soil, which is a good habitat for microorganisms. Therefore, the microbial remediation technology of heavy metals in soil has been concerned by people. Microbial remediation technology is a way to use some microorganisms or their secretion for Heavy Metals Absorption, adsorption, precipitation, complexation, oxidation, reduction and other functions, reducing the toxicity or content of heavy metals in soil. Being absorbed into some microorganisms or adsorbed outside the cell, it can temporarily reduce the heavy metal content in the soil. Because the growth and reproduction of microorganisms has generation cycles, and close relation to the soil environment, and frequent materials exchange with the environment, the death and the excretion of microorganisms have temporary effects on the absorption and adsorption of heavy metals. But on the whole, the growth environment of microorganisms will not become very poor, due to some microbial populations can maintain a certain amount of heavy metal absorption. A microorganism can grow and multiply in a population environment, so it can only absorb a certain amount of heavy metals.

Some microbial secretions and effluents react with heavy metals to form complexation, precipitation, and other chemical reactions. Min *et al*. [17] demonstrated that siderophore secreted by some microorganisms can bind copper, chromium and zinc in soil. Zhao *et al*. [18] precipitated heavy metals through the reduction of sulfate by citrate bacteria, and the sulfate reducing product sulfur ions formed insoluble precipitates with metal ions. Cui[19] through the production of citric acid, gluconic acid, oxalic acid and other small molecular acids from a Aspergillus niger that separated from soil, obtained that its bioleaching has good effect on soil containing Zn, Cd, Pb heavy metal. Some microorganisms use low valence or high valence metal ions as electron donors or acceptors, keeping metals oxidation-reduction reaction, changing the valence and solubility of metals, in this way heavy metals are dissolved to reduce the content of specific heavy metals in soil. For example, Thiobacillus ferrooxidans can oxidize ferrous minerals in minerals under aerobic conditions, the bioleaching for sludge can effectively dissolve heavy metals [20]. This method is also applicable to heavy metals in soil.

2.3. Analysis of composite remediation method

The flexible interleaving and splicing between physical, chemical and biological methods can be used to reduce the total amount of heavy metals in soil. Feng [21] using deep turning method and leaching method invented a method for removing the active heavy metals in soil. It is mainly through the continuous plowing and mixing between water and soil, static, drainage, heavy metals, water reuse and other operations, so that transfer heavy metals to liquid phase to achieve the purpose of heavy metal removal. In the same way, heavy metals are activated by acid washing soils, and the water-soluble heavy metals are absorbed from the water to the adsorbent. Zhang *et* al. [22] used organic acid leaching and activated carbon, tourmaline and other adsorption methods to remove heavy metals in soil. Tao *et al*. [23] evaluated the adsorption effect of modified zeolite on heavy metals in soil filtrate under acid rain condition, relative to the amount of blankness leaching the amount of lead and zinc adsorption capacity by zeolite was more 30%~50%. However, none of the two studies mentioned the reuse of the adsorbent through desorption. It is easy to apply adsorption material to soil, but it is difficult to remove it from soil. Pan [24] uses a permeable device to remove metal enrichment agents. Li [25] uses a special material bag to wrap metal adsorbent, so that the adsorbent is easy to retract after being buried in the soil. But this reduces the mixing degree, reduces the contact area and weakens the transition pathway of heavy metals from soil to adsorbent. However, there are also some physical separation techniques applied to the separation of materials with soil,

such as magnetic separation. Pan [26] has put forward its reuse effect in the invention of a heavy metal chelating trapping material. Fan [27] researched that chemical chelating heavy metal and magnetic separation technology were combined to reduce the total amount of heavy metals in soil, the separation from soil again being realized by combining the chelating agent on magnetic carrier. Ma [28] researched that using magnetotactic bacteria and cell surface characteristics of adsorption for heavy metals will separate the enrichment of heavy metals bacteria from soil in the external magnetic field.

Most of the traditional methods are improved and combined, so the traditional and basic methods can be classified to renovate according to that whether the total amount of heavy metals in soil can be reduced. Details see Table 1.

Table 1. Classification for methods according to the principle of reducing total amount of heavy metals in soil.

Items	Failing to reduce the total amount of heavy metals in soil	Unfailing to reduce the total amount of heavy metals in soil
Physical or chemical methods	Exchange soil, deep soil, turn off table soil, adsorption(without removing adsorbent)	Electric field transfer, heat treatment, ventilation, leaching
Biological methods	Plant fixation, volatilization; microbial secretion complexation, precipitation, redox	Microbial enrichmentextraction, plant enrichmentextraction

3. Conception of reducing total amount of heavy metals in soil

Governance process is the migration process of heavy metals from solid soil to liquid phase or solid phase receptor. This migration process includes direct water soluble migration, organic acids and other chemical substances extraction and migration, biological enrichment and migration, physical or chemical adsorption and migration. This basic idea depends on that the fractionation of heavy metals in soil is generally classified by Amacher [29], which is divided into 6 types: water soluble, exchangeable state, carbonate bound, Fe Mn oxide bound, organic matter bound and residual. The bioavailability of these is reduced in turn. At present, the treatment methods will concentrate the heavy metal forms into the water soluble state, so that remove the target, or concentrate on the stable adsorption state such as oxide bound state and organic matter bound state, so as to achieve the purpose of reducing the toxicity of the target. In order to reduce the total amount of heavy metals in soil, it is necessary to wait for the reaction or interaction to collect or recover the heavy metals after the treatment, and remove heavy metals from the treated materials.

3.1. Improve existing or traditional governance methods

For situ soil remediation, soil excavation of soil leaching solution uses the collection system, constructing culverts and laying pipes with holesin the underground, making soil leaching liquid collecting device, so sump is collected into pollution extraterrestrial, The supernatant in the tank is separated for metal precipitation, and the mud part can be used for biological enrichment treatment, or do again leaching process. In situ remediation, leaching should be selected to form little secondly pollution eluent. Compared with situ chemical elution, microbial eluent is more environmentally friendly. If the soil water soluble metal ions are more, the water is directly used for leaching. Leaching process should reduce the leaching rate and prevent heavy metals from polluting groundwater.

When the adsorbent is added to the soil, the adsorbent material can be made into porous, multi channel brick or globular material, buried in the soil, marking well. The product can also be piled into a permeable wall, the assumption diagram is shown in Figure 1. The smooth but having

transverse direction of remittance charging heavy metal pollution area uses water moving through the wall, the carrying heavy metals are adsorbed on adsorbent material. By studying the desorption mode of the product, the heavy metal can be enriched, and the adsorption material can be reused. The physical requirement of brick or finished product is high, the hardness is high, the water solubility is poor and the weathering resistance is strong. When fix up a permeable wall and embed adsorption products, it is need to do the research clearly about heavy metals pollution soil, how to ensure migration to the water soluble and exchangeable ion, take appropriate promoting migration measures; It is necessary to investigate the water content and heavy metal concentration at the same level and depth, judge and understand the flow direction of the surface water, and prepare for the permeable walls.

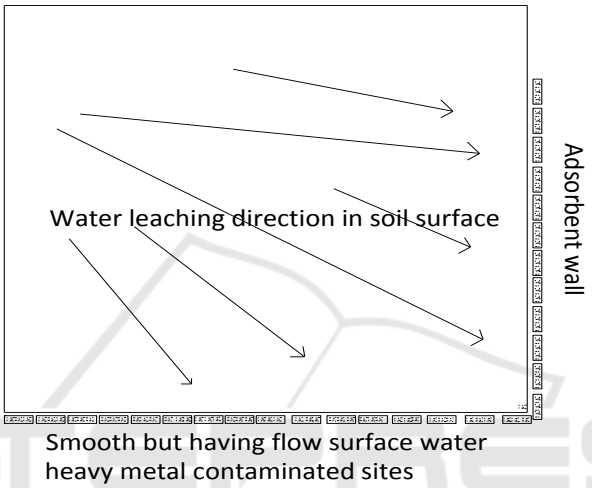

Figure 1. Imagination of adsorption and permeation wall with porous structure and adsorption material for heavy metal.

3.2. Use heavy metal sludge treatment technology to control heavy metal contaminated soil

It is suitable for the remediation of heavy metal contaminated soil with pollution area small, with heavy metal concentration high and with pollution harmful. Because of the small amount of treatment, the soil can be removed as a whole part, and it can be applied to the structure or reactor that usually used for sludge treatment. The extraction methods of heavy metals in soil are similar with that in sludge, and methods are many. But Chen Meng and other people[30] referred to the use of algae for heavy metal enrichment and extraction, the study was about sludge disposal. J He[31], K.Suresh Kumar[32] highly evaluated the advantages of algae adsorption and enrichment for heavy metal ions, and concluded that it is economical, easy to obtain from nature and has highly efficient absorption. The heavy metals in the soil can also be enriched and extracted by algae, and the algae that are suspended on the water surface are easy to separate from the water body. And, here are researches about collection. M Rajfur and other[33] use Spirogyra sp. algae to adsorb and enrich Mn^{2+}, Cu^{2+}, Zn^{2+}, Cd^{2+} heavy metal ions in surface water. Wang[34] removed the metal from algae cells in a way that it was washed out by water after using organic solvents to break.

3.3. Other ideas

The pollution soil itself contains iron aluminum and manganese oxide, silicate, sulfide and other natural organic adsorption matter. We can remove out these materials with soil, desorb these materials without breaking their property, return their adsorption capacity of the metal, mix it with the contaminated soil again, wait for full, remove out and desorb a portion again. However it is not the last part of the all that was taken out, but so repeatedly, it would reduce the content of heavy metals in soil finally.

Can electrophoresis technology be used to separate the enriched heavy metal microorganisms from soil? Electrophoretic technique is the process of transporting charged particles under the action of electric field[35]. Magnetic bacteria can dissociate into the surface of soil under the action of external magnetic field, then the microbial cell is a charged body, and the electrophoretic technique can be applied to the separation of the enriched heavy metal bacteria with soil particle.

For the larger land area and mild heavy metal pollution, it is considered to plant hyperaccumulator, harvest ground part in autumn, transport it to the barren minerals and organic matter content places. On the one hand, this style can provide enough trace elementsfor the local plantsgrowth, improve soil fertility, decrease the subsequentextraction process ofheavy metal from plants.

3.4. Applied engineering ideas for heavy metal pollution control

3.4.1 As for the heavy metals contaminated mines or slopes area. The collection is made for the rainleaching or chemical leaching of heavy metals from soil, because the underground operation is difficult, so the idea of collecting water device is from Xinjiang Pit Well in the underground, divided into center culverts, water collecting branch, ventilation, ground confluence channel and collection pool five parts. It is suitable for heavy metal pollution in mines or slopesarea, as shown in figure 2.

3.4.2. Heavy metal contaminated sites with severe pollution. Use gas stripping method for groundwater remediation engineering[36], artificially simulate transpiration of trees and plants to absorb water,provide power by gas instead of transpiration,provide pipeline instead of trunk and root, make pipe hole transmission channel for heavy metals filtrate, buried gravel around hole to prevent large particles in the soil blocking holes and pipes, its design structure diagram is shown in Figure 3.

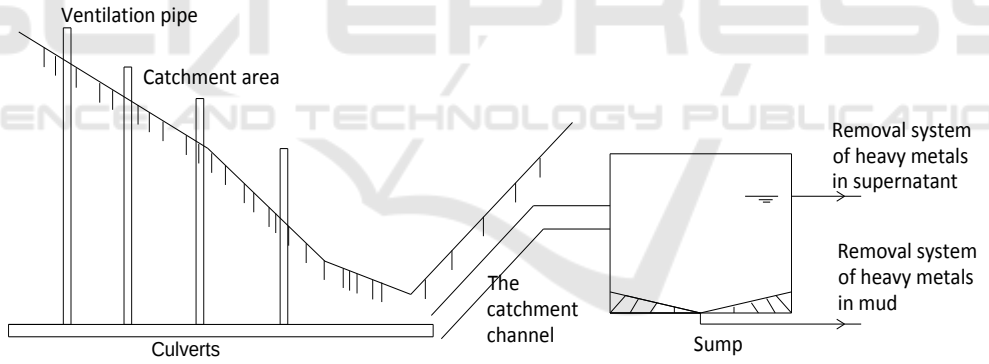

Figure 2. Catchment unit.

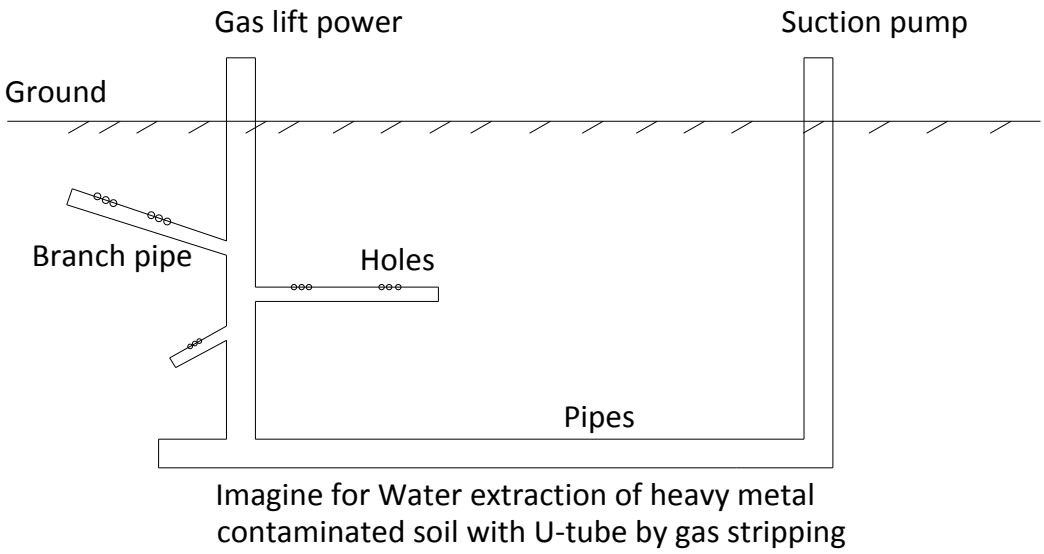

Figure 3. Extraction system of heavy metal leaching by gas stripping with U type structure.

4. Conclusions

Understanding the status of soil pollution and the key external factors affecting the change of heavy metals, and finding appropriate treatment methods are the basic work to reduce the total amount of heavy metal pollution in soil. Because the remediation of heavy metal contaminated soil has difficulty, composition is complex, soil is a mixture of three-phase gas, liquid and solid, and is a common component of inorganic and organic matter system.Its surface and inner layer have life atmosphere.Sunshine, rivers, climate and other external environmental conditions have an impact on it, bringing changes to it. So as for the heavy metal contaminated soil this determines its complex morphology, its changeable process of migration and transformation, its long process of governance, and its more severe technical implementation of the treatment method.

The governance process is the migration of heavy metals from solid soil to liquid phase or solid phase receptor, and the treatment. Find a available way: enrichment, separation and treatment. Enrichment migration includes liquid phase enrichment, soild phase enrichment and biological phase enrichment; separation migration is the separation of receptor substances from soil; the treatment is that heavy metal would be removed from enrichment receptor, collecting heavy metal, reusing receptor. Based on the three aspects, this paper discusses the achievements of other people and puts forward my own ideas from the basic point of reducing the total amount of heavy metals in soil, and discusses the methods and techniques for the treatment of reducing the total amount of heavy metals in soil. Centring on this basic process, knowing government technology and methods, and understanding environmental equipment and facilities will be helpful for developing specific measurement of soil pollution treatment.

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