CHEMICAL ENGINEERING TRANSACTIONS

VOL. 59, 2017

A publication of AIDIC

The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Zhuo Yang, Junjie Ba, Jing Pan

ISBN 978-88-95608- 49-5; **ISSN** 2283-9216

DOI: 10.3303/CET1759160

Research on Effects of Heavy Metals on Agricultural Soil Pollution and its Control

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In this paper, the author discussed the effects of heavy metals on agricultural soil pollution and its control. This paper briefly reviews the famous events of metal pollution in soil at home and abroad, discusses the source of heavy metals pollution in soil from four aspects, and elaborates the phytoremediation and application from aspects of the migration, transport of heavy metals ion, selection of hyper accumulator and telltale effects of the plants. Finally, it discusses the key problems existing in this field. The AHP method and algorithm is proposed in this paper and the experiment result shows the proposed method can improve the performance of the system.

1. Introduction

With the rapid development of economy, some areas of China have been shortage of water because of water pollution such as rich nutrient and so on. The problem of shortage of water resources has also been exacerbated. Wastewater irrigation could alleviate the conflict of water providing and demanding on some degree. But part of civil and industry wastewater always contains heavy metals or organic compounds. Using wastewater irrigation it may lead to poisonous pollutants accumulated in soils and crops (Li et al., 2013; Kim and Kim, 1999). At present, Beijing and some lack-water cities plan to develop large scale recycle of post-treatment sewage, so the deeper research of effects of wastewater irrigation on heavy metal accumulation also has consulting value for evaluating environmental risks in recycle of post-treatment sewage (Romić, 2007). We conducted the systemic research on the accumulation of heavy metal in wastewater-test area. Take the typical wastewater-test area as an example; we investigated the heavy metal accumulation in soils and crops systemically. Discussing the status in quo of As, Cd, Cr, Cu, Hg, Ni, Pb and Zn pollution and the origin and path of pollutants, through the model of soil column combining the field investigation of soil profile, we evaluate the polluted risks of heavy metal on the low underground water and reasonably evaluate the effects of wastewater irrigation on ecological environment of test area.

The concentration of Hg had an affinity for wastewater irrigation, meanwhile, restricted by other factors such as soil character and so on (Massas et al., 2013; Yanai et al., 1998; Ezeh and Chukwu, 2011).

The research which analyzed the spatial structure of concentrations of As, Cd, Cr, Cu, Hg, Ni, Pb and Zn using statistic method in the soil of test area indicated that the 8 kinds heavy metals all show well transition character (Chen and Bi, 2016). The semi-variorum of As, Cd, Cr, Cu, Hg could be fitted well with global model and Ni, Pb, Zn could be fitted well with exponential model. The high concentration of Hg mainly concentrated in the area of river and the high concentrations of As, Cu, Hg and Pb also had distribution in it Relative to river, the content of As, Cr, Hg, Pb and Zn was lower, but the content of Hg, Cu and Pb exceeded the soil baseline in different degree in large area, behaving higher pollution risks. In test soils, the source of Hg mainly is wastewater irrigation and a part of Cd* Cr and Pb also comes from it As, Ni and partly Cr mainly affected by soil character, the sources of Cu and Zn have diversity (Xu et al., 2014).

2. Overview

Total amount of heavy metals in sludge is evaluated for the determination of heavy metals in bottom mud of bioavailability and environmental effect of. Many studies have shown that, on the bioavailability of heavy metals in sediments and its environmental impact assessment, the total heavy metals alone cannot make

Please cite this article as: Qi Meng, 2017, Research on effects of heavy metals on agricultural soil pollution and its control, Chemical Engineering Transactions, 59, 955-960 DOI:10.3303/CET1759160

good predictions. Studies show that potential impacts on the environment of heavy metals in sludge only the physic-chemical properties of the part, that part of the heavy metal is easily absorbed by biological, with potential implications for biological, so the need for heavy metal amount and sediment physicochemical properties of effective content for study. Heavy metal generally refers to the bioavailability of heavy metals in the environment are organisms absorb, accumulate or have toxic effects on the biological traits. Heavy metal bio-availability of information is an important means of contaminated sediment risk assessment, but also the management and remediation of contaminated sediments Foundation (Cicchella et al., 2014; Soffianian et al., 2014; Králiková and Andrejiová, 2015).

At present, the biological evaluation method for the effectiveness of much chemical extraction method is the most common major, followed by biological methods. Biological methods using ecological and toxicological analysis includes plant indication, microbiological evaluation and other chemical extraction method is the use of different chemicals to extract classified by morphology of heavy metals in the bottom mud, through more live in sediment physicochemical properties of that part of the contents of heavy metals, and thus to evaluate bioavailability. At this stage, chemical extraction procedure because of its efficient, economic characteristics, are widely used in the evaluation of heavy metal bio-availability. Chemical extraction method mainly has following several kinds. (1) A single extract. Single extraction reagent on extracting heavy metals in the sediments is called single extraction. Heavy metals to the environment caused by short-term or medium-term harm is usually evaluated by single extraction based on samples of different nature, composition, and extraction of heavy metals different kinds for different purposes, the extract of your choice will not be exactly the same when extracting heavy metals of different extraction agent, according to their own nature of the integration agent can be divided into extraction of neutral salt, acid extraction method, and the infusion method (Miśkowiec et al., 2015; Deng and Yan, 2014; Fard and Matinfar, 2016). (2) The order of extraction. Sequential extraction method is based on a series of natural and artificial simulation of changes in environmental conditions, using different selective reagent, from weak to strong, continuous melting different absorption of trace elements in mineral phases. At present, widely used extraction methods with Tessier in the order of five-step extraction Tessier and EC standards Council based on BCR in the development of a three-step method.

3. Soil pollution model and AHP algorithm

The basic equation in AHP algorithm is shown in equation (1) (Yang et al., 2014):

$$R_k = \frac{R_{es}^k}{N_{BS}} = \frac{1}{N_{BS}} \sum_{i=1}^{N_{BS}} \left(R_i - \hat{R}_i^k\right)^2 = \frac{1}{N_{BS}} \sum_{i=1}^{N_{BS}} \left(R_i - \sqrt{\left(\hat{x}^k - x_i\right)^2 + \left(\hat{y}^k - y_i\right)^2} \right)^2 \tag{1}$$

Besides, $(\hat{x}^k, \hat{y}^k)$ is obtained location result by using No.k location algorithm, so the ultimate location coordinate of mobile station $(\hat{x}, \hat{y})$ is:

$$\begin{bmatrix} \hat{x} \\ \hat{y} \end{bmatrix} = \begin{bmatrix} \frac{1}{\sum_{k=1}^{K} R_k^{-1}} \left(\sum_{k=1}^{K} \hat{x}^k R_k^{-1} \right) \\ \frac{1}{\sum_{k=1}^{K} R_k^{-1}} \left(\sum_{k=1}^{K} \hat{y}^k R_k^{-1} \right) \end{bmatrix} \tag{2}$$

In the structure of GA algorithm, we can get the optimization equation as the following equation (6):

$$h_j = \exp\left(- \frac{\left\| X - C_j \right\|}{2b_j^2} \right), \quad j = 1, 2, \ldots, m \tag{3}$$

The output of the network is given as:

$$y_m(k) = wh = w_1 h_1 + w_2 h_2 + \ldots + w_m h_m \tag{4}$$

Assuming the ideal output is y (k), the performance index function is:

$$E(k) = \frac{1}{2}\left(y(k) - y_m(k) \right)^2 \tag{5}$$

The equation of basic function is as equation (9) as follows:

$$\partial_j (C_{ijkl} \partial_k u_l + e_{kij} \partial_k \varphi) - \rho \ddot{u}_i = 0 \tag{6}$$

Under the linear relationship, basic equation is shown in equation (2):

$$\partial_j(e_{ijkl}\partial_k u_l - \eta_{kij}\partial_k \varphi) = 0 \tag{7}$$

The linear differential equation can be expressed into the following simplified forms:

$$L(\nabla,\omega)f(x,\omega) = 0, \ L(\nabla,\omega) = T(\nabla) + \omega^2 \rho \mathrm{J} \tag{8}$$

$$u_{P1}(X,Y) = \begin{cases} 0 \\ X\begin{cases} < 2\pi k + \pi - \alpha_1 - \pi M \sin Y \\ \geq 2\pi k + \pi - \alpha_1 + \pi M \sin Y \end{cases} \\ E/6 \\ X\begin{cases} < 2\pi k + \pi - \alpha_1 + \pi M \sin Y \\ \geq 2\pi k + \pi - \alpha_1 - \pi M \sin Y \end{cases} \end{cases} \tag{9}$$

The double Fourier series of function $u_{P1}(X, Y)$ is given:

$$u_{P1}(X,Y) = \frac{A_{00}}{2} + \sum_{n=1}^{\infty}(A_{on}\cos nX + B_{on}\sin nY) +$$
$$\sum_{n=1}^{\infty}(A_{mo}\cos mX + B_{mo}\sin mY)$$
$$\sum_{m=1}^{\infty}\sum_{\pm 1}^{\pm\infty}[A_{mn}\cos(mX+nY) + B_{mn}\sin(mX+nY)]$$

In the above formula

$$A_{mn} + jB_{mn} = \frac{2}{(2\pi)^2} \int_{-\pi}^{\pi}\int_{-\pi}^{\pi} u_{P1}(X,Y)e^{j(mX+nY)}dXdY \tag{10}$$

Take the formula (3) into formula (4)

$$\begin{aligned} A_{mn} + jB_{mn} &= \frac{E}{6\pi^2} \int_0^{\pi}\int_{2\pi k+\pi-\alpha_1-\pi M\sin Y}^{2\pi k+\pi-\alpha_1+\pi M\sin Y} e^{j(mX+nY)}dXdY \\ &= \frac{E}{j6m\pi}e^{jm(n-\alpha_1)} \\ &[\frac{1}{\pi}\int_0^{\pi} e^{jmM\pi\sin Y}e^{jnY}dY - \\ &\frac{1}{\pi}\int_0^{\pi} e^{-jmM\pi\sin Y}e^{jnY}dY] \end{aligned} \tag{11}$$

Immobilization to repair part of the sediment contamination by heavy metals chemical remediation methods, which can be applied to in-situ remediation can also be applied to the different repair. Experiment and data analysis

Agricultural soil value analysis indicators are pH, water content, total phosphorus, heavy metals (Zn, Mn, Pb, and Cd) and organic matter. Results are shown in table 1.

Table 1: Contaminated sediment physicochemical properties

Parameter	Values
water content	29
pH	8.2
total phosphorus	1.5
Zn	6865
Mn	876
Pb	298
Cd	5.2
organic matter	14.2

(1) Sludge pre-treatment. Back to remove the upper layer of the sediment with water rolled out in the tray, picking up shells, rocks, leaves and other debris. Sediment in ventilation, natural conditions losing cattle dried mud mortar grinding.
(2) Sludge-determination of pH value. Take 5 grams of sediment samples placed in a small beaker, 1:5 Add deionized water using magnetic Range Rover with vigorous stirring 112 minutes, that sediment in the water completely dispersed and then rest for 30 minutes. Measurements of sediment samples with pH meter pH value repeated three times and take the average.
(3) Determination of organic matter in sediments.
(4) Determination of total phosphorus in sediment. Digestion for determination of total phosphorus in sediment of a PIN spread anti-spectrophotometry. Weigh the amount of soil, add concentrated sulphuric and per chloric acid digestion, adding Noah pH regulating digestion fluid, to the solution is yellowish, then add Mo TI resistant reagent, 700nm wavelength using a spectrophotometer absorbance, are compared with the standard curve, phosphorus concentrations in the soil.
(5) Determination of heavy metals in sediment. Determination of heavy metals is calculated in sediment using HN03-HC1-HF method.
Test by two big part composition, first part is curing agent of optimization research, main research common of curing agent on end of mud in the heavy metal of fixed of effect, optimization out effect best of curing agent, and determine optimal curing agent of best voted added volume; second part is complex distribution curing agent on heavy metal of fixed of research, main is through to filter out of curing agent in the joined additives get complex distribution curing agent, research complex distribution of curing agent on heavy metal of fixed of effect, and through curing end of mud in the pollutants of static release Institute GUI, Simulation investigation cured in sediment metal and total phosphorus in natural conditions to unleash that potential.
Sediment samples, respectively 1%, 5%, and 10% to determine the effects of different application amount, respectively, sediment samples and mixes, 1:]0 add a second water, indoor place, stir once a day for 7 days, then continue to stand for 7 days, dried by quadrant sampling, put the samples in a sealed refrigeration, for follow-up testing. After curing mud extracted by BCR and the toxicity characteristic leaching procedure (TCLP) for curing effect, two parallel samples in each group, each test sediment quality as 50g, set the pure sediment samples for the control group, and the results averaged.
Figure 1 (a) shows that when the effect of curing agent of 1%, on the whole, various curing agents for polluted sediments in the immobilization of Zn has some effect. Contrast can be found with the blank sample, imposing sample of curing agent, acid-extractable Zn content of 3%-6%, reducible Zn contents increase range is 3%-6%, oxidation States of Zn content and clear State of Zn residue content is small, only about 1% changes. Visible 1% of addition of curing agent is set to easily extract speciation work. When the effect of curing agent of 5%, compared with the blank samples, acid-extractable Zn content has a certain amount of reduction. Application samples are compared with the control group of the nHAP, reduces the content of acid-extractable Zn 8%, reducible and residual content of Zn 5% and 3% respectively, visible under the action of acid-extractable Zn in nHAP's transformation to reducible, a small amount of reducible Zn and oxidation States to clear residue transformation. Overall, the after effects of curing agent can make the acid-extractable Zn reducible to Zn into. When the hardener dosage as 10%, Eva Dehydrogenase algae soil, can be seen Korean and carbonate sediments in the acid-extractable Zn was decreased to 9.92%, 7.61% and 7.38%, accordingly, reduced Zn contents increase the 5.09%, 2.47% and 3.46%, clear State of Zn residue content is to 34.08%, 35.62% and 34.02% respectively. But it can be seen that oxidized Zn content does not change much. HAP and nHAP acid-extractable Zn content reduced by 9.5% and 8.98%, people clearly state Zn increases 5.97% and 5.03% can be oxidized Zn contents are not very clear.
Taking sediment samples cured using toxicity characteristic leaching procedure (TCLP) to evaluate the immobilization of heavy metals contaminated sediments. Figure 1 (b) stabilizer under different fertilizer conditions the amount of heavy metals.

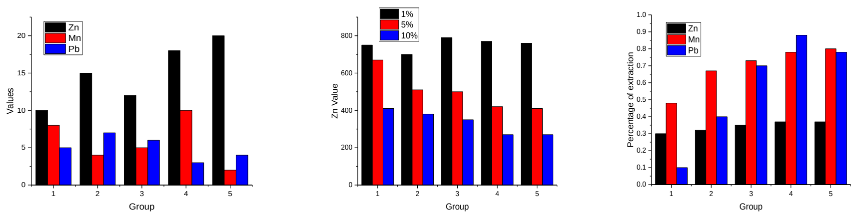

Figure 1: (a) Content distribution of Zn in sediments under different fertilizer under conditions for curing agent; (b) Content distribution of Mn in sediments under different fertilizer conditions for curing agent; (c): Percentage of extraction of heavy metal in sediments different fertilizer conditions for curing agent

As shown in Figure 1 (b), not of imposing curing agent in sediment in the control group, the amount of Mn for 224 mg-kg. Imposed after the curing agent, the amount of Mn was reduced to a certain degree when the hardener dosage as 1%, slight decreases the amount of Mn and when the hardener dosage as 5%, the amount of Mn began a significant decline. When the hardener dosage as 10%, obvious from the diagram of beggar carbonate, HAP and nHAP best for Mn immobilization in sediments, it decreases in the amount of leaching of Mn and 25.01%, and 23.66%. No control group of imposing curing agent in sediment, the amount of Pb is 0.45 mg. Imposed after the curing agent, has obvious effect on the amount of Pb in sediment, especially with hardener. As the amount of hardener to impose increased immobilization of Pb was more obvious. Dang curing agent added volume for 10% Shi, imposed baby algae soil and carbonate Bute of curing end of mud in the, Pb of dip out volume respectively for 1.03 mg-kg>0.89 mg-kg, and blank group compared, respectively reduced has 50.72% and 57.42%; imposed phosphate II hydrogen Han, and HAP and nHAP, containing p curing agent of end of mud in the, Pb of dip out volume respectively for 0.42 mg.kg-i, and 0.45 mg-kg, 0.56mg-kg, and blank group compared, Reduced, and 79.9% and 73.21%, respectively.

Visible, phosphorus-containing curing agent for immobilization of Pb in sediment is going with good results. By comparing different in different fertilizer conditions on immobilization of heavy metals in sediments can be found, HAP and nHAP on curing effect of heavy metals in the sediments are more prominent, but nHAP prone to accumulation in the water, sediment mixed with hooks, leads to reduced effect. Meanwhile, higher cost of Nano-HAP, is three times the normal HAP, and between the two there is little difference between the curing effects of heavy metals in sediment, so use normal HAP as heavy metal pollution in sediments of curing agent. It will by base apatite (HAP) by end of mud samples volume of 5%, and 8%, and 10%, and 12%, and 14% determine different application volume, respectively and end of mud samples full mixed, 1:10 added II times water, Yu indoor placed, daily mixing a times, continuous 7 days, then continues to static reset 7 days, dried used four points method sampling, will samples put Yu sealed bags in the refrigerated save, for follow-up test. After curing mud extracted by BCR method and effect evaluation of curing the TCLP procedure, each set of two parallel samples test sediment quality as the 50 g of each group, set the pure sediment samples for the control group, and the results averaged.

Effect of different HAP on the morphology of heavy metals is going in the sediments of effects and fixed effects. As the HAP dosage increases, mud acid-extractable Zn content in a certain amount of reduction, oxidation state, and clearly state and other content has a certain increase of stable form. But when the hardener application rate is greater than 10%, the reduction in acid-extractable Zn and stable Zn increases less and less, and different forms of Zn contents in different fertilizer conditions not very obvious differences between each other. When HAP quantity is greater than 10%, the amount of Zn in sediments in 220mg, change is not obvious.

Ranking of the static capacity of heavy metals in these 4 sorts of soil in test zone were: meadow soil, shrub meadow soil, Aeolian sandy soil and saline soil: Pb>Cr>Zn>Cu>Co; While the dynamic capacity of the same heavy metals in different types of soil were: when Co and Pb are in control terms 20, 50, 80 years: saline soil > shrub meadow soils>meadow soil>Aeolian sandy soil; and when Cr, Cu, Zn are in control terms 20, 50, 80 years: saline soil>shrub meadow soils>Aeolian sandy soil>meadow soil; all these elements got the same average annual capacity when the control term is 100 years despite the types of soil. The static capacity of heavy metals in saline soil, shrub meadow soil were both larger than that in Aeolian sandy soil and meadow soil, so it is possible to take advantage of the larger soil capacity for the local economic development.

The heavy metals presented definite pollution in soils of test area; we investigated the concentrations of heavy metals in crops growing on test area. Take wheat as an example, we analyzed concentrations of 8 kinds heavy metals in wheat seeds and determined that there were distinct heavy metal pollution in them. The percent super scales of Ni, Pb and Zn were 38.1%, 28.6% and 4.8%, respectively, meanwhile, in some samples; the concentrations of Hg and Cd were close to the standard of Chinese food hygienic standards.

Compared with the results of investigation in 1976, the concentrations of Hg, Pb and Cu had significant increase in wheat seeds and the pollution of these heavy metals showed aggravating trend. The wheat seeds had strong accumulating ability of Zn, Cu and Cd, the secondary was Hg, Pb and Ni, the last was As and Cr. The validity coefficient in soil and the accumulating coefficient in wheat seeds of Cd and Hg were distinct relative. . Through the soil column model in lab, taking As, Cd, Cu and Pb as examples and leaching the soil column at different quantity of irrigation and different condition of water quality, we found that As, Cu and Pb mainly concentrated in depth of 0-50cm and had little trend to move to deep soil and had little risk to low underground water; Cd had strong trend to move to deep soil and had definite risk to low underground water of 1m; when the concentration of extraneous pollutants were lower, the distribution of them was comparatively even; when higher, the pollutants accumulated in the surface soil and the content was clearly higher than non-test group.

4. Conclusions

In this paper, the author discussed the effects of heavy metals on agricultural soil pollution and its control. However nearly a century, with the development of agriculture, industry, and technology, human beings have an increasing demand on land, which on one hand, accelerates the speed of land development and enlarges the development scope, and on the other hand, emissions and strands in a variety of pesticides, heavy metals, and wastes, that deteriorates soil quality, expands pollution areas, and aggravates polluting situations. This paper briefly reviews the famous events of metal pollution in soil at home and abroad, discusses the source of heavy metals pollution in soil from four aspects, and elaborates the phytoremediation and application from aspects of the migration, transport of heavy metals ion, selection of hyper accumulator and telltale effects of the plants. Finally, it discusses the key problems existing in this field. This kind of state has not been effectively controlled by now. Meanwhile, due to the soil characteristics, once contaminated, it is difficult to repair and a great amount of money and time is required. The lack of legal system on soil protection and governance in China makes the actual work no laws to abide by and seriously impact the effectiveness of the prevention and control. The AHP method and algorithm is proposed in this paper and the experiment result shows the proposed method can improve the performance of the system.

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