Experimental Research on Mechanisms of Soil Pollution

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ABSTRACT: Soil pollution can result in a lot of serious situation, especially safety, health and environment problems. In this paper, a serial of experiments were designed and conducted in a closed-loop wind tunnel to study the mechanisms of soil pollution. Through the research work, the mass transfer acts an important role in the pollution process. Thus the principle is proposed in this paper to prevent soil pollution based on the theory of solute transfer. That is, to cut the connecting channel between the polluted ground water and the surface soil. Based on this principle, some practical measurements were proposed.
KEYWORD: Soil Pollution; solute transfer; experimental research; mechanisms

1 INTRODUCTION

Soil contamination results in a lot of serious situation, such as poisonous rice, poisonous vegetable and so on. We have mass cases in history, the most famous maybe is the Loulan Ancient (Liu W, 1995).Soil pollution is due to human activities producing harmful and toxic substances into the soil. When the poisonous substances were accumulated to a certain degree more than self-purification capacity of the soil itself, the changes happened in soil properties and quality, composition of crops and the phenomenon of the influence and harm of human body.

Soil pollution mainly comes from industrial and urban wastewater and solid waste, pollutants in the atmosphere (such as sulfur dioxide, nitrogen oxides and particulate matter, etc.) by precipitation falls to the ground subsidence and sedimentation, and pesticides, chemical fertilizers, livestock excreta, etc. Contaminated soil of main pollutants include inorganic pollutants (such as heavy metals, acid, salt, etc.), organic pesticide (such as pesticides, herbicides, etc.), organic wastes (such as biodegradable or refractory organic waste, etc.), chemical fertilizers, sludge, slag and fly ash, radioactive substances, parasites, pathogens and disease. Of contaminated soil, physical and chemical properties change itself, such as compaction, reduced fertility, soil is poison, etc., can also through the rainwater leaching, pollutants from soil to groundwater or surface water, cause the pollution and deterioration of water quality. Growth of living things on the contaminated soil, the absorption and accumulation and enrichment of soil pollutants, after enters the body through the food chain, can cause to the person's influence and harm. But not easy flow, soil self-purification ability is limited, so it is very important to protect soil is not contaminated.

In most cases it is avoided to cultivate or take other activities in the poisonous areas. But the problem is the pollution cases often occur in the area “not” polluted before. How the poisonous substances get there? And how it can be prevented? That’s what we’ll study in this paper.

2 EXPERIMENTAL RESEARCH

2.1 *Physical Theory.*

Soil is typical porous media composed of solid matrix, water of liquid phase and vapor phase and air. In such cases, the study of soil moisture movement, temperature, and solute transport in porous media is of great importance to the disciplines of hydrology, agriculture, and environmental engineering. Solute transfer in the soil profile under different watertable condition is often connected with the evaporation on the soil surface, especially in the vertical direction of soil profile.

2.2 *Experimental Design.*

In order to investigate the process of SSS, especially solute transport phenomena, a serial of indoor soil column experiments were conducted in laboratory within a closed-loop wind tunnel, in which air tem-

perature, relative humidity and wind speed can be controlled at constant values. A transparent cylindrical sand soil bed was used. In this bed, soil surface was exposed to artificial atmosphere in the wind tunnel. And Mariotte bottles were used to keep an experimental condition of providing constant groundwater table, and the influence of different water table could be studied. Through the reading of the Mariotte bottles it can be shown that how much water had been consumed, thus evaporation rates of the soil column could be calculated. A serial of experimental study of evaporation from uniform columns in the presence of a shallow watertable was designed and conducted. The influence of ground watertable were studied and the development of soil salinity were observed in laboratory. The process of SSS were simulated and "salt crusting" formation were observed in laboratory. In order to investigate the process of SSS, especially solute transport phenomena, a serial of indoor soil column experiments were conducted in laboratory within a closed-loop wind tunnel(see fig.1), in which air temperature, relative humidity and wind speed can be controlled at constant values. A transparent cylindrical sand soil bed was used. In this bed, soil surface was exposed to artificial atmosphere in the wind tunnel. And Mariotte bottles were used to keep an experimental condition of providing constant groundwater table, and the influence of different water table could be studied. Through the reading of the Mariotte bottles it can be shown that how much water had been consumed, thus evaporation rates of the soil column could be calculated.

3 EXPERIMENTAL RESULTS AND ANALYSIS

3.1 *Critical Depth of Ground Water*

Due to the pioneer's hard work on the studying of SSS, critical depth of groundwater (abbreviated as CDG in this article) is gradually recognized as one of the most important factors influencing the process of SSS (V.A. Kovda et al, 1986). An experiment was designed and conducted in the wind tunnel to study the influence.

In a soil column of 50cm height, with groundwater table to be 30cm from the soil surface, and the saline of groundwater to be 10g/l, the experiment was conducted. Five probes were buried in the soil evenly along soil column.

CDG is related to the soil property, such as soil's porosity and particle size distribution. CDG could be defined experimentally as shown above. Under the steady state of evaporation, water and solute transfer in the soil due to gravity and capillary force of the soil. Thus from the groundwater table, water and solute will reach certain point from which both moisture content and soil salinity becomes to be very small and almost keep steady till soil surface. This point is defined as critical depth of groundwater (CDG).

From the experiment above, the CDG of the soil column could be defined to be about 10cm when considering the root zone of plants, it will be different. The root zone should be added to this value. When the root zone is 50cm, the CDG is 10+50=60cm.

The concept of CDG will be used for analysis of SSS process later.

3.2 *Observation of soil moisture/salinity development*

The study of solute transfer was done before (Lixiang Chen et al, 2006) (Liu W, 2002).Aiming to study solute transfer in soil, experiments were designed and conducted to observe salinity development in soil column. As water-soluble salts always moves with water in soil, moisture development was also observed. The experiment duration was about 2700h.

The four probes were buried evenly along the soil column, that is 7.5cm (E), 12.5cm (D), 17.5cm (C), and 22.5cm (B) above the ground watertable.

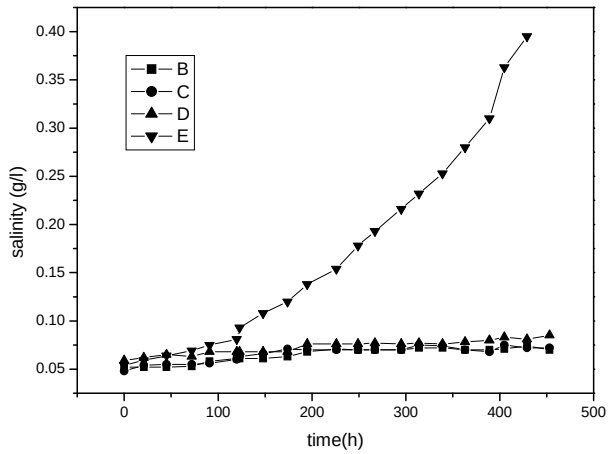

Fig. 1 salinity development curve at different height from water table

From the experimental curves shown in fig.1, it could be seen very clearly that both moisture and salinity developed very quickly at E point. But at other three points, things are quite different. Both moisture and salinity developed very slowly. The further away from the watertable, the more slowly the point moisture/salinity developed. As the CDG defined before is 10cm, we can see that E is within the range of CDG, but the other three points were beyond CDG. That's the reason for the obvious difference between the curves. It can be seen that CDG acts an important role in the analysis of SSS.

From this it can be concluded that the watertable must be kept beyond the CDG to prevent soil secondary salinization.

3.3 *Observation of SSS process simulation in laboratory*

To find out the influence of different watertable, a comparison experiment was designed and conducted. With soil salinization development, water-soluble salts were brought to the soil surface and formed “salt crust”. This can be observed in natural field. The process was stimulated in laboratory as below.

Fig. 2 soil salinity development duo to different groundgwater table

As shown in fig.2, two soil column were put in the same environment of wind tunnel. In the closed-loop wind tunnel, air temperature is set to be 54℃, relative humidity is 15%, and the frequency of the transducer is set to be 30 Hz. The parameters of the air in the wind tunnel is set to be much more hot and dry than in environmental situation, so the process can be observed within much shorter period due to the limitation of our experiment condition. The left soil column is 20cm high, with watertable to be 7cm from bottom. The right one is 15cm high, with watertable to be 7cm from bottom as well. The probe is buried near the soil surface. We can see the difference very clearly from the picture. From the experiment, the principle could be proposed that the CDG acts important role in SSS. That means, the principle of preventing soil contamination is cutting the connecting channel between the saline ground water and the surface soil.

4 CONCLUSION

Soil pollution is a serious problem to be solved urgently. Through the research work, the mass transfer acts an important role in the pollution process. Thus the principle is proposed in this paper to prevent soil pollution based on the theory of solute transfer. That is, to cut the connecting channel between the polluted ground water and the surface soil. Based on this principle, some practical measurements were proposed. Preventing soil pollution, can take the following measures: (1) strengthen to the management of industrial waste gas, waste water, waste residue, etc. and comprehensive utilization, to prevent any discharge of waste contains a variety of pollutants to the soil; (2) the reasonable use of pesticides and fertilizers, and actively develop high efficiency, low toxicity and low residue of pesticides; (3) the feces, garbage and sewage disposal. (4) to promote sewage irrigation, the irrigation farmland sewage to strict monitoring and control, it is best to use the treated sewage irrigation field. Critical depth of Groundwater table (CDG) has a significant effect on solute transfer in soil. With the groundwater table below or beyond CDG, evaporation from the soil surface will be quite different. Thus the solute transfer shows great difference as well. Investigation of groundwater table is meaningful for prediction of soil secondary salinization. Based on present research work, principle to prevent soil secondary salinization was proposed, that is to hinder the connection between the cultural area and the groundwater.

REFERENCES

http://lostcivilization.baike.com/article-131790.html

Liu W., A general mathematical modeling for heat and mass transfer in unsaturated porous media: an application to free evaporative cooling, Heat and Mass Transfer, 31(1): 49-55, 1995

Liu W., Heat transfer and phase change of fluid in a inclined enclosure packed with unsaturated porous media, International journal of heat and mass transfer, 2002(45). P5209-5219

Lixiang Chen, W. Liu, Study on Solute Transfer Principle in Soil Secondary Salinisation, Engineering Thermophysics, 2006.5, p466-468(in Chinese)

V.A.Kovda, I.Schbolz, Numerical Simulation on Soil Salinity, Beijing: Science Press, 1986 (in Chinese)