Analysis of hot topics in soil remediation research based on VOSviewer

Ya Hu1, 2, 3, 4, Zenghui Sun1, 2, 3, 4, Dan Wu1, 2, 3, 4
1Shaanxi Provincial Land Engineering Construction Group, Xi’an 710075, China, Xi’an 710075, China
2Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Land and Resources, Xi’an 710075, China
3Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group, Xi’an 710075, China
4Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi’an 710075, China

*Corresponding author e-mail: Huya0403@163.com

Abstract. Through the cluster analysis of the keywords and draw scientific knowledge map by VOSviewer in the field of soil remediation in order to further explore the hot topics of soil remediation research. The results were analyzed by manual analysis. The key words in the field of soil remediation research were divided into 4 topic groups. They are in the field of heavy metal pollution, chemical remediation technology, bioremediation technology, and electric remediation technology. The hot topic in the field of soil remediation research is mainly “heavy-metals”, “removal”, “bioremediation”, “degradation”, “biodegradation”, “phytoremediation”, “contaminated soil”, “water”, “cadmium”, “polycyclic aromatic-hydrocarbons”, “adsorption”, “lead”, and “sorption”, “bioavailability”, “extraction.”

1. Introduction
The scientific knowledge map has the dual nature and characteristics of “graph” and “spectrum”. It is both a visual indicator and a serialized knowledge pedigree showing the network, structure, interaction, intersection, and knowledge between knowledge units or groups of knowledge. Many complex relationships such as evolution or derivation [1]. VOSviewer is a professional software for drawing scientific maps in various knowledge fields based on the principle of co-citation and coupling of literature [2].

The problem of soil pollution is becoming more and more serious. Protecting the soil is to protect ourselves. Strengthening soil remediation theory and technology research is particularly important [3]. Soil pollution is a global problem. Therefore, based on the relevant literature on soil remediation research in the Web of Science database, the scientific knowledge map can be used to identify the research topics in the field of soil remediation, which can better help researchers quickly understand the topic structure and research topics from large-scale scientific literature in the field of soil remediation, and provide reference for later research on soil remediation.
2. Data collection and processing
This research database is selected from the "Web of Science Core Collection"[4]. Subset selects "SCIE", "SSCI", "CPCI", "CPCI-SSH", "ESCI".

The search term is “soil restoration” and the field is “theme” which contains the title, abstract and keywords from 1988 to 2018, and retrieved 13932 papers.

Delete the keyword “remediation” in order to prevent the most common keywords from affecting the display of other keywords. Use VOSviewer software to co-occurrence analysis of more than 50 high frequency keywords.

3. Hot topics and structure of field
Cluster analysis was performed by Vosviewer to construct a knowledge map of the mainstream domain of soil remediation science. In the visualization results, each keyword is represented by a circle. The diameter of the circle and the size of the label indicate how often the keyword appears. The larger the circle, the more the occurrences appeared. The distance between the circle and another circle indicates the proximity of the two keywords [5]. Lines represent co-occurrence links between two keywords. The more frequently two keywords appear together, the thicker the line between them.

3.1. Hot topic analysis

![Knowledge map of soil remediation](image)

Figure 1. Knowledge map of soil remediation

There are 395 keywords with soil remediation higher than 50 frequency (Fig 1), and 4 topic groups are identified, which are heavy metal pollution field, chemical remediation technology field, bioremediation technology field and electric motor remediation technology field. Among them, the field of bioremediation technology is the link between the field of chemical remediation technology and the field of heavy metal pollution, and it has a close relationship with the two. It can be widely used in soil remediation research. Although there are only four clusters in the figure, the field of phytoremediation...
technology is closely related to the field of organic pollution and heavy metal pollution. The fields of bioremediation technology and heavy metal pollution all contain research topics in the field of phytoremediation technology.

3.2. Detection the structure of field

3.2.1. Heavy metal pollution field

![Figure 2. Knowledge map of heavy metal pollution field](image)

The field of heavy metal pollution mainly studies heavy metal pollution from pollution sources and remediation materials, and describes the types of heavy metal pollution and the corresponding phytoremediation techniques (Fig 2). The cluster consists of 124 words and phrases. The important topic groups are: (1) heavy metal pollution types, and (2) phytoremediation techniques. Through analysis, we can know that in the topic group (1), “heavy metals” is the most central keyword, but because it is a phrase with a wide meaning, and the relationship with other clusters is also relatively close, so the specific heavy metal element vocabulary of "cadmium", "lead", "copper" is a research hotspot of heavy metal pollution types in recent years. Heavy metal pollution is the most studied direction in soil pollution. The topic group (2) "Phytoremediation" is the most commonly used remediation method for heavy metal contaminated soil. Hot topics in the field include “heavy-metals”, “phytoremediation”, “contaminated soils”, “cadmium”, “lead”, “bioavailability”, “accumulation”, “plant”, ”copper”, ”zinc”, “toxicity”, “immobilization”, “speciation”, “phytoextraction”.
3.2.2. Chemical remediation technology field

![Knowledge map of chemical remediation technology field](image)

The field of chemical remediation technology mainly studies the theory, technology and method of separating chemical substances by the application of various chemical reagents according to the chemical characteristics of pollutants or contaminated media (Fig 3). The cluster consists of 106 words and phrases, and the key topics that are summarized include: (1) rinsing techniques, and (2) oxidation and dissolution techniques. The main theme (1) is to study the nano-zero-valent iron leaching pollutants under the action of soil water, which is at the core of the network. The theme (2) focuses on the study of the mechanism of action of remediation materials such as PAH and trichloroethylene. Hot topics in the field include “zero valent iron”, “water”, “volatilization”, “vadose zone”, “and unsaturated zone”, “trichloroethylene”, “transport”, “temperature”, “surfactant, solute transport”, “solubilization”.

Figure 3. Knowledge map of chemical remediation technology field
3.2.3. Bioremediation technology field

![Figure 4. Knowledge map of bioremediation technology field](image)

Bioremediation technology field focuses on organic pollution types and bioremediation technologies for organic pollution. The cluster consists of 78 words and phrases, which are summarized in the following categories: (1) organic pollution types, and (2) bioremediation techniques (Fig 4). In the topic group (1), “polycyclic aromatic-hydrocarbons” is a hot topic in this field, and it is at the core. The topic group (2) mainly studies biodegradation and remediation technologies for organic pollution. Hot topics in the field include “bioremediation”, “degradation”, “biodegradation”, “polycyclic aromatic-hydrocarbons”, “phenanthrene”, “bacteria”, “hydrocarbons”, “waste-water”, “rhizosphere”, “microorganisms”, “bio augmentation”, “crude-oil”.
3.2.4. Electric remediation technology field

Figure 5. Knowledge map of electric remediation technology field

In the field of electric refinery research, the main research is on the mechanism and effect of on-site remediation of contaminated soil under the action of DC electric field (Fig 5). The cluster consists of 32 words and phrases. From the closeness of the relationship between the keywords, this cluster is closely related to the research of heavy metal pollution. The researchers adopt electrodynamic remediation methods for heavy metal pollution. Important topic terms include “removal”, “extraction”, “electro kinetic remediation”, “EDTA”, “soil washing”, “electro kinetics”, “chelating-agents”, “decontamination”, “electroosmosis”, “electro remediation”.

4. Conclusion
The key words in the field of soil remediation research are divided into four thematic groups, namely, heavy metal pollution, chemical remediation technology, bioremediation technology, and electric remediation technology. Phytoremediation technology is an important link between the field of bioremediation technology and heavy metal pollution. After further domain structure detection, the main topics in the field of soil remediation research are mainly “heavy-metals”, “removal”, “bioremediation”, “degradation”, “biodegradation”, “phytoremediation”, “contaminated soil”, “water”, “cadmium”, “polycyclic aromatic-hydrocarbons”, “adsorption”, “lead”, “sorption”, “bioavailability”, “extraction”.

Acknowledgments
This work was supported by the Scientific Research Item of Shaanxi Provincial Land Engineering Construction Group (DJNY-2019-26) and the Fund Project of Shaanxi Key Laboratory of Land Consolidation (2018-TD02).
References

[1] Rongying Z, Ju W. Knowledge Mapping Analysis of Library Science [J]. Journal of Library Science in China, 2011.

[2] Eck N J V, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping [J]. Scientometrics, 2010, 84 (2): 523 - 538.

[3] Aguilar J, Dorronsoro C, E. Fernández, et al. Soil pollution by a pyrite mine spill in Spain: evolution in time [J]. Environmental Pollution, 2004, 132 (3): 0 - 401.

[4] Norris M, Oppenheim C. Comparing alternatives to the Web of Science for coverage of the social sciences’ literature [J]. Journal of Informetrics, 2007, 1 (2): 161 - 169.

[5] Haunschild R, Bornmann L, Marx W. Climate Change Research in View of Bibliometrics [J]. Plos One, 2016.