Based on Bibliometric Analysis of Saline Alkali Soil Improvement Technology Research Status and Hot Spot Analysis

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Abstract. Saline alkali soil is a common form of soil degradation. Soil salinization is an important factor restricting the sustainable development of agriculture in irrigated agricultural areas in the world. Soil salinization improvement materials and technologies have always been a research hotspot. Based on the data source of CNKI, through setting key search words and years, searching relevant literature and patents, using bibliometric method, and drawing and tabulating tools such as origin and excel, the data were statistically analyzed. The results showed that the literature related to saline alkali land improvement technology was first published in 1957, and then increased year by year. Ningxia University was the institution that publishes the largest number of related scientific and technological papers. Wei Kunfeng, from Dezhou saline alkali soil greening Research Institute of Shandong Province, was the researcher with the largest number of related scientific and technological papers. Most of them belong to the field of Engineering Technology (nature). Most of the papers were supported by National Natural Science Foundation, National Science and technology support plan and other national fund projects Ningxia Hui Autonomous Region holds the most published papers.

Keywords: All manuscripts, must be, figure texts.

1. Introduction
Saline alkali soil was a kind of soil type widely distributed on land, covering more than 100 countries and regions, accounting for about 25% of the total land area. Soil salinization mainly occurs in arid, semi-arid and semi humid areas. Adverse climate, geology, topography, hydrology and hydrogeology and other natural factors promote the formation of soil salinization. Inappropriate land use and
Irrigation measures were also the main causes of soil salinization. Soil salinization seriously restricts agricultural production and affects ecological environment. Under the current situation of large population, less land and shortage of arable land in China, it was of great significance to improve saline alkali land as a potential way to increase the reserve resources of cultivated land.

The improvement and utilization of saline alkali land has been studied for many years, and some remarkable achievements have been made. The improvement methods of saline alkali land mainly include physical improvement, water conservancy improvement, chemical improvement and biological improvement. The improvement effect and adaptability of different improvement measures were different. At present, many improvement techniques were used to improve the soil salinity in saline alkali soil.

Most of the papers on saline alkali land improvement technology focus on the improvement materials, and discuss the improvement effect and influencing factors of soil salt content, fertility factors and soil properties. Taking CNKI as the data source, this paper analyzes the annual change of the number of published papers, the analysis of the publishing institutions, the number of papers issued by the authors and the fund support, etc., and forecasts the research hotspots and future development trends, so as to provide data reference for relevant researchers.

2. Data sources and analysis methods

2.1. Data sources
Based on the knowledge discovery network platform of CNKI, the advanced retrieval method was used to search the literature with the theme of "saline alkali land" and "improvement", and the retrieval time was limited to December 2020. The results showed that there were 3177 articles about saline alkali land improvement in CNKI species. The retrieval time was December 4, 2020.

2.2. Analysis methods and tools
Bibliometrics was an interdisciplinary science that integrates mathematics, statistics, philology and other disciplines. It uses the methods of mathematics and statistics to make quantitative analysis of literature, author, document identification and other carriers. Literature includes academic journals, dissertations, conference papers, newspapers, yearbooks, books, patents, standards, achievements, academic journals, government documents, scientific and technological reports, statistical data, reference books, etc. It has a wide range of applications, which has important reference value for the evaluation of publications, the evaluation of literature utilization, the prediction of the development direction of literature services, and the capture of related research topics and research hotspots.

Through the multi-dimensional statistics and analysis of the trend, research institutions, authors, research levels and other variables, using origin, Excel and other drawing and tabulation software, draw the annual distribution of the number of papers published, research institutions and other statistical data, draw a visual chart, describe the research and development situation of saline alkali land improvement measures, and predict the future development trend.

3. Results and analysis

3.1. Time distribution and development trend of literature
From 1957 to 2020, the change of literature quantity of saline alkali land improvement measures was shown in Figure 1. A total of 2447 Chinese academic papers, 414 dissertations, 50 conferences and 45 others have been published. It can be seen from Figure 1 that before 2000, the annual number of papers published ranged from 2 to 31. At this time, the research on saline alkali land improvement was at the initial stage, mainly focusing on saline alkali land, improving saline alkali land, improving utilization, saline alkali soil, etc. the first scientific and technological paper included was turning barren land into good farmland - measures for improving saline alkali land, red soil and low-lying land "from agricultural economy and management [1]. The improvement measures of saline alkali land, red
soil and depression were introduced. From 2000 to 2012, the number of papers published increased linearly. At this stage, the number of papers published by scientific researchers increased from 40 papers/a to 198 papers/a. The improvement materials and technical measures of saline alkali soil improvement, such as biological improvement, salt tolerant plants and improvement effect, were proposed. The number of papers published from 2013 to 2020 was relatively stable, and the research mainly focused on biological improvement, organic fertilizer, amendment, soil fertility improvement, etc.

![Annual trend of the number of articles published](image)

**Fig. 1** Annual trend of the number of articles published

3.2. Analysis of the sending organization

The top 10 scientific papers published on saline alkali soil improvement were shown in Figure 2. According to the number of published papers, Ningxia University (82), Shandong Agricultural University (71), Beijing Forestry University (57), Jilin Agricultural University (52), INNER MONGOLIA AGRICULTURAL UNIVERSITY (44), Northeast Forestry University (32), Xi'an University of science and Technology (32), Institute of agricultural resources and environment of Ningxia Academy of agricultural and Forestry Sciences (31) and Tianjin Agricultural University (25) 450 technical papers, accounting for 18.39% of the total number of papers published over the years. According to the nature of the institutions, it was found that institutions of higher learning and research institutes account for 22.76% and 11.12% of the total number of scientific and technological papers published by the institutions, and 4.07% of the articles published by other institutions such as enterprises and non-institutional information.

Chen from Geography Department of Ningxia University first published a paper entitled "soil salinization and its control in Pingluo County" in 1993 [2]. He emphatically analyzed the importance of rational irrigation for improving saline alkali land, and put forward necessary irrigation measures and construction supporting projects for soil salinization control in Pingluo County. During the period of 2002-2019, Ningxia University mainly focused on the improvement of saline alkali land, desulfurization gypsum and other waste materials, and the improvement of soil physical and chemical properties. The area was mainly concentrated in Yinchuan plain and Hetao area, in the diversity of salt tolerant plants and soil animals, water and salt transport, and agricultural basic science.

Shandong Agricultural University ranked second, with 71 scientific papers published, accounting for 2.90% of the total. There were 37 theses, accounting for 52.11% of the total. The first one was a scientific paper entitled "experience of rice yield increase in coastal saline alkali land" published by Jin and Zhang in 1991 [3]. Through the Yellow River Diversion and alkali transformation, rice planting was developed, and the yield increase effect was obvious.
3.3. Analysis of the number of papers published by authors

The top 10 authors who published papers related to saline alkali soil improvement were shown in Table 1. The top 10 authors of scientific and technological papers were mainly from seven units, including Dezhou City Administration Bureau of Shandong Province, Ningxia University, Ningxia Academy of Agricultural and Forestry Sciences, Liaoning Academy of Forestry Sciences, Northeast Forestry University, Ningxia Academy of Agricultural and Forestry Sciences and Inner Mongolia University for Nationalities. Wei published 17 papers and published the paper "Preliminary study on soil improvement and tree planting in saline alkali soil" for the first time in 1988. It mainly introduced the methods of saline alkali soil treatment in micro area, including salt layer, salt bag, humic acid fertilizer, calcium superphosphate, acidified water and other measures to improve the soil physical conditions and nutritional conditions in the rhizosphere of green trees. The research mainly focuses on saline alkali soil greening, micro area soil improvement, saline alkali soil crop cultivation technology, etc., and also has certain concern in humic acid and soil improvement mechanism. The most frequently cited articles were Niu and Wang of Ningxia University and Institute of Northwest Plateau Biology, Chinese Academy of Sciences published "Research progress on saline alkali land treatment" in 2003 [5], which systematically introduced the causes of land salinization and the situation of saline alkali land treatment, with emphasis on the research hotspots and fields at home and abroad. Secondly, Wang et al. published a review on the sustainable utilization of saline alkali land in 2011 [6], which systematically introduced the important progress made in the sustainable utilization of saline alkali land from the aspects of technology research and development, supporting technology management and research methods.

Many papers have been published on salinization, saline alkali land improvement technology and application of desulfurization waste in saline alkali land improvement in Yellow River Irrigation Area [7,8]. Xu mainly studied the improvement measures, salt tolerance, application of desulfurization gypsum and soil microflora of saline alkali land in Yinchuan Plain [9,10]. Pan's research mainly focused on muddy coast, coastal saline alkali land, tree species allocation and optimization model of shelter forest [11,12].

![Fig. 2](image-url)  
**Fig. 2** Top 10 institutions with literature quantity
Table. 1 Authors of papers on remediation technology of soil heavy metal pollution

| Serial Number | Author         | Number | Author’s Office                                      |
|---------------|----------------|--------|-----------------------------------------------------|
| 1             | WEI Kunfeng    | 17     | Dezhou City Administration Bureau                   |
| 2             | SUN Zhaojun    | 15     | Ningxia University                                  |
| 3             | XU Xing        | 12     | Ningxia Academy of Agricultural and Forestry Sciences |
| 4             | PAN Wenli      | 10     | Liaoning Academy of Forest Science                   |
| 5             | ZU Yuangang    | 9      | Northeast Forestry University                       |
| 6             | WANG Wenjie    | 9      | Northeast Forestry University                       |
| 7             | YANG Jianguo   | 9      | Ningxia Academy of Agricultural and Forestry Sciences |
| 8             | FAN Fu         | 8      | Inner Mongolia University for Nationalities         |
| 9             | ZHANG Qingguo  | 8      | Inner Mongolia University for Nationalities         |
| 10            | LI Qian        | 8      | Ningxia University                                  |

3.4. Fund support analysis

According to the statistics of fund types supported by scientific papers, the results were shown in Figure 3. There were 431 papers supported by fund, accounting for 17.61% of the total number, the top 10 funds were as follows: National Natural Science Foundation of China(111), National Science and Technology Support Plan(110), National Science and technology research plan(22), National key R & D Plan(17), Knowledge Innovation Project of Chinese Academy of Sciences(14), National High Tech Research and development plan(12), National Fund for transformation of agricultural scientific and technological achievements(11), Ningxia Natural Science Foundation(10), National key basic research development plan(9), and Natural Science Foundation of Inner Mongolia Autonomous Region(8). A total of 324 scientific papers were supported, accounting for 75.17% of the total. The number of scientific and technological papers supported by national fund was 292, accounting for 90.12% of the top 10 scientific and technological papers supported by National Natural Science Fund, and the number of scientific and technological papers supported by National Natural Science Fund was 111, accounting for 25.75% of the total number of scientific and technological papers supported by National Natural Science Fund. The most cited scientific and technological paper was "Research on water and salt transport characteristics of saline alkali soil under drip irrigation under mulch", which was published in the Journal of Agricultural Engineering in 2000, with 316 citations.

There were 10 scientific papers supported by Ningxia Natural Science Foundation and 8 scientific and technological papers supported by Natural Science Foundation of Inner Mongolia Autonomous Region, which were two provincial funds among the top 10 funds. Most of the supported papers focus on the improvement of saline alkali land by biological waste, and the improvement of saline alkali land by waste and irrigation measures.
3.5. **Analysis of research hotspots**

By consulting the subject hot spots of China academic literature online publishing general database, it was found that there were many researches on alkalized plants, halophytes, biological improvement, plant restoration, afforestation technology, landscaping and so on around the improvement engineering measures of saline alkali land, including excavation and support, well irrigation (drainage) measures, and subsurface water collection, etc.

4. **Conclusion and Prospect**

The shortage of cultivated land resources and the development of saline alkali land improvement technology make it possible to change saline alkali waste land into agricultural land. On this basis, a variety of improvement technologies and materials were developed and widely used. Based on the analysis and measurement of relevant literature by using CNKI database, it was found that the earliest literature on saline alkali land improvement technology was published in 1957, and then increased year by year, and reached the maximum of 217 in 2019. From 2000 to 2012, the number of published papers showed a linear increasing trend. Irrigation and drainage measures, salt tolerant plants and alkali tolerant plants, and improvement effect were the research hotspots. From 2012 to 2019, the number of published papers increased exponentially, and the research mainly focused on microbial improvement, afforestation and other improvement technologies, as well as non-destructive testing technology.

Ningxia University was the institution that publishes the largest number of related scientific and technological papers. Wei from of Shandong Province was the researcher with the largest number of related scientific and technological papers. Nearly half of the published scientific and technological papers belong to the field of Engineering Technology (nature), and the papers supported by National Natural Science Foundation, National Science and technology support plan and other national fund projects occupy the top Ningxia Hui Autonomous Region was the region with the largest number of papers supported by provincial fund projects.

**Acknowledgements**

Financial support was provided by the Fund Project of Shaanxi Key Laboratory of Land Consolidation (2019-JC04).
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