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A Bibliometric Analysis of Soil Nutrient Testing Using Digital Image Processing with Vosviewer

Shivani Sisodia[1], Saurabh Dhyani[2]

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Abstract: As we know our environment is deteriorating rapidly. We need technological interventions to speed up the work done in order to save our environment. Our scientists, researchers, agriculturists and government invest a great deal of money in order to test soil samples. This area of research is based on use of technology in order to help with soil testing. This study is done to examine current and future trends in research related to "soil nutrient analysis using image processing". We have used Scopus database to get articles related to area of interest and VOSviewer (1.6.19) version is used to extract details from articles using bibliometric analysis. Parameters such as keywords, author names, publication journals, organization, countries and citations have been considered. Statistics show that soil nutrient analysis using machine learning is a trending topic in research field. A total of 1400 publications were used from Scopus database. Findings suggest that maximum research has been done in this field by researchers of China. Major work has been done on identifying soil calcite, soil organic carbon etc. using image processing and minor work has been done in order to identify other micro-nutrients, macro-nutrients in soil such as NPK and pH of soil.

Keywords: *Bibliometric analysis, image processing, soil testing, VOSviewer.*

1. Introduction

"Soils are fundamental to life on Earth, but pressure on soil resources is reaching critical limits," states the World Soil Charter (FAO, 2015). One crucial component of sustainable agriculture is careful soil management, which also offers a useful lever for climate regulation and a route for preserving ecosystem services and biodiversity. When we use soil to grow a crop, the crop absorbs certain nutrients from soil. Thus, endless cultivation can leave the soil with little or no nutrients. Soil can be replenished by adding what is required in the correct amount. More than the correct amount will lead to pollution of soil which will have a negative impact. What is implied here is that analysis of soil in maintaining fertility as well as in managing land degradation is important.

Traditionally the scientific methods used for testing of soil were time consuming and required expertise. As machine learning was developed work started to automate testing of soil. Algorithms were developed in order to test soil quickly using machines. Decision trees, KNN, ANN, and SVM have been employed to build soil testing algorithms. These algorithms majorly used segmentation and classification based on various criteria. Our focus is on use of image processing to automate the soil testing process. The study and classification of soil is inspiring researchers lately. These studies include an understanding of soil genetic process and identifying patterns seen on different soil.

[1] *Uttaranchal University – Uttarakhand, India*
ORCID ID : 0000-0002-5518-9037
[2] *Uttaranchal University – Uttarakhand, India*
ORCID ID : 0000-0003-4218-6782

** Corresponding Author Email: shivani888999@gmail.com*

A type of statistical method to carry out a quantitative evaluation of research is bibliometric analysis. VOSViewer is a software available free of cost to develop and study bibliometric maps based on data from Scopus, web of science and PubMed. Table 1. describes various approaches of analysis that VOSviewer provides.

This study is aimed to determine the following:

RQ1. Which countries, authors, journals are working majorly in identifying soil nutrients using image processing?

RQ2. What are the most frequently used keywords and themes in the study of identifying soil nutrients using image processing?

RQ3. What kind of bibliographic coupling exists in the subject of identifying soil nutrients using image processing?

Section cover: The first section describes what bibliometric analysis is along with its benefits for research. After that we describe how our database was created. Following is a table that describes various bibliometric analysis techniques. Later we provide various bibliometric analysis done on data with diagrams, tables and description. Last but not the least is the conclusion of our study.

2. Methods And Materials

2.1. Data Extraction

For the purposes of this analysis, we chose the articles using a two-step process. In the first step, suitable search terms for mining the Scopus database for pertinent publications were described. Due to its comprehensive coverage of peer-reviewed research published in reliable journals and its

widespread presence across the educational network. In the second step, we used certain criteria to decide which articles should be added to our database for the bibliometric and content analyses.

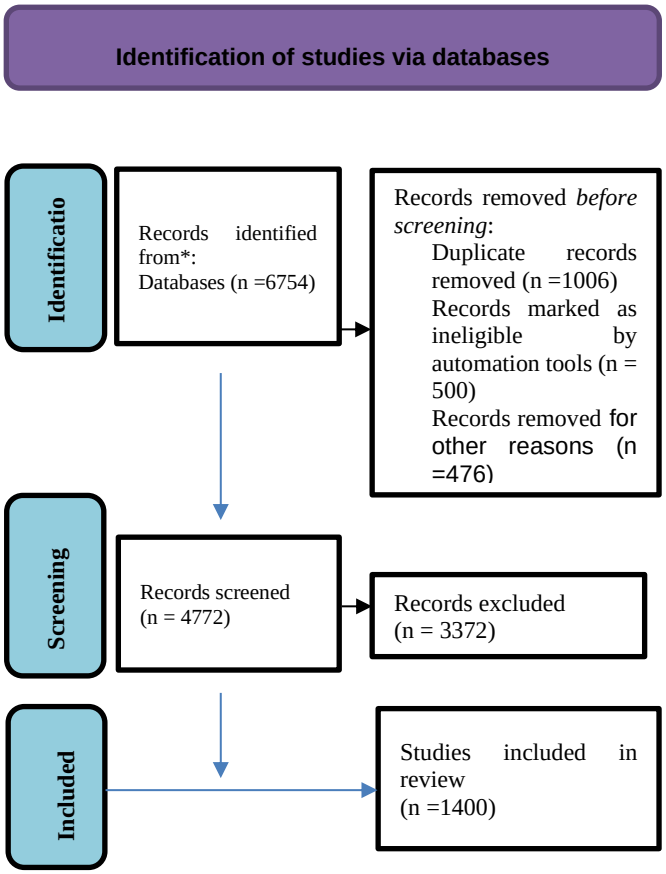
2.2. Bibliometric Analysis

In 1969, Pritchard developed bibliometric analysis, which is now

Table 1. Description of various bibliometric analysis.

Applied technique	***Description***	***Pros***	***Cons***
Bibliometric analysis of co-occurrence of author keyword	Author keywords are provided by authors in their writings, this analysis is to determine how many times an author keyword occurs in all the documents selected.	It helps in identifying articles with similar are of study and similar findings.	Unstable outcomes may arise due to temporal changes in keyword use [1].
Bibliometric analysis co-citation of cited reference	This helps is identifying how many times a publication is referenced by other publications [2].	It helps in identifying collaborative network of citations as well as popularity of documents.	Trends of citation among different field may vary. Unless comparisons are made between researchers working in the same field or at similar phases of their careers, they might not provide significant results[3]
Bibliographic coupling sources	Examines the frequency at which a publication is referenced by other prominent publications.	Assists in the full evaluation of a publication's intellectual influence.	Only evaluates the impact caused by citations in reputable journals.
Co-authorship analysis	The units demonstrating the highest level of collaborative publication have been identified, and the most productive group of documents has been evaluated [4].	Assists in determining the degree of collaboration between writers, institutions, and countries. The level of cooperative productivity may be quantified by academics.	Authorship network visualization has received less attention.

recognized as a method for examining the temporal growth of a research area from a multidisciplinary aspect [5]. The identity of distinguished authors, the mapping of a studies location's limitations, and the improvement of new studies are all made possible by using bibliometric evaluation [6]. Researchers from an expansion of fields have used this approach, along with those in manufacturing [7], arts-based totally control [8], advertising [9], social media or networks [10], finance [11]. Utilizing community evaluation, co-incidence analysis, and bibliographic coupling, bibliometric analysis is completed with this research. In order to deal with this, the methods of co-occurrence, co-authorship, citation, and co-citation analyses had been applied with RQ1 to create a complete profile of the state of the studies in this topic. Dynamic co-quotation and co-word research have been achieved to comprehend the improvement of this field and the primary regions that have been studied by preceding researchers (RQ2). On the way to decide the top 3 important publications in research subject matter. Two attributes applied are “no. of links” and “Total link strength” [12].



4. Results and visualizations using bibliometric analysis.

This section summarizes the current status of research field, including publication trends, types of publications and top journals. The number of publications in the field of soil analysis using image processing was taken from the period of 2013 to 2023. The number of publication in the field of soil analysis using image processing significantly increased during last 7 years. The reason could be developments in the field of artificial intelligence and the rate at which people are adapting to the artificial intelligence era.

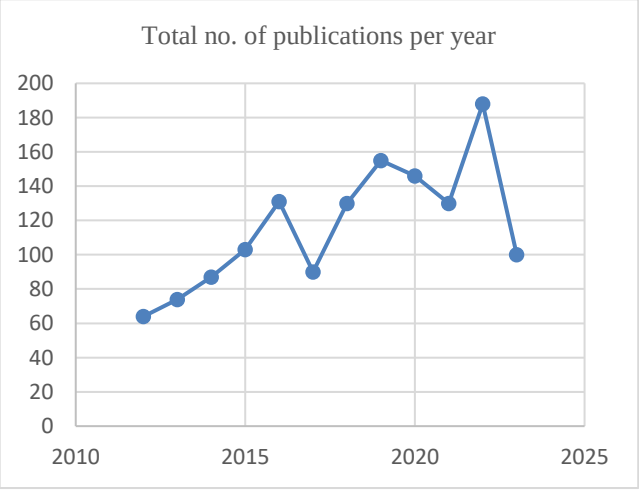


Fig.1. year wise publication trend

It is seen that there was a spike in research publications related to "soil nutrient analysis using image processing" after 2016. There was a drop during 2017 in year wise publications. After 2017 there was a rise and after 2019 a slight drop. After 2021 the spike has been on rise. This study was done in the beginning of 2023 thus not much papers were not published. This proves that this is an upcoming topic of interest and much work can be done in this field as not much work has been done before 2016.

4.1. Bibliometric analysis of co-occurrence of author keyword

When we examine links with soil it seems that research has been done on meso structure, x-ray tomography, water content, cracks, computed tomography, vegetation, crops using machine vision, machine learning, ANN, segmentation, classification, remote sensing. Three clusters that appear to be bigger than the rest are bright blue, blue and red.

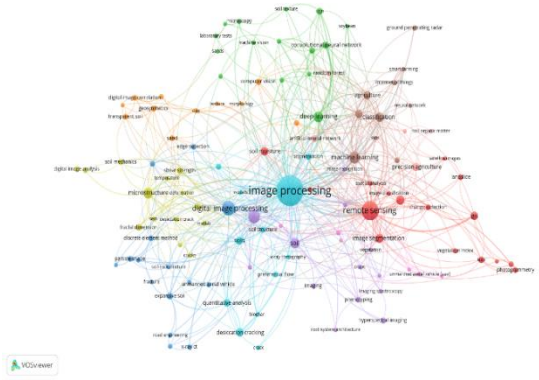


Fig.2. author keyword analysis

The bright blue consists of areas related to image processing, blue consists of areas related to digital image processing and red consists of areas related to remote sensing. This clears that soil testing can be achieved using image processing, earlier works have mostly focused on remote sensing based approaches. Image processing has been widely used but not for soil nutrient testing specially pH and NPK, it has been used for various other testing such as moisture, soil calcite, soil organic carbon etc. Each keyword is examined by VOSviewer, which calculates its linkages, overall link strength, and co-occurrences with other keywords. The number of articles where the keyword appears is represented by the occurrences. The keyword with maximum frequency are presented in Table 2. Image processing, remote sensing, machine learning, deep learning, digital image processing, microstructure, Agriculture, soil, classification, image analysis are the top 10 keywords that co-occur in articles we picked from Scopus database.

It is concluded that most work has been done on image processing and remote sensing.

Minimum number of occurrences of a keyword: 5, of the 4210 keywords, 117 meet the threshold.

Table 2: keyword name, cluster, no. of links, total link strength and occurrences.

KEYWORD	*CLUSTERSNK*	*TOTAL LINK STRENGTH*	*OCCURANCES*
image processing	6	89	245	230
remote sensing	1	45	98	89
Machine learning	3	34	61	36
Deep learning	2	26	50	28
Digital image processing	3	34	44	18
Microstructure	4	21	39	27
Agriculture	8	22	37	22
Soil	5	24	37	44
Classification	8	22	36	16
Image analysis	5	29	34	17

If we see the link between soil and image processing, the link strength is 5, Soil and digital image processing, the link strength is 3, Soil and remote sensing, the link strength is 1.

4.2. Bibliometric analysis co-citation of cited references

Minimum number of citations of cited reference: 8, Of the 47716 cited references, 3 meet the thresholds. We find 23 items, 4 clusters 66 links total link strength 119.

Table 3: Most cited references along with their no. of citations

ITEM	*TOTAL LINK STRENGTH*	*CITATIONS*
lakshmikantha m.r., prat p.c., ledesma a., experimental evidence of size effect in soil cracking, can. geotech. j., 49, 3, pp. 264-284, (2012)	5	8
morris p.h., graham j., williams d.j., cracking in drying soils, can. geotech. j., 29, 2, pp. 263-277, (1992)	5	9
white d.j., take w.a., bolton m.d., soil deformation measurement using particle image velocimetry (piv) and photogrammetry, geotechnique, 53, 7, pp. 619-631, (2003)	2	17

4.3. Bibliometric analysis co-citation of cited authors

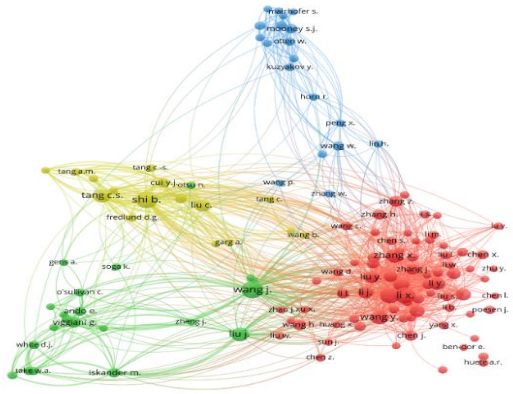


Fig.3. co-citation cited authors

Minimum number of citations of an author: 50, Of the 75250 authors, 132 meet the threshold.

Table 4: most cited authors and their no. of citations.

AUTHORS	*CITATIONS*	*TOTAL LINK STRENGTH*
Shi b.	326	10239
Li x.	325	6961
Li x.	273	4863
Zhang y.	269	6424
Wang y.	223	4754

4.4. Bibliometric analysis of co-authorship countries

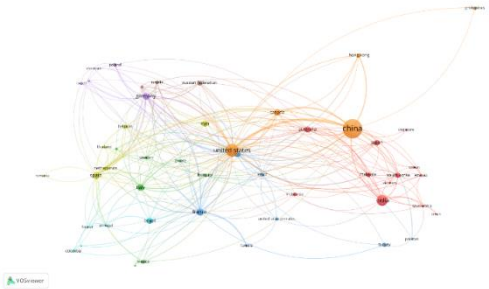


Fig.4. Co- authorship between countries is illustrated.

An essential type of co-authorship analysis is country co-authorship analysis. It may be an indicator of the level of international communication as well as the dominant

nations in this area. Figure 4 displays the national co-authorship network for papers relevant to soil analysis. The map has a variety of colors, which illustrates how the directions of research are varied. The powerful nations are represented by the large nodes. The cooperative interactions between institutions are represented by the links between nodes. The degree of country cooperation is represented by the distance between nodes and the thickness of the linkages. The USA and China have a link strength of 41, whereas the USA and Germany have a link strength of 9. It shows that the cooperative relationship is not primarily influenced by geographic advantage. Minimum number of documents of a country are 5. Total countries were 95, 50 meet the threshold.

Table 5: country names, number of documents published by them along with citation number.

COUNTRIES	LINKS	TOTAL LINK STRENGTH	DOCUMENTS	CITATIONS
China	28	120	431	5129
United States	38	153	206	4624
Germany	22	69	59	2493

4.5. Bibliographic coupling sources

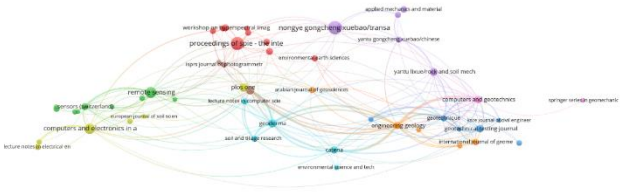


Fig.5. Sources of publication.

Minimum no. of documents of a source: 5, Out of 688 sources, 57 meet the threshold

Table 6: top three publishers based on no. of citations

SOURCE	*DOCUMENTS*	*CITATIONS*	*TOTAL LINK STRENGTH*
engineering geology	12	551	214
Computers and geotechnics	12	249	128
Geoderma	15	312	107

The list in Figure 6 provides a summary of 3 main sources of publication. The list was created based on the quantity of papers on "soil nutrient analysis using image processing" published in the source. Engineering geology has the maximum number of publications with total link strength 214, followed by Computer and geotechnics and Geoderma. Computer and geotecnics and geoderma have link strengths 12 and 15 respectively.

4.6. Bibliographic study of emerging topics with time

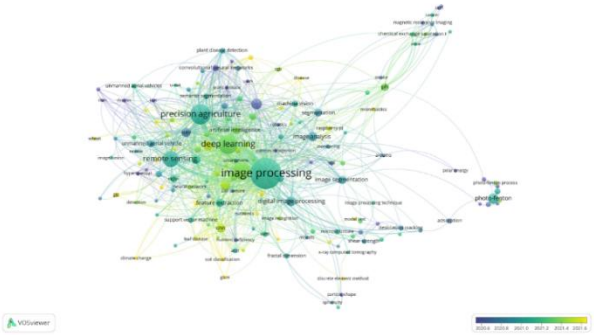


Fig.6. Topic emerging with time related to search area.

This data shows that image processing is the most trending topic, followed by precision agriculture, deep learning and remote sensing. Very less work has been done on soil classification, analysis of pH and NPK using image processing.

4.7. Bibliographic analysis of published journals

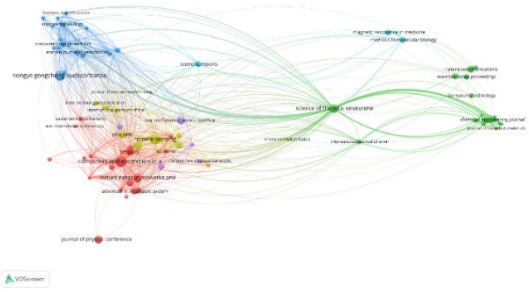


Fig.7. Analysis of published journals.

This analysis tells us that Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering is the journal with most publications in the field of soil study. Computers and electronics in agriculture has the second highest number of publications and Science of total environment is the third in publishing soil studies.

4.8. The distribution of organizations where work is done in soil study

According to this analysis we can see that maximum work in this field has been done by University of Chinese studies, China. We also found out that after China the maximum amount of work done in this field is by United States. After China and United States it is India doing study in this field but there is no correlation between any of these studies. Few links have been found in studies that are done in China and United states.

Fig.8. Organizations working on the area of research.

5. Conclusion

In this study we have made an attempt to evaluate and examine previous research done on soil nutrient analysis using image processing. In order to answer RQ1 various bibliographic coupling were done and a comprehensive review was provided based on top articles and authors. In order to answer RQ2 various co- occurrence analysis have been done. According to our year wise publication analysis, interest in this area of research started in 2012 and has been on a rise till date. We also noticed that image processing and remote sensing are most used keywords in our searched literature. Shi b is the most cited author in this area of study. Co- authorship between countries is maximum between China and the United States. Topics in this area of study that are emerging with time are deep learning and precision agriculture so future research can be done in these areas. We offer five conclusions mostly based on the data for furthering studies on image-based soil nutrient analysis. First, our findings help scholars understand the current constraints and range of study in this field. As a result, researchers can use our results to spark our curiosity in unexplored and novel challenges. Second, it may be advantageous for researchers to identify leading figures in the field as prospective collaborators and forces that will help to advance the field's research. Thirdly, we identify significant articles that can be thought of as the cornerstones of this research topic for more in-depth studies.

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Author contributions

Shivani Sisodia: Conceptualization, Methodology, Software, Field study

Saurabh Dhyani: Data curation, Writing-Original draft preparation, Software, Validation., Field study

Dharmendra Kumar: Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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