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Scientific Landscape on Phthalates Biodegradation Research: A Bibliometric and Scientometric Study

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Abstract

This study investigated the scientific landscape of research on phthalate esters biodegradation using the Web of Science database up to 2022. The collected data were analysed using bibliometric and scientometric tools. A total of 863 scholarly documents published between 1975 and 2022 in 266 journals were selected for analysis. The analysis revealed a growth rate of 6.9% in the research field, with an average document age of 10.8 years. The trend in phthalate biodegradation research showed a steady increase in citations until 1997, followed by a slight decrease until 2005, but experienced renewed interest in 2006 and significant growth in 2016. Chemosphere was identified as the prominent journal, and China had the most publications (417) followed by India (78), while Africa had the least productivity, with South Africa contributing the highest number of publications (9). Thematic evolution in the field focused on understanding the mechanisms of phthalate breakdown through microbial enzymes like hydrolases, while revealing changing patterns with the current research focus being "microbial community" and "metabolism" as indicated by strongest burstiness strengths. The study sheds light on the scientific landscape of phthalate biodegradation research, highlighting research gaps and suggesting potential research policy improvements such as enhancing funding and capacity building in biodegradation research in Africa.

Keywords: Phthalate biodegradation, Bibliometric and scientometric, Microbial enzymes, Research policy.

Introduction

Phthalates are a group of synthetic chemicals that are commonly used as plasticizers in a wide range of industrial and consumer products (Rahman and Brazel 2004). They are normally added to plastic products to enhance the durability, flexibility, and transparency of plastic products. Although phthalates are economically important chemicals, they are potential pollutants capable of persisting in the environment for extended periods of time (Verasoundarapandian et al. 2021). Phthalates enter the environment through various sources, including landfills, industrial effluents and wastewater treatment plants (Bergé et al. 2014). Phthalates are known to pollute soil, water and air (Hu et al. 2003, Xu et al. 2008).

Phthalates have been reported to have adverse toxic effects on both aquatic and terrestrial ecosystems (Cuvillier-Hot et al. 2014). Due to their capacity to interact with the endocrine system, phthalates have been extensively recognized as endocrine disruptors, which can cause poor growth and decreased reproductive rates in all types of organisms (Johnson et al. 2012). For instance, they have been linked to a reduction in the abundance of several fish species (Yuen et al. 2020). Exposure to phthalates has been reported to have consequences on growth and development across multiple generations in different organisms (Robaire et al. 2022).

Additionally, research has revealed that the toxicity of phthalates in humans can differ based on the type and degree of exposure, mostly they have been linked to a number of harmful health outcomes, such as toxicity to reproduction and development, neurotoxicity, and endocrine disruption (Engel et al. 2021). Numerous studies have highlighted the risks associated with exposure to phthalates in various contexts, such as workplace and consumer exposure through food, water, and personal care products (Heudorf et al. 2007, Robaire et al. 2022).

Biodegradation is a method which uses microorganisms to break down and transform complex chemical molecules into simpler and less hazardous compounds. Biodegradation is a promising strategy for removing hazardous chemicals from the environment (Boll et al. 2020). Biodegradation of phthalates has been reported to be through both aerobic and anaerobic microbial pathways (Hu et al. 2021), and several studies have demonstrated the potential of this approach to remove phthalates from soil, water and sediment (Liang et al. 2008, Becky et al. 2022). There are several considerable numbers of systematic reviews available on the phthalate biodegradation research (Becky et al. 2022). Although these works have offered critical analyses of the findings of earlier studies, bibliometric and scientometric investigations offer an additional perspective that might be helpful in comprehending the field of phthalate biodegradation.

Bibliometric and scientometric research involves analysing publications, particularly scientific papers, to assess scientific output and impact (Carpenter et al. 2014). Scientific scholarly publications are the best units for bibliometric and scientometric study since they adhere to norms like the peer-review process, originality of research findings and accessibility in indexing databases (Carpenter et al. 2014). The bibliometric components of publications, co-authors, references, and citations can be categorized into counting units like journals, subject areas, institutions and countries (van Leeuwen et al. 2016).

Traditional counting systems are often utilized to communicate basic measurements of research productivity, such as the number of publications or citations that a group of authors, articles, or journals has received. However, to manage the ever-increasing volume of data, specialized tools that utilize mathematical models have been developed (Aria and Cuccurullo 2017). These tools are capable of providing in-depth classifications, sophisticated statistical analyses, and meaningful networks among scholarly publication datasets. The information obtained from these tools can assist to highlight areas for future research and offer potential collaborations, which can have an impact on research policy and practice (Sugimoto and Larivière 2018).

Therefore, the rationale for conducting this study was to address the lack of a comprehensive understanding on the evolving scientific landscape in phthalate biodegradation research. This study aimed to fill this gap by employing bibliometric and scientometric analyses, which quantitatively assessed various aspects such as publication patterns, collaborative endeavours, and research impact of countries, research institutes, journals, and articles. These analytical methods provided a unique perspective and revealed significant trends and insights that were not previously available in the literature. The results of this study contribute to a more comprehensive understanding of phthalate biodegradation research and advance knowledge in this crucial domain.

Materials

The software used in the study included; Citespace 6.2.R4 (standard version), bibliometrix 4.0.0, and VOSviewer 1.6.19.

The computer system used in the present study was MacBook Air running on macOS Monterey 12.6.8. The database used to retrieve data was Web of Science (Clarivate Analytics PLC).

Methods

Data source

The study utilized the Web of Science database to obtain relevant publications related to phthalate biodegradation and bioremediation. The search included all documents published and indexed in Web of Science until 2022. A search string (("biodegradation" or "bioremediation") or ("phthalate" or "phthalates" or "phthalic acid" or "phthalate esters")) was used to retrieve relevant publications. The search terms were selected based on their relevance to the research topic. The study used Meta-analysis protocols (PRISMA-P) 2015 to select the publications. The inclusion criteria were publications that focused on phthalate biodegradation and bioremediation, published in peer-reviewed journals, and available in the English language. The exclusion criteria were publications that were not related to phthalate biodegradation or bioremediation and publications in languages other than English.

Data processing and analysis

Data were processed using bibliometrix (Aria and Cuccurullo 2017), CiteSpace (Chen 2006) and VOSviewer software (van Eck and Waltman 2010). The study utilised different software tools for analysis. CiteSpace was utilised to identify the thematic growth of the field by analysing the burstiness of keywords, while bibliometrix was used for bibliometric analysis to examine publication trends, collaboration patterns, and research hotspots. In addition, VOSviewer was utilised for visualizing and cluster analysis of research themes using keyword analysis, as well as for visualizing networks on sources and country co-citation. Descriptive statistics such as frequency, percentage, and mean were also used to present data.

Result and Discussion

Summary of the results

Table 1 provides a summary of the main information about the data generated using an R Bibliometrix tool in the study. This overview provides the quantity and quality of the data analysed as well as an understanding of the scope and relevance of the study.

Yearly productivity

Figure 1A-D provides insights into the trend of research productivity on phthalate biodegradation from 1975 to 2022. Figure 1A shows the number of articles published in a particular year. Figure 1B denotes the mean total citations per article (MeanTCArt), which is the average number of citations received by each article in a particular year. Figure 1C shows citable years (CY), which is the number of years an article is considered available to be cited. Figure 1D shows the trend of the mean total citation per year (MeanTCperYear), which is the number of citations received by articles published in a particular year.

The trend in research can be observed by comparing the MeanTCperYear and MeanTCArt over the years in the scope (1975–2022). The trend shows that there was an increase in the mean total citations received by articles published on phthalate biodegradation from 1975 to 1997, with a spike in 1997 with a MeanTCArt and MeanTCperYear of 167.54 and 6.21, respectively. This indicates there was a significant breakthrough in the field of phthalate biodegradation research in 1997, with the number of articles published in that year being 13.

On the other hand, there was a slight decrease in the mean total citations received per year from 1998 to 2005, with a decrease in the number of publications during that period. The research trend shifted in 2006 with a MeanTCArt and MeanTCperYear of 28.54, which indicated a renewed interest in phthalate biodegradation research. From 2006 to 2016, the MeanTCArt received per year remained relatively stable, indicating a sustained interest in phthalate biodegradation research during that period.

In 2016, the MeanTCArt denoted a considerable increase, with a MeanTCperYear of 35.88 per year, indicating a rise in the interest in phthalate biodegradation research. The number of articles published that year was 49, which was significantly higher than the previous years, and this could be attributed to the growing awareness of the harmful effects of phthalates on the environment and human health.

A comparison of the MeanTCArt between 2016 and 2020 shows that there was a significant decrease in the MeanTCArt received per year from 35.88 in 2016 to 6.99 in 2020, despite an increase in the number of articles published. This could be attributed to the fact that there was a high saturation of research on phthalate biodegradation during that period, which could have led to a decline in the quality of research.

Table 1: Summary of the main results

Description	**Results**
Main information about data	
Timespan	1975:2022
Sources (Journals, Books, etc)	266
Documents	863
Annual growth rate %	6.9
Document average age	10.8
Average citations per doc	26.72
References	16687
Document contents	
Keywords Plus (ID)	1596
Author's Keywords (DE)	1735
Authorship details	
Total number of authors	2480
Authors of single-authored documents	18
Single-authored documents	20
Co-authors per documents	4.93
International co-authorships %	15.99
Document types	
Article	759
Article; data paper	2
Article; early access	9
Article; proceedings paper	20
Editorial material	1
Meeting abstract	6
Note	4
Proceedings paper	28
Review	34

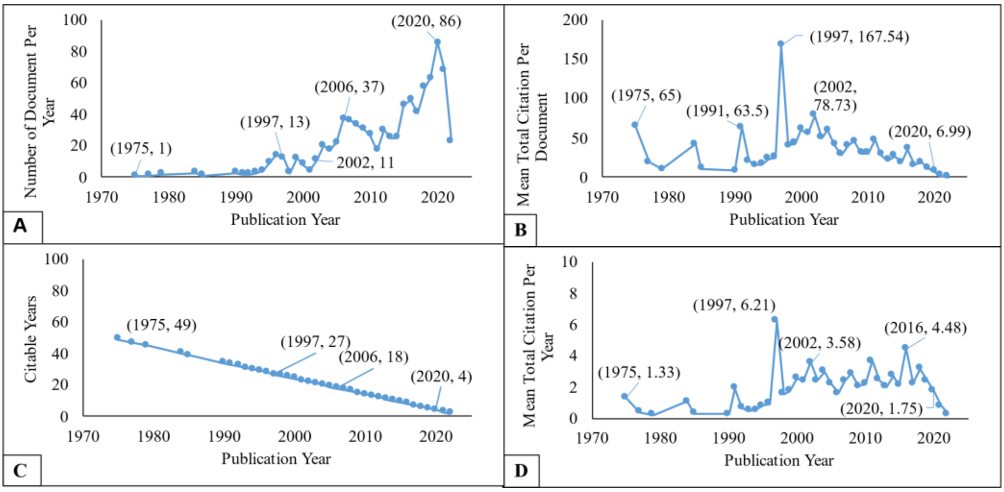


Figure 1: Yearly publication productivity on phthalate biodegradation research.

Relevant journals in the field of phthalate biodegradation

Table 2 provides information on the 10 most productive journals in the field of phthalate biodegradation based on various metrics such as h-index, g-index, m-index, total citations (TC), number of papers (NP), and year of publication start (PY_start). Furthermore, Figure 2 shows the co-citation network of all journals, showing at least four clusters as depicted by the green, red, blue and yellow colour.

Table 2: Most relevant journals in the field of phthalate biodegradation

Journal Name	h_index	g_index	m_index	TLC	TC	NP	PY_start
Chemosphere	31	61	0.66	1983	3818	65	1977
Sci. Total Environ.	21	45	1	1175	2220	45	2003
Int. Biodeterior. Biodegrad.	19	30	0.95	1007	1007	40	2004
J. Hazard. Mater.	19	29	0.76	992	1035	29	1999
Bioresour. Technol.	15	22	0.882	571	710	22	2007
Appl. Microbiol. Biotechnol.	11	13	0.5	1151	935	13	2002
Process Biochem.	11	13	0.407	404	590	13	1997
Water Res.	11	13	0.355	694	861	13	1993
Ecotoxicol. Environ. Saf.	10	14	0.588	310	216	19	2007
Biodegradation	9	17	0.321	279	416	17	1996

According to the results, among all journals, Chemosphere had the highest h-index (31) and g-index (61), indicating that it has published a significant number of highly cited articles in the field. Furthermore, Chemosphere also had the highest total citations (3818) and the highest number of papers (65). The journal started publishing in 1977 and has a TLC (total life cycle) value of 1983, which suggests that its articles tend to have a longer citation half-life than the other journals in the list.

The Science of the Total Environment journal had the highest m-index (1), which is an indicator of how well the articles from this journal are cited relative to the number of published papers. This suggests that the articles published in this journal are highly relevant and impactful in the field of phthalate biodegradation. The relevance of the journal in the field of phthalates biodegradation is further evident from the fact that it has been publishing since 2003 and has garnered a significant number of citations (2220) and papers (45), securing the second-highest position in these metrics.

Other journals on the list include International Biodeterioration and Biodegradation, Journal of Hazardous Materials, Bioresource Technology, Applied Microbiology and Biotechnology, and Water Research. These journals have published a significant number of papers on phthalate biodegradation and have varying levels of impact in the field based on their h-index, g-index, and m-index. Results from the study provide a useful guide for researchers interested in publishing their work in relevant and impactful journals in the field of phthalate biodegradation.

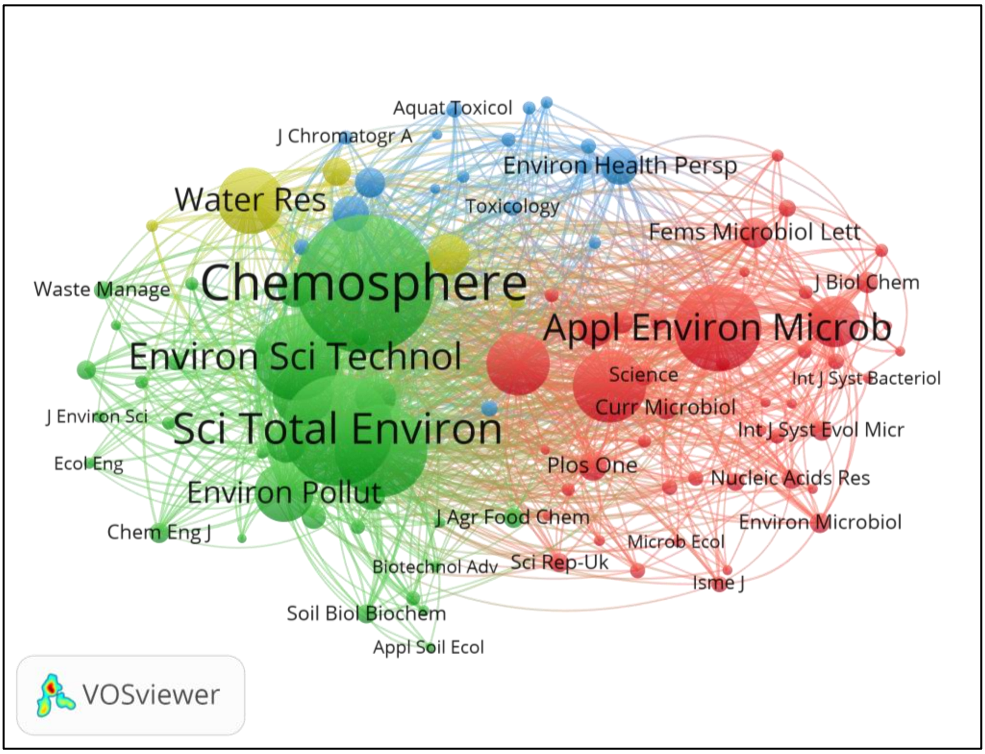


Figure 2: Citation network links among journals on phthalate biodegradation Research.

Most influential references

Tables 3 and 4 provide insights into the most locally and globally cited papers on phthalate biodegradation, respectively. Table 3 shows that Staples et al. (1997) published in Chemosphere is the most cited local paper with 246 citations, followed by Liang et al. (2008) published in the journal of Applied Microbiology and Biotechnology with 148 citations. The other papers in the list have between 98 to 59 citations, indicating their relatively lower impact compared to the top two papers.

Table 4 presents the most globally cited papers on phthalate biodegradation, with Staples et al. (1997) again emerging as the top paper with 1160 citations. Harris et al. (1997) published in Environmental Health Perspectives is the second most cited paper with 623 citations. The papers in this list have a higher number of citations compared to those in Table 2, indicating their global impact.

It is worth noting that both Tables 3 and 4 show that papers published in Chemosphere, Applied Microbiology and Biotechnology, and Science of the Total Environment have a higher citation count compared to other journals. This suggests that these journals are popular publication media for publishing research on phthalate biodegradation. The trends observed in these tables suggest that the field of phthalate biodegradation has been active over the years and researchers have been working on this topic extensively.

Table 3: Most locally cited references

S/N	Paper	DOI	Citations
1	Staples et al. 1997, Chemosphere	10.1016/S0045-6535(97)00195-1	246
2	Liang et al. 2008, Appl. Microbiol. Biotechnol.	10.1007/S00253-008-1548-5	148
3	Chang et al. 2004, Chemosphere	10.1016/j.chemosphere.2003.11.057	98
4	Xu et al. 2005, Int. Biodeter. Biodegr.	10.1016/j.ibiod.2004.05.005	98
5	Gao and Wen 2016, Sci. Total Environ.	10.1016/j.scitotenv.2015.09.148	86
6	Lu et al. 2009, J. Hazard Mater.	10.1016/j.jhazmat.2009.02.126	79
7	Cartwright et al. 2000, Fems Microbiol. Lett.	10.1111/J.1574-6968.2000.TB09077.X	67
8	Yuan et al. 2002, Chemosphere	10.1016/S0045-6535(02)00495-2	66
9	Wu et al. 2010, J. Hazard Mater.	10.1016/j.jhazmat.2009.11.022	65
10	Eaton 2001, J. Bacteriol.	10.1128/JB.183.12.3689-3703.2001	59

Table 4: Most globally cited papers

S/N	Paper	DOI	Citations
1	Staples et al. 1997, Chemosphere	10.1016/S0045-6535(97)00195-1	1160
2	Harris et al.1997, Environ. Health Persp.	10.2307/3433697	623
3	Steinmetz et al. 2016, Sci. Total Environ.	10.1016/j.scitotenv.2016.01.153	495
4	Megharaj et al. 2011, Environ. Int.	10.1016/j.envint.2011.06.003	482
5	Gao and Wen 2016, Sci. Total Environ.	10.1016/j.scitotenv.2015.09.148	378
6	Yuan et al. 2002, Chemosphere	10.1016/S0045-6535(02)00495-2	278
7	Dua et al. 2002, Appl. Microbiol. Biotechnol.	10.1007/s00253-002-1024-6	257
8	Liang et al. 2008, Appl. Microbiol. Biot.	10.1007/s00253-008-1548-5	246
9	Roslev et al. 2007, Water Res.	10.1016/j.watres.2006.11.049	189
10	Xu et al. 2008, Sci. Total Environ.	10.1016/j.scitotenv.2008.01.001	181

Productive countries and affiliations

Figures 3A-C display the productivity of corresponding authors from different countries based on the number of publications they have produced. China tops the list with 417 articles, followed by India with 78 articles. The United States, Canada, Japan, and Mexico are next in line with 40, 44, 27, and 22 articles, respectively. Germany, Korea, Thailand, and Turkey consisted 18, 15, 15, and 14 articles, respectively. It is crucial to remember that the quantity of publications published does not, by itself, determine the quality or impact of study. The quality of research is influenced by many factors, including study methods, funding, and teamwork, However, the results show good performance on the research productivity and funding provision commitment of those countries relative to other countries across the world.

Results in Figure 3A shows that McGill University is the most productive institution in terms of the number of articles published by corresponding authors, with 54 articles. The University of Hong Kong closely follows with 51 articles, while China University of Geosciences, Jinan University, and Universidad Autónoma de Tlaxcala have 33, 26, and 22 articles, respectively.

Compared to other studies, the results are consistent with previous bibliometric research on environmental biodegradation topics, which identified China as one of the most productive countries in terms of publications (Akinpelu and Nchu 2022, Zeng et al. 2022, Xia et al. 2023). Additionally, the data indicates that China had a considerable number of research institutions as four of her research institutions, namely Zhejiang University, Chinese Academy of Sciences, Sichuan Agricultural University and Institute of Soil Science, were among the top ten productive research affiliations. Moreover, the results of the present study are consistent with other studies that have identified McGill University from Canada as the leading institution in environmental biodegradation research (Zeng et al. 2022, Xia et al. 2023). Furthermore, similar to other bibliometric studies, the results of this study highlight the research productivity of other countries such as India, the United States, Canada, and Japan, providing evidence of their commitment to funding research and supporting researchers (Zeng et al. 2022, Xia et al. 2023).

In contrast, the data presented in Figure 3C shows that Africa was the least productive continent in this field. South Africa had the highest number of publications with 9 publications, followed by Egypt (7), Tunisia (6), Nigeria (5), Algeria (3), Morocco and Sierra Leone (2), whereas Ethiopia, Uganda, and Tanzania had only one scholarly work each. The low level of scholarly works in Africa can be attributed to a lack of research funding, poor research infrastructure and shortage of experts in environmental biodegradation. Addressing these challenges would require Africa governments and other stakeholders to increase investment in research funding, infrastructure improvisation, and capacity building for researchers, which could ultimately improve Africa's research productivity and contribute to the global knowledge base on this important topic.

The results presented in Figures 3A-C as well as Figure 4 have several policy implications. The high productivity of China and India in phthalate biodegradation research underscores the need for other countries to increase their funding and support for research in this field. Governments, funding agencies, and other stakeholders can achieve this by investing more in research and creating an enabling environment for researchers. The dominance of certain research institutions such as McGill University and the University of Hong Kong from Canada and China respectively highlights the importance of establishing and supporting research centres of excellence in biodegradation research. The low productivity of African countries in this field emphasizes the urgent need for increased investment in research funding, infrastructure, and capacity building for researchers on the continent. African governments and other stakeholders can prioritize research funding and support to enhance research productivity, ultimately contributing to the global knowledge base on phthalate biodegradation.

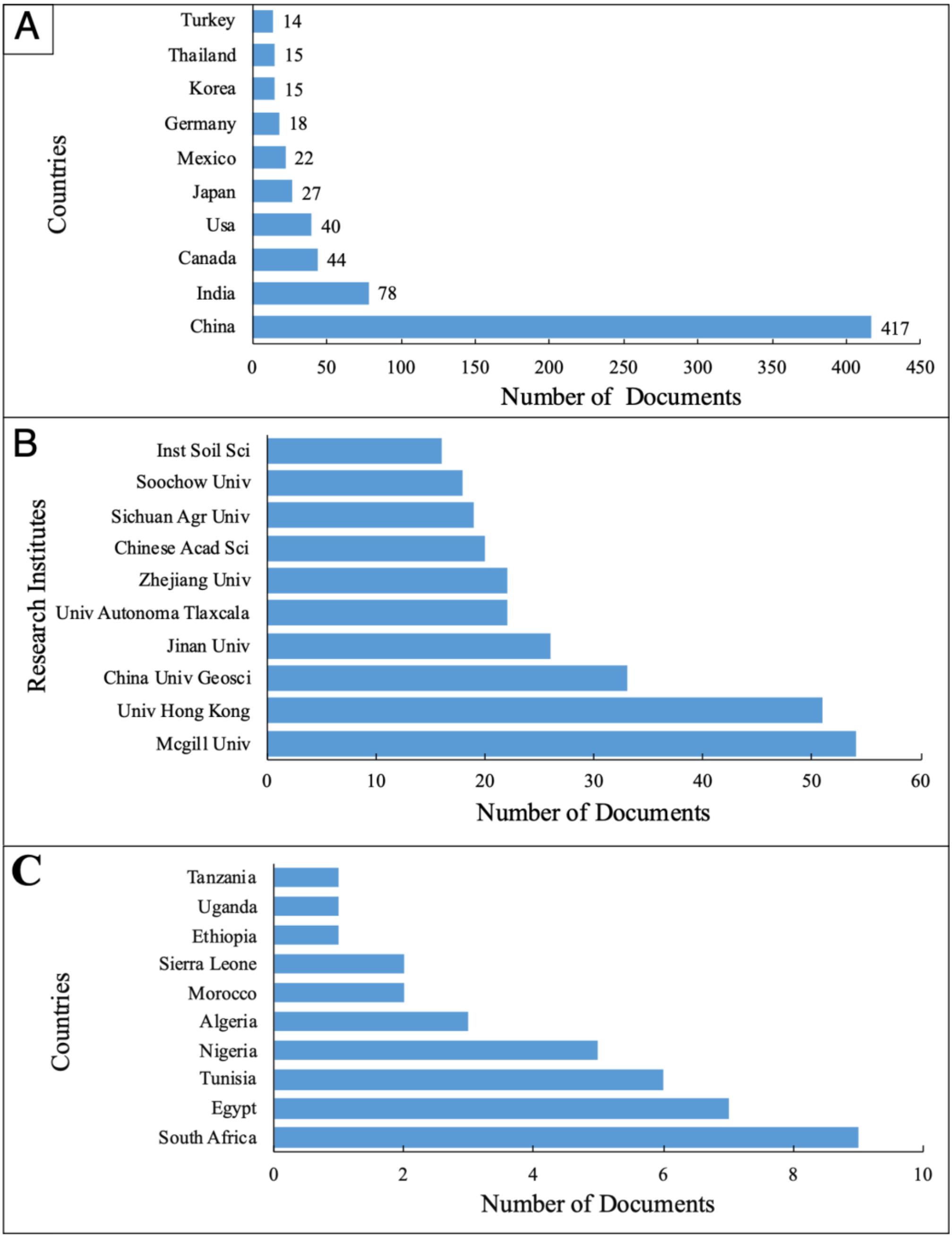


Figure 3: Countries and institutions research productivity (A) 10 most productive countries affiliations (B) 10 most productive research institutes (C) Research productivity in Africa.

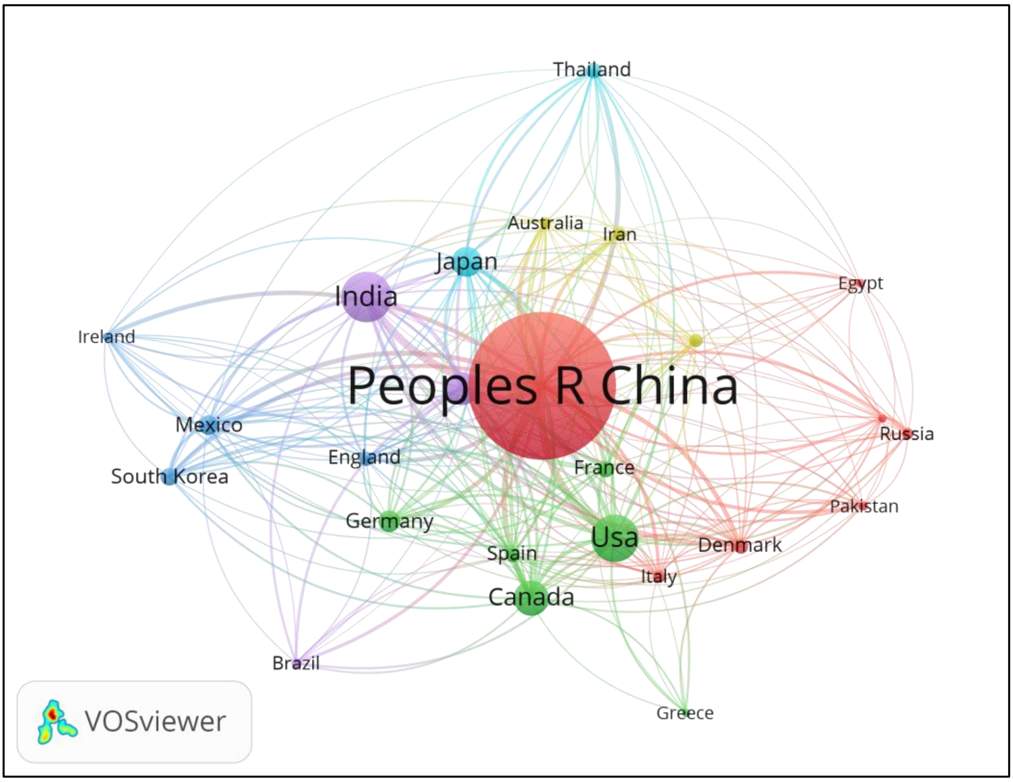


Figure 4: Co-authorship link between countries on phthalate biodegradation research.

Research thematic evolution of phthalate biodegradation

Table 5 and Figures 5–6 present indexing keywords and abstract phrases extracted from the data on phthalates biodegradation research field in three distinct yet interconnected and complementary ways. Figure 5 displays the 10 most popular authors' keywords and Web of Science indexing keywords (Keyword Plus) and their frequencies generated using Bibliometrix software, whereas Figure 6 shows a map of authors' keyword co-occurrences. Table 5 lists the chronology (beginning and end years) and burstiness strength of the top 20 author's keywords. The illustrations offer an avenue for understanding the changing research themes related to phthalate biodegradation over the years, dating back to the emergence of the first literature on this topic in 1970s.

The VOSviewer clustering of keywords and keyword plus map in Figure 5, is based on the co-occurrence and the strength of their associations. The size of the circle representing each keyword indicates how often it occurs in the papers, while the proximity of the circles shows the level of association between the keywords. The different colours of the circles in the map represent the identified clusters. Out of the 3035 terms analysed, 296 terms were identified as occurring at least five times (5) and were subsequently clustered into five groups. Cluster 1 is the largest cluster containing 113 terms, while clusters 2 to 5 consist of 56, 45, 42, and 40 terms, respectively. One of the most frequently occurring and strongly associated terms in the dataset is "biodegradation," with 575 links. This suggests that biodegradation was the significant topic or theme among the papers analysed.

The data presented in Table 5 depicts the evolution of research on phthalate biodegradation over time, with rising and falling trends indicating their time point specific significance in the field. The earliest keywords, "activated sludge" and "removal," date back to the 1970s and 2010s, respectively, while the most recent keyword, "microbial community," emerged between 2019 and 2022. Additionally, the burstiness strength of the keywords in Table 5 varies, with "metabolism" being the strongest and "China" being the weakest.

Therefore, based on the burstiness strength in Table 5 the research on phthalate biodegradation has been evolving since the 1970s, with a strong focus on "activated sludge" and "anaerobic digestion" in the 2000s and "microbial degradation" in the 1990s and 2000s. The research on different types of phthalates, such as "dimethylphthalate" and "n-butyl phthalate," has gained attention over the past two decades, indicating an increasing concern for the potentially harmful effects of these chemicals on the environment and public health.

The research on the "microbial community" and its role in phthalate biodegradation has been growing since the 2010s, as it has become evident that the biodegradation of phthalates is a complex process involving various microbial species. The research on the "biodegradation pathway" and "hydrolase" has also gained relevance in recent years, indicating a focus on understanding the mechanisms involved in the breakdown of phthalates and the potential application of microbial enzymes for their removal.

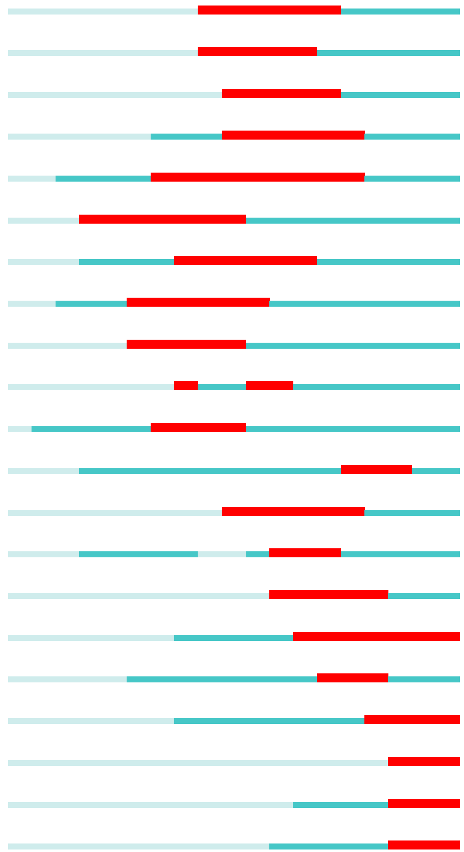
The findings presented in Figure 5 demonstrate the data's relevance to the research field and its most studied themes. The terms "biodegradation" and "phthalate esters" are highly frequent, indicating their significance to the research field. Moreover, the study revealed that dibutyl phthalate, di(2-ethylhexyl) phthalate, dimethyl phthalate, and diethyl phthalate are the most researched among many phthalates. These four chemicals are considered priority phthalates due to their environmental and public health concerns, making them popular among authors. Table 5 further supports this finding by showing the long burstiness of the terms "dimethylphthalate" and "n-butyl phthalate."

Furthermore, the results showed that research on phthalate biodegradation is global, with China being a more productive country focus in recent years. The beginning and end dates of the significant periods for each keyword show that the research on phthalate biodegradation has been ongoing for several decades, with some keywords being significant for more than a decade, such as "sludge" and "activated sludge." This indicates changing themes of biodegradation research overtime.

The results indicated that research on phthalate biodegradation has been evolving over time, with different keywords being significant in different time. Comparing with other studies, it can be seen that the research on phthalate biodegradation is a growing field of interest (Akinpelu and Nchu 2022, Zeng et al. 2022, Xia et al. 2023). Bibliometric studies on plastic biodegradation and other organic pollutants have revealed similar trends, indicating that biodegradation research is gaining increasing importance in environmental science. For instance, a study by Akinpelu and Nchu (2022) on the bibliometric analysis of plastic biodegradation revealed that the research on this topic has grown exponentially in the past two decades, with a strong focus on the microbial degradation of plastics. Similarly, other studies on the bibliometric analysis of research on organic pollutants also revealed a growing interest in the biodegradation of pollutants and the use of microbial communities for their removal (Zeng et al. 2022, Xia et al. 2023). The results suggest a growing interest in the use of microbial strains on removing organic pollutants phthalate biodegradation research to enhance the environmental sustainability.

Table 5: Evolution of phthalates biodegradation research over time indicated by top 22 keywords with the strongest citation bursts

Keywords	**Year**	**Strength**	**Begin**	**End**	**1975–2022**
Sludge	1991	5.78	1991	2009	
Water	1992	4.86	1992	1999	
Anaerobic biodegradation	1996	4.13	1996	2006	
Metabolism	1990	11.7	2000	2007	
Activated sludge	1977	5.23	2000	2011	
Anaerobic digestion	2003	5.99	2003	2013	
Anaerobic degradation	1997	4.76	2003	2008	
Microbial degradation	1995	8.56	2004	2009	
Dimethylphthalate	2006	6.46	2006	2012	
Terephthalate	2007	4.87	2007	2009	
Waste	1977	5.37	2011	2015	
Purification	2000	4.41	2013	2016	
China	2013	4.06	2013	2018	
Removal	1977	4.63	2015	2017	
Gordonia sp	2015	4.56	2015	2019	
Strain	2007	4.61	2016	2022	
N-butyl phthalate	2005	5.78	2017	2019	
Contamination	2003	6	2018	2022	
Biodegradation pathway	2018	4.55	2018	2022	
Hydrolase	2015	4.43	2019	2022	
Microbial community	2010	4.12	2019	2022	



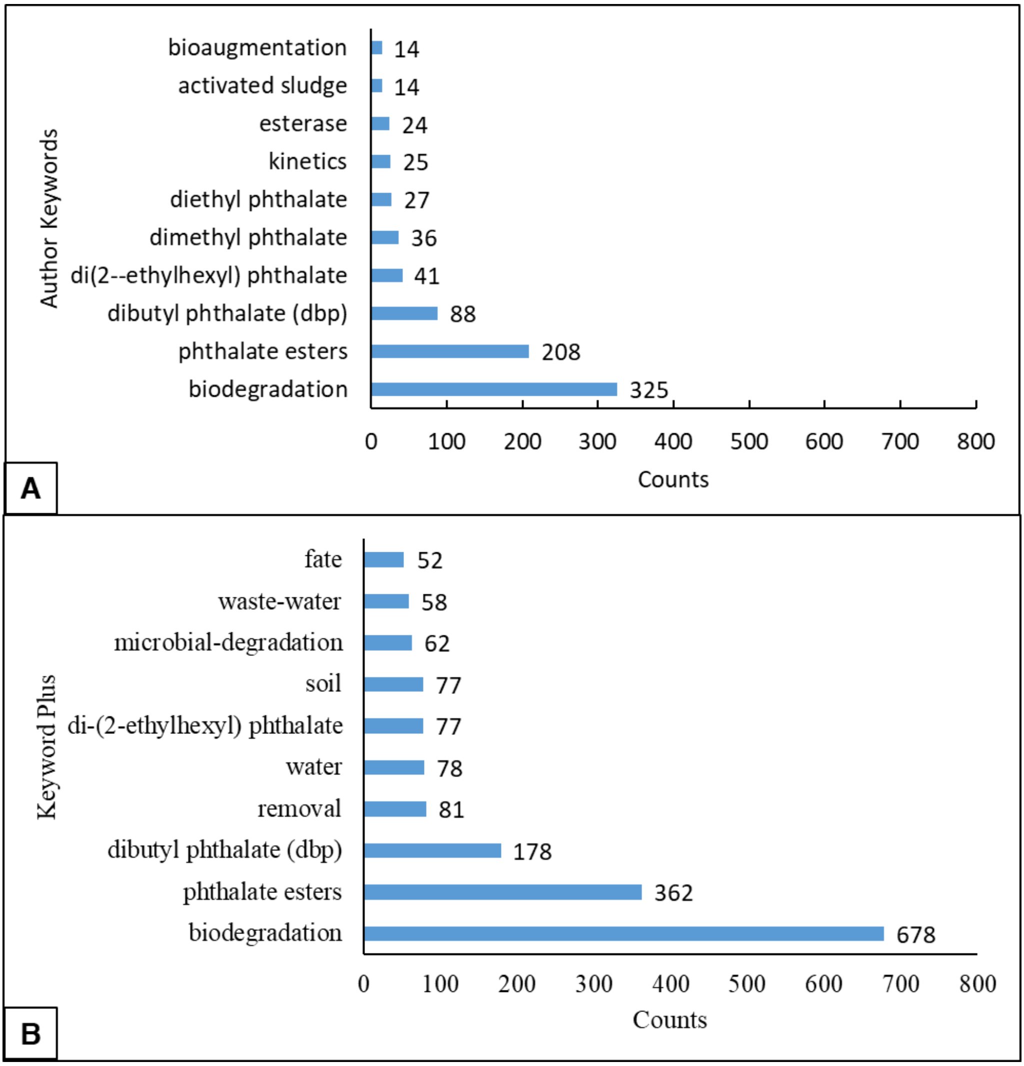


Figure 5: Top 10 frequent keywords extracted from the data using bibliometrix software (A) Authors keywords (B) Web of Science indexing keywords (Keyword Plus)

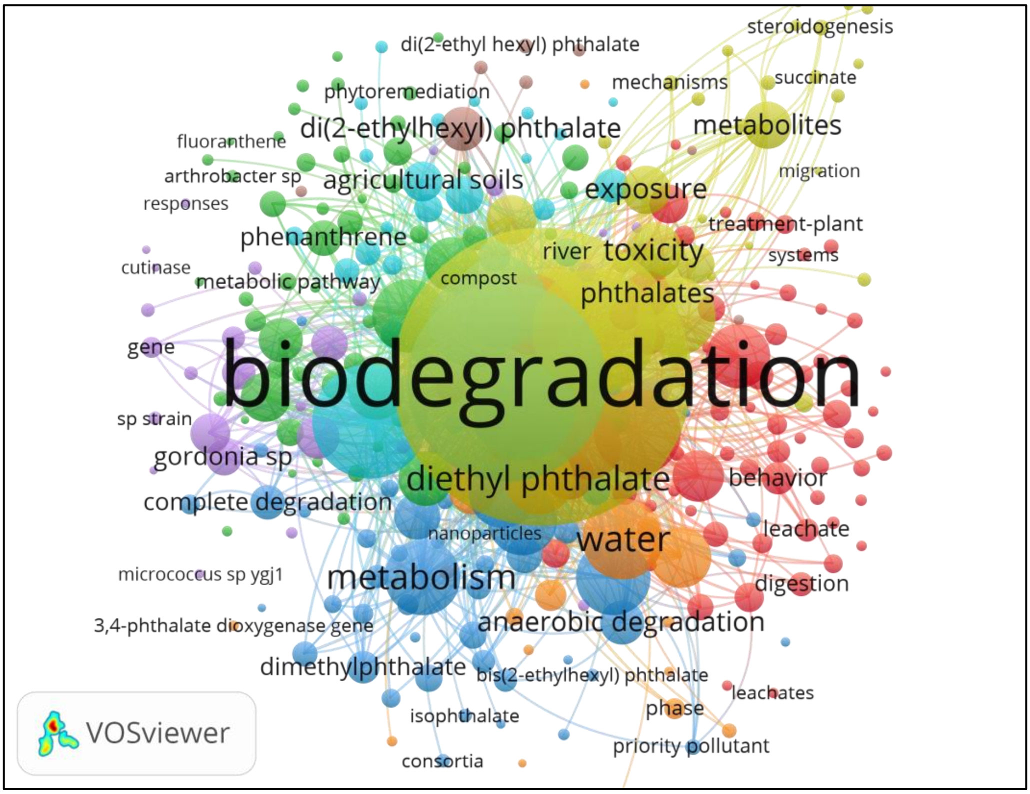


Figure 6: Authors' keywords map co-occurrences of phthalate biodegradation research.

Policy implications of the study in Africa

The findings of the present study hold significant policy implications for African researchers, governments and stakeholders. The findings of the study on phthalate biodegradation in African countries are consistent with previous research highlighting Africa's lagging investment in the biodegradation research (Akinpelu and Nchu 2022, Zeng et al. 2022, Xia et al. 2023). Other studies have also indicated that Africa faces challenges in terms of research funding and infrastructure (Uwizeye et al. 2022, Aiyede and Muganda 2023). The observed low research productivity in the field of phthalate biodegradation in African countries serves as a compelling indicator, underlining the critical necessity for African governments to prioritize and invest more significantly in research funding, infrastructure and capacity building in the realm of environmental biodegradation research. Other similar studies have suggested that Africa should commit to the establishment of research grants, scholarships and fellowships focusing on the biodegradation research (Akinpelu and Nchu 2022, Aiyede and Muganda 2023). The presence of adequate infrastructure will create the enabling environment for researchers to conduct experiments, analyse samples and generate robust scientific data worth publishing in highly reputable journals, thereby contributing to the global knowledge base on this critical topic to support researchers working and interested in building expertise in this field.

Furthermore, universities and research institutes in Africa should focus on fostering collaboration and partnerships between international counterparts. This will help African researchers benefit from knowledge exchange programs, collaborative research projects and capacity-building initiatives with universities and research institutions in countries that have demonstrated high research productivity in phthalate biodegradation, such as China, India, Canada and the United States. Such collaborations partnership can enhance research capacity, transfer of knowledge and technology as well as increase access to funding opportunities.

Generally, in order to cultivate productive research areas in Africa, it is crucial to encourage interdisciplinary research collaborations to achieve a comprehensive understanding of phthalate biodegradation. Governments and stakeholders should actively support collaborations between researchers from diverse fields such as microbiology, chemistry, environmental science, and engineering. Through promoting multidisciplinary approaches, innovative solutions and advancements in phthalate biodegradation research can be achieved.

Conclusion

The study aimed at applying scientometric and bibliometric analyses to examine the landscape of phthalate biodegradation research from 1975 to 2022. The results showed that the field has experienced notable thematic shifts over time, as evidenced by the varying significance of specific keywords across different periods. The results demonstrated that the research on phthalate biodegradation is a growing field of interest, with an annual growth rate of 6.9% and an average of 26.72 citations per document. By using CiteSpace, bibliometrix, and VOSviewer, the study identified publication trends, collaboration patterns, research hotspots, and visualized networks on sources and country co-citation. The findings suggest that there are low scientific outputs in this field from the African continent, indicating the need for increased research funding and collaboration to address the gaps in knowledge and promote research in this important area. The study provides valuable insights for researchers and policymakers to identify emerging research trends and allocate research funding accordingly.

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Competing Interests

The authors declare no competing of interests.

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