Scientific Trends in Animal Waste and Environmental Sustainability: A Bibliometric Study

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***Abstract*—** This study aims to comprehensively reveal academic trends, publication distribution, and research collaborations in this field by evaluating scientific research on the environmental effects of animal waste using the bibliometric analysis method. Within the scope of the study, 33,887 academic studies published between 1970-2025 were examined in line with the searches made in international scientific databases such as Web of Science and Scopus. Annual publication trends, most cited studies, leading researchers, most frequently used keywords, international collaborations, and institutions with the most publications were analyzed. The findings show that scientific productivity on the environmental effects of animal waste has increased significantly, especially in the last twenty years, and that the studies in this field have an interdisciplinary structure. It has been determined that the research is primarily concentrated in areas such as waste management, environmental pollution, sustainability, and biotechnological transformation. This analysis provides an important framework for understanding current research trends in animal waste management and environmental sustainability and identifying potential research gaps for future studies. The findings will guide scientists, policymakers, and industry representatives in reducing the environmental impacts of animal production and developing sustainable waste management strategies.

***Keywords*—** Bibliometric, R Software, Animal Waste, Livestock Waste and Environmental Impacts

I. Introduction

The sustainability of agricultural production systems and the increasing global demand for animal products have attracted significant attention in recent years. Waste, especially from animal production processes, creates significant environmental pressures on ecosystems. Improper management of animal waste contributes significantly to various ecological degradations through pollution of water resources, soil degradation, increased greenhouse gas emissions, and waste management difficulties. Organic waste from large-scale animal production facilities causes eutrophication, especially in aquatic environments, due to its high nutrient load, resulting in decreased water quality and imbalances in aquatic ecosystems [1]. In addition, gases such as methane (CH_4) and nitrous oxide (N_2O) released during the decomposition of animal waste are among the important greenhouse gases that accelerate global warming [2]. Therefore, effective management of animal waste is a critical necessity in terms of both environmental sustainability and the protection of natural resources. Adopting efficient waste treatment technologies is an important factor in reducing the environmental impacts associated with livestock waste [3]. Inappropriate animal husbandry operations cause significant decreases in the yield and quality of animal products. By adopting a community-centered approach to waste management, farmers can engage in sustainable practices that effectively reduce the ecological footprint of their operations. Inadequate waste management not only affects environmental health, but also poses a threat to public health due to the potential for zoonotic diseases resulting from improperly managed animal waste. The industrialization of the livestock sector often leads to excessive accumulation of waste products, making it necessary to implement strategies that adopt circular economy principles [4,5]. Using biological methods to recycle waste into valuable resources offers an effective way to reduce the pollution burden generated by animal husbandry. For example, anaerobic digestion technologies can convert animal waste into biogas while simultaneously reducing methane emissions [2,4]. In this context, it is important to understand the current status of scientific research evaluating the environmental impacts of animal waste and to determine research trends in this field.

Bibliometric analyses provide a powerful method that systematically examines the scientific literature published on a specific topic, revealing the development processes of research areas, key research topics, the most influential studies, and international collaborations [6,7]. This study examines scientific literature on the environmental impacts of animal waste using the bibliometric analysis method. It evaluates research trends, dissemination in the literature, impact, and development process in this field. In this context, a comprehensive scan will be conducted in international scientific databases such as Web of Science and Scopus, and the published studies will be analyzed in terms of bibliometric parameters such as distribution by year, most cited articles, influential researchers, collaboration networks, and essential research topics. The data obtained will reveal academic trends in the environmental impacts of animal waste, the countries and institutions in which it is intensively studied, and the subfields

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in which more research is conducted. This study will significantly contribute to understanding the current status of scientific productivity on animal waste management and its environmental impacts and identifying potential gaps for future research. It will also guide researchers working on environmental sustainability, waste management, and ecosystem health in shaping their future research by providing a comprehensive perspective on the field's current state.

II. Material And Methods

This study used the bibliometric method to analyze scientific literature on the environmental impacts of animal waste. The Web of Science database, which provides access to international scientific publications, was preferred in the data collection process. In order to examine the relevant literature comprehensively, a search query was created as "Animal Waste" AND "Livestock Waste" OR "Environmental Impact," and a total of 33,887 academic publications were reached. The data obtained were analyzed in terms of publication distribution by year, most cited studies, prominent research topics, influential authors, collaboration networks and basic bibliometric indicators. Bibliometric analysis was performed in the study using R software with bibliometrix package [8]. With bibliometric analysis, citation networks, collaborations between authors, publication distribution by country and keyword clusters were visualized, thus determining scientific productivity and research trends. In order to ensure the reliability and validity of the study, the data were classified using certain filters. Only articles, reviews, and conference proceedings were considered in the analysis, while editorials, book chapters, and short notes were excluded from the evaluation. In addition, only studies published in English were analyzed. Thanks to this method, current trends in research on the environmental impacts of animal waste, its spread in the scientific literature, and the dynamics of academic collaborations were revealed in detail.

III. Results

This study details the results of the bibliometric analysis of the environmental impacts of animal waste. As a result of the systematic search conducted in the Web of Science database, 33,887 scientific studies were identified. Within the scope of the analysis, publication trends by year, the most cited studies, leading researchers, academic collaborations, and key research topics were examined. The findings reveal the development of the scientific literature on the environmental impacts of animal waste over time, which countries and institutions are pioneers in this field, and which sub-disciplines the research is concentrated in. In addition, gaps in the literature and potential areas for future research were evaluated. The analyses aim to determine the current status of scientific productivity in animal waste management and environmental sustainability and address research trends in this field from a broader perspective. The findings obtained are detailed in the following sections, and the distribution of publication trends, the most cited studies, leading researchers, international collaborations, and research topics is presented comprehensively. The data presented in Table 1 consists of 33887 academic studies covering 1970-2025. These studies have been published through 6152 different scientific sources (journals, books, etc.) and show an average annual growth rate of 7.77%. The average age of publications is calculated as 10.5 years, while the average number of citations per article is determined as 31.9.

TABLE II:
MAIN INFORMATION ABOUT STUDIES ON THE ENVIRONMENTAL IMPACTS OF ANIMAL WASTE

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1970:2025
Sources (Journals, Books, etc)	6152
Documents	33887
Annual Growth Rate %	777
Document Average Age	10.5
Average citations per document	31.9
DOCUMENT CONTENTS	
Keywords Plus (ID)	42034
Author's Keywords (DE)	56567
AUTHORS	
Authors	110927
Authors of single-authored docs	1929
AUTHORS COLLABORATION	
Single-authored docs	2248
Co-Authors per Doc	5.29
International co-authorships %	25.57
DOCUMENT TYPES	
article	25684
article; book chapter	396
article; data paper	22
article; early access	204
article; early access; retracted publication	2
article; proceedings paper	854
article; publication with expression of concern	1
article; retracted publication	20
biographical-item	1
book	2
book review	4
correction	19
correction, addition	2
editorial material	136
editorial material; book chapter	10
letter	24
meeting abstract	260
news item	16
note	91
proceedings paper	1628
proceedings paper; retracted publication	2
reprint	4
retraction	1
review	4378
review; book chapter	65
review; early access	59
review; retracted publication	2

The keywords used in the study were analyzed in two categories: Keywords Plus (42034 words) and Keywords specified by the author (56567 words). When evaluated on an author basis, it is seen that a total of 110927 different authors contributed. The number of single-authored studies is 1929, and a single author wrote a total of 2248 articles. The average number of authors per article was calculated as 5.29, while 25.57% of the studies were published with international co-authorship. When examined according to document types, the

most common publication type was scientific journal articles, with 25684 articles, followed by 4378 review articles. Proceedings papers were identified as 1628, book chapters as 396, early access articles as 204, editorial articles as 136, and meeting abstracts as 260. This analysis shows that academic studies on the environmental impacts of animal waste have increased over the years, are examined by a wide range of authors, and have an important share in international collaborations. The findings reveal the development processes of scientific productivity in this field and provide important clues about future research directions.

Figure 1 shows the annual production trend of scientific publications on the environmental impacts of animal waste between 1970 and 2025. The graph shows that academic interest in this field has increased significantly. While a relatively low number of publications was observed between 1970 and 1990, a significant increase began in the 2000s, and this growth continued to accelerate after 2010. A sharp increase in scientific production is observed, especially between 2015 and 2023. This situation reflects that the environmental impacts of animal waste are increasingly brought to the scientific and political agenda, the expansion of research, and the increasing interest of scientists from different disciplines in this subject.

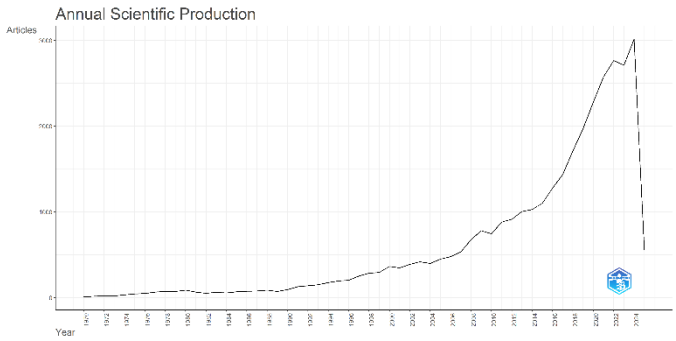

Fig. 1. Annual scientific production for the environmental impacts of animal waste

The findings show that research on the environmental impacts of animal waste is gaining importance and that scientific contributions in this field are constantly increasing. This trend points to an increase in academic interest in topics such as sustainable waste management, environmental policies, and the role of animal production in combating climate change. Figure 2 shows the institutions that have contributed the most to scientific research on the environmental impacts of animal waste. The institutions in the graph are ranked according to the number of articles published in this field. The Chinese Academy of Sciences is the most published institution, with 1,565 articles, followed by the United States Department of Agriculture (USDA), with 1473 articles. The Egyptian Knowledge Bank (EKB) comes in third place with 1,089 articles, indicating that Egypt’s academic productivity in this field is significant. The other academic institutions that contributed the most are the University of California System and Wageningen University and Research, with 835 and 539 articles, respectively.

In addition, research institutes such as the University System of Ohio (528), the Indian Council of Agricultural Research (ICAR) (527), and INRAE (525) have also made significant contributions to academic studies on the environmental impacts of animal waste. The inclusion of European institutions such as the Autonomous University of Barcelona, the Centre National de la Recherche Scientifique (CNRS), and the Consejo Superior de Investigaciones Científicas (CSIC) on the list shows that a broad scientific network at the global level carries out research in this field.

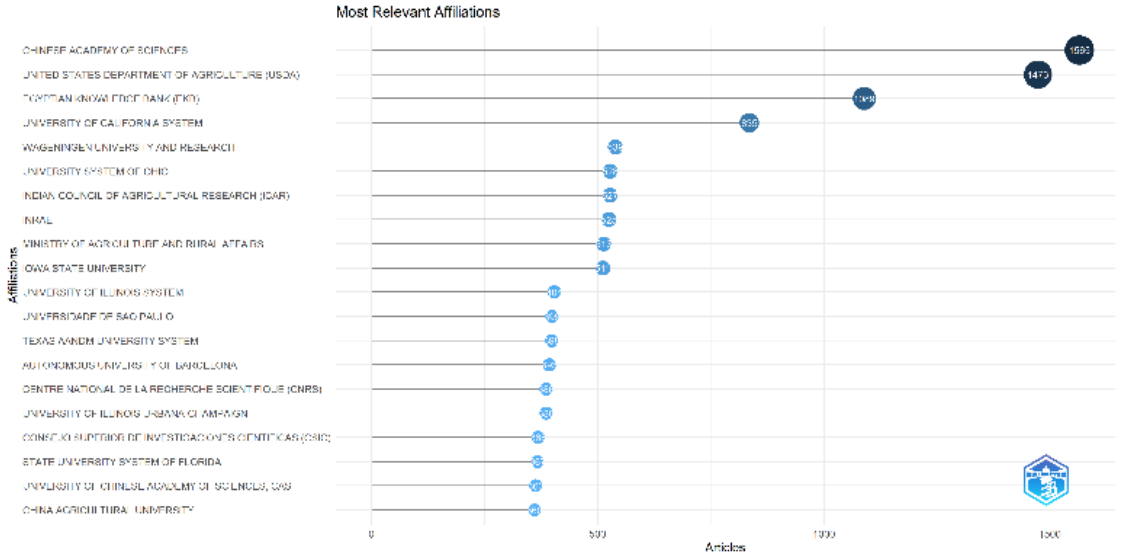

Fig. 2. Most relevant affiliations for the environmental impacts of animal waste

Overall, this analysis shows that academic and research institutions in China, the US, and European countries play a leading role in studies on the environmental impacts of animal waste. In particular, universities and research institutes specializing in agricultural and environmental sciences are making scientific contributions to sustainable waste management and environmental protection.

Figure 3 shows the academic journals with the most scientific articles on the environmental impacts of animal waste. According to the data, research in this field is addressed in a broad interdisciplinary framework and published in journals in different fields, such as environmental science, waste management, sustainability, and animal science.

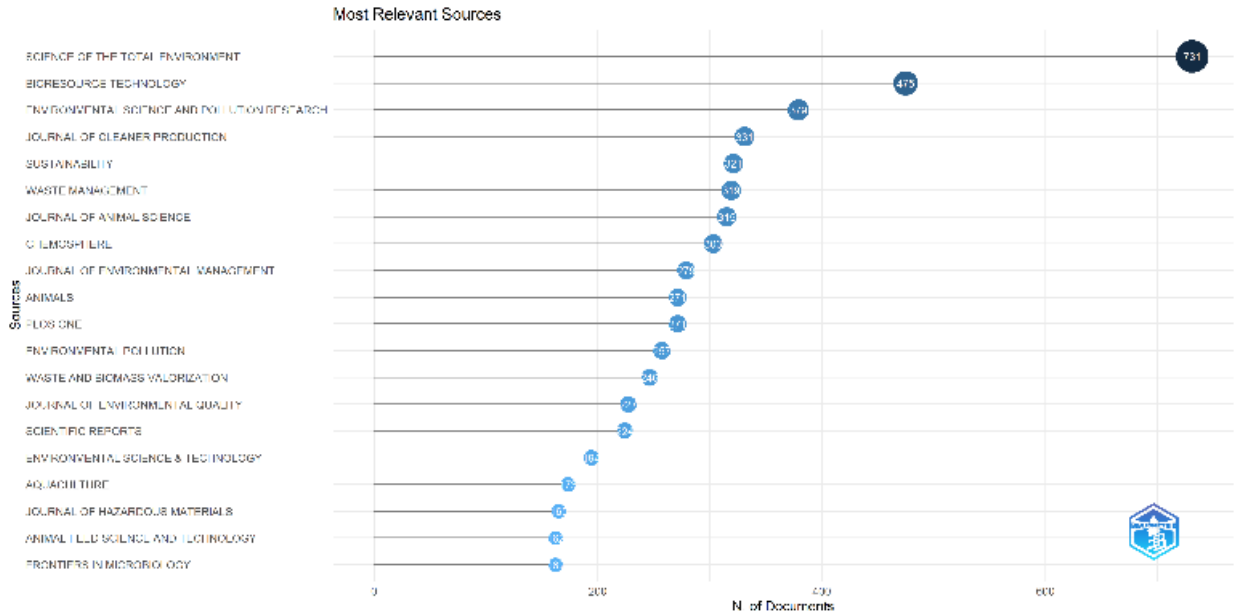

Fig. 3. Sources for the environmental impacts of animal waste

The journal with the most publications is Science of the Total Environment, with 731 articles, followed by Bioresource Technology, with 475 articles. These journals have a high impact on environmental sciences and biological resource management and provide an important publication platform for research on the environmental impacts of animal waste.

Other leading sources include journals focusing on environmental sustainability and pollution research, such as Environmental Science and Pollution Research (379), Journal of Cleaner Production (331), and Sustainability (321). In addition, the high number of publications in journals focusing on waste management issues, such as Waste Management (319) and Journal of Environmental Management (303), indicate that

this topic is an important research area regarding waste reduction, recycling, and management strategies.

In general, this analysis shows that research on the environmental impacts of animal waste is published in a wide range of academic disciplines, and these studies are particularly concentrated in fields such as environmental science, waste management, sustainability, and animal sciences.

Figure 4 shows a thematic map that visualizes the relationships between the most frequently used author keywords in the academic literature on the environmental impacts of animal waste. This network map allows us to identify the main themes where scientific research is concentrated and to analyze how research is organized in different disciplines.

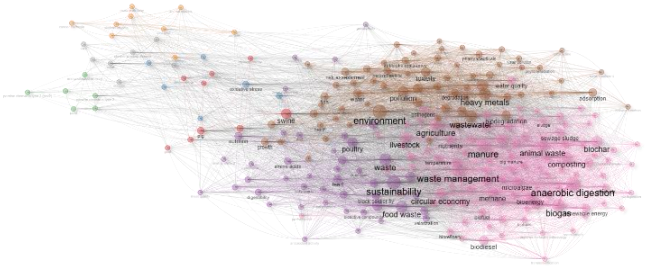

Fig. 4. Thematic map according to author’s keyword for the environmental impacts of animal waste

The nodes (dots) on the network represent specific keywords, while the connections between the nodes show the frequency of these words being used together. The color groups on the map represent different research areas and thematic clusters:

- Pink Cluster (Waste Management and Transformation Technologies): Keywords such as "Anaerobic digestion", "biochar", "composting", "biogas", "circular economy" and "waste management" are included in this group. This cluster emphasizes the importance of research on sustainable management of animal waste and biotechnological transformation processes.
- Orange Cluster (Environmental Pollution and Risk Assessment): Keywords such as "Pollution", "heavy metals", "microplastics", "toxicity" and "water quality" are prominent in this field. This thematic group represents studies focusing on the adverse effects of animal waste on the ecosystem and potential risk factors.
- Purple Cluster (Sustainability and Agricultural Practices): Concepts such as "Sustainability", "food waste", "livestock", "agriculture", "nutrients" and "waste" are concentrated in this group. This structure shows how animal waste is evaluated in the context of agricultural sustainability.
- Red Cluster (Effects on Animal Nutrition and Health): Terms such as "swine", "pigs", "nutrition", "oxidative stress" and "growth" are included in this group and represent studies examining the effects of animal waste on animal health and nutrition.
- Green Cluster (Independent Subtopics and New Research Areas): Keywords with fewer connections and seen as independent clusters indicate emerging research trends in the field.

Overall, this thematic map shows that research on the environmental impacts of animal waste is structured around major themes such as waste management, environmental pollution, sustainability, animal health, and new research areas Figure 5 presents a Three-Field Plot visualizing the most frequently used keywords in scientific research on the environmental impacts of animal waste (left side), the most published academic journals (middle side) and the most contributing countries (right side). This plot helps to understand how keywords are published in specific journals and which countries researchers come from.

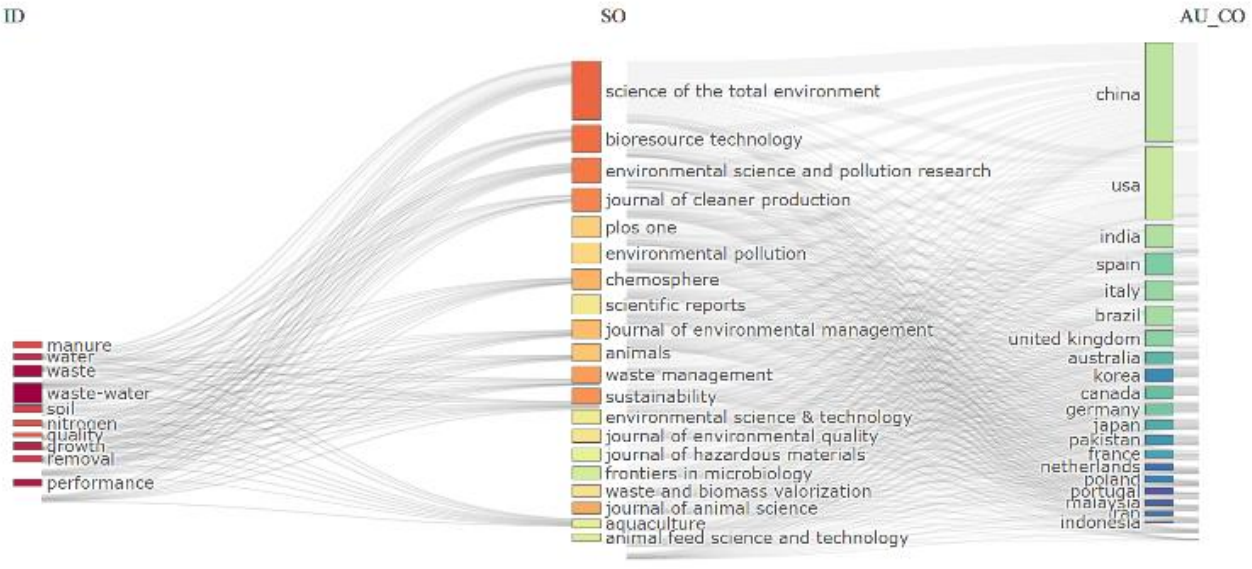

Fig. 5. Three-area graph showing the relationship between keywords, publication sources and countries on the environmental impacts of animal waste

The most frequently used keywords in the studies include "manure", "waste", "water", "waste-water", "soil", "nitrogen", "quality", "growth", "removal" and "performance". These keywords show that the research largely focuses on issues such as animal waste management, water and soil pollution, nutrient recycling, and environmental quality.

The most published academic journals include leading journals in the fields of environmental sciences, sustainability and waste management such as Science of the Total Environment, Bioresource Technology, Environmental Science and Pollution Research, Journal of Cleaner Production, Waste Management and Sustainability. In addition, journals related to agriculture and animal husbandry such as Journal of Animal Science and Aquaculture are among the important sources where research in this field is published. This situation shows that the environmental impacts of animal waste require an interdisciplinary approach and are addressed in different scientific fields such as environmental sciences, engineering, sustainability and animal husbandry.

Among the countries that publish the most on the environmental impacts of animal waste, countries that are strong in scientific research such as China, the USA, India, Spain, Italy, Brazil, the United Kingdom, Australia, Canada and Germany stand out. China and the USA in particular stand out as the two countries that contribute the most in this field. This situation can be associated with the large-scale animal production in these countries and the increase in scientific investments in environmental sustainability issues. In addition, countries such as Japan, Pakistan, France, the Netherlands, Poland, Malaysia and Indonesia are other important actors contributing to scientific production in this field.

In general, this three-area graph reveals that research on the environmental impacts of animal waste has a wide academic distribution at the global level and is addressed within an interdisciplinary framework. It is seen that the majority of the studies focus on issues such as waste management, water and soil pollution, nitrogen cycle and sustainability, while scientific publications are published in leading journals in the fields of environmental sciences, waste management and agricultural sciences.

The findings show that research on the environmental impacts of animal waste has increased steadily over the years and that scientific studies in this field have increasingly evolved into an interdisciplinary approach. The results of the bibliometric analysis show that publications are primarily concentrated in areas such as waste management, environmental pollution, sustainability and biotechnological transformation. At the same time, the high level of international collaboration shows that the environmental impacts of animal waste are considered a global problem and that different countries around the world conduct research in this field. This comprehensive analysis provides an important framework for understanding academic trends in animal waste management and identifying potential areas of study for future research.

IV. Conclusion

This study presents a bibliometric analysis of scientific research on the environmental impacts of animal waste, comprehensively revealing academic trends, publication distribution, and research collaborations in this field. The results show that areas such as waste management, environmental sustainability, biotechnological transformation, and ecosystem health are prominent in research on animal waste. Identifying the countries and institutions with the most publications helped understand the dynamics of international scientific collaborations in this field. At the same time, the most frequently used keywords and thematic analyses provided important clues in terms of identifying future research gaps.
It is seen that research on the environmental impacts of animal waste is increasingly gaining importance and that this topic has a critical role in terms of sustainable agriculture, circular economy, and environmental policies. In this context, more research is needed to develop waste management strategies, reduce the environmental footprint of animal production, and integrate it with biotechnological solutions. The findings will serve as a guide for scientists, policymakers, and sector representatives and contribute to developing more effective and sustainable solutions for animal waste management.

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