Pesticide Research Trend With Bibliometric Analysis

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KEYWORDS

Pesticide, Enviroment, Impact

ABSTRACT:
Pesticide use increased significantly in 1940. Human exposure to pesticides can occur through consumption of contaminated food or water, inhalation of contaminated air and skin contact with contaminated water, air, food or soil. Using pesticides that do not meet standards will cause health problems, environmental pollution and disrupt the ecosystem. The aim of this research is to analyze publication trends regarding the impact of pesticides on the environment and health. The method used is bibliometric analysis using VOSviewer visualization. The data comes from Scopus on the topic of pesticides and their impact on the environment and health from 1975 to 2024. Data from Scopus must be exported and then screened first so that there are no duplicate keywords. The total number of articles analyzed from 1975 to 2024 was 7,478 articles. The keyword that appears most often is pesticide with a total link strength of 454. The results of bibliometric analysis using the VOS viewer showed 11 clusters. Each cluster consists of several keyword items. The most frequently appearing keyword, namely pesticide, is in cluster 4. The trend of publications about pesticides increased sharply from 2021 to 2024. The highest number of publications was in 2023, namely 849 articles. The language used in article publication is mostly English with the publisher Elsevier. . The most cited article is the article with the title Pharmaceuticals And Personal Care Products In The Environment: Agents Of Subtle Change?. The authors of the article are Daughton, Christian G. ; Ternes, Thomas A. The number of citations from this author is 4024.

1. Introduction

Pesticides are toxic chemical compounds used for controlling agricultural pests. According to the Republic of Indonesia Law Number 22 of 2019, Article 75 states that pesticides are all chemical substances and other materials, as well as microorganisms and viruses, that can be used to eradicate or prevent pests or animals, weeds, or unwanted plants. The improper use of pesticides endangers the health of farmers, consumers, and non-target microorganisms, and has an impact on environmental pollution, both soil and water [1]. Pesticides are chemical substances used in the vicinity of human life. In addition to its beneficial effects, the active ingredients in pesticides also serve as a source of toxins that pose a danger to human health.

According to FAO (2021), pesticides consist of insecticides, fungicides, herbicides, disinfectants, and mixtures of other substances to control pests that disrupt the production process. The use of pesticides increased significantly in the year 1940. Pesticides are used in various fields, including agriculture, trade, housing, and industry. The use of pesticides can have negative impacts on biodiversity and human health [2].

The use of pesticides is necessary to maximize crop production. The mechanism of environmental degradation due to pesticides involves biological, physical, and chemical processes. Pesticides can be toxic when they come into contact with target organs and can decompose biologically. Pesticides used to spray pests on plants can also leave residues on the plants as well as in the soil. Pesticide residues will cause contamination of the soil, groundwater, and surface water. This will cause a high toxicity effect on non-target organisms, including humans. Pesticide poisoning kills about 355,000 people each year, two-thirds of whom are in developing countries. Pesticide exposure in humans can occur through the consumption of contaminated food or water, inhaling contaminated air, and skin contact with contaminated water, air, food, or soil [2,3]. Pesticides can also cause several neurological and general effects on humans, such as the relationship between diabetes and DNA methylation in the indigenous population of Mexico. Pesticide poisoning among indigenous people is a concerning statement that continues to this day. Reports such as the chemical attack at the restart of Guyra Kambi'y in 2015, the poisoning incidents in the village of Guyraroká in 2019, and the findings of violence in villages and indigenous territories across six municipalities in Cone Sul, Mato Grosso do Sul in 2016, highlight the urgency of addressing these issues.

The agricultural sector is very vulnerable to disasters and calamities. Most pesticides are used to improve the quality and quantity of plants and animals, and they can also be used to enhance productivity and the income of communities. The annual pesticide consumption worldwide in 2019 reached a record high of 4.19 million tons. China consumed 1.41 million tons, followed by the US, Brazil, Argentina, and Canada. It seems that your message is incomplete. Could you please provide more context or additional text for translation? Advancements in pesticide applications have replaced traditional weed control methods using horses or donkeys, thereby enhancing overall agricultural efficiency. The improvement of the agricultural sector requires various supporting means, namely agricultural tools, fertilizers, and chemical substances including pesticides. Agricultural systems that rely on high energy inputs such as chemical pesticides lead to environmental degradation, particularly in agricultural environments.

Pesticides are pollutants that enter the environment through air, water, or soil, which can have direct effects on living beings and the environment. The almost annual attacks by pests encourage farmers to use pesticides as a control measure. Pesticides are considered a key input in modern agriculture, but they are also a major cause of environmental pollution and a threat to the health of living organisms. In addition to improving agricultural yields, pesticides are chemical substances that are bioactive and are considered toxins. Each of its toxins contains dangers in its use, both to the environment and to humans. According to the World Health Organization (WHO), it is estimated that pesticide poisoning cases occur in 1-5 million people each year in agricultural work, with a death toll reaching 220,000 victims. About 80% of poisoning cases are reported to occur in developing countries, while these countries only use 25% of the total pesticide consumption worldwide, yet the death toll reaches 99% [1,3].

Pesticides have both positive and negative impacts in their use. The positive impact obtained is the liberation from pests that disturb the plants, while The negative impacts include that the pesticides sprayed do not entirely reach the plants; instead, 80% of the pesticides sprayed will fall to the ground. Causing the nutrients in the soil to start decreasing, the soil relatively has a high pH because it has been sprayed with chemicals too often, leading to a decline in soil fertility. Similarly, the water around the rice fields often carries residues from spraying into the rivers, affecting aquatic animals such as fish and birds. The significant influence of behavior and pesticide use on environmental impact is classified as high, reaching 94.2%. This means that the better the behavior and use of pesticides, the better the environmental impact will be [4,5].

The use of pesticides, influenced by toxicity, volume, and level of exposure, significantly affects health. In addition, the impact of pesticide use on plants will also leave residues on the plants themselves and in the soil and surrounding environment. If the residues on this plant are consumed by humans, it will have adverse effects on health in the future, and if these pesticide residues accumulate in the soil, it will also affect the life of organisms in the soil and the plants grown in that soil [6,7]. According to Setiawan and Bernik (2019), the accumulation of pesticide residues results in the pollution of agricultural land. When entering the food chain, the toxic properties of pesticide substances can lead to various diseases such as cancer, mutations, birth defects, CAIDS (Chemically Acquired Deficiency Syndrome), and so on.

Environmental pollution is mostly caused by the excessive use of chemicals, particularly in the agricultural sector, where the use of pesticides can harm the environment. Its effectiveness is reliable, its use is easy, its success rate is high, its availability is sufficient and easily accessible, and its cost is relatively low. However, the use of pesticides is also detrimental. The increase in pesticide use has led to instability in ecosystems, the presence of residues on harvested crops and their processed products, environmental pollution, and even poisoning and death in humans. Based on the research findings Regarding the impact on the environment, the assessment is conducted using three indicators, namely: (1) soil pollution, (2) water pollution, (3) organisms and wildlife.

According to Ibrahim et al., in Ibrahim and Sillehu (2022), it is stated that the use of pesticides that do not meet standards can lead to health issues, environmental pollution, and disruption of ecosystems [8]. Farmers are one of the populations at risk of exposure to chemical pesticides due to the high use of pesticides in agricultural areas. Farmers are often unaware that any activities or operations in areas contaminated with pesticides pose significant risks to their safety and health. Improper use of pesticides can endanger the health of farmers and consumers, non-target microorganisms, and can also lead to soil and water pollution.

Persistent pesticides can remain in the environment for years, even decades, so their impact on the environment and plants will accumulate in both. Non-persistent pesticides can decompose in nature into other compounds that are harmless. (terjadi detoksifikasi). This decomposition can occur chemically (photolysis) or biologically by plants or microorganisms. The effects of non-persistent pesticide residues can only last for a few days to a few months [9,10]. The persistent nature of pesticides, which leads to prolonged deposition in the soil, causes soil degradation [2,11].The use of pesticides at every stage of agriculture results in pesticide residues being left on agricultural products, which has negative impacts on humans and the environment.

Pesticides will undergo natural processes in the soil. These reactions are influenced by soil type, soil moisture, soil pH, soil temperature, pesticide volatility, microorganisms, and the chemical substances present in the soil. The activities or actions of farmers that are at risk of pesticide exposure include the process of mixing pesticides without using gloves, not wearing masks, and mixing several types of pesticides in a single spraying session. Meanwhile, during spraying, farmers do not use personal protective equipment (PPE) such as head coverings, goggles, masks, long-sleeved shirts, long pants, and boots. Additionally, farmers also spray against the wind direction, which significantly increases the risk of pesticide exposure. After spraying, most farmers clean their spraying equipment in the irrigation channels, in the river, and some others in wells. This reflects that farmers' understanding of the dangers of pesticides is still limited. Farmers are unaware of the dangers of pesticides due to their incorrect usage.

In addition to impacting the environment, pesticides also affect humans, particularly farmers, due to direct exposure to pesticides (inhaling, being splashed, or touching pesticides) [12]. Pesticide products can have acute health effects (for example: mild or severe intoxication) as well as long-term health effects on humans, such as neurological diseases, respiratory diseases, genetic disorders, and adverse effects on reproductive organs. Farmers who still have a negative attitude because they are not fully aware of the dangers and impacts of pesticides, which affect the surrounding environment.

2. Methods

Bibliometrics, according to Chen et al. (2014), is a statistical method that can quantitatively analyze research papers related to a specific topic through mathematical means. Initially, this concept started as a statistical bibliography and then evolved into the main field now known as bibliometric studies [13]. Bibliographic software such as Gephi, Leximancer, VOSviewer, and scientific databases like Scopus and Web of Science. Bibliographic analysis is useful for describing and mapping cumulative scientific knowledge and trends in established fields by recognizing a large amount of improperly structured data. Thus, a well-conducted bibliometric study can provide a solid foundation for advancing learning in new and meaningful ways, allowing for: (1) an overview; (2) identification of knowledge gaps; (3) access to the latest items for review; and (4) necessary contributions in various situations. This research also utilizes the Scopus database. Scopus, as a database used for indexing high-reputation international scientific publications, offers an abstract database in the form of citations from peer-reviewed results on various literature, scientific journals, books, and conference proceedings. Comprehensive information and descriptions of various research results published internationally across different fields of science are available on Scopus. Searching for scientific literature can be easily conducted in Scopus by exploring its advanced search features, which allow searches based on author, keywords, publisher, publication year, and geography [13,14].

The data used as the research source was taken from the Scopus database. The reason the researchers chose to use Scopus is due to its rigorous peer review process and also considering its reputation. The retrieval date is August 23, 2024, and a total of 7,152 article documents covering publication years from 1975 to 2024 were obtained using the keywords pesticide, environment, and impact. The criteria used are only articles in English, which are then exported in CSV format. To determine the most frequently occurring keywords, the author must use co-occurrence analysis and then establish a minimum number of keywords. The smaller the minimum threshold we set, the higher the number of keywords that will appear. In the keyword verification, we determine the keywords that are relevant to the topic of pesticides, then right-click on the selected keyword, next click on export selected keywords and choose the CSV format. Once saved as a CSV, we can open the file and analyze it.VOSviewer is applied to conduct a bibliometric analysis of this article. VOSviewer is used to analyze co-authorship, co-occurrence, citation, bibliographic coupling, co-citation, and themes. Additionally, the VOSviewer software is utilized for data exploration, mapping, and clustering of the retrieved articles. Keywords and countries are marked with colored circles. The size of the circle positively correlates with the occurrence of keywords or countries in the title and abstract. Therefore, the size of the label and circle of a topic is determined by the weight of that topic. The greater the weight of a topic, the larger the label and circle of that topic will be.

3. Results and Discussion

Research Keyword Analysis

Keywords in the literature on pesticide research were analyzed using the co-occurrence network analysis tool in VOSviewer software. In this analysis, the minimum number of occurrences of keywords in the title and abstract was set at 9. The results of the analysis found pesticide, toxicity, risk assessment, insecticide, pollution and agriculture as the most common keywords.

The analysis carried out in this study found 17,667 keywords, with 295 meeting the threshold and classified into 11 large groups (clusters). The most frequently appearing keyword is

Pesticide (total link strength 4306) which has strong links to "Pesticide" and "toxicity".
By using the keyword co-occurrence clustering, we can get 11 large groups:

1. Cluster 1 consists of 48 items. Cluster 1 consists of the keywords water, apis mellifera, biochar, biocontrol, biodegradation, biofilm, bioremediation, contaminants, contaminants of emerging concern, disease management, endophytes, food, food security, fungi, growth, gut microbiota, honey bee, hormones, impact, metabolism, metabolomics, metagenomics, pollutants, pathogens, plants, productivity, etc
2. Cluster 2 consists of 36 items. Cluster 2 consists of the keywords apoptosis, chemicals, fertility, environmental factors, emerging contaminants, environmental risk assessment, health risk, malaria, mercury, inflammation, mosquito, organochlorine, organophosphate, soil contamination, surface water, pregnancy, phyrethroid, organic pollutant, etc
3. Cluster 3 consists of 35 items. Cluster 3 consists of the keywords acute toxicity, atrazine, herbicides, malathion, neurotoxicity, pesticide exposure, toxicity, toxicology, environmental fate, fish, transformation product, photodegradation, sublethal effect, stress, reproduction, pollutant, marine environment, microbial community, etc. .
4. Cluster 4 consists of 34 items. Cluster 4 consists of the keywords agroecology, biotechnology, environmental health, environmental impact, health risk, heany metal, herbicide resistance, human health, mitigation, organic contaminants, pesticide, pesticide residues, pesticide toxicity, regulation, risk assessment, risk management, waste management, vegetables, weed control, spray drift, wheat, transgenic crops, nonpoint source pollution, etc
5. Cluster 5 consists of 28 items. Of the 28 items, including agriculture, climate change, fertilizer, ecotoxicity, fresh water, global warming, horticulture, irrigation, metals, pathogens, pesticide resistance, marine, metal, land use, environmental risk, environmental impact assessment, soil erosion, sustainability, water footprint, public health, plant protection product, production, livestock, occurrence, etc
6. Cluster 6 consists of 27 items. The 27 items consist of the following keywords: agrochemical, biopesticide, disease, earworms, ecosystem service, essential oil, integrated pest management, invertebrates, microorganisms, natural enemies, nontarget organisms, organic farming, pest control, pest management, pest, phytotoxicity ,plant protection, pollinators, review, safety, secondary metabolites, soil health, soil pollution, sustainable development, weeds.
7. Cluster 7 consists of 25 items. Cluster 7 consists of the following keywords adsorption, biological control, degradation, indicators, kinetics, knowledge, leaching, management, metabolites, organic agriculture, persistence, pesticide use, potato, residue, resistance, runoff, soil, soil fertility, sorption, tomato, training, yield, etc.
8. Cluster 8 consists of 23 items. Cluster 8 consists of acetylcholinesterase, biomarker, ecological risk assessment, heavy metal, organochloline pesticide, organophosphorus pesticide, phytoplankton, pops, river, sediment, sources, spatial distribution, species sensitivity distribution, trace metal, water pollutions, water quality, pholichlorinated biphenyl, etc
9. Cluster 9 consists of 16 items. Cluster 9 consists of the following keywords biodiversity, fungicide, herbicide, insecticide, environment, micropollutants, monitoring, multiple stressors, pesticides, photocatalysis, remediation, urbanization, wastewater, wastewater treatment, water, water treatment.
10. Cluster 10 consists of 14 items. Cluster 10 consists of the following keywords: bioaccumulation, biomonitoring, DDT, ecotoxicology, environmental contamination, environmental monitoring, epidemiology, exposure, flame retardants, neurodevelopment, organophosphate pesticides, pcb, sensors, surfactants

11. Cluster 11 has 9 items. Cluster 11 consists of the following keywords agroecosystem, copper, nanofertilizers, nanomaterials, nanoparticles, nanopesticide, nanosensors, nanotechnology, nanotoxicity.

Table 1. Ten Keywords

No	Keyword	Total Link Strenght	Occurances
1	Pesticides	454	368
2	Toxicity	259	194
3	Risk assessment	178	167
4	Insecticides	162	114
5	Agriculture	141	111
6	Sediments	138	80
7	Pollution	135	120
8	Soil	133	109
9	Sustainability	126	119
10	Organochlorine pesticides	117	96

Based on table 1 above, the highest total link strength is the keyword Pesticide with 368 occurrences. Based on table 1 above, there are 10 keywords ordered based on the highest total link strength.

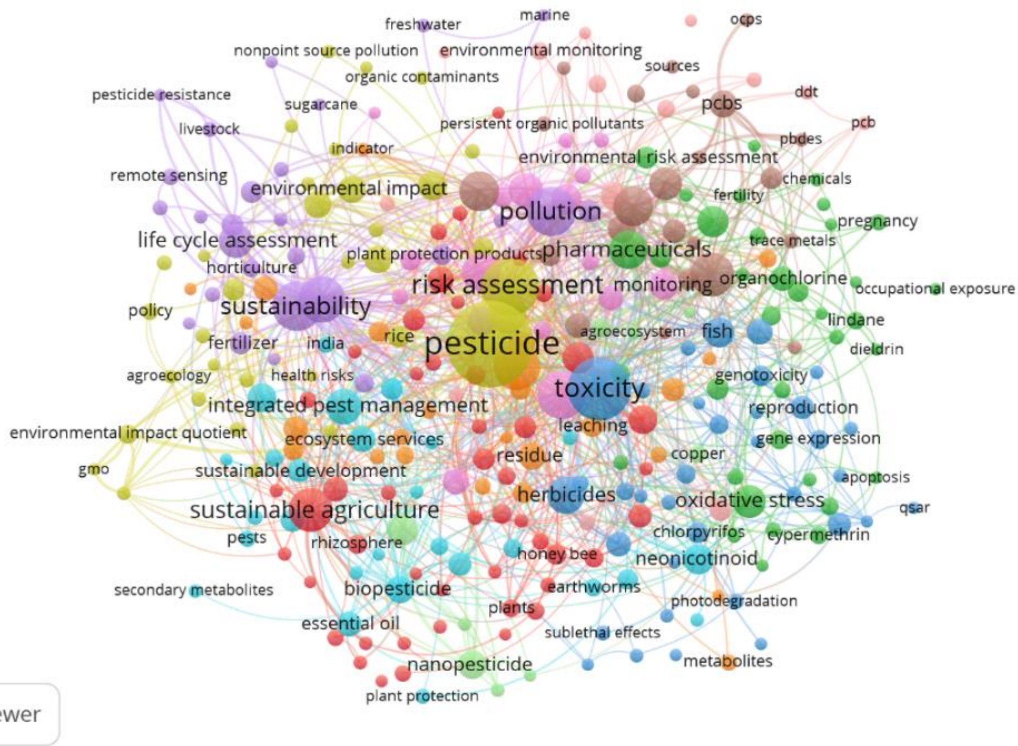

Figure 1. Network Map Showing Keywords (Network Visualization)
Source: VOSviewer 2024

From the overlay network (Figure 1), we can see in 2012 from the color that the research focus on the topic of pesticides is displayed from light green. This pesticide is in cluster 4. Cluster 4 consists of 34 interrelated keyword items. The keyword in cluster 4 that appears most frequently is pesticide with a total link strength of 454 and an occurrence of 368. For the pesticide keyword in cluster 4, based on the 34 keywords that appear in cluster 4, it can be analyzed that cluster 4 discusses pesticide residues and their impacts. on the environment and then also discusses the assessment of a risk by comparing it to the level or risk criteria that have been determined (regulation).

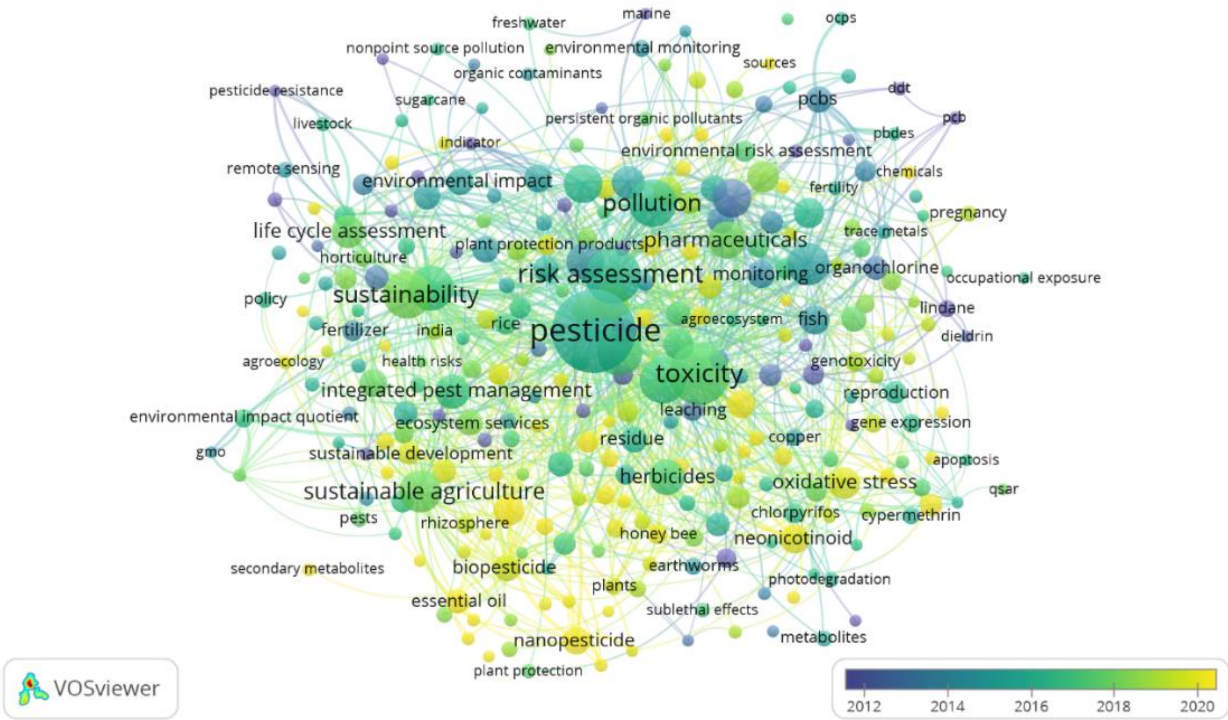

Figure 2. Network Map Showing Keywords (Overlay Visualization)
Source: VOSviewer 2024

Based on Figure 2 (overlay visualization) above, the most research on the topic of pesticides was carried out starting in 2012. The topics that are least discussed with the lowest link strength are pyrethroids (total link strength 3) and ocurances 9. Figure 2 above also shows Colors range from dark blue, blue green, light green to yellow. The blue and green colors show that from 2012 to 2018 there was a lot of research on the topics of pesticides, toxicity (total link strength 259), pollution (total link strength 135), risk assessment (total link strength 178), monitoring (total link strength 66, sustainability (total link strength 126) and others. Based on Figure 2 above, it shows that the yellow color displays are fewer (only in 2020) than the blue to green displays. The bigger the circle, the more often the keyword appears to be used as a discussion topic Based on image 2 above, the largest circle is the keyword pesticide.

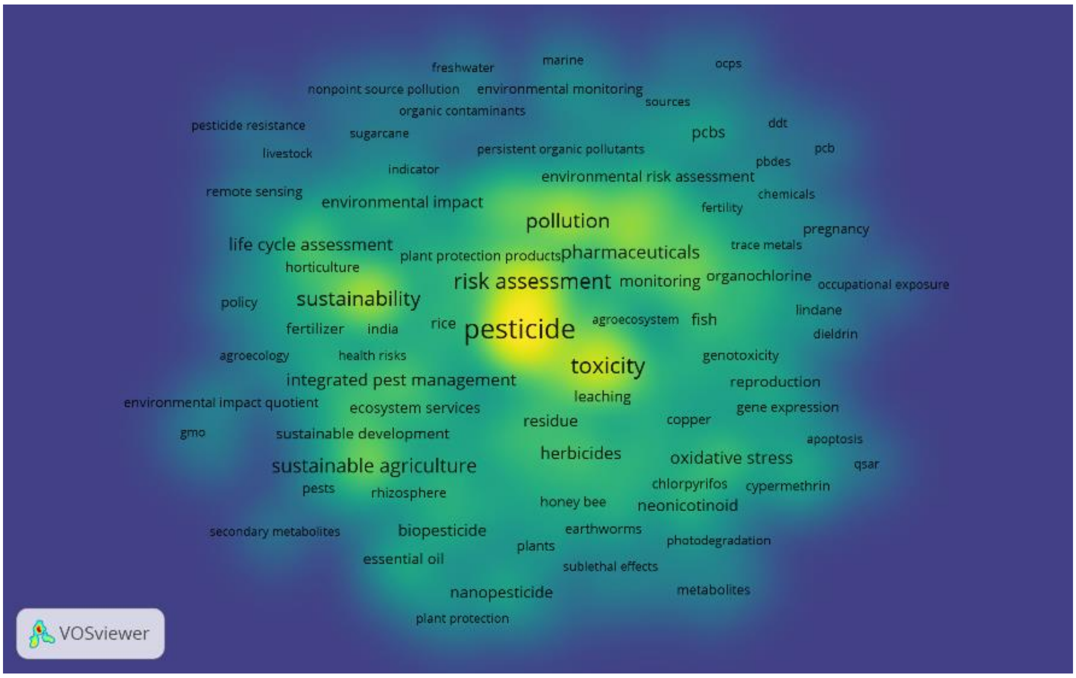

Figure 3. Network Map Showing Keywords (Density Visualization)
Source: VOSviewer 2024

Each point in the density visualization has a topic that is still a little to be discussed. This is shown in blue. In the density visualization you can also find topics that have been discussed a lot which are shown in yellow (keyword pesticide with a total link strength of 454). The more and more often it is discussed, the yellower the color becomes. The yellow color will fade and over time the yellow color will disappear if the topic is rarely discussed or discussed. Based on Figure 3 above, it can be concluded that the keywords that are colored yellow are pesticide, toxicity, risk assessment, pollution, sustainability, monitoring, sustainable agriculture, residue, herbicide. Of these keyword topics, only the pesticide keyword topic has the yellowest color.

Publication Development According to Publication Year

Development of growth in publications on the topic of pesticides and their impact on the environment from 1975 - 2024 taken from data on Scopus. The number of articles found was 7478. The number of published articles increases every year. Based on data from Scopus, publications start from 1976 to 2024. In 1976 the number of publications was still relatively rare until 1994. In 1997 there began to be an increase/increase in the number of scientific publications. The number of scientific publications increased sharply in 2021. The highest number of publications was in 2023, namely 849. Second place for the highest number of publications by year was in 2022, namely 733 articles. Based on data taken from Scopus, it shows that starting in 2004, the number of scientific publications about pesticides began to show a significant number, namely reaching more than 100 publications. From 1975 to 1982, the number of scientific publications related to pesticides was still relatively rare. This is shown by the number of articles published between these years being less than 10 articles each year.

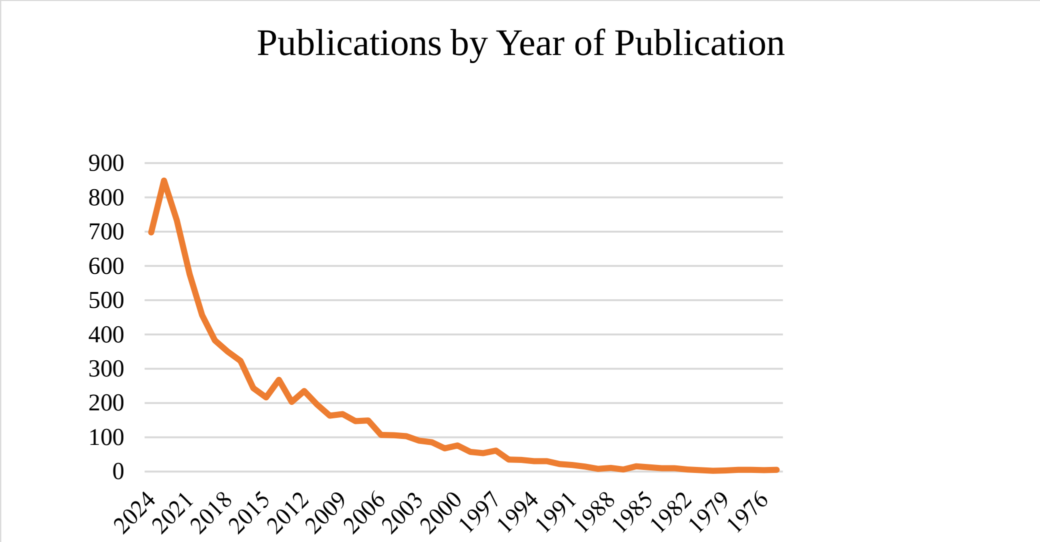

Figure 4. Number of Articles by Year of Publication
Source: Scopus 2024

Publication Trends Based on Language

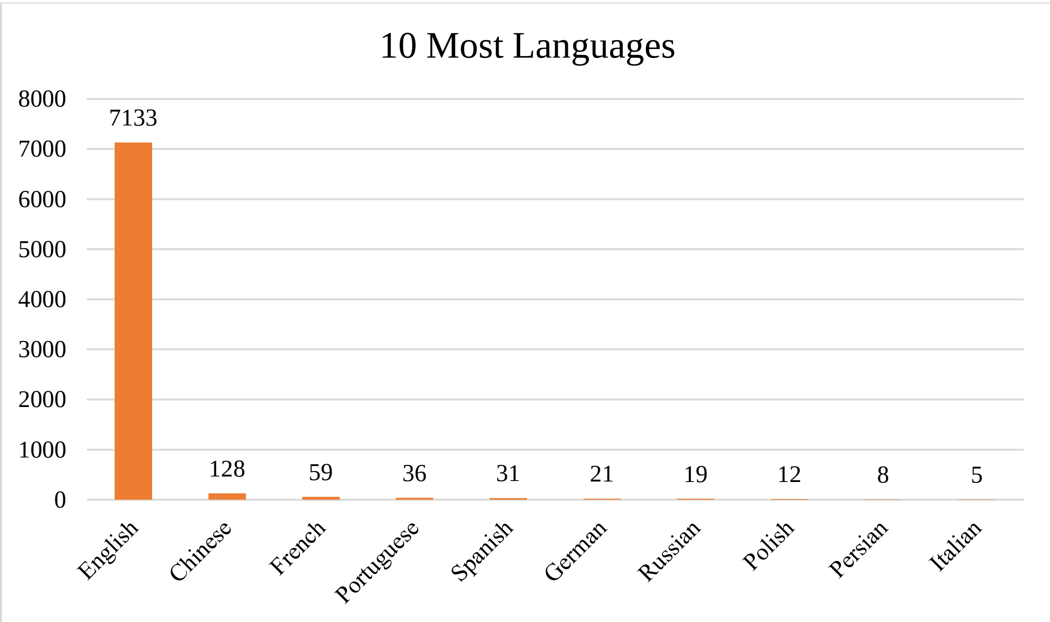

Figure 5. Publication Trends Based on Language Used
Source: Scopus 2024

Based on Figure 5 above, it shows the 10 languages most frequently used to write articles published in the period between 1975 and 2024. The language most widely used to write published articles about pesticides is the international language, namely English, namely 7133 articles. In second place, the language most often used to write scientific articles on the topic of pesticides is Chinese, with 128 articles. The third place is French, followed by Portuguese, Spanish, German, Russian, Polish, Persian and the 10th language that is widely used in writing scientific articles about pesticides is Italian.

Development of Scientific Article Publishers

Figure 6. Most Article Publishers
Source: Scopus 2024

Based on figure 6 above, there are the 10 most article publishers who publish articles on the topic of pesticides and their impact on the environment. The source of this data is taken from Scopus 2024. Based on Figure 6 above, it can be seen that Elsevier.B.V is the publisher that is at the top of the list that published the most articles from 1975 to 2024, namely 718 articles. In second place as the publisher of the most articles on the topic of pesticides is Elsevier L.T.D, with 690 articles. Publisher Elsevier is still in 3rd place, with 258 articles published between 1975 and 2024. The publisher in 4th place with the most articles published between 1975 and 2024 about pesticides is MDPI (Multidisciplinary Digital Publishing Institute), with 174 articles. From the data that has been obtained, it can be concluded that Elsevier is the publisher that publishes the most reputable scientific journals from year to year.

Table of the highest number of articles cited

No	Title	Author	Publication Year	Citation
1	Pharmaceuticals And Personal Care Products In The Environment: Agents Of Subtle Change?	Daughton, Christian G. ; Ternes, Thomas A.	1999	4024
2	Forecasting Agriculturally Driven Global Environmental Change	Tilman, D.; Fargione, J.; Wolff, B.; D'Antonio, C. ; Dobson, A.; Howarth, R.; Schindler, D.; Schlesinger, W.H.; Simberloff, D.; Swackhamer, D.	2001	2994
3	The Challenge Of Micropollutants In Aquatic Systems	Schwarzenbach, RenÃ P. Escher, Beate I.; Fenner, Kathrin ; Hofstetter, Thomas B.; Johnson, C. Annette; Von Gunten, Urs; Wehrli, Bernhard	2006	2905

No	Title	Author	Publication Year	Citation
4	Impact Of Pesticides Use In Agriculture: Their Benefits And Hazards	Aktar, Wasim ; Sengupta, Dwaipayan ; Chowdhury, Ashim	2009	2360
5	Environmental, Economic, And Energetic Costs And Benefits Of Biodiesel And Ethanol Biofuels	Hill, Jason ; Nelson, Erik; Tilman, David; Polasky, Stephen; Tiffany, Douglas	2006	2323

Based on table 5 above, there are the top 5 most cited articles. The five (5) most cited articles in the year came from 1999 to 2006. The most cited article was the article with the title Pharmaceuticals And Personal Care Products In The Environment: Agents Of Subtle Change?. The authors of the article are Daughton, Christian G. ; Ternes, Thomas A. The number of citations from this author is 4024 and the article was published in 1999.

4. Conclusions

Based on the results and discussion described in the previous chapter, it can be concluded that there were 7477 articles published in international journals indexed by Scopus. A total of 7477 articles indexed by Scopus all discuss the topic of pesticides and their impact on the environment and health. Scopus indexed international scientific publications on pesticides have been published from 1975 until now 2024. All articles use English and are Scopus indexed. The author keyword that appeared most frequently from 1975 to now in 2024 was Pesticide, with a total link strength of 454 and occurrences of 368. In this analysis, the minimum number of occurrences of the keyword in the title and abstract was determined to be 9. With 295 meeting the threshold and classified as 11 large groups (clusters). The top 10 most frequently discussed keywords include pesticide, toxicity, risk assessment, insecticide, agriculture, sediment, pollution, soil, sustainability, organochlorine pesticide. Of the 10 keywords (Author Keywords) the one most discussed is the topic of pesticides. This research consists of 11 clusters. Each cluster consists of author keywords. The keyword with the highest total link strength is in cluster 4, namely pesticide. Each cluster discusses certain topics.

Based on publication trends related to the topic of pesticides, there is always an increase from year to year. A significant increase occurred from 2014 to 2023. In the early years (from 1975 to 1984) there were still relatively few publications related to the topic of pesticides and their impact on the environment. The number of article publications in that year (1975-1984) was still below 10 articles per year. Starting in 2004, the number of articles published has crept up to reach over 100 publications each year. A significant increase in article publications occurred from 2021 to 2024. In this year's range, the number of articles published each year reached over 500 articles per publication. The highest peak in the publication of articles about pesticides will occur in 2023. In 2023 the number of articles that can be published will reach 849.

The language used in the publication of articles related to the keyword topic pesticides is mostly English. There are 7133 articles about pesticides published in English. English is an international language so it is widely used to publish articles from various nations in the world. From the results of the analysis of Scopus data taken in 2024, the 10 languages that rank in 10th place are Italian. Based on the data obtained, there were 5 articles that used Italian to publish articles related to the topic of pesticides.

Elsevier is the largest publisher that publishes world-renowned articles. Based on the data analysis that has been carried out, Elsevier B.V is the publisher of the most articles between the years 1975-2024, namely 718 articles. Second place is at the publisher Elsevier L.T.D with 690 articles. Based on the results of the analysis of the 10 largest publishers from 1975 to 2024, publisher John Wiley and Sons Inc is the 10th publisher.

Topics related to pesticides and their impact on the environment need to be explored so that the risks and problems arising from the effects of pesticides on the environment and the effects on health can be handled properly in accordance with developments in technology and science. In bibliometric analysis, to reduce research errors, researchers must be careful when cleaning the bibliometric data obtained, including deleting duplicates and incorrect entries so that the data obtained is correct and accurate data. If the resulting data is correct and accurate data, then the visualization results from bibliometric analysis will also be accurate results.

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