Central themes of the relationship between pesticides and cancer: A systematic review of the literature

João Carlos Belarmino Aguiar
Master's student in the Professional Graduate Program in Public Administration in National Network (PROFIAP)/UFAL, Campus A.C. Simões, Maceió – AL.
ORCID: 0009-0005-2697-3999
E-mail: joao.aguiar@feac.ufal.br

Luciana Santos Costa Vieira da Silva
Professor at the Faculty of Economics, Administration and Accounting of the Federal University of Alagoas (FEAC/UFAL), Campus A.C. Simões, Maceió – AL.
ORCID: 0000-0002-9538-7150
E-mail: luciana.vieira@feac.ufal.br

Wesley Vieira da Silva
Professor at the Faculty of Economics, Administration and Accounting of the Federal University of Alagoas (FEAC/UFAL), Campus A.C. Simões, Maceió – AL.
ORCID: 0000-0001-5354-8676
E-mail: wesley.silva@feac.ufal.br

Fernando Fleury Curado
Researcher at the Brazilian Agricultural Research Corporation – Embrapa Food and Territories. Rua Cincinato Pinto, nº 348, Centro, Maceió – AL.
ORCID: 0000-0002-0498-7944
E-mail: fernando.curado@embrapa.br

Paola Hernandez Cortez Lima
Researcher at the Brazilian Agricultural Research Corporation – Embrapa Food and Territories. Rua Cincinato Pinto, nº 348, Centro, Maceió – AL.
ORCID: 0000-0001-6676-831X
E-mail: paola.cortez@embrapa.br

Lidiane de Almeida Pereira
Master's student in the Professional Graduate Program in Public Administration in National Network (PROFIAP)/UFAL, Campus A.C. Simões, Maceió – AL.
ORCID: 0009-0007-5841-4539
E-mail: lidiane.pereira@feac.ufal.br

Bianca Lima Silva
Master's student in the Professional Graduate Program in Public Administration in National Network (PROFIAP)/UFAL, Campus A.C. Simões, Maceió – AL.
ORCID: 0009-0004-0039-7236

E-mail: bianca.silva@prograd.ufal.br

Luciana Peixoto Santa Rita
Professor at the Faculty of Economics, Administration and Accounting of the Federal University of Alagoas (FEAC/UFAL), Campus A.C. Simões, Maceió – AL.
ORCID: 0000-0002-6868-9014
E-mail: luciana.santarita@feac.ufal.br

Ibsen Mateus Bittencourt Santana Pinto
Professor at the Faculty of Economics, Administration and Accounting of the Federal University of Alagoas (FEAC/UFAL), Campus A.C. Simões, Maceió – AL.
ORCID: 0000-0002-6543-143X
E-mail: ibsen@feac.ufal.br

ABSTRACT
Objective – to identify central themes in the relationship between pesticides and cancer associated with rural areas, agriculture or agribusiness, through a Systematic Literature Review. Methodology – The research is exploratory, with a quantitative approach for bibliometric analysis and qualitative for the supervision of articles in the final corpus and the discussion of central themes. Results - The analysis of corpus indicators demonstrated that the topic can be considered recent and with a tendency to grow. The coupling bibliographic of the corpus, using the VOSviewer software, showed low quantitative and intensity connections. The thematic map highlights emerging central themes about "breast cancer", "childhood cancer" and "nervous system", niche themes such as "DNA damage", basic themes about "environmental protection" and motors, "health study", "risk of cancer" and "exposure to pesticides". Methodological contributions – Identification of themes with reduced bias by centrality and density statistics, which may represent advances in knowledge. Social and environmental contributions – The discussion of the central themes points to the approach of research techniques such as biomarkers and evidence mapping, exposure to pesticides associated with other areas, such as gardens, parks, urban areas, which can cause damage to health beyond the cancer, such as lung and coronary diseases, DNA damage, reporting strategies to reduce these risks

through the use of PPE, distance from homes to places that use pesticides, training of farmers. However, these measures seem insufficient, as State regulation allows the use of pesticides within certain limits, generally exceeded, which contributes to damage to health and the environment.

1 INTRODUCTION

According to the World Health Organization, twenty thousand deaths per year are recorded due to the consumption of pesticides (INCA, 2023). Approximately 2.5 million tons of pesticides are used worldwide. The national consumption is over 300 thousand tons (SPADOTTO; GOMES, 2021), and in 2021, the total sale of these products was 720.87 thousand tons, an increase of 5.03% compared to the previous year (IBAMA, 2023).

According to Brazilian legislation, pesticides and related products are products and agents, whether of physical, chemical or biological processes, to be used in the production sectors, in the storage and processing of agricultural products, in pastures, in the protection of forests, native or implanted, and other ecosystems, including urban, water and industrial environments. which aim to alter the composition of flora or fauna in order to preserve the harmful action of living beings that are considered harmful, as well as substances and products used as defoliants, desiccants, growth stimulators and inhibitors (BRASIL, 1989).

However, according to the National Cancer Institute, these synthetic chemicals are used as a justification for the control of diseases of various vectors – insects, larvae, fungi, ticks – and to regulate the growth of vegetation in urban and rural environments (INCA, 2023).

Scientific research around the world reports studies on the association between the use or exposure to pesticides in agricultural activities and cancer, such as in Pakistan (PARVEEN *et al., 2023), Nigeria (ABUGU et al., 2023), the United States (VIKRAM et al., 2023), China (YOU* et al., *2022),* suggesting sustainable agricultural practices and the role of regulatory agencies in the inspection of prohibited pesticides.

Therefore, to better understand the relationship between pesticides and cancer associated with rural areas, agriculture, or agribusiness, a search was conducted in the *Scopus* journal database in September 2023, where 937 documents were found. The application of the inclusion and exclusion criteria and an analysis of adherence to the theme consolidated the *final corpus* in 46 articles and reviews. It was found that the studies did not present a systematic review of the literature in the area of environmental sciences that sought to identify the central themes addressed here, which motivated the development of this research.

Thus, the research question arose: What central themes can be evidenced from the relationship between pesticides and cancer associated with rural areas, agriculture or agribusiness? The objective of this systematic literature review (RSL) is to identify the central themes of the relationship between pesticides and cancer associated with rural areas, agriculture or agribusiness.

To achieve the objective, systematic mapping was developed according to Tranfield *et al.* (2003), with rigid stages of planning, conduction and dissemination of knowledge. In the last stage, in addition to the analysis of indicators of scientific and temporal production, it was based on the premise that the articles and reviews could be bibliographically coupled by analyzing the references with the VOSviewer software and that the abstracts, after being processed in *the* Bibliometrix® software, could reveal central themes of the research, based on calculations of centrality and density. which reduces research bias.

It is intended to contribute to studies in the area of environmental sciences, interrelating pesticides and cancer with rural areas, agriculture or agribusiness, which can foster academic debates and influence government decision-making, as well as identify advances in knowledge of the subject.

This article, in addition to this first section, is organized as follows: the second section is dedicated to methodological procedures; the third section includes the analysis and discussion of the results; and the fourth presents the conclusions and limitations of this study.

2 METHODOLOGICAL PROCEDURES

The methodological procedures were carried out in three stages, namely: planning, conducting the systematic literature review (RSL) and disseminating knowledge (TRANFIELD *et al.*, 2003). In the planning stage, the *Scopus database was chosen and the search* string *was defined*, using the booleans "AND" and "OR" between words that cover the objective of analysis of this study, with research in the titles, abstracts and keywords, as shown in Chart 1. The choice of the *Scopus journal database* stems from the information that its content comes from more than seven thousand publishers, with more than 1.8 billion cited references and the source's list of titles includes 43,034 results (ELSEVIER, 2023).

Chart 1 – Search string and general result of identified works

| *String* searched in *TITLE-ABS-KEY*	Result
"pesticide" AND "cancer" AND ("rural" OR "agriculture" OR "agribusiness")*	937

Source: The Authors (2023). Data from the Scopus journal database

The systematic literature review was conducted according to the previously defined inclusion and exclusion criteria. Thus, the inclusion criteria used were open access papers, articles, and reviews in the area of environmental sciences, reducing the *corpus*, respectively, to 373, 346, and 122 papers.

Subsequently, detailed and in-depth readings were performed for adherence analysis, which was used as an exclusion criterion for other articles that did not meet the requirement. This criterion refers to the concomitant existence of the constructs "*pesticide**", "*cancer*" and at least one of the others, "*rural" or "*agriculture*" or "agribusiness*" in the abstracts of the studies, which led to the exclusion of 76 articles, bringing the* final corpus *to 46 studies, as shown in Figure 1.*

Figure 1 - Summarized flowchart of the RSL steps.
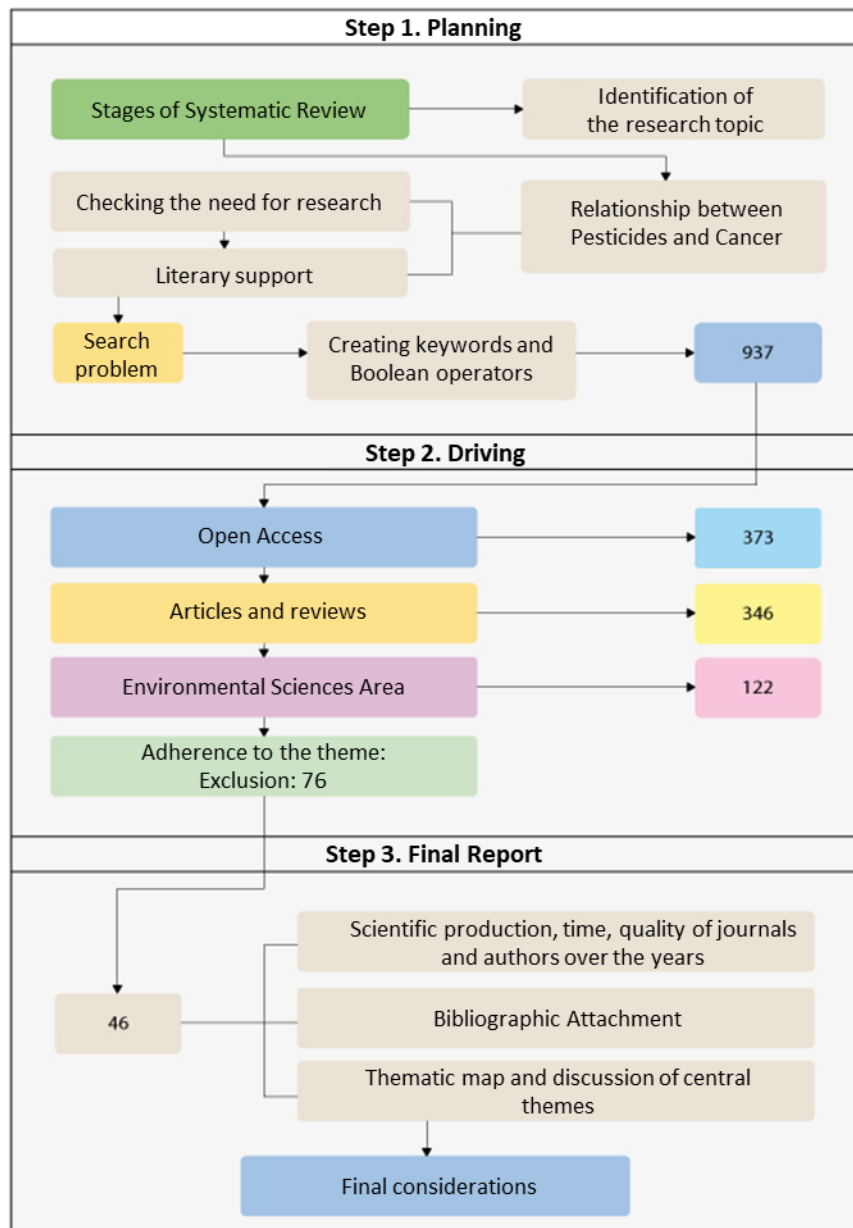
Source: The Authors (2023). Adapted from Tranfield *et al.* (2003)

The flowchart presented in Figure 1 covers all the stages relevant to this research and can be replicated by any researcher or interested party, which is why we move on to the dissemination of knowledge, through the results and discussion, with the analysis of indicators of scientific and temporal

production, bibliographic coupling by the use of the VOSviewer® software and thematic map organized by centrality and density. through the *Bibliometrix®* software.

Finally, it is appropriate to make considerations about the thematic map:

i) the data processed were the abstracts of the 46 papers of the *final corpus*;

ii) the bigrams parameter was used to include at least two words in the cluster name;

iii) 1 label was defined to keep only the two indicator words of each cluster in evidence;

iv) a minimum frequency of five words was also chosen to form each cluster;

v) words that prevented the formation of clusters relevant to this research were excluded, such as "*authors licensee", "north carolina", "basel switzerland"* and *"data gaps"*, as well as "*comet assay*", related to a technique for detecting DNA damage, which was presented as an emerging theme, but was excluded to enable the discussion of other themes, in addition to "*agriculture home*", considering that the search for the words together in the abstracts did not identify any works;

vi) synonymized the words "pesticide exposure" and *"pesticide exposures", which were forming 2 distinct clusters despite having the same meaning, and;*

vii) once the map was plotted, the words of each cluster were jointly identified in the abstracts of the papers, reporting the central themes categorized by Bibliometrix® based on centrality and density, which allowed the answer to the central research question.

3 RESULTS AND DISCUSSION

This section is composed of three subsections: the first is the analysis of the indicators of scientific and temporal production of the textual *corpus*, the quality of the journals in which the articles were published and the production by the authors over the years; the second is dedicated to the study of bibliographic coupling and the third is dedicated to the analysis of the thematic map based on the values of centrality and density of words contained in the abstracts of these Work. This stage allowed the identification of the central themes, which were divided into emerging, basic, niche and drivers of the relationship between pesticides and cancer associated with rural areas, agriculture or agribusiness.

3.1 ANALYSIS OF SCIENTIFIC AND TEMPORAL PRODUCTION INDICATORS

The objectives of this analysis are: i) to present the indicators of scientific and temporal production, contextualized by the descriptive statistics data from the textual *corpus*, ii) to evaluate the quality of the journals from which the articles came and, iii) to contextualize the annual production over the years in order to bibliometrically analyze the articles published on the theme studied.

Health and Medicine: Science, Care, and Discoveries
Central themes of the relationship between pesticides and cancer: A systematic review of the literature

Figure 2 - Indicators of scientific production of the *corpus*.

Timespan	Sources	Documents	Annual Growth Rate
1991:2023	26	46	2.19 %

Authors	Authors of single-authored docs	International Co-Authorship	Co-Authors per Doc
328	1	23.91 %	7.39

| Author's Keywords (DE)	References	Document Average Age	Average citations per doc
200	2998	7.26	44.28

Source: The Authors (2023). *Bibliometrix*® Software

Figure 2 shows that the articles in the *corpus* cover the period from 1991 to 2023, from 26 journals, totaling 46 documents, with an annual growth rate of 2.19%, with an average of 7.26 documents per year and an average of citations per document of 44.28, including 2,998 references.

The documents present 200 keywords defined by 328 authors. The co-authorship rate per document is 7.39, with an international co-authorship rate of 23.91%. Only 1 author produced a study in a singular way, which demonstrates a tendency that the studied theme is usually developed through collaboration between authors and co-authors.

Although the annual growth rate was 2.19%, the analysis of the temporal distribution shown in Figure 3 shows that, from 1991 to 2016, the publications reached a cumulative of 15 papers, equivalent to approximately 33% of the *corpus*.

Figure 3 - Annual scientific production of the *corpus*
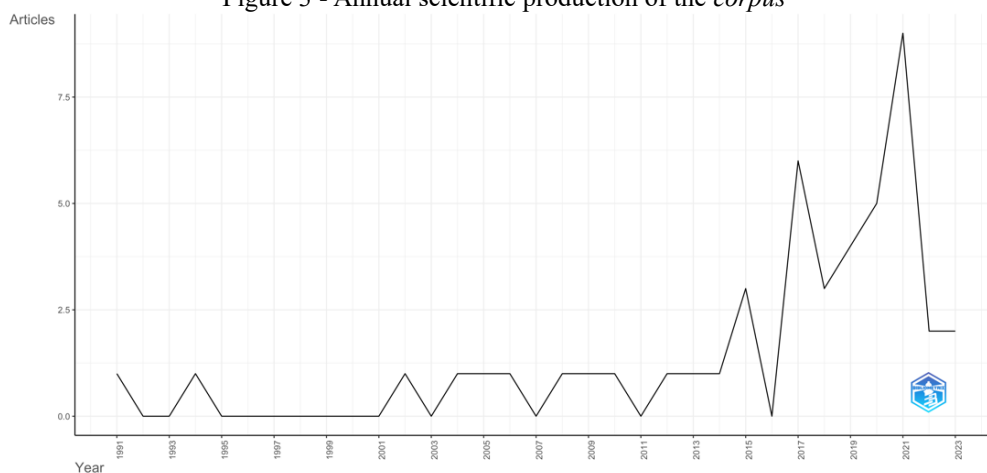
Source: The Authors (2023). Bibliometrix®.

From 2017 to 2023, 31 papers were published, which corresponds to approximately 67% of the *corpus*. In this context, although the average age of the documents was 7.26 years, the temporal distribution of the publications is concentrated in the last six years, which is why it is possible to

identify that research on the subject is recent, with an upward trend. However, before proceeding, it is important to evaluate the quality of the journals in which the work of this study was published.

Table 1 – Journals, number of articles published and SCImago quartile in 2022

Newspaper	Articles	SCImago
International Journal of Environmental Research and Public Health	8	Q2
Environmental Health Perspectives	6	Q1
Environmental Health: A Global Access Science Source	3	Q1
Environmental Research	3	Q1
Air, Soil and Water Research	2	Q2
Ecotoxicology and Environmental Safety	2	Q1
Environment International	2	Q1
Environmental Sciences Europe	2	Q1
Annals of Agricultural and Environmental Medicine	1	Q3
Case Studies in Chemical and Environmental Engineering	1	Q1
TOTAL	30	

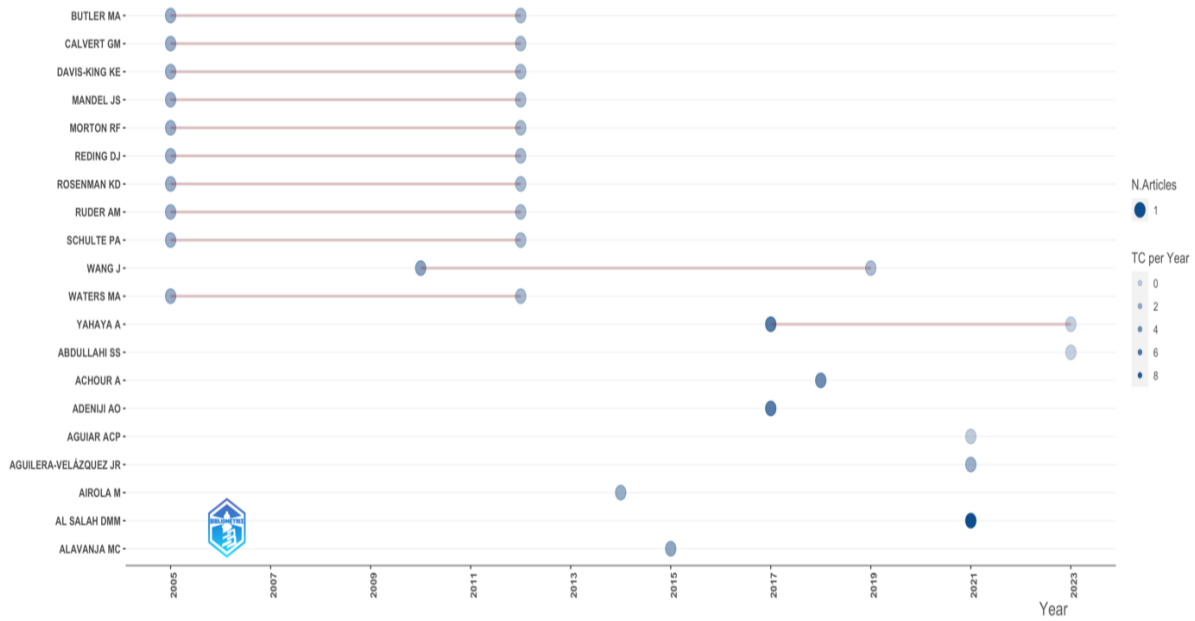Source: The Authors (2023). Adapted from *Bibliometrix*® software

Table 1 shows the top ten most relevant journals, organized by Bibliometrix® according to the number of publications of the articles selected to compose the final *corpus* of this study. Considering that the articles were obtained from the search in the *Scopus* journal database and that the SCImago Journal & Country Rank *is a portal that makes publicly available a* ranking of the journals in the aforementioned database, based on citations that are extracted from more than 34,100 titles from more than 5,000 international publishers and performance metrics from 239 countries (SCImago, 2023), it was decided to verify the quality of the journals in which the articles involved in this research were published.

Thus, from the analysis of the ten journals made available by Bibliometrix®, it can be seen that, of the 30 articles, approximately 63% were published in journals classified in the first quartile (Q1) of the SCImago, 33% in the second quartile (Q2) and 3% in the third quartile (Q3). It is noteworthy that this classification helps to compare a given journal with others in the same category, and that the Q1 classification indicates that the performance of the journal is better than 75% of the others in the category analyzed, as well as Q 2 is between 50% and 75%, Q3 is between 25% and 50%, and Q4 is up to 25% (MATTHEWS, 2016). For this reason, it can be inferred that *the corpus* selected for the analysis is of high quality in terms of classification of the journals in which they were published.

The authors' production over time (ARIA; CUCCURULLO, 2017), in terms of number of publications and total citations per year, was plotted in Figure 4.

Figure 4 – Authors' production over time

Source: The Authors (2023). Bibliometrix®

In this type of figure, the size of the spheres is closely linked to the number of published papers, while the shading of the spheres, from light blue to darker, refers to the increase in the total number of citations of articles per year.

Among the twenty main authors, Bibliometrix® highlights the author Al Salah (2021), who despite having published only one article in relation to the topic under study, in 2021, reached an index of 8.67 citations per year, surpassing all other authors who came from the *software*' s output. In second place, tied, are Yahaya (2017) and Adeniji (2017), both with one publication and, despite being four years older compared to the highlight, they have a 5.86 citation index per year.

In terms of production over the years, it is identified that Wang (2010; 2019) continued to publish for a longer period, approximately nine years, compared to the others. However, this analysis was carried out using the timeline between two articles, one in 2010 and the other in 2019, with 3.29 and 1.4 citation rates per year, respectively.

All the other authors shown in Figure 4 presented citation rates below the values mentioned or published only one work related to the topic under study or, when they published two, no constancy was identified over the years in the development of the subject.

These findings justify a detailed analysis of the bibliographic coupling of the articles of the entire *corpus, in* order to verify the sharing of theories and/or methodologies, which is presumed to be low due to the low citation rates of the authors in the analysis of this subsection.

3.2 BIBLIOGRAPHIC COUPLING

The objective of this subsection is to analyze the bibliographic coupling between the works of the textual corpus, which, according to Kessler (1963), allows measuring the degree of similarity between the pairs of references. Thus, the number of references shared between two works admits the assumption that the content of these works is related and, in this way, it is possible to map the *research portfolio* and measure the strength of the connection between the works based on the overlapping of references, i.e., the more identical references shared, the greater the intensity of the coupling (EGGHE; ROUSSEAU, 2002; ZHAO; STROTMANN, 2008).

Coupling analysis involves connections, called *links*, that establish the relationships between two or more jobs. The thicker the *links*, the greater the strength, measured numerically by the *total link strength*, meaning that the articles have a greater intensity of methodological and/or theoretical cooperation in terms of coupling. The nodes represent each work and are calculated based on the density and degree of correlation between the other articles, whose intensity is also measured by the total strength of connections, which shows the works with greater intensity in the respective clusters. Thus, the larger the nodes, the greater the intensity of cooperation of the scientific article (VAN ECK; WALTMAN, 2020).

The VOSviewer was used for the intended analysis, whose chosen unit was the document, with the total count method and the minimum of 5 citations per document, reaching the limit of 38 documents. The analysis option was based on the connections established between the articles, with the method of association by force, as well as for the scale of the nodes. This option allowed the plotting of Figure 5, which presents 10 connections and *total link strength* of 12, forming 5 clusters, identified by the colors red, green, blue, yellow and lilac, with attraction parameters of 7 and repulsion -5 to improve the image *layout*.

Figure 5 - General bibliographic coupling network by *link strenght*
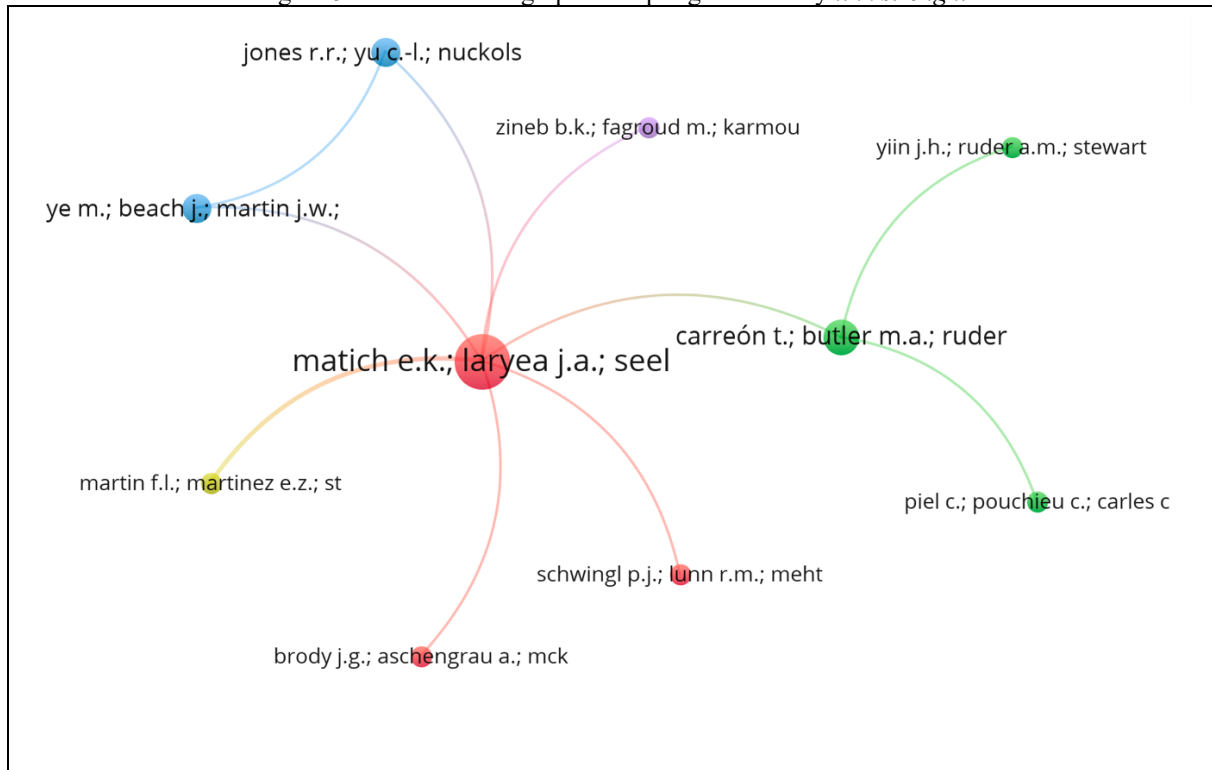
Source: The Authors (2023). *VOSviewer* Software

Following the logic for obtaining a *layout* to facilitate understanding, the procedure carried out by Aguiar was adopted *et al.* (2023), in which the selection of the main works of each cluster makes it possible to highlight the connections established between the selected article and the other documents of the entire network. In this analysis, this procedure does not form a new cluster, but visually highlights these connections to compare the quantity (*link*) and intensity (*total link strenght*) of the relationships established with the main work of each cluster, thus considered the one that has the largest node among the others in the cluster.

Figure 6 – Connections Established from Red Cluster Primary Job Selection
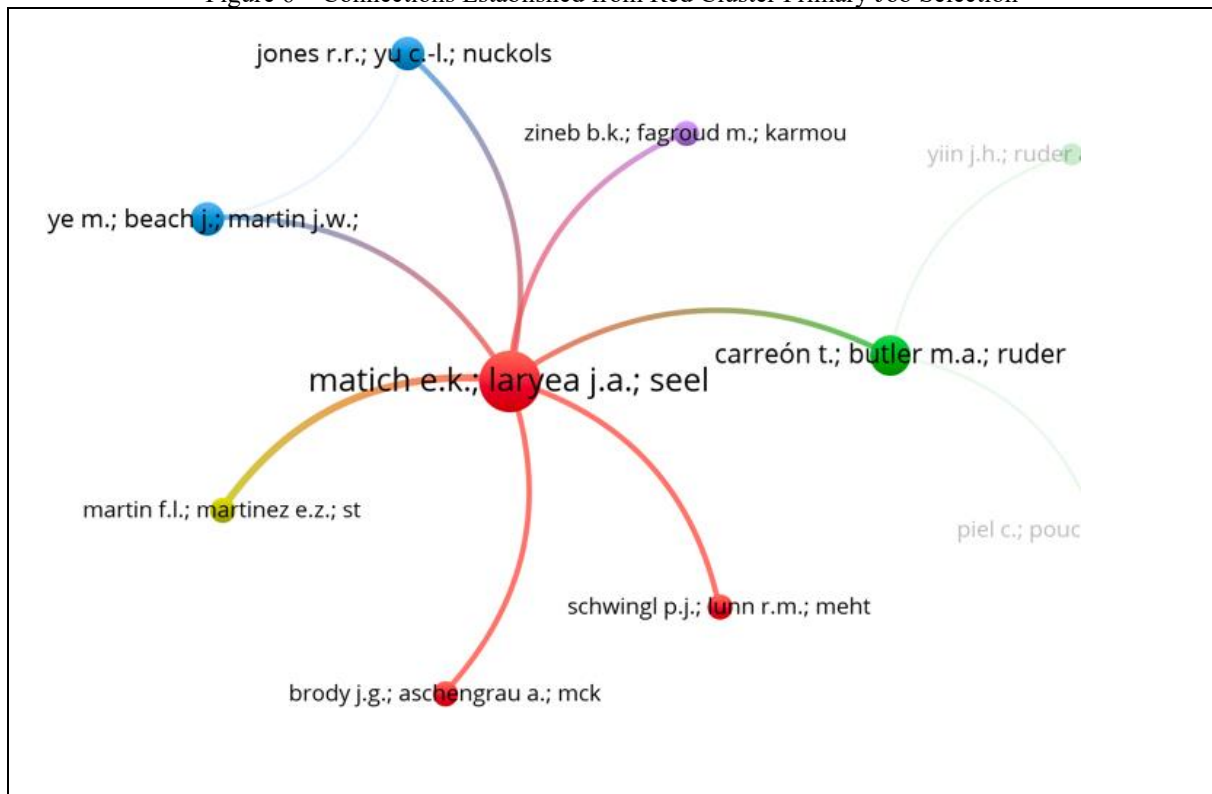
The red cluster (Figure 5) has three studies, with emphasis on Matich *et al.* (2021), the article with the highest *intensity (link strength* 9) in the network, in addition to establishing connections, totaling 7 *links*, with all other clusters, at least one work (Figure 6). This phenomenon can be explained by the nature of the study, since it is a systematic review of the literature, which usually establishes a broad theoretical and/or methodological relationship with other studies on a given subject studied.

Entitled "*Association between pesticide exposure and colorectal cancer risk and incidence: A systematic review*" and with the aim of investigating this association, the results of the article, in general, were not conclusive in such a way that it could be stated that exposure to pesticides causes colorectal cancer (CRC). However, the authors reported concern about some types of pesticides and highlighted that pesticide exposure by farmers, industrial workers, and those living in rural communities, among others, may occur due to the possibility of these pesticides remaining in the environment, for example, in soil, water, and air for weeks or years, warning that, in the United States, 60 million people live in rural areas and that all *CRC mortality hotspots* are within rural communities (MATICH *et al.* 2021).

This research is more closely related (*link strength* 3) to the work of Martin *et al*. (2018), which composes the yellow cluster in isolation (Figure 7), with the article entitled "*Increased exposure to pesticides and colon cancer: Early evidence in Brazil*", whose objective was to investigate the association between pesticide exposure and colon cancer (CHD). However, differently from the study by Matich *et al*. (2021), Martin *et al*. (2018) identified a correlation between the increase in CHD

mortality over a decade and the amount of pesticides sold in Brazil, with higher concentrations in the South and Southeast regions. In this context of divergence, it is important to emphasize that the studies adopted different methodologies, which is why, in terms of bibliographic coupling, it is possible to infer that they share theories.

Figure 7 – Connections Established from the Selection of the Yellow Cluster Main Job
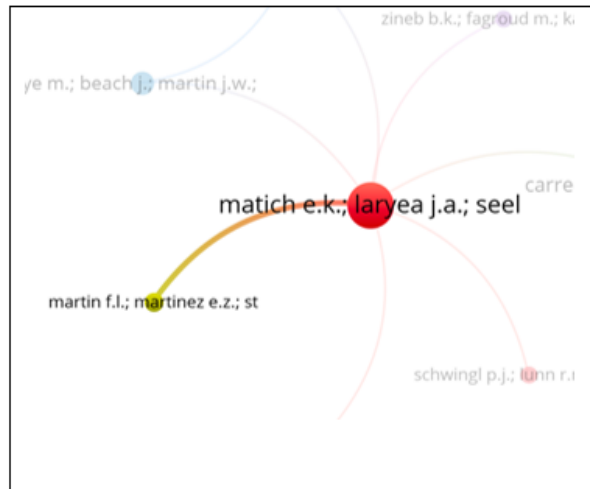
Source: The Authors (2023). *VOSviewer* Software

Figure 8 – Connections established from the selection of the main job of the lilac cluster
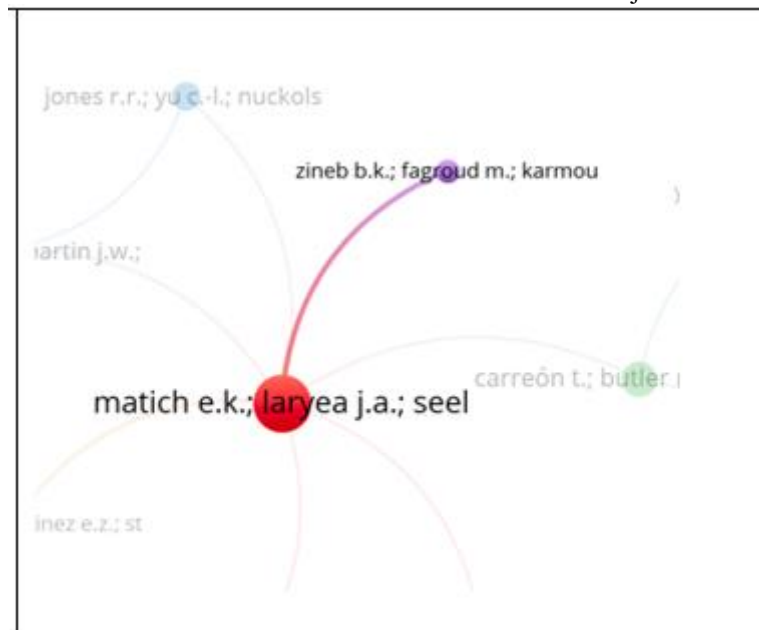
Source: The Authors (2023). *VOSviewer* Software

The single work of the lilac cluster (Figure 5) follows practically the same path as the previous analysis, with the difference that the article has a quantity and intensity of connections in the value of 1 and is linked only to the main work of the red cluster (Figure 8). In the paper, Zineb Ben Khadda *et al*. (2021), entitled "*Farmers' knowledge, attitudes, and perceptions regarding carcinogenic pesticides in fez meknes region (Morocco)*", sought farmers' perceptions and the results showed that, in addition

---

Health and Medicine: Science, Care, and Discoveries
Central themes of the relationship between pesticides and cancer: A systematic review of the literature

to the lack of information on pesticide application for most respondents, 40% of the farmers did not properly store pesticides or dispose of them in an environmentally appropriate manner, systematizing, through descriptive statistics, the possible consequences of exposure to these substances by the interviewees: visual impairment (46%); dizziness (44.3%); headache (39.4%); excessive sweating (34.4%); and 30.2% had respiratory problems.

Similarly to the previous analysis, it is noted that this study adopted a different methodology compared to the article that is attached, by Matich *et al*. (2021), that this is a systematic review, while the work analyzed above is a qualitative research, with primary data collection, which is why it can be inferred that the articles, in terms of bibliographic coupling, share theories.

Figure 9 – Connections Established from the Selection of the Green Cluster Main Job
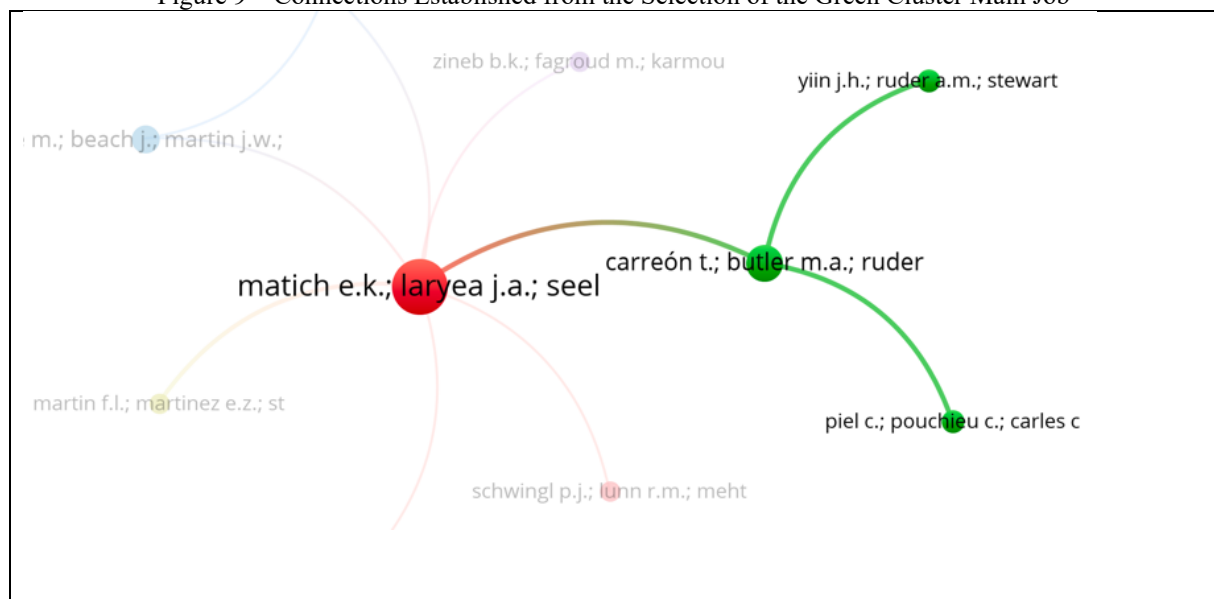
Source: The Authors (2023). *VOSviewer* Software

The green cluster is composed of three studies (Figure 5), in which the study by Carreón *et al*. stands out. (2005), with the number and intensity of 3 connections, one of which occurs with the main work of the red cluster (Figure 9). The article is entitled "*Gliomas and farm pesticide exposure in women: The Upper Midwest Health Study*", and aimed to investigate gliomas in women due to the fact that there were, at the time, several studies that made this association in relation to men. However, the results showed, statistically, that there was no association between exposure to pesticides and increased risk of intracranial gliomas in women, however, they highlighted an increased risk due to carbamate herbicides.

The article by Yiin *et al*. (2012), a member of the Green Cluster, seems to be theoretically and methodologically coupled to the previously analyzed work, having concluded that there is a lack of evidence on positive associations between glioma and pesticides. On the other hand, Piel *et al*. (2019), another component of the green cluster, also developed studies on the association between gliomas,

among others, and exposure to pesticides, however, they reported an increased risk of development in relation to exposure to pesticides called carbamates and a significant association for fungicides and herbicides.

Figure 10 – Connections established from the selection of each blue cluster job
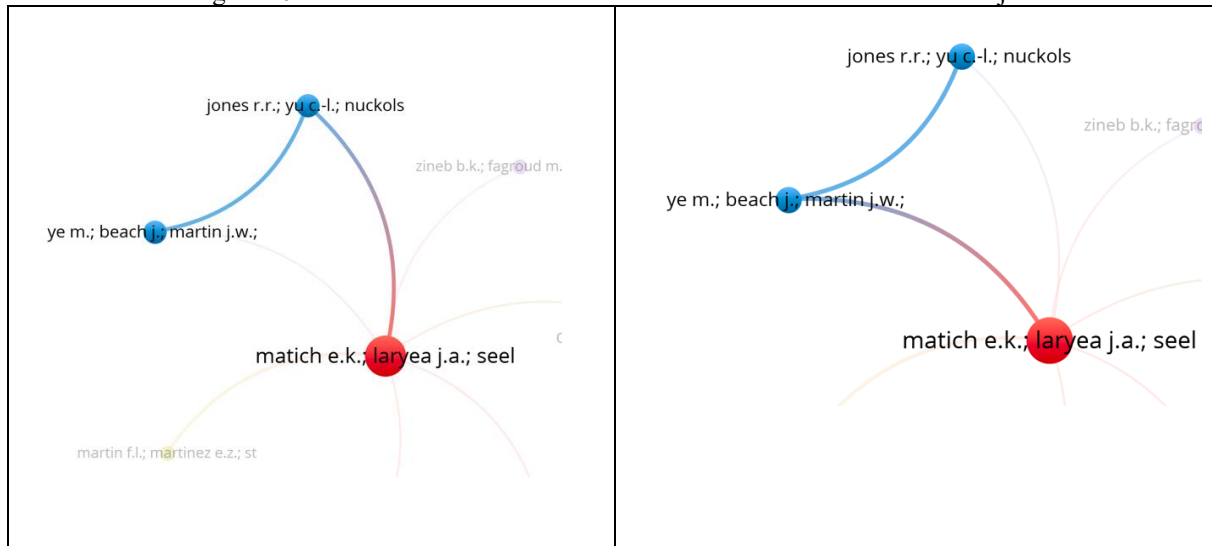
The blue cluster is formed by two studies (Figure 5), which have identical values for the number and intensity of connections (2). Both establish a connection with each other and with the main work of the red cluster (Figure 10). The work of Ye *et al.* (2013) and Jones *et al.* (2014) will be reported later among the central themes, however, it should be noted that they are not methodologically coupled. The first is a review and the second followed up on previous research, documented records on the subject studied, and investigated the distance between homes and places exposed to pesticides. This allows us to infer that the articles share theories in terms of bibliographic coupling.

As can be seen, the bibliographic coupling was shown to have a low quantity and intensity, to the extent that only 10 studies, out of a total of 46, formed five clusters, and the main work of the red cluster (Figure 5) became a highlight due to the methodology adopted, a systematic review that, by its very nature, conducts broader studies.

After analyzing the descriptive information associated with *the corpus* and the bibliographic coupling, it is of interest to this work to identify and discuss the central themes, composed of emerging or declining, basic, niche and motors, based on the analysis of the thematic map.

3.3 THEMATIC MAP BY CENTRALITY AND DENSITY VALUES

The thematic map is based on the variables centrality (horizontal axis) and density (vertical axis), measured, respectively, by the degree of relevance and development of the theme investigated. The division of the map into four quadrants allows us to evaluate the relationship between the variables

studied and the situation of the central themes under discussion in the literature over the period analyzed.

Each cluster represents a network of words derived from the abstracts, related to each other through connections, forming nodes, where these words are located. The formation and positioning of the clusters in the quadrants are calculated by Bibliometrix® and, in this study, organized by the centrality and density values themselves, as shown in Table 2.

Table 2 – Clusters and centrality and density statistics

Cluster	Centrality	Density
pesticide exposure	18,33	294,29
cancer risk	12,16	191,67
breast cancer	3,03	36,00
dna damage	8,25	115,00
health study	15,38	181,76
central nervous	5,50	93,75
environmental protection	11,15	91,23
childhood cancer	1,75	85,00

Source: The Authors (2023). Bibliometrix® data

The values of centrality and density associated with the main word forming the cluster determine the quadrants of positioning of these clusters in Figure 11, classifying them into basic themes, *motor* themes, niche themes, *and emerging or* declining *themes*.

Figure 11 – Thematic Map
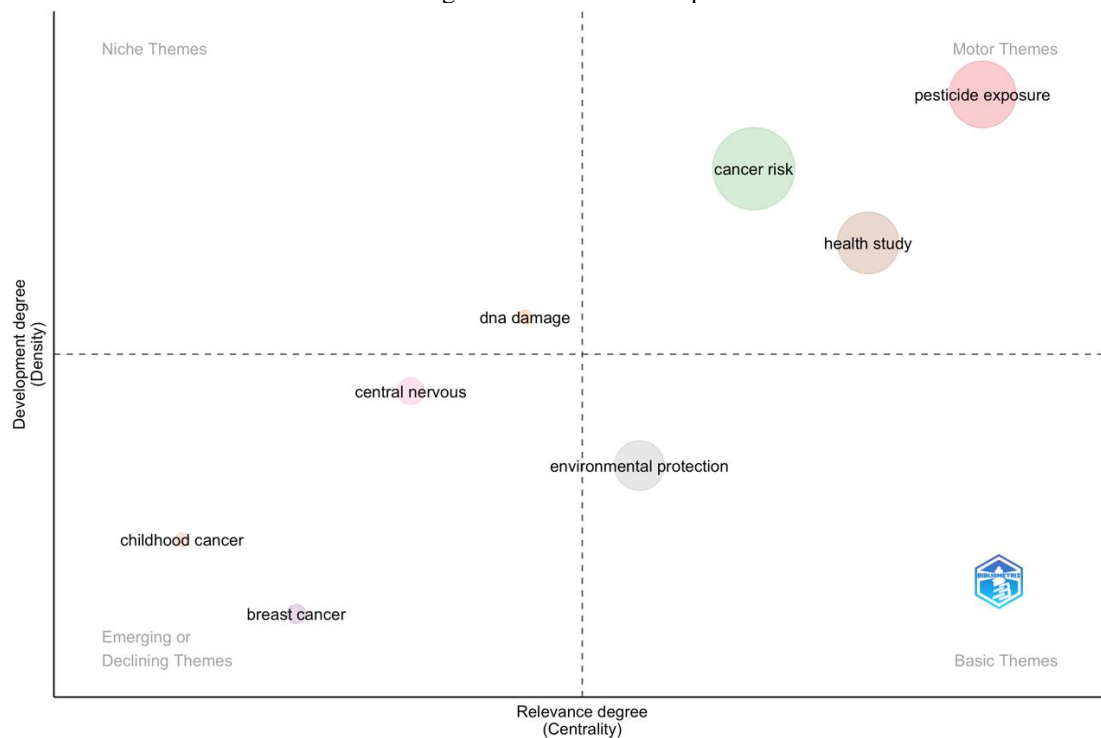
Source: The Authors (2023). *Bibliometrix*® software.

Emerging or declining themes are considered marginal and have little impact on the final *corpus*, as they are marked by low centrality and density. It should be noted that, in this study, the themes were considered emerging, since most of the articles identified are recent, formed by the clusters breast *cancer*, childhood cancer, and central nervous nerve.

The basic themes have high centrality and low density, they are considered relevant for the development of a research theme, however, they are not sufficiently developed (MARTÍNEZ *et al.* 2015). In this quadrant, the environmental protection cluster stands out.

In niche themes, the DNA damage cluster appears, characterized by research that is developed, however, in an isolated way, given its low centrality and high density.

The clusters with high centrality and density form the motor themes, which are sufficiently developed and relevant to the theme studied. In the case of the *corpus* under analysis, the clusters of *health study*, *cancer risk* and *pesticide exposure* are the driving themes.

In view of this, we present some identified studies and a brief discussion, excluding quantitative information as much as possible, which can be accessed in the studies reported and referenced in this article. This choice is justified in order to construct an intelligible narrative centered on the importance of research associated with the basic, niche, emerging and motor themes identified, using 23 works, which corresponds to 50% of the final *corpus*.

3.3.1 Basic, niche and emerging themes

As **basic** themes, there are studies on the pesticides carbaryl, dichloropropene, dimethoate, mancozeb, metolachlor, pendimethalin, permethrin and trifluralin, used in large volumes in various sectors (agriculture, home and garden, industry, commercial and/or government) and classified with carcinogenic potential by the U.S. Environmental Protection Agency (USEPA). These substances were related to human cancer, based on a systematic literature review, in at least three primary peer-reviewed studies, concluding that the mapping of evidence carried out in the research can guide decision-making in order to update the cancer risk assessment (SCHWINGL *et al.*, 2021).

Organochlorines (OCP) are widely used in agriculture, industry and even in domestic use, but they are resistant to biodegradation. A recent primary study, conducted along the Okura River in the Eastern Senatorial District of Kogi State, Nigeria, concluded that there was no health risk when measuring the hazard quotient (HQ), average daily dose (ADD), and cancer risk (CR) based on the methods and limits set by the USEPA. However, the research identified that the concentrations of the OCPs were slightly above the maximum limit allowed by the USEPA (MUHAMMED *et al.*, 2023).

Another primary study identified, in the surface waters of the Buffalo River in the Eastern Cape, South Africa, that the concentrations of seventeen organochlorine types (OCP) were above the limits established by the USEPA and that the cancer risk assessment was below the permissible limit, despite

having found that the average daily dose over the lifetime was at a level higher than that established by that agency. suggesting that both regulation and the use and elimination of agrochemicals are necessary in the studied region and in other locations in South Africa, given that PCOs impact human health and biota if found in concentrations higher than permitted (YAHAYA *et al*., 2017).

In emerging themes, a study on the relationship between exposure to pesticides as an environmental risk factor and **breast cancer concluded that, when living in the vicinity of agricultural areas that use pesticides, women over 50 years of age who menstruated early had a higher risk of developing breast cancer compared to the control group (SILVA** *et al*., 2019). In the context of breast cancer, research has been carried out with pesticides that can affect humans and animals, used in agriculture and livestock, such as flumethrin, classified as a pyrethroid for insect control (KARA-ERTEKIN et al., *2021) and chlorpyrifos, one of the most used in extensive agriculture, that is, characterized by using rudimentary or traditional techniques in production (LASAGNA* et al., 2020).

Related to childhood cancer, in the **Cerrado biome, Brazil, a study on the advance of agribusiness and the use of pesticides highlights, in addition to the environmental impacts (reduction of native vegetation, migration of springs, among others.), that the region consumed 73.5% of the country's pesticides in 2018, resulting in higher rates of childhood cancer compared to the national average (EGGER** *et al*., 2021). A review of French scientific studies on the effects of pesticides on children's health indicates that there is an increased risk of otitis at 2 years of age, as well as an increased risk of developing several types of childhood cancer, although it did not identify other effects on the neurological development of 6-year-old children who were exposed to pesticides in the prenatal period (CHEVRIER; BÉRANGER, 2018).

The increased risk of **central nervous** system tumors in children under 6 years of age was inferred through research that focused on mothers living in rural areas during pregnancy, whose distance was 4,000 meters between homes and areas of application of certain pesticides (LOMBARDI *et al*., 2021). Studies on the occurrence of central nervous system tumors in people involved in agriculture indicate that there is an increased risk of development in relation to exposure to pesticides called carbamates, having reported a significant association for fungicides and herbicides, the latter at a lower level, and highlighted the need for further studies for confirmation (PIEL *et al*., 2019).

As a **niche** theme, we can highlight a community-based research carried out with ten Latino children of rural workers, in North Carolina, United States, in which silicone bracelets (samplers) were used, which allowed the identification of pesticides and other substances harmful to health, such as organophosphates, organochlorines and pyrethroids. The results of the research showed a significant association between the number of pesticide detections and **DNA damage to** hair follicles,

highlighting the high acceptability of the collection method among children, as it is non-invasive and the possibility of monitoring pesticides (VIDI *et al.*, 2017).

3.3.2 Driving themes

In **health studies**, it is noteworthy that agricultural health research in North Carolina, USA, indicates that a study on the use of Biomarkers of Exposure and Effect in Agriculture (BEEA) can provide *insights* into how exposure to pesticides influences disease risk through the investigation of molecules. The study is relevant because it collected samples of blood, urine and house dust from people who had been exposed to contact with pesticides in the last twelve months, especially because, of the 1,233 participants, 70% of farmers reported that they had been exposed to herbicides, such as glyphosate, and insecticides such as malathion, cyfluthrin and permethrin, which enables diagnosis and subsequent research (HOFMANN *et al.*, 2015).

A study in Iowa, USA, suggested the need to investigate specific exposures of women who lived in agricultural or rural areas, considering that a higher risk of developing acute myeloid leukemia (AML) was identified just by living in these areas. In addition, it was identified that living close (750 meters) to pastures or row crops possibly conferred an increased risk of chronic lymphocytic leukemia (CLL) and small lymphocytic lymphoma (SLL), regardless of whether the place of residence was in a rural area or not (JONES *et al.*, 2014).

The other health studies were closely related to pesticide exposure and cancer risk. In this context, the protection of children from **exposure to pesticides** requires improvement in health practices and policies, because it can occur during prenatal care and until childhood, with possible exposures in various scenarios, for example, domestic environments through insecticides, whose exploitative behavior of children increases this risk, in parks and gardens, contact with domestic animals treated with pesticides, as well as in rural environments, whether by the application of pesticides, contaminated equipment and work clothes of the parents, ingestion of contaminated fruits, water, milk, eggs, among others, and the dose, duration and life span of exposure to pesticides are considered determinant of the toxic effects, and may be associated, although at low levels, to cancer, among other diseases (PASCALE; LABORDE, 2020).

An ecological study in Brazil indicates that exposure to pesticides may be associated with colon cancer (CHD) by correlating data on deaths from the type of cancer mentioned, obtained from data from the Ministry of Health, with the use of pesticides extracted from the Brazilian Institute of the Environment and Renewable Natural Resources, emphasizing that, for another decade, mortality was concentrated in the South and Southeast regions of the country (MARTIN *et al.*, 2018).

On the other hand, the relationship between the colorectal cancer (CRC) mortality rate and pesticide exposure in rural areas did not obtain a conclusive result in a systematic literature review,

however, pesticides such as terbufos and dicamba were reported as a concern in the association studied, as well as aldicarb and dieldrin, which were banned in the USA, highlighting the relevance of this exposure and its permanence in the environment for long periods (MATICH *et al.*, 2021).

Lung diseases, such as asthma and chronic bronchitis, have been associated with work-related occupational exposure, although there have been inconclusive results for lung cancer, suggesting that the use of personal protective equipment and training on the proper use of PPE are measures that can control this type of exposure in agriculture. fisheries, forestry, and the food industry (YE *et al.*, 2013).

Respiratory problems, excessive sweating, headache, dizziness and visual impairment were categorized as possible consequences of agricultural exposure to pesticides based on a study conducted in Fez-Meknes, Morocco, which investigated attitudes, knowledge and practices about the use of pesticides in fifteen rural communities, in which most farmers reported not having received training on the use of pesticides. and almost half of them used glyphosate and malathion, classified as human carcinogens by the International Agency for Research on Cancer, highlighting the risk to the environment and human health (BEN KHADDA *et al.*, 2021).

The use of biomarkers is suggested to confirm the results of research that demonstrate that the intake of fruits and vegetables, although recommended to prevent coronary heart disease, if exposed to pesticides, can compromise the benefits of consuming these foods (CHIU *et al.*, 2019).

Regarding **cancer** risk, in Bizerte, Tunisia, a study reported that organochlorines and hydrocarbons in aerosols were in high concentrations in dry disposition, that is, in the air, being considered a carcinogenic risk in winter (BARHOUMI *et al.*, 2018).

In the province of Lecce, southern Italy, exposure to smoking, environmental conditions (use of pesticides in agriculture without PPE), occupational conditions and lifestyle itself need to be further explored as they contribute to the increased risk of cancer, especially due to the identification of a higher incidence of adenocarcinoma, considered a malignant tumor. in men and women from the studied region (MINICHILLI *et al.*, 2022).

The probability of exposure to cancer was not considered low in soils of Kapsabet, Voi and Nyeri, Kenya, proposing control measures based on a study that demonstrated the distribution, concentrations and threat that organochlorines (OCP) pose to human health and the environment, highlighting that OCP pollution was derived from the use of hexachlorocyclohexane (HCH) and dichlorodiphenyltrichloroethane (DDT), the first as a control of diseases transmitted by insects and the second, for its use in agriculture (MUNGAI; WANG, 2019).

A literature review indicates that molecular biology and genetics can contribute to studies related to bioremediation, i.e., the degradation of the insecticide called Dichlorvos (O,O-dimethyl O-(2,2-dichlorovinyl)phosphate, DDVP), considered a toxic product, to transform it into non-toxic products, considering that DDVP has been used for more than four decades, and it is still sought after

in developing countries, reporting that microbial degradation is more environmentally friendly compared to physicochemical methods (ZHANG *et al*., 2021).

4 FINAL CONSIDERATIONS

This article aimed to identify the central themes of the relationship between pesticides and cancer associated with rural areas, agriculture or agribusiness. The analysis of the indicators of scientific and temporal production showed that the theme can be considered recent, with a growing trend in the area of environmental sciences.

The investigation of the quality of the journals found that most of the articles in the sample came from journals classified in the first quartile (Q1) of the SCImago and the analysis of the authors' production over the years was dispersed, with low citation rates and little production over the period in relation to the theme studied.

In this sense, the analysis of bibliographic coupling was presented, which evidenced low sharing of theories and/or methodologies, based on the study of the quantity and intensity of the connections established between the works, which suggests a probable need to foster the intersection between the researches developed in the area of environmental sciences, considering that the *corpus* has shown a trend of growth of studies in recent years.

The central themes were obtained from the abstracts *of the final corpus*, through bibliometric calculations of centrality and density, from which emerged, basic, niche and motor themes, identified and contextualized, qualitatively, with the exclusion of quantitative data and research techniques used as a means to obtain research results.

Despite the attempt not to approach techniques as means to achieve results, the *corpus* presented the relevance of biomarker studies and evidence mapping in investigations on the subject in the area of environmental sciences, which was made possible by reducing the bias provided by the methodology adopted in this article.

In this sense, although this study achieved the objective of identifying central themes on the relationship between pesticides and cancer associated with rural areas, agriculture or agribusiness, it was verified that the *corpus* went beyond the adopted cut, to the extent that it reported the risk of exposure to pesticides associated with cancer in areas such as gardens, parks, urban areas near crops that use pesticides, domestic use, clothing or work tools taken home, contaminated food, lifestyle factors such as smoking, among others.

In addition, the risk of exposure to these substances beyond cancer was demonstrated, given that the results indicated risks of developing other diseases, such as pulmonary diseases (asthma and chronic bronchitis) in occupational exposure, coronary diseases in the ingestion of contaminated food, DNA damage and farmers' perception of respiratory problems, excessive sweating, headaches,

dizziness and visual impairment, proving that it is a public health problem that affects the environment through the contamination of soil, water, air, fauna and flora, reaching the contamination of people.

Strategies that aim to reduce these impacts can be inferred from the *corpus*, such as the use of personal protective equipment, the establishment of residence far from places that use pesticides, the control of children's behavior in relation to the risk of exposure, training of farmers on the use of pesticides, among others. However, these measures seem to be insufficient, since the widespread use of pesticides is widespread, even with the consent of the States, which regulate maximum limits for the presence of pesticides in water, soil, air and even in the human body, with mathematical or statistical calculations that allow, at least in theory, to infer the absence of cancer risk.

Despite the State's regulation, studies show that the allowed limits are exceeded in most cases, causing the problems and diseases reported. In this context in Brazil, in the field of environmental law, the precautionary principle is in force, that is, even if it is not scientifically proven, the risks inherent to exposure must be avoided, which is why there is a need for a social pact for health and the environment in the search for alternatives to the production model adopted in the world. Among the models with low environmental impact and high socioeconomic impact, the valorization of agroecology and organic food production and the need for public policies that foster this transition process with the public of family farming, traditional peoples and communities, as well as incentives for urban and peri-urban agriculture, along these lines, stand out. In addition to these, the development of bioremediation techniques for already contaminated areas, such as the microbial degradation of insecticides demonstrated by the *corpus* in studies related to cell biology and genetics, in attention to the principle of prevention.

The limitations of this study include the in-depth analysis of quantitative data, description of laboratory techniques, formulations of these substances and the chemical and biological interactions inherent to several areas of knowledge, which is why it is suggested that, in future research, the multidisciplinary nature of the studied theme should be considered, with an expansion of the *corpus* without being limited to rural areas, agriculture or agribusiness, such as meta-analysis, which allows the mapping of scientific evidence through statistical methods, in addition to the development of studies that associate these analyses with qualitative perspectives, such as the perception of the actors involved and intervention through action research.

REFERENCES

ABUGU, H.O., ALUM, O.L., UCHEANA, I.A. et al. Screening, Spatial Distribution and Human Health Risk Assessment of Pesticide Residues in Freshly Harvested Vigna unguiculata. Int J Environ Res 17, 50 (2023). https://doi-org.ez9.periodicos.capes.gov.br/10.1007/s41742-023-00537-7

AGUIAR, J. C. B.; SILVA, B. L.; PEREIRA, L. de A.; SILVA, L. S. C. V. da; SILVA, W. V. da. Tipologia e Tendências da Relação entre Gerenciamento de Resíduos Sólidos e Políticas Públicas: Uma Revisão Sistemática de Literatura. Scientific Journal ANAP, [S. l.], v. 1, n. 7, 2023. Disponível em: https://publicacoes.amigosdanatureza.org.br/index.php/anap/article/view/4352. Acesso em: 21 nov. 2023.

ARIA, M. & CUCCURULLO, C. (2017) Bibliometrix: uma ferramenta R para análise abrangente de mapeamento científico, Journal of Informetrics, 11(4), pp 959-975, Elsevier.

BARHOUMI B.; CASTRO-JIMÉNEZ J.; GUIGUE C.; GOUTX M.; SEMPÉRÉ R.; DEROUICHE A.; ACHOUR A.; TOUIL S.; DRISS M.R.; TEDETTI M. Levels and risk assessment of hydrocarbons and organochlorines in aerosols from a North African coastal city (Bizerte, Tunisia). Environmental Pollution, Volume 240, September 2018, Pages 422-431. https://doi.org/10.1016/j.envpol.2018.04.109

BEN KHADDA, Z.; FAGROUD, M.; EL KARMOUDI, Y.; EZRARI, S.; BERNI, I.; DE BROE, M.; BEHL, T.; BUNGAU, S.G.; SQALLI HOUSSAINI, T. Farmers' Knowledge, Attitudes, and Perceptions Regarding Carcinogenic Pesticides in Fez Meknes Region (Morocco). Int. J. Environ. Res. Public Health 2021, 18, 10879. https://doi.org/10.3390/ijerph182010879

BRASIL. Lei nº 7.802, de 11 de julho de 1989. Dispõe sobre a pesquisa, a experimentação, a produção, a embalagem e rotulagem, o transporte, o armazenamento, a comercialização, a propaganda comercial, a utilização, a importação, a exportação, o destino final dos resíduos e embalagens, o registro, a classificação, o controle, a inspeção e a fiscalização de agrotóxicos, seus componentes e afins, e dá outras providências. Disponível em: < https://www.planalto.gov.br/ccivil_03/leis/l7802.htm >. Acesso em 7 de set. 2023.

CHEVRIER, C., BÉRANGER, R. Pesticides and Child's Health in France. Curr Envir Health Rpt 5, 522–530 (2018). https://doi.org/10.1007/s40572-018-0216-x

CHIU Y.-H.; SANDOVAL-INSAUSTI H.; LEY S.H.; BHUPATHIRAJU S.N.; HAUSER R.; RIMM E.B.; MANSON J.E.; SUN Q.; CHAVARRO J.E. Association between intake of fruits and vegetables by pesticide residue status and coronary heart disease risk. Environment International, Volume 132, November 2019, 105113. https://doi.org/10.1016/j.envint.2019.105113

EGGER D.D.S.; RIGOTTO R.M.; LIMA F.A.N.D.S.E.; COSTA A.M.; AGUIAR A.C.P. Ecocídio nos Cerrados: agronegócio, espoliação das águas e contaminação por agrotóxicos. Desenvolvimento e Meio Ambiente. ISSN: 1518-952X, eISSN: 2176-9109. http://dx.doi.org/10.5380/dma.v57i0.76212

EGGHE, L.; ROUSSEAU, R. (2002). Co-citation, bibliographic coupling and a characterization of lattice citation networks. Scientometrics, 55(3), 349–361.

ELSEVIER (2023). Scopus content. Disponível em < https://www-elsevier-com.ez9.periodicos.capes.gov.br/solutions/scopus/how-scopus-works/content >. Acesso em 14 abr. 2023.

ELSEVIER (2023). Scopus Source List. Disponível em < https://www-scopus.ez9.periodicos.capes.gov.br/sources?zone=TopNavBar&origin=NO%20ORIGIN%20DEFIN ED >. Acesso em 14 abr. 2023.

HOFMANN J.N.; BEANE FREEMAN L.E.; LYNCH C.F.; ANDREOTTI G.; THOMAS K.W.; SANDLER D.P.; SAVAGE S.A.; ALAVANJA M.C. The Biomarkers of Exposure and Effect in Agriculture (BEEA) Study: Rationale, Design, Methods, and Participant Characteristics. Journal of Toxicology and Environmental Health, Part A, Current Issues, Volume 78, 2015 - Issue 21-22. https://doi.org/10.1080/15287394.2015.1091414

IBAMA. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. Relatórios de Comercialização de Agrotóxicos. Boletim, 2021. Página atualiz. em 27 jun. 2023. Disponível em: < https://www.gov.br/ibama/pt-br/assuntos/quimicos-e-biologicos/agrotoxicos/relatorios-de-comercializacao-de-agrotoxicos/relatorios-de-comercializacao-de-agrotoxicos >. Acesso em 7 de out. 2023.

INCA. Instituto Nacional de Câncer. Agrotóxico. Disponível em: < https://www.gov.br/inca/pt-br/assuntos/causas-e-prevencao-do-cancer/exposicao-no-trabalho-e-no-ambiente/agrotoxico >. Publicado em 20 de mai. 2022, Atualiz. 17 mai. 2023. Acesso em 7 de out. 2023.

JONES R.R.; YU C.-L.; NUCKOLS J.R.; CERHAN J.R.; AIROLA M.; ROSS J.A.; ROBIEN K.; WARD M.H. Farm residence and lymphohematopoietic cancers in the Iowa Women′s Health Study. Environmental Research, Volume 133, August 2014, Pages 353-361. https://doi.org/10.1016/j.envres.2014.05.028

KARA-ERTEKIN S, YAZAR S, ERKAN M. In vitro toxicological assessment of flumethrin's effects on MCF-7 breast cancer cells. Human & Experimental Toxicology. 2021;40(12):2165-2177. doi:10.1177/09603271211022789

KESSLER, M. M. Bibliographic coupling between scientific papers. American Documentation, Leesburg, v. 14, n. 1, p. 10-25, 1963. Disponível em: https://doi.org/10.1002/asi.5090140103. Acesso em: 20 out. 2023.

LASAGNA M.; HIELPOS M.S.; VENTURA C.; MARDIROSIAN M.N.; MARTÍN G.; MIRET N.; RANDI A.; NÚÑEZ M.; COCCA C. Chlorpyrifos subthreshold exposure induces epithelial-mesenchymal transition in breast cancer cells. Ecotoxicology and Environmental Safety, Volume 205, 1 December 2020, 111312. https://doi.org/10.1016/j.ecoenv.2020.111312

LOMBARDI C.; THOMPSON S.; RITZ B.; COCKBURN M.; HECK J.E. Residential proximity to pesticide application as a risk factor for childhood central nervous system tumors. Environmental Research, Volume 197, June 2021, 111078. https://doi.org/10.1016/j.envres.2021.111078

MATTHEWS, Jessica. 2016. "Searching the SCImago Journal Ranking Database". Youtube, 4:20. https://youtu.be/JeC6qMhLaRs.

MATICH E.K.; LARYEA J.A.; SEELY K.A.; STAHR S.; SU L.J.; HSU P.-C. Association between pesticide exposure and colorectal cancer risk and incidence: A systematic review. Ecotoxicology and Environmental Safety, Volume 219, August 2021, 112327. https://doi.org/10.1016/j.ecoenv.2021.112327

MARTIN F.L.; MARTINEZ E.Z.; STOPPER H.; GARCIA S.B.; UYEMURA S.A.; KANNEN V. Increased exposure to pesticides and colon cancer: Early evidence in Brazil. Chemosphere, Volume 209, October 2018, Pages 623-631. https://doi.org/10.1016/j.chemosphere.2018.06.118

MARTÍNEZ, M. A., COBO, M. J., HERRERA, M., & HERRERA-VIEDMA, E. (2015). Analyzing the Scientific Evolution of Social Work Using Science Mapping. Research on Social Work Practice, 25(2), 257-277. https://doi.org/10.1177/1049731514522101.

MINICHILLI, F.; GORINI, F.; DE FILIPPIS, G.; BUSTAFFA, E.; RAHO, A.M.; MELCARNE, A.; QUARTA, F.; MAGGIORE, G.; IDOLO, A.; SERIO, F.; et al. Risk Factors for Lung Cancer in the Province of Lecce: Results from the PROTOS Case–Control Study in Salento (Southern Italy). Int. J. Environ. Res. Public Health 2022, 19, 8775. https://doi.org/10.3390/ijerph19148775

MUHAMMED H.A.; YAHAYA A.; ABDULLAHI S.S.; JAGABA A.H.; BIRNIWA A.H. Mitigating water contamination by controlling anthropogenic activities of organochlorine pesticides (OCPs) for surface water quality assurance. Case Studies in Chemical and Environmental Engineering, Volume 8, December 2023, 100474. https://doi.org/10.1016/j.cscee.2023.100474

MUNGAI, T.M.; WANG, J. Occurrence and Toxicological Risk Evaluation of Organochlorine Pesticides from Suburban Soils of Kenya. Int. J. Environ. Res. Public Health 2019, 16, 2937. https://doi.org/10.3390/ijerph16162937

PARVEEN, A., ANJUM, M., MAHMOOD, S. et al. Environmental implication and cancer risk assessment of residual pollutants in cotton crop: a case study of Multan District, Pakistan. Environ Monit Assess 195, 1100 (2023). https://doi-org.ez9.periodicos.capes.gov.br/10.1007/s10661-023-11710-y

PASCALE, A. & LABORDE, A. (2020). Impact of pesticide exposure in childhood. Reviews on Environmental Health, 35(3), 221-227. https://doi.org/10.1515/reveh-2020-0011

PIEL C.; POUCHIEU C.; CARLES C.; BÉZIAT B.; BOULANGER M.; BUREAU M.; BUSSON A.; GRÜBER A.; LECLUSE Y.; MIGAULT L.; RENIER M.; RONDEAU V.; SCHWALL X.; TUAL S.; ARVEUX P.; BARA S.; BOUVIER A.M.; BUSQUET T.; COLONNA M.; COUREAU G.; DELANOÉ M.; GROSCLAUDE P.; GUIZARD A.V.; HERBRECHT P.; LAPLANTE J.J.; LAPOTRE-LEDOUX B.; LAUNOY G.; LENOIR D.; MARRER E.; MARCOTULLIO E.; MAYNADIÉ M.; MOLINIÉ F.; MONNEREAU A.; PAUMIER A.; POUZET P.; THIBAUDIER J.M.; TROUSSARD X.; VELTEN M.; WAVELET E.; WORONOFF A.S.; PIERRE L.; BALDI I. Agricultural exposures to carbamate herbicides and fungicides and central nervous system tumour incidence in the cohort AGRICAN. Environment International, Volume 130, September 2019, 104876. https://doi.org/10.1016/j.envint.2019.05.070

SCHWINGL, P.J., LUNN, R.M. & MEHTA, S.S. A tiered approach to prioritizing registered pesticides for potential cancer hazard evaluations: implications for decision making. Environ Health 20, 13 (2021). https://doi.org/10.1186/s12940-021-00696-0

SCImago, (n.d.). SJR — SCImago Journal & Country Rank [Portal]. Retrieved Date you Retrieve, from http://www.scimagojr.com. Acesso em 23 nov. 2023.

SILVA, A.M.C.; CAMPOS, P.H.N.; MATTOS, I.E.; HAJAT, S.; LACERDA, E.M.; FERREIRA, M.J.M. Environmental Exposure to Pesticides and Breast Cancer in a Region of Intensive Agribusiness Activity in Brazil: A Case-Control Study. Int. J. Environ. Res. Public Health 2019, 16, 3951. https://doi.org/10.3390/ijerph16203951

SPADOTTO, C. A.; GOMES, M. A. F (2021). Agrotóxicos no Brasil. Empresa Brasileira de Pesquisa Agropecuária, conteúdo migrado em 21 dez. 2021. Disponível em: < https://www.embrapa.br/agencia-de-informacao-tecnologica/tematicas/agricultura-e-meio-ambiente/qualidade/dinamica/agrotoxicos-

no-brasil#:~:text=Anualmente%20s%C3%A3o%20usados%20no%20mundo,mil%20toneladas%20de%20produtos%20comerciais.>. Acesso em 7 out. 2023.

TRANDIELD, D.; DENYER, D.; SMART, P. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, v. 14, p. 207–222, 2003.

VAN ECK, N.J.; WALTMAN, L. VOSviewer Manual. *Leiden: Universiteit Leiden*; 2020.

VIKRAM VASAN, MATHILDA ALSEN, DRAGAN VUJOVIC, ERIC GENDEN, CATHERINE SINCLAIR & MAAIKE VAN GERWEN (2023) Endosulfan use and the risk of thyroid cancer: an ecological study, Journal of Environmental Science and Health, Part B, 58:1, 51-57, DOI: 10.1080/03601234.2023.2169099

VIDI P.-A.; ANDERSON K.A.; CHEN H.; ANDERSON R.; SALVADOR-MORENO N.; MORA D.C.; POUTASSE C.; LAURIENTI P.J.; DANIEL S.S.; ARCURY T.A. Personal samplers of bioavailable pesticides integrated with a hair follicle assay of DNA damage to assess environmental exposures and their associated risks in children. Mutation Research/Genetic Toxicology and Environmental Mutagenesis, Volume 822, October 2017, Pages 27-33. https://doi.org/10.1016/j.mrgentox.2017.07.003

YAHAYA, A.; OKOH, O.O.; OKOH, A.I.; ADENIJI, A.O. Occurrences of Organochlorine Pesticides along the Course of the Buffalo River in the Eastern Cape of South Africa and Its Health Implications. Int. J. Environ. Res. Public Health 2017, 14, 1372. https://doi.org/10.3390/ijerph14111372

YE, M.; BEACH, J.; MARTIN, J.W.; SENTHILSELVAN, A. Occupational Pesticide Exposures and Respiratory Health. Int. J. Environ. Res. Public Health 2013, 10, 6442-6471. https://doi.org/10.3390/ijerph10126442

YIIN, J.H., RUDER, A.M., STEWART, P.A. et al. The upper midwest health study: a case–control study of pesticide applicators and risk of glioma. Environ Health 11, 39 (2012). https://doi.org/10.1186/1476-069X-11-39

YOU, H., ZHANG, J., XIA, S. et al. Farmland transfer and esophageal cancer incidence rate: mediation of pollution-related agricultural input intensity. Environ Sci Pollut Res 29, 43826–43844 (2022). https://doi-org.ez9.periodicos.capes.gov.br/10.1007/s11356-022-18921-9

ZHAO, D.; STROTMANN, A. (2008). Evolution of research activities and intellectual influences in information science 1996-2005: Introducing author bibliographic-coupling analysis. Journal of the American Society for Information Science and Technology, 59(13), 2070–2086. https://doi.org/10.1002/asi.20910.

ZHANG, Y.; ZHANG, W.; LI, J.; PANG, S.; MISHRA, S.; BHATT, P.; ZENG, D.; CHEN, S. Emerging Technologies for Degradation of Dichlorvos: A Review. Int. J. Environ. Res. Public Health 2021, 18, 5789. https://doi.org/10.3390/ijerph18115789