

## Pesticides: A Perspective of Scientific Production in West of Bahia

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**Abstract:** The use of pesticides has intensified with agricultural modernization process, triggered by the Green Revolution, which brought about changes in the production system, resulting in high social costs, environmental and public health. Brazil is the world's largest consumer of pesticides and assesses that this market will grow even more in the near future. Given the risk that pesticides pose, it was found that there is an urgent need to intensify the studies, as are scarce research in the Northeast and especially in western Bahia. This research aimed to evaluate the scientific literature on pesticides in West of Bahia. Therefore, publications consultation was made in the database Portal.periodicos.Capes with the keywords "West of Bahia" and "Pesticides". The results show that the number of worldwide publications has been growing over the years, representing 98% of the total, while Brazil has only 2% in West of Bahia was not found publication. There are many challenges in front of the dimension that the theme "pesticide" offers. Thus, priorities and strategies for research should be defined, seeking to boost scientific productivity in an attempt to make changes to help chart a way to sustainable development.

**Keywords:** pesticides; publications; scientific research; west of Bahia

### 1. INTRODUCTION

The rapid population growth in the last 50 years has increasingly required in food production processes. Therefore, it was necessary the use of fertilizers and pest control agents with emphasis on chemical pesticides. Currently, they used different pesticide classes such as organophosphates, pyrethroids, carbamates, triazines, neonicotinoids and others [1]. The production process is increasingly efficient and thus more dependent on these chemical species [2]. However, they do not contribute directly to better crop yields, but help control potential losses caused by biological organisms (insects, mites, nematodes, rodents, weeds, fungus, bacteria and viruses) [3].

According to the International Union of Pure and Applied Chemistry, IUPAC [4], pesticides are chemical species deliberately exposed to the environment, able to prevent, destroy or combat the proliferation of pests that may interfere with the production, processing, storage, transport and storage of food, agricultural products, wood and wood

products. They are a group of natural contaminants emerging due to their environmental persistence, lipofilicidade and acute toxicity [5].

Pesticides gained more attention from the 60s, a period when there was an exponential increase in the consumption of chemical inputs to control pests and diseases in crops [6]. Thus, modern agriculture has significantly stepped up its use for increased productivity, but also brought consequences of social, environmental and public health [7].

Agrochemical consumption in Brazil was boosted due to the implemented public policies, which provided subsidies to large landowners, fulfilling the role of forcing the implementation of the "Green Revolution" [8].

In 2008, Brazil became the world's largest consumer of pesticides, when they were used about 986,500 tons of active ingredients, which generated revenues of more than 7 billion and in 2009 were consumed 1 million tonnes [9]. In the last decade the consumption of chemical inputs increased 190% and

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93% above the world average [10] and assesses that this market will grow even more in the near future. According to Xu et al. [11], increased consumption of these compounds may be explained by a political structure that promotes consumption of pesticides, reduction of natural predators, the development of resistance of these organisms and appear to be the simplest way for better crop yields.

The intensive use of pesticides, also due to the growth of large agricultural areas in various regions of the country, placing it as the Organisation for Economic Co-Operation and Development and Food and Agriculture Organization-OECD/FAO [12] as the second largest producer of agricultural commodities. According to the Confederation of Agriculture and Livestock in Brazil CNA [13], the agricultural sector has gained share in the economy, with 23% of Gross Domestic Product-GDP in 2015, demonstrating its importance in national economic scenario. In west of Bahia, agriculture generates more than 6 billion reais, reaffirming its production potential [14].

In Brazil, about 512 active ingredients have use authorization [15]. According to the Brazilian Institute of Environment and Renewable Natural Resources IBAMA [16] responsible for preparing the Annual Bulletin Production, Import, Export and Pesticide Sales in Brazil, Mato Grosso is the largest consumer of pesticides, representing 19,08 %, followed by São Paulo (15.58%), Rio Grande do Sul (12.67%), Paraná (12.35%), Goiás (9.69%), Minas Gerais (7.13%), Mato Grosso do Sul (6.37%), Bahia with 5.32%, is eighth in the consumer ranking and the other states together consumed 11.81% of Brazil's total.

Over time, agriculture was seen as the fundamental basis of identity and economy of Brazil. Thus, it is observed that the significant increase in pesticide consumption is strongly related to land use, which is leading to a variety of effects, including environmental degradation and damage to human health.

The hypothesis of Environmental Kuznets Curves proposes that environmental degradation follows a path in the form of inverted "U", in other words, environmental degradation increases in the early stages of economic growth, however, decrease when the level of income increases [17]. Using this tool, Managi [18] states that countries with greater economic development, tend to reduce the use of pesticides, it is suggested therefore that lower pollution levels are associated with high economic levels.

In a survey conducted by Lebeuf et al [19] in Canada and Nostbakken et al [20] in Norway, with biomonitoring data, decreasing time trends were observed in the persistent organic pesticide concentrations. Shunthirasingham et al. [21] and Choi et al. [22], show a decline in the concentration of volatile organic pollutants in Canada and in coastal areas of Korea respectively, reflecting the regulatory effects on the use of these contaminants. Ecobichon [23] states that "pesticides are more valued in lower middle income countries, especially in tropical regions, which are seeking to enter into the global economy." upper middleincome countries are giving priority to environmental safety and human health, while emerging countries such as Brazil, are stepping up the use of pesticides, regardless of their risk [24, 25].

Agrochemicals are ubiquitous compounds and their intensive use cause impacts to the ecosystem as a result of spray drift (different dispersion processes and transport of pesticides to the atmosphere) [26, 27]. During the spraying process, the exposure of nontarget areas may vary from 30-50% of the total dose applied and another fraction can be lost to atmosphere [28]. The volatilization of soil and plants as well as wind erosion represents an additional contribution to reissue pesticide into the atmosphere [27]. Once in the atmosphere, they can contaminate all environmental compartments (air, soil, surface and ground water) out of the target areas [29].

Pesticides can be present in the gaseous or particulate phase, and its distribution depends on the physicochemical properties (vapor pressure, constant Henry's Law and water solubility) and environmental conditions (temperature, humidity, rainfall and nature and concentration of particulate matter) [30, 31]. The atmospheric transport capacity of pesticides for short or long distances depends on the stage you are in (gaseous or particulate). Its partition can also influence the removal of these compounds, either by dry or wet deposition as well as by the photochemical degradation [32].

Several studies have found pesticide concentrations in urban, rural and remote areas of different countries furthermore indicated that the concentration of pesticide in the atmosphere ranging from a few  $\text{pg m}^{-3}$  to a few  $\text{ng m}^{-3}$  [33, 34, 35, 36, 37, 38].

The pesticide present in the gaseous and particulate phases are associated to adverse effects on the environment and human health. Human exposure to atmospheric pesticides occurs by dermal absorption,

inhalation and ingestion [39]. Several studies show evidence of acute injury (weakness, headache, nausea, vomiting, tremors, salivation, abdominal cramps, confusion and convulsions) and chronic, such as skin diseases, endocrine disruption, effects on reproduction and the immune system, teratogenesis, carcinogenesis and neurotoxicity caused by the action of pesticides [40, 41, 42, 43, 44, 45, 46, 47].

The impacts generated by the use of pesticides has caused adverse changes in the environment, causing contamination and bioaccumulation of biotic and abiotic segments of ecosystems (animals, plants, air, soil, surface and groundwater), as well as having high toxicological risk species that do not interfere in the agricultural process (nontarget species)[48, 82]. Bossi, Vorkamp and Skov [49] claim that atmospheric average concentrations of pesticides remained stable in northern Greenland, between the years 2008 to 2010, indicating that the transport long distances from point sources and / or reissuing contaminated surfaces (ground, sea and sea ice) play a significant role in the concentration of these compounds in the atmosphere. Vryzas et al. [50] found concentrations above 100  $\mu\text{g L}^{-1}$  atrazine, s-metolachlor, alachlor, molinate and prometryne in surface waters in northwestern Greece, highlighting the ecological risk potential.

Another study investigated the presence of pesticides in the air and water of mountainous regions in two national parks located in the southeastern and southern Brazil. The results show concentrations of HCB/ hexachlorobenzene (4.0-29  $\text{pg.m}^{-3}$ ),  $\alpha$ -endosulfan (1.8-20  $\text{pg.m}^{-3}$ ),  $\beta$ -endosulfan (0.5-2,5  $\text{pg.m}^{-3}$ ),  $\alpha$ -HCH/ hexachlorocyclohexane (<LD a 3.2  $\text{pg.m}^{-3}$ ), endosulfan sulfate (0.5-2.5  $\text{pg.m}^{-3}$ ), endrin (<LD a 1.9  $\text{pg.m}^{-3}$ ) e p,p'-DDT/dichloro-diphenyl-trichloroethane (<LD a 0.06  $\text{pg.m}^{-3}$ ) emitted by point sources of long distances in both environmental matrices [36].

## 2. MATERIAL AND METHODS

The research is characterized as descriptive analysis, source document data. In search of a comprehensive data collection, it was decided to search for information, primarily, the database Portal Periodicos Capes through the site [www.capes.gov.br](http://www.capes.gov.br), which concentrates vast scientific production and also database of dissertations and theses. Data collection took place during the months of January and February 2016, using as keywords: "Pesticidas", "Pesticides", "Pesticidas e alimentos", "Pesticides and food",

"Pesticidas e água " "Pesticides and water", "Pesticidas e atmosfera", "Pesticide and atmosphere", "Pesticidas e solo" "Pesticides and soil", "Pesticidas e sedimentos", "Pesticides and sediment", "Pesticidas no Brasil", "Pesticides in Brazil", "Pesticidas e Bahia Brasil", "Pesticides and Bahia Brazil", "Pesticidas e região sudeste do Brasil "" Pesticides and southeast Brazil ", "Pesticidas e sul do Brasil ", " Pesticides and South Brazil ", " Pesticidas e nordeste do Brasil", "Pesticides and northeast Brazil ", " Pesticidas e centroeste do Brasil" "Pesticides and midwest Brazil", "Pesticidas e norte do Brasil", "Pesticides and north Brazil", "Pesticidas e Oeste da Bahia Brasil" and "Pesticides and West of Bahia Brazil". As for the period covered, the survey considered the publications the period 1928 to 2016. The choice of this period had the sensed show the evolution of the subject pesticides publications over the years. This research originated tables that allowed to make an analysis and discussion with the relevant literature.

## 3. RESULTS AND DISCUSSION

According to a survey conducted in Capes Journal Portal were found 123,631 published studies using the terms in English: Pesticides, pesticides and food, pesticides and water, pesticide and atmosphere, pesticides and soil, pesticides and sediment; 2,310 only in Portuguese: pesticides, pesticides, food, pesticides and water, pesticides and atmosphere, pesticides, soil, sediment and pesticides, pesticides and food (Figure 1).

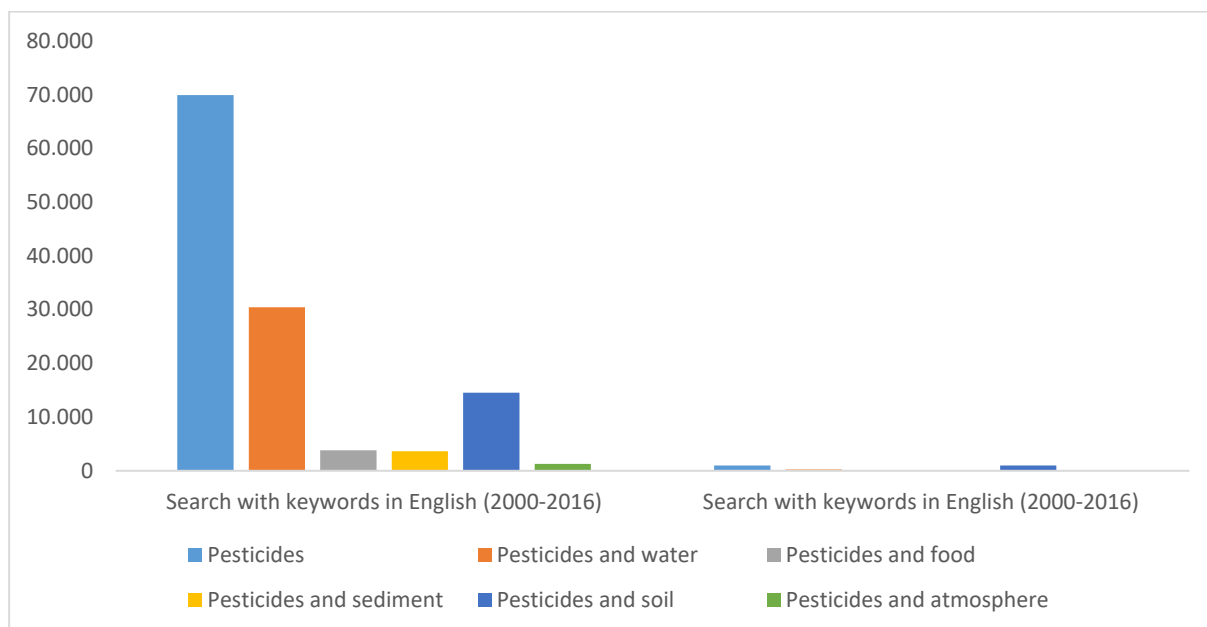
According to the results, it was observed that in the period 2000 to 2016 there was a greater number of publications using keywords in English than using keywords in Portuguese. This is because English is considered the official language of science, and consequently there is a larger number of international works written in that language rather than in relation to other [51].

In a study by Kopp et al. [52] with respect to publications related to the effects of pesticides on amphibians, in the period from 1980 to 2007, jobs were found written in the English language published by authors from 27 countries, the majority (54 %) were developed by authors working in the United States (USA), followed by authors working in Canada (7%). In this case, the US leadership could be related to the fact that most of the journals indexed in the database used to belong to this country.

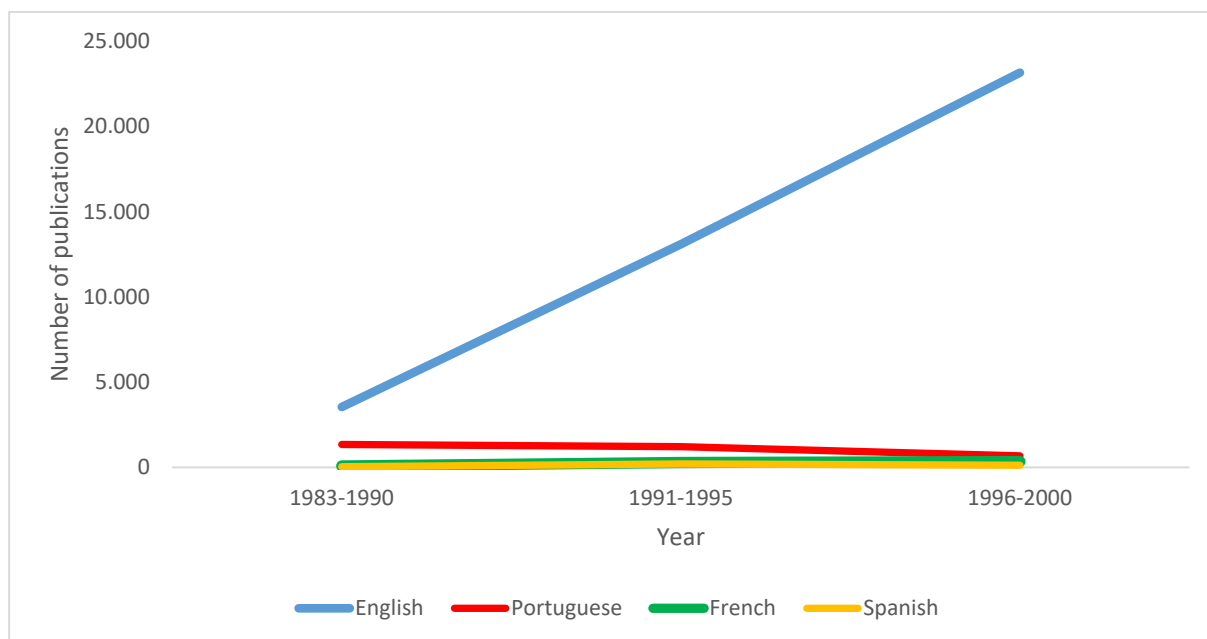
Mugnaini, Jannuzzi and Quoniam [53] analyzing the Brazilian scientific production from

international Pascal database, specifically the distribution of works of authors and coauthors of Brazilian institutions according to publication language was also observed absolute predominance of jobs in English between the years 1983-2000. Among the Works published between 1996-2000, most were written in English (95%). But the number of jobs

registered in Portuguese was lower, with a sharp drop, after a little more than 1,300 in the 1980s to just under 700 in the second half of the 90s (Figure 2). Thus, the use of English makes it may become increasingly widespread in the scientific, no longer something imposed from outside, and establishing itself as a natural language to the globalization context [51].



**Figure 1.** Number of publications with keywords in Portuguese and English.

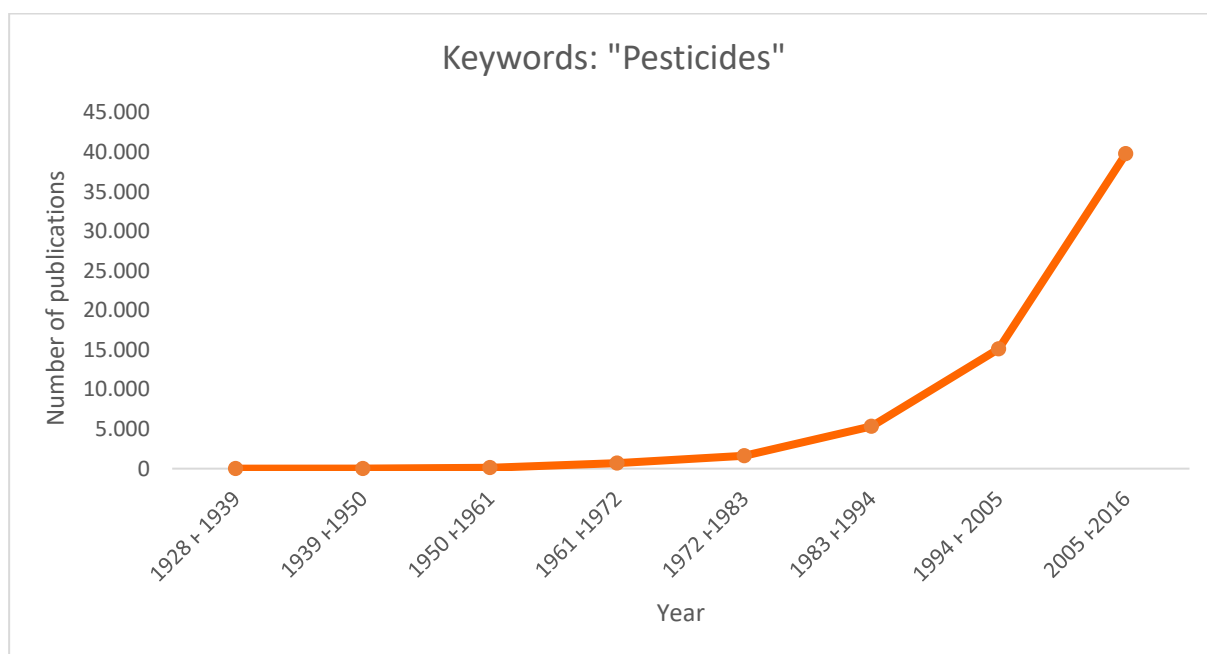


**Figure 2.** Number of work with the participation of Brazil in international Pascal database, second language and publication period. Source: Mugnaini, Jannuzzi and Quoniam, 2004.

Through the survey taking as reference search the keyword "Pesticides", notes that the number of publications in the electronic database of the Portal Periodicos Capes in the 1928 period by 2016 presents a sharp exponential growth in a time interval constant. As seen in Figure 3, it is seen that in the years 1928-1939 was published only one article related to the theme. Between 1928-1950 the number of publications has remained very low, around 1 to 6. Between 1950-1961 has been a small increase, around 119 publications. Until 1972 the numbers increased to 688. But the 1972 to 1983 growth begins to accentuate

reaching more than 1,600 publications from that period, it has maintained a gradual increase trend until 2016, and identified almost 40,000 published articles.

Using the keyword "Pesticides", the works are related to studies on pesticides made around the world, showing an overview of the evolution of scientific literature on this subject over the years. The data show a significant increase in the publication of studies on pesticides, mainly from the 1990s, it was evident how relevant is this topic in scientific production.



**Figure 3.** Number of publications with the keyword "Pesticides" between the year 1928-2016.

According to the World Health Organization-WHO [54], poisonings by exposure to pesticides are the annual 3 million order (estimate 1990), but there are uncertainties in this estimate, because the annual poisoning incidence rates can be much higher. Caldas [55] states that every year is more than 12,000 cases of pesticide poisoning in Brazil, a number that can be highly underestimated because of underreporting or irregular notification. Also according to the WHO for each case of poisoning by pesticides that are notified, 50 are not registered (1:50) [54].

According to the National System data Poison Information SINITOX [56], were recorded in the period 2005-2009, 5,527 cases of poisoning for veterinary use pesticides 15,789 per household, 19,063 by use of rodenticides and 28,393 for pesticide agricultural use, the first group with the largest case of

poisoning, representing 41.29% of cases.

In a survey conducted by Teixeira et al. [57], in order to investigate cases of poisoning by pesticide use in agriculture in the Brazilian northeast states, from 1999 to 2009, noted that the state of Pernambuco led the ranking of cases of poisoning by pesticide use in agriculture, with a total of 3,822 (39.5%) occurrences. Second was the state of Ceará, with 2,173 (22.5%) incidents, and third to Bahia, with 1,648 (17.0%) cases.

Thus, it is observed that the International Code of Conduct violations on the Distribution and Organization Pesticide Use the United Nations Food and Agriculture, have been going on without having effective oversight mechanisms to publicize such violations [58, 59, 60, 61, 62, 63, 64].

Actions and efforts are being taken to reduce

toxic effects of pesticides on the environment and humans. However, despite these efforts, deaths continue to occur and the problem is worsening increasingly due to the increasing use of these agricultural inputs [59, 65, 66, 67, 68, 69].

Some cases have occurred exemplify this situation: the increasing number of deaths between the years 2001 and 2011, organophosphate insecticides, 2,2-dichlorovinyl dimethyl phosphate and endosulfan, reported in an autopsy study in Ankara and nearby cities Turkey; the increased incidence of intentional and accidental poisoning by organophosphates, organochlorines, pyrethroids, carbamates, and others, either the agricultural or household in New Delhi, India, from 1999 to 2012; cases of neurobehavioral reduction and increased psychiatric morbidity between 2009 to 2011 due to occupational poisoning by insecticides, herbicides and fungicides of rural workers in three areas of Jiangsu province, China; and the increase in suicide rates over a period of 15 years (1996-2010) by exposure to pesticides in 558 Brazilian geographic microregions [70, 71, 72, 73].

Thus, the use of pesticides and indiscriminately

consequent problems of human poisoning may have led to a significant increase in pesticides on Publication Number especially from the 1990's.

Based on the conducted survey, with the home search the keyword "Pesticides in Brazil" (Figure 4), considering the years of publication between 1968 to 2016, we note that there was an increase in the number of publications in this period, however these publications occurred belatedly, compared with the number of publications in the world. In the early years of publication for this study from 1968 to 1976 there was only one publication related theme pesticides in Brazil. Since then the number of publications has grown very little until 1992, not exceeding 16 posts (1.06%). However, between 2000 and 2008 there was a growth of 25%, and since then has gradually increased until 2016, corresponding to more than ten thousand publications held (68.79%).

Kopp et al. [52] assume that the increase in cultivable areas, as well as the increased use of chemical pesticides, caused scientists to worry more and more to check the effect of these chemical species mainly on wildlife.



**Figure 4.** Number of publications with the keyword "Pesticides in Brazil" between the year 1968-2016.

In recent decades Brazil recorded significant jumps in agriculture. The planted area has increased considerably second National Agricultural Policy Secretariat SNPA and the National Supply Company CONAB [74]. According to Brazilian Institute of

Geography and Statistics, IBGE [75], in Brazil there are about 136 million hectares of planted area and is considered the country with the greatest potential of arable land.

One consequence of this agricultural expansion is the sharp growth in the use of chemicals, which when released in large quantities in the environment can cause severe impacts, as these chemical species are potentially harmful to all exposed living organisms [16].

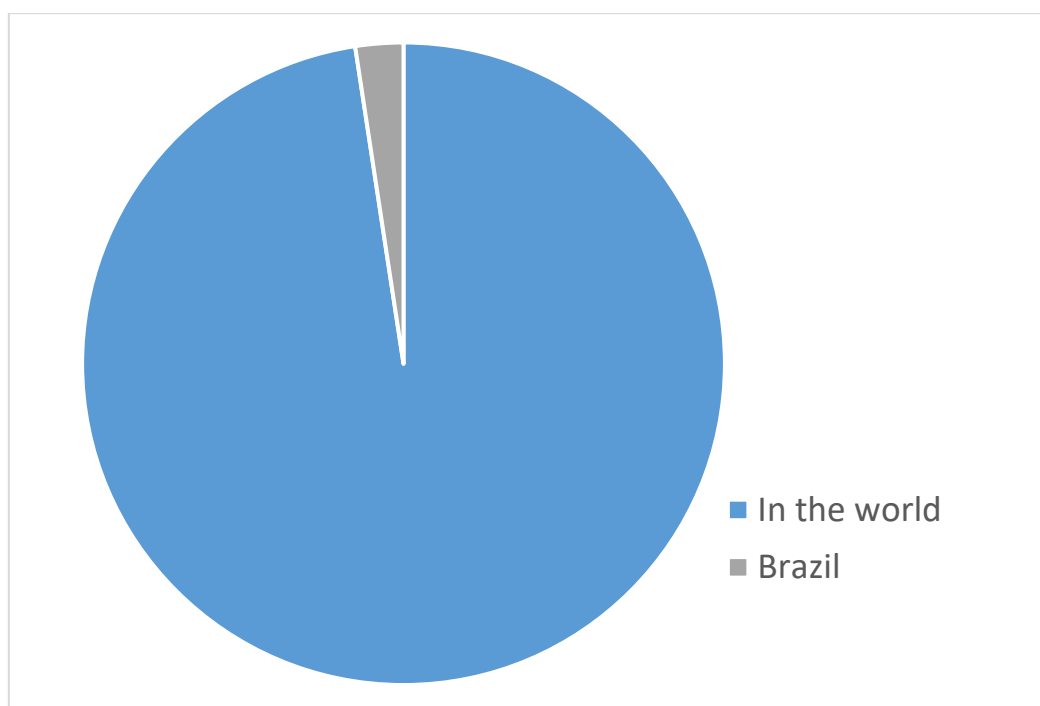
The potential of pesticides in causing damage to ecosystems is variable and is directly related to the properties of the active ingredients that make up the chemical, but its effects acute (immediate), subchronic (medium term) and chronic (long term) may cause interference in physiology, behavior, life expectancy in reproducing organisms, among other problems [76]. Thus, the widespread use of pesticides and cause substantial environmental damage, also contributes to the deterioration of human health [77].

In this sense, it is clear that advances in the use of pesticides increase the risk of environmental

contamination and human poisoning, causing growing concern, which may have led to a marked development of research on pesticides and their effects on the environment and human health and consequently, an increase in the number of publications from the years 2000 to 2016.

Santos et al. [78] also reported a greater number of publications between the years 2000-2009, about organophosphates insecticides and its relationship with clinical and epidemiological aspects of human poisoning, showing that these national investigations have gradually increased over the years.

As shown in Figure 5, Brazil has only 2% share in publications with the theme pesticides. This growth in scientific production in Brazil, observed in the database in Portal Periódicos Capes, accompanied the growth of world scientific production.



**Figure 5.** Publications with the keyword: "Pesticides".

According bibliometric indicators of basic international and multidisciplinary bibliographic Pascal data, the number of Brazilian goods increased especially from the 1990s. Between 1991 and 2000, there was an increase of about 120% of the scientific production registered in basis, past 2,642 to 5,822 articles [53].

The percentage of publications in Brazil accompanies their participation in global scientific

production, being inserted into the block of countries with participation of up to 2%, according to the bibliographic records of the worldwide scientific publications indexed in multidisciplinary database Science Citation Index Expanded (SCIE), the Institute for Scientific Information (ISI), analyzed by the Foundation for Support to Research of the State of São Paulo FAPESP between the years 1998 to 2002 [79]. The results of this work show that countries like the

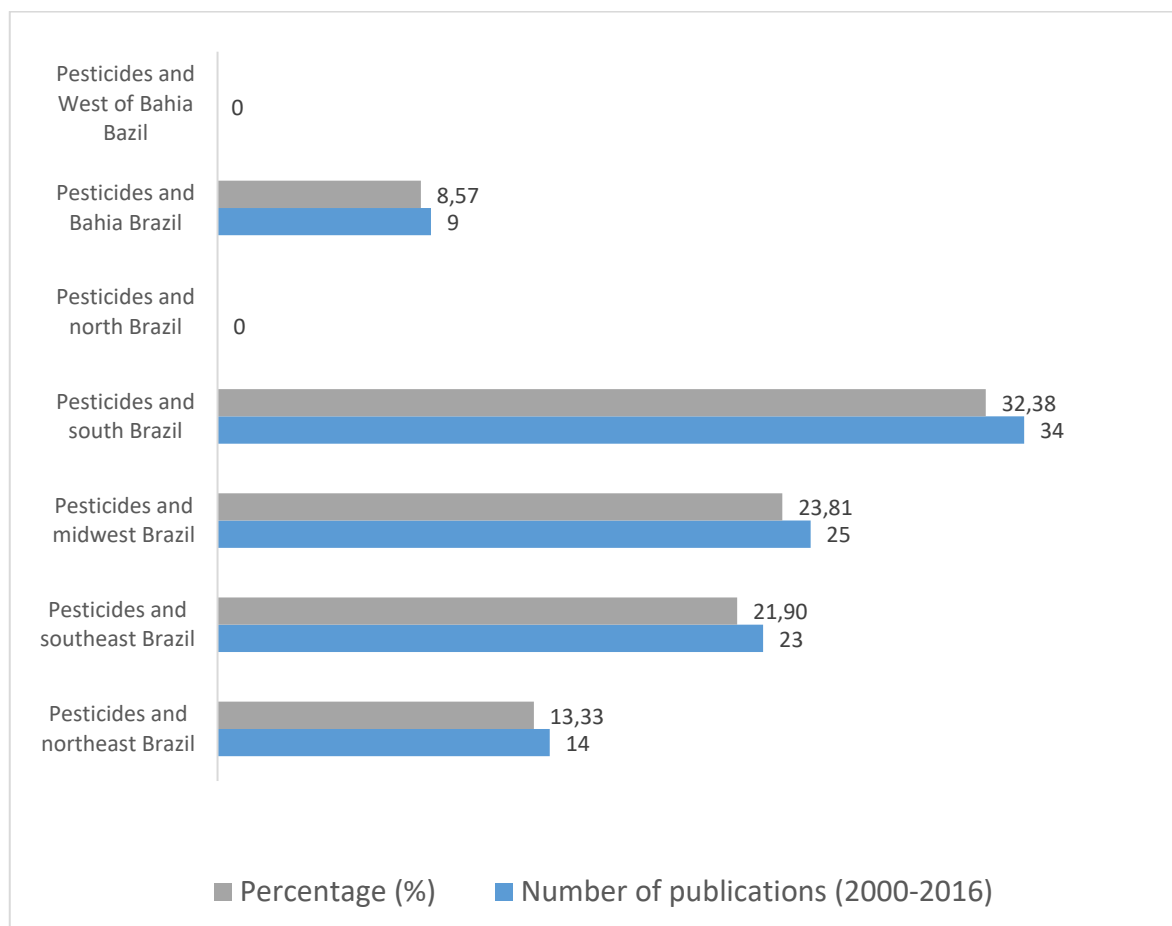
United States, Britain, Japan, France and Germany have participation above 5% in the global scientific production; among them, the United States has increased participation, corresponding to 32.2%. Among those with participation from 2% to 5% are Spain, Canada, China, India and Australia. The latter revealed a more discreet growth in the same period, and among these, China stood out with the highest percentage of publications of the period examined, from 20,194 records of scientific articles indexed in SCIE in 1998 to 41,094 in 2002.

Brazil, for its part, maintained its leading position among the countries of Latin America in the period examined, since their scientific production, according to data from SCIE increased from 1.1% of the world total in 1998 to 1.5% in 2002, which is above the growth rate of some Latin American countries like Argentina, Chile and Mexico and getting behind South Korea; the latter, as well as Brazil, joined the group of countries considered in the development process [79].

The combination of arable land, widespread availability of water, use of new production

technologies related to so-called modern inputs (improved seeds, agricultural correctives, chemical fertilizers, pesticides, irrigation, more developed agricultural machinery) and high productivity makes Brazil a great protagonist in food production. However, the number of publications with the theme pesticides are still discrete, an nonsense, since Brazil is the largest consumer of pesticides.

According to the survey conducted using the terms Pesticides and north Brazil; Brazil and South; and midwest Brazil; and southeast Brazil; and northeast Brazil to verify the studies on pesticides in Brazil and its regions, attached in database of Portal do Periódicos Capes, one can note a larger number of publications in Southern Brazil (34), followed by Centralregion west (25), Southeast (23) and Northeast (14), not being checked any publication on pesticides in the North. Publications on pesticides in the State of Bahia are still discrete, with only 8.57%. This shows that the studies related to this topic are still scarce for this state (Figure 6).



**Figure 6.** Percentage and number of publications with keywords "Pesticides and south Brazil", "Pesticides and southeast Brazil", "Pesticides and midwest Brazil", "Pesticides and north Brazil", "Pesticides and northeast Brazil", "Pesticides and Bahia Brazil" and "Pesticides and West of Bahia Brazil".



The region West of Bahia is presenting a grate advance in the development of agribusiness and is considered one of the regions with the highest production of grains and fibers of Brazil. Only in the last 15 years, the area of the three main crops (soybean, corn and cotton) increased by 108% from 913,000 in 2000/01 to 1.9 million hectares in the 2014/2015 harvest. In terms of production, these same cultures, there was an increase of 164% passing from 2,690 tons in 2000/2001 to 7,114 tonnes in 2014/2015, reaffirming its productive potential [80]. Despite the intense agricultural activity the west region, no publication on pesticide was found in the database of the Periódicos Capes.

According to study by Mendonça [81] using logistic model projection on the potential of grain production growth in Western Bahia, it is estimated an increase of the total cultivated area of 4.4 millions hectares in 2024, representing 83% increase compared to 2004. According to the author, grain production will also accompany this growth, which is projected at about 9.0 million tonnes in 2024.

Thus, this rapid growth of grain production in this region reflect the proportional increase in pesticide consumption.

#### 4. CONCLUSION

The analysis of scientific production through the database of the Portal Periódicos Capes, on pesticides allowed a comprehensive view of the importance and possibilities of scientific research.

There was a significant increase in the number of pesticides on publications since 1990 due to the steep rise in the use of chemicals and the consequent increase in the number of human poisoning and death, and environmental damage.

The major shortcomings in pesticide-related publications occur mainly in emerging countries as they seek insertion into the world economy and place a low priority on controlling environmental degradation. In addition, the current model of agricultural development and its production and consumption processes, based on economic growth and increased productivity, have masked the negative impacts of pesticides. In this way, the myth that mankind is on the way to progress, isolated from nature, thus, with the possibility of irreversible environmental disasters, society took a position of risk that no previous generation had to face.

The large gap in publications related to pesticides occurs mainly in developing countries, as they seek an integration into the world economy and put a low priority on the control of environmental degradation. In addition, the current model of agricultural development and its production and consumption processes, based on economic growth and increased productivity have been masking the negative impacts of pesticides. Thus, it developed the myth that humanity is heading towards progress, isolated from nature, so, with the possibility of irreversible environmental disasters society took a risk position that no previous generation had to face.

Regarding the research conducted in Brazil, this study shows that there is a higher concentration of publications in the south, southeast and center-west of the country, given the importance of these regions in the national economic scenario, however, despite significant agricultural production in west of Bahia, no research has been developed in the region. It should be noted that the East has half of the leading higher education institutions in the country and concentrates the most important and well-equipped Brazilian graduate institutions such as USP, Unicamp, ITA, FGV, UFRJ and UFMG. Thus, the smaller number of higher education institutions in the north and northeast, can be a factor that attenuates the development of research..

The constant advancing agricultural production in western Bahia, has driven the economic growth of the state and the strengthening of thanks sector to government incentives, which eventually converges to the increase in production, the intensive use of pesticides and the expansion of the risk of exposure human, in a matter of setting imminent public health. In this sense, this study reaffirmed the indispensability of studies on the effects on human health and the environment, as these data are still preliminary to know more precisely the extent of the damage caused by these chemical species.

Still, there are many spaces to be filled in the development of studies that will uncover the implications of pesticide, becoming an important issue for researchers from different areas of knowledge.

It is noteworthy that the survey does not cover the totality of the scientific production, which can be dispersed in other types of more restricted access publications. However, the intention of the cut adopted by the authors was to contribute to the debate on the subject and reveal areas that need a thorough study, enabling the characterization of the most diverse

arrays.

There are many challenges in front of the dimension that the theme "pesticide" offers. Therefore, should be priorities and strategies for research, seeking to boost scientific productivity in an attempt to make changes that help to trace a path for sustainable development within a systemic and transdisciplinary vision.

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