Socio-sanitary-environmental process of pesticides in the basin of the rivers Juruena, Tapajós and Amazonas in Mato Grosso, Brazil[1]

Processo sócio-sanitário-ambiental da poluição por agrotóxicos na bacia dos rios Juruena, Tapajós e Amazonas em Mato Grosso, Brasil

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Abstract

This study aimed to understand the process of pesticide-related environmental pollution in the cities of Campo Novo do Parecis, Sapezal, and Campos de Júlio, in Mato Grosso, Brazil. We used an integrated, multidimensional, and contextualized interpretative model, which understands the phenomenon of contamination as a historical, social-sanitary-environmental process, to overcome an approach restricted to the results of laboratory tests. In the real process of rural chemical pollution, we identified that latifundiums, where millions of metric tons of agricultural products are produced per year, are the main areas with pesticide use, causing environmental pollution and diseases in people. In the current rural chemical pollution, we highlight the high use of pesticides per inhabitant (350 to 600 liters per inhabitant) and of the herbicide glyphosate on plantations of transgenic soybean (45% of total volume) and the recent authorizations for the use of the insecticide emamectin benzoate and 2,4-D-resistant transgenic soybean and corn. The application of this broadened interpretative model allowed us to expand our scientific perspective, incorporating essential aspects to understand the negative impact of pesticides on health and the environment and to build collective actions of

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disease prevention and health promotion in the context of Brazilian agribusiness.
Keywords: Environment; Health; Agribusiness; Pesticides; Intoxication.

Resumo

O objetivo do estudo foi compreender o processo de poluição ambiental por agrotóxicos nos municípios de Campo Novo do Parecis, Sapezal e Campos de Júlio, em Mato Grosso, Brasil. Utilizou-se modelo interpretativo integrado, multidimensionado e contextualizado, que compreende o fenômeno da contaminação como processo histórico, sócio-sanitário-ambiental, de modo a superar a abordagem restrita aos resultados das análises laboratoriais. Identificou-se no processo de poluição química rural real que os latifúndios, onde são produzidos anualmente milhões de toneladas de produtos agrícolas, são os principais responsáveis pelo uso de agrotóxicos, gerando processos de poluição ambiental e doenças no ser humano. Na poluição química rural atual, destacou-se uso elevado de agrotóxicos por habitante (350 a 600 litros/habitante) e do herbicida glifosato nas plantações de soja transgênica (45% do volume total), e as recentes autorizações do uso do inseticida benzoato de emamectina e da soja e do milho transgênicos resistentes ao herbicida 2,4-D. A aplicação deste modelo interpretativo ampliado permitiu expandir o olhar científico, incorporando aspectos indispensáveis para a compreensão do impacto negativo dos agrotóxicos à saúde e ao ambiente e para construção de ações coletivas de prevenção de doenças e promoção da saúde no contexto do agronegócio brasileiro.
Palavras-chave: Ambiente; Saúde; Agronegócio; Agrotóxicos; Intoxicação.

Introduction

The (re)occupation of the Cerrado and Mato Grosso's Amazon territories, inserted into the chemical-dependent and exporter pattern of agricultural and industrial production, took place with the alliance consolidated in the 1960s and 1970s between the international capital, the authoritarian state run by the civil-military regime, and the regional rural oligarchy, and was implemented by regional development projects in the region – opening of highways and private projects of colonization (Martins, 1999; Moreno, 2007; Pignatti, 2005).

With the democratic opening in the 1980s, the weight of the centralized power of the Brazilian state declined in these areas, increasing the economic and political power of the oligarchies formed in that period of land sale/delivery to private colonizers. The alliance between international capital, national oligarchies, and state regarding the domination over the territory remains to this day (Moreno, 2007; Pignatti, 2005).

In the production chain of agribusiness, pesticide-related pollution, harms, and diseases are the most relevant impacts on occupational, populational, and environmental health. In this agrochemical-dependent process, the use of pesticides by farms aiming to reach the target or the "pests" (insects, fungi, or weeds) ends up contaminating the crops, the environment, the workers, and the surrounding population (Carneiro et al., 2015; Pignati, 2007). Therefore, the environmental pollution by pesticides is a component that determines the epidemiological profile or the health-disease process of the population in productive areas of the agribusiness.

Understanding the health-environment-disease relationship in these territories implies analyzing the chemical contamination caused by the use of pesticides in agricultural production as a **process**. Thus, one must research the **determinations** and the **genesis** of contamination, for not considering only the empirical results of the laboratory tests that indicate it.

The complexity of this problem requires approaches beyond the positivist empirical concept, which reduces the understanding of pesticide contamination only to the verification and discussion of objective data produced in laboratory tests. Although the research field on the effects of pesticides on human and environmental health is permeated by this notion, other theoretical perspectives based on critical epistemology question the principles of this lineage and point to the restrictions of the notion of linear risk and causality, which trigger fragmented, punctual, and isolated research and action programs.

Latin American social medicine has sought, since the 1970s, to overcome the emphasis on positivist causality and on reductionist notions of risk. Laurell (1982) and Breilh (2006), for example, highlight the need to look at health as a whole and as a **process**, adding the categories of **time** and **motion** in the analyses and rescuing the **historical** temporal dimension of the space. This is essential to overcome the one-dimensional and static view of "risk factors," still prevalent in epidemiology. The notion of "risk factors" ends up underrating the structural processes that degrade health, considering them as segmented situations external to the subject ("ex"position). Thus, health problems are only considered relevant if the statistical calculation of risk presents significant association, otherwise, the analysis and action on these degrading processes are overlooked or disregarded (Breilh, 2006).

Researches that deviate from the idea of **factor** to that of **process** contribute to break the exclusivity of the principle of identity for the incorporation of the principle of motion, which recognizes the contradictory and dialectic aspect of the reality phenomena (Breilh, 2006). This critical look has motivated several experiences of scientific research committed to promoting the health of people in complex contexts, such as in the productive regions of agribusiness.

Such a task can only be carried out by an integrated, multidisciplinary, interdisciplinary, and/or transdisciplinary team, with a theoretical and methodological framework that includes qualitative and quantitative approaches and that considers the analysis of the different dimensions of the object's complexity, to actively involve the affected communities and make the state and all involved sectors of civil society be accountable for solving the existing problems (Augusto; Florêncio; Carneiro, 2005; Breilh, 2006; Carneiro et al., 2015; Minayo, 2002; Pignati, 2007; Tambellini; Câmara, 1998).

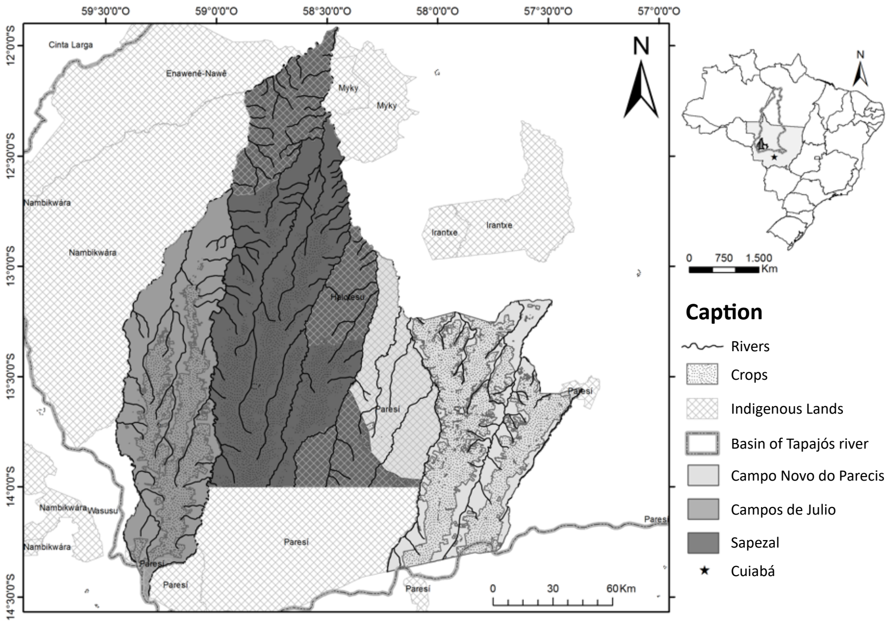
Following the trail of these critical studies on the relationships between health, environment, and production processes, this article sought to understand the process of pesticide-related environmental pollution in the cities of Campo Novo do Parecis, Sapezal, and Campos de Júlio (Mato Grosso, Brazil), a region with high agricultural production where laboratory tests detected pesticide residues in surface water and groundwater, in rain, and in fish (Beserra, 2017; Oliveira, 2016).

Methods

This study was carried out in the cities of Campo Novo do Parecis, Sapezal and Campos de Júlio, which are located in the Western region of Mato Grosso and compose the basin of Juruena, Tapajós, and Amazon rivers (Figure 1). Campo Novo do Parecis is located 390 km away from Cuiabá (capital of Mato Grosso), has an area of 9,434.3 km^2 and an estimated population of 31,985 inhabitants, and contains part of the Utiariti Indigenous Land, occupied by the Pareší indigenous people. Sapezal is located 470 km away from Cuiabá, has an area of 13,624 km^2 and an estimated population of 22,665 inhabitants, and contains three indigenous lands: part of the Utiariti Indigenous Land, of Paresí ethnicity; the Tirecatinga Indigenous Land, of Nambikwara ethnicity; and part of the Enawenê-Nawê Indigenous Land, of Enawenê-Nawê ethnicity. Campos de Júlio is located 520 km away from Cuiabá, has an area of 6,801 km^2 and an estimated population of 6,155 inhabitants.[2]

2 IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. *Cidades*. Available from: <https://cidades.ibge.gov.br/>. Access on: May 11, 2016.

Figure 1 – Location of the cities of Campos de Júlio, Sapezal, and Campo Novo do Parecis



Source: Francco Antonio Neri de Souza Lima, for this article

We adopted the proposal of Breilh (2006), based on dialectical realism, as interpretative model to understand more comprehensively the **real** and **current** situation of pesticide contamination (Chart 1). Thus, this study focused on two dimensions (real and current) of rural chemical pollution, using some elements of these dimensions to understand the process of pesticide contamination in these cities, since the empirical dimension was already developed in other researches (Beserra, 2017; Oliveira, 2016).

Chart 1 – Dimensions of pesticide-related rural chemical pollution

→ Real rural chemical pollution

Determination: economy, politics, land concentration, agricultural model, etc.

Accumulation, interaction, bioaccumulation, biomagnification, toxicokinetics and toxicodynamics of the several pesticides sprayed since the beginning of the implementation of chemical-dependent crops: dispersion and contamination in the product/food, the biome, the human being, the air, the rain, the soil, the water table, the rivers, and other ecosystems.

→ Current rural chemical pollution

Accumulation, interaction, bioaccumulation, biomagnification, toxicokinetics and toxicodynamics of the several pesticides sprayed in the past harvests: dispersion and contamination in the product/food, the biome, the human being, the air, the rain, the soil, the water table, the rivers, and other ecosystems.

→ Empirical rural chemical pollution

Residues detected by laboratory analyses: water, sediment, soil, air, food, blood, urine, fat, milk, and biopsy of animals and population, among others.

Source: Adapted from Breilh, 2006, p. 127

To study the dimension of the real chemical pollution, we consulted bibliographies on the history of the territory occupation and used secondary data of land structure and agricultural production available in the IBGE System of Automatic Recovery (Sidra-IBGE - *Sistema IBGE de Recuperação Automática*) of the three cities (IBGE, 2016).

These data allowed us to quantitatively identify the extension and agricultural production per city. This information is valuable to understand the social-sanitary-environmental aspects of the region, as it provides the dimension of the agricultural production process, allowing one to infer not only the amount of "wealth" produced, but, above all, the negative health and environment impacts from this productive model, including the consequences of pesticides.

For the dimension of current chemical pollution, we analyzed the use of pesticides in the agricultural production by the proposal of Pesticide Surveillance (*Vigilância aos Agrotóxicos*) of Pignati, Oliveira, and Silva (2014), which quantifies the amount of pesticides sprayed from the average of liters of active ingredients used per hectare (ha) planted of the main agricultural crops of Mato Grosso (soybean, corn, cotton, and sugarcane) in 2012. We used this technique for estimating the use of pesticides because, since 2012, the Institute of Agricultural and Livestock Defense of Mato Grosso (*Instituto de Defesa Agropecuária do Estado de Mato Grosso*) does not systematizes nor publicly provides data on pesticide consumption in the crops of Mato Grosso.

From the pattern of agricultural production and the use of pesticides identified in the cities, we selected critical processes of current rural chemical pollution, i.e., toxic active ingredients of great impact on the environment and human health, such as the high use of glyphosate, endosulfan, emamectin benzoate, and 2,4-D.

Results and discussion

Real rural chemical pollution: land concentration and agricultural production in the process of contamination

In recent decades, the state of Mato Grosso has become a strategic region for the expansion of globalized agribusiness. However, it has a low degree of agroindustrialization, remaining a primary sector exporting economy, dependent on the import of chemical fertilizers, pesticides, and machinery (Pereira, 2012). It gathers the largest Brazilian cattle herd, with 28.6 million heads (IBGE, 2016), which occupy most farms of the state, in 22 million hectares of land (IBGE, [2008?]). In 2014, Mato Grosso used 13.4 million hectares for agricultural production, which represented 19.2% of the total planted area in Brazil (IBGE, 2016).

For a contextualized understanding of the land structure and agricultural production in the cities of Campo Novo do Parecis, Sapezal, and Campos de Júlio, we must comparatively analyze the land structure of Brazil and Mato Grosso.

In Mato Grosso, land concentration is sharply higher compared to the national one (Table 1). The 76.8 thousand rural properties of the state with up to 100 ha occupy only 6.4% of the agricultural area, while 8.7 thousand properties over 1000 ha occupy 78% of the agricultural territory, and 62.1% of the state's rural area are distributed only in 3,800 properties over 2,500 ha.

If these data presented a stratification of the size of properties over 2,500 hectares, which in Mato Grosso represent 62.1% of the rural territory, we could have a dimension of the real land concentration in the state. Anyway, these data show part of the historic process of privatization of extensive areas of land in the Brazilian Cerrado and Amazon, directed to a few owners, or rather, to the rural oligarchies (Moreno, 2007).

Table 1 – Agricultural establishments and their respective occupied areas in Brazil, in Mato Grosso, and in the cities of Campo Novo do Parecis, Sapezal, and Campos de Júlio, 2006

Size of property	Brazil		Mato Grosso	
	Number of properties	Total area of the properties (%)	Number of properties	Total area of the properties (%)
Less than 10 ha	2,477,151	2%	14,989	0.1%

continues...

Table 1 — Continuation

Size of property	Brazil		Mato Grosso	
	Number of properties	Total area of the properties (%)	Number of properties	Total area of the properties (%)
From 10 to 100 ha	1,971,600	19%	61,781	5.3%
From 100 to 1,000 ha	424.288	34%	26,467	16.6%
From 1,000 to 2,500 ha	32,242	14.6%	4,929	15.9%
More than 2,500 ha	15,336	30.4%	3,815	62.1%
Size of property	**Campo Novo do Parecis**			
	Number of properties	Total area of the properties (ha)	Total area of the properties (%)	
Less than 10 ha	41	31	0%	
From 10 to 100 ha	70	2,670	0.5%	
From 100 to 1,000 ha	49	25,903	4.5%	
From 1,000 to 2,500 ha	72	117,037	20.6%	
More than 2,500 ha	69	422,573	74.4%	
Size of property	**Sapezal**			
	Number of properties	Total area of the properties (ha)	Total area of the properties (%)	
Less than 10 ha	0	0	0%	
From 10 to 100 ha	0	0	0%	
From 100 to 1,000 ha	15	9,103	1.7%	
From 1,000 to 2,500 ha	24	40,506	7.5%	
More than 2,500 ha	48	491,312	90.8%	
Size of property	**Campos de Júlio**			
	Number of properties	Total area of the properties (ha)	Total area of the properties (%)	
Less than 10 ha	0	0	0%	
From 10 to 100 ha	4	107	0%	
From 100 to 1,000 ha	25	16,544	6.3%	
From 1,000 to 2,500 ha	36	52,239	19.6%	
More than 2,500 ha	31	197,028	74.1%	

Source: Adapted from IBGE, [2008?]

This oligarchic rural reality in Brazil and Mato Grosso comes from the process intensified since the 1970s, with the insertion of more international capital in agriculture. This process has reproduced a non-sustainable model of "development" by enterprises of chemical-dependent mechanized agricultural production, livestock production, wood and ore extraction, among other forms of nature exploitation and work aimed at exporting, thus creating a socioeconomic reality of enormous concentration of land, wealth, and power, accompanied by the socialization of the costs of environmental degradation and the pressure and direct and indirect extermination of people living off the land – indigenous people, *quilombolas*, riverines, peasants, among others (Moreno, 2007; Pignati, 2007; Pignatti, 2005).

The region of the high basin of Juruena river, of which the studied cities are part, started to be occupied for the purpose of chemical-dependent mechanized agricultural production, inserted in the international capitalist market, from projects of private colonization and of regional economic growth created during the regime of the civil-military dictatorship during the 1970s and 1980s, implemented by the National Institute of Colonization and Land Reform (Incra – *Instituto Nacional de Colonização e Reforma Agrária*) and the Integrated Program for the Development of Northwest Brazil (*Programa Integrado de Desenvolvimento do Noroeste do Brasil*) (Moreno, 2007; Pignatti, 2005).

The land currently occupied for agricultural production in Campo Novo do Parecis, Sapezal, and Campos de Júlio were passed on to the private sector during this historical period by two main mechanisms: business colonization and legalization of land grabbing of vacant lands. This process occurred during the Diamantino Land Project (*Projeto Fundiário Diamantino*), which incorporated, among other regions, the cities of Campo Novo do Parecis and Sapezal, privatizing 1.3 million hectares of vacant lands between 1970 and 1992, and the Vale do Guaporé Land Project (*Projeto Fundiário Vale do Guaporé*), which covered the region of Campos de Júlio, transferring 695.5 thousand hectares of vacant lands to the private sector between 1980 and 1992 (Moreno, 2007).

Table 1 shows this private colonization that concentrated the land in this region. Campo Novo do Parecis has only 160 rural properties below 1,000 ha, in an area corresponding to 5% of the arable land of the city. In the properties above 2,500 ha, 74.4% (422.5 thousand ha) belong to only 69 rural establishments, which is equivalent to an average of 6.1 thousand ha per rural establishment (IBGE, [2008?]).

Sapezal has the highest land concentration of the three cities (Table 1). This occurs because of the maintenance of the monopoly of ownership of land by the same group that colonized it (Ferreira, 2001). Agricultural establishments occupy a total of 540.9 thousand ha, with 90.8% of them (491.3 thousand ha) owned by only 48 rural establishments above 2,500 ha, equivalent to an average of 10.2 thousand ha per rural establishment.

Similarly to Campo Novo do Parecis and Sapezal, Campos de Júlio also has a high land concentration in latifundiums (Table 1). The city has only four properties below 100 ha, which do not reach 1% of the area occupied by rural establishments, showing the shortage of peasant agriculture. The properties above 2,500 ha present a land concentration similar to that of Campo Novo do Parecis, occupying 74.1% (197 thousand ha) of the rural area, with an average rural establishment size of 6.3 thousand ha.

These few large rural establishments are responsible for the increased agricultural production of these cities (Graph 1). From 2008 to 2014, soybean was the predominant agricultural crop in the three cities, followed by corn, cotton, sugarcane, and sunflower. The distribution of agricultural crops in the region follows the same pattern of other cities of Brazil and Mato Grosso, which destine their lands mainly to the production of agricultural commodities, showing annual growth of the planted area, with soybean as main culture, planted in the first crop – from September to February – and other crops such as corn, cotton, and sunflower planted in the second crop – from February to August (Graph 1).

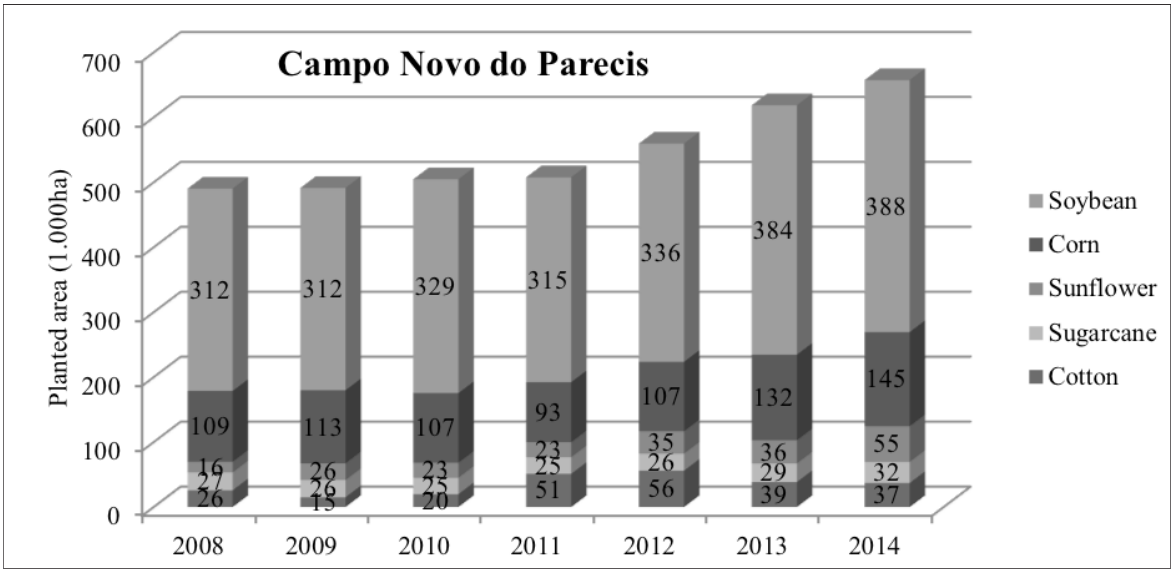
Annually, these extensive plantations produce millions of metric tons of soybean, corn, cotton, sugarcane, and sunflower, resulting in total monetary values that reach billions of reais. In 2014, Campo Novo do Parecis produced 1.2 million metric tons (t) of soybean (equivalent to BRL 1.1 billion), 805 thousand tons of corn (BRL 176.4 million), 133.3 thousand tons of cotton (BRL 190.2 million), 2.4 million tons of sugarcane (BRL 151.5 million), and 70 thousand tons of sunflower (BRL 56.2 million), with a total return of about BRL 1.7 billion (IBGE, 2016). Campos de Júlio presents the same pattern of production of agricultural crops of Campo Novo do Parecis, but, because it has a lower production area, it reached in 2014 a total return of BRL 876.2 million (IBGE, 2016).

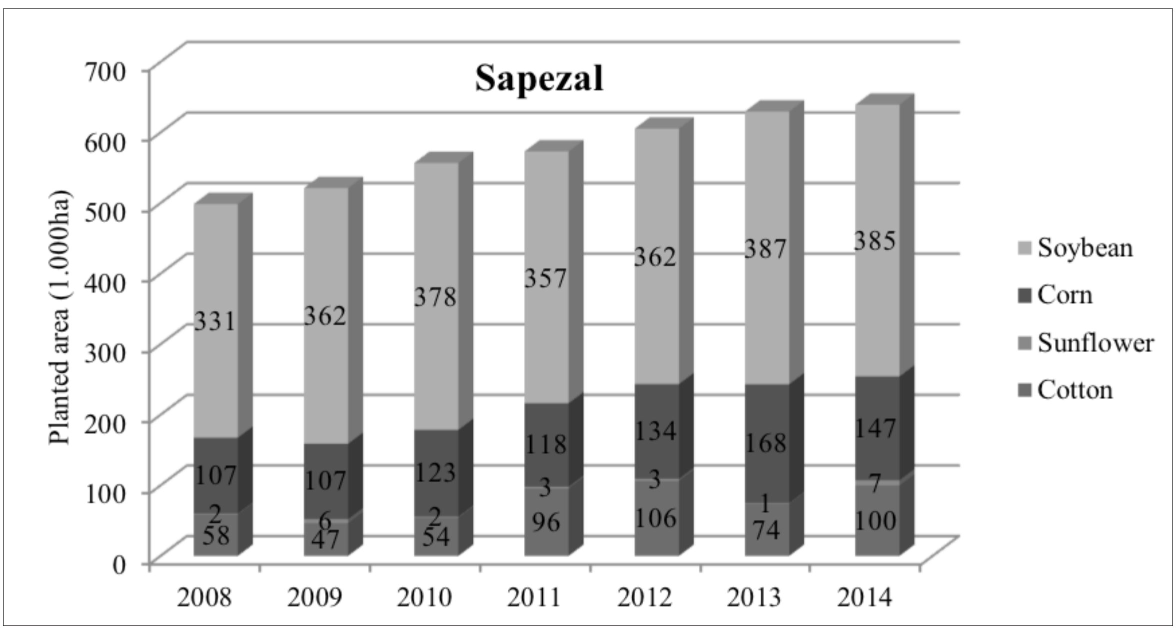
In Sapezal, the size of the area destined to agricultural production is similar to that of Campo

Novo do Parecis, but it has a different distribution of agricultural crops, with high cotton production and low sugarcane production (Graph 1). In 2014, the production of cotton in Sapezal reached 432.3 thousand metric tons (BRL 637.6 million), and the total return of its agricultural production was about BRL 1.9 billion.

Combining this analysis with the history of occupation of the territory, land structure, planted area, agricultural production in metric tons, and accumulated monetary value of the three cities, one can understand the elements that form the determination of the real dimension of rural chemical pollution (Chart 1).

Graph 1 – Planted area (1,000 ha) per temporary crop in Campo Novo do Parecis, Sapezal, and Campos de Júlio, 2008 to 2014





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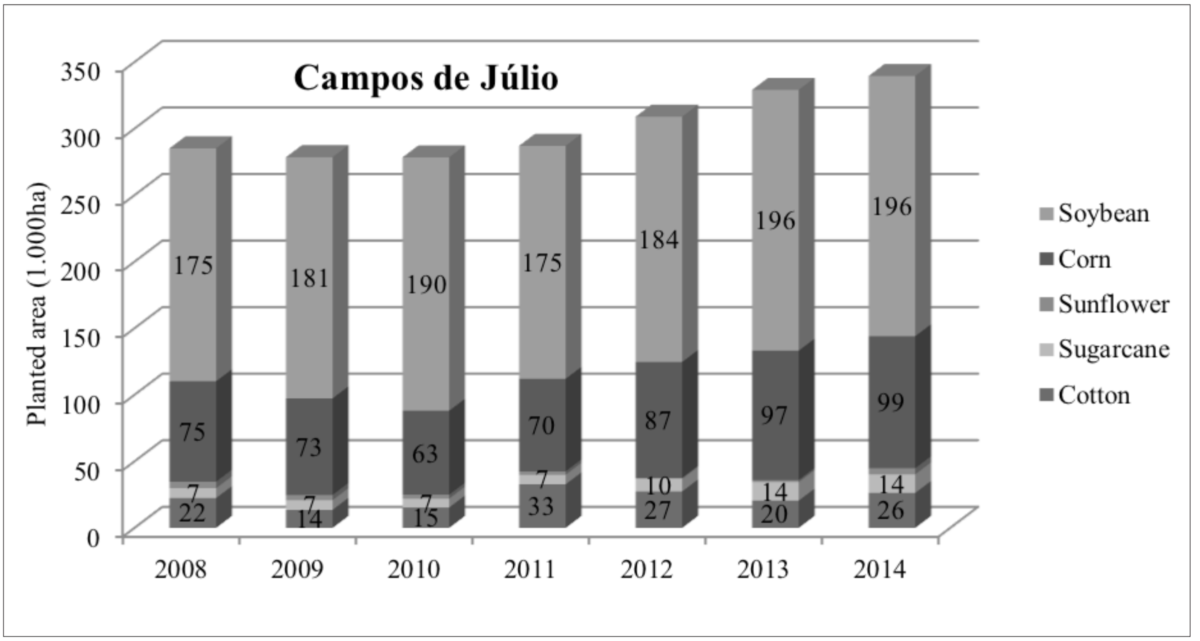
Graph 1 –Continuation



Source: IBGE, 2016

Current rural chemical pollution: pesticides sprayed in the cities of Juruena river basin

The agricultural production of Campo Novo do Parecis reached an estimated total use of 6.6 million liters of pesticides (Table 2) in 2014, generating an average exposure (or imposition) of 208 liters of pesticides per inhabitant. Sapezal reached the highest consumption of pesticides of the three in 2014, estimated at around 7.9 million liters of pesticides and with an average exposure of 351.5 liters per inhabitant. Campos de Júlio, even consuming a lower total volume of pesticides than the others, estimated at 3.7 million liters of pesticides, is the one with the highest average exposure, of 598.2 liters per inhabitant in 2014.

Soybean crops have the greatest weight in the total consumption of pesticides in the three cities, with 59% in Sapezal, 64.7% in Campos de Júlio, and 71% in Campo Novo do Parecis. In Sapezal and Campos de Júlio, the planted area of cotton, even though lower than the corn area, reached 30% and 17% of the total volume of pesticides applied, respectively. In Campo Novo do Parecis, the volume in the cotton crop reached 13.3% of the total use.

Table 2 – Estimated volume of pesticides consumed (1,000 L) in cotton, sugarcane, corn, and soybean crops in the cities of Campo Novo do Parecis, Sapezal, and Campos de Júlio, 2014

Culture	Campo Novo do Parecis	Sapezal	Campos de Júlio
Cotton (24 L/ha)	885	2,380	626
Sugarcane (5 L/ha)	156	0	68
Corn (6 L/ha)	890	903	609
Soybean (12 L/ha)	4,722	4,685	2,379
Total (thousand liters)	6,653	7,968	3,682

Source: IBGE, 2016; Pignati, Oliveira, and Silva, 2014

Several factors affect the definition of the pesticides used in crops, including the type of seed, the pesticides used in the previous harvest, the unwanted emerging species, the ban and liberation of new molecules and agricultural technologies, among others.

Among the processes defining the use of pesticides in agricultural production, because of the importance they have to understand the current rural pesticide-related pollution in the cities of Juruena river basin, we highlight the following aspects to discuss their impacts on health and environment: (1) transgenic seeds and the use of glyphosate; (2) prohibition of insecticide endosulfan in 2013 and emergence of the larva *Helicoverpa armigera* with the release of insecticide emamectin benzoate; and (3) release of 2,4-D-resistant transgenic soybean and corn.

Transgenic seeds and the use of glyphosate

Since the creation of the National Technical Commission of Biotechnology (CTNBio – *Comissão Técnica Nacional de Biotecnologia*) by law no. 11,105/2005 (Brasil, 2005) – result of a political maneuver to allow transgenic seed crops in Brazil –, tens of transgenic species were authorized for trading and planting, and other tens are in process of release in the country (Ferment; Zanoni, 2007). According to the list published by CTNBio in July 2017, 13 transgenic plant species of soybean, 44 of corn, 15 of cotton, one of bean, one of eucalyptus, and one of sugarcane are free for trading and planting in Brazil (CTNBio, 2017).

The promise of increased soybean productivity associated with the transgenic seed Roundup Ready®/Monsanto (RR), resistant to the herbicide glyphosate – illegally introduced in Brazilian plantations in the late 1990s –, was the flagship of the implementation of transgenic seeds in the country and affected the ruralist class in such a way that it converted most of the national soybean crops to this transgenic seed, increasing the consumption of glyphosate, so that, in 2008, Brazil became the world's largest consumer of pesticides, with glyphosate representing about 30% of the pesticides consumed in the country (Ferment; Zanoni, 2007; Ibama, [201-]).

After 15 years from the registration of the patent of RR soybean, in 1998, the company which holds the patent could no longer charge royalties on its use, which allowed any rural company and small farmer to freely reproduce and use this transgenic species in their soybean crops.

One can see the reflection of the expansion and predominance of transgenic soybean plantations by the high consumption of glyphosate in the soybean crop. Pignati, Oliveira, and Silva (2014) verified an estimated average of 5.5 liters of glyphosate per hectare of planted soybeans, representing about 45% of the total volume of pesticides applied in soybean crops, while the average of the other active ingredients does not exceed 1.3 liter per hectare or 10% of the total volume applied.

From the hectares of soybean planted in the cities of Juruena river basin in 2014 (Graph 1), about 2.13 million liters of glyphosate were sprayed in Campo Novo do Parecis, 2.12 million liters in Sapezal, and 1.08 million liters in Campos de Júlio.

Studies using several methods (clinical, epidemiological, experimental, reviews, etc.) have shown different health outcomes that can be caused by the glyphosate contamination. The long-term studies of Séralini et al. (2014), carried out over two years (720 days) with 200 rats, have shown alarming effects from a diet with transgenic corn (11% of the diet) and consumption of water treated with Roundup® (glyphosate + "inert ingredients"), within the limits of glyphosate residues allowed in the United States of America (USA).

They observed hepatic congestions and necrosis 2.5 to 5.5 times higher and severe nephropathies 1.3 to 2.3 times higher in male rats treated with transgenics and Roundup compared to the control group. Regarding teratogenesis, the treated females developed large breast tumors more frequently and earlier than the control group, and the treated males developed tumors 20 months earlier than the control group (Séralini et al., 2014).

In other laboratory experiments with glyphosate, the following effects were found: cytotoxicity and genotoxicity in bioassays (Gasnier et al., 2009); estrogen deregulation and breast cancer induction in bioassays (Thongprakaisang et al., 2013); carcinogenesis, teratogenesis, and congenital malformation in amphibians and birds (Paganelli et al., 2010).

The acute harms in humans caused by glyphosate include: corrosive (ulcerative) lesions of oral, esophageal, gastric, and duodenal mucosa; contact dermatitis (erythema, burning, itching, blisters, eczema); stomach pain, nausea/vomiting; colic; diarrhea; eye irritation, pain, and burning; blurred vision; conjunctivitis; eyelid edema; respiratory irritation; chemical pneumonitis; anicteric hepatitis; acute pancreatitis; hypotension; cardiogenic shock, mild hypoxemia; tachypnea; dyspnea; cough; bronchospasm; pulmonary edema; respiratory failure; metabolic acidosis; renal failure; convulsions; coma; and death in case of hypoxia or hypotension.[3]

The chronic harms to human health associated with glyphosate indicated in the scientific literature are: chronic kidney disease (CKDu) (Jayasumana et al., 2015); enzyme suppression; gastrointestinal disorders; obesity; diabetes; heart diseases; depression; autism; infertility; Alzheimer's disease; gluten intolerance and celiac disease (Samsel; Seneff, 2013a, 2013b); non-Hodgkin lymphoma and hairy cell leukemia (Hardell; Eriksson; Nordstrom, 2002); and multiple myeloma (De Roos et al., 2003).

Prohibition of insecticide endosulfan in 2013 and emergence of the larva *Helicoverpa armigera* with the release of insecticide emamectin benzoate

Until 2012, endosulfan (extremely toxic insecticide) was significantly used in soybean, corn, and mainly cotton crops, the latter reaching the average of 3.35 liters per hectare (Pignati; Oliveira; Silva, 2014). Since the use of endosulfan was banned in the country from July 2013 on (Anvisa, 2010), it is important to ask: in these cities, which insecticides are being sprayed in thousands of liters after July 2013 instead of endosulfan, causing the rural chemical pollution and forced exposure?

We can get part of that answer in the recent authorization for the use of the insecticide emamectin benzoate, from the emergence of the larva *Helicoverpa armigera*, which has affected, since 2013, Brazilian crops of soybean, corn, cotton, coffee, among others, causing major financial losses in these agricultural productions. The action of this larva in agricultural productions mobilized the entire rural entrepreneurship class for the creation of political and technical measures of control. During this period, the chemical-agricultural company Syngenta presented emamectin benzoate as an active ingredient with power to fight *Helicoverpa armigera*. However, this insecticide had it registration prohibited by the Brazilian Health Regulatory Agency (Anvisa – *Agência Nacional de Vigilância Sanitária*) in 2003, because of its strong neurotoxic action.

This led to a process of rapid deregulation of the legislation of control and release of pesticides in Brazil, carried out by the rural entrepreneurs of the country, who, in less than a month, managed to create a legal device that ignores the opinions of Anvisa and of the Brazilian Institute of the Environment and Renewable Natural Resources regarding the permission of pesticides, authorizing the use of emamectin benzoate in some Brazilian states, including Mato Grosso.

The parliamentary group that represents the ruralist sector in the National Congress articulated and approved Law no. 12,873, of October 24, 2013, regulated by Decree no. 8,133, of October 28, 2013, which establishes the device of the "state of phytosanitary emergency," giving powers to the Ministry of Agriculture, Livestock, and Supply (Mapa – *Ministério da Agricultura, Pecuária e Abastecimento*) to declare a state of phytosanitary emergency when there is the "risk of outbreak or epidemic of agricultural disease or plague" and to "**grant temporary emergency authorization** of production, distribution, trading, and use **of non-authorized products**" (Brasil, 2013a, bold added).

Three days after the Decree, Mapa declared in Ordinance no. 1,059, of October 31, 2013, "a state of phytosanitary emergency regarding the intensive attack of pest *Helicoverpa armigera"* (Brasil, 2013b), and, six days later, they authorized the import of products that have emamectin benzoate as active ingredient, in Ordinance no. 1,109, of November 6, 2013 (Brasil, 2013c).

In the state of Mato Grosso, the phytosanitary emergency was declared on November 18, 2013 by Ordinance no. 1,130 of Mapa (Brazil, 2013d), and since then the agricultural productions of the state have used emamectin benzoate for the control of *Helicoverpa armigera*, with the state of phytosanitary emergency being renewed every year. The last Ordinance, no. 273, published on

3 BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. *Agrofit*: Sistema de Agrotóxicos Fitossanitários. 2003. Available from: <https://bit.ly/2gmNSs7>. Access on: May 3, 2016.

December 23, 2016, extended the permission to use emamectin benzoate in the crops of the state until January 2018 (Brasil, 2016).

According to the report by Anvisa, acute exposure to emamectin benzoate can cause tremors, ptosis (eyelid drop), bradypnea (slow breathing), change in the central nervous system and peripheral nerves, chronic convulsions, ataxia (lack of coordination of muscle movements), loss of reflexes, blood in the urine, and even death (Anvisa, 2003).

It is known that when agricultural pest outbreaks occur in crops, rural companies tend to use large amounts of the product that fights them, to avoid losses in crop production. Certainly, this practice must be similar in Campo Novo do Parecis, Sapezal, and Campos de Júlio, and it is worth asking: what is the volume of application of emamectin benzoate in these cities? Which is the rural chemical pollution and human exposure that the use of this pesticide is producing in these cities?

Release of 2,4-D-resistant transgenic soybean and corn

In April 2015, CTNBio authorized the trading and planting of the variety of transgenic soybean and corn Enlist®/Dow, which is resistant to 2,4-D, an extremely toxic herbicide (CTNBio, 2015). The proposal of this new biotechnology occurred because of the resistance that plants unwanted in agriculture acquired regarding the herbicide glyphosate, in transgenic crops of RR soybean and corn, over these past decades. Thus, the proposal in the release of 2,4-D-resistant transgenic soybean and corn is to replace the RR crops in Brazil for this new transgenic product, to ensure the productivity and profit that the RR soybean and corn crops are not reaching.

This replacement movement of the Brazilian agricultural market can be considered one of the most alarming recent critical processes for health and the environment in the cities with high agricultural production of the country, including Campo Novo do Parecis, Sapezal, and Campos de Júlio. If the 2,4-D-resistant transgenic soybean and corn crops use an average amount of liters per hectare of 2,4-D, close to the average use of glyphosate, there will be an increase of at least five times in the spraying of 2,4-D on these crops. That means a potential five-fold increase in rural chemical pollution and exposure to population, workers, and environment by 2,4-D. And there is no controversy about it: it is proven to be carcinogenic for decades (Ferment, 2014).

A literature review on the effects of pesticides on human health observed that 2,4-D was the main component of the chemical weapon Agent Orange (2,4,5-T + 2,4-D), used in the forests by the U.S. Army in the Vietnam War (1955-1975), aiming to contaminate the Vietnamese with the poison and to defoliate trees to help the search for enemies (Opas, 1996). Adapted for crops and agricultural pastures since the 1960s, 2,4-D has been widely used worldwide, also being known for the strong toxic effects to the body that its active ingredient and its residues (dioxin) produce, including the its proven genotoxic action, which produces acute and chronic poisoning and other diseases and harms to health (Opas, 1996).

The signs and symptoms of acute poisoning by 2,4-D can be: loss of appetite, exposed skin irritation, vomiting, nausea, thoracic and abdominal pain, gastrointestinal tract irritation, muscle fasciculation, muscle weakness, mental confusion, convulsions, and coma (Opas, 1996). Regarding chronic diseases, the scientific literature points out that 2,4-D may cause: fetal malformations (teratogenesis), endocrine disruption (hormonal disorders: functions of the estrogens, androgens, thyroid), immunotoxicity (defense system), nephrotoxicity (kidney function), neurotoxicity, hematological changes, respiratory changes, gastric cancer, non-Hodgkin lymphoma, prostate cancer, and spina bifida (Ferment, 2014).

Both the cases of the emergence of *Helicoverpa armigera* and consequent release of emamectin benzoate because of the resistance of plants to the glyphosate in RR crops and the release of 2,4-D-resistant transgenic soybeans are consequences of the chemical war against nature promoted by the chemical-dependent model followed by the modern agricultural production. This productive model creates a growing and endless spiral of pesticide-resistant species in the monocultures and, combined with the use of more toxic poisons to fight them, serves to ensure the productivity and profits of rural enterprises.

The big question is: how and when the health of population, workers, and environment will be considered amid this endless war? Until when will we let the desire for immediate profit expand and ignore the growing evils created by this model of agricultural production?

Final considerations

From this analysis of the pesticide-related environmental pollution as a multidimensional process (real, current, and empirical), one can see that the productive agricultural model of these cities has concentrated the land and wealth for rural enterprises and socialized the environmental pollution and human diseases for workers and population.

When one only examines the results of pesticide residues found in laboratory tests in a decontextualized way, disregarding the real and current dimensions of pollution, the common practice is that the state and rural companies ignore their responsibilities in the process of systemic contamination, considering the case of contamination only as an isolated fact ("accident"), directing the liability to workers who apply pesticides (pilot or tractor driver), with the thesis of "incorrect" use of pesticides by them.

By analyzing the real and current processes of pesticide pollution in the productive areas of agribusiness, we are able to highlight processes that make up the determination of the epidemiological profile of the population being studied. Intervention measures must be carried out regarding these determinations, to prevent pesticide-related diseases and harms to the health of the population.

Therefore, this study emphasized that, when we consider pesticide contamination as a historical, social-sanitary-environmental process, we can expand our scientific perspective, incorporating essential aspects to understand the negative impact of pesticides on health and the environment and to build collective actions of disease prevention and health promotion in the context of Brazilian agribusiness.

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Authors' contribution

Oliveira, Pignati, and Pignatti collaborated with research conception and design. All the authors contributed with data analysis and interpretation, participaram da análise e interpretação dos dados, redação do artigo, revisão crítica e aprovação da versão a ser publicada.

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