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ENVIRONMENTAL HEALTH, SOCIAL DETERMINANTS AND SURVEILLANCE OF EXPOSURE TO CHEMICAL CONTAMINANTS IN BRAZIL: AN INTEGRATIVE LITERATURE REVIEW

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ABSTRACT
This article presents an integrative review on environmental health, social determinants of health (SDH), and exposure to chemical contaminants in Brazil. The study analyzed 38 publications, dated between 1970 and 2024, extracted from databases such as SciELO and Google Scholar, as well as institutional documents, following PRISMA protocols and thematic content analysis. The objective was to examine the role of Environmental Health Surveillance (VSA), as a public policy, and of the National Program for Health Surveillance of Populations Exposed to Chemical Contaminants (VIGIPEQ), in mitigating health risks. Results indicate that industrialized urban communities, agricultural areas and smelting and mining regions are more vulnerable to exposure to contaminants such as mercury, lead, benzene, pesticides and asbestos, especially in groups such as children, women, the elderly and populations with low socioeconomic status. Tools such as SISSOLO and SINAN help in monitoring these areas and populations, but face limitations such as lack of integration, underreporting of cases, absence of georeferencing, and availability of data in the public domain. The gaps identified include barriers to action in remote territories,

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regional peculiarities and social inequalities that intensify impacts, and insufficient data for robust analyses. It is concluded that the integration between SDH, environmental monitoring and intersectoral public policies is essential to mitigate risks, promote equity and ensure greater transparency and effectiveness in environmental health surveillance actions.

Keywords: Environmental health. Social determinants. Chemical contaminants. Health surveillance. Brazil.

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INTRODUCTION

Health is a universal right guaranteed by the Federal Constitution of 1988, and the Unified Health System (SUS) is responsible for implementing public policies that promote quality of life, going beyond the absence of disease. This expanded perspective understands that environmental, social, and economic factors directly influence the well-being of populations.

In Brazil, environmental health emerges as an interdisciplinary field that analyzes the interactions between humans and the environment, addressing how environmental conditions and SDH, such as poverty and unequal access to basic services, affect public health. Since 2001, VSA has been working to identify and mitigate risks associated with chemical contamination and other adverse environmental factors, with emphasis on tools that seek to monitor critical areas and populations at risk (BRASIL, 2024).

In this context, the present study is characterized as an integrative review of the literature. The methodology was developed based on the PRISMA 2020 protocol[6] (MOHER *et al.* 2020), adapted for integrative reviews. The research included documents published between 1970 and 2024, extracted from databases such as *SciELO, Google Scholar,* and institutional sources. After the initial identification of 258 records, 38 publications met the criteria for qualitative analysis in this review. The methodology used thematic content analysis by Bardin (2016), organizing the data into themes and subthemes aligned with the object of study.

The article is structured in four textual sections. In addition to the introduction, the methodology section details the design of the integrative review in stages of pre-analysis and treatment of the material, where criteria for selecting sources and the analytical procedures adopted were described.

The results and the discussion, subdivided into thematic sections, explore the relationship between health, environment and SDH, the historical milestones of environmental health, the performance of VSA and VIGIPEQ in Brazil and the gaps and challenges faced. Finally, the final considerations highlight the interdisciplinary importance between environment and health, the contexts of social vulnerability, in addition to the

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[6] *Preferred Reporting Items for Systematic Reviews and Meta-Analyses*: an instrument developed by MOHER *et al.* (2020) at the *Universities of Ottawa*/Canada and *Oxford*/UK, it consists of a set of organizational guidelines for summaries, systemic reviews, meta-analyses, and data flowcharts.

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growing need for integration between systems, community agents and society to face the challenges of environmental health in Brazil.

METHODOLOGY

This study is characterized as an integrative literature review with a qualitative approach, descriptive purposes and bibliographic procedure in primary and secondary sources. The data treatment follows Bardin's (2016) (thematic) Content Analysis divided into phases of: pre-analysis, material exploration and results and discussions: inference and interpretation.

PRE-ANALYSIS

The initial process consisted of floating reading to identify records, define the main elements, formulate objectives, define the *research corpus*, structural and analytical guidelines and eligibility criteria. The structural flow was made by adapting items from the PRISMA *checklist* as shown in chart 1 below:

Chart 1 – *PRISMA Checklist* adapted for integrative review.

Item/topic	Item do *checklist*		*Check*
	n.	Identification	
Title	1	Identified in the title as a review.	✓
Structured summary	2	Structured abstract including: *framework*, objective, eligibility criteria, summary of methods, results, limitations, conclusions and main findings.	✓
Introduction			Section 1
Rational	3	The justification for the review is described in the context of what is already known.	
Objectives	4	An explicit statement was made about the issue addressed with the results and design of the study.	✓
Methods			Section 2
Protocol and registration	5	A review protocol with an electronic address was indicated: *Google Sholar* – https://scholar.google.com/ , *Scielo* – https://www.scielo.br/; *institutional sites*.	✓
Eligibility criteria	6	Specified the characteristics of the study as well as the eligibility criteria in the study methodology with the justification.	✓
Sources of information	7	The sources of search information (descriptors) are described.	✓
Quest	8	Presented the electronic search strategy for the database, including the limits used, so that it can be repeated.	✓
Selection of studies	9	The process of selecting studies (screened and excluded) was presented. Inclusion criteria, exclusion and filters used (flowchart)	✓
Data collection process	10	Described the method of extracting data from the logs	✓
Summarization measures	11	The main measures for summarizing results have been defined	✓
Results			Section 3 and 4

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Item/topic	n.	Item do *checklist*	*Check*
	n.	Identification	
Selection of studies	12	The numbers of the studies screened, evaluated for eligibility and included in the review, exclusion reasons at each stage were presented.	✓
Risk of bias in each study	13	Data on risk of bias in each study were presented.	✓
Results of individual studies	14	Presented for each study: summary with objectives, results and conclusions.	✓
Risk of bias between studies	15	Results of the risk of bias assessment between studies (item 13)	🔍
Discussion			Section 3 and 4
Summary of the evidence	16	Summarized the main results, their relevance and contributions.	✓
Limitations	17	Limitations at the level of studies and contributions were discussed.	✓
Conclusions	18	The general interpretation of the results in the context of other evidence and implications for future research was presented.	✓
Financing			⃠
Caption		✓served 🔍 on another ⃠ non-applicable item	

Source: Prepared by the authors from PRISMA 2020.

Therefore, in the exploration phase of the materials the eligibility criteria were established as detailed in section 2.2.

EXPLOITATION OF THE MATERIAL

The selected documents were explored following eligibility criteria to ensure the relevance and quality of the included studies. It is organized into inclusion and exclusion criteria. The inclusion criteria were:

- Databases and sources: *SciELO, Google Scholar;* Ministry of Health (MS), Ministry of the Environment (MMA), Oswaldo Cruz Foundation (FIOCRUZ), National Health Surveillance Agency (ANVISA), World Health Organization (WHO), relevant national and international institutional websites, Brazilian government. These sources were chosen in view of their importance, availability and public coverage;
- Records published between 1970 and 2024, due to the fact that the 70s are the initial milestone of Environmental Health and in 2024 the Ministry of Health launched the Surveillance and Health Guide.
- Types of documents: scientific articles, dissertations, theses, manuals, handouts, institutional guides; legislation, reports and technical standards (or similar).
- Approach: articles, theses and review dissertations with a predominantly qualitative approach. In this item, coherence and congruence with the methodological approach of this study was sought.

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- Language: Studies published in Portuguese and/or English, due to the fact that the mother tongue and English are the most used worldwide.
- Thematic relevance: studies that address the main theme of the research according to research descriptors: (Health AND environment) OR (Environmental Health) AND (Surveillance OR public health) AND (chemical contaminants OR environmental contaminants) AND (social determinants of health OR socioeconomic status). Studies with "include" results in *the Robvis*[7] platform (Mcguinness *et al.* 2020). The exclusion criteria were:
- Availability: Studies or documents unavailable in the specified databases or sources. Types of Documents and approach: Publications that do not comply with those defined in the inclusion criteria (experience report, opinion article, quantitative studies, empirical studies, etc.)
- Language: Documents in languages other than Portuguese/or English. Thematic Relevance: Studies that do not present pertinence to the central objective of the research according to descriptors and result "exclude" in *Robvis.*

Or *Robvis* was used only in secondary sources (articles, theses and dissertations) and, as an instrument of evaluative domains *Robvis* (questions) the *Checklist for Systematic Reviews and Research Syntheses* JBI[8].

Other primary sources (technical standards, manuals, handouts, guides, among other similar ones) were not submitted to the Robvis/JBI domains, since their nature consolidates an institutional normative/informative character, it was understood that there was no need for a new evaluative screen.

In the results, the quantum flow of records identified, tracked, and included was illustrated in a Prisma 2020 identification flowchart. Therefore, the records were organized by presenting Rovis traffic light direction in summarized tables and graphs.

The discussions of the results were divided into thematic sections and subsections: HEALTH AND ENVIRONMENT (ENVIRONMENTAL HEALTH); Environmental Health and its Social Determinants; Environmental Health Historical Landmarks; ENVIRONMENTAL HEALTH SURVEILLANCE IN BRAZIL ; Health Surveillance of Populations Exposed to Contaminated Areas; Chemical Contaminants with Environmental Health Surveillance ;

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[7] *Risk of Bias Visualization* : is a visual tool that allows a clear and understandable assessment of the included studies, facilitating the interpretation and presentation of data.
[8] Checklist for systematic reviews and research summaries from the *Critical Appraisal tools for use in Joanna Briggs Institute (JBI) Systematic Reviews*.

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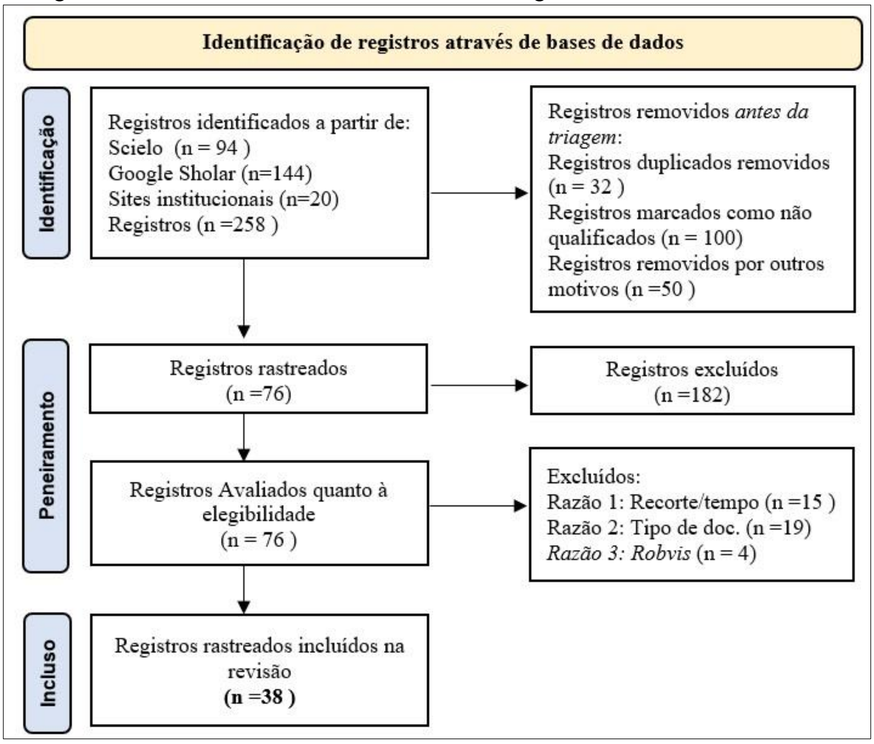
GAPS AND CHALLENGES . In the final considerations, the contributions of the review to the understanding of the social determinants of health and the environmental health surveillance policy and the gaps and challenges found were highlighted.

RESULTS AND DISCUSSIONS: INFERENCE AND INTERPRETATION

The process of tracking the records identified in *Google Scholar, SciELO,* and websites were illustrated in an adaptation of the PRISMA 2020 flowchart (figure), in three phases: initial identification, sifting, and inclusion of the tracked studies.

Figure 1 – flowchart of identification, sieving and inclusion of records.



Source: Prepared by the authors from *PRISMA* (2020).

As can be seen, based on the eligibility criteria, 258 records were identified: 144 from *Google Scholar*, 94 from *SciELO* and 20 from *institutional websites. Before screening, 182 records were removed, 32 duplicates, 100 not* eligible and 50 deleted for other reasons.

Thus, 76 records went to the selection phase by eligibility, of which 15 were excluded due to the time frame, 19 by the type of document and 4 according to the Rovis evaluation. In the end, 38 records were included in the qualitative research

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For data analysis, Bardin's (2016) Thematic Content Analysis was used. This method involves organizing and categorizing data according to its central themes. Thus, the following is a summary and evaluation of the institutions and studies.

Chart 2 – Summary of the institutional data record

Instituição (Ano)	Assunto	Objetivo	Tipo de Documento
1. Organização das Nações Unidas– ONU (1972)	Declaração sobre o Meio Ambiente Humano	Estabelecer princípios para a proteção ambiental.	Declaração Internacional
2. ONU (1992)	Declaração do Rio sobre Meio Ambiente e Desenvolvimento	Promover desenvolvimento sustentável com foco ambiental.	Declaração Internacional
3. Brasil (1988) Constituição da República Federativa do Brasil	Art. 225 *caput*. Meio ambiente	todos têm direito ao meio ambiente ecologicamente equilibrado. Poder Público e sociedade, devem garantir sua integridade	Legislação
4. Comissão Nacional sobre Determinantes Sociais da Saúde –CNDSS (2008)	Causas Sociais das Iniquidades em Saúde	Analisar as causas sociais das desigualdades em saúde no Brasil.	Relatório Técnico
5. Brasil, Ministério da Saúde (2007)	Política Nacional de Saúde Ambiental	Criar uma política para melhorar a saúde ambiental no país.	Política Pública
6. Fundação Oswaldo Cruz – Fiocruz (2009)	Saúde Ambiental no Brasil	Discutir e definir diretrizes para uma política de saúde ambiental no Brasil	Relatório Técnico
7. Brasil, Ministério da Saúde – MS (2010)	Populações sob exposição a contaminantes químicos.	estabelecer diretrizes para identificar e priorizar áreas com populações sob risco de exposição a contaminantes químicos.	Diretriz Técnica
8. Centro de Tecnologia Mineral –CETEM (2011)	Contaminação por Chumbo	Apresentar casos de contaminação por chumbo em diversas regiões do mundo.	Relatório Técnico
9. Brasil, MS (2016)	Risco à Saúde Humana por Contaminantes Químicos	Elaborar estudos de risco relacionados a contaminantes químicos.	Relatório Técnico
10. Brasil, MS (2017)	Vigilância em Saúde de Populações Expostas a Agrotóxicos	Estabelecer diretrizes para a vigilância de populações expostas.	Diretriz Técnica
11. Instituto Nacional de Câncer José Alencar Gomes da Silva – INCA (2017)	Contaminação por Benzeno	Informar sobre os componentes do combustível e seus efeitos na saúde.	Cartilha
12. Fiocruz (2017)	Vigilância em Saúde Ambiental	Estudar práticas de vigilância em saúde ambiental.	Manual
13. Brasil, MS (2018)	Intoxicação Exógena	Orientar sobre como preencher a ficha de investigação de intoxicação.	Ficha Técnica
14. Organização Pan-Americana da Saúde (OPAS)/Organização Mundial da Saúde (OMS) (2020)	Saúde Ambiental	Abordar questões de saúde pública em relação ao meio ambiente.	Relatório de Saúde
15. INCA (2020)	Contaminação por Amianto	Informar sobre os riscos do amianto e suas consequências para a saúde.	Cartilha
16. Brasil, MS (2024a)	Vigilância em Saúde	Fornecer orientações sobre a vigilância em saúde pública.	Guia Técnico
17. Brasil, Ministério do Meio Ambiente (2024b)	Contaminação por Mercúrio	Avaliar a implementação da convenção internacional de Minamata sobre mercúrio.	Convenção Internacional
18. Companhia Ambiental do Estado de São Paulo – CETESB (2024)	Informações Toxicológicas	Oferecer dados sobre riscos tóxicos e ambientais.	Fichas técnicas

Source: Prepared by the Authors, 2024.

The qualitative analysis of the institutional results included was organized in the discussions of the thematic sections and subsections**:** 3.1, 3.1.1, 3.1.2, 3.2, 3.2.1, 3.2.2 and 3.3. As expected, the reliability evaluation of the studies was carried out and results were generated in a traffic light plot (Robvis) illustrated in figure 2.

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Figure 2 – Graph drawn at the traffic light evaluative domains of the studies included in the review.

Source: Elaborate auto hairs from *Robvis* https://www.riskofbias.info/, 2024.

The general analysis of the studies on the traffic light layout in figure 2 showed positive overall compliance. Most studies show high agreement in the criteria evaluated, especially in the domains related to coherence between philosophy, methodology, data interpretation, and conclusion. The predominance of the + symbol (Yes/Include) reflects a general pattern of good methodological quality and theoretical-contextual relevance.

Consequently, the summary of the evaluation studies with *status* + Incluir was made based on their theoretical, historical, and methodological contributions, with emphasis on the interrelationship between surveillance, public health, and exposure to environmental contaminants. Chart 3 was then elaborated according to the objective, method and result obtained by each study/author, as illustrated below.

Chart 3 – Summary of the data record of indexed studies.

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Autor	Objetivo	Método	Resultados	Base
1. **Lacerda (1997)**	Comparar fontes de contaminação por mercúrio: industrial e garimpo de ouro.	Revisão de literatura.	Garimpo de ouro é a maior fonte de contaminação por mercúrio no Brasil.	*SciELO*
2. **Buss (2000)**	Discutir os conceitos de promoção da saúde e qualidade de vida.	Ensaio teórico.	Integração de determinantes sociais e qualidade de vida como pilares para a promoção da saúde.	
3. **Mendes (2001)**	Revisar o conhecimento científico sobre asbesto e suas implicações para políticas públicas.	Revisão de literatura.	Asbesto é associado a várias doenças, exigindo mudanças urgentes nas políticas brasileiras.	
4. **Augusto (2003)**	Discutir a relação entre saúde e vigilância ambiental.	Análise teórica.	Identificação da vigilância ambiental como um campo interdisciplinar em desenvolvimento no Brasil.	
5. **Tavares *et al.* (2004)**	Documentar a construção da Política Nacional de Saúde Ambiental (PNSA).	Relato técnico e histórico.	Avanços na implementação da PNSA, com perspectivas de ampliação das ações intersetoriais.	
6. **Buss; Pellegrini Filho (2007)**	Examinar os determinantes sociais da saúde e suas implicações.	Ensaio teórico.	Destaca a interação de fatores sociais, econômicos e ambientais na determinação da saúde.	
7. **Rohlfs *et al.* (2011)**	Examinar o desenvolvimento da vigilância em saúde ambiental no Brasil.	Análise histórica e teórica.	Evolução significativa na vigilância ambiental, mas com desafios persistentes.	*Google Sholar*
8. **Rodrigues *et al.* (2011)**	Demonstrar a aplicabilidade do SISSOLO entre 2004 e 2010.	Análise documental	5.995 áreas cadastradas, industriais, agrícolas, disposição de resíduos e outras.12 milhões de pessoas expostas. Maioria no Nordeste (38,8 %)	
9. **Ramos (2013)**	Propor uma abordagem interdisciplinar para saúde ambiental.	Revisão teórica.	Sugestões de estratégias interdisciplinares para promover saúde ambiental.	
10. **Barata-Silva *et al. (2014)***	Analisar os impactos do benzeno na saúde pública e os indicadores biológicos de exposição.	Revisão de literatura.	Evidências do impacto do benzeno na saúde pública e limitações dos indicadores biológicos de exposição.	*SciELO*
11. **Gouveia *et al.* (2014)**	Relatar o Projeto Piloto do Primeiro Inquérito Nacional de Populações Expostas a Substâncias Químicas.	Relato técnico e análise de dados.	Evidências preliminares sobre a exposição a substâncias químicas em populações brasileiras.	
12. **Villardi (2015)**	Avaliar o modelo de atuação da vigilância em saúde ambiental no Brasil.	Estudo de caso e análise crítica.	Identificação de lacunas no modelo atual e propostas de melhorias para maior eficácia.	*Google Sholar*
13. **Fernandes *et al.* (2016)**	Comparar respostas institucionais e ações comunitárias em casos de contaminação química.	Estudo de caso bibliográfico Brasil e Portugal.	Contrastes na atuação institucional e na mobilização social frente à contaminação química.	*SciELO*
14. **Bezerra (2017)**	Discutir a vigilância em saúde ambiental no Brasil, suas heranças e desafios dentro das políticas públicas do SUS.	Revisão teórica de normas regulatórias.	A vigilância em saúde ambiental no Brasil tem avançado, mas ainda enfrenta desafios na integração das questões ambientais nas políticas de saúde.	
15. **Souza *et al.* (2017)**	discutir a atuação da Vigilância em Saúde Ambiental (VSA) em relação à agrotóxicos	revisão sistemática da literatura	Necessidade de ampliar a discussão e a pesquisa sobre o impacto dos agrotóxicos no ar para fortalecer a capacidade de atuação da VSA.	
16. **Lopes; Albuquerque (2018)**	Revisar os impactos dos agrotóxicos na saúde humana e ambiental.	Revisão sistemática.	Evidências de impactos severos dos agrotóxicos, sugerindo a necessidade de políticas públicas rigorosas.	
17. **Schifer *et al.* (2018)**	Analisar os aspectos toxicológicos do chumbo.	Revisão de literatura.	Chumbo é altamente tóxico, com efeitos severos na saúde humana, especialmente em crianças.	*Google Sholar*
18. **Campanelli (2022)**	Investigar a relação saúde pública-meio ambiente e o papel do biomonitoramento.	Pesquisa aplicada com revisão teórica.	O biomonitoramento é uma ferramenta eficaz para avaliação e promoção da saúde ambiental.	*SciELO*
19. **Machado *et al.* (2023)**	Explorar os determinantes sociais da saúde e seus impactos no processo saúde-doença.	Revisão bibliográfica	Determinantes sociais desempenham papel central na saúde das populações vulneráveis.	*Google Sholar*
20. **Costa; Silva (2024)**	Analisar o SISSOLO para proposição de ações de promoção e prevenção de agravos à saúde em populações expostas à contaminação do solo.	Análise documental de dados SISSOLO entre 2007 e 2022.	O SISSOLO é uma ferramenta útil, mas a ausência de integração do SISSOLO com outros sistemas de informação dificulta uma análise abrangente e a automação dos dados.	

Source: Prepared by the Authors, 2024.

As for the discussions, the authors were cited according to the previously detailed discussion topics, demonstrating the qualitative analysis of the results in a structured way.

HEALTH AND ENVIRONMENT (ENVIRONMENTAL HEALTH)

Human health is deeply connected to the environment, and the quality of life of populations depends directly on this interaction. Campanelli (2022) explains that the environment is composed of elements such as air, water, soil, fauna, and flora, which can exert positive or negative influences on human health. Ramos (2013) adds that the interaction of the individual with environmental factors (chemical, physical and biological) affects his health and is linked to aspects of social, cultural and economic development.

The relationship between health and the environment in the international context was built over decades and helped to consolidate environmental health as an essential field for human well-being (FIOCRUZ, 2017). In 1972, the United Nations Conference on the Human Environment (UN, 1972), held in Stockholm, Sweden, was an event that highlighted for the first time the need to integrate health and the environment into global policies.

Campanelli (2022) and (FIOCRUZ 2017) also emphasize that human activities have generated significant impacts on the environment. These include changes in land use, accelerated urbanization, overexploitation of natural resources, introduction of invasive species, and climate change, compromising the balance of ecosystems, human and environmental health (PAHO/WHO, 2020).

Faced with this reality, CAMPANELLI (2022) explains that international organizations, such as PAHO/WHO (2020) have broadened their vision by incorporating wildlife and the ecosystem into the approach previously called "*One Medicine*", transforming it into the more comprehensive concept of "*One Health*". Thus recognizing that sustainable development is intrinsically linked to human, animal and environmental health. In this context, Ramos (2013) reiterates that environmental health must adopt an interdisciplinary approach between environment, health, economic and social development.

Environmental Health and its Social Determinants

According to Buss (2000), environmental health is an area of public health that encompasses knowledge, public policies and interventions (actions) aimed at the interaction between human health and the environmental and social factors that determine, condition and influence quality of life. In line with this understanding, add the concept of Social Determinants of Health (SDH) proposed by Buss and Pellegrini Filho (2007) from the perspective of the *Dahlgren and Whitehead* model proposed in the CNDSS reports

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(2008), where in figure 3 we can observe five macrofields that can directly impact the health of a population.

Figure 3 – Social Determinants of Health: *Dahlgren and Whitehead* model.

Source: Buss; Pellegrini Filho (2007).

According to Buss and Pellegrini Filho (2007) and Machado *et al.* (2023) the concept of SDH has been a growing field of study and practice, highlighting the need for a broader approach to health promotion taking into account social, economic, cultural, environmental, social networks, lifestyle, and individual factors such as age, sex, and heredity. Thus, Machado *et al.* (2013) and CNDSS (2008) emphasize that health is directly determined by social and economic conditions, such as the level of education, access to health, working conditions, housing, basic sanitation, food and environmental conditions. It concludes that health cannot be understood only as the absence of disease, but must consider the broader context that involves social and environmental factors.

Environmental Health Historical Landmarks

According to Brasil (2017) and Tavares et al (2004), countries and organizations carried out actions that consolidated the relationship between health and the environment, as illustrated in figure 4:

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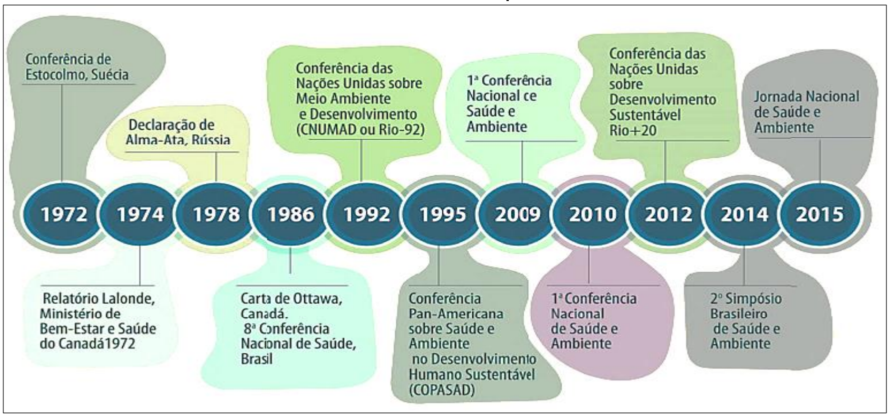
Figure 4 – Historical milestones in the relationship between health and the environment



Source: Brazil (2017).

Outstanding examples of this period include: the Stockholm Conference (UN, 1972); the Declaration of Alma-Ata, in 1978, on Primary Health Care; and the Ottawa Charter, of 1986 (UN, 1992), among others

Tavares *et al.* (2004) also explains that, in Brazil, in 1986, the 8th National Health Conference promoted a debate and systematized changes in the paradigms of health practices, expanding the concept of health to include environmental conditions. That was when the Constitution of the Federative Republic of Brazil (BRASIL, 1986) created the Unified Health System (SUS) and in its Article 200, distributed the connection between health and the environment, defining as one of the attributions of the SUS, "to collaborate in the protection of the environment" (BRASIL, 2007).

Brasil (2016) describes that, in Law No. 8,080/1990, the competence of the SUS is detailed in objectives and responsibilities that strengthen and implement the relationship between health and the environment, especially by determining that basic sanitation and the environment are determinant and conditioning factors of health; collaboration in the protection of the environment, including the work environment; and the integrality of the actions of preventive and curative services, resulting from the integration between the attributions of the Union and the states.

Tavares *et al.* (2004) recalls that two years after the Stockholm Conference (UN, 1972), the Lalonde Report, published by the Canadian Ministry of Welfare and Health, brought an advance by associating the environment as an explanatory factor in the health-disease process, supporting the idea that social and environmental determinants affect public health. The author also explains that, in the same context, in 1978, the Declaration of Alma-Ata, adopted during the Declaration of Alma-Ata, reinforced the concept of health

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as a fundamental human right, including environmental conditions as essential elements for health promotion.

Therefore, Tavares *et al.* (2004) says that in 1986, the Ottawa Charter expanded the vision of health beyond medical care, proposing the creation of environments that favor health, which includes the control of environmental factors that affect populations. Therefore, in 1992, the United Nations Conference on Environment and Development (UN), held in Rio de Janeiro (Rio-92), reinforced the idea of sustainable development and the integration between health and the environment, proposing that countries adopt practices that minimize negative environmental impacts on populations.

According to Rohlfs *et al.* (2011), in 2000, the International Conference on Health and Environment, held in Bangkok, Thailand, emphasized the importance of integrating environmental health into economic development policies, monitoring that environmental determinants can exacerbate social inequalities, especially in developing countries.

Gouveia *et al.* (2014), Rohlfs *et al.* (2011), Tavares *et al.* (2004) and (FIOCRUZ 2017) explain that the period from 2000 to 2015 was marked by efforts to achieve the Millennium Development Goals (MDGs), which, although focused on a broader approach to human development, also included goals for improving health and sanitation.

According to Fiocruz (2009), in 2009 the 1st National Conference on Environmental Health (CNSA) took place in Brasilia, preceded by municipal and state conferences with the purpose of establishing guidelines for an environmental health policy in the country. Certainly, the 1st CNSA created opportunities for Brazilian society to participate in a national debate on environmental health.

According to Fiocruz (2017), the 2030 Agenda for Sustainable Development, adopted by the United Nations General Assembly in 2015, brought the Sustainable Development Goals (SDGs), several of which are directly related to environmental health. SDG 3, for example, aims to ensure healthy lives and promote well-being for all, at all ages, with an emphasis on reducing environmental health risks. SDG 6, which deals with clean water and sanitation, also highlights the importance of access to these essential services for public health (FIOCRUZ, 2017).

In 2021, the World Health Organization (WHO) Health and Environment Report highlighted that 13 million annual deaths could be prevented by improving global environmental conditions, especially in relation to air, water, and soil pollution (BRASIL, 2024a). In this context, Tavares *et al.* (2004) reiterates that global efforts must reflect a

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growing consensus that human health cannot be dissociated from environmental conditions and public policies that integrate the health, environment and social development sectors.

ENVIRONMENTAL HEALTH SURVEILLANCE IN BRAZIL

According to Fiocruz (2017), in Brazil, public environmental health policies seek to mitigate the effects of contracting adverse environmental factors. In this sense, Gouveia *et al.* (2014) and Campanelli (2022) explain that the role of the SUS is not only to treat diseases, but also to act preventively, identifying and eliminating risks that compromise the health of the population. To this end, the country has the National Basic Sanitation Policy and the National Environmental Health Policy (BRASIL, 2007), which aim to reduce environmental risks and provide a safer environment through Environmental Health Surveillance (VSA).

According to Brasil (2024a), VSA focuses on environmental factors that pose risks to the health of the population, with the objective of anticipating and predicting diseases through inspection, control, monitoring, intervention, and communication actions. In this process, Bezerra (2017) explains that VSA works together with the health services and units of the SUS Health Care Network (RAS-SUS), especially with epidemiological and sanitary surveillance, occupational health surveillance, and the network of laboratories and primary care units. In addition, it works in collaboration with agencies of the state and municipal departments of environment, education, civil defense and sanitation.

According to Rohlfs *et al.* (2011) and Tavares *et al.* (2004), VSA uses methods such as the analysis of the environmental health situation, which involves the investigation of social, economic and environmental trajectories and the application of tools with environmental health indicators. Thus, FIOCRUZ (2017) and Brasil (2024a) explain that within the structure of VSA, logistical work takes place through intersectoral health surveillance actions and programs. Among which, we highlight the Health Surveillance of Populations Exposed to Contaminated Areas – VIGIPEQ program (BRASIL, 2024a).

This program aims to monitor populations exposed to chemical contaminants, such as those present in water, soil, air, and biota (FIOCRUZ 2017). It builds on strategic actions that have been detailed in the subsequent section.

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Health Surveillance of Populations Exposed to Contaminated Areas

The variety and quantity of chemical substances used in different countries vary according to the specific characteristics of each nation, such as its economy, industrial sector, and agricultural practices. According to Fernandes *et al.* (2016) each year new substances are synthesized, with about 100 thousand available on the market, and approximately 2 thousand are introduced annually. Souza *et al.* (2017) and Fiocruz (2017) reiterate that many of these substances have toxic potential, posing risks to human health and the environment, especially during the manufacturing, transportation, and disposal processes.

Rohlfs *et al.* (2011) explains that these substances, when released inappropriately, can pollute the air, water, and food, affecting wildlife and altering ecosystems, and can be more harmful to vulnerable groups, such as children, the elderly, and pregnant women. Some of these substances accumulate over time in the body, causing damage that can manifest itself years later.

As reported by Brasil (2007), VIGIPEQ, since 2004, has mapped and monitored populations exposed to contaminants. The methodology used considers parameters such as the proximity of contaminated areas, the vulnerability of the population and the toxicity of the agents present, prioritizing preventive and corrective actions.

The program follows a workflow that takes place with: mapping of exposed or potentially exposed populations; preparation and updating protocols for diagnosis and treatment of poisoning; sensitization of health professionals; structuring of the health system; mandatory notification of suspected and confirmed cases of exogenous poisoning; and collecting data on morbidity and mortality and developing action plans to reduce exposures (BRASIL, 2024a).

Rodrigues *et al.* (2011) and Brasil (2024a) explain that the data supply uses systems such as SINAN (Information System for Notifiable Diseases), SISSOLO (Information System on Contaminated Areas and Soils).

SINAN is a tool for monitoring notifiable diseases and conditions in Brazil, offering data that support prevention and control policies (BRASIL, 2018). It allows consolidating information on public health events, such as exogenous poisonings, communicable diseases and work-related injuries. Although it is partially in the public domain, with access to consolidated data via platforms such as DATASUS, detailed information is restricted to access by municipal, state, and federal networks (BRASIL, 2018).

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SISSOLO, on the other hand, registers and monitors areas contaminated by chemical substances and their exposed populations. It was implemented in 2004 as part of the VSA, with the objective of providing data to guide actions to prevent and control health risks associated with soil contamination (BRASIL, 2024a). The system allows the continuous registration of contaminated areas and the construction of environmental and health indicators, enabling the analysis of the situation in different regions. However, Costa (2024) clarifies that access to SISSOLO is restricted to authorized users.

According to Rodrigues *et al.* (2011) VIGIPEQ, through SISSOLO, registered between 2004 and 2010, 5,995 registered areas and industrial, agricultural, waste disposal and other locations, with a total of 12 million people exposed, the majority (38.8%) in the Northeast region of the country.

In the study by Costa e Silva (2024), which analyzed data from Porto Seguro (2007-2022), an increase in registered areas was observed in recent years, with gas stations representing 84% of the sources of contamination. An estimated 25,750 people are potentially exposed to chemical contaminants, mostly in urban areas. The use of QGIS software allowed the creation of heat maps, highlighting areas of greater risk and facilitating the prioritization of actions.

Thus, Brazil (2024a) emphasizes the centrality in populations living in conditions of vulnerability, mining areas, marginalized urban areas or regions with large sources of industrial and agricultural pollution, as these are the most likely to develop health problems, exacerbated by social and environmental determinants, in this scenario, chemical contaminants are an imminent risk.

Chemical Contaminants with Environmental Health Surveillance

To implement a Health Surveillance System focused on the problems caused by chemical risks, five priority substances with a high risk to the health of the population were selected by the Permanent Commission on Environmental Health (COPESA) and the National Commission on Chemical Safety (CONASQ) (BRASIL, 2024a). The five substances with evidence of high risk to the health of the population are pesticides, asbestos, benzene, lead, and mercury (BRASIL, 2024a). The substances are illustrated in figure 5 below:

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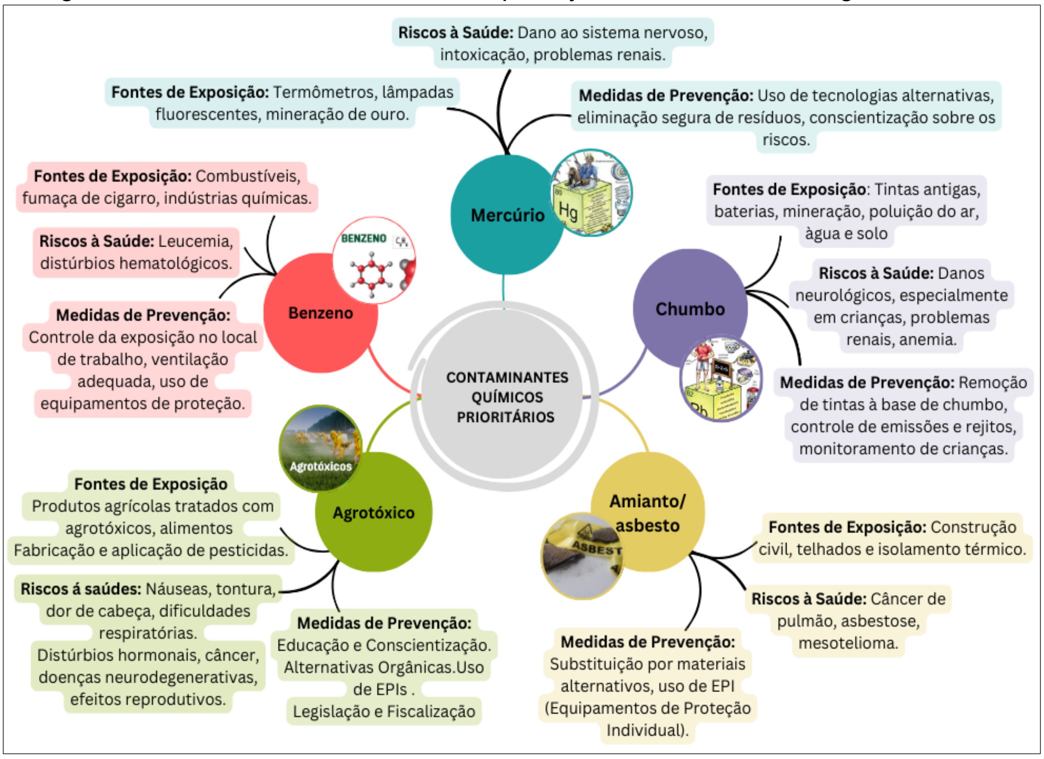
Figure 5 – Chemical substances under priority surveillance due to high health risk.



Source: Prepared by the authors based on Brazil (2024a).

According to Brasil (2016) Pesticides, asbestos, benzene, lead and mercury are priorities in VIGIPEQ due to their high toxic potential and risk to human and environmental health. Pesticides contaminate food and affect workers and consumers; asbestos causes serious lung diseases; benzene is carcinogenic; lead can impair neurological and cognitive development; and mercury, accumulating in the food chain, mainly impacts the nervous system (BRASIL, 2024a).

However, VIGIPEQ does not rule out the occurrence of other contaminants, as the Brazilian territorial extension and local social and environmental peculiarities can reverberate in various contexts. However, this study specifically addressed those identified by VSA, COPESA, CONASQ and VIGIPEQ.

Souza *et al.* (2017) clarifies that pesticides, according to Law No. 7,802 of 1989, are chemical, biological or physical substances used to control harmful organisms, protecting flora and fauna. Its use is common in activities such as agriculture, forest management, and public health. Lee; Albuquerque (2018) clarify that Brazil has become the world's largest consumer of these products since 2008. The variability available in Brazil is significant, as illustrated in Figure 6.

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Figure 6 – Main active ingredients of the most widely used pesticides in Brazil.

Source: Prepared by the authors from Agrofit, MAPA, 2024.

According to Agrofit, the official system of the Ministry of Agriculture, Livestock and Supply (MAPA), several active ingredients are widely used in Brazilian agriculture. Among the herbicides, glyphosate, 2,4-D and atrazine stand out, applied mainly in the control of crops such as soybean and corn.

Lee; Albuquerque (2018) report that in the group of insecticides, acephate, abamectin and chlorpyrifos are used to control caterpillars and stink bugs, among others. Among the fungicides, the most common are mancozeb, thiram and carbendazim, used to control fungal diseases in crops such as soybeans, wheat, coffee, fruits, etc. Other active ingredients are carbofuran, an insecticide used to control soil pests, and paraquat, a non-selective herbicide that was banned in Brazil in 2020 due to its high toxicity. Souza *et al.* (2017) also emphasizes that, in Brazil, several agricultural crops use these pesticides, such as coffee, soybeans, corn, cotton, and pineapple. These crops are essential to the country's economy, but the unregulated use of crops brings serious risks. Rural workers and populations near agricultural areas are exposed to these products, and can suffer from allergies to more serious diseases, such as cancer and neurological problems (LOPES; ALBUQUERQUE, 2018).

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Another substance of concern is asbestos (asbestos), a group of minerals with different chemical and crystallographic compositions, as detailed in the toxicological sheet in figure 7.

Figure 7 – Asbestos (asbestos) toxicological data sheet.

Amianto

Identificação da substância

Nome comum	Fórmula química	Nº CAS	Sinônimos
Amianto		1332-21-4	Asbesto
Crisotila	$[Mg_3Si_2O_5(OH)_4]_n$	12001-29-5	Asbesto serpentina, Asbesto branco
Crocidolita	$[NaFe^{2+}{}_3Fe^{3+}{}_2Si_8O_{22}(OH)_2]_n$	12001-28-4	Asbesto azul
Amosita	$[(Mg,Fe^{2+})_7Si_8O_{22}(OH)_2]_n$	12172-73-5	Asbesto marrom
Antofilita	$[(Mg,Fe^{2+})_7Si_8O_{22}(OH)_2]_n$	17068-78-9	Ferroantofilita
Actinolita	$[Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2]_r$	13768-00-8	-
Tremolita	$[Ca_2Mg_5Si_8O_{22}(OH)_2]_n$	14567-73-8	Ácido silícico; sal de magnésio e cálcio (8:4)

Source: Adapted by the authors from CETESB (2022).

Mendes (2011) explains that there are two main varieties: chrysotile (white asbestos) and amphiboles (such as crocidolite and amosite). Chrysotile is a hydrated magnesium silicate, with flexible, fine, silky fibers, which resist heat and can be easily woven. This variety accounts for the majority of the world's asbestos production. Due to so many properties, asbestos is used in the production of tiles, water tanks, pipes, vessels, friction materials (brake pads, linings, friction discs), joints, seals, floors and coatings, asphalt floors, phenolic resins, waterproofing, plates, and thermal insulators (CETESB, 2022).

Also according to Mendes (2011), asbestos is associated with several diseases, it is classified as carcinogenic to humans. The National Cancer Institute – INCA (2020) informs that the substance is banned in more than 75 countries due to serious health risks, such as asbestosis, lung cancer and mesothelioma. The fibers can be released into the air or water, being highly dangerous, their residues are classified as hazardous (Class D) by CONAMA Resolution No. 348, requiring special disposal (BRASIL, 2016).

Another contaminant present in the daily life of the world's population is benzene (C6H6), an aromatic hydrocarbon, a colorless, flammable, and volatile liquid (CETESB, 2022) as illustrated in figure 8.

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Figure 8 – Benzene (C6H6) toxicological data sheet.

FiT Ficha de Informação Toxicológica

Benzeno

Identificação da substância

Fórmula molecular: C_6H_6 **Nº CAS:** 71-43-2 **Sinônimo:** Benzol

Padrões, valor guia OMS e valores orientadores CETESB

Meio	Concentração	Comentário	Referência[1]
Ar	1,7 µg/m³	Estimativa de risco[2]	WHO, 2000
Solo	0,03 mg/kg* 0,06 mg/kg* 0,08 mg/kg* 0,15 mg/kg*	Valor de Prevenção VI cenário agrícola-APMax VI cenário residencial VI cenário industrial	CONAMA 420/2009
Solo	0,002 mg/kg* 0,02 mg/kg* 0,08 mg/kg* 0,2 mg/kg*	Valor de Prevenção VI cenário agrícola VI cenário residencial VI cenário industrial	Valores orientadores para solo e água subterrânea no Estado de São Paulo- CETESB- DD 125/2021/E
Água potável	5 µg/L	VMP (Padrão de potabilidade)	Portaria GM/MS 888/2021
Água subterrânea	5 µg/L 10 µg/L	VMP (consumo humano) VMP (recreação)	CONAMA 396/2008
Água subterrânea	5 µg/L	VI	Valores orientadores para solo e água subterrânea no Estado de São Paulo- CETESB- DD 125/2021/E
Águas doces	0,005 mg/L	VM (classes 1, 2 e 3)	CONAMA 357/2005
Águas salinas	700 µg/L 51 µg/L	VM (classes 1 e 2) VM pesca/cultivo de organismos (classes 1 e 2)	CONAMA 357/2005
Águas salobras	700 µg/L 51 µg/L	VM (classes 1e 2) VM pesca/cultivo de organismos (classes 1 e 2)	CONAMA 357/2005

Source: Adapted by the authors from CETESB (2022).

Barata-Silva (2014) explains that benzene can contaminate air, water and soil because it is used in the petrochemical industry to produce ethylbenzene, phenol, lubricants, solvents and pesticides, and is emitted by refineries, engines, cigarette smoke and industrial processes. Exposure occurs through the inhalation of contaminated air, in addition to the oral and cutaneous route.

According to INCA (2017) in the body, benzene is metabolized in the liver, causing cell damage and increasing the risk of leukemia and other hematological diseases. Barata-Silva (2014) adds that short-term exposures cause nausea, drowsiness, irritation and mental confusion and prolonged exposure can lead to serious diseases such as aplastic anemia and cancer.

According to Brasil (2024a), among the priority chemical contaminants of VIGIPEQ are also two heavy metals, lead (Pb) and mercury (Hg). Pb is a bluish-gray metal found in the Earth's crust, mainly in the ore galena (lead sulfide). Also according to CETESB (2022), about 40% of lead is used as a metal, 25% in alloys and 35% in chemical compounds, in addition to being widely used in solders, batteries, coatings, cables, glass, pigments and paints.

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It is released into the environment mainly by human activities, such as foundries, battery factories, open-pit mining, and is found in the air in the form of particles that are deposited in the soil and water CETEM (2011). According to Schifer *et al.* (2018), water contamination occurs by industrial effluents and the dissolution of lead-containing pipes. In the soil, its concentration is higher in the surface layers due to atmospheric deposition and incorrect forms of disposal.

Schifer *et al.* (2018) further emphasizes that the main routes of human exposure to lead are inhalation and ingestion. Being highly toxic, lead is not safe to be exposed to, requiring strict control to minimize its impacts on health and the environment, as shown in the toxicological information sheet in figure 9:

Figure 9 – Lead (Pb) toxicological information sheet.


FIT
Ficha de Informação Toxicológica

Chumbo e seus compostos

Identificação da substância

Símbolo: Pb **Nº CAS:** 7439-92-1 (chumbo metálico)
Sinônimos: Metal de pigmento, lasca de chumbo

Padrões e valores orientadores

Meio	Concentração	Comentário	Referência[1]
Ar	0,5 µg/m³*	Padrão de Qualidade do Ar adotado no Estado de São Paulo - MAA	Decreto Estadual nº 59113 de 23/04/2013
Solo	72 mg/kg** 180 mg/kg** 300 mg/kg** 900 mg/kg**	Valor de Prevenção VI cenário agrícola-APMax VI cenário residencial VI cenário industrial	CONAMA 420/2009
Solo	72 mg/kg** 150 mg/kg** 240 mg/kg** 4400 mg/kg** 17 mg/kg**	Valor de Prevenção VI cenário agrícola VI cenário residencial VI cenário industrial VRQ	Valores orientadores para solo e água subterrânea no Estado de São Paulo- CETESB-DD 125/2021/E
Água potável	0,01 mg/L	VMP (Padrão de potabilidade)	Portaria GM/MS 888/2021
Água subterrânea	10 µg/L 100 µg/L 5000 µg/L 50 µg/L	VMP (consumo humano) VMP (dessedentação de animais) VMP (irrigação) VMP (recreação)	CONAMA 396/2008
Água subterrânea	10 µg/L	VI	Valores orientadores para solo e água subterrânea no Estado de São Paulo- CETESB-DD 125/2021/E
Águas doces[2]	0,01 mg/L 0,033 mg/L	VM (classes 1 e 2) VM (classe 3)	CONAMA 357/2005
Águas salinas[2]	0,01 mg/L 0,21 mg/L	VM (classe 1) VM (classe 2)	CONAMA 357/2005
Águas salobras[2]	0,01 mg/L 0,21 mg/L	VM (classe 1) VM (classe 2)	CONAMA 357/2005
Efluentes[2]	0,5 mg/L	VM (padrão de lançamento)	CONAMA 430/2011

Source: Adapted by the authors from CETESB (2022).

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Schifer *et al.* (2018) and CETESB (2022) warn that children are especially vulnerable due to the habit of taking contaminated objects to their mouths and ingesting particles containing Pb. In addition, CETEM (2011) clarifies that Law No. 11,762/2008 limits the presence of lead in paints for children and school use.

Exposure to metal can cause a variety of health effects. In the short term, it can cause anemia, colic, kidney changes, and damage to vitamin D metabolism. In the long term, the damage includes neurological, cardiovascular, renal, and reproductive effects (SCHIFER *et al.* 2018).

Mercury (Hg), in turn, is a highly toxic substance, with extremely worrisome harmful potential. According to CETESB (2022), Hg is a liquid metal that evaporates easily at room temperature, as can be seen in its toxicological file.

Figure 10 – Mercury (Hg) toxicological data sheet.

Mercúrio e seus compostos

FiT Ficha de Informação Toxicológica

Identificação da substância

Mercúrio - sinônimos: mercúrio elementar, mercúrio metálico; símbolo: Hg; Nº CAS: 7439-97-6.

Sais de mercúrio:

Cloreto mercuroso - sinônimos: cloreto de mercúrio (I), calomelano (mineral); fórmula: Hg_2Cl_2; Nº CAS: 10112-91.

Cloreto mercúrico - sinônimos: cloreto de mercúrio (II), cloreto mercúrico, dicloreto de mercúrio, dicloromercúrio, sublimado corrosivo; fórmula: ($HgCl_2$); Nº CAS: 7487-94-7.

Sulfeto de mercúrio - sinônimos: sulfeto de mercúrio (II); cinábrio (mineral); fórmula: (HgS); Nº CAS: 1344-48-5.

Compostos orgânicos de mercúrio:

Metilmercúrio - sinônimo: MeHg; fórmula: CH_3Hg; Nº CAS: 22967-92-6.

Fulminato de mercúrio - sinônimos: fulminato de mercúrio (II); fórmula: $Hg(CNO)_2$; Nº CAS: 628-86-4.

Tiocianato de mercúrio - sinônimos: tiocinato de mercúrio (II); fórmula: $Hg(SCN)_2$; Nº CAS: 592-85-8.

Tiossalicilato de sódio e etilmercúrio - sinônimos: timerosal; etil(2-mercaptobenzoato-(2)-O,S) mercurato (I) de sódio; fórmula: $C_9H_9HgNaO_2S$; Nº CAS: 54-64-8.

Padrões e valores orientadores

Meio	Concentração	Comentário	Referência[1]
Solo	0,5 mg/kg* 12 mg/kg* 36 mg/kg* 70 mg/kg* E[2]	Valor de Prevenção VI cenário agrícola- APMax VI cenário residencial VI cenário industrial Valor de Referência de Qualidade	CONAMA 420/2009
Solo	0,5 mg/kg* 1,2 mg/kg* 0,9 mg/kg* 7 mg/kg* 0,05 mg/kg*	Valor de Prevenção VI cenário agrícola- APMax VI cenário residencial VI cenário industrial VRQ	Valores orientadores para solo e água subterrânea no Estado de São Paulo- CETESB-DD 125/2021/E
Água potável[3]	0,001 mg/L	VMP (Padrão de potabilidade)	Portaria GM/MS/888/2021
Meio	**Concentração**	**Comentário**	**Referência[1]**
Água subterrânea	1 µg/L 10 µg/L 2 µg/L 1 µg/L	VMP (consumo humano) VMP (dessedentação) VMP (irrigação) VMP (recreação)	CONAMA 396/2008
Água subterrânea	1 µg/L	VI	Valores orientadores para solo e água subterrânea no Estado de São Paulo- CETESB-DD 125/2021/E
Águas doces[3]	0,0002mg/L 0,002 mg/L	VM (classes 1 e 2) VM (classe 3)	CONAMA 357/2005
Águas salinas[3]	0,0002 mg/L 1,8 µg/L	VM (classes 1) VM (classe 2)	CONAMA 357/2005
Águas salobras[3]	0,0002 mg/L 1,8 µg/L	VM (classe 1) VM (classe 2)	CONAMA 357/2005
Efluentes[3]	0,01 mg/L	VM (Padrão de lançamento)	CONAMA 430/2011

Source: Adapted by the authors from CETESB (2022).

CETESB (2022) explains that Pb, when released into the air, water, and soil by human activities, can transform and reach a degree of danger due to its numerous properties. For example, when it falls into the water, under the right conditions, it becomes methylmercury, a more toxic version, which causes neurological, heart, lung, kidney and immune system damage.

Lacerda (1997) explains that the main sources of Hg in Brazil are the industry and gold mining. Until the 1970s, most of the mercury released came from industrial activities, such as the production of chlorine soda. On the other hand, from the 1980s onwards, gold mining (with the use of Hg currently illegal) in the Amazon became the largest source of contamination, responsible for about 80% of the total. When used in the reception of gold, it is released into the air, water and soil, causing serious risks to the environment and people's health.

According to the same author, mercury was present in thermometers, barometers and fluorescent lamps. In dentistry, it was an essential component of dental amalgam for restorations. It has also been used in batteries, antiseptics, scientific instruments, mirror production, and catalyst in chemical reactions.

International regulation, such as the Minamata Convention, seeks to reduce or eliminate their use to protect health and the environment. The Convention is an international treaty adopted in 2013, with the objective of protecting human health and the environment from the adverse impacts of mercury, controlling its production, use and emissions (BRASIL, 2024a). The name refers to the environmental and health disaster that occurred in the city of Minamata, Japan, in the 1950s, where the release of mercury into local waters by the chemical industry resulted in mass contamination, causing the "Minamata Disease", severe neurological damage in humans and animals (BRASIL, 2024a). Lacerda (1997) and Brasil (2024b) draw attention to the challenges of controlling these emissions, especially in the Amazon, where fishing, essential for many communities, can amplify the impacts of contamination.

The priority chemicals identified by VIGIPEQ pose a significant risk to the health of the population and the environment. Pesticides expose workers and communities to serious problems, such as cancer and neurological diseases. Asbestos, although prohibited, still requires care due to its association with severe respiratory diseases. Benzene, present in industrial processes and urban pollution, is a known carcinogen.

Heavy metals, such as lead and mercury, accumulate in the body, causing neurological and cardiovascular damage, in addition to contaminating the environment.

GAPS AND CHALLENGES

The literature analysis shows significant gaps in the field of environmental health and chemical contaminant surveillance in Brazil, highlighting structural and operational challenges that compromise the effectiveness of surveillance policies and actions. Understanding health and the environment as interconnected and inseparable aspects is essential for any area of social activity or practice.

Augusto (2003) points out that environmental health cannot be treated in isolation, since it is intrinsically connected to social, economic and environmental factors. In the same perspective, Buss and Pellegrini Filho (2007) highlight that social inequalities, such as poverty and exclusion, intensify the environmental impacts on the most vulnerable populations.

Rohlfs *et al.* (2011) reinforce the need for policies articulated between sectors to face the challenges of environmental surveillance, while Machado *et al.* (2023) underline the importance of integrated, multisectoral approaches to promote health and equity in contexts marked by environmental risks.

In Brazil, systems such as SISSOLO and SINAN play a central role in monitoring and surveillance, but face limitations that compromise their effectiveness. SISSOLO, according to Costa e Silva (2024) and Rodrigues *et al.* (2011), is a relevant tool for mapping contaminated areas and monitoring populations at risk. However, its condition as a closed system, without public access, makes it difficult for researchers and managers to use it. In addition, the presentation of data makes it impossible to automate and integrate with other information systems, such as SINAN, which is essential for an integrated and effective approach.

Villardi (2015) and Gouveia *et al.* (2014) point out that this fragmentation hinders robust analyses and the implementation of comprehensive public policies. Another critical problem is the underreporting of chemical poisoning in SINAN, often caused by the similarity of symptoms with other diseases, which makes diagnosis difficult. Barata-Silva *et al.* (2014) show that this failure hinders the planning of preventive interventions.

While the impact of substances such as benzene, asbestos, and mercury is widely documented, lead still lacks significant attention. Schifer *et al.* They point out that activities

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such as foundries and battery manufacturing continue to release waste of this heavy metal into the environment. This scenario requires more rigorous monitoring of emission sources and their impacts.

Brazil's territorial extension and regional diversity are other challenges. The vastness of the territory, associated with climatic and social differences, makes it difficult to collect data and implement surveillance actions. Lacerda (1997) exemplifies this issue with mining in the Amazon, which remains one of the main sources of mercury contamination, but faces difficulties in monitoring due to limited infrastructure and the crime linked to this type of extraction. These barriers make populations in remote areas, such as indigenous and riverine people, even more vulnerable to the impacts of contamination (Campanelli, 2022; Rodrigues *et al.*, 2011).

The absence of georeferencing in the data made available by the Ministry of Health is another important obstacle. Costa and Silva (2024) show, in a study carried out in Porto Seguro, that the use of tools such as QGIS can facilitate the creation of heat maps and the identification of critical areas. However, the lack of public access to detailed data compromises the replication of similar initiatives in other parts of the country.

In addition, social and economic inequalities amplify the impacts of contamination. Buss and Pellegrini Filho (2007) highlight how poverty and social exclusion intensify the risks for vulnerable populations, while Bezerra (2017) reinforces that these inequalities hinder the inclusion of these communities in public policies, perpetuating cycles of exposure and exclusion.

Finally, the quality of the data collected is still a significant challenge. Gouveia *et al.* (2014) identify inconsistencies in the available information, often caused by the lack of rigorous validation. Campanelli (2022) highlights that data on biomarkers of exposure are essential to understand and mitigate the impacts of contamination, but they are still scarce in Brazil.

Overcoming these gaps requires investments in technology, systems integration, and training of professionals, in addition to the implementation of greater transparency and accessibility to data. Ramos (2013) highlights that community participation is essential to engage society in the monitoring and mitigation of environmental risks. An integrated and collaborative approach is essential to strengthen surveillance and ensure the protection of public health in an equitable and effective manner.

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FINAL CONSIDERATIONS

Environmental health is an interdisciplinary field that integrates social, economic, and environmental factors in promoting better living conditions for the population. In Brazil, Environmental Health Surveillance (VSA) and the National Health Surveillance Program for Populations Exposed to Chemical Contaminants (VIGIPEQ) play a central role in identifying, monitoring, and mitigating risks associated with chemical contaminants, especially in vulnerable regions and populations. These efforts emphasize the importance of intersectoral public policies that address not only health but also the impact of inequalities

The study highlighted the relevance of tools such as SINAN and SISSOLO for monitoring environmental conditions, although it identified important limitations, such as data fragmentation, underreporting of cases, and lack of integration between systems. These frameworks undermine the effectiveness of surveillance challenges and require greater investment in technology, training of professionals, and strategies to facilitate public access to surveillance challenges.

Brazil's territorial and climatic diversity, combined with social inequalities, intensifies the impacts of chemical contaminants, such as pesticides, asbestos, lead, mercury, and benzene, on vulnerable groups. Populations in remote areas, such as indigenous and riverine communities, face aggravated risks due to the precariousness of services and infrastructure. In this sense, the use of georeferencing technologies and the expansion of the reach of surveillance policies are urgent measures to overcome these gaps

Finally, the integration between public health, environmental sustainability, and community participation is essential to strengthen the confrontation of environmental health challenges in Brazil. Investing in collaborative and intersectoral solutions, combined with transparency and access to information, is essential to ensure the protection of human health and the preservation of the environment in an equitable and sustainable manner. This study contributes to the debate by emphasizing the need for articulated strategies that promote equity, safety, and efficacy in wakefulness actions

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