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Approaches to water springs in literature: a systematic bibliographic review

Abordagens sobre nascentes de cursos de água na literatura: uma revisão bibliográfica sistemática

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ABSTRACT: The protection, conservation, evaluation, and monitoring of natural water sources are the basis for Integrated Water Resources Management and Planning, including *spring water* sources which have special importance for the ecosystem services provided. The definition of spring water in scientific literature is characterized by imprecision and subjective interpretations. The term "spring" is included in the Brazilian environmental legislation. It needs to be structured by involving the different areas of knowledge that study them since the applicability of legal penalties established in environmental laws depends on its correct understanding. This research aimed to identify and analyze the information available in academic-scientific literature, as well as in non-scientific materials or documents related to spring water, for characterizing the main approaches currently applied to this topic. The methodology was based on a Systematic Literature Review (SLR) developed through three stages: 1. SLR planning; 2. research processing; and 3. expected results. These steps frame the Input-Processing-Output system, which is intended to guarantee the consistency of the data collected with the review's objectives to identify, describe, and analyze the scientific literature on the subject in a simplified and organized way. The articles and documents consulted were filtered and classified according to their relevance and relationship with the topic. Also, it formulated some categories to group all the references according to the main approaches. 1.216 articles and 960 materials/documents were checked, and 102 references were finally chosen. It was identified that the physical-chemical and microbiological monitoring and assessment of surface water quality had the highest number of associated results, showing an academic priority in seeking ways to ensure human water supply, disregarding all ecological and environmental functions that spring water has.

Keywords: systematic search; integrated water resources management; Academic Search Premier; Google Scholar.

RESUMO: A proteção, conservação, avaliação e monitoramento das fontes naturais de água constituem a base para a Gestão Integrada de Recursos Hídricos e o planejamento de bacias hidrográficas, sendo as nascentes fontes de água de especial importância pelos serviços ecossistêmicos prestados. A definição do termo nascentes na literatura cientifica se caracteriza pelas imprecisões e interpretações subjetivas. O termo nascente, por estar inserido nas legislações ambientais, precisa estruturar envolvendo as diferentes áreas de conhecimento que as estudam, pois do seu correto entendimento depende a aplicabilidade das penalidades legais estabelecidas nas normas ambientais. O objetivo desta pesquisa foi identificar e analisar a informação disponível na literatura acadêmico-científica, assim como em materiais/documentos não científicos, relacionada à temática de nascentes de cursos d'água, caracterizando as publicações e analisando as abordagens que atualmente direcionam as pesquisas sobre esse assunto. Para isso, foi desenvolvida uma Revisão Bibliográfica Sistemática (RBS) em três etapas: 1. planejamento da RBS; 2. processamento da pesquisa; e 3. resultados esperados. Essas etapas conformam o sistema Entrada-Processamento-Saída que pretendeu garantir a coerência dos dados coletados com os objetivos da revisão, a fim de identificar, descrever e analisar de forma simplificada e organizada a literatura científica sobre o assunto. Os artigos e documentos consultados foram sendo filtrados e posteriormente classificados de acordo com sua pertinência e relação com a temática, foram formuladas algumas categorias para agrupar as principais abordagens das pesquisas analisadas. No total, foram consultados 1.216 artigos e 960 materiais/documentos, sendo finalmente escolhidas 102 referências. Identificou-se que a categoria de monitoramento e avaliação físico-química e microbiológica da qualidade da água superficial foi a que teve maior número de resultados associados, mostrando que existe uma prioridade acadêmica em buscar formas de garantir o abastecimento humano de água, desconsiderando todas as funções ecológicas e ambientais que as nascentes possuem.

Palavras-chave: busca sistemática; gestão integrada dos recursos hídricos; *Academic Search Premier*; Google *Scholar*.

1. Introduction

The imprecise definitions of the term "headwaters" have become an important discussion among researchers, due to subjective interpretations that bring out inconsistencies and gaps, hindering the advancement of science and even influencing decision-making processes in water resource management.

The use of the same term associated with different perceptions and interpretations in multiple spheres, which encompass colloquialism, regionalism, and technical-scientific discussions, is a major challenge because when all those involved do not consider that the same attributes correspond to a concept, divergences in understanding and interpretation arise, making it difficult to contribute, apply and/or carry out actions for that specific topic (Felippe & Magalhães, 2013; Queiroz, 2015).

In national and international academic literature, there is little discussion of the source of a body of water, based on the assumption that it is something simple, when in reality, there is a great deal of confusion, even among the group of researchers who study them. Most studies on springs focus on the physical-chemical and microbiological characterization of the water that emerges, monitoring and studying its dynamics without even needing a concrete definition (Felippe, 2009; Felippe & Magalhães, 2009).

Environmental issues are usually approached from a multidisciplinary perspective, and studies on springs are no exception. However, the development of this concept does not follow this approach, resul-

ting in the creation of a series of isolated interpretations that only work for the field of knowledge in which each researcher is inserted. Thus, between the different areas involved (geology, geomorphology, biology, ecology, hydrology, and hydrogeology), there are different perspectives on the same subject, turning what could be an advantage of scientific interconnection into conceptual divergences that generate imprecision (Felippe & Magalhães, 2013).

The importance of concretizing the concept of springs is related to its use in the technical-scientific context, mainly due to environmental legislation that addresses it and establishes legal penalties for infringing them. In this sense, fair supervision of the scope of these stipulated rules will depend directly on the clarity with which the concept is treated, and the application of mixed terms in the legal sphere results in a problem that transcends from the conceptual to the practical (Rodrigues *et al.*, 2020). However, as a promoter of knowledge in society, the scientific community has a responsibility to help build, communicate, and disseminate this concept from the different areas involved.

One factor that hinders conceptual standardization and the collection of international bibliographical references on the subject of springs is the lack of correspondence of the term in other languages. In English-language literature, the equivalent term for *nascente* is *spring* or *springfed*, which has two different meanings when translated into Portuguese: the first and most common is *primavera* (season), and the second is *nascente* or fonte. In Spanish, we use *manantial*, *nacederos*, or *nacimientos*, which are equally ambiguous terms. In French, *source d'eau* means source of water, and in German and Italian, the terms used – *quelle* and *fonte*, respectively – correspond to the source in Portuguese. Therefore, only in Portuguese is it possible to conceptually differentiate the term "*nascente*", which describes the birth, origin, emergence, or appearance of water on the earth's surface. This means that research and studies carried out by researchers in different regions are fragmented and isolated, making it difficult to share scientific experiences (Felippe & Magalhães, 2013).

A more appropriate concept of the term springs in the scientific sphere was presented by Fitts (2002), who defines them as the place where groundwater rises above the surface of the ground, with two relevant aspects:

1. the word local is synonymous with place or site, which even abstractly implies the existence of an area or space (Felippe & Magalhães, 2013); and
2. the word aflorar, indicates the interception of the aquifer by the land's surface, with groundwater migrating to surface water via the spring.

In hydrology and hydrogeology, one of the most common classic concepts is that of Davis & De Wiest (1966, p. 63), who consider that "any natural surface water discharge large enough to form a small stream can be called a spring". This definition continues to be used today with some adaptations. For example, Bonacci & Andrić (2015, p. 2) conceptualize it as "the natural and concentrated discharge of groundwater with a velocity high enough to maintain the flow at the surface". Both concepts coincide in the need to maintain the flow, forming a channel downstream from the source, and this characteristic is an attribute of the concept that has remained constant over the years. However, Bonacci & Andrić (2015) recognize the existence of different types of flow, citing those springs can be perennial or intermittent. The authors also relate this last type to the dependence of the flow on the season.

In the Brazilian legal sphere, Federal Law 12.651/2012 defines spring as a "natural outcropping of groundwater that is perennial and gives rise to a watercourse" (BRASIL, 2012; Art. 3, XVII). The law also differentiates the concept of a waterhole, defining it as "a natural outcrop of groundwater, even if intermittent" (BRASIL, 2012; Art. 3, XVIII). These concepts are considered official because they are in legislation and will be applied in Brazilian environmental practice, such as in licensing projects, inspection activities, and environmental impact studies. However, this segregation of terms disagrees with scientific literature. It makes protecting and conserving springs more complex, especially in semi-arid environments, where flows (underground and surface) are often temporary. In this research, springs are considered elements of the natural environment configured from a set of processes involving everything from hydro-geological dynamics to geomorphological, climatological, ecological, and anthropogenic aspects of the landscape. They function as an environmental system in which groundwater spontaneously emerges temporarily or perennially, forming a small stream downstream that will contribute to the volume of water in another watercourse.

In national and international scientific literature, the concept of springs comprises different attributes or characteristics that depend on the academic background of each researcher. For this reason, it is necessary to establish the existing directions and approaches through a Systematic Bibliographic Review (SBR), which makes it possible to find, analyze and evaluate as many qualities of bibliographic references as possible to build the theoretical basis from a scientific and structured perspective (Kitchenham & Charters, 2007). It is essential to generate reflection in the scientific community on the need to promote interdisciplinarity in research associated with springs, avoiding the directing of resources, materials, and technical efforts toward water quality diagnoses, as this disqualifies the real state of conservation and disregards the ecological, environmental and social functions of springs as an environmental system.

With this in mind, this research aimed to identify and analyze the information available in academic-scientific literature, as well as in non-scientific materials/documents, related to the subject of watercourse springs, characterizing the publications and analyzing the main concepts and approaches that currently guide research on this subject, to identify the needs for scientific improvement.

2. Material and methods

The methodology used to find out about and select the studies related to the subject of watercourse springs was the Systematic Bibliographical Review (SBR), through which the bibliographical references found were identified, described, and analyzed in a simplified and organized manner. According to Conforto *et al.* (2011), this methodology is exploratory, as it allows the discovery of intuitions and thoughts that enrich and support new theories. However, for the results to be satisfactory and represent an advance in scientific knowledge, they must be conducted in a structured and rigorous manner.

Sampaio & Mancini (2007) state that the Systematic Bibliographic Review (SBR) is a methodology that summarizes the evidence related to a specific intervention strategy by applying

explicit and systematized methods of searching, critical appraisal, and synthesis of information. It is important for its efficiency to correctly define the keywords, fields, search modes, limits of the results, and journals, among other preliminary data. Thus, by carrying out the SBR, it is possible to analyze the existing information on the subject of springs, allowing articles and documents to be identified and categorized.

The Systematic Bibliographic Review was developed considering the three stages proposed by Biolchini *et al.* (2005), Conforto *et al.* (2011), Kitchenham *et al.* (2009), and Levy & Ellis (2006), which correspond to:

i) RBS inputs or planning;

ii) processing or executing the research (knowing the literature, understanding the literature, applying, analyzing, synthesizing, evaluating); and

iii) expected outputs or results. These steps make up the Input-Processing-Output system on which the SBR is based, whose function is to ensure that the data collected is consistent with the initial objectives of the review.

The Systematic Bibliographic Review was developed with the following specific objectives:

A. To carry out a survey of scientific works and information of different types on the subject of springs, through which indicators, tools, or instruments for their evaluation, conservation, monitoring, management, and/or use are proposed, applied, or modified;

B. To identify the main approaches of scientific productions in the last ten years on springs, classifying the information gathered into categories.

2.1. Search strategies

The SBR was conducted using the advanced search tool available on the Academic Search Premier database platform of EBSCO Information Services, chosen after a preliminary exploratory review in which articles related to the topic were identified. The search strategies defined for the execution of the SBR were:

• Language - English.

• Period - the search was carried out over nine years (2008 - 2017);

• Number of fields - SBR was developed using a maximum of three fields joined by the "AND" logical operator and up to nine fields joined by the "NOT" logical operator;

• Search type - the search type selected was abstract;

• Type of document or publication - all types were considered (magazines, newspapers, books, primary source documents, and educational reports);

• Definition of keywords for SBR - the keywords were classified into two groups:

1. group A (objective a) related to the search for indicators, tools, and/or instruments for the evaluation, conservation, monitoring, management, and use of watercourse springs; and

2. group B (objective b) aimed at researching relevant criteria and aspects for determining the environmental conditions of watercourse springs.

Table 1 shows the keywords adopted and used to develop the SBR.

TABLE 1 - Keywords for the Systematic Bibliographical Review on watercourse springs.

Database field 1		Database field 2	Database field 3
Group A	**Group B**		
Indicators	Aspects	Assessment	Springs
Tools	Criterion	Evaluation	Water Springs
Instruments		Conservation	Spring-fed
Protocol		Management	
		Monitoring	
		Use	

SOURCE: Prepared by the author (2021).

However, the search was carried out according to all the possible associations between the keywords (*Strings*[1] search established for each field in Table 1, for both objective A and objective B). In total, 72 and 38 strings were formed, respectively, for each of the SBR objectives.

2.2. Complementary search for references on Google and Google Scholar

Google and Google Scholar were used to search for references in non-scientific sources of information on a national scale. The keywords were written in Portuguese, and the analysis was limited to the first 30 occurrences in the last ten years. The use of Google was necessary due to the importance of incorporating non-scientific documents into the research, such as news, web pages, reports, and handouts, among others, which deal with subjects related to the theme, including presenting tools or instruments for the evaluation, conservation, monitoring, management and/or use of watercourse springs. Google Scholar, on the other hand, allowed us to search for scientific papers (complete or abstracts) developed mainly in Brazil, which were published on university platforms, scientific journals, or proceedings of national scientific events. The keywords adopted and used are shown in Table 2.

TABLE 2 - Keywords for Google and Google Scholar searches on watercourse springs.

Group A	Group B
Source indicators	Nascent aspects
Indicators water sources	Aspects of water sources
Source tools	Source criteria
Water source tools	Water source criteria
Nascent instruments	
Water source instruments	
Source indices	
Water source indices	
Springs protocol	
Water sources protocol	
Use of springs	
Use of water sources	

SOURCE: Prepared by the author (2021).

2.3. Preliminary analysis of the title, keywords, and abstract of the papers found

The first condition for identifying and selecting the articles was to check that they had access to the complete file in PDF format, which was an eliminatory criterion. After this, the requirements presented in Table 3, which acted as criteria for Filter 1, were evaluated to select the references, resulting in a list of pre-approved works. As this was the first Filter, these requirements did not include an integrated assessment of the spring as an environmental system, and articles with a more simplistic or specific approach to assessing just one environmental condition were accepted.

[1] The search *strings* or expressions are defined by identifying keywords and terms related to the subject of the search, using logical operators commonly implemented in advanced searches (Conforto *et al.*, 2011).

TABLE 3 - Requirements for the preliminary identification of the papers researched on the subject of watercourse springs.

Requirement 1	Requirement 2	Requirement 3
The title, abstract, or keywords indicate that the work refers to the assessment, conservation, monitoring, management, and/or use of springs.	The title, abstract, or keywords indicate the proposal or application of indicators, tools, and/or instruments for the evaluation, conservation, monitoring, management, and/or use of springs.	The objective of the work, defined in the abstract, focuses on the evaluation, conservation, monitoring, management, and/or use of springs.

SOURCE: Prepared by the author (2021).

2.4. Analysis of the introduction and conclusion of pre-approved works

The introduction and conclusion of the pre-approved works were studied, considering the requirements presented in Table 4. This second analysis (Filter 2) yielded a list of articles and documents in which the main aspects and criteria for determining the environmental conditions of springs were studied and discussed and texts in which various indicators, tools, and/or instruments are proposed or applied for this same purpose. In this case, the requirements for Filter 2 were drawn up considering the view of the spring as an environmental system. Identifying approaches or approaches related to integrated assessment was necessary to approve the articles.

The RBS processing described above is summarized and illustrated in Figure 1.

2.5. Formulating categories and classifying articles and documents

Using the analysis carried out in the SBR processing as a basis, categories were drawn up to classify the selected works. These categories were proposed as the articles were analyzed, making it possible to identify and group together the main approaches that currently guide research on springs and to determine the need to produce scientific knowledge on this subject. The Mendeley Desktop reference management software recommended by Conforto *et al.* was used to organize the articles and documents. (2011) and Excel® 2016 to prepare the tables compiling the results.

TABLE 4 - Requirements for identifying the papers to be analyzed on watercourse springs.

Requirement 1	Requirement 2	Requirement 3
The paper presents a tool, instrument, or indicator for the integrated assessment, conservation, monitoring, integrated management, and/or sustainable use of springs.	The introduction to the study presents theoretical information and an objective related to the integrated assessment, conservation, monitoring, integrated management, and/or sustainable use of springs.	The conclusions show methodological processes and relevant results for integrated assessment, conservation, monitoring, integrated management, and/or sustainable use of springs.

SOURCE: Prepared by the author (2019).

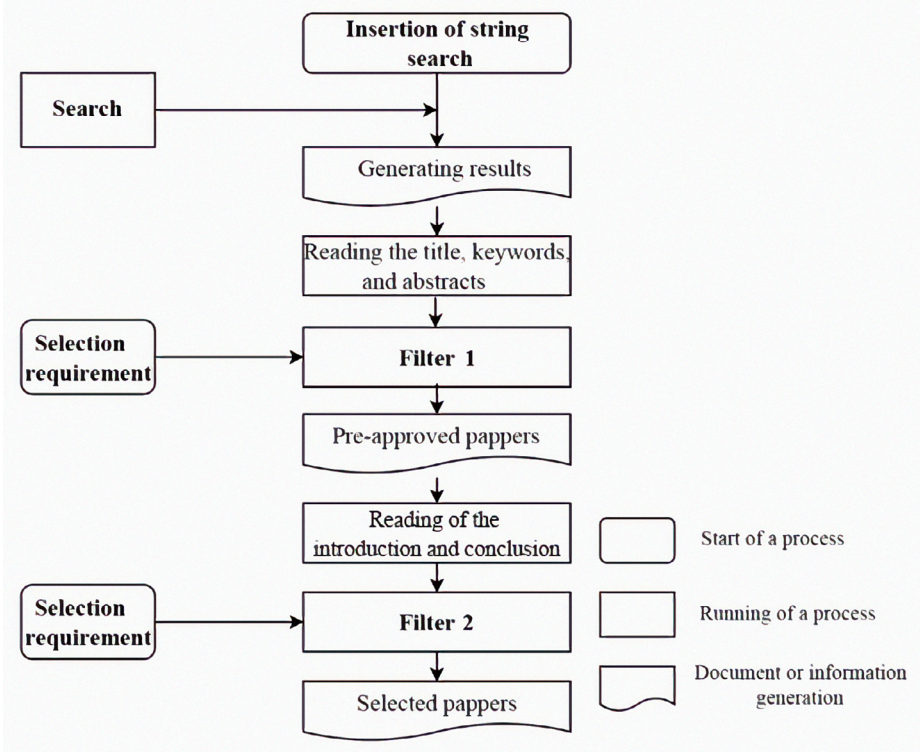

FIGURE 1 - Summary of the processing of the Systematic Bibliographic Review.
SOURCE: Prepared by the author (2021).

3. Results and discussion

Preliminary analysis of the title, keywords, and abstract made it possible to determine which of the papers resulting from the search for each keyword were related to themes such as assessment, conservation, monitoring, management, and/or use of springs.

The total number of results obtained using the previously established set of keywords was 1,216 articles, of which 1,097 resulted from the keywords in group A (indicators, tools, and instruments) and 119 from those in group B (aspects and criteria). The 1,216 articles were analyzed by reading the title, keywords, and abstract, and the three requirements set out in Filter 1 (Table 3) had to be met for them to be pre-approved, of which approximately 91% were not approved, and 9% were approved.

The number of approved articles seems low compared to the total results. However, due to the specific nature of the subject studied and the selection requirements established to find articles that were relevant and consistent with the research objective, it is considered a significant number that indicates the relevance of this subject to the scientific community. It is important to clarify that the category "repeated pre-approved works"

corresponds to those approved for two or more strings, which have been counted as "pre-approved selected" only once.

The three requirements established in Filter 1 (Table 3) were analyzed individually, with Requirement 1 being the most achieved (51% of the works) and Requirement 2 having the lowest percentage. As a result, only 13% of the articles are directly related to the proposal or application of indicators, tools, and/or instruments for determining the environmental conditions of springs, and it is necessary to promote innovation in methodologies for the integrated study of springs as environmental systems.

In addition, the evolution of publications from 2008-2017 was analyzed. Figure 2 shows that, although it is not possible to establish a trend in publications on watercourse springs, which occurred randomly over the period studied, comparing only the years 2008 - 2017 shows an increase of more than 100%, which indicates a growing interest in studying and disseminating information on this subject.

According to the nationality in which each of the 108 pre-approved articles was published (Filter 1), the United States topped the list with 16 papers, followed by Italy, which had eight publications. In South America, Brazil was the only country with publications related to this topic, with five papers published.

After reading and analyzing the introduction and conclusion, the pre-approved papers were classified according to the objective, the theoretical basis of the work, and the final considerations on the methodology and results. Table 5 shows the relationship between the categories drawn up and the number of pre-approved works falling into each.

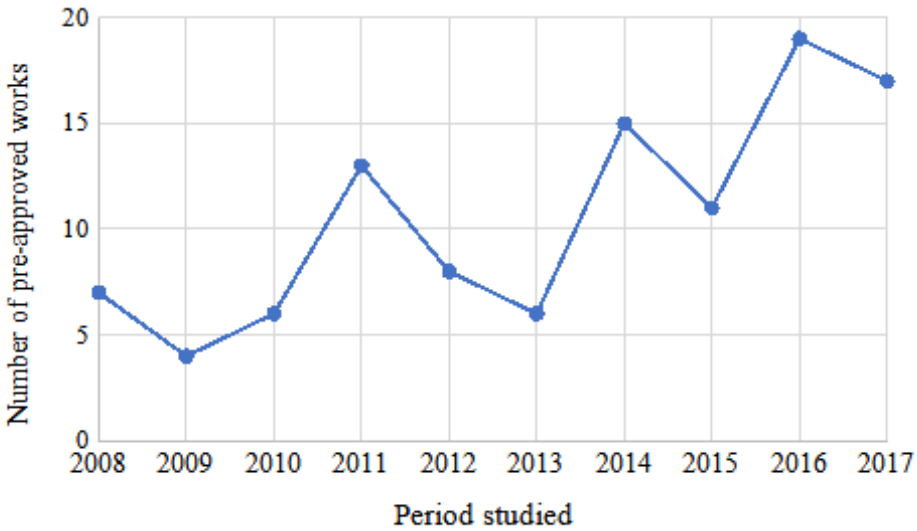

FIGURE 2 - Pre-approved publications over the study period of the Systematic Bibliographic Review on the subject of watercourse springs.
SOURCE: Prepared by the author (2021).

TABLE 5 - Classification and categories of the pre-approved papers in the Systematic Bibliographical Review on watercourse springs.

Elaborated categories	No. of related papers
Monitoring and physical-chemical and microbiological assessment of surface water quality	54
Remote sensing and geoprocessing as a technique for environmental analysis in spring areas	18
Monitoring aquifers and groundwater quality	10
Geochemical studies related to hot springs and aquifers	8
Diagnosis and environmental characterization of the conditions of watercourse springs and their Permanent Preservation Areas (PPAs)	4
Study of the geological conditions of springs and aquifers	4
Use of bioindicators for environmental assessment of springs and other water bodies	4
Geological conditions and water quality in springs in icy regions	3
Geological conditions for the formation of wetlands	2
Applying strategies to recover springs	1

SOURCE: Prepared by the author (2021).

Half of the papers approved had as their main theme the monitoring and physical-chemical and microbiological evaluation of spring water, which indicates a strong trend in scientific production related to determining water quality conditions. This is justified by the need for information to help solve the various challenges related to sanitation and public health problems. However, the repetitiveness of research in the same area affects the dynamism of science. It reduces the data supply to develop integrated studies, making it necessary to explore new knowledge and fill the gaps in scientific production.

In this sense, it is suggested that studies on environmental sciences use methodologies that go beyond the characterization and description of the various problems, whether specific or global, to analyze why these problems exist and persist in proposing ways and mechanisms that lead to solutions. The assessment and monitoring of springs require a more holistic understanding of their ecosystem and environmental functions, which are linked to the origin of the watercourses and the shaping and integration of a dynamic environmental system in these places.

Analysis of the introduction and conclusion of the pre-approved papers made it possible to re-evaluate and filter the articles, defining those that considered the systemic vision of Integrated Water Resources Management. To do this, it was necessary to check whether the most important aspects of the methodology and results were directly related to the processes of integrated assessment, conservation, monitoring, integrated management, and/or sustainable use of springs. In addition, a more detailed study of the works allowed us to identify those that propose or apply indicators, tools, or instruments concerned with methodological innovation and not just the description and characterization of results. Of the total number of papers evaluated (108 articles), 28% (30 articles) were identified with content on integrated management of springs, showing that of the 1,216 articles, only 30 incorporate methodological proposals and/or comprehensive discussions that allow effective interpretation of the environmental problems related to this issue. In this

sense, it showed the limitation of research aimed at characterization or long and intense evaluations of specific parameters that do not make it possible to generate comprehensive conclusions or propose solutions to global impacts. The authors of this paper suggest that scientific and technical studies on springs should focus on other aspects and contents that undoubtedly influence the environmental dynamics of the system, including geological, geomorphological, climatological, forestry, pedological, landscape, biotic, and even social and cultural variables. This positioning should be seen as an opportunity to explore new possibilities in developing knowledge, consolidating and improving all springs' theoretical and practical backgrounds and their various forms of assessment, conservation, and management.

It is important to point out that the classification by category of the pre-approved papers described in Table 5 already showed this trend, indicating that scientific production on springs is focused on generating and recording data in the area of physical-chemical and microbiological assessment of surface water quality and that this is mistakenly presented as environmental monitoring of springs.

The results of the complementary search were evaluated based on the work's title for pre-approval, taking into account the same requirements established in Filters 1 and 2 (Tables 3 and 4). The choice based solely on the title is justified by the limitations of these platforms (Google Scholar and Google), which do not allow access to the abstract without downloading the full paper.

As a result, 216 papers were pre-approved by analyzing the title on Google Scholar. It should be emphasized that the complementary search was carried out to study scientific production on springs at a national level, and it can be inferred that there is great interest in studying this subject in Brazil. However, it is still necessary to assess these studies' focus and main results.

Taking into account the results of the preliminary selection phase, it was possible to infer that the works identified, in addition to being related to the processes of assessment, conservation, monitoring, management, and use of springs, also indicated scientific production related to the proposition or application of indicators, tools or instruments.

On the other hand, the results of the Google search showed that the highest percentage of papers identified was in the category of repeated and unavailable papers, which is justified by two assumptions: firstly, Google is not a scientific database that can be registered on university platforms and, therefore, does not grant free access to researchers, so there are limitations to finding complete works; secondly, Google has a tool called Rankbrain launched in 2015 that has the function of providing artificial intelligence, capable of learning from the searches made by the user and, thus, presenting better results according to the recurrence of their searches, therefore, when using similar keywords in the search, the repeated results increased (SEARCH LAB, 2017).

The individual assessment of the requirements for pre-approval showed that, of the 84 pre-approved results, only 31 were related to the application or proposal of indicators, tools, or instruments, inferring that the complementary search on Google resulted in descriptive information on the issues related to determining the environmental conditions of watercourse springs, with few methodological proposals (of indicators, tools and/or instruments) being identified.

The pre-approved results were classified by document type, showing the different sources of information (academic and non-academic). Figure 3

shows this comparison, in which, although scientific sources (articles, theses, dissertations, and Course Conclusion Papers) still prevail, there is evidence of the existence of other types of bibliographic references, such as documents/reports and *applications/software*.

The 216 pre-approved results were classified by category, as shown in Table 6. It can be seen that the predominant category continued to be the physical-chemical and microbiological monitoring and evaluation of surface water quality, indicating that Brazil is also following this worldwide trend of specific scientific productions focused on a technical approach that is not very comprehensive, insufficient for generating conclusions and proposing effective solutions. As Brazil is a developing country, extremely rich in biodiversity and natural resources, it is necessary to promote research aimed at optimizing strategies and processes for environmental conservation and protection that will enable it to stand out worldwide in this area, to improve the population's quality of life.

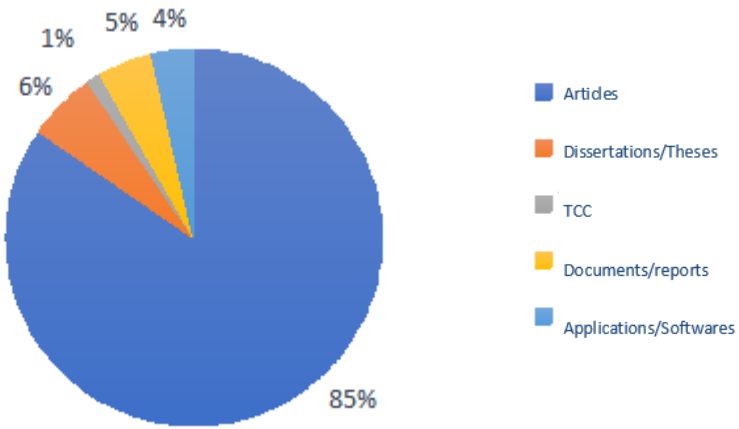

FIGURE 3 - Percentage of types of literature consulted on Google Scholar and Google on watercourse springs.
SOURCE: Prepared by the author (2019).

TABLE 6 - Classification of pre-approved works by categories identified in Google Scholar and Google on watercourse springs.

Categories defined	No. of papers
Monitoring and physical-chemical and microbiological assessment of surface water quality	127
Diagnosis and environmental characterization of the conditions of watercourse springs and their Permanent Preservation Areas (APPs)	47
Monitoring aquifers and groundwater quality	14
Applying strategies to recover springs	8
Remote sensing and geoprocessing as a technique for environmental analysis in spring areas	6
Study of the geological conditions of springs and aquifers	5
Use of bioindicators for environmental assessment of springs and other water bodies	5

SOURCE: Prepared by the author (2019).

The analysis of the introduction and conclusion of the pre-approved articles, carried out using Filter 2 (Table 4), resulted in 55 selected papers, corresponding to 25%, significantly more than the final number of articles selected using the RBS developed in Academic Search Premier. In this second phase of the RBS, 17 articles (20%) were identified on Google, showing fewer existing works from the three sources used. This is due to the difficulty of accessing the complete work and the repetitiveness of the Google Scholar and Google results.

3.1. Accounting for processing results

The articles identified at each stage of the SBR were counted to draw up the information flowchart (Figure 4) proposed by Moher *et al.* (2009), which adopted the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* - PRISMA methodology.

The flowchart shows the effectiveness of the SBR processing, in which it was possible to analyze the references collected according to the criteria established in each Filter. Conforto *et al.* (2011) rightly compare this system to the operation of a sequence of sieves, which allow searches to be refined to obtain only those that are capable of supporting the development of the research, also helping future work in this area by proposing a new starting point, which will reduce the time of the literature review and allow the research to be better directed and focused. In the end, the list of articles and documents consisted of 102 bibliographical references, of which 30 were obtained from the Academic Search Premier database, 55 from Google Scholar, and 17 from Google.

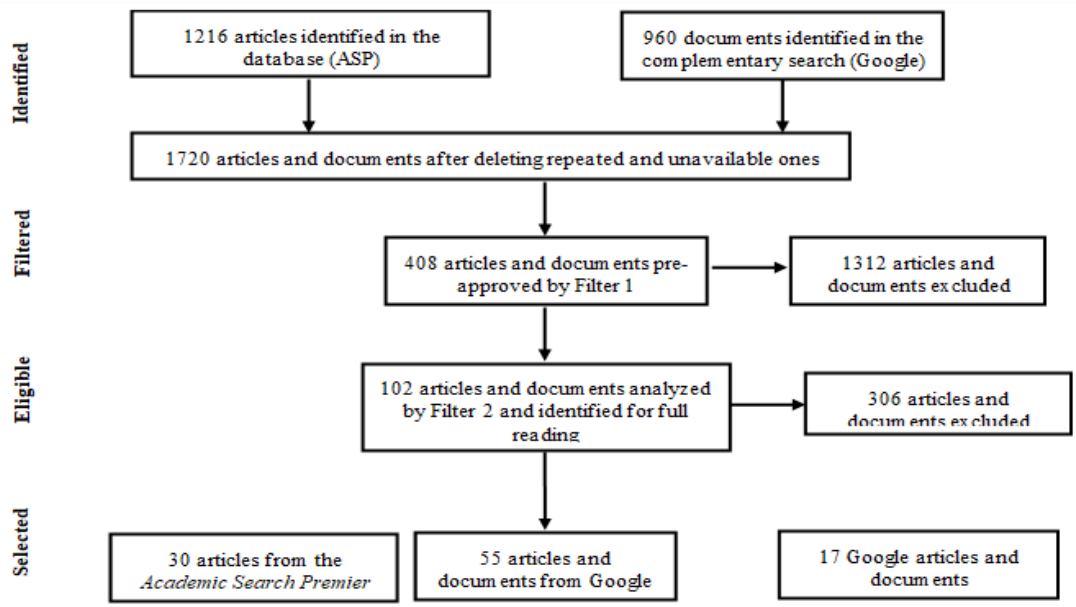

FIGURE 4 - Flowchart accounting for the Systematic Bibliographical Review's processing results on watercourse springs.
SOURCE: Prepared by the author (2019).

4. Conclusions

The relevance of the theme of springs to the maintenance of various ecosystem services is evident in the significant amount of research with different approaches and perspectives. This shows the interest of the national and international scientific community in analyzing and understanding the functioning and dynamics of these environmental systems that are essential for life. However, it was found that most of these studies are justified by the need to guarantee the supply of watercourses for human use, disregarding other ecological and environmental functions that springs have.

Methodologically, the Systematic Bibliographic Review (SBR) is an excellent strategy for surveying, describing, analyzing, and synthesizing scientific information on the subject of watercourse springs, as it allows for the collection, classification, and organization of a group of articles and documents whose information reflects the achievement of the initial search objectives. However, it is important to plan this process properly, rigorously defining the search inputs to obtain results that truly represent the scientific panorama of interest.

In the case of this study, when the results of the three sources of information used (*Academic Search Premier, Google, and Google Scholar*) were taken into account, a total of 408 papers were pre-approved in Filter 1. This represents the number of studies that have tackled the subject of springs from the perspective of their assessment, conservation, monitoring, management, and/or use. In some cases, there have been intentions to propose methodologies for developing these processes efficiently. However, it was necessary to study in greater depth the theoretical and methodological information included in these studies and the main results of each one to determine whether they achieved SBR's initial objectives (Filter 2).

In the end, 102 articles and/or documents on springs aimed at integrated assessment and environmental monitoring were identified and analyzed. However, most of these studies did not fully follow the concept adopted in this research, which defines springs as complex and dynamic environmental systems. This concept is based on a current of thought that considers the upwelling of water as a process that, in addition to giving rise to watercourses, necessarily involves hydrogeological, geomorphological, climatological, ecological, landscape and biological aspects, among others, which are interrelated and control the balance of the system. In this sense, it is important to highlight the relevance of studies on this subject, understanding the fact that to evaluate, monitor and, consequently, conserve, it is first necessary to identify, characterize and understand all the relationships that occur dynamically between the aspects of the biotic, abiotic and social environment that make up the springs, to propose more efficient prevention, mitigation, control and/or recovery measures specifically associated with the established diagnosis.

The analysis of the evolution of publications over the years showed the growth of research on this topic, which increased in the last two years of the period evaluated (2008 - 2017). Similarly, publications by country were analyzed, with the United States having the largest publications worldwide. In South America, Brazil appeared as the leader in research published on springs, including in international journals, showing great concern for the scientific community to support decision-making

processes related to water resource management, in the specific case of springs and river basin planning.

The classification by category showed that the current trend in research on springs is aimed at determining water quality by monitoring physical, chemical, and microbiological properties. Therefore, Scientific interest should be aroused in studying aspects other than hydrogeological ones, which also influence the state of conservation of springs and on which many of the environmental functions that water possesses depend. To this end, it is necessary to carry out studies aimed at the integrated assessment of springs and possible strategies for their conservation; the importance of maintaining surface and underground water resources; techniques for recovering and remediating the physical and chemical conditions of the environment and reforesting riparian forests; and even social, cultural and economic aspects that can be linked to the existence of springs and their state of conservation in a given region.

It was concluded that a significant amount of scientific and non-scientific information is available in the literature related to springs. Still, most of it focuses on analyzing problems related to a specific ethical area: water quality assessment. For this reason, this article has sought to show this situation and encourage the development of more comprehensive research that generates dynamism in current scientific knowledge on springs and proposes or applies interdisciplinary methodologies to integrate water management problems.

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