

Cyanobacteria in urban springs: sanitary implications and risks to public health

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Cianobactérias em mananciais urbanos: implicações sanitárias e riscos à saúde pública

RESUMO

Objetivo - revisão sistemática da literatura sobre as implicações ambientais e os riscos à saúde pública decorrentes da proliferação de cianobactérias, que tem se tornado cada vez mais comum em mananciais urbanos e discutir o potencial de produção de toxinas presente em algumas espécies, que pode comprometer os usos múltiplos da água, em especial, o abastecimento humano. Abordar, também, as causas frequentes de sua proliferação em corpos hídricos e os métodos de prevenção como estratégia para o controle dada a realidade brasileira.

Metodologia - revisão narrativa da literatura em bases de alto impacto utilizando palavras-chave individuais e cruzadas em n=bases como sciencedirect, web of Science e outras.

Originalidade/relevância - atualização do estado da arte para gerar novos pontos de atenção para novas pesquisas.

Resultados - foi realizada uma análise detalhada sobre os riscos que as cianobactérias representam para a saúde humana e animal, com a descrição de diversos sintomas associados à exposição. Independentemente da presença de ações preventivas, destaca-se a necessidade de estabelecer e manter programas contínuos de monitoramento da qualidade da água. Quando a presença de cianobactérias é detectada, recomenda-se a implementação de medidas corretivas, utilizando tecnologias eficazes para controle e remoção desses organismos. Quando a presença de cianobactérias é detectada, recomenda-se a implementação de medidas corretivas, utilizando tecnologias eficazes para controle e remoção desses organismos. Além disso, conclui-se que a gestão do aporte excessivo de nutrientes — provenientes de esgotos domésticos e do escoamento superficial de águas de irrigação, bem como de outras fontes que contribuem com nutrientes para os corpos hídricos — pode ser uma estratégia eficiente e de baixo custo. Por fim, ressalta-se a importância de aprofundar o estudo sobre cianobactérias, abrangendo todos esses aspectos, para desenvolver medidas eficazes de controle e prevenção da sua proliferação.

Contribuições teóricas/metodológicas – a revisão bibliográfica contribui para o entendimento do estado atual pesquisa no assunto e permite vislumbrar os caminhos potenciais de novos estudos e novas descobertas na temática.

Contribuições sociais e ambientais – permitiu o entendimento dos riscos reais e potenciais da presença das cianobactérias nos mananciais urbanos e a busca de soluções remediativas e proativas.

PALAVRAS-CHAVE: Cianobactérias. Mananciais. Toxicidade. Saúde. Fitoplâncton.

Cyanobacteria in urban springs: health implications and risks to public health

ABSTRACT

Objective - To conduct a systematic literature review on the environmental implications and public health risks arising from the proliferation of cyanobacteria, which has become increasingly common in urban water sources, and to discuss the toxin production potential present in some species, which can compromise the multiple uses of water, especially for human supply. It also addresses the frequent causes of their proliferation in water bodies and prevention methods as a control strategy given the Brazilian reality.

Methodology - A narrative literature review in high-impact databases using individual and combined keywords in databases such as ScienceDirect, Web of Science, and others.

Originality/Relevance - Updating the state of the art to generate new points of focus for future research.

Results - A detailed analysis was conducted on the risks that cyanobacteria pose to human and animal health, with a description of various symptoms associated with exposure. Regardless of the presence of preventive actions, the need to establish and maintain continuous water quality monitoring programs is highlighted. When the presence of cyanobacteria is detected, the implementation of corrective measures using effective technologies for the control and removal of these organisms is recommended. The presence of cyanobacteria when detected, it is recommended to implement corrective measures using effective technologies for control and removal of these organisms. Furthermore, it is concluded that managing excessive nutrient input—from domestic sewage and surface runoff from irrigation water, as well as from other sources that contribute nutrients to water bodies—can be an efficient and low-

cost strategy. Finally, the importance of deepening the study of cyanobacteria, covering all these aspects, is emphasized to develop effective measures for controlling and preventing their proliferation.

Theoretical/Methodological Contributions - The literature review contributes to the understanding of the current state of research on the subject and allows for envisioning potential paths for new studies and discoveries in the field.

Social and Environmental Contributions - It allowed for an understanding of the real and potential risks of the presence of cyanobacteria in urban water sources and the search for remedial and proactive solutions.

KEYWORDS: Cyanobacteria. Water supply sources. Toxicity. Health. Phytoplankton.

Cianobacterias en fuentes de agua urbanas: implicaciones sanitarias y riesgos para la salud pública

RESUMEN

Objetivo - Realizar una revisión sistemática de la literatura sobre las implicaciones ambientales y los riesgos para la salud pública derivados de la proliferación de cianobacterias, que se ha vuelto cada vez más común en manantiales urbanos, y discutir el potencial de producción de toxinas presente en algunas especies, que puede comprometer los múltiples usos del agua, en especial, el abastecimiento humano. Abordar, también, las causas frecuentes de su proliferación en cuerpos hídricos y los métodos de prevención como estrategia de control dada la realidad brasileña.

Metodología - Revisión narrativa de la literatura en bases de datos de alto impacto utilizando palabras clave individuales y cruzadas en bases como ScienceDirect, Web of Science y otras.

Originalidad/Relevancia - Actualización del estado del arte para generar nuevos puntos de atención para futuras investigaciones.

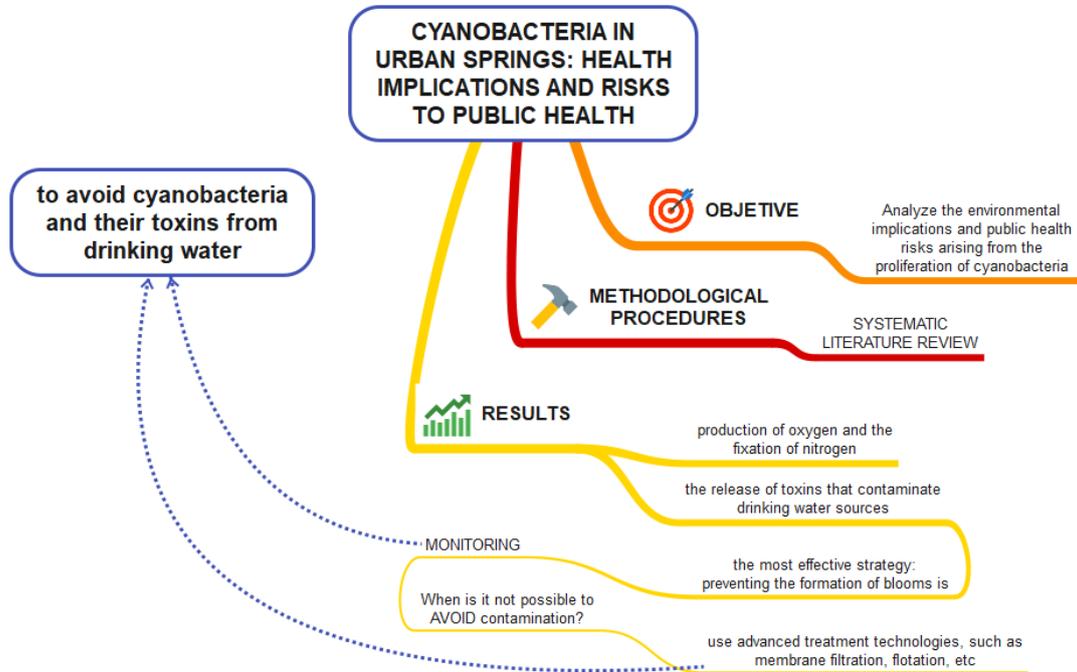
Resultados - Se realizó un análisis detallado sobre los riesgos que las cianobacterias representan para la salud humana y animal, con la descripción de diversos síntomas asociados a la exposición. Independientemente de la presencia de acciones preventivas, se destaca la necesidad de establecer y mantener programas continuos de monitoreo de la calidad del agua. Cuando se detecta la presencia de cianobacterias, se recomienda la implementación de medidas correctivas, utilizando tecnologías eficaces para el control y remoción de estos organismos. Cuando se detecta la presencia de cianobacterias, se recomienda la implementación de medidas correctivas, utilizando tecnologías eficaces para el control y remoción de estos organismos. Además, se concluye que la gestión del aporte excesivo de nutrientes —provenientes de aguas residuales domésticas y de la escorrentía superficial de aguas de riego, así como de otras fuentes que contribuyen con nutrientes a los cuerpos hídricos— puede ser una estrategia eficiente y de bajo costo. Finalmente, se resalta la importancia de profundizar el estudio sobre las cianobacterias, abarcando todos estos aspectos, para desarrollar medidas eficaces de control y prevención de su proliferación.

Contribuciones Teóricas/Metodológicas – La revisión bibliográfica contribuye a la comprensión del estado actual de la investigación en el tema y permite vislumbrar los caminos potenciales de nuevos estudios y descubrimientos en la temática.

Contribuciones Sociales y Ambientales – Permite la comprensión de los riesgos reales y potenciales de la presencia de cianobacterias en los manantiales urbanos y la búsqueda de soluciones remediativas y proactivas.

PALABRAS CLAVE: Cianobacterias. Manantiales. Toxicidad. Salud. Fitoplancton.

GRAPHIC SUMMARY



1 INTRODUCTION

Cities present several types of serious environmental problems. Among them, interferences with aquatic environments stand out. These modifications date back to ancient times and accompany the development of civilizations, according to the temporal analysis carried out by Braga (2003). Silva et al. (2022) corroborate this by addressing the close historical relationship between rivers and cities and the contemporary urban and environmental complications resulting from a conflicting coexistence.

The inefficiency of sanitation services is among the main pressures of urbanization on water resources that can compromise water quality and, consequently, its multiple uses. Among the most affected uses is public supply, but several others can also be made unviable, such as recreation, quenching animals' thirst and irrigation (Tucci, 2008; Braga, 2003; Tundisi, 2009).

Human water supply and animal watering are considered nobler uses, established as priorities in situations of scarcity by Federal Law No. 9433, of January 31, 1997, which institutes the National Environmental Policy (Brasil, 1997). Water intended for the first purpose must meet a strict environmental quality standard, so as not to pose risks to the consumers' health. The quality standard for this purpose is established by means of a standard established by the Ministry of Health, called the Potability Ordinance (Mota, 2008).

In order to comply with the requirements of that standard, the water taken from springs (whether they are underground or surface springs) must undergo a process of treatment to become drinkable. According to Libânio (2016), potabilization aims to adapt raw water to the physical, chemical, biological and radioactive limits established by law, so that the effluent from the station does not pose risks to the population served. Brazilian Environmental Legislation, through the Resolution of the National Environmental Council (known as CONAMA, an acronym standing for *Conselho Nacional do Meio Ambiente*) No. 357, of March 17, 2005, in its article 2, defines three types of treatment:

XXXII - advanced treatment: techniques for removing and/or inactivating constituents that are refractory to conventional treatment processes, which can give water characteristics such as: color, odor, taste, toxic or pathogenic activity;

XXXIII - conventional treatment: clarification using coagulation and flocculation, followed by disinfection and pH correction;

XXXIV - simplified treatment: clarification through filtration and disinfection and pH correction when necessary (Brasil, 2005).

In general, treatment consists of removing suspended particles, organic matter, microorganisms and other substances that may be potentially harmful to one's health. Thus, the characteristics and quality of the water spring are decisive in defining the type of treatment and choosing the technology to be used (Libânio, 2016).

The Potability Ordinance is updated as substances and pathogens become a concern and/or threaten public health. Nowadays, the Ordinance GM/MS No. 888, of May 4, 2021, is in effect, which changes the Annex XX of the of the Consolidation Ordinance GM/MS No. 5, of

September 28, 2017, to establish procedures for controlling and monitoring the quality of water for human consumption and its potability standard (Brasil, 2021).

The importance of the initial decisions regarding the choice of a spring must be highlighted, since at the time of collection, the choice of raw water will affect all the subsequent stages of the supply system. As the need to monitor more parameters and reduce the allowed concentrations of contaminants increases, the process of making water potable becomes more complex, especially in large cities with polluted springs. Therefore, it is clear that effective water treatment must start with the appropriate choice of a spring and the strict control of human activities in the river basin area, thus emphasizing the connection between the quality of the water source and public health (Libânio, 2016).

Since September 29, 2000, Ordinance MS No. 1469 has established, among other requirements, the mandatory monitoring of microorganisms known as cyanobacteria by water supply companies (whether they are public or private companies), to be carried out at the catchment area of the springs. This obligatoriness is due to the constant massive proliferation of these organisms in water bodies, which is brought about by the excess nutrients from pollution sources, that might make several uses of water unviable, especially for human supply, since many species of cyanobacteria may produce toxins. That Ordinance defined cyanobacteria as:

...autotrophic prokaryotic microorganisms, also known as cyanophyceae (blue-green algae), capable of occurring in any surface water source, especially those with high levels of nutrients (nitrogen and phosphorus), and capable of producing toxins with adverse health effects (Brasil, 2000).

Thus, the present study aims to discuss the environmental implications and public health risks resulting from the proliferation of cyanobacteria, which has become increasingly common in urban water springs. This work also considers the potential for toxin production present in some species of the group, which can compromise the multiple uses of water, especially human supply. To achieve this objective, a systematic bibliographic review was carried out on the topic discussed.

2 CYANOBACTERIA AND THEIR MAIN CHARACTERISTICS

From the point of view of cellular organization, cyanobacteria are prokaryotic organisms, that is, they are cells which do not have a defined nucleus, and their genetic material is found dispersed throughout the cytoplasm. Besides that, they do not have membrane-bound organelles. Despite their similarity to bacteria, they are photosynthetic organisms and therefore primary producers. They are found in almost every conceivable ecosystem on Earth, where they play a fundamental role (Calijuri; Alves; dos Santos, 2006; Reynolds, 1997).

These organisms tend to be very common in the majority of aquatic environments, where they live suspended in the water column or attached to substrates, but they can also be found in the soil, glaciers and even in extreme environments, such as hot springs, hypersaline lakes and deserts. They have a wide variety of forms, such as unicellular beings, which can form

colonies with cells grouped together or arranged in filaments (Atroch, 2018; Calijuri; Alves; dos Santos, 2006; Oliveira; Molica, 2017; Schumacher Fermino, 2021; Wehr; Sheath 2003).

In the aquatic environment, cyanobacteria are part of the phytoplankton community, which forms the basis of the food chains of these ecosystems. In addition to these, there are other different groups of organisms included as microscopic algae and free-living protozoa, technically recognized as “animals” (Reynolds, 1997). According to Calijuri, Alves and Santos (2006, p. 5):

Phytoplankton (from the Greek word *phytos* – plant) is made up of a set of diverse taxonomic groups, which have different physiological needs and respond differently to physical and chemical parameters, such as light, temperature and nutrient regime. Basically, it is made up of organisms capable of carrying out photosynthesis (Calijuri; Alves; dos Santos, 2006, p.5).

According to the same authors, there are also the cells known as akinetes, which can be considered resistance cells or spores, as they are highly resistant to drying. They are produced when environmental conditions are unfavorable and can remain in the sediment for many years. These differentiated and specialized cells, such as akinetes, heterocysts and gas vacuoles, are added to other metabolic conditions and contribute to the evolutionary and adaptive success of the group and to its wide distribution and dominance in many water bodies.

Some species of cyanobacteria also have, as an important characteristic, the ability to produce toxins, which are called cyanotoxins.

The causes of this toxin production are not yet fully understood, but some researchers believe that cyanotoxins play a protective role against zooplankton species, their primary predators, as some vascular plants do when they produce tannins, phenols, alkaloids or steroids.

Other researchers suggest that toxin production is related to growth conditions or competition for resources. (Calijuri; Alves; dos Santos, 2006, p. 25).

Such metabolic characteristics, as well as their survival strategies, give the cyanobacteria the versatility that allows them to play a fundamentally important ecological role in the ecosystems where they are present. Together with other classes of the phytoplankton community, they are widely recognized for their prominent position in food webs, as the basis of the food chains of aquatic ecosystems, as well as for their contribution to the assimilation of atmospheric carbon. In addition to these considerations that permeate the maintenance of planetary balance, some species of cyanobacteria have also stood out for their compounds, which can be used as pharmacological and food resources, in the form of supplements.

According to Kamp et al. (2016), several species of the group have been identified as a new and rich source of bioactive compounds. The isolated compounds belong to the groups of polyketides, amides, alkaloids, fatty acids, indoles, and lipopeptides. Most of the bioactive compounds isolated from cyanobacteria tend to be lipopeptides, that is, they consist of an amino acid fragment linked to a fatty acid moiety (Gomez-Maldonado et al., 2019). The range of biological activity of secondary metabolites isolated from cyanobacteria includes antibacterial,

antifungal, antialgal, antiprotozoal, and antiviral activities. Cyanobacteria have been used to synthesize isotopically labeled compounds, such as sugars, lipids, and amino acids, which are now commercially available.

Cyanobacteria also play an essential role in biological sewage treatment systems, such as stabilization ponds, especially in facultative ponds. In these environments, the symbiosis between the phytoplankton community and heterotrophic bacteria plays a decisive role, contributing to the system's efficiency in removing organic matter. Some species in this group, recognized for benefiting from and proliferating intensely in aquatic environments with high nutrient loads, commonly act as key players in biological processes in facultative ponds (Granado, 2004; Morales, Kellner, Cordeiro, 2014).

Regarding cyanobacteria and their blooms, certain species can multiply rapidly and accumulate under certain circumstances, presenting a considerable increase in their biomass in hours or days; this is called cyanobacterial bloom (Almeida; Pinheiro, 2018). The proliferation of cyanobacteria in recreational waters and drinking water sources is a public health problem due to the production of toxins (cyanotoxins) with acute and chronic effects on human health.

Historically, there have been reports of these blooms throughout the world. However, experimental and prospective studies and case reports about the impact of these blooms on health increased in the last decade, as did the search for monitoring, mitigation and implementation strategies of safe levels of exposure for humans (Muller, 2018).

When there are blooms, there may be risks to public health, because, under certain conditions, cyanobacteria — taking advantage of the excess nutrients available in the environment in which they are found — proliferate excessively and the blooms can release toxins that are harmful to human health. In some cases, contact with such substances can cause neurological and liver problems, for example. Furthermore, in addition to being able to proliferate in a worrying way, cyanobacteria have a high tolerance to abnormal conditions, surviving even in inhospitable environments. (Calijuri; Alves; dos Santos, 2006).

Cyanobacterial toxins can then be classified into three main types: hepatotoxins, neurotoxins, and lipopolysaccharide (LPS) endotoxins. Gastroenteritis is the most common acute illness after the consumption of potable water contaminated by cyanobacteria. Cyanobacteria do not depend on a fixed carbon source and, as such, are widely distributed throughout aquatic environments. These include freshwater and marine environments, but also some soils (Almeida; Pinheiro, 2018). Direct microscopic examination of the bloom material allows the identification of the cyanobacteria species present.

Preventing the formation of blooms at the raw water source is the best way to ensure drinking water free from these toxins, which can be achieved through pollution control measures targeting water bodies. However, the environmental conditions of many water sources lead to the occurrence of undesirable blooms, highlighting the importance and necessity of constant monitoring of species with toxic potential, in order to prevent harm to human and animal health and to ecosystems (Melo-Santos et al., 2022).

3.1 ENVIRONMENTAL AND HEALTH IMPLICATIONS OF CYANOBACTERIA

The characteristics of the cyanobacteria presented here demonstrate their undeniable ecological importance. But they also denote the versatility of the group in colonizing different environments, where they can proliferate excessively, unbalancing ecosystems and compromising multiple uses of water, to the point of representing significant environmental and health implications. The mass proliferation of some species, in fact, can pose significant public health problems.

Health risks from cyanobacteria are related to the supply and treatment of drinking water as well as to aquatic environments used for recreational activities when there is a general production of toxins (cyanotoxins) by cyanobacteria which form blooms (Komarek et al., 2019). Evidence of harm to human health has been observed from case reports of poisoning in humans and animals, and from experimental studies of exposure to cyanobacterial blooms. Such studies on animals have identified the mechanism of action of cyanotoxins. However, the risk to humans cannot be derived directly from these mechanisms of action. The combined evaluation of different types of evidence is a way of knowing the real health risk of exposure to these toxins in humans (Atroch, 2018).

Most cases of poisoning involving phycotoxins (toxins produced by plant species) in freshwater or marine waters are reported to be caused by toxic cyanobacteria. Ingestion of water contaminated by cyanotoxins can cause organic disorders of different nature s (Libânio, 2016). All reported cases of health effects attributable to cyanobacteria have been linked to the presence of algal blooms, either in drinking water sources or in lakes, rivers and coastal waters used for recreation. The severity of symptoms expressed in humans will depend on the type of species present in the blooms, the duration and intensity of exposure, as well as individual factors such as age, pathological history, among others (Schumacher Fermino, 2021).

Unlike many other waterborne microbial and toxic health hazards, cyanobacteria can often be detected by human senses by their visual appearance and characteristic odor. This is due to the ability of cyanobacterial blooms to change the color of water, accumulate in easily observable mass populations, and often produce odorous compounds. However, there are conditions under which the production of odorous compounds does not necessarily mean toxicity risks. This is the case with the production of geosmin, whose production is usually not related to the synthesis of toxins by the community in the environment (Macário et al., 2021).

Most of the attention paid to the adverse effects of cyanobacteria on human health has focused on acute poisoning. In all reported cases of community poisoning, the cause was the supply of chlorinated drinking water (Silva; Peleja; Melo, 2019).

Several species of cyanobacteria have been identified in human poisoning. Among them, we can highlight the ones belonging to following genera: *Anabaena*, *Microcystis*, *Nostoc*, *Plankothrix*, *Hapalosiphon*, *Anabaenopsis*, *Nodularia* *Cylindrospermopsis*, *Plankothrix*, *Aphanizomenon* e *Schizothrix* (Calijuri; Alves; dos Santos, 2006). Cyanobacteria have variable toxicity and can lead to death by respiratory arrest shortly after exposure or produce more prolonged effects. According to their mode of action, the toxins produced by cyanobacteria can be divided into the following groups: hepatotoxins, neurotoxins, endotoxins and dermatoxins (LIBÂNIO, 2016). The toxic effects related to cyanotoxin and the genus of cyanobacteria responsible for its production are presented in Table 1.

Table 1: Cyanotoxins, genus responsible for its production and toxic effects occurred

Cyanotoxin	Genus of cyanobacteria responsible	Toxic effects
Microcystin	Anabaena spp, Microcystis, Nostoc, Plankothrix, Hapalosiphon, Anabaenopsis	Liver damage and tumor development.
Nodularin	Nodularia	Liver damage.
Cylindrospermopsin	Cylindrospermopsis, Plankothrix, Aphanizomenon, Umezakia	Damage to the kidneys, liver and other organs, and development of tumors.
Saxitoxin	Anabaena, Aphanizomenon, Cylindrospermopsis Lyngbya	Damage to the nervous system, respiratory failure and acute symptoms*.
Anatoxin-a	Anabaena, Aphanizomenon, Plankothrix	Damage to the nervous system, respiratory failure and acute symptoms*.

Source: Libânio (2016).

Studies so far have shown that the toxic effects can be acute or chronic with harm to the liver, kidneys and other organs of the respiratory system, which might lead to the development of tumors in extreme cases and to skin irritation in some cases. Human health incidents associated with exposure to toxic cyanobacteria reported have resulted in health damage ranging from mild to fatal (Macário et al., 2021).

Investigated cases of human illness and death following exposure to cyanobacterial toxins are not always conclusive. There are data gaps, particularly on the concentrations of cells and toxins to which individuals were exposed and, on the doses, actually received. The characterization of hazards to humans therefore relies heavily on animal studies, from which quantitative estimates of the hazards to humans must be extrapolated (Komarek et al., 2019).

Human exposure to cyanotoxins can be oral, dermal, inhalation, and parenteral, with the oral route being by far the most important. The means of exposure are related to consumption and/or contact with water containing cyanotoxins, but also to the consumption of food and dietary supplements and contact with aerosols and dust, in addition to entry via hemodialysis (Macário et al., 2021). Direct toxicity due to swimming and ingestion of cyanobacteria has been widely reported. Some cases appear to be primarily allergic responses (Chorus; Welker, 2021). Neurotoxicity is also possible, due to ingested or inhaled cyanobacteria.

The toxicity mechanisms of the various cyanobacterial toxins include blockade of nerve ion channels, neuromuscular blockade, anti-acetylcholinesterase activity, antiphosphatase activity and inhibition of protein synthesis. The liver is particularly damaged by these last two activities as well as the gastrointestinal tract and, in the case of inhibition of protein synthesis, the kidneys (Silva; Peleja; Melo, 2019).

According to Komarek et al. (2019), the antiphosphatase activity of microcystins and nodularin has significant potential to stimulate tumor growth. Experimentally, this ability is clearly demonstrated, and its mechanism is under detailed investigation. Assessing the impact on public health requires epidemiological investigation of human populations in areas known to be exposed to cyanobacteria in water supplies.

The studies conducted and analyzed here highlight the serious risks to public health resulting from the ingestion of cyanotoxins. And although insufficient, they show the need for a risk management strategy to mitigate the problems presented by the presence of cyanotoxins in water sources and bodies of water used for recreation, which has already been recognized several times in different countries in recent years. Mass populations of cyanobacteria and toxins in water resources are clearly not a recent phenomenon. And the lack of recognition of the health hazards presented has been, and continues to be, a major factor in accounting for the late and irregular development of risks.

Thus, effective communication between scientists, water treatment engineers, decision-makers and stakeholders, the formulation of contingency plans, and continuous education of the public about the health risks of cyanobacteria and cyanotoxins are recognized as essential actions for risk management of these poisonings and their dangerous consequences.

Conventional water treatment, which exists in most Brazilian municipalities with surface water springs, is not efficient in removing toxins. However, it is important to make it clear that there are several technologies currently available for removing cyanobacteria and cyanotoxins, but their high cost and the Brazilian context do not allow them to be used for treating water for public supply on a large scale in the country. Therefore, prevention and control by reducing the input of nitrogen and phosphorus (whether from organic sources, such as domestic and industrial sewage, or inorganic sources, resulting from the drainage of agricultural areas due to excessive fertilization) is still the most compatible approach to the Brazilian context.

Although cyanobacterial blooms can be found in environments with low nutrient concentrations, it is especially under eutrophic conditions (high concentrations, especially of nitrogen and phosphorus) that blooms are more common and frequent. This shows that stressful environmental conditions and the impacts of human action are what trigger the process the most, resulting in unbalanced ecosystems with serious harm to multiple uses of water.

4. CONCLUSIONS

It can therefore be concluded that cyanobacteria play a crucial role in the ecosystem, contributing to the production of oxygen and the fixation of nitrogen. However, they do not only provide benefits to the environment in which they are found, as their blooms can pose serious risks to public health due to the release of toxins that contaminate drinking water sources.

The understanding that prevention, through continuous monitoring of water quality and nutrient inputs into water sources, is the most effective and viable strategy for controlling the formation of cyanobacteria blooms and the production of toxins and thus minimizing risks to public health.

However, it is not possible to prevent blooms from occurring in all cases, but when they do occur, we must use advanced treatment technologies, such as membrane filtration, flotation, among other techniques, which are essential to remove cyanobacteria and their toxins from drinking water. These technologies have the potential to ensure that water remains safe for human and animal consumption.

The combination of prevention, monitoring and advanced treatment technologies is essential to protect public health from the risks associated with cyanobacteria. Proper management of these factors can ensure that drinking water remains safe and free from contamination.

REFERENCES

ALMEIDA, J. M.; PINHEIRO, J. H. P. A. Efeitos de cianobactérias tóxicas em ambientes aquáticos. **Fórum Ambiental da Alta Paulista**; v.14, n. 2, 2018.

ATROCH, Rosa de Fátima Silva et al. **Cianobactérias e poluição da água: uma sequência didática para o ensino de ciências ambientais**. 2018.

BRAGA, Roberto; CARVALHO, Pompeu F. C. **Recursos hídricos e planejamento urbano e regional**. Rio Claro: Laboratório de Planejamento Municipal-IGCE-UNESP. 2003. p. 113-127 - ISBN 85-89154-04-01.

BRASIL. **Lei nº 9433, de 8 de janeiro de 1997**. Institui a Política Nacional de Recursos Hídricos, cria o Sistema Nacional de Gerenciamento de Recursos Hídricos, regulamenta o inciso XIX do art. 21 da Constituição Federal, e altera o art. 1º da Lei nº 8.001, de 13 de março de 1990, que modificou a Lei nº 7.990, de 28 de dezembro de 1989. Disponível em: <www.planalto.gov.br/ccivil_03/Leis/L9433.htm>. Acesso em: 16 jul. 2023.

BRASIL. Fundação Nacional de Saúde. **Portaria nº 1.469/2000, de 29 de dezembro de 2000: aprova o controle e vigilância da qualidade da água para consumo humano e seu padrão de potabilidade**. Brasília: Fundação Nacional de Saúde, 2001.

BRASIL. Conselho Nacional do Meio Ambiente. **Resolução CONAMA nº 357, de 17 de março de 2005**. Dispõe sobre a classificação dos corpos de água e diretrizes ambientais para o seu enquadramento, bem como estabelece as condições e padrões de lançamento de efluentes, e dá outras providências. Diário Oficial da União, Brasília, DF, 18 mar. 2005. Seção 1, p. 58-63.

BRASIL. Ministério da Saúde. **PORTARIA Nº 2.914, DE 12 DE DEZEMBRO DE 2011**. Dispõe sobre os procedimentos de controle e de vigilância da qualidade da água para consumo humano e seu padrão de potabilidade.

BRASIL. Ministério da Saúde. Secretaria de Vigilância em Saúde. Coordenação-Geral de Vigilância em Saúde Ambiental. **Portaria MS nº 518/2004** / Ministério da Saúde, Secretaria de Vigilância em Saúde, Coordenação Geral de Vigilância em Saúde Ambiental – Brasília: Editora do Ministério da Saúde, 2005.

CALIJURI, M.C.; ALVES, M.A.S.; DOS SANTOS, A.C. **Cianobactérias e Cianotoxinas Em Águas Continentais**. São Carlos: Rima, 2006

CHORUS, I., & WELKER, M., Eds. **Toxic Cyanobacteria in Water; A Guide to Their Public Health Consequences, Monitoring and Management**. World Health Organization, CRC Press. 2021, 859 p.

GOMEZ-MALDONADO, D.; ERRAMUSPE, I. B. V.; FILPPONEN, I.; JOHANSSON, L. S., LOMBARDO, S.; ZHU, J.; THIELEMANS, W.; PERESIN, M. S. Cellulose-cyclodextrin copolymer for the removal of cyanotoxins on water sources. **Polymers**, v. 11, n. 12, 1 dez. 2019.

GRANADO, D.C. **Variações nictemerais e sazonais na estrutura da comunidade fitoplanctônica num sistema de lagoas de estabilização (Novo Horizonte, SP)**. São Carlo, SP, 2004. Dissertação (Mestrado em Engenharia Civil – Hidráulica e Saneamento). Escola de Engenharia de São Carlos. Universidade de São Paulo – USP. Disponível em:

<https://www.teses.usp.br/teses/disponiveis/18/18138/tde-15072006-195556/pt-br.php>. Acesso em: 28 de abril de 2025.

LIBÂNIO, Marcelo. **Fundamentos de qualidade e tratamento de água**/Marcelo Libânio. - 4ª ed - Campinas, SP: Editora Átomo, 2016.

KAMP, L.; CHURCH, L. J.; CARPINO, J.; MARA, E. F.; RUBIO, F. The effects of water sample treatment, preparation, and storage prior to cyanotoxin analysis for cylindrospermopsin, microcystin and saxitoxin. **Chemico-Biological Interactions**, v. 246, p. 45–51, 25 fev. 2016.

KOMAREK, J., KASTOVSKY, J., MARES, J. & JOHANSEN, J.R. **Taxonomic classification of cyanoprokaryotes (cyanobacterial genera) 2014, using a polyphasic approach**. Preslia. 2019, 86: 295-335.

MACÁRIO, I. P. E., VENTURA, S. P. M., GONÇALVES, F. J. M., TORRES-ACOSTA, M. A., & PEREIRA, J. L. The “bright Side” of Cyanobacteria: Revising the Nuisance Potential and Prospecting Innovative Biotechnology-Based Solutions to Integrate Water Management Programs. **ACS Sustainable Chemistry and Engineering**. 2021, 9(21), 7182–7197).

MELO-SANTOS, G. L. et al. **Aspectos da Ecotoxicologia de Cianobactérias**. In.: POMPÊO, M.; CARLOS, V. M.; DORVA, J. C. L. Aspectos da ecotoxicidade em ambientes aquáticos. 1. ed. São Paulo: Instituto de Biociências, Universidade de São Paulo, 2022. Cap. 11. p. 164-189.

MORALES, F. I.; KELLNER, E. CORDEIRO, J. S. avaliação Avaliação da qualidade do efluente de lagoa de estabilização em relação à resolução Resolução CONAMA 430/2011: estudo de caso da ETE Santa Eudóxia - São Carlos (SP). **Revista Nacional de Gerenciamento de Cidades**. ISSN eletrônico 2318-8472, v.olume 02, n.úmero 08, p. 39-54, 2014

MOTA, Suetônio. **Gestão ambiental de recursos hídricos**. Rio de Janeiro: ABES, 2008.

MÜLLER, Luciana et al. Cianobactérias, cianotoxinas e o tratamento químico da água: uma análise bibliométrica da produção científica mundial. **Revista Brasileira de Planejamento e Desenvolvimento**, v. 7, n. 4, p. 570-586, 2018.

OLIVEIRA, C. S. P.; FONSECA, A. S.; DÍAZ, C. A.; SANTOS, W. P.. Reflexões sobre o desafio ambiental: níveis de eutrofização e floração de cianobactérias na Bacia Apodi-Mossoró. **Revista Ibero Americana de Ciências Ambientais**, v.11, n.5, p.519-530, 2020.

OLIVEIRA, E.J.A.; MOLICA, R.J.R. **A poluição das águas e as cianobactérias**. Recife: IFPE, 2017. Disponível em: https://numeb.furg.br/images/stories/materia_textual/ebooks/cartilha-a-poluio-das-aguas-ifpe.pdf. Acesso em: 03 de out. de 2024.

SCHUMACHER FERMINO, Fabiana. **Algas e Cianobactérias: Propostas Lúdicas de Ensino: Atividades didáticas de acordo com a BNCC para a Educação Básica**. Santana do Livramento: UERGS, 2021. 119 p.

SILVA, S.C.F., PELEJA, J.R.P. & MELO, S. Flutuação temporal de cianotoxinas (Microcistina- LR) no rio Tapajós (Santarém, Amazônia-Brasil). **Scientia Plena**. 2019, 15(8): 1-13.

SILVA, E. M.; CARVALHO, G. L. L.; SILVA, P. R. O.; SILVEIRA, J. A. R.; CANOVA, C. R. A cidade e as águas: análise fluvial e ambiental do Rio Espinharas na cidade de Patos-PB. **Revista Nacional de Gerenciamento de Cidades**, v. 10, n. 80, p. 42-56, 2022. Disponível em: https://publicacoes.amigosdanatureza.org.br/index.php/gerenciamento_de_cidades/article/view/3344. Acesso em: 22 ago. 2025.

STAL, L. (2007). **Cyanobacteria**. In S. J (Ed.), **Algae and Cyanobacteria in Extreme Environments. Cellular Origin, Life in Extreme Habitats and Astrobiology**, (Vol. 2011, pp. 659-680). Springer.

TUCCI, C.E.M. Águas urbanas. **Estudos avançados**. 22 (63), 2008.

TUNDISI, J.G. **Água no século XXI: enfrentando a escassez**. 3a. ed. São Carlos, SP: Rima, 2009.

DECLARAÇÕES

CONTRIBUIÇÃO DE CADA AUTOR

Ao descrever a participação de cada autor no manuscrito, utilize os seguintes critérios:

- **Concepção e Design do Estudo:** Informe quem teve a ideia central do estudo e ajudou a definir os objetivos e a metodologia: **Ilda Barbosa Garbim, Wilson José Constante Júnior e Danielli Cristina Granado Romero.**
- **Curadoria de Dados:** Especifique quem organizou e verificou os dados para garantir sua qualidade: **Ilda Barbosa Garbim, Wilson José Constante Júnior, Danielli Cristina Granado Romero e Fernando Sérgio Okimoto.**
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- **Redação - Rascunho Inicial:** Indique quem escreveu a primeira versão do manuscrito: **Ilda Barbosa Garbim e Wilson José Constante Júnior.**
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- **Supervisão:** Indique quem coordenou o trabalho e garantiu a qualidade geral do estudo: **Danielli Cristina Granado Romero e Fernando Sérgio Okimoto**

CONFLITOS DE INTERESSE

Nós, Fernando Sérgio Okimoto, Ilda Barbosa Garbim, Danielli Cristina Granado Romero e Wilson José Constante Júnior, declaramos que o manuscrito intitulado "CIANOBACTÉRIAS EM MANANCIAS URBANOS: IMPLICAÇÕES SANITÁRIAS E RISCOS À SAÚDE PÚBLICA" não possui conflitos de interesse:

1. **Vínculos Financeiros:** Não possui vínculos financeiros.
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