Journal of Ecology and Toxicology

Editorial Open Access

Breathing in Toxicity: Harmful Algal Bloom Aerosols and Human Health Concerns

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Abstract

Toxins from HABs can be incorporated into aerosols and transported inland, where subsequent exposure and inhalation can induce adverse health effects. However, the relationship between HAB aerosols and health outcomes remains unclear despite the potential for population-level exposures. In this review, we synthesized the current state of knowledge and identified evidence gaps in the relationship between HAB aerosols and human health. Aerosols from Karenia brevis, Ostreopsis sp., and cyanobacteria were linked with respiratory outcomes. Harmful algal blooms (HABs) have become a growing environmental concern in recent years, with their impacts reaching far beyond aquatic ecosystems. As these blooms proliferate, they can release harmful toxins into the air, leading to the formation of aerosols that pose significant risks to human health. In this article, we delve into the emerging field of harmful algal bloom aerosols and the associated concerns for human health.

Keywords: Harmful algal blooms; Aerosols; Human health; Climate change; Toxins

Introduction

The economic impacts of HABs on fishing and aquaculture, drinking water treatment and availability, livestock, and property values are substantial. HABs also pose a significant threat to public health as many HAB species can produce secondary metabolites, including potent toxins that adversely impact many different human organ systems. The most well-understood and described routes of exposure to HABs and associated health effects include direct dermal contact leading to multiple symptoms such as rash and irritation, as well as ingestion of contaminated water or seafood resulting in gastrointestinal and neurotoxic effects. Under certain environmental conditions, toxins generated from HABs may become airborne, and subsequent inhalation of the generated aerosols can induce adverse health effects [1].

Harmful algal blooms occur when certain species of algae experience rapid and excessive growth in bodies of water, fueled by factors such as warm temperatures, nutrient pollution, and changes in water chemistry. While HABs are most commonly associated with freshwater and marine environments, they can also occur in brackish water and even in certain terrestrial habitats. As these blooms flourish, they can release toxins that are harmful to both aquatic organisms and humans [2].

Aerosolization

Aerosolization is the process or act of converting some physical substance into the form of particles small and light enough to be carried on the air into an aerosol [3]. The infectious organism is said to be aerosolized. This can occur when an infected individual coughs, sneezes exhales, or vomits, but can also arise from flushing a toilet, or disturbing dried contaminated feces. Harmful algal blooms (HABs) are diverse phenomena consisting of rapid and exponential expansions and accumulation of microalgal populations, such as cyanobacteria, diatoms, and dinoflagellates, in aquatic ecosystems [4].

Transport

The maximum distance travelled by aerosolized toxins could be transported depends on the stability of the compound in question under a range of environmental conditions and remains unclear due to the difficulty of measuring some toxins and scarce direct measurement data. During the Florida red tide, brevetoxins produced by Karenia brevis were detected in the aerosol samples as far as 4.2 km from the beach of origin,33 while during cyanobacteria HAB events, microcystic in atmospheric particles could be transported many kilometres inland without degradation as it is a very stable compound [5].

Inhalation

When the lungs inhale, the diaphragm contracts and pulls downward. At the same time, the muscles between the ribs contract and pull upward. This increases the size of the thoracic cavity and decreases the pressure inside. As a result, air rushes in and fills the lungs [6].

Overview of current exposure assessment and surveillance methods

Harmful algal blooms occur when certain species of algae experience rapid and excessive growth in bodies of water, fueled by factors such as warm temperatures, nutrient pollution, and changes in water chemistry. While HABs are most commonly associated with freshwater and marine environments, they can also occur in brackish water and even in certain terrestrial habitats. As these blooms flourish, they can release toxins that are harmful to both aquatic organisms and humans. Traditionally, the primary route of human exposure to HAB toxins has been through the consumption of contaminated seafood or direct contact with affected water bodies [7]. However, recent research has shed light on another pathway of exposure that is gaining recognition: the inhalation of harmful algal bloom aerosols. When

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Received: 01-May-2023, Manuscript No: jety-23-100781, **Editor assigned:** 03-May-2023, Pre-QC No: jety-23-100781 (PQ), **Reviewed:** 17-May-2023, QC No: jety-23-100781, **Revised:** 23-May-2023, Manuscript No: jety-23-100781 (R), **Published:** 30-May-2023, DOI: 10.4172/jety.1000160

Citation: Lim C (2023) Breathing in Toxicity: Harmful Algal Bloom Aerosols and Human Health Concerns. J Ecol Toxicol, 7: 160.

waves break and winds whip across HAB-affected water surfaces, tiny droplets and particles become aerosolized, carrying the toxins into the air and creating a potential health hazard.The inhalation of harmful algal bloom aerosols can lead to a range of respiratory and systemic health effects. One of the most well-known toxins associated with HABs is microcystin, which can cause liver damage, gastrointestinal symptoms, and even long-term health complications. Additionally, other HAB-derived toxins, such as brevetoxins and saxitoxins, have been linked to respiratory issues, neurological symptoms, and allergic reactions in humans [8].

The exact mechanisms through which harmful algal bloom aerosols affect human health are still being studied. It is believed that the toxins can directly irritate and damage lung tissue upon inhalation, triggering inflammation and impairing respiratory function [9]. The aerosols can also act as carriers for other harmful substances present in the water, such as bacteria and viruses, further exacerbating the potential health risks. While the understanding of harmful algal bloom aerosols is still in its infancy, there is growing concern about their implications for human health, particularly in communities living near affected water bodies or those involved in recreational activities on HAB-impacted lakes or coastlines. Efforts are underway to develop monitoring and surveillance systems that can detect and track HAB aerosols, providing early warnings and guidance to minimize exposure risks [10].

Conclusion

Harmful algal bloom aerosols pose significant concerns for human health, adding a new dimension to the already complex challenges posed by HABs. As our understanding of this emerging field grows, it becomes increasingly important to address the risks associated with inhalation exposure to HAB toxins. By implementing proactive measures, fostering research collaborations, and promoting public awareness, we can strive to minimize the impacts of harmful algal bloom aerosols and safeguard the well-being of communities affected by these environmental phenomena. Preventing and mitigating harmful algal blooms at their source is crucial for addressing the issue of aerosolized toxins. This includes reducing nutrient pollution from agricultural runoff, wastewater discharge, and other human activities that contribute to the eutrophication of water bodies. Additionally, promoting the understanding of HAB risks among healthcare professionals, policymakers, and the general public can help raise awareness and ensure appropriate measures are taken to protect public health.

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