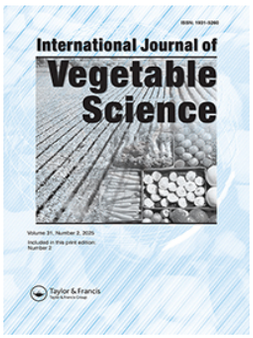

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Between green and safety: navigating sustainability and public health risks in growing media

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ABSTRACT

Production and use of growing media involve a trade-off between sustainability and public health. We claim that a paradigm shift is needed, focusing on properties supporting environmental sustainability and human health, with a holistic approach involving One Health expertise. We use *Legionella* in growing media, soil, and gardening as an example to highlight key knowledge gaps.

KEYWORDS

Compost; *Legionella longbeachae*; *Legionella pneumophila*; public health; risk assessment; societal side stream raw material

Strategies to cope with a changing climate will increase the demand for growing media, not only for indoor production activities, but also to mitigate abiotic stresses in outdoor vegetable production during the early season or extended cropping season. Peat is still widely used as a growing medium constituent, but its extraction and use are highly controversial due to environmental and sustainability concerns. Efforts to replace peat have been ongoing since the 1980s, with alternatives such as coir, wood fiber, bark, composted bark, other plant fibers, green composts, and digestates from anaerobic fermentation. These materials may be pristine raw materials or derived from societal side streams. The phase-out of peat has begun in some countries, and the EU Nature Restoration Act (EU, 2024) is pushing this agenda forward. The ink to sign the EU Nature Restoration Act had not yet dried when a new *Legionella* outbreak related to growing medium was a fact. The outbreak raises questions about whether the composition of growing media contributes to *Legionella*-related diseases. Higher numbers of *L. longbeachae* cases related to growing media and gardening activities were recorded in New Zealand and Australia, where a higher share of wood-based raw material is used, in contrast to Europe, where higher shares of peat are mixed into growing media (Chambers et al., 2021). The peat phase-out is not just about finding replacements, but also involves a shift in perspective from a strict plant production

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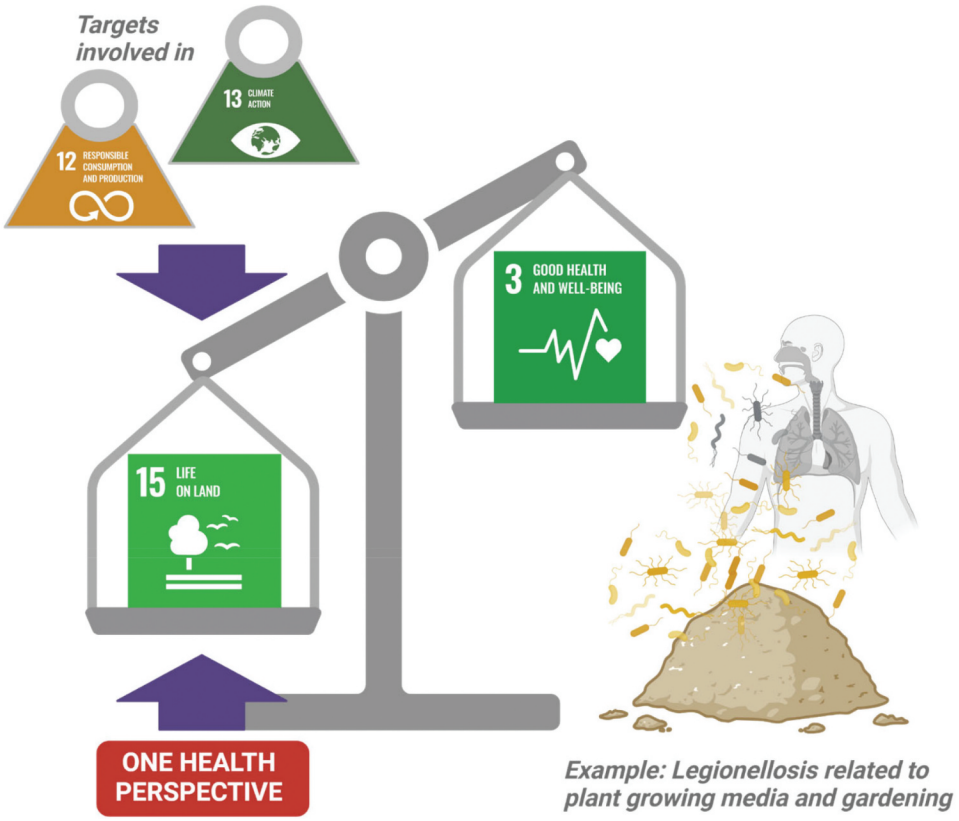

Figure 1. The shift to peat-free growing media balances sustainability and public health concerns. This complex transition requires a holistic, one health approach. Legionellosis risk associated with growing media, compost, soil, and gardening serves as an example. *(illustration: B. Alsanius; supported by biorender.com).*

focus (until now, mainly physical and chemical properties have been considered) and economic realities (price, availability over time, maintained quality over time) to broader sustainability and societal perspectives, involving public health when selecting raw materials to blend growing media. We use the example of *Legionella* spp., an outbreak organism governed by the communicable diseases act with record on linkages to gardening, growing media, composts, and soil to discuss the complexity of peat phase-out from a public health perspective in an era of changing climate (Figure 1).

Legionella spp. an emerging pathogen associated with growing media constituents

The association between *Legionella* infections and gardening activities is well known, but rather as individual cases than outbreaks. However, outbreak alerts have increasingly recurred during the last couple of years. We are aware of three

events with an unexpected number of cases in Northern Europe since 2018, with 41, 36, and 11 patients in Sweden (2018 (Löf et al., 2021); 2024: (Public Health Agency of Sweden, 2024)) and Denmark (2024: (Eves et al., 2024)), respectively. A literature review reveals the presence of *Legionella* species in green and garden waste composts and organic growing media (e.g., Casati et al., 2009; Cramp et al., 2009; Mccabe et al., 2011). Furthermore, cases of Legionnaires' disease and Pontiac fever have been linked to the exposure to growing media prior to the disease on-set (e.g., Cramp et al., 2009).

Legionella spp. is commonly associated with man-made water systems within buildings (such as showers and air conditioning units), industry (e.g., cooling towers), and transport (vehicle windshield wiper fluid) or recreational facilities (e.g., swimming pools) but occurs naturally in freshwater environments such as lakes and streams and also in soil (Kanarek et al., 2022). Temperature-dependent growth patterns have been stated for genotypes from different ecological niches (Sharaby et al., 2017). It thrives at an optimal temperature range between 20 and 45°C, survives 0 and 50°C, and is also reported from environments exceeding 60°C. There are over 60 *Legionella* spp. described, and 24 of these have been reported to cause human infection (Girolamini et al., 2022). The organism is the causative agent of Legionnaires' disease, a severe form of pneumonia. Individuals with underlying respiratory disease or compromised immune systems are at an increased risk of developing clinical disease. It can manifest as Pontiac fever, a mild infection in the upper respiratory system with influenza-like symptoms, but also as extrapulmonary as cutaneous infection. While *L. pneumophila* is in focuses on water-transmitted infections, *L. longbeachae* is mostly associated with gardening and the use of growing media, compost, and soil.

Legionella spp. have been isolated from composts and growing media containing wood waste, bark, green waste, and peat (e.g., Casati et al., 2009). The key challenge lies in understanding and mitigating these risks through improved processing, hygiene measures, and public awareness. According to tests conducted using various methods for determination, the organism is present in exceedingly high levels in some of these media (viable count: 10^3 –10^5 CFU; qPCR: 10^4 –10^6 GU) (Casati et al., 2009). It has been demonstrated that *L. longbeachae* serogroup 1 and *L. pneumophila* can persist in garden soil or organic growing media for several months (Van Heijnsbergen et al., 2016). A recent study investigated potential alternative uses for digestates from biogas facilities, namely as a liquid fertilizer in hydroponic cultivation (Alsanius, Vendrame, Karlsson; manuscript), and showed an increased occurrence of *L. pneumophila* post-anaerobic fermentation.

Developing understanding to handle public health issues in a new context: example *Legionella*

Several trends in the sustainability transition intersect with the search for peat-free growing media: *e.g.*, changing climate (increasing temperature, extreme

weather events, and irregular weather patterns), shift from linear to circular horticulture, including residual material from societal side streams. These side-stream resources are typically optimized for primary purposes, not for demands in secondary contexts, like growing media requiring additional hygienization for public health safety. Organic peat substitutes, such as composts and solid digestates from anaerobic fermentation, are subject to dynamic microbial changes pre- and post-blending. Shifts in abiotic conditions (e.g., temperature, humidity) provoked by climate change alter microbial growth and life-styles. Not only aerosol and dust exposure but also heavy rainfalls and humidity increase the risk for legionellosis (Wade and Herbert, 2024). This infers new challenges for pre- and post-production storage of raw materials and blended growing media.

The presence of human pathogens in growing media, including peat substitutes, is not inherently problematic if the likelihood of infection is low. Guidelines exist for enteric pathogens, using *E. coli* as an index organism and *Salmonella* (European Commission and European Parliament, 2019). The use of *E. coli* or *Salmonella* as a proxy implies several biases: (i) the route of transmission is fecal-oral, and (ii) it favors the manifestation of disease in plant-food related situations. This second bias involves a very long chain of events from the plot to the plate. The advantage of using *Legionella* as an example in the present perspective is that it illustrates the direct link between exposure to the plant growing medium and the risk of infection and subsequent disease. From this perspective, the *Legionella* outbreak in Sweden 2018 is particularly interesting as it coincided with an early season heat wave.

Health risk perceptions regarding *Legionella* in growing media vary, leading to recommendations to label consumer bags with a warning (Cramp et al., 2009), to use protective clothing (facial masks) (Cramp et al., 2009), and to disseminate information to users to enhance health awareness and hand hygiene. Understanding public health risks associated with growing media requires identifying hazards and assessing risks through critical control points and conditions. This task is complex due to the variety of raw materials and processing steps involved. This process requires transdisciplinary expertise.

The case-control study conducted by Löf et al. (2021) after the Swedish *Legionella* outbreak in 2018 gives an interesting trace-back perspective. It identified gardening practices, including exposure to dust from growing media and irrigation, as risk factors for contracting the disease. Even if certain factors can be extrapolated for the conditions in growing medium manufacturing, establishing of critical control points must include the different steps in the product chain, pre-manufacturing, manufacturing, post-manufacturing storage, and users' practices.

Not only the hobby gardener, but also the occupational environment perspective needs attention. To prevent occupational health and safety issues in horticultural businesses, it is proposed that a risk-based approach be

adopted in order to facilitate evidence-based risk management. Exposure and dose-response models might be employed in order to estimate risks and the impacts of risk management measures.

Gaps of knowledge for green and safe transition

The search for suitable raw material substituting peat in growing media focuses mainly on organic matrices. The set of physical, chemical, and economic – and to some extent biological – parameters governing the choice of suitable raw material must also comprise a rigorous analysis of potential microbial hazards and their subsequent public health risks. Their dynamics during different phases of manufacturing and storage are unknown. Evaluation of hazards posed by human pathogens in peat replacement material is also imperative, and to appoint relevant critical control points, indicator organisms, and thresholds. Such analysis should not be restricted to hazards causing food-borne illnesses, but also include infectious diseases, e.g., respiratory in the case of *Legionella*.

Most patients that are diagnosed with *Legionella* are the ones that acquire the severe form of pneumonia (Legionnaires disease, LD), which most often require hospital care (98% of LD-patients in Skåne between 2011–2021, Wiken, Eliasson, Alanko Blomé, Fält, Resman, Ljungquist, Wasserstrom manuscript 2024). Risk factors for LD include, but are not limited to, chronic lung disease, smoking, immune suppression, and high age (Cunha et al., 2016). The milder form, Pontiac fever, which requires hospital care to a lesser extent than LD is most likely underdiagnosed. Little is known about long-term exposure to workers' health in the growing medium industries and commercial greenhouses and plant factories. Such information would be important to tailor relevant prevention strategies, for example, by studying the seroprevalence for *L. longbeachae* in this group.

Also, the realities of a changing climate need to be addressed when predicting hazards related to growing media and peat alternatives. How should raw materials and ready-to-use blends be stored? A common consumer view is pallets with bagged growing media stored in open areas exposed to full sun in garden centers: is this a mitigating or conducing strategy?

Conclusion

Production and use of growing media represent a trade-off between sustainability and public health. The substitution of peat in growing media is imperative and must be expedited. It is essential to strike an optimal balance between the various factors involved. But it must be preceded by a shift in paradigm, embracing growing media properties relevant to sustaining the environment and people's health. To face this dilemma, a holistic approach, which involves

One Health expertise, is imperative. Mitigation strategies to avoid microbial hazards need to be considered for the individual peat substitutes. We used the example of *Legionella* related to growing media, soil, and gardening as an example, as it illustrates an immediate interaction. Also, other critical hazards, such as enteric human pathogens and antibiotic resistance genes, need to be considered when the trade-offs are examined. The full portfolio of actions that this turning point inhabits still needs to be discussed. Quoting W. Churchill "Now this is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning."

Disclosure statement

No potential conflict of interest was reported by the author(s).

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