



OPEN ACCESS

EDITED AND REVIEWED BY
William James Hickey,
University of Wisconsin–Madison, United States

*CORRESPONDENCE

Hari Prasanna Deka Boruah
✉ dekaboruah@yahoo.com
Puneet Singh Chauhan
✉ puneetnbri@gmail.com

RECEIVED 27 July 2023
ACCEPTED 04 August 2023
PUBLISHED 22 August 2023

CITATION

Deka Boruah HP, Chauhan PS and Acharya C
(2023) Editorial: Trends of microbial
technologies in rehabilitation of contaminated
environments. *Front. Microbiol.* 14:1268002.
doi: 10.3389/fmicb.2023.1268002

COPYRIGHT

© 2023 Deka Boruah, Chauhan and Acharya.
This is an open-access article distributed under
the terms of the [Creative Commons Attribution
License \(CC BY\)](#). The use, distribution or
reproduction in other forums is permitted,
provided the original author(s) and the
copyright owner(s) are credited and that the
original publication in this journal is cited, in
accordance with accepted academic practice.
No use, distribution or reproduction is
permitted which does not comply with these
terms.

Editorial: Trends of microbial technologies in rehabilitation of contaminated environments

Hari Prasanna Deka Boruah^{1*}, Puneet Singh Chauhan^{2*} and
Celin Acharya³

¹Biotechnology Group, Government Model College, Kaziranga, Kaziranga, Assam, India, ²Microbial Technologies Division, CSIR-National Botanical Research Institute, Lucknow, India, ³Molecular Biology Division, Bhabha Atomic Research Centre, Mumbai, India

KEYWORDS

contaminant, pollution, microbial remediation, microbial community, soil

Editorial on the Research Topic

Trends of microbial technologies in rehabilitation of contaminated environments

Introduction

Civilization coupled with the industrial revolution and population growth accelerates the degradation and contamination of the environment to a large extent. The contamination of the environment, including soil, water, and air, arises due to a myriad of human activities, such as industrialization, modern agricultural practices, the release of unwanted chemicals, minerals, and effluents released from different industries and municipalities, and the dumping of waste materials and gas. Consequently, the contaminated environment has become a threat to the sustainable environment and is of serious concern. To contain and rehabilitate contaminated environments, microbial technologies have recently overshadowed the conventionally prevalent physical and chemical technologies (Chandran et al., 2020). In microbial technologies, microbes are used to clean up the contaminated environment and boost other allied technologies, such as phytoremediation and the breaking up of contaminants into small fractions using enzymes. The advantage of microbial technologies in the rehabilitation of contaminated environments is conferred by their complete nature, *in-situ* and *ex-situ* capability, ability to convert contaminants to their non-toxic form, shorter duration, cost-effectiveness, and eco-friendliness. Due to the many benefits of microbial technologies in decontaminating and rehabilitating contaminated environments, a Research Topic “Trends in Microbial Technologies in the Rehabilitation of Contaminated Environments” was proposed to explore the trends in this field. The topic aims to identify the most appropriate microbes for use in these technologies, as well as their diversity, methods, and molecular insights. This information will be used to target specific genes and traits that are relevant to the decontamination and rehabilitation of contaminated environments.

In microbial technologies, microbes are used to rehabilitate contaminated environments. The type of contaminants are heavy metals, pesticides, polycyclic aromatic hydrocarbon, oil, organic and inorganic chemical deposits, mine- and oil-explored wasteland, drilling, industrial effluents, municipal waste, dumping grounds, etc; plastics are the different major unwanted waste chemicals that contaminate the environment (Aktar et al., 2009; Machlis and Mcnutta, 2010; Othumpangat and Castranova, 2014; Wexler, 2014; Baruah et al., 2017; Briffa et al., 2020). The microbial technologies and basic parameters

used to address the individual contaminants involved the assessment of microbial diversity, natural attenuation, biostimulation, bioaugmentation, and remediation. Investigations have reported the importance of parameters involved in bioremediation processes such as a microbial diversity assessment to understand the nature of microbes available in specific contaminated environments (Baruah et al., 2017), natural attenuation process (Kennedy, 2004), biostimulation (Seklemova et al., 2001), bioaugmentation (Garbisu et al., 2017), and overall microbe-assisted remediation approaches (Kumar et al., 2021). In addition, recent genes and traits of individual microbes were evaluated to reduce the targeted time of remediation (Bialy, 1997; Iyer et al., 2013; Puig et al., 2021). In the present Research Topic, five manuscripts were submitted for consideration, including a mini review on microbial enzymes for microplastic solution pesticide Diquat management through yeast (De Jesus and Alkendi), including insight into the genes (Wang et al.); arsenic and nitrogen contaminated groundwater treatment using *Hydrogenophaga* sp. H7 (Fan et al.); and the treatment of oily sludge with a bacterial consortium (Hentati et al.). The diversified reports on microbes in the remediation of contaminated environments showed the importance of microbes in the rehabilitation, decontamination, or revival of contaminated environments.

Trends in microbial investigations on the remediation of contaminated environments

From the above discussion, it is now the view that microbes play a vital role in recovering contaminated environments to their original state. Conceptualizing the use of microbes in the rehabilitation of a contaminated environment encompasses the diverse type of biochemical mechanisms that lead to a target's mineralization, transformation to a new product, and alteration of the state of the contaminants, e.g., metallic state. Conceptually, we observed that the use of microbial technology in the remediation

of contaminants mostly involved removal, degradation, oxidation, and leaching, as well as groundwater. Overall, if we look at the type of contaminants in soil and water, mostly heavy metals, other minerals, organic pollutants, wastewater released from industries, municipal waste, and microbial technologies were mentioned in each subject. A Web of Science database search using the term "bioremediation reports" uncovered nearly 6,000 publications between 1988 and 2022, a significant increase in publications encompassing diverse fields.

Analyses of the conceptual structure of the bioremediation of contaminated environment trends for different types of contaminated environments have mostly evaluated the overall diversity of microbial communities in specific environments and their role in decontamination. Based on the diversity of microbial community evaluation, researchers targeted the screening of bacteria most suited for degrading, mineralizing, or oxidizing contaminants, or ameliorating their toxic effects. The assessment of diverse microbial communities is reported to evaluate the entire environment, including water, soil, and industrial effluent. In evaluating microbes for remediation, many investigations also evaluated the toxicity of contaminants. The trends in microbial evaluation reported adsorption, biosorption, decolorization, reduction, biodegradation, and degradation. Based on the overall investigation, the appropriate bacteria were further screened for a microbial technology evaluation. In a microbial technology evaluation, both biotic and abiotic parameters were assessed for their full-proof technology development. In the latest trends in bioremediation, researchers try to identify the specific genes and traits responsible for decontamination. The latest overall strategy of research trends is the development of microbial full-proof technology (Figure 1).

It is evident that microbes play a vital role in the rehabilitation of contaminated environments through appropriate microbial technology and also have a diversified effect. To develop microbial technology in the remediation of contaminated environments, in most cases, the technology will be derivative of a case-specific program. To overcome the specific hurdles and to achieve universal acceptance, one must integrate the diverse parameters

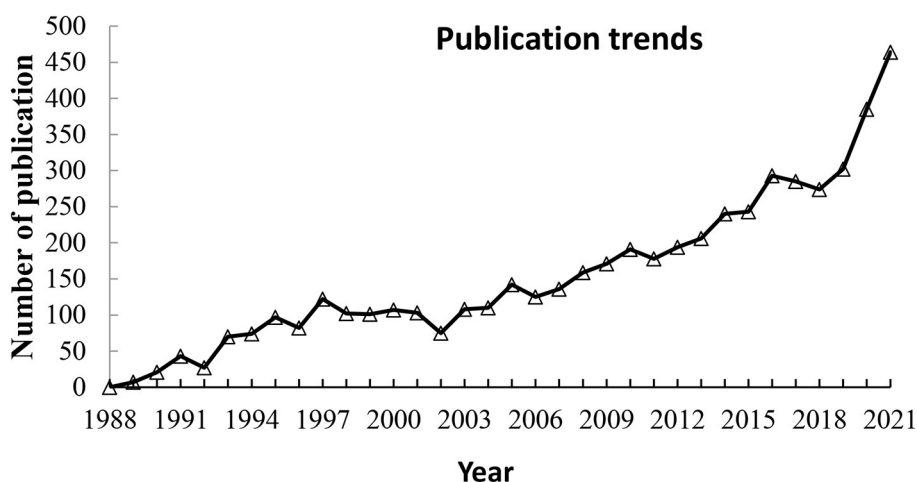


FIGURE 1
Publication evolution in the period 1989–2021 for the subject of bioremediation.

with pathway linking, the fate of the final product, etc. From a techno-economic viewpoint, including the total remediation of contaminants, the use of microbial technology has a long-lasting impact on the rehabilitation of the contaminated environment.

Author contributions

HD: Writing—original draft, Writing—review and editing. PC: Writing—original draft, Writing—review and editing, Conceptualization. CA: Writing—original draft.

Acknowledgments

The authors are highly thankful to Frontier Microbiology and Editorial teams for extending us the opportunity to edit the Research Topic. We will remain indebted to the continued

faith showed by Sharna Ramsden, Journal Specialist, Frontiers in Microbiology and the topic editors. Lastly, I extend whole hearted thanks to all the contributors of this Research Topic.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Aktar, W., Sengupta, D., and Chowdhury, A. (2009). Impact of pesticides use in agriculture: their benefits and hazards. *Interdiscip. Toxicol.* 2, 1–12. doi: 10.2478/v10102-009-0001-7
- Baruah, R., Mishra, S. K., Kalita, D. J., Silla, Y., Chauhan, P. S., Singh, A. K., and Deka Boruah, H. P. (2017). Assessment of bacterial diversity associated with crude oil-contaminated soil samples from Assam. *Int. J. Environ. Sci. Technol.* 14, 2155–2172. doi: 10.1007/s13762-017-1294-2
- Bialy, H. (1997). Biotechnology, bioremediation, and blue genes. *Neture Biotech.* 15, 110. doi: 10.1038/nbt0297-110
- Briffa, J., Sinagra, E., and Blundell, R. (2020). Heavy metal pollution in the environment and their toxicological effects on humans. *Heliyon* 6, e04691. doi: 10.1016/j.heliyon.2020.e04691
- Chandran, H., Meena, M., and Sharma, K. (2020). Microbial biodiversity and bioremediation assessment through omics approaches. *Front. Environm. Chem.* 1, 570326. doi: 10.3389/fenvc.2020.570326
- Garbisu, C., Garaiurrebaso, O., Epelde, L., Grohmann, E., and Alkorta, I. P. (2017). lasmid-mediated bioaugmentation for the bioremediation of contaminated soils. *Front. Microbiol.* 8, 01966. doi: 10.3389/fmicb.2017.01966
- Iyer, R., Iken, B., and Damania, A. A. (2013). Comparison of organophosphate degradation genes and bioremediation applications. *Environ. Microb. Rep.* 5, 787–798. doi: 10.1111/1758-2229.12095
- Kennedy, L. G. (2004). "Nine: Transportation and environmental justice," in *Running on Empty* (Bristol: Policy Press). doi: 10.51952/9781847426000.ch009
- Kumar, V., Roy, S., Behera, B. K., Swain, H. S., and Das, B. K. (2021). Biofloc microbiome with bioremediation and health benefits. *Front. Microbiol.* 12, 741164. doi: 10.3389/fmicb.2021.741164
- Machlis, G. E., and McNutta, M. K. (2010). Scenario-building for the deepwater horizon Oil spill. *Science.* 329, 1018–1019. doi: 10.1126/science.1195382
- Othumpangat, S., and Castranova, V. (2014). Oil spills. *Encyclopedia Toxicol.* 2014, 677–681. doi: 10.1016/B978-0-12-386454-3.00359-6
- Puig, S., Jourdin, L., and Kalathil, S. (2021). Editorial: Microbial Electrogenesis, Microbial Electrosynthesis, and Electro-bioremediation. *Front. Microb.* 12, 742479. doi: 10.3389/fmicb.2021.742479
- Seklemova, E., Pavlova, A., and Kovacheva, K. (2001). Biostimulation-based bioremediation of diesel fuel: field demonstration. *Biodegradation.* 12, 311–316. doi: 10.1023/A:1014356223118
- Wexler, P. (2014). *Encyclopedia of Toxicology, US National Library of Medicine.* Bethesda, MD, USA: Elsevier Inc.