Integrating Bioremediation Practice in Greening the Libraries/Information Spaces for Sustainability: An Application Overview

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ABSTRACT

This paper explores the need for integrating librarianship and environmental sustainability by introducing the bioremediation practices within library/information spaces. As libraries strive to become more eco-friendly and socially responsible, incorporating bioremediation techniques will offers a unique approach to address environmental challenges. This topic discusses the classification, benefits and process of bioremediation. It also looked into the advantages as well as the challenges of bioremediation. The overview paper is to create awareness on the call for sustainable practices and also to serve as an eye opener of the needed transformative power of libraries in shaping healthier and more eco-friendly community for a greener future, while also contributing to the growing field of sustainable library practices.

Keywords: Libraries, Bioremediation, Sustainability

INTRODUCTION

The term of bioremediation has been made of two parts: "bios" means life and refers to living organisms and "to remediate" that means to solve a problem. "Bioremediate" means to use biological organisms to solve an environmental problem such as contaminated soil or groundwater. Bioremediation is an ecologically sound and state of the art technique that employs natural biological processes to completely eliminate toxic contaminants. Bioremediation utilizes living organisms, such as bacteria, fungi, and plants, to degrade, transform, or remove contaminants from the environment. Bioremediation stands as a pragmatic and scientifically grounded approach to environmental restoration. This process primarily utilizes living organisms, including microorganisms like bacteria, fungi, and certain types of plants, to degrade, detoxify, or stabilize hazardous substances present within the environment. The principle behind bioremediation hinges on the natural ability of these organisms to break down harmful substances into less toxic or non-toxic compounds.

Choosing appropriate bioremediation technique, which will effectively reduce pollutant concentrations to an innocuous state. Environmental pollution has been on the rise in the past few decades owing to increased human activities on energy reservoirs, unsafe practices and rapid industrialization. Amongst the pollutants that are of environmental and public health concerns due to their toxicities are: heavy metals, nuclear wastes, pesticides, greenhouse gases, and hydrocarbons. Remediation of polluted sites using microbial process (bioremediation) has proven effective and reliable due to its eco-friendly features' Azubuike (2016). Bioremediation is an option that offers the possibility to destroy or render harmless various contaminants using natural biological activity. As such, it uses relatively low-cost, low-technology techniques, which generally have a high public acceptance and can often be carried out on site. The end goal of bioremediation is to remove or reduce harmful compounds to improve soil and water quality (Canak 2019)

Bioremediation techniques are typically more economical than traditional methods such as incineration and some pollutants can be treated on site, thus reducing exposure risks for clean-up personnel, or potentially wider exposure as a result of transportation accidents. Since bioremediation is based on natural attenuation it is

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considered more acceptable than other technologies. Most bioremediation systems are run under aerobic conditions, but running a system under anaerobic conditions may permit microbial organisms to degrade otherwise recalcitrant molecules. Bioremediation applies living microorganisms to degrade environmental pollutants or to prevent pollution or it is a technology for removing pollutants from the environment thus restoring the original natural surroundings and preventing further pollution. The rapid expansion and increasing sophistication of the chemical industries in the last century has meant that there has been increasing levels of complex toxic effluents being released into the environment, Vidali (2001).

In recent years, the global emphasis on environmental sustainability has prompted various sectors to reevaluate their practices, seeking innovative ways to reduce their ecological footprint. Libraries, as custodians of information and community hubs, are no exception to this trend. The evolving role of libraries extends beyond traditional realms, now encompassing a commitment to eco-conscious operations and the creation of environmentally friendly information spaces. This paradigm shift has given rise to a novel and interdisciplinary approach: the integration of bioremediation practices within library environments.

The concept of greening libraries through bioremediation introduces a fusion of environmental science and librarianship. Bioremediation, a process that employs living organisms to remove pollutants and contaminants from the environment, has predominantly found application in soil and water remediation. However, its integration into indoor spaces, especially those frequented by communities, is a relatively unexplored frontier.

This paper seeks to show the potential synergies between bioremediation and librarianship, envisioning libraries as not only guardians of knowledge but also as champions of sustainable practices. As libraries transition into dynamic and multifunctional community spaces, their environmental impact becomes an important aspect of their social responsibility. The integration of bioremediation practices aligns with this responsibility, aiming to transform libraries into ecologically conscious institutions that actively contribute to the well-being of both patrons and the environment.

This paper is to create awareness on the global call for sustainable practices and also an eye opener of the needed transformative power of libraries in shaping healthier and more eco-friendly community as the world grapples with environmental challenges; libraries have to follow the sustainability trend for a greener future.

Classification of Bioremediation

Bioremediation techniques can be classified as:

(i) *in situ* techniques, which treats polluted sites directly, and
(ii) *ex situ* techniques which are applied to excavated materials, (Kensa 2011)

In both these approaches, additional nutrients, vitamins, minerals, and pH buffers are added to enhance the growth and metabolism of the microorganisms. In some cases, specialized microbial cultures are added (biostimulation). Some examples of bioremediation related technologies are phytoremediation, bioventing, bioattenuation, biosparging, composting (biopiles and windrows), and land farming. Other remediation techniques include thermal desorption, vitrification, air stripping, bioleaching, rhizofiltration, and soil washing. Biological treatment, bioremediation, is a similar approach used to treat wastes including wastewater, industrial waste and solid waste.

Benefits Of Integrating Bioremediation Practices into Libraries for Sustainability

To create a clean environment without endangering the ecosystem, bioremediation is a well-known and widely approved solution, Kour et.al (2021). The integration of bioremediation practices into libraries for sustainability will offers a range of benefits, encompassing environmental, health, social, and economic aspects. Here are some key benefits of incorporating bioremediation into information spaces such as libraries:

Improved Indoor Air Quality: Bioremediation processes, especially those involving plants, contribute to the removal of indoor air pollutants, leading to improved air quality. This can positively impact the health and well-being of library patrons and staff, reducing respiratory issues and enhancing overall comfort.

Reduced Chemical Dependency: By relying on natural processes and living organisms, bioremediation reduces the need for synthetic chemicals in indoor environments. This minimizes chemical exposure for occupants and helps create a healthier space with fewer potentially harmful substances.

Enhanced Biodiversity: Incorporating bioremediation practices, such as introducing plants and microbial communities, promotes biodiversity within the library space. This not only contributes to the aesthetics of the environment but also supports ecological balance and resilience.

Cost Savings on Maintenance: Bioremediation methods, such as the use of plants for air purification, can lead to reduced maintenance costs. Natural processes often require less upkeep compared to mechanical systems, resulting in potential long-term cost savings for libraries.

Energy Efficiency: Bioremediation practices can enhance energy efficiency within information spaces. For example, strategically placed plants can provide natural shading, reducing the need for artificial cooling, and contributing to energy conservation.

Educational Opportunities: Integrating bioremediation provides educational opportunities for library users. Libraries can host programs, workshops, and exhibits to inform the community about the environmental benefits of bioremediation, promoting awareness and eco-friendly practices.

Contribution to Sustainable Development {SDGs): Bioremediation aligns with several Sustainable Development Goals (SDGs), including those related to clean water and sanitation, responsible consumption and production, and life on land. Libraries adopting bioremediation practices contribute to global sustainability objectives.

Positive Image and Reputation: Libraries that prioritize sustainability through bioremediation practices enhance their image as responsible and environmentally conscious institutions. This positive reputation can attract support from the community, local authorities, and potential partners.

Integration with Green Building Standards: Bioremediation aligns with green building standards and certification programs. Libraries incorporating bioremediation may find it easier to meet criteria for certifications such as LEED (Leadership in Energy and Environmental Design) or other regional green building standards.

Thus, integrating bioremediation practices into information spaces for sustainability brings multiple benefits, ranging from environmental conservation to community well-being and cost-effectiveness. It represents a holistic and innovative approach to creating libraries that are not only repositories of knowledge but also champions of sustainability.

Process Of Bioremediation

The process typically involves a series of steps, and the specific approach may vary depending on the type of contaminants, the environmental conditions, and the desired remediation goals. Here are the key steps in the bioremediation process:

Site Assessment and Characterization: Identify and characterize the contaminants present in the environment. This involves conducting a thorough site assessment to understand the nature and extent of contamination, including the types of pollutants, their concentrations, and the physical and chemical properties of the site.

Selection of Bioremediation Approach: Choose the most suitable bioremediation strategy based on the site assessment. Common bioremediation approaches include:

1. **Biostimulation:** Enhancing the growth and activity of indigenous microorganisms by providing nutrients, oxygen, or other growth-promoting factors.
2. **Bioaugmentation:** Introducing specific microorganisms or microbial consortia to enhance the existing microbial community's ability to degrade contaminants.
3. **Phytoremediation:** Using plants to absorb, accumulate, or transform contaminants in soil or water.

Preparation of the Site: Prepare the site for bioremediation by removing any obstacles or contaminants that may hinder the process. This may involve physical site preparation, such as removing debris or excess contaminants, to create optimal conditions for bioremediation.

Application of Bioremediation Agents: If bioaugmentation is part of the strategy, introduce the selected microorganisms or microbial cultures into the contaminated area. This may involve inoculating the site with bacteria, fungi, or other organisms capable of degrading the specific contaminants.

Nutrients Addition (Biostimulation): In biostimulation, nutrients such as nitrogen, phosphorus, and trace elements are added to the contaminated site to enhance microbial growth and activity. This step promotes the metabolic processes of microorganisms involved in contaminant degradation, such as

1. **Oxygen Supply:** Ensure that there is an adequate supply of oxygen if the bioremediation process is aerobic, as many microorganisms involved in contaminant degradation require oxygen. Oxygen can be supplied through natural aeration or by mechanical means if necessary.
2. **Monitoring and Control:** Implement monitoring systems to assess the progress of bioremediation. This includes regular sampling and analysis of soil, water, or air to track changes in contaminant concentrations and microbial activity. Adjust environmental conditions based on monitoring data to optimize the remediation process.
3. **Completion and Post-Remediation Monitoring:** Once the desired remediation goals are achieved, conduct post-remediation monitoring to confirm that contaminant levels have reached acceptable levels. Evaluate the overall success of the bioremediation process and determine whether any additional steps or monitoring are needed.
4. **Documentation and Reporting:** Document the entire bioremediation process, including site assessments, strategies employed, monitoring data, and results. Provide a comprehensive report detailing the success of the remediation effort, and share findings with relevant stakeholders.

It's important to note that the success of bioremediation depends on various factors, including the type of contaminants, environmental conditions, and the adaptability of chosen organisms. The process is often site-specific, and a tailored approach is crucial for effective remediation.

Advantages Of Bioremediation

Bioremediation has a great potential with notable achievements already reported from around the globe. But still this excellent and eco-friendly low input biotechnology has been underutilized, Arora (2018). Therefore below are a few advantages of bioremediation:

- Bioremediation is a natural process and is therefore perceived by the public as an acceptable waste treatment process for contaminated material such as soil. Microbes able to degrade the contaminant increase in numbers when the contaminant is present, when the contaminant is degraded, the biodegradative population declines. The residues for the treatment are usually harmless products and include carbon dioxide, water, and cell biomass.
- Theoretically, bioremediation is useful for the complete destruction of a wide variety of contaminants. Many compounds that are legally considered to be hazardous can be transformed to harmless products. This eliminates the chance of future liability associated with treatment and disposal of contaminated material.
- Bioremediation can often be carried out on site, often without causing a major disruption of normal activities. This also eliminates the need to transport quantities of waste off site and the potential threats to human health and the environment that can arise during transportation.
- Bioremediation can prove less expensive than other technologies that are used for clean-up of hazardous.

Green Initiatives and Indoor Air Quality Management at Covenant University Library, Ota, Nigeria: A case study

Covenant University, a leading private university located in Ota, Ogun State, Nigeria, is widely recognized for its innovative approaches to sustainable campus development and environmental responsibility (Adebayo & Ogunlade, 2020). The institution promotes green building practices, energy efficiency, and eco-consciousness across its academic infrastructure. A prominent example is its Centre for Learning Resources (CLR), which integrates environmentally friendly strategies into library operations and facility management.

Initiative Highlights

- **Green Landscaping and Indoor Plant Integration**

  The library incorporates green surroundings and indoor ornamental plants such as *Dracaena*, *Aloe vera*, and *Spider plant* (*Chlorophytum comosum*) species scientifically validated for their phytoremediation abilities (Darlington, A., Dixon, M. A., & Pilger, C. (2001). These plants naturally absorb indoor toxins such as benzene, formaldehyde, and carbon monoxide, thereby enhancing air quality and reducing pollutant loads in enclosed spaces (Umeokeke & Okoye, 2021).

- **Air Quality Improvement Strategy**

  The use of indoor plants reflects a form of **phytoremediation**, which is a subset of bioremediation employing plants to absorb or transform contaminants in the environment (Rai, 2008). While Covenant University's CLR does not explicitly label its green initiatives as bioremediation, its environmental management strategy aligns with bioremediation principles in indoor spaces.

- **Energy-Efficient Building Design**

  The library is constructed with features that promote natural lighting and passive ventilation. This reduces the need for artificial lighting and air conditioning, thus limiting chemical emissions from HVAC systems and related indoor pollutants (Adebayo & Ogunlade, 2020). These design elements enhance indoor air quality and reduce energy costs.

- **Student and Faculty Engagement**

  The university organizes sustainability-themed workshops, exhibitions, and seminars within the library space, educating staff and students about the role of nature-based solutions in environmental management. These efforts align with Sustainable Development Goals particularly SDG 4 (Quality Education) and SDG 13 (Climate Action) (United Nations, 2015).

Outcomes and Implications

- Reports from students and staff indicate **improved indoor comfort and satisfaction**, particularly related to air freshness and thermal regulation.
- There has been a **notable reduction in chemical air fresheners and disinfectants**, which were formerly used for odor and air quality control.
- The current framework creates opportunities for future installations of **green walls**, **biofiltration units**, or **microbial air detox systems**, which would constitute full-scale indoor bioremediation.
- The university can also encourage interdisciplinary research collaboration between its departments of environmental science, microbiology, and library studies to **pilot microbial-based remediation techniques** in information spaces.

Application to This Study

The case study of Covenant University's Centre for Learning Resources (CLR) demonstrates the practical feasibility of integrating bioremediation principles into Nigerian academic library settings. Though not yet fully realized as a formal bioremediation program, Covenant University's strategic use of indoor plants for air purification, coupled with energy-efficient infrastructure, highlights a workable model of greening information spaces using biological systems. The initiative reveals that environmental consciousness and eco-friendly practices are attainable within the Nigerian university context. More importantly, it validates the natural synergy between librarianship and ecological innovation a central argument of this study.

This localized example strengthens the relevance of bioremediation as a sustainable design element in Nigerian libraries by:

- Proving that *living organisms (plants)* can improve indoor air quality and reduce chemical exposure,
- Supporting the broader goals of sustainability, health, and comfort within academic spaces,
- Encouraging libraries to shift from conventional sterilization practices toward *eco-responsive solutions*.

The scalability of this model presents a significant opportunity for other institutions, particularly emerging universities such as Aliko Dangote University of Science and Technology, Wudil (ADUSTECH, Wudil) in Kano State. As a science-focused institution, ADUSTECH, Wudil is well positioned to:

- Pilot microbial-based bioremediation solutions in its new library spaces,
- Leverage collaborations between its environmental science, biology and library departments, and
- Serve as a benchmark for Northern Nigerian institutions looking to align with the Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action).

Adapting such initiatives, ADUSTECH, Wudil and similar universities can foster interdisciplinary innovation, enrich student learning environments and reinforce their commitment to environmental responsibility.

Challenges Of Integrating Bioremediation Practice In Greening The Libraries/Information Spaces For Sustainability

While integrating bioremediation practices in greening the library for sustainability offers numerous benefits, there are also challenges associated with implementing these practices, among which includes:

Contaminant Complexity: The type and complexity of contaminants present in information spaces can vary widely. Designing bioremediation strategies that effectively address diverse pollutants, such as heavy metals, organic compounds, or indoor air pollutants, requires careful consideration of contaminant characteristics and the selection of appropriate microbial species.

Site-Specific Consideration: Bioremediation success is often site-specific, and the effectiveness of certain methods may vary based on local environmental conditions. Factors such as soil composition, temperature, humidity, and the presence of competing microorganisms can influence the feasibility and success of bioremediation.

Time Considerations: Bioremediation is generally a time-consuming process. The rate of microbial degradation and the transformation of contaminants can be slow, particularly in large or heavily contaminated spaces. Patience is required, and there may be limitations on the rapidity of achieving desired results.

Regulatory Compliance: Bioremediation practices may be subject to environmental regulations, and obtaining necessary permits can be a complex process. Compliance with regulatory standards requires careful planning and coordination with relevant authorities to ensure that the chosen bioremediation methods meet legal requirements.

Knowledge and Expertise: Successful bioremediation requires a deep understanding of microbiology, ecology, and environmental science. Libraries and facility managers may lack the necessary expertise to design, implement, and monitor bioremediation strategies. Collaboration with experts in the field is essential.

Unpredictable Environmental Conditions: Environmental conditions can be unpredictable, and factors such as extreme weather events, changes in temperature, or fluctuations in moisture levels may affect the performance of bioremediation processes. Planning for environmental variability is critical to maintaining the effectiveness of these practices.

Long-Term Maintenance: Sustaining the benefits of bioremediation over the long term requires ongoing maintenance and monitoring. Libraries may face challenges in allocating resources for continued monitoring, adjusting conditions as needed, and addressing any unexpected issues that may arise.

Despite these challenges, the integration of bioremediation practices remains a promising and sustainable approach. Addressing these challenges through careful planning, collaboration, and ongoing commitment can lead to successful implementation and contribute to the creation of healthier and more environmentally friendly library/information spaces.

CONCLUSION

In conclusion, the integration of bioremediation practices into the library for sustainable information spaces represents a visionary approach to addressing environmental concerns, promoting community well-being and contributing to a broader culture of sustainability. While challenges such as site-specific considerations, public perception, and regulatory compliance may arise, strategic solutions and collaborative efforts can overcome these hurdles.

The benefits of integrating bioremediation into library/information spaces, including improved indoor air quality, reduced chemical dependency, and positive contributions to biodiversity, underscore the importance of pursuing sustainable initiatives. Bioremediation not only aligns with global environmental goals but also positions information spaces, such as libraries, as leaders in innovative and responsible practices.

To successfully navigate the integration of bioremediation, careful planning, ongoing monitoring, and a commitment to community engagement are essential. Public awareness campaigns, training programs, and transparent communication can foster understanding and support from library patrons and staff. Collaboration with regulatory authorities, research institutions, and environmental experts ensures that bioremediation practices meet compliance standards and leverage the latest advancements in the field.

As libraries embrace the challenge of becoming not only repositories of knowledge but also champions of sustainability, the potential for positive impact on both the environment and the community becomes evident. The journey toward sustainable library/information spaces through bioremediation is a dynamic and forward-thinking endeavor, embodying the transformative power of integrating eco-friendly practices into the core of community-oriented institutions. In this way, libraries can contribute to a greener, healthier, and more sustainable future for all. This study is mainly to pave way for an interdisciplinary relationship among fields of knowledge.

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