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Posted Date: 21 May 2024

doi: 10.20944/preprints202405.1342.v1

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Making the Research and Innovation Ethical: A Conceptual Framework for Ethics Assessment of Nanotechnology Innovations

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Abstract: In the current era of emerging technologies and cutting-edge inventions, it is equally important to consider the ethical aspects of research and innovations to have an ethical space for the sustainable progress and safety of humanity. The field of nanotechnology research and innovation often faces criticism due to its potential adverse impacts on health, the environment, limited accessibility, high costs, and concerns about data privacy. Therefore, it is crucial to address and resolve these ethical issues systematically. In this regard, we present our findings and methods for exploring the application of the ethics technology assessment method by considering its relevance at different stages of innovation development. Specifically, the present work provides a conceptual framework for ethics technology assessment focused on evaluating a significant innovation in nanotechnology within the domain of food safety with specific reference to mycotoxin remediation. By leveraging the value-sensitive design approach, we described various strategies for analyzing the ethical implications of nanotechnology-based innovations in mycotoxin remediation. Through comprehensive ethics technology assessment, nanotechnology-based innovations can be guided toward becoming more value-oriented, thereby making substantial contributions to social progress.

Keywords: nanoethics; technology assessment; ethical space; mycotoxin

1. Introduction

New innovations in nanotechnology research are often criticized for their consequences, such as health risks, environmental hazards, high cost and limitations in access to use, patient data privacy issues, lack of assessing community needs, and patent and intellectual property issues [1–6]. These demands reviewing and assessing medical research innovations based on ethics principles [7,8]. Ethics assessment of research and innovations originates from the idea that research and innovations are not value neutral [9–11]. Ethics assessments provide the scope for research and innovation to maximize its benefit and reduce the risk of its application [12]. Ethics assessments for research and innovation can make innovations more inclusive and fairer to consumers. Structured ethics assessment methods will help to understand the possible ethical concerns related to innovations and help to resolve ethical issues. The applicability of technology ethics assessment methods is broadly based on assessing innovations at different levels, i.e., Anticipatory technology ethics (ATE), which is developed for assessing the ethical aspects of emerging technologies in the future [13]. Value-sensitive design is based on assessing and incorporating values during the design phase of research and innovation [14]. An ethical matrix is a tool that enables innovators to perform ethical augmentation with existing innovations [15,16]. Nanotechnology-based interventions for mycotoxin remediation in wheat grain is now an emerging innovation in food safety [17,18]. In the context of

 doi:10.20944/preprints202405.1342.v1

ethics assessment of research and innovation, it is important to analyze the ethics aspects behind nanotechnology incubation for mycotoxin remediation. Value-sensitive design can be a suitable methodology for assessing mycotoxin remediation, as the innovation is in the design phase.

2. Methods

Value-sensitive design analysis involves conceptual and empirical technical methods for analyzing and applying values relevant to innovation. **Conceptual method:** The conceptual method uses tools to identify direct and indirect stakeholders, assess their perception of value assignment to this context and assess whether any value conflicts emerge. **Empirical method:** The empirical method adapts qualitative and quantitative data to inform designers regarding the user's perception of values.

Technical method: Technical assessments can involve either the analysis of models developed after the conceptual or empirical phase or the design of systems to support values identified in conceptual and empirical investigations.

Methodology: Ethics assessment of mycotoxin remediation innovation needs analysis based on conceptual, empirical, and technical methods.

3. Conceptual Methods

In the conceptual phase of the assessment of mycotoxin remediation innovation, the specific stake holders and applicability of values need to be understood through stakeholder analysis and the Stakeholderlder Token approach.

4. Stakeholder Analysis

Stakeholder analysis will be carried out to identify major direct and indirect stakeholders. The stakeholders will be identified through help from previous literature on mycotoxin remediation with nanotechnology and with information from identified stakeholders. In this context, the major stakeholders can be farmers, food technologists, nano scientists, environmental scientists, food supply chain managers and representatives from the general population since the food consumers are important in the context of mycotoxin remediation in foods.

5. Stakeholder Tokens

The stakeholder token approach is used to assess interactions between different stakeholders. Value is also dependent on interactions between stakeholders. In the assessment of mycotoxin remediation innovation, specifically curated role play activity can be conducted for analyzing the emergence and perception of values between different stakeholders.

6. Empirical Method Phase

In this phase of assessment, comprehensive assessments of the perception and applicability of ethical values with mycotoxin remediation innovation can be achieved through value source analysis and co-evolution of technology and social structure approaches.

7. Value Source Analysis

In the context of mycotoxin remediation, innovation value sources can be identified by conducting specific objective-centered questionnaire-based surveys.

8. Coevolution of Technology and Social Structure

Technology incubation can be coevolved through proper conscience over existing law, regulation, and usefulness. This can be achieved through the engagement of experts from these relevant domains. In the context of mycotoxin remediation innovation, Delphi method-based expert panel interviews can be conducted with food safety regulatory experts, food products licensing

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authorities, legal experts, and social workers working in the domain of food safety and food access. It is important to review the process of consensus achieved through Delphi panel discussion. Focused group discussions need to be held to assess the collective perceptions of stakeholders regarding the applicability of values for innovation in mycotoxin remediation.

9. Technical Phase

In this final phase, the prototype model of innovation developed after the conceptual and empirical phases will be analyzed. The Technical phase will use the Value Scenario and Value-oriented Mockup, Prototype or Field Deployment approach for assessment.

10. Value Scenario

The values that are suitable for mycotoxin remediation Innovation are identified after the conceptual and empirical phases. These values are analyzed with stakeholders through semi structured interviews.

11. Value-Oriented Mockup, Prototype or Field Deployment

In this approach, a prototype of a value-incorporated model of mycotoxin remediation innovation will be analyzed in real-world settings. The specific direct stakeholders, such as farmers, nano scientists, consumers, and food technologists, will assess the prototype model of the innovation through questionnaire-based surveys.

12. Conclusion

The innovation of mycotoxin remediation using nanotechnology demands ethics assessment to maximize the benefit and minimize the risk. The value-sensitive design approach of assessment will be suitable for mycotoxin remediation innovation, as the innovation is in the design phase. The value-sensitive design assessment will help mycotoxin remediation innovation to increase ethical values, which can make innovation contribute more significantly to social progress.

Author Contributions: The authors confirm contribution to the paper as follows, study conception and design: Skanthesh L., O. S. N. Ghosh; data collection: Skanthesh L., O. S. N. Ghosh, Vinayak P.; analysis and interpretation of results: Skanthesh L., O. S. N. Ghosh; draft manuscript preparation: Skanthesh L., O. S. N. Ghosh, Vinayak P.; All authors reviewed the results and approved the final version of the manuscript.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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