UNIVERSITATEA DE ȘTIINȚE AGRONOMICE ȘI MEDICINĂ VETERINARĂ DIN BUCUREȘTI
ȘCOALA DOCTORALĂ: INGINERIA ȘI MANAGEMENTUL RESURSELOR VEGETALE ȘI ANIMALE
DOMENIUL DE ABILITARE: BIOTEHNOLOGII

HABILITATION THESIS

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BUCUREȘTI
2025

ADVANCING SUSTAINABILITY THROUGH NANOTECHNOLOGICAL AND ENVIRONMENTAL BIOTECHNOLOGY

Key words: Nanotechnology, environmental biotechnology sustainability, nanoencapsulation, phytoremediation

SUMMARY

The habilitation thesis entitled "*Advancing sustainability through nanotechnological and environmental biotechnology*" represents a synthesis of the most significant scientific, professional, and academic achievements obtained after completing the PhD, with biotechnology as the central pillar, focusing on the sustainable valorization of plant resources and the integration of nanotechnologies in agriculture and environmental protection. The research activities have aimed at developing and characterizing nanostructured materials for use in plant fertilization and protection, optimizing nanoencapsulation technologies to enhance the stability and efficacy of bioactive compounds, and implementing innovative biotechnological solutions for the assessment and remediation of contaminated environments. This thesis highlights a sustained commitment to applied research and the development of innovative solutions to current challenges in health, food security, and environmental sustainability.

The thesis is structured into several sections. The first part outlines the academic and professional trajectory, starting with undergraduate studies in the fields of agriculture and biology, continuing with the defense of the PhD thesis in 2003 at USAMV Bucharest, and the subsequent development of expertise through postdoctoral training and international courses. Since 1999, academic activity at USAMV Bucharest has involved the design and delivery of courses and practical work, authoring textbooks and teaching materials, supervising bachelor's and master's theses, and actively involving students in research activities. These initiatives have aimed to foster critical thinking, practical skills, and adaptability, while promoting innovation and scientific inquiry. Additionally, efforts were made to develop laboratory infrastructure and consolidate a competitive, multidisciplinary academic team.

The second part synthesizes the scientific contributions, grouped into two main research directions: advanced nanotechnologies for biotechnological applications and innovative biotechnological approaches for environmental assessment and remediation. It presents results from national and international research projects on the use of iron oxide and hydroxyapatite nanoparticles in crop fertilization, with documented effects on photosynthesis, root system development, chlorophyll content, and plant biomass. Moreover, nanoencapsulation systems for natural compounds with antioxidant, antimicrobial, and antitumor properties were developed, demonstrating enhanced effectiveness and environmental stability. In parallel,

environmental remediation studies addressed the phytoremediation of heavy metal-contaminated soils and the use of microorganisms and biosorbents in wastewater treatment processes, in alignment with circular bioeconomy principles and green transition objectives.

The chapter dedicated to the recognition and impact of the activity highlights the consolidation of a complex professional and scientific profile, validated by participation in national and international research projects, involvement in scientific networks and strategic initiatives, and the establishment of collaborations with institutions from Italy, Germany, Greece, Morocco, Egypt, and Tunisia. Scientific dissemination has been achieved through publications in ISI-ranked journals, book chapters in reputable international publishing houses, and participation in international scientific conferences. Editorial activities, including peer-review and membership in scientific boards, as well as involvement in institutional and national strategy groups, further illustrate the commitment to academic excellence and the dissemination of knowledge beyond academia.

The final part of the thesis outlines the professional, academic, and scientific development plan. On the educational level, objectives include enhancing the quality of teaching through modern pedagogical methods such as active learning, digital platforms, and student-centered approaches, all supporting the development of professional and transversal competencies relevant to biotechnology and environmental sciences. Emphasis is placed on research-based learning, engaging students in experimental activities, and cultivating scientific thinking. Scientifically, future directions include expanding research into biocompounds and nanomaterials, with assessments of biocompatibility, toxicity, and therapeutic potential using healthy and tumor cell lines. Further priorities include the use of biodegradable nanomaterials and plant extracts for sustainable agricultural practices, biosafety, and environmental remediation, aligned with European goals for the green transition, bioeconomy, and climate adaptation. In this context, the plan involves attracting funding through national and international competitions, coordinating interdisciplinary research teams, and mentoring early-career researchers. In this way, I aim to contribute to the development of an institutional culture grounded in scientific excellence, innovation, and responsibility toward society and the environment.