

## REZUMAT

Teza de abilitare este structurata pe trei sectiuni, respectiv: **Sectiunea I. Realizari Stiintifice, Academice si Profesionale, Sectiunea II. Planuri de evolutie si dezvoltare carierei si III. Referintele bibliografice.**

Activitatea proprie de cercetare prezentata in **Sectiunea I** este relevanta, originala si complexa si ea demonstreaza capacitatea subsemnatului de a elabora si coordona viitoare studii complexe in domeniul tehnicilor, tehnologiilor si materialelor avansate pentru protectia mediului inconjurator in vederea remedierii si conservarii acestuia, precum si pentru monitorizarea parametrilor fizici, chimici si biologici care conduc la perturbarea factorilor de mediu. Activitatea ce o voi prezenta pe parcursul acestei sectiuni este definitorie pentru formarea mea in acest domeniu de o importanta cruciala pentru starea de bine a omului, pentru asigurarea unui mediu curat in care acesta sa se simta in siguranta in ceea ce priveste sanatatea, bunastarea, familia si societatea. Ea este aferenta perioadei 1986 – 2016, perioada in care am fost cofondatorul a doua institute de cercetare romanesti, am dotat laboratoare la standarde internationale, am format tineri cercetatori, am elaborat peste 60 de lucrari stiintifice cotate ISI, 15 brevete de inventie si am contribuit la cresterea vizibilitatii internationale a institutelor in care am activat ca si director filiala, director stiintific sau sef de departament al unui Institut National de Cercetare-Dezvoltare.

Realizarile mele profesionale s-au materializat prin proiecte de cercetare stiintifica si dezvoltare tehnologica din care au rezultat instalatii si standuri de laborator, metode si tehnologii, produse, lucrari stiintifice publicate in reviste internationale cotate ISI si comunicate international, precum si carti si capitole de carte publicate in tara si strainatate. O parte dintre acestea au vizat masuri eficiente pentru protectia si conservarea mediului ce constau in materiale, procese si tehnologii de tratare a apei, aerului si solului.

Capitolul debuteaza cu o introducere succinta in problemele de mediu ce caracterizeaza etapa actuala de dezvoltare a omenirii avand in vedere contextul socio-economic actual, problemele provocate de industrializarea excesiva, de agricultura intensiva ce utilizeaza din ce in ce mai mult fertilizanti chimici, de dezvoltarea urbana generatoare de deseuri menajere ce produc grave dereglari ale mediului. De asemenea sunt trecute in revista masurile ce se iau pe plan european si international pentru a preveni poluarea mediului si dezastrele ecologice ce ar putea avea consecinte grave asupra vietii pe pamant.

Gradul de poluare a mediului este in stransa legatura cu natura poluantilor, iar cei organici necesita o atentie deosebita deoarece, recuperarea lor din apele uzate are doua beneficii, pe deoparte tratarea apei si, pe de alta parte, recuperarea acestora, in speta a nutrientilor (fosfor,

azot) care pot constitui o resursa importanta de fertilizant organic natural pentru agricultura. In acest context sunt prezentate metode actuale de recuperare a acestor nutrienti din apele uzate, precum si cercetari actuale care vin sa imbunatateasca procesul de tratare si recuperare a nutrientilor, masuri in care autorul tezei este implicat din punct de vedere stiintific, tehnic si tehnologic.

In cei peste 30 de ani de activitate in cercetarea stiintifica, autorul tezei a coordonat, in calitate de director/responsabil, un numar de opt proiecte de cercetare stiintifica (**I.5.1 Proiecte de cercetare stiintifica coordonate in calitate de director/ responsabil proiect**) cu aplicatii in domeniul prevenirii, protectiei si conservarii mediului. Contributia stiintifica a autorului tezei in acest domeniu este prezentata in cadrul a cinci subcapitole ce se refera la publicatiile stiintifice semnificative in domeniu (**I.5.2 Lucrari stiintifice semnificative**), dupa cum urmeaza:

**1. Metode de tratarea apei** - se refera la procesele de tratare a apelor uzate provenite din activitati industriale si casnice, precum si a apelor de suprafata si subterane si care impun ca necesitate imediata dezvoltarea unor tehnologii eficiente si accesibile pentru epurarea si potabilizarea apelor uzate.

Managementul resurselor de apa conform noilor standarde privind calitatea apei si modificarea normelor ce vizeaza evacuarea apelor uzate presupun elaborarea de noi procedee cu eficienta crescuta in tratare care insa, au si ele avantaje si dezavantaje, motiv pentru care se impun noi tehnologii de epurare pentru a diminua impactul negativ al industrializarii si al dezvoltarii urbane asupra resurselor naturale de apa.

Procesele de tratare a apelor uzate rezultate in special prin deversarea efluentilor industriali, consumului excesiv de pesticide, fertilizantilor chimici si deseurilor domestice se realizeaza prin procedee fizice si biologice. Dupa eliminarea particulelor solide are loc tratarea biologica (decontaminarea naturala) procedeu care, din pacate, nu are efect asupra unor poluanti organici ne biodegradabili motiv pentru care procedeele de oxidare avansata sunt tot mai utilizate pentru degradarea acestor contaminati deoarece sunt stabili chimic, foarte putin biodegradabili si, mai ales, acesti poluanti nu pot fi indepartati prin tehnicile conventionale.

S-a aratat in studiu faptul ca tehnologiile electrochimice si fotochimice pot fi considerate tehnologii eficiente de reducere a poluarii deoarece electroliza, fotocataliza heterogena sau electroliza asistata electrochimic sunt considerate procese de oxidare avansata fiind utilizate ca tehnici suplimentare de epurare.

Studiile asupra fotodegradarii unor diverse tipuri de contaminati din apa (hidrocarburi halogenate, hidrocarburi aromatice, heterociclii cu azot, sulfuri de hidrogen, surfactanti, ierbicide, ionii metalelor toxice, etc) au aratat ca cea mare parte din poluantii organici pot fi fie mineralizati, fie macar degradati partial, iar procesul fotocatalitic, influentat de proprietatile de suprafata si

structurale ale catalizatorului de tip semiconductor s-a dovedit a fi eficient pentru eliminarea mai multor tipuri de compusi organici.

**2. Materiale avansate si procedee pentru indepartarea compusilor organici din apa uzata** - Cercetarile au vizat identificarea unor noi metodologii pentru recuperarea si reutilizarea unor compusi organici din apele uzate. De asemenea, a fost investigata posibilitatea utilizarii unor materiale hibride pentru degradarea unor poluanti organici din apa de suprafata. Un alt aspect studiat in cadrul tematicii a urmarit dezvoltarea unor metode ecologice si eficiente pentru decontaminarea apei (procese oxidative, electrochimice, etc.).

Apa, unul dintre elementele esentiale carora li se datoreaza viata pe Pamant, impune, datorita poluarii cauzate de factori in general dependenti de om, elaborarea unor strategii durabile, eficiente de tratare in vederea redarii ei consumului casnic si industrial si care au un aport esential la sustinerea strategiilor globale de dezvoltare durabila a mediului.

In contextul orientarii cercetarilor actuale pentru elaborarea si dezvoltarea unor tehnologii ecologice pentru tratarea apei, s-a acordat o atentie crescuta unor metode eficiente de tratare bazate pe noi fotocatalizatori hibridi cu eficienta ridicata. Aceasta implica identificare de noi materiale avansate, iar materialele hibride organic/anorganic sunt o solutie promitatoare de viitor, iar autorul tezei este coautor la implementarea ei in cadrul unui institut de cercetare stiintifica.

Aceste materiale, in functie de natura, dimensiunea si concentratia componentelor, sunt proiectate a contribui la decontaminarea apelor uzate, a celor de suprafata si subterane atat in ceea ce priveste poluantii organici, cat si metalele continute de acestea (As, Cu, Pb, Zn, Cd, Fe si Ni). Performanta si eficienta activitatii fotocatalitice a acestor materiale a fost determinata prin studii comparative de fotocataliza si fotoliza.

Rezultatele acestor studii au fost materializate prin articole ISI, un capitol de carte publicat in strainatate, proiect de cercetare national finantat, cereri de brevet si premii internationale obtinute.

**3. Procese de sinteza a unor materiale avansate pentru decontaminarea aerului si apei**

Materialele avansate in general, cele hibride in special, au o contributie importanta la elaborarea proceselor si tehnologiilor eficiente de decontaminare a apei, solului si aerului. Unul dintre cele mai eficiente materiale pentru acest scop este dioxidul de titan forma anatase de dimensiuni nanometrice, atat nedopat cat si dopat cu diferiti ioni metalici (Au, Ag, Pt, etc.).

Procedeele utilizate pentru sinteza acestor materiale sunt moderne, cu eficienta ridicata in ceea ce priveste calitatea acestora, ecologice si mici consumatoare de energie. Se evidentiaza in special metoda

hidrotermala la temperaturi si presiuni moderate (200-280<sup>0</sup>C si 100 atm) cu diferite variatii in ceea ce priveste incalzirea reactantilor, cele mai eficiente fiind incalzirea in camp de microunde si cea prin imersare in baia de ulei siliconic preincalzita, acestea presupunand un timp de procesare de cateva zeci de minute fata de zeci de ore cat dureaza metoda hidrotermala clasica. Mediul de lucru este ermetic inchis, astfel incat procesul de sinteza nu afecteaza in nici un fel calitatea mediului ambiental, procesul fiind unul inchis, izolat de mediu.

#### **4. Identificarea compusilor organici prin spectroscopie de FT-IR**

In chimia organica identificarea si elucidarea structurii moleculare a unei substante are o importanta deosebita. Spre deosebire de alte proprietati fizice cum sunt punctul de topire, indicele de refractie, densitate specifica, care ofera cate un singur element de comparatie cu alte tipuri de substante, spectrul de IR al unui anumit compus ofera mai multe informatii printre care pozitia si intensitatea benzilor de absorbtie, acest ultim indicator furnizand informatii asupra numarului de grupe functionale care contribuie la absorbtia intr-o anumita regiune spectrala. Moleculele unei substante absorb un set unic de frecvente de radiatie IR, cele care corespund vibratiilor ce determina o modificare a momentului sau dipolar deoarece vibratia de o anumita frecventa este dependenta de masa atomilor respectivi, de natura legaturii chimice si de geometria moleculei.

Fiecare molecula, cu exceptia enantiomerilor, are un spectru IR caracteristic materializat prin doua regiuni: asa-numita zona a „ampretei” care este unica pentru fiecare molecula si zona grupelor functionale care este similara pentru moleculele cu aceleasi grupe functionale. Benzile spectrului IR al unei molecule sunt caracteristice tipurilor de legaturi si structurii unei anumite molecule chimice. Prin spectroscopie de IR se pot analiza probe solide, lichide sau gazoase. In mod obisnuit, singurele molecule transparente sunt moleculele monoatomice si homonucleare: Ne, He, O<sub>2</sub>, N<sub>2</sub>, si H<sub>2</sub>.

**5. Materiale si metode avansate pentru producerea de energie curata cu impact pozitiv asupra mediului ambiental** - interesul pentru aceasta tematica de cercetare este de mare actualitate si este determinat atat de nevoia de energie curata, cat si de masurile de prevenire a poluarii mediului ambiental. Rezultatele publicate au fost obtinute in cadrul unui proiect national de cercetare stiintifica in care s-a urmarit obtinerea de biocombustibili din lignoceluloza. Obiectivul studiului l-a constituit identificarea unor tehnici durabile si performante pentru pretratarea lignocelulozei avand in vedere faptul ca acesta etapa este determinanta pentru disponibilitatea si eficienta economica a bioetanolului. Au fost elaborate studii pentru evaluarea eficientei noilor metode combinate de pretratare propuse si proiectarea unor procese pentru eficientizarea resurselor vegetale (deseuri vegetale provenite din agricultura, forestiere,

plante fara valoare economica) ca sursa de energie curata. De asemenea, studiile au urmarit proiectarea si elaborarea unor tehnologii inovative, ecologice, performante si eficiente economic pentru obtinerea unor noi materiale hibride organic/anorganic cu proprietati speciale prin valorificarea unor deseuri (agricole, forestiere, industriale) si a unor poluanti din apa uzata.

Rezultatele obtinute au fost diseminate prin articole publicate in reviste recunoscute international, lucrari comunicate la manifestari stiintifice de prestigiu, capitole de carte publicate in edituri din strainatate si un brevet national acordat.

Relevanta si recunoasterea nationala si internationala a rezultatelor stiintifice obtinute in cadrul tematicilor stiintifice abordate si prezentate in Sectiunea I a tezei de abilitare este dovedita prin lucrarile stiintifice publicate, premiile obtinute la saloanele internationale de inventica, proiectele de cercetare finantarea in competitii nationale si international pe care le-am elaborat si coordonat in calitate de director /responsabil proiect.

Realizarea acestor rezultate a fost posibila datorita unei stranse colaborari cu echipe de specialisti din tara si din strainatate in care au fost implicati cercetatori seniori alaturi de tineri cercetatori printre care si masteranzi, doctoranzi, post doctoranzi.

Competentele manageriale dobandite au fost demonstrate prin coordonarea in calitate de director /responsabil de proiect a unor echipe multi si interdisciplinare de cercetare, dar si prin atragerea unor contracte [de servicii stiintifice finantate de agenti economici](#).

Abilitatea de a aborda cercetari complexe, multidisciplinare s-a format prin implicarea in calitate de coordonator in peste 40 de proiecte de cercetare stiintifica nationale si internationale in cei peste 30 ani de cariera stiintifica.

Dezvoltarea si implementarea domeniului materialelor hibride multifunctionale pentru aplicatiin tehnologii de medu si obtinerea de energie curate contribuie in mod esential la imbunatarirea sigurantei si securitatii persoanei, economice, energetice si cresterea calitatii vietii. Din acest motiv, consider ca un aspect important in dezvoltarea viitoarei cariere este formarea si consolidarea unei echipe de cercetare multidisciplinara in domeniul materialelor hibride multifunctionale in cadrul Universitatii Aurel Vlaicu din Arad astfel incat sa fie valorificata la nivel superior infrastructura de cercetare stiintifica pe care o detine aceasta institutie, precum si expertiza personalului cercetator in domeniul protectiei mediului prin implicarea activa in activitatile de cercetare si didactice a studentilor de la toate formele de invatamant astfel incat acestia, dupa finalizarea cursurilor, sa fie capabili sa transmita noi cunostiinte atat viitorilor specialisti cat si in mediul academic sau privat pentru a aduce plus valoare activitatilor stiintifice si economice viitoare

## SUMMARY

The habilitation thesis is organized in three major chapters: **Section I. Scientific, Academic and Profesional Achievements;** **Section II.** Development plans and career development and **III. References.**

The own research activity presented in Section I is relevant, original and complex and it demonstrates the ability of the undersigned to develop and coordinate future complex studies in the field of advanced techniques, technologies and materials for the protection of the environment in order to remedy and monitoring Physical, chemical and biological parameters that lead to disruption of environmental factors. The activity I will present during this section is crucial for my training in this area of crucial importance to the well-being of man, to ensure a clean environment in which he feels safe in terms of health, well-being, family and society. It is related to the period 1986 - 2016, the period when I was the cofounder at two Romanian research institutes, we have equipped laboratories to international standards, we have formed young researchers, we have developed over 60 ISI scientific papers, 15 patents and contributed To increase the international visibility of the institutes in which I worked as a subsidiary director, scientific director or head of department.

My professional achievements have been materialized through scientific research and technological development projects that have resulted in laboratory installations and stands, methods and technologies, products, scientific papers published in internationally rated ISI journals and international papers as well as book chapter published in Country and abroad. They aimed at effective measures to protect and preserve the environment consisting of materials, processes and technologies for water, air and soil treatment.

The chapter begins with a brief introduction to the environmental issues that characterize the current stage of human development considering the current socio-economic context, problems caused by excessive industrialization, intensive agriculture that increasingly use chemical fertilizers, urban development Generators of household wastes that cause serious environmental degradation. Also, the European and international measures are being reviewed to prevent environmental pollution and ecological disasters that could have serious consequences for life on earth.

The degree of pollution of the environment is closely related to the nature of the pollutants, and the organic ones require considerable attention because their recovery from the wastewater has two benefits, as well as the treatment of water and, on the other hand, their recovery, in the context of nutrients (Phosphorus, nitrogen) may constitute an important natural organic fertilizer resource for agriculture. In this context are presented current methods of

recovering these nutrients from the wastewater, as well as current research that improve the process of nutrient treatment and recovery, measures in which the author of the thesis is scientifically, technically and technologically involved.

In the over 30 years of scientific research activity, the author of the thesis coordinated as a director / responsible a number of eight scientific research projects (1.5.1 Scientific coordinated research projects as project manager / responsible) with Applications in the field of prevention, protection and conservation of the environment. The scientific contribution of the author of the thesis in this field is presented in five subchapters referring to the significant scientific publications in the field (1.5.2 Significant Scientific Papers), as follows:

**1. Water treatment methods** - refers to waste water treatment processes from industrial and domestic activities as well as surface and underground water and which require the immediate development of efficient and accessible technologies for the treatment and potable water treatment.

The management of water resources according to the new water quality standards and the modification of the rules regarding the wastewater discharge presuppose the elaboration of new processes with higher efficiency in treatment which, however, also have advantages and disadvantages, which is why new purification technologies are required to diminish The negative impact of industrialization and urban development on natural water resources.

Sewage treatment processes, results in especially due to industrial effluent discharges, excessive pesticide use, chemical fertilizers and domestic wastes are achieved through physical and biologic processes. After the elimination of solid particles, biological treatment (natural decontamination) takes place, which unfortunately has no effect on non-biodegradable organic pollutants, for which advanced oxidation processes are increasingly used for the degradation of these contaminants because they are chemically stable, very little biodegradable And, above all, these pollutants can not be removed by conventional techniq.

Studies on the photodegradation of various types of water contaminants (halogenated hydrocarbons, aromatic hydrocarbons, nitrogen heterocycles, hydrogen sulphides, sulfates, herbicides, toxic metal ions, etc.) have shown that most of the organic pollutants can either be mineralized or At least partly degraded, and the photocatalytic process, influenced by the surface and structural properties of the semiconductor catalyst, has proven to be effective in eliminating several types of organic compounds.

**2. Advanced materials and processes for the removal of organic compounds from wastewater** - the research aimed at identifying new sustainable methodologies for the recovery and re-use of organic compounds from wastewater. It has also been investigated the

possibility of using hybrid materials for the degradation of organic pollutants from surface water. Another topic studied was the development of ecological and efficient methods for water decontamination (oxidative, electrochemical processes, etc.).

Water, one of the essential elements for life on Earth, requires, due to pollution caused by factors generally dependent on humans, the development of sustainable, efficient strategies for treating domestic and industrial consumption, and which have an essential contribution to Sustaining global strategies for sustainable environmental development.

In the context of the current research orientation for the development and development of ecological technologies for water treatment, increased attention has been paid to efficient methods based on new high efficiency hybrid photocatalysts. This involves the identification of new advanced materials and the organic / inorganic hybrid materials are a promising solution for the future, and the author of the thesis aimed this field within a research institute.

These materials, depending on the nature, size and concentration of the components, are designed to contribute to the decontamination of wastewater, surface and groundwater both with regard to organic pollutants and the metals they contain (As, Cu, Pb, Zn, Cd, Fe and Ni). The performance and efficiency of photocatalytic activity of these materials was determined by comparative photocatalysis and photolysis studies. The results of these studies have been materialized in ISI articles, a book chapter published abroad, national funded research project, patent applications and international prizes.

**3. Processes of synthesis of advanced materials for decontamination of air and water** - generally advanced materials, especially hybrids, have an important contribution to developing efficient processes and technologies for decontamination of water, soil and air. One of the most effective materials for this purpose are titanium dioxide-anatase- nanometric particles, undoped and doped with different metal ions (Au, Ag, Pt, etc.).

The processes used for the synthesis of these materials are modern, with high efficiency in terms of their quality, ecological and low energy consuming. Particularly highlighting is the hydrothermal method at moderate temperatures and pressures (200-280<sup>0</sup>C and 100 atm) with different variations in the heating of the reactants, the most effective being to find the heating in the microwave field and the immersion in the pre-heated silicone oil bath, that Assuming a processing time of several tens of minutes compared to tens of hours of hydrothermal recovery. The work environment is hermetically sealed, so the synthesis process does not in any way affect the quality of the environment, the process being a closed one, isolated from the environment.



**4. Identification of organic compounds by FT-IR spectroscopy** - in organic chemistry, the identification and elucidation of the molecular structure of a substance is of particular importance. Unlike other physical properties such as the melting point, refractive index, specific density, which offer only one element of comparison with other types of substances, the IR spectrum of a particular compound provides more information including the position and intensity of the bands Absorption. This latter indicator provides information on the number of functional groups that contribute to absorption in a particular spectral region. A substance molecules absorbs a unique set of IR frequencies that correspond to vibrations that cause a change in its dipolar moment since vibration at a certain frequency is dependent on the mass of the atoms involved, the nature of the chemical bond, and the geometry of the molecule.

Each molecule, with the exception of enantiomers, has a characteristic IR spectrum in two regions: the so-called "fingerprint" area that is unique to each molecule and functional group area that is similar for molecules with the same functional groups. The IR spectrum bands of a molecule are characteristic of the types of bonds and structure of a particular chemical molecule. Through IR spectroscopy, solid, liquid or gaseous samples can be analyzed. Typically, the only transparent molecules are monoatomic and homonuclear molecules: Ne, He, O<sub>2</sub>, N<sub>2</sub>, and H<sub>2</sub>.

**5. Advanced materials and methods for producing clean energy with positive impact on the environment** - The interest in this research topic is of great relevance and is determined both by the need for clean energy and by measures to prevent environmental pollution. The published results were obtained within a national research project in which the production of biofuels from lignocellulose was improved. The objective of the study was to identify long-lasting and efficient techniques for pretreatment of lignocellulose, given that this stage is decisive for the bio-ethanol availability and efficiency. Studies have been developed to evaluate the effectiveness of proposed new combined pretreatment methods and to design processes to increase the efficiency of plant resources (agricultural, forestry, non-economical plant waste) as a clean energy source. The studies also aimed at designing and developing innovative, ecological, efficient and economically technologies for obtaining new organic / inorganic hybrid materials with special properties by using waste (agricultural, forestry, industrial) and pollutants from wastewater.

Rezultatele obținute au fost diseminate prin articole publicate în reviste recunoscute pe plan internațional, lucrări comunicate la prestigioase manifestări științifice, capitole de carte publicate în edituri străine și brevet național acordat.

The relevance and the national and international recognition of the scientific results obtained within the scientific themes approached and presented in Section I of the empowerment

thesis is evidenced by published scientific papers, prizes obtained at international inventions salons, research projects financing in national and international competitions on which We have developed and coordinated them as project manager / responsible.

Achieving these results was possible due to a close collaboration with teams of specialists from the country and abroad, involving senior researchers with young researchers, including master students, doctoral students, post-doctoral students.

The managerial skills gained have been demonstrated through the coordination of several multidisciplinary research teams as Project Manager / Project Officer, as well as by attracting scientific services contracts funded by economic agents.

Abilitatea de a aborda o cercetare complexă multidisciplinară a fost formată prin implicarea în calitate de coordonator în peste 40 de proiecte științifice naționale și internaționale de peste 30 de ani de carieră științifică

The development and implementation of multifunctional hybrid materials for applications in environmental technologies and the obtaining of clean energy contributes to the improvement of the safety and security of the person, the economic, the energetic and the improvement of the quality of life. For this reason, I consider that an important aspect in the development of the future career is to train and consolidate a multidisciplinary research team in the field of multifunctional hybrid materials at Aurel Vlaicu University in Arad so as to capitalize on top the scientific research infrastructure it owns This institution as well as the expertise of the research personnel in the field of environmental protection through active involvement in the research and didactic activities of the students from all the forms of education so that after the completion of the courses they will be able to transmit new knowledge to the future specialists as well as to the The academic or private environment to bring added value to future scientific and economic activities.