emphasis is put on the use of biological methods and processes for the remediation of contaminated soils and water resources.

BIOL 615 Principles of Bioremediation (1 Hour) Laboratory and field experiments conducted to familiarize students and methodologies. Identification and classification of microorganisms, use of bacteria in toxicity assessment, biodegradation of organic contaminants, and phytoremediation ot toxic metals are dicussed.

BIO 620 Independent Study Students will elect a specific topic that is not covered in other biology courses. The student, working independently, will be required to submit a research paper that includes an exhaustive review of literature.

BIO 621 Advanced Plant Morphology. (4 Hours) Prerequisite: Bio 521. Analysis and morphology of vascular plants ranging from pteridophyta through angiosperms with phylogenetic considerations.

BIO 650 Analysis of Hormone Action. (3 Hours) Prerequisite: Graduate status and consent of the instructor. An analysis of the cellular mechanisms of hormone action. The role of target tissues, receptors, hormone analogs and metabolic inhibitors in studies of hormone action will be discussed.

BIO 630 Thesis Research. Thesis representing original research.

*These courses (or close equivalents) also may be taken during summers at the Gulf Coast Research Laboratory, Ocean Springs, Mississippi; Dauphin Island Sea Laboratory, Alabama, or other coastal teaching/research laboratory for credit at JSU subject to approval on individual basis by JSU administration and coastal laboratory administrators.

Doctor of Philosophy
ENVIRONMENTAL SCIENCE

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Faculty

(Interdisciplinary, listed by their Primary Department)

Biology:
Dr. M. T. Begonia, Assoicate Professor
Dr. P. Chigbu, Associate Professor
Dr. I. Farah, Associate Professor
Dr. E. Hamadain, Associate Professor
Dr. M. Hardy, Professor
Dr. H. Hwang, Professor
Dr. R. Isokpehi, Assistant Professor
Dr. R. Kafoury, Assistant Professor
Dr. A. Mohamed, Professor
Dr. A. Patolla, Assistant Professor
Dr. D. Sutton, Assistant Professor

Chemistry:
Dr. Z. Arslan, Assistant Professor
Dr. A. Hamme, Assistant Professor
Dr. J. Leszczynski, Distinguished Professor
Dr. Y. Liu, Associate Professor
Dr. H. Tachikawa, Professor
Dr. H. Yu, Associate Professor

Civil and Environemtal Engineering
Dr. F. Amini, Professor
Dr. Y. Li, Assistant Professor

Computer Engineering
Dr. M. Manzoul, Professor
Dr. R. Whalin, Professor

Computer Science
Dr. W. Brown, Associate Professor
Dr. Q. Malluhi, Professor
Dr. L. Moore, Associate Professor

Mathematics
Dr. T. Kwembe, Professor
Dr. R. Gompa, Professor

Physics, Atmospheric Sciences and General Science
Dr. Y. Li, Assistant Professor
Dr. S. Reddy, Associate Professor
Dr. Q. Williams, Associate Professor

Technology
Dr. I. Mosley, Associate Professor
Dr. P. C. Yuan, Professor

Program Mission

To produce highly skilled environmental scholars who in turn will provide for policy makers and the general public, scientific and factual information derived from laboratory and field applied research encompassing basic sciences, engineering and technology. As such, it is related to the assessment of water contamination, food contamination, air pollution, global warming, toxic and hazardous substances releases and associated environmental issues; and the development of cost-effective methodologies and strategies to protect the environment and human health.

Program Objectives

1. To provide graduate students with essential knowledge, skills and aptitudes needed for successful careers in environmental science related jobs at various institutions including government agencies, academia and the environmental industry.
2. To protect the environment and human health by educating and training students on the interactions between the various components/systems of the environment, the complex and fragile nature of the environment, and how to sustain ecosystem integrity and protect human health.
3. To establish applied environmental science research initiatives that will lead to an authoritative base of knowledge concerning the State of Mississippi's environment and natural resources; by assessing and understanding the mechanisms by which physical, chemical, and biological agents generated by nature many cause alterations of ecosystem integrity, disability and diseases in man and other life forms.
4. To develop and understand cost-effective methodologies and means whereby the impact of various environmental pollutants may be prevented and/or controlled, and to integrate important knowledge and technologies in the physical, chemical, biological and social sciences needed to set policies and guidelines for appropriate utilization and management of vital resources.
5. To render services to the community through outreach programs, technology transfer for the protection of natural resources and the development of the economy, and communication to convey environmental science education to the public.

Admission Requirements

Admission to the doctoral program in Environmental Science is open to persons holding the master's degree in science, technology, engineering, or agriculture; demonstrated satisfactory performance on the Graduate Record Examination (GRE), and the Test of English as Foreign Language (TOEFL) for international students; and acceptable academic records.

All students seeking admission to this Ph.D. Program must meet the following criteria:

1. A Master's degree in natural sciences or related sciences from an accredited university. *An applicant with a Bachelor's degree only may be admitted when that student shows exceptional potential as determined by a GPA of 3.5 or better, a satisfactory GRE, and extraordinary work experience*,
2. A completed program application submitted to the Graduate School,
3. An official score on the Graduate Record Examination (GRE),
4. An overall GPA of 3.25 or above (on a 4.0 scale) on the highest earned degree,
5. Transcripts for all post secondary and graduate work attempted prior to a program application,
6. Recommendations from three major graduate professors knowledgeable of the applicant's professional academic ability, job experiences, and leadership and research potential,
7. Acceptable evidence of a student's writing ability as determined by a writing sample,
8. A satisfactory TOEFL score for international students,
9. A successful interview with the program screening committee, and
10. Recommendation for admission by the program screening committee.

All applications received are reviewed by a standing Environmental Science Doctoral Advisory Committee which recommends acceptance or denial of admission to the Graduate School. The Graduate School officially informs the prospective student of its decision for the University.

Transfer Credits

A maximum number of nine credit hours can be transferred into the Program. Courses for which transfer credits are sought must be at least 700-Level; must have been completed with a grade of B or better; and must be approved by the student's Advisory Committee, the Environmental Science Advisory Committee, the Dean of the School of Science and Technology, and the Dean of the Division of Graduate Studies. Credit for thesis or dissertation research as well as "internship" course work in any form is not transferable.

Time Limit

No student will be granted a doctoral degree unless all requirements are completed within a period of ten (10) consecutive calendar years from the time of admission to the program.

Financial Aid

Graduate research and teaching assistantships are available on a competitive basis to highly qualified students.

Residence

Students are required to spend one academic year in resident

study on the campus. One academic year may include two adjacent regular semesters or one regular semester and one adjacent summer session. To satisfy the continuous residence requirement, the student must complete a minimum of eighteen (18) hours for the required period.

Candidacy Requirements

To be admitted to candidacy for the doctoral degree, a student must have:

1. Completed the formal coursework with a GPA of 3.0 or better.
2. Passed the Comprehensive Examination.
3. Filed with the Dean of the Graduate School, the dissertation proposal approved by the student's Advisory Committee, the Program Director and the Academic School Dean.

Degree Requirements

The program requires approximately two years of course work (40 semester hours) and a minimum of twenty (20) semester hours of dissertation research credit beyond the MS degree. The exact program of study will be determined by the student's graduate committee. Additional requirements include:

1. Satisfactory performance on the Comprehensive Examination administered after the student has completed all course work; and
2. Successful defense of the dissertation research. The final basis for granting the degree shall be the candidate's grasp of the subject matter in a specialized area of environmental science, and a demonstrated ability to express thoughts clearly and forcefully in both oral and written languages.

Required Courses		**Semester**
Course	**Title**	**Hours**
ENV 700	Environmental Systems	3
ENV 701	Environmental Chemistry	4
ENV 702	Environmental Health	3
ENV 711	Applied Environmental Biostatistics	3
ENV 751	Water Quality Management	3
ENV 755	Air Quality Management	3
ENV 800	Environmental Toxicology	4
ENV 801	Risk Assessment and Management	3
ENV 900	Environmental Science Seminar	2
ENV 999	Dissertation Research	20
	Total Hours	48

In addition to the required courses shown above, the student must complete a minimum of 12 semester hours selected from the elective courses listed below. Other electives in biological sciences, physical sciences, engineering, technology, and public policy will be added as developed.

Elective Courses		**Semester**
Course	**Title**	**Hours**
CSC 700	Computer modeling	3
CSC 800	Image Interpretation	3
MATH 700	Statistics and Experimental Design	3
MET 800	Environmental Meteorology	3
ENV 715	Principles of Bioremediation	4
ENV 721	Solid Waste Management	3
ENV 780	Environmental Epidemiology	3
ENV 802	Environmental Physiology	4
ENV 803	Wetland Ecology	4
ENV 830	Environmental Microbiology	4

The minimum total semester hours required for the doctoral degree is 60.

DESCRIPTION OF COURSES

ENV 700 Environmental Systems. (3 hours). A groundwork of environmental science, environmental awareness and ecological literacy for the incoming Ph.D. students is presented. The environment and its living and non living components, and the interactions of these component areas studied. The course is set in a thermodynamic perspective and is based on a nested hierarchy of systems. Key concepts and principles that govern how we think the environment works are presented while learning how to apply these concepts to possible solutions of various environmental degradation, pollution and resource problems.

ENV 701 Environmental Chemistry. (3 hours). Prerequisites: One year of general Chemistry and one year of organic chemistry. Studies of the basic concepts of environmental chemistry; the nature of chemical compounds; organic and inorganic; chemical reactions; their effects, and fate of chemical species, in aquatic systems. This include: Studies of equilibrium phenomena of acids, bases, salts, complex compounds, and oxidation/reduction reactions. Studies of water pollution, environmental chemistry of water and its properties.

ENVL 701 Environmental Chemistry (1 hour). Experiments done for the purpose of water quality control and assessment, such as the determination of alkalinity, acidity, water hardness, biochemical oxygen demand (BOD), and other important parameters. The laboratory is coordinated to go with the lecture material.

ENV 702. Environmental Health. (3 hours). This course focuses on the impact of environmental problems on human health. Health issues related to water pollution/contamination by physical, chemical and biological agents; wastewater discharges; radiations; air pollution; municipal, and industrial wastes; food contamination; pesticides; occupational hazards; and vector-borne diseases are discussed.

ENV 711 Applied Environmental Biostatistics. (3 hours) Prerequisite: Biostatistics (Bio 511) or equivalent. This course is designed as an applied, advanced biostatistics course for students in the Environmental Science Ph.D. Program. Students will learn how to apply important concepts and principles of environmental biostatistics in the conduct of their research, from the initial designing of experiments to proper data collection and analysis, inferences, interpretation of results in applied terms, reporting and presentation of the results. The statistical computer software (SAS) will be used to analyze and interpret results.

ENV 751 Water Quality Management. (3 hours). This course provides students with basic concepts and principles in Water Quality Management. The effects of organic, inorganic, biological and thermal pollutants/contaminants in various systems of the hydrologic cycle including streams, reservoirs, and estuaries; eutrophication; water quality criteria and standards; monitoring concepts; methods in water quality management; regulatory considerations; and non point source pollution control, are discussed.

ENV 755 Air Quality Management. (3 hours). This course provides students with basic concepts and principles of air quality management. Contaminant classification, pollutant sources, criteria pollutants, health effects, exposure and risk assessment are discussed. Pollutant measurements and air quality assessment techniques are considered with regard to atmospheric effects on dispersion and transport. Identification of, and control strategies for, stationary and mobile sources, and environmental regulations are studied, and indoor air quality considered.

ENV 800 Environmental Toxicology. (3 hours). Prerequisites: ENV 701, ENV 702. This course is designed to provide an overview of the basic principles and concepts of toxicology including : exposure characterization, dose-response relationship, kinetics and distribution of toxicants in a biological system; to understand the fate, behavior and toxicities of xenobiotic chemicals, and the mechanisms by which they affect cells and organs; and to identify the sources and discuss the effects of various groups of environmental toxicants including heavy metals, pesticides and other industrial byproducts.

ENVL 800 Environmental Toxicology. (1 hour). This course is designed to familiarize the students with important laboratory and field procedures and methods used in toxicological testing of environmental toxicants; and to discuss the strengths and weaknesses of major methodologies including acute, subacute, subchronic and chronic bioassays.

ENV 801 Risk Assessment and Management. (3 hours). Prerequisites: ENV 800, MATH 700. This course is designed to provide students with qualitative and quantitative skills necessary to evaluate the probability of injury, disease and death in humans and other life forms, from exposure to various environmental contaminants. Hazard identification, exposure assessment, dose-response evaluation and risk characterization are emphasized. Regulatory and technical aspects of risk assessment in the promulgation of public and environmental safety standards are discussed.

ENV 900 Seminar. (0.5 hr x 4 semesters =2) (Lecture). This course focuses on contemporary issues in environmental health science. The student is expected to review, discuss, and present orally a report on a topic related to contemporary environmental issues. Topic areas for selection include (but not limited to): environmental biology, environmental chemistry, environmental microbiology, environmental toxicology, atmospheric science, water quality management, solid and hazardous waste management, computer modeling and remote sensing. Students are required to attend all scheduled seminars.

ENV 999 Dissertation Research. (20 hours). Original research in one of several subdisciplines in Environmental Science. Credit per academic session allowable is 1-6 hours. Student must produce, present and defend a document of publication quality.

Elective Courses

CSC 700 Computer Modeling. (3 hours). The purpose of this course is to provide the student with the fundamental knowledge of simulation models, writing programs to generate random numbers from various probability distributions using differential methods, and testing the statistical properties of random number generators. The student will also be trained to write simple programs to simulate real life situation models using GPSS language.

CSC 800 Image Interpretation. (3 hours). This course presents a broad overview of various image processing concepts and techniques. Topics include the history of remote sensing, image digitation, data formats, hardware and software functions, commercial and public available digital processing systems, image preprocessing (radiometric and geometric correction), image enhancement, image classification, change detection, interfaces of remote sensing and geographical information system (GIS), and the future of digital image processing.

MATH 700 Statistics and Experimental Design. (3 hours) Prerequisite: MATH 272. Or 2 semesters of Introductory Statistics. Probability; random variables; expectation of a function of random variables; sampling distribution; estimation; hypothesis testing; designed experiments; completely randomized design; randomized complete block design; Latin square design; factorial experiments; statistical software application to statistical analysis, are discussed.

MET 801 Environmental Meteorology. (3 hours). Principles of atmospheric science as applied to gaussian modeling of pollutants. Includes source review and receptor identification and modeling, National Ambient Air Quality Standards and human health and welfare impacts, plume

behavior, and access of EPA models, running of EPASCREEN, and web site information. Special topics covered include: scavenging; acid precipitation; weather modification, green house enhancement; stratospheric ozone; scrubbers; and indoor air quality.

ENV 715 Principles of Bioremediation. (3 hours). This course uses modern knowledges in life sciences, as well as new developments in biotechnology to address important issues related to environmental clean-up of hazardous wastes. The nature of environmental pollution is reviewed, and basic concepts in molecular biology, biochemistry, microbiology and plant physiology are applied to demonstrate the significance of bioremediation and phytoremediation in pollution control. Therefore, an emphasis is put on the use of biological methods and processes for the remediation of contaminated soils and water resources.

ENVL 715 Principles of Bioremediation. (1 hour). Laboratory and field experiments conducted to familiarize students with relevant bioremediation techniques and methodologies. Identification and classification of microorganisms, use of bacteria in toxicity assessment, biodegradation of organic contaminants, and phytoremediation of toxic metals are discussed.

ENV 721 Solid Waste Management. (3 hours). This course emphasizes on waste control methodologies for both municipal and industrial wastes including hazardous and nonhazardous waste under the Resource Conservation and Recovery Act (RCRA). The students are familiarized with environmental legislation regulating these wastes at state and federal levels. A thorough review is done on waste handling, transport, treatment technologies including chemical, physical, biological and thermal treatments, and disposal options such as land disposal of wastes. Waste minimization techniques such as source reduction and recycling are also discussed.

ENV 780 Environmental Epidemiology. (3 hours) This course is designed to provide students with the basic knowledge and skills required to develop and apply epidemiologic principles and concepts to the study of adverse effects of various environmental factors on both human and ecological health. Emphasis is put on the study of the health effects of physical, chemical and biologic factors in the external environment, broadly conceived from the epidemiologic point of view. As such, it enables students to interpret epidemiological data and understand the approaches used in the epidemiologic investigations of acute and chronic diseases. The course also covers the basic methods and issues involved in epidemiologic investigation of disease conditions in human populations.

ENV 802 Environmental Physiology. (3 hours). This course provides students the basic concepts of homeostasis and adaptation to the environment. Discussions are designed to provide an understanding of the physiological responses to various types of pollutants in The different environmental systems including aerospace, hyperbaric, marine and terrestrial environments. Emphasis is placed on homeostatic responses at cellular, organ and organ system levels to various environmental stresses.

ENVL 802 Environmental Physiology. (1 hour). Laboratory exercises are performed to introduce students to instrumental techniques necessary in the understanding of homeostatic regulatory mechanisms that permit adaptation of organisms to varied and peculiar habitats.

ENV 803 Wetland Ecology. (3 hours). This course is designed to provide scientific knowledge for a better understanding of interactions between biological, physical and chemical components of wetlands. The structure and function of various types of wetlands; their biodiversity, biogeochemistry, and the impact of pollution on their ecological characteristics are discussed. Discussions are also done on how constructed wetlands can be used as water quality enhancers.

ENVL 803 Wetland Ecology. (1 hour). Emphasis is placed on field works designed to evaluate the physical, chemical and biological characteristics of wetlands.

ENV 830 Environmental Microbiology. (3 hours). The general objective of this course is to study the roles of microorganisms in natural ecosystems. Attention is given to the examination of nutrient cycles, methods of analysis of microbial biomass and activities, and the functional roles of microorganisms. In addition, this course offers in-depth examination of the role of microbial processes related to environmental deterioration, its control and remediation, and ultimately its prevention.

ENVL 830 Environmental Microbiology. (1 hour). Laboratory designed to acquaint students with modern techniques for measuring microbial biomass and microbial degradative activities of natural and xenobiotic chemicals in natural environments. Specific projects of microbial analysis will be assigned to students.