NORTH MAHARASHTRA UNIVERSITY, JALGAON

Syllabus for M.Sc. Chemistry (with specialization in Pesticides and Agrochemicals)

Semester (III to IV)

(With Effect from June 2016)

Course Structure for Second Year

Semester - III

Sub.Code	: Title
AC 301	: Pest & Pest Management
AC 302	: Pesticides Synthesis-I
AC 303	: Pesticide Formulations
AC 304	: Advanced Agrochemicals, Biopesticides and Fertilizers

Practical Course

AC 004	:	Laboratory Course in Pesticides and Agrochemicals -I

Semester - IV

Sub.Code	:	Title
AC 401	:	Biochemistry, Toxicology of Pesticides
AC 402	:	Pesticide Synthesis-II
AC 403	:	Herbicides & Plant Growth Regulators.

Project and Practical Course

AC 005	:	Laboratory Course in Pesticides and Agrochemicals –II
AC 006	:	Project

Educational Tour	:	Organizing Educational Tour aiming at giving practical exposure to second year students is expected (at their own cost)
In-plant Training	:	Students are expected to undergo one month practical training (At their own cost) in relevant industries. The said training is proposed after II/III semester.
Field Visits	:	Organizing field visits for Collection, identification of different pests to study about nature of damage and their management.

SEMESTER III

AC 301 : Pest & Pest Management (60 hrs. and 100 marks)

1. (a) Definition, importance & general classification of agrochemicals. Classification of pesticides on chemical nature and according to target species, mode of action (12 hrs)

   (b) Definition of insect and classification of insects (orders) .

2. (a) Introduction, classification of pests. Damage economic threshold level Life cycle, morphology, nature of damage and management of following pests : (12hrs)
   Public health pests - mosquitoes, houseflies etc.
   Agricultural pests - Boll worms, sucking pests, nematodes, grasshoppers etc.
   Domestic pests - Bed bugs, cockroaches etc.
   Animal husbandry pests - Stable flies, horn flies etc.
   Structural Pest - termites and wood borers

   (b) Methods of pest controls – Classification: Natural & applied control [Physical, mechanical, cultural, biological, genetic, regulatory, chemical controls] Integrated pest management.

3. (a) Concept of insect pest- definition, classification, morphology & internal systems (12hrs)

   (b) Plant pests –weeds, bacteria, molluscs, fungi, Viruses, birds, mites, nematodes, insects, vermins, orthopods, plant pathogens, causes of outbreak of pest, growth & development. Insect pest control- Principle, practices.

4 (a) Crop pests- Pests of grams, banana, sorghum, cotton, groundnut, tomato, and sugar cane: Nature of damage & pest management. (12hrs)

   (b) Plant diseases- definition, concept, classification of diseases, symptoms, plant parts, occurrence, spread – diseases of wheat, banana, groundnut, cotton, citrus, papaya.

5. (a) Herbs/Weeds- definition, classification, life cycle, methods of weed control- Physical, cultural, biological, mechanical, chemical (12hrs)

   (b) Pesticides (Insecticide) act & industry- role, shape, names and details.

Recommended Books

1. Agricultural insect pests of the topics and their control-D.S.Hill, Cambridge Univ. Press,1983.
2. Principles and procedures of plant protection - S.B.Chattopadhyay, Oxford-IBH
3. Agricultural pests of India and south East Asia - A. S. Atwal, 1979.
4. Insect pest of crops - S.Pradhan, National Book trust, 1st Edition, 2011.
5. Insect pest management - Devid Dent, CAB International, 2nd Edition, 2000.
6. All about weed control - S. Subramanian, Kalyani
7. Plant diseases management - R. S. Singh, Oxford – IBH, 2001.
8. Fundamentals of Plant Pest Control- D.A. Roberts, 1978.
9. Green Trends in Insect Control, Ed. Oscar Lopez & Jose G. Fernandez-Bolanos, Royal Soc of Chemistry (2011)

AC 302: Pesticides Synthesis - I (60 hrs. and 100 marks)

Part -A	**1.**	Synthetic Organic Chemistry - Retrosynthetic approach, synthone approaches, types of Disconnections.	(12 hrs)
	2.	Retro synthesis of Agrochemicals.	(12 hrs)
Part -B	**3.(a)**	Introduction: History of pesticides, innovation of pesticides chemistry, development of Pesticides. (4 hrs.)	(12 hrs)
	3.(b)	Chemistry of Pesticides: Brief introduction to classes of pesticides (Chemical class, targets), structures, chemical names, physical properties, chemical properties, synthesis, degradation, metabolism, formulations, mode of action, uses, toxicity (acute and chronic toxicity in mammals, birds, aquatic species etc.), methods of analysis. (8 hrs.)	
	4.	Insecticides: Classification and Study of following insecticides with respect to structure, chemical name, Physical properties, chemical properties, synthesis, degradation, metabolism, formulations, Mode of action, uses, toxicity, **Organo phosphates**: Acephate, Dimethoate, Chlorpyriphos. **Organochlorines**: Endosulfan, **Carbamate**: Cartap hydrochloride, Methomyl Coxiecarbmates. **Amides and similar functions**: Rynaxypyr, Phthalic dicarboxamide, **Miscellaneous**: Fipronil, Bifentrin, Buprofezin, Decamethrin, Fenvalerate, Imadichloprid, Indoxacarb.	(12 hrs)
	5(a).	Insecticides: Brief introduction to classes, structure, chemical name, Physical properties, chemical properties, synthesis, degradation, metabolism, formulations, Mode of action, uses, toxicity (acute and chronic toxicity in mammals, birds, aquatic species etc. **Organo phosphates and Phosphothionates:** Monocrotophos, Temephos, Quinolphos, parathion-methyl. **Carbamate:** Propoxur (08 hrs.)	(12 hrs)
	5(b).	Manufacturing processes of some pesticides: Lindane (BHC), DDT, Parathion, and Phorate. (04 hrs.)	

Recommended Books:

1. Pesticide Synthesis Handbook : Thomas A. Unger, Prochrom Industrias Quimicas S/A Elsevier, 1996.
2. Metabolic pathways of Agrochemicals. Part-2 [Insecticides and Fungicides] : Terry.R.Roberts and David H. Hutson, 1999.

3. Metabolic pathways of agrochemicals. Part 1 [Herbicides and plant growth regulators] : Ed-in-chief T Roberts, Royal Society of Chemistry, Cambridge, 1998.
4. Chemistry of Insecticides and Fungicides : U.S.Shree Ramulu Oxford & IBH Pub., 2nd, 1995.
5. Principles of Pesticide Chemistry : S. K. Handa, Ed. By Agrobios (India), 2008.
6. Handbook of Systemic Fungicides Vol- I : S.C.Vyas, Published by Mcgraw Hill, 1993.
7. Analytical Methods for Pesticides, Plant growth regulators & food additives : Vol. I-XVII Ed. By Gunter Zweig.
8. The Agrochemical Handbook : Royal Society, England, Hartley, D., Kidd, H.,1984.
9. Pesticide Science and Biotechnology : R. Greenhalgh and T.R.Roberts International Union of Pure and Applied Chemistry, Blackwell Scientific Publication, 1987.
10. The Chemical Process Industries : D.N. Shreve
11. Pesticides in India- Recent facts and figure : R & D section, Yawalkar Pesticides, Nagpur (Agri-Horticulture, Nagpur).
12. Pesticide Chemistry : G. Matolcsy, M. Nádasy, V. Andriska, Elsevier Science Publishing, USA, 1988.
13. Pesticides: preparation and mode of action : Cremlyn. R., 1978.

AC 303: Pesticides Formulations (60 hrs. and 100 marks)

1. A Introduction of pesticide formulations: Definition, history, purpose, types and codes, brief account of main types. (12 hrs)
Study of conventional formulations : Dusting Powders/ Dust Formulations (DP), Granules (GR), Water Dispersible Powders/Wettable powders (WDP/WP), Soluble Concentrates (SL), Emulsifiable concentrates (EC), Ultra Low volume (ULV) with respect to ingredients, advantages and disadvantages. (8 hrs)

B Important parameters of pesticides formulations : affecting quality of pesticides - particle size, bulk density, flowability, electrostatic charge, sorptivity, compatibility, surface acidity, alkalinity and their effects on stability, rainfastness and shelf life of formulation, Rheological properties. (4 hrs)

2. A Solvents: Green solvents safer alternative to petroleum based solvents, Carriers, additives, adjuvant technology for efficacy enhancement (anti-drift, anti-setting, anti-freezing, antifoaming agents, penetrants, preservatives, dyes) and synergists used in pesticide Formulations. (4 hrs) (12 hrs)

B Surfactants : definition, structure, Role, types, Hydrophilic Lipophilic Balance (HLB), physical properties and examples of **Anionic** – Carboxylate, Sulphate, Sulphonate, Phosphates and there Esters, **Cationic** – Quaternary Ammonium Products, **Non-Ionic** – Ethoxylates of Fatty Acids, Castor oil, Phenol (4 hrs)

C. Equipment used in preparation of formulations.- Air jet mill, Extruders, Granulators, Sand/ Bead mill, Fluid Bed Dryer, Spray Dryer etc. and maintenance of process

parameters for excellent physico-chemical properties of the formulation (4 hrs)

3. Study of Formulations with respect to composition, preparation, properties, application, advantages and disadvantages. (12 hrs)

A. Current trends: safer water based formulations: Suspension Concentrates (SC), Suspoemulsions (SE), Water Dispersible Granules /Wettable Granules (WDG/WG), Microcapsule suspension (CS), Oil Dispersion (OD), Microemulsions (ME), Emulsion in water (EW), and multiple emulsions, Tablets (TB), and Dispersion Concentrates (DC) formulations. (8 hrs)

B. Formulations in seed treatment : Brief study of Dry powder Seed Treatments (DS), Water Slurriable Powders (WS), Liquid Solution Seed Treatments (LS), Flowable Seed Treatments (FS), Emulsion Seed Treatments (ES), Microcapsule Seed Treatments (CF), Gel For seed Treatments (GF), Water dispersible Granules Seed Treatments (WG). (2 hrs)

C. Formulations for specific Applications : Aerosols, Fogging formulations, Smoke generators, Baits, Soluble Powders (SP) (2 hrs)

4. A. Important parameters of pesticides formulations : affecting quality of pesticides - particle size, bulk density, flowability, electrostatic charge, sorptivity, compatibility, and their effects on stability, rainfastness and shelf life of formulation, Rheological properties. (6 hrs) (12 hrs)

B. Tests for quality control - A brief introduction on Specifications of Pesticide technical and formulations (WHO/FAO/BIS) Methods of analysis of Physical properties of formulations- Suspensibility, Wettability, Emulsion stability, wet sieve test, acidity, alkalinity, moisture content, Flash Point, Specific gravity, Persistent foaming, water runoff test, dry sieve test etc and their significance during field application. (6 hrs)

5. A. Regulatory Requirements and Regulations of Pesticides Formulations (4 hrs) (12 hrs)

B. Formulation packaging : introduction, current trends in single trip containers (6 hrs)

i. Liquid Formulations : rigid plastics, High Density Polyethylene, (HDPE), Polyethylene Terephathalate (PET), Ethylene Vinyl Alcohol (EVOH), Polyamide (PA).

ii. Solid Formulations : Polyethylene, Laminates – Low Density Polyethylene (LDPE), Aluminium foil, LDPE plus ether, Polypropylene (PP), Polyester (PET), Polyamide (PA), Paper, Water soluble Films Pa on packaging material used to pack pesticides (technical and formulation) like Dust, EC, SC, WP, WDG).

C. Application of Pesticides and devices used – Dusters and sprayers, types of nozzles. Calculation of amount of formulation required for field application. (2 hrs)

Recommended Books

1. Agrow Reports : New Developments in Crop Protection Product Formulation – Alan Knowles,DS243, Pub : T & F Informa UK, 2005.
2. CIPAC Hand Book Volume F Analysis of Technical and Formulated Pesticides Editors : W Dobrat A Martijn Pub : Collaborative International Pesticides Analytical Council Limited England 1994.
3. Pesticide Formulations : Van Wade. Velkenburg- Marcel & Delker, Published by Marcel Dekker, New York, ISBN 10: 0824716957 / ISBN 13: 9780824716950, 1973.
4. Pesticide Formulation : Theory : B. S. Parmar, S. S.Tomar, CBS Publishers and Distributors. (2008)
5. Agrobases industries & pesticide formulations (Modern pesticides industry & their formulations) : S.B. Shrivastava & V.K.Agrawal – Small Business Pub.
6. Pesticide formulations & Agro based, chemical, food & paper product : R.K.Goel & R.K.Gupta - Small Business Pub
7. Pesticide formulation- recent development and their application in developing countries : WadeVan Valkenburg, B. Sugavanam, Sushil K. Khetan, UNIDO, Year : 1998 Edition : Ist Reprint : 2008.
8. Pesticide Formulation and Adjuvant Technology : Foy C. L. and Pritchard D. W. CRC Press (2008)
9. Manual for pesticides users- Salil Singhal : Pesticides Association of India, New Delhi, 1989.
10. Advances in pesticides formulation technology : H.B.Scher ACS No. – 254, Washington, DC, 1984.
11. Pesticide chemistry Human Welfare and the Environment vol. IV Pesticide Residue and Formulation Chemistry : J. Miyamoto and P. C. Kearney – Pergamon press, 1985.
12. Chemistry of plant protection vol. 6 : M Bahadir and G. Pfister, Springer Verlag Berlin Heidelberg , 1990.
13. B. Cross and H.B. Scher Pesticides formulations : ACS symposium series 371, 1987.
14. web link http://www.fao.org/docrep/007/y4353e/y4353e00.htm
    Link for FAO specifications of formulations of different pesticides
    http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/jmps/ps/en/

AC 304: Advanced Agrochemicals, Biopesticides and Fertilizers (60 h and 100 marks)

1. a) Botanicals and biopesticides – (12 hrs)
   a) Introduction
      a) Potential pesticidal plants of India
      b) Plant extraction and Bio-organisms - use and potential
      c) Role of Neem in plant protection-constituents, Bioefficacy of various preparations, Azadirachtin and its role in pest control, Chemistry of Pyrethrins and Pyrethroids, Rotenone, Nicotine and nicotinoids (6 hrs)

b) Biological pest control- Use of predators (lady bird beetle, crysopa) and parasites (Trichogramma) in insect control, pathogens in disease and insect control (Bacillus thuringiensis, NPV). (4 hrs)

c) Chemosterilants - (ANTU, Apholate, Tepa). (2 hrs) (12 hrs)

3. a) Pheromones and attractants – Introduction, types and application (Trimedlure, Cue-lure, methyl eugenol). (8 hrs)

b) Insect Growth Regulators – Definition, types, Mode of action and role in pest management (12 hrs)
Natural and synthetic Juvenile hormones (JH) - JH- I,II,III, Methoprene, Fenoxycarb)
Chitin synthesis inhibitors – Novaluron, Buprofezin
Moulting Hormone Agonists – Halofenozide, Tebufenozide
Moulting Hormones – A-Ecdysone, Ecdysterone
Moulting Inhibitors - Diofenolan
Precocenes – I, II, III. (4 hrs)

4. Biotechnology in Pest Management
Brief Introduction, BT methodology, genetically modified and transgenic plants. **(6 hrs.)**

5. a) Fluid fertilizes – Brief introduction, Methods of fertilizer applications, fertigation,Types of fluid fertilizers, properties, characteristics, criteria of application.**(6 hrs.)**

b) Biofertilizers – Introduction, definition, classification, Rhizobium, Azatobactor, Azospirillium , Azolla, Blue Green Algae, VAM, Vermicomposting.**(6 hrs.)**

Recommended Books

1. Botanicals and Biopesticides - Ed. B. S. Parmar and C. Devakumar, New Delhi Westvill Publishing House, 1993.
2. Pesticides – Ed. G.S. Dhaliwal and B. singh.
3. Green Trends in Insect Control, Ed. Oscar Lopez & Jose G. Fernandez-Bolanos, Royal Soc of Chemistry (2011)
4. Biological Insect Pest Suppression - H.C. Coppel and J.W. Mertins (Springer Verlag) ISBN-3-540-07931-9, 1977.
5. Biological Pest Control- The glasshouse experience - N.W. Hussey and N. Scopes, ISBN- 0-7137- 1439-5, 1985.
6. Safer Insecticides Development and Use, E. Hodgson and R.J. Kuher (Dekker) North Carolina State Raleigh University, North Carolina, 1990.
7. Insects Sex Pheromones- M. Jacobson United Kingdom edition published by Academic Press Inc New York, 1972.
8. Biochemical Insect Control its Impact on Economy, Environment, and Natural Selection. - M.S. Quraishi, ISBN- 0-471-70275-7, 1977.
9. Principles of Pesticide Chemistry - S. K. Handa, Ed. By Agrobios (India) ISBN 9788177542165, 2008.

AC 004* : Laboratory Course in Pesticides & Agrochemicals – I (Marks-100)

(Minimum 16 practicals are necessary)

I. Spectroscopic Characterization
Identification of organic compounds and pesticides on the basis of given UV, IR, PMR and Mass data.

II. Synthesis of pesticides/ analogs

1. Phenyl benzoate. 2. Acetanilide 3. p-Bromoacetanilide
4. p-Bromoaniline 5. Benzanilide. 6. N,N-Diphenyl benzanilide
7. Phthalimide

III. Pesticides analysis

1. Determination of bulk density of pesticidal WP/WDG/Dust/SP.
2. Determination of wettability of pesticidal WP/WDG/Dust/SP.
3. Performing wet sieve test of pesticidal WP/WDG/Dust/SP.
4. Determination of Suspensibility of pesticide formulation WP/WDG/SC.
5. Preparation of granules/WDG formulation.
6. Preparation of WP formulation.
7. Volumetric determination of acidity/ alkalinity of WP.
8. Preparation of EC formulation.
9. Preparation of SC formulation.
10. Optimization of emulsifier ratio for formulation of given pesticide. .
11. Determination of stability of emulsion.
12. Estimation of available chlorine in bleaching powder.
13. Estimation of technical Lindane by hydrolysable chlorine method.
14. Estimation of Malathion content in a given sample.
15. Colorimetric estimation of Parathion.
16. Estimation of Phorate in a given formulation.
17. Determination of Quinolphos content.

IV Collection, identification and classification of different insect pests- study about nature of damage and their management. (Field visits).

V. Rearing of – Spodoptera Litura / Helothis amigera / Red cotton bug.

Recommended Books

1. Methods of Pesticides analysis - U.S.Sree Ramulu, Oxford-IBH
2. Pesticides, Plant Growth Regulators and Food Additives, Vol I to IV - Gunter Zweig – Academic press
3. A textbook of Practical Organic Chemistry - A.I.Vogel- ELBS with Longman, 5th Ed., (1989)
4. Laboratory manual of Organic Chemistry - R.K.Bansal- Wiley Eastern 3rd Ed., (1994)
5. Advanced Practical Organic Chemistry - N.K.Vishnoi - Vikas 2nd (1996)
6. Applications of Absorption Spectroscopy of Organic Compounds- J.R.Dyer - Prentice Hall
7. Spectroscopic methods in Organic Chemistry - D.H.Williams & I.Flemming -McGraw Hill, 4th Ed., (1989)
8. CIPAC Hand Book Volume F Analysis of Technical and Formulated Pesticides Editors : W Dobrat A Martijn Pub : Collaborative International Pesticides Analytical Council Limited England 1994.

SEMESTER IV

AC 401: Biochemistry and Toxicology of Pesticides (60 hrs. and 100 marks)

1. Pesticide Biochemistry: (12 hrs)

a) Penetration - Mode of entry of pesticide.
b) Distribution - transfer within the organism, distribution, methodology.
c) Metabolism - biochemistry and physiological significance, microsomal and extra microsomal metabolism, metabolism of organo chlorinated, organophosphorous, carbamate, botanical & biopesticides.

2. Toxicology: (12 hrs)

a) Introduction- basic principle of toxicology, areas of toxicology and categories of toxicologist, routes of exposure/exposure characteristics, chemical interaction of toxicants, dose- response relationships, GLP/protocols for toxicity studies (descriptive animal toxicity test) and their significance, natural defense mechanism.
b) Toxicology of organophosphates, carbamates and organochlorines- signs, symptoms and medical treatment for poisoning, bioactivation and inactivation, cholinesterase inhibition and mechanism, antidote action and mechanism.
c) Selectivity of pesticides- concept and significance, penetration & metabolism, excretion, experimental study of toxicology.

3. Effects of Pesticides (12 hrs)

d) Action of pesticide on nervous system - physiology of nervous system, cholinesterase inhibition pesticide resistance.
e) Special effects of pesticides/ toxicants- teratogenic , mutagenic, carcinogenic effects (mechanism for cancer formation).
d) Resistance to pesticides- concept, types and significance.

4. Safety with pesticides: (12 hrs)

a) First aid, antidotes, pesticide label and leaflet, pesticide deterioration tests.
b) Storage & transportation of pesticides.
c) decontamination (pesticide spills, pesticide containers, application equipments and safety equipments)
Sanitary classification of pesticides.
d) Effluent treatment of agrochemicals, ETP for waste water streams generated in manufacture of Pesticides. (one Ex)
e) Safety of pesticides to wild life and public places.

5. Pesticides residues: (12 hrs)

a) Introduction- application of agrochemicals, dissemination path ways of pesticides, causes of pesticide residues, remedies.
b) Pesticides residues in atmosphere- entry into atmosphere, action of pesticides, effects on environments.
c) Pesticides residues in water – entry into water systems, action and effect in aquatic environment.
d) Pesticides residues in soil. entry into soil, absorption, retention and transport in soil, effects on

microorganism, soil condition and fertility, decomposition and degradation by climatic factors and microorganism.

e) Effects of pesticides residue on human life- model ecosystem, studies of bio-concentration and biodegradation of pesticides on life, consequent effects on human life, use of pesticides in food and health of human.

f) Effect of pesticides residues on birds and animals- routes for exposure to .pesticides, action of pesticides on birds and animals.

g) Analysis of pesticides residues- sample preparation, extraction of pesticides residues (soil, water and vegetables) simple methods and schemes of analysis, multiresidue analysis, statistical methods and validation.
Methods of residue analysis: Brief methodology for few compounds from organochlorines, organophosphates, carbamates and other pesticides.

Recommended Books

1. Applied Agriculture- Insecticides in Agriculture and Environment Retrospects and Prospects, Perry,A.S., Yamamoto, I. Ishaaya, I., Springer-Verlag,
2. Insecticides: Action & metabolism - o' Brien. D. Acdemic.
3. Insecticide Biochemistry & physiology - Wilkinson C.A., Plenum.
4. A textbook of insect toxicology - RP.Srivastava and RC.Saxena - Himanshu.
5. Pesticides and environmental pollution – R.M.Lodha
6. The Biochemistry and uses of Pesticides - K.A.Hassall
7. Progress in Pesticide Biochemistry and Toxicology ,Vol I-III- D.H.Hutson and T.R.Roberts John Wiley & Sons Pub., 1st Ed., (1983)
8. The Chemical Protection of Plants- G.S.Gruzdyev, V.A.Zinchenco, V.A.Kalinin and R.I.Slovtsov, Mir Publisher 1983.
9. Evaluation of Pesticides in Groundwater- W.Y. Garnett, RC. Honeycatt and H.N. Nigg (ACS).
10. Pesticides in Aquatic Environments, Planum. Agrochemical Residue-biota, interaction in soil and aquatic ecosystem- M.A.Q. Khan.
11. Handbook of Pest Management in Agricultural- Vol. I-III- D. Pilmental (CRC).
12. Chemistry of Pesticides- Melinikov (Springer Verlag)
13. Analysis of Pesticides Residues- H.A. Moye.
14. The Future of Insecticides- R.L. Metcalf and J.J. McKelvey.
15. Safer Insecticides- E. Hodgson and R.J. Kuhr (Dekker).
16. Instrumental Methods of Chemical Analysis- Willard, Merrit and Dean.
17. Pesticide Analysis- K.G. Das.
18. Analytical Methods for Pesticides, Plant growth regulators & food additives. Vol,I-XVI Ed. By Gunter Zweig

AC 402 : Pesticide Synthesis-II (60 hrs. and 100 marks)

1. Classification and Importance and role of Acaricides, Fungicides, Rodenticides, Nematicides, Molluscicides, Fumigants and Repellents (12 hrs)

2. (a) Manufacturing processes of some pesticides: Dimethyl phthalate, Ethylene oxide, Copper Sulphate.(3 hrs) (12 hrs)

2. (b) Chemistry of Acaricides: Brief introduction to classes of pesticides, structure, chemical name, physical properties, chemical properties, synthesis, degradation and metabolism, formulations, mode of action, uses, toxicity (acute and chronic toxicity in mammals, birds, aquatic species etc.
Organophosphate: Dichlorvos, Triazophos, Vamidothion.
Organosulfones: Oxydemeton methyl.
Phenyl Derivatives: Dinocap, Dicofol. (9 hrs)

3. Chemistry of Fungicides:: Brief introduction to classes of pesticides, structure, chemical name, physical properties, chemical properties, synthesis, degradation and metabolism, formulations, mode of action, uses, toxicity (acute and chronic toxicity in mammals, birds, aquatic species etc: (12 hrs)
Heterocyclic Compounds: Benomyl, Captafol, Carbendazim, Hexaconazole, propiconazole, Tricyclazole, Prothioconazole, Tebuconazole, Azoxystrobin. Dithianon.
Organochlorines: Captan.
Organomercurics: Phenyl mercury acetate,
Dithiocarbametes: Ziram, Mancozeb
Amides: Metalaxyl
Inorganic fungicides: Copper oxy chloride.

4. Chemistry of Rodenticides and Nematicides:: Brief introduction to classes of pesticides, structure, chemical name, physical properties, chemical properties, synthesis, degradation and metabolism, formulations, mode of action, uses, toxicity (acute and chronic toxicity in mammals, birds, aquatic species etc. (12 hrs)
Rodenticides: Bromodiolone, Coumachlor, Coumafuryl, Warfarin, Zinc Phosphide.
Nematicides: Aldicarb, Diazinon, Ethoprophos, Terbufos.

5. Chemistry of Fumigants , Repellants and Molluscicides: Brief introduction to classes of pesticides, structure, chemical name, physical properties, chemical properties, synthesis, degradation and metabolism, formulations, mode of action, uses, toxicity (acute and chronic toxicity in mammals, birds, aquatic species etc. (12 hrs)
Fumigants: Aluminum Phosphide, Ethylene dibromide, Methyl bromide.
Repellents : DEET, Dimethyl phthalate, Indalone, Piperonyl butoxide,
Molluscicides: Fentin acetate, Metaldehyde

Recommended Books

1. Pesticide Synthesis Handbook - Thomas A. Unger, Prochrom Industrias Quimicas S/A Elsevier, 1996.
2. Metabolic pathways of Agrochemicals. Part-2 [Insecticides and Fungicides] by Terry.R.Roberts and David H. Hutson, 1999.
3. Metabolic pathways of agrochemicals. Part one – herbicides and plant growth regulators. Ed-in-chief T Roberts, Royal Society of Chemistry, Cambridge, 1998.
4. Chemistry of Insecticides and Fungicides - U.S.Shree Ramulu Oxford & IBH Pub., 2nd, 1995.
5. Principles of Pesticide Chemistry - S. K. Handa, Ed. By Agrobios (India) ISBN 9788177542165, 2008.
6. Pesticide Synthesis Handbook By Thomas A. Unger, Publish in a United State of America by Noyes Publications, 1996.
7. Handbook of Systemic Fungicides Vol- I - S.C.Vyas, Published by Mcgraw Hill/Star Educational Books Distributor Pvt. Ltd, ISBN 10: 007460466X / ISBN 13: 978007460466, 1993.
8. Analytical Methods for Pesticides, Plant growth regulators & food additives. Vol. I-IV Ed. By Gunter Zweig, Hardcover, ISBN-13: 978-0127843100, August, 1978.
9. The Agrochemical Handbook - Royal: Society, England, Hartley, D., Kidd, H., ISBN- 0-85186-406-6, 1984.
10. Pesticide Science and Biotechnology - R. Greenhalgh and T.R.Roberts International Union of Pure and Applied Chemistry, Blackwell Scientific Publication, 1987.
11. The Chemical Process Industries - D.N. Shreve
12. Pesticides in India- Recent facts and figure- R & D section, Yawalkar Pesticides, Nagpur (Agri-Horticulture, Nagpur).
13. Pesticide Chemistry By G. Matolcsy, M. Nádasy, V. Andriska, Elsevier Science Publishing, USA, 1988.
14. Pesticides: preparation and mode of action- Cremlyn. R., ISBN- 0-471-99631-9, 1978.

AC 403 Herbicides and Plant Growth Regulators (60 hrs. and 100 marks)

Part A **Herbicides:** (12 hrs)

1. a) Weed and weed control- brief account
   Herbicides - Definition. Introduction and classification
   b) Chemical Control - according to action and chemical structures, selective, foliage, soil, aquatic contact, translocated, nonselective herbicides.
   c) Methods of herbicide application – Pre-sowing, pre-emergence, post- sowing, post-emergence, direct, band, spot applications.

2. a) Persistence of herbicides. **(3 hrs.)** (12 hrs)
   b) Formulations of herbicides. **(3 hrs.)**
   c) Mode of action of herbicides **(3 hrs.)**
   d) Herbicides safener – Cloquintocet-mexyl, Dichlormid, Fenclorim **(3 hrs.)**

Part B **Plant Growth Regulators:**

3. a) Growth and development, factors affecting growth, measurement of growth. (12 hrs)
b) Plant growth regulators - definition and introduction, important roles and actions of PGRs
c) Plant growth hormones - Auxins, Gibberellins, Kinins, Growth inhibitors and ethylenes - their responses, metabolism, assay and agricultural uses.

4. Plant growth modification Dormancy and germination, breeding and propagation, retardation of vegetative growth, flowering, and fruit set and development metabolic effects- ripening, yield increasing, defoliation. Desiccation, chemical pruning, abscission, photosynthesis.**(5 hrs.)** (12 hrs)
Chemistry, synthesis and uses of following Plant Growth Regulators:
Ancymidol, Chlormequat chloride, Chlorpropham, Ethephon, IAA, IBA, Mepiquat, Naphthyl Acetic Acid (NAA)

5. **Chemistry, synthesis and uses of following herbicides :** (12 hrs)
Alachlor, Anilofos, Atrazine, Bromoxylene, 4-CPA, 2,4-D (manufacturing process), 2,4-DB, Dalapon, Daminozide, Dicamba, Dichrorprop, Diuron, Endothall, Maleic hydrazide, Metsulfuron methyl, Paraquat, Picloram, Propanil, Propazine, metoxuron, Tiaojiean, sulfosulfuron, bensulfuron methyl, clodinafop propargyl,cyhalofop butyl, Glyphosate acid and glyphosate-ammonium, Dimethyl ammonium, isopropyl ammonium salts.

Recommended Books

1. Principles and procedure of plant protection - Chattopadhyay.
2. Chemistry weekly's - Agrochemical Dictionary.
3. Agrochemical handbook - Royal Society.
4. Handbook of Pest Management in Agriculture Vol. I, II -D.Pimentel.
5. Control mechanisms in Plant Developments - A. W. Galston, PJ.Davies.
6. Chemistry of Herbicides - U.S.Shree Ramulu., Oxford IBH Pub., 1st (1985)
7. Herbicide Vol. 3 Ed. P.C. Kearney and D.D.Kaufman.
8. Plant Growth Regulators- Agricultural Uses- Nickel, Springer-Verlag

AC 006: Laboratory Course in Pesticides & Agrochemicals – II (Marks-100)

(Minimum 16 practicals are necessary)

I. Spectroscopic Characterization
Interpretation of UV, IR, PMR and Mass spectra of pesticides.

II. Synthesis of pesticides/ analogs

1. Phenyl Urea	2. 1-Naphthoxy acetic acid	3.Dimethyl phthalate
4. Maleic / Phthalyl hydrazide	5. 2-Chlorophenoxy acetic acid	6.Benzoyl glycine
7. 4-chlorophenoxy acetic acid	8. Ferbam /Nabam / Zineb/ maneb	

III. Pesticides analysis

1. Estimation of copper from Copper oxy chloride.
2. Estimation of copper in copper sulphate pentahydrate
3. Estimation of Dichlorvos in a given formormulation.
4. Estimation of Carbendazim in a given formulation.
5. Electrometric determination of acidity / alkalinity of WP.
6. Determination of moisture content by Karl-Fischer method.
7. Estimation of Phosphamidon/ Dicofol in a given sample.
8. Estimation of Carbaryl in a given formulation.
9. Estimation of sulphur content from pesticides containing Sulphur.
10. Estimation of Ziram by hydrolysis method.
11. Gas chromatographic analysis of Pesticides
12. Estimation of barium in barium carbonate
13. Estimation of Simazine by colorimetric method.

IV Analysis of Soil / Fertilizers

1. Estimation of total P_2O_5 content in fertilizer.
2. Estimation of nitrogen from ammonium sulphate
3. Estimation of potassium content (soil/fertilizer) by flame photometer.
4. Determination of pH and conductivity of soil sample.
5. Estimation of Phosphorous from soil by colorimetric method
6. Estimation of nitrogen from soil by Kjeldahals method

v. Collection, identification and classification of different Weeds - study about nature of damage and their management.

Recommended Books :

1. Methods of Pesticides analysis - U. S. Sree Ramulu, Oxford-IBH

2. Pesticides, Plant Growth Regulators and Food Additives, Vol I to XI - Gunter Zweig Academic press

3. A textbook of Practical Organic Chemistry - A. I. Vogel- ELBS with Longman, 5th Ed., (1989)

4. Laboratory Manual of Organic Chemistry - R.K.Bansal- Wiley Eastern 3rd (1994) 5.

5. Advanced Practical Organic Chemistry - N.K. Vishnoi - Vikas

6. Applications of Absorption Spectroscopy of Organic Compounds- J.R.Dyer-Prentice Hall

7. Spectroscopic methods in Organic Chemistry - D.H.Williams & I Flemming (McGraw Hill)

8. CIPAC Hand Book Volume F Analysis of Technical and Formulated Pesticides Editors : W Dobrat A Martijn Pub : Collaborative International Pesticides Analytical Council Limited England 1994.

AC 006 Project Work (Marks-100)

Students are required to work for a specific project under supervision of concerned faculty member. The allotment of the topic will be done in the initial period of third semester so that students can start their work in the third semester itself. Each student is supposed to work for at least 60 hrs. for his/her project. At the last he/she has to submit his/her project report and present the work done at the time of viva voce.