CHEMISTRY COMPONENT - DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 03)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanotechnology in Agriculture; ALS CHEM DSE 03	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The Learning objectives of this course are as follows:

- to create foundational knowledge of Nanotechnology.
- to educate students about the current green and sustainable methods of preparation of nanomaterials.
- to teach difference between conventional and modern agriculture.
- to give idea about the importance of nanomaterials in agriculture.
- to impart knowledge on toxicity of nanomaterials.

Learning Outcomes:

By studying this course, students will be able to:

- identify the different types of nanomaterials and their properties.
- understand the role of nano- agrochemicals in enhancing crop productivity.
- articulate the study of nanomaterials in the treatment of soil.
- summarize the toxicity risks of nanomaterials on soil and environment.

Unit 1: Introduction (6 Hours)

Basics of nanoscience and technology: Definition, Classification of nanoparticles based on dimension and origin, Quantum confinement, properties of nanoparticles (optical only).

Synthesis of nanoparticles: Overview of physical and chemical routes, green methods of nanoparticles synthesis.

Introduction to agriculture: Limitations of conventional farming, role of nano- agrochemicals in modern agriculture. Benefits of nanomaterials in agriculture (plant growth, crop protection, crop nutrients, etc.).

Unit 2: Application of Nanomaterials in Agriculture (14 Hours)

Nano fertilizers: Types and synthesis: Nitrogen-based, Phosphate based and Iron based. Role towards enhancement of crop productivity. Molecular mechanism of nano- fertilizer for plant growth and mechanism.

Advantages over conventional fertilizers, limitations, optimization of nutrient use efficiency (NUE) and environment sustainability.

Nano pesticides: Brief discussion about nano- insecticides, nano- herbicides and nano-fungicides, role in agriculture. Advantages over conventional pesticides and limitations.

Unit 3: Treatment of Soil using Nanomaterials (6 Hours)

Treatment of polluted soil by nanoremediation. Utilization of nanoparticles like nanoclay and zeolites in soil boosting. Smart pest control.

Unit 4: Nanotoxicity in Agriculture (4 Hours)

Toxicity of nanoparticles. Toxic effects of metal nanoparticles on soil ecosystem. Toxicity of nanoparticles to crop production. Health and environmental concerns related to nanomaterials.

PRACTICAL (60 Hours)

1. Basic introduction to the characterization of nanoparticles employing the following techniques (Data and/or images for few reference compounds will be provided for analysis):
    i. UV-Visible spectroscopy

ii. Fourier transform infrared spectroscopy (FT-IR)

iii. Powder X-ray diffraction (PXRD)

iv. Scanning electron microscopy (SEM)

v. Transmission electron microscopy (TEM)

2. Sol-gel synthesis of nanoparticles.
3. Synthesis of metal and metal oxide nanoparticles by green methods:
   i. Silver nanoparticles and their characterization using UV-visible spectrophotometer.
   ii. Zinc oxide nanoparticles.
   iii. Iron oxide nanoparticles using potato extract.
4. Synthesis of Nano urea.
5. Analysis of soil:
   i. Comparative study of pH of untreated and nano fertilizer treated soil
   ii. Estimation of composition of zinc in nano fertilizer treated soil using complexometry.

Essential/Recommended readings:

1. Varghese, T., Balakrishna, K.M., (2020) *Nanotechnology- An Introduction to synthesis, properties and applications of nanomaterials.* Atlantic Publishers & Distributors (P) Ltd; ISBN: 9788126916375.

2. Shah, M.A.; Shah, K.A., (2019) *Nanotechnology-The Science of Small*. Wiley; ISBN: 9788126579976.

3. Swayam (MHRD) Portal online: Nanotechnology in Agriculture (https://nptel.ac.in/course/102104069); Book download link: 102104069.pdf - Google Drive .

4. Axelos, M. A., & Van de Voorde, M. (Eds.). (2017). *Nanotechnology in agriculture and food science*. John Wiley & Sons, ISBN: 3527339892.

5. Chattopadhyay K.K., Banerjee A.N., (2009) *Introduction to Nanoscience and* Technology; PHI Learning Pvt. Ltd. ISBN: 9788120336087.

6. Jogaiah, S., Singh, H. B., Fraceto, L. F., & De Lima, R. (Eds.). (2020). *Advances in Nano-Fertilizers and Nano-Pesticides in Agriculture: A Smart Delivery System for Crop Improvement*. Woodhead Publishing; ISBN: 978-012-820092.

7. Singh, H. B., Mishra, S., Fraceto, L. F., & De Lima, R. (Eds.). (2018). Emerging trends in agri-nanotechnology: fundamental and applied aspects; CABI Publishing, ISBN: 9781786391445.

8. Mallick, M. A., Solanki, M. K., Kumari, B., & Verma, S. K. (Eds.). (2021). *Nanotechnology in Sustainable Agriculture*. CRC Press; ISBN: 9780367369408.

9. Subramanian, K. S., Gunasekaran, K., Natarajan, N., Chinnamuthu, C. R., Lakshmanan, A., & Rajkishore, S. K. (2015). *Nanotechnology in Agriculture*. New India Publishing Agency; ISBN: 9789383305209

10. Tarafdar, J. C. (2021). Nanofertilizers: challenges and prospects.; Scientific Publishers (India); ISBN: 978938889696931.

11. Fraceto, L. F., De Castro, V. L. S., Grillo, R., Ávila, D., Oliveira, H. C., & Lima, R. (2020). *Nanopesticides*. Springer International Publishing. ISBN: 978-3-030-44873-8.

Suggestive readings:

1. Craig, E. (2019) Nanomaterials: An Introduction to Properties, Synthesis and Applications. Larsen and Keller Education (New York). ISBN: 1641721065.
2. Fraceto, L. F. (2022). *Inorganic Nanopesticides and Nanofertilizers: A View from the Mechanisms of Action to Field Applications*. Springer Nature; ISBN: 9783030941543.
3. Prasad, R., Kumar, M., & Kumar, V. (Eds.). (2017). *Nanotechnology: an agricultural paradigm*. Springer.ISBN:9789811045721.
4. Kumar, V., Guleria, P., Ranjan, S., Dasgupta, N., & Lichtfouse, E. (Eds.). (2021). *Nanotoxicology and Nanoecotoxicology Vol. 1* (Vol. 59). Springer International Publishing; ISBN: 978-3-030-63241-0.

E-contents:

1. E-content on e-PG Pathshala portal of Government of India: (**P08**) Nanoscience and Nanotechnology (**33**) (https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=5VgWkgm+I3FGq9cGlsbNmQ==).
2. Swayam (MHRD) Portal online: Nanotechnology in Agriculture

   (https://nptel.ac.in/course/ 102104069); study material, videos and other material link for course (NPTEL).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.