Course title: Industrial Ecology			
Course code: NRE 129	**No. of credits:** 3	**L-T-P:** 28-14-0	**Learning hours:** 42
Pre-requisite course code and title (if any): NRE 131 Environmental Chemistry and Microbiology, NRE 137 Environmental Monitoring laboratory			
Department: Energy and Environment			
Course coordinator:	**Course instructor:** Dr Lakshmi Raghupathy		
Contact details: lakshmi.raghupathy@terisas.ac.in; lakshmi.raghupathy23@gmail.com			
Course type: Elective	**Course offered in:** Semester 3		

Course Description

Industrial ecology involves the study of industrial systems with a view to identifying strategies that emulate ecological ecosystems and that can be applied to try to minimize the waste produced in industrial processes and to recycle or reuse as much of the waste as possible. This would involve primarily, the development of cyclic, as opposed to linear processes.

This course aims to introduce the concepts underlying industrial ecology and some tools used in it. It will also discuss eco-industrial development, the key issues involved and some cases from India. It will, therefore, expose students to the multidisciplinary nature of environmental issues and integrate pollution prevention with sustainable development.

As an economy that is developing at a rapid pace, Indian industry should be planned with eco-industrial goals and strategies. This course will attempt to show how that might be done.

Course objectives

1. To understand the present Industrial Systems operations in terms of the linear pattern of using resource, energy and water and the ecological imbalances.
2. To study the natural ecosystems with a perspective to associate with the possibility of developing cyclic approaches in the industrial systems by emulating the natural systems.
3. To understand the process of transformation from Linear to Circular Economy in various sectors.
4. To understand the concept of Eco-industrial development and evolve the mechanism for India.

Course content

Module	Topic	L	T	P
1.	**Introduction to industrial ecology**	1	2	
2.	Origin of IE, its definition, the environment and the anthrosphere, industrial systems, material resources, societal factors and environmental equity. Link to sustainable development.			
3.	**Ecologically sustainable systems**	3	2	
4.	The environment and the anthrosphere, industrial systems, material resources, societal factors and environmental equity. Link to sustainable development.			
5.	**Goals and concepts**	6	2	
6.	Systems analysis, industrial metabolism, biological analogies, material and energy flow and their transformations, closing the materials cycle (open vs, closed-loop systems)			

7.	**Industrial ecosystems and key issues in eco-industrial development**	6	2	
8.	Components of an industrial ecosystem (Kalundborg example), industrial symbiosis, role of government, community, developers, management, evaluating the success of eco-industrial development.			
9.	**Life Cycle Analysis**	8		
10.	Life cycles of products, processes and facilities; life cycle assessment (components, methodology, applications, difficulties), design for environment, efficient use of material (remanufacturing, recycling, reuse, etc.			
11.	**Perspective on industrial ecology from India and other developing countries such as China and Thailand, with cases studies.**	4	6	
	Total	**28**	**14**	

Evaluation criteria

- Test 1: 20%
- Test 3(end semester): 40%
- Seminar: 20%
- Class discussions/participation: 10%
- Tour report: 10%

Learning outcomes

On successful completion of this course students should:

- Be able to understand the significance of the sustainable industrial activities
- Be able to visualize the need for closing the manufacturing loop by converting waste into resource or raw material.
- Be able to understand the need establish synergy between Ecosystems and Anthopogenic activities for a balanced consumption pattern.
- Be able to understand the significance of various policy instruments, strategy options and institutional arrangements to develop Eco-industrial activity
- Application of the concepts of LCA, Environment Audit, Circular Economy, resource conservation and recovery.

Pedagogical approach

Classroom teaching, global and local case studies, brain storming sessions.

Materials

Required text

1. Bourg D. and Erkman S, (edited) Perspectives on Industrial Ecology, 46(2) (hardback).
2. Case Study of the Textile Industry in Tirupur (available at http://www.roi-online.org/bookchapters.php?bid=1, accessed on 17 June 2011).
3. Edward Cohen-Rosenthal E. and Musnikow J. (edited) (2003) Eco-industrial Strategies, Sheffield, UK: Greenleaf Publishing.
4. Erkman S. and Ramaswamy R. (2003) *Applied Industrial Ecology – A New Platform for Planning Sustainable Societies,* AICRA Publishers, Bangalore, India.
5. Industrial Symbiosis and Residual Recovery in the Nanjangud Industrial Area, report by ROI (2010) Bangalore and Yale University.
6. Manahan S.E.(1999) Industrial Ecology Environmental Chemistry and Hazardous Waste.
7. Thomas E.G. and Brad R.A., Industrial Ecology and Sustainable Engineering, 3nd edition.

Suggested readings

1. Ayres R.U. (2004) On the Life Cycle Metaphor: Where Ecology and Economics Diverge, *Ecological Economics*, 48, 425-438.
2. Baumann H. and TillmanA.M. (2004)LCA in a Nutshell, Chapter 1 in *The Hitch Hiker's Guide to LCA*, Lund, Sweden, Studentlitteratur.
3. Chertow M. (2007) Uncovering' Industrial Symbiosis,*Journal of Industrial Ecology* 11(1), 11-30.
4. Frosch R. and Gallapoulos N. (1989) Strategies for Manufacturing,*Scientific American*,261(3), 144-152
5. Gibbs D., Deutz P. and ProctorA. (2005) Industrial Ecology and Eco-industrial Development: A New Paradigm for Local and Regional Development?, *Regional Studies*,38(2), 171-183.
6. Hinterberger F., GiljumS. and Hammer M.(2003)*Material Flow Accounting and Analysis (MFA): A Valuable Tool for Analyses of Society-Nature Interrelationships*, Sustainable Europe Research Institute (SERI), Vienna.
7. Hobbes M., Stalpers S., KoojimanJ., LeT.T.T., TrinhK.C. and Da PhanT.A. (2007) Material Flows in a Social Context: A Vietnamese Case Study Combining the Materials Flow Analysis and Action-in-Context Frameworks, *Journal of Industrial Ecology*, 11(1), 141-159.
8. International Organization for Standardization (2006) ISO 14040 Standard: Life Cycle Assessment.
9. Jackson T. (2005) Live Better by Consuming Less?, *Journal of Industrial Ecology, 9* (1-2), 19-36.
10. Kakkar M. (2003) India [Iron and Steel LCA], Chapter 2 in *Life Cycle Assessment for Green Productivity: An Asian Perspective*, Singapore: Asian Productivity Organization.
11. Karnani A. (2006) Misfortune at the Bottom of the Pyramid, *Greener Management International*, 51, 99-110.
12. Kitzes J. and Wackernagel M. (2009) Answers to Common Questions in Ecological Footprint Accounting, *Ecological Indicators*, 9(4), 812-817.
13. Lebel L. (2005) Transitions to Sustainability in Production-Consumption Systems, *Journal of Industrial Ecology*,9(1-2), 11-13.
14. McDonough W., BraumgartM., Anastas P. and ZimmermanJ. (2003) Applying the Principles of Green Engineering to Cradle-to-Cradle Design, *Environmental Science & Technology*,37(23), 434A-441.
15. Prahalad C.K. (2004) Why Selling to the Poor Makes for Good Business, *Fortune* 150(10).
16. Rivela B, Moreira M.T., Bornhardt C., Mendez R. and Feijoo F., Life Cycle Assessment as a Tool for the Environmental Improvement ofthe Tannery Industry in Developing Countries,*Environmental Science & Technology*, 38, 1901-1909.
17. Spiegelman J. (2003) Beyond the Food Web: Connections to a Deeper Industrial Ecology, *Journal of Industrial Ecology*,7(1), 17-23.
18. Xu M. and ZhangT. (2007) Material Flows and Economic Growth in Developing China, *Journal of Industrial Ecology*, 11(1), 121-140.

Journals

1. Environmental Science & Technology
2. Journal of Industrial Ecology

Additional information (if any)
Student responsibilities Attendance, feedback, discipline, guest faculty etc.