		Category	L	T	P	Credit
14EN111	**APPLIED STATISTICS AND OPTIMIZATION**	BS	3	1	0	4

Common to 14IM111

Preamble

The correlation refers to the techniques used in measuring the closeness of relationship between the variables. When three or more variables are studied, it is a problem of either multiple or partial correlation. Estimators refer to the problem of determining the functions of sample observations such that the distribution is concentrated as closely as possible near the true value of the parameter. A statistical hypothesis is a quantitative statement about the probability distribution characterizing a population which we want to verify on the basis of information available from a sample. Non-Parametric or distribution free methods that often assume no knowledge whatsoever about the distributions of the underlying populations, except perhaps that they are continuous. In design of experiments we consider some aspects of experimental design briefly and analysis of data from such experiments using analysis of variance techniques.

Prerequisite

Probability and Statistics

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Calculate the value which relates the dependent variable to one or more independent variables.	Apply
CO2	State a statistical inference from information contained in random samples about the populations from which the samples were obtained.	Understand
CO3	Estimate the characteristic of the population with degree of confidence from the random sample.	Apply
CO4	Determine the most reliable results of the population based on all the information available in a sample using non-parametric methods.	Apply
CO5	Calculate the experimental error and hence to control the extraneous variables involved in the experiment.	Apply
CO6	Determine the optimum values of unconstrained optimization problems using search methods.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	L	-	-	-	-	L	-	L	L	-
CO2.	M	L	L	-	-	-	L	-	L	L	S
CO3.	S	L	-	M	-	-	L	-	L	S	M
CO4.	S	L	M	M	-	-	L	-	L	S	-
CO5.	S	L	M	M	-	L	L	-	L	S	-
CO6.	S	L	-	M	-	L	L	-	L	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	20	20	10
Understand	30	20	20	20
Apply	60	60	60	70
Analyse	-	-	-	-

Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1)**:**

1. Define Multiple Correlations.
2. If x_1, x_2 ,… x_n are random observations on a Bernoulli variable x taking the value 1 with probability θ and the value 0 with probability (1- θ), show that $\frac{\tau(\tau-1)}{n(n-1)}$ is an unbiased estimate of θ^2 where $\tau=\sum_{i=1}^{n} x_i$.
3. Calculate the M.L.E of the parameter α of the population having the density function $f(x,y)=\frac{2}{\alpha^2}(\alpha-x)$,0<x< α for a sample of unit size (single sample) and also Show that the estimate is biased.

Course Outcome 2 (CO2)**:**

1. Define one tailed and two–tailed tests.
2. In a large city A, 20% of a random sample of 900 school boys had a slight physical defect. In another large city B, 18.5% of a random sample of 1600 school boys had the same defect. Identify whether the difference between the proportions is significant or not.
3. The following information was obtained in a sample of 40 small general shops:

	Shops in areas	
	Urban	Rural
Owned by Men	17	18
Owned by Women	3	12

Discuss is it possible to say that there are more women owners in rural areas than in urban areas? Use Yate's Correction for continuity.

Course Outcome 3 (CO3):

1. Examine whether the two samples for which the data are given in the following table could have been drawn from populations with the same SD.

	Size	S.D
Sample 1	100	5
Sample 2	200	7

2. The heights of 10 males of a given locality are found to be 175, 168, 155, 170, 152, 170, 175, 160, and 165 cm. Based on this sample, determine the 95% confidence limits for the height of males in that locality.

3. Identify whether the sample having the values 63, 63,64,55,66,69,70,70 and 71 has been chosen from a population with mean of 65 at 5% level of significance.

Course Outcome 4 (CO4):

1. The following are the number of minutes it took a sample of 15 men and 12 women to complete the application form for a position.

   Men: 16.5, 20.0, 17.0, 19.8, 18.5, 19.2, 19.0, 18.2, 20.8, 18.7, 16.7, 18.1, 17.9, 16.4, 18.9.

   Women: 18.6, 17.8, 18.3, 16.6, 20.5, 16.3, 19.3, 18.4, 19.7, 18.8, 19.9, 17.6.

   Apply the Mann-Whitney test at the level of significance $\alpha = 0.05$ to the null hypothesis that the two samples come from identical population.

2. The following are the number of misprints counted on pages selected at random from the Sunday editions of a newspaper:

   April 11: 4, 10, 2, 6, 4, 12
   April 18: 8, 5, 13, 8, 8, 10
   April 25: 7, 9, 11, 2, 14, 7

Apply Kruskal-Wallis test at the level of significance $\alpha = 0.05$ to test the null hypothesis that the three samples come from identical populations against the alternative that the compositors and/or proofreaders who worked on the three editions are not equally good.

3. The following arrangement indicates whether sixty consecutive care which went by the toll booth of a bridge had local plates,L,or out-of state plates O: L L O L L L L O O L L L L O L O O L L L L O L O O L L L L L O L L L O L O L L L L O O L O O O O L L L L O L O O L L L O. Illustrate whether this arrangement of 's and O's may be regarded as random by using the level of significance $\alpha = 0.05$.

Course Outcome 5 (CO5):

1. To determine optimum conditions for a plating bath, the effects of sulfone concentration and bath temperature on the reflectivity of the plated metal are studied in a 2x5 factorial experiment. The results of three replicates are as follows:

Concentration (grams/liter)	Temperature (degrees F)	Rep.1	Rep.2	Rep.3
5	75	35	39	36
5	100	31	37	36
5	125	30	31	33
5	150	28	20	23
5	175	19	18	22
10	75	38	46	41
10	100	36	44	39
10	125	39	32	38
10	150	35	47	40
10	175	30	38	31

Determine the bath condition or conditions that produce the highest reflectivity.

2. The following data resulted from an experiment to compare three burners B_1, B_2, B3. A latin square design was used as the tests were made on 3 engines and were spread over 3 days.

	Engine 1	Engine 2	Engine 3
Day 1	B_1-16	B_2-17	B_3-20
Day 2	B_2-16	B_2-21	B_1-15
Day 3	B_2-15	B_1-12	B_2-13

Test the hypothesis and determine whether there is any difference between the burners.

3. The following table shows the lives in hours of four brands of electric lamps brand.

A: 1610 1610 1650 1680 1700 1720 1720 1800
B: 1580 1640 1640 1700 1750
C: 1460 1550 1600 1620 1640 1660 1740 1820
D: 1510 1520 1530 1570 1600 1680.

Perform an analysis of variance to test the homogeneity of the mean lives of the four brands of lamps.

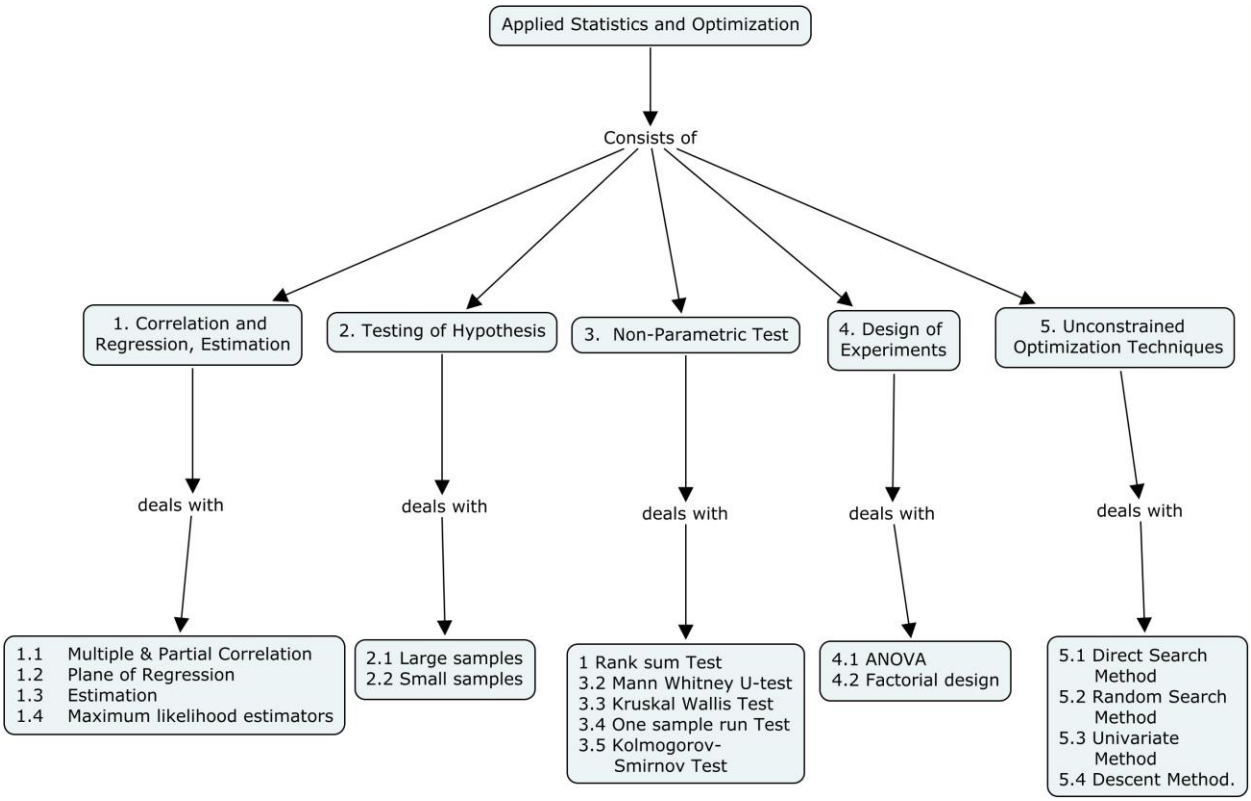
Course Outcome 6 (CO6):

1. Find the gradient of a function $f(x_1,x_2) = 6x_1^2-6x_1x_2+2x_2^2-x_1-2x_2$.

2. Minimize the function $f(x_1,x_2) = 6x_1^2+2x_2^2$ from the starting point (1,2) by univariate search method.

3. Minimize the function $f(x_1,x_2) = 2x_1^2+2x_1x_2+x_2^2+x_1-x_2$.

Concept Map



Syllabus

Correlation & Regression Analysis, Sampling Distribution & Estimation

Multiple and Partial Correlation, Yules notation, plane of regression, Coefficient of partial and multiple correlation-properties, Sampling-distribution statistics, Standard error, point and interval estimation for population mean, variance, Maximum likelihood estimators. **Testing of Hypothesis** Testing of hypothesis-inferences concerning to means, variances and proportions, t-test, Chi-Square test, F-test. **Non Parametric Tests** Sign test of paired data**,** Rank Sum test, Mann Whitney U-test, Kruskal Wallis test, One sample run test, Kolmogorov-Smirnov test. **Design of Experiments** Analysis of Variance-One way classification, Two way classification, Block randomized design, Latin Square design, Factorial design, Test of Significance of main and interaction effects. **Unconstrained Optimization Techniques** Direct Search Method, Random Search Method, Univariate Method, Pattern search Method, Descent Method, Steepest Descent Method.

Reference Books

1. Irwin Miller, John E.Freund "Probability and Statistics for Engineers" Prentice Hall of India Pvt. Ltd.; New Delhi, 1977.
2. S.S Rao "Optimization Techniques". Wiley Eastern Ltd.; 1992.
3. T.Veerarajan "Probability, Statistics and Random Processes" Tata McGraw-Hill, New Delhi, 2003.
4. Ronald E.Walpole, Sharon L.Myers "Probability and Statistics for Engineers and Scientists". Eighth Edition, Pearson education, New Delhi, 2007.

Course Contents and Lecture Schedule

Module No.	Topics	No.of Lectures
1.0	**Correlation & Regression Analysis, Sampling Distribution & Estimation**	
1.1	Multiple and Partial Correlation, Yules notation, plane of regression	1
1.2	Coefficient of partial and multiple correlation-properties	2
	Tutorial	1
1.3	Sampling-distribution statistics, Standard error	1
	Tutorial	1
1.4	Point and interval estimation for population mean & variance, Maximum likelihood estimators	2
	Tutorial	1
2.0	**Testing of Hypothesis**	
2.1	Testing of hypothesis-inferences concerning to means, variances and proportions	2
2.2	t-test	2
	Tutorial	1
2.3	Chi-Square test, F-test	2
	Tutorial	1
3.0	**Non Parametric Tests**	
3.1	Sign test of paired data	1
3.2	Rank Sum test	2
	Tutorial	1
3.3	Mann Whitney U-test, Kruskal Wallis test	1
	Tutorial	1
3.4	One sample run test, Kolmogorov-Smirnov test	2
	Tutorial	1
4.0	**Design of Experiments**	
4.1	Analysis of Variance-One way classification	2
4.2	Two way classification	2
	Tutorial	1
4.3	Block randomized design	2

4.4	Latin Square design	1
	Tutorial	2
4.5	Factorial design, Test of Significance of main and interaction effects	2
	Tutorial	1
5.0	**Unconstrained Optimization Techniques**	
5.1	Direct Search Method, Random Search Method	2
	Tutorial	1
5.2	Univariate Method, Pattern search Method	2
	Tutorial	1
5.3	Descent Method, Steepest Descent Method	2
	Tutorial	1
	Total	**48**

Course Designers:

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14EN120 ENVIRONMENTAL CHEMISTRY

Category	L	T	P	Credit
BS	4	-	-	4

Preamble

To impart knowledge on various aspects of chemical equilibrium, kinetics, pollution in the environment and its effects on the biological systems. This course would also enable the students to systematically analyze different materials using analytical chemistry and imply them in characterization and treatment of industrial and municipal wastes.

Prerequisite

Basic knowledge on Engineering Chemistry.

Course Outcomes

On the successful completion of the course, students will be able to

	Explain the chemical concepts involved in miscibility of solutions and gases	Understand
	Predict the extent of adsorption occurring in solid, liquid and gas adsorbents	Apply
	Express the ecological imbalance caused by modern agricultural practice and mining activities	Understand
	Determine the water quality parameters like alkalinity, Total hardness and Oxygen demand in sewage and industrial effluents	Apply
	Identify the sources of Air pollution and its implications on the environment	Understand
	Ascertain the air quality parameters by means of various methods	Apply
	Suggest suitable qualitative and quantitative analysis of different materials in solid, liquid and gaseous forms.	Apply
	Explain the prospects of clean energy technologies.	Understand
	Assess the role of size dependent properties of different materials in environmental applications.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	L	L	L	-	-	-	-	M	-	-
CO2	S	L	L	L	-	-	-	-	M	-	-
CO3	S	S	S	S	-	M	L	L	M	M	L
CO4	S	S	L	L	L	-	L	-	-	L	L
CO5	S	-	-	L	L	-	-	-	L	-	L
CO6	S	S	S	S	L	M	L	L	L	L	L
CO7	S	S	S	S	S	M	M	L	M	M	M
CO8	S	L	L	L	L	L	-	-	L	-	L
CO9	S	S	S	S	L	L	-	-	M	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's	Continuous	Terminal

Category	Assessment Tests			Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define Molarity, Normality and Molality of standard solutions?
2. Explain the electrochemical stability limit of water with the help of Eh-pH diagram.
3. Exemplify the influence of common ion effect in solubility of salts.

Course Outcome 2 (CO2):

1. Calculate the volume of gas adsorbed per gram of the charcoal adsorbent at 250C. The weight of the charcoal is 6 g and its density is 1.5 g.cm-3. The pressure of the gas prior and after adsorption is observed to decrease from 700 to 400 torr.
2. Predict how long a hydrogen atom will remain on the surface of a solid at 1000 K if its desorption activation energy is 150 kJ mol-1.
3. Determine how many grams of $Ba(IO_3)_2$ can be dissolved in 500 ml of water at 250C

Course Outcome 3 (CO3):

1. Elaborate how modern agricultural practice had resulted in chemical intoxication of surface waters.
2. Discuss how copper pyrite mining results in environmental imbalance.
3. Give a brief account ion exchange process occurring in water softening processes using polymeric membranes

Course Outcome 4 (CO4):

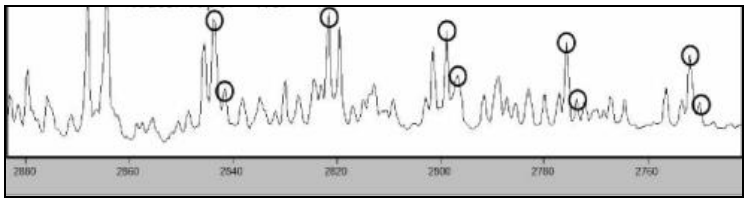
1. 100 ml of water sample required 4 ml of N/50 HCl for neutralization to phenolphthalein end point. Another 16 ml of water sample was needed for further titration to methyl orange end point. Determine the type of and amount of alkalinity.
2. The sample water of volume 20 ml in the presence of 20 ml of $K_2Cr_2O_7$ and 10 ml of 10% H_2SO_4 and 10 ml of 5% KI and starch upon titration with $Na_2S_2O_3$ solution has got decolourized by 12 ml. The standard $Na_2S_2O_3$ solution is prepared by dissolving 124.09 g in 1 litre. Calculate the dissolved oxygen present in the sample.
3. In an experiment to determine the hardness of a sample of water, 25 ml of N/50 Na_2CO_3 solution was added to 100 ml of water sample. After completion of precipitation of insoluble carbonate, the unreacted Na_2CO_3 was titrated against N/50 H_2SO_4 solution, when 10 ml of the acid was required. Calculate the hardness and comment on the nature of hardness so determined.

Course Outcome 5 (CO5):

1. Explain the sources, causes of air pollution and derive its consequences in both plant and animals.
2. Describe ozone layer depletion and list few of its implication in the environment?
3. Discuss the probable interaction of electromagnetic radiation from cell phone towers with flora and fauna

Course Outcome 6 (CO6):

1. How will you use spectrophotometers to monitor the concentration of carbon monoxide as per the regulations established by OSHA?
2. As an environmental consultant, suggest the methods available for measuring the indoor air quality in cement production industry.
3. Using the IR spectrum of the air sample collected from an port land cement industry, estimate the content present in the air by assigning the molecular vibrations of possible pollutants.



Course Outcome 7 (CO7):

1. A photometer with a linear response to radiation gave a reading of 837 mV with a blank in the light path and 333 mV when the blank is replaced by absorbing solution. Calculate the percentage transmittance and absorbance of the absorbing solution.
2. A substance when dissolved in water at 10^{-3} M concentration absorbs 10 percent of incident radiation in a path of 1 cm length. Calculate the concentration of the solution if it absorbs 90% of radiation.
3. The molar extinction coefficient of phenonthroline complex of iron (II) is 12000 dm3 $mol^{-1}cm^{-1}$ and the minimum detectable absorbance is 0.01. Calculate the minimum concentration of the complex that can be detected in a Lambert-beer law of path length 1 cm.

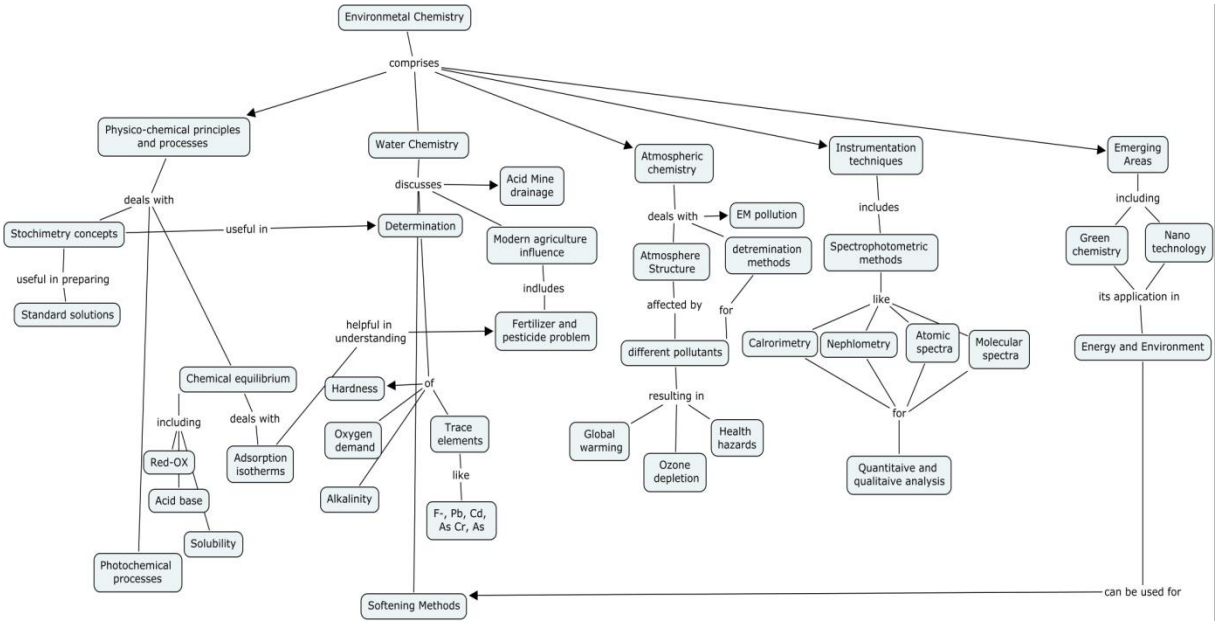
Course Outcome 8 (CO8):

1. Explain the working principle of solar scheffler concentrators.
2. Exemplify the significance of hydrogen gas as a potential energy resource.
3. Explicate the ways to derive energy out of bio mass gasification?

Course Outcome 9 (CO9):

1. Justify why green chemistry would play a major role in resource conservation.
2. Express your views on application of Nano materials for energy and environment.
3. Demonstrate with the help of an example how surface area of carbon Nano materials will be useful in environmental application.

Concept Map



Syllabus

Physico-chemical principles and processes – Stoichiometry - Mass Balance – Ideal solutions and Gases – Concentration – Standard solutions – Primary and Secondary standards – Chemical Equilibrium – Acid base, Oxidation-reduction and Solubility equilbria - Colloids – Adsorption isotherms – Eh-pH diagram – Photochemical processes.**Water Chemistry -** Water Quality parameters – Significance and determination – trace element contamination – Contamination by fertilizer and pesticides – Eutrophication and Environmental tolerances. Water Treatment Processes – Softening – Principles of precipitation, coagulation and filtration – Ion exchange – Acid mine drainage. **Atmospheric chemistry -** Structure of atmosphere – Thermo chemical and Photochemical reactions – Atmospheric cycles – Ozone chemistry – acid rain – Green house gases – Global warming – Air quality parameters – Hazardous air pollutants effects and determination – Electromagnetic radiation and its effects. **Instrumentation techniques -** Error analysis – sources of errors and determination – Introduction to spectrophotometric analysis – Colorimetry – Nephlometry – UV-VIS-NIR spectroscopy – FTIR spectroscopy – Chromatography – Gas and Liquid – Electrochemical methods – Voltammetry – Corrosion analysis. **Emerging areas -** Principle of Green Chemistry – Renewable energy systems – Biomass utilization – Hydrogen energy – Nano Technology – Carbon materials and composites – Environmental applications.

Reference Books

1. Clair N Sawyer, Perry L. McCarty & Gene. F.Parkin, “Chemistry for Environmental Engineering”, Tata Mcgraw hill, Fourth edition, 2000.

2. Dara.S.S. “Environmental Chemistry”, 3rd edition, S.Chand & Co, New Delhi, 2001.
3. De. A. K,” Environmenal Chemsitry ,” New Age International (P) limited, 3rd edition 1994.
4. Sharma B.K and Kaur H. “Environmental Chemistry”, Goel Publishing House 3rd edition, 1996-97.
5. Stanley E. Manohar, Environmental Chemistry, Williard Grant press, Beston, Massachutes

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.0	**Physico-Chemical Principles and Processes**	
1.1	Stoichiometry - Mass Balance	1
1.2	Ideal solutions and Gases – Concentration	1
1.3	Standard solutions – Primary and Secondary standards	1
1.4	Chemical Equilibrium – Acid base, Oxidation-reduction and Solubility equilbria	2
1.5	Colloids – Adsorption isotherms	3
1.6	Eh-pH diagram – Photochemical processes	2
2.0	**Water Chemistry**	
2.1	Water Quality parameters – Significance and determination	2
2.2	Determination of trace element contamination – F, Pb, As, Cr, Hg	2
2.3	Contamination by fertilizer and pesticides – Influence of chloro organics	3
2.4	Eutrophication and Environmental tolerances	1
2.5	Water Treatment Processes – Softening	1
2.6	Principles of precipitation, coagulation and filtration	2
2.7	Ion exchange – Acid mine drainage	1
3.0	**Atmospheric Chemistry**	
3.1	Structure of atmosphere	1
3.2	Thermo chemical and Photochemical reactions	1
3.3	Atmospheric cycles – Ozone chemistry	1
3.4	Acid rain – Green house gases – Global warming	2
3.5	Air quality parameters – Hazardous air pollutants effects and determination	2
3.6	Electromagnetic radiation and its effects.	1

S.No.	Topic	No. of Lectures
4.0	**Instrumentation Techniques**	
4.1	Error analysis – sources of errors and determination	2
4.2	Introduction to spectrophotometric analysis –	1
4.3	Colorimetry – Nephlometry	1
4.4	UV-VIS-NIR spectroscopy	1
4.5	FTIR spectroscopy	1
4.6	Chromatography – Gas and Liquid	2
4.7	Electrochemical methods –Voltammetry	1
4.8	Corrosion analysis.	2
5.0	**Emerging Areas**	
5.1	Principle of Green Chemistry	1
5.2	Renewable energy systems	1
5.3	Biomass utilization - Hydrogen energy	1
5.4	Nano Technology	2
5.5	Carbon materials and composites -Environmental applications	2
	Total	**48**

Course Designers

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		Category	L	T	P	Credit
14EN130	**ENVIRONMENTAL MICROBIOLOGY**	BS	3	-	-	3

Preamble

Microbiology is the study of living organisms of microscopic size, which include bacteria, fungi, algae, protozoa and the infectious agents. It is concerned with their form, structure, reproduction, physiology, metabolism and classification. It includes the study of their distribution in nature, their relationship to each other and to other organisms, their effects on human beings and on other animals and plants, their abilities to make physical and chemical changes in our environment, and their reactions to physical and chemical agents.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Understand the characteristics and structure of microbes.	Understand
CO2.	Isolate and identify different microbes present in various sources.	Understand
CO3.	Understand the metabolism of microbes and its respiration	Understand
CO4.	Acquire knowledge on soil, aquatic and air microbiology.	Understand
CO5.	Identify, quantify and understand the impacts of microorganisms in drinking water.	Understand
CO6.	Understand the role of microorganisms in pollution control and apply the knowledge in biological treatment processes.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	-	-	-	-	-	-	-	M	-	M
CO2	S	-	-	-	-	-	-	-	M	-	M
CO3	S	-	-	L	-	-	-	-	L	-	L
CO4	S	L	L	L	-	L	-	-	L	-	L
CO5	S	M	M	M	L	M	L	M	M	M	M
CO6	S	M	M	M	L	M	-	-	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	80	60	60	60
Apply	-	20	20	20
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Distinguish between prokaryotes and eukaryotes
2. Find the classification of microbes with examples
3. Depict the double helical structure of DNA
4. Schematically explain the growth curve of bacteria
5. Define plasmids

Course Outcome 2 (CO2):

1. List out and explain the various methods of inoculation
2. Explain pure culture.
3. Differentiate liquid from solid media
4. Describe the serial dilution technique
5. Comment on Gram staining

Course Outcome 3 (CO3):

1. Define facultative anaerobes.
2. Identify psychrophiles.
3. Describe the formation of ATP molecules in glycolytic pathway.
4. Explain β-Oxidation.
5. Identify the entry of Acetyl CoA into the Kreb's cycle?

Course Outcome 4 (CO4):

1. Describe gravitational setting in air microbiology.
2. Explain MOER.
3. Discuss the Nitrogen cycle.
4. Define bio-magnification.
5. Give an account on biodeterioation.

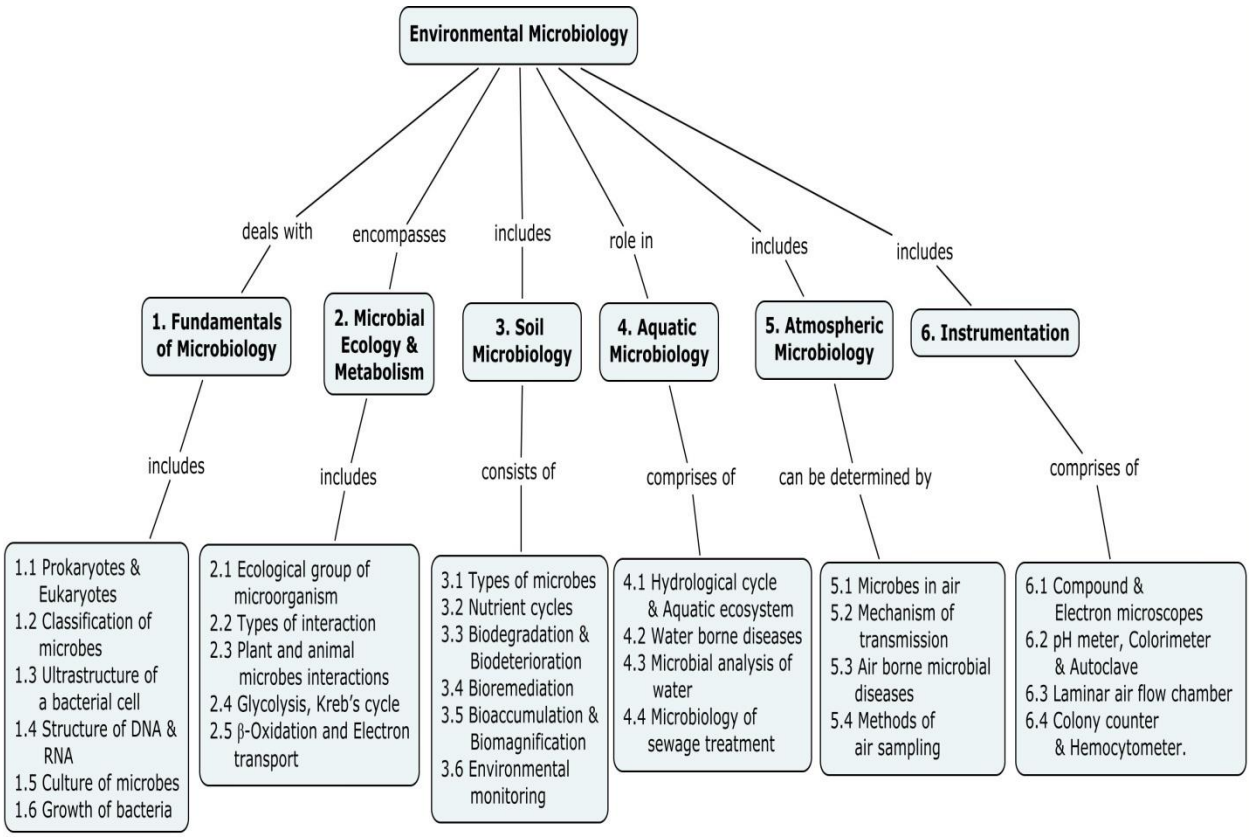
Course Outcome 5 (CO5):

1. Discuss the significance of algal problem in drinking water supply.
2. Interpret the results of the IMViC test.
3. Defend that the provided drinking water sample is free from coliform bacteria.
4. Make an account on microbial bio-indicators.
5. Comment on cholera.

Course Outcome 6 (CO6):

1. Demonstrate the application of bio-sensors in pollution control.
2. Explain the role of microbes in sewage treatment.
3. Show that the given water sample is potable.

Concept Map



Syllabus

Fundementals of Microbiology: Cell – Prokaryotes vs Eukaryotes; Classification of microbes; Ultrastructure of a bacterial cell and cell wall; Size, shape and arrangement of bacterial cells; Structure of DNA (double helical and chemical), RNA types and plasmids. Types of Microbiological media; Methods of sterilization and inoculation; Isolation, development of pure culture and preservation of soil bacteria. Simple and Gram staining. Growth of bacteria –Factors influencing growth, Growth curve, Determination of growth. **Microbial Ecology and Metabolism:** Ecological group of microorganism based on Oxygen requirement, Carbon source, temperature, habitat and nutrient requirements; Extremophile bacterial types. Types of interaction-symbiosis, mutualism, commensalism, competition, parasitism and predation. Plant and animal microbes interactions. Glycolysis, Kreb's cycle, β-Oxidation and Electron transport chain. **Soil Microbiology:** Soil bacteria, actinomycetes, algae, fungi and protozoans and their role; Rhizosphere microbes. Carbon, Nitrogen, Phosphorous and Sulfurcycles. Biodegradation (cellulose, pectin) and Bio-deterioration (leather). Bioremediation of oil spills. Microbial leaching of mineral ores. Bioaccumulation and Biomagnification. Environmental monitoring - environmental impacts and their assessments using bio-indicators, biomarkers, biosensors and toxicity testing. **Aquatic**

Microbiology: Hydrological cycle; Marine, Brackish and Fresh water ecosystems. Water borne bacterial diseases – Cholera and typhoid. Microbiological analysis of water for coliform bacteria – Presumptive, Confirmed and Completed tests; IMViC test. Biological indicators of water pollution. Quality checking of potable water. Algae in water supplies – problems and control - Microbiology of sewage treatment.. **Atmospheric Microbiology:** Aerofungi, algae and bacteria; Microbial aeroallergens; Deposition of microbes in atmosphere - Gravitational setting, Surface impaction and rain and electrostatic deposition. Air borne microbial diseases – Pertussis, Q fever. Methods of air sampling – Impingement, Centrifugation, Filtration and Deposition. **Instrumentation in Microbiology:** Compound and Electron (SEM and TEM) Microscopes; pH meter; Colorimeter; Autoclave; Laminar air flow chamber; Colony counter; Hemocytometer.

Reference Books

1. Atlas, R.A. and Bartha, R. 2000. Microbial Ecology- Fundamentals and Application, Benjamin Cummings, New York.
2. Egbert Boeker andRienkVangrondella. 2001. Environmental Science. John Wiley & Sons, Ltd., USA.
3. Grant, Wd. And Long, PL. 1981. Environmental Microbiology. Blackie Glasgow, London.
4. Grerard J. Tortora, Berdell R. Funke, Christine and L. Case. Microbiology: An Introduction. Benjamin Cummings, U.S.A. 2004.
5. Pelczar Jr. MJ, Chan ECS and Krieg, NR. Microbiology. McGraw Hill. Inc, New York 1993.
6. Prescott, L.M., Harley, J.P. and Klein, D.A. Microbiology. McGraw Hill, Newyork 2006.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Fundamentals of Microbiology	
1.1	Cell – Prokaryotes vs Eukaryotes	1
1.2	Classification of microbes	
1.2	Ultrastructure of a bacterial cell and cell wall; Size, shape and arrangement of bacterial cells	1

1.3	Structure of DNA (double helical and chemical), RNA types and plasmids	2
1.4	Types of Microbiological Media; Methods of sterilization and inoculation; Isolation, development of pure culture and preservation of soil bacteria. Simple and Gram staining	2
1.6	Growth of bacteria – Factors influencing growth, Growth curve, Determination of growth	1
2. Microbial Ecology and Metabolism		
2.1	Ecological group of microorganism based on Oxygen requirement, Carbon source, temperature, habitat and nutrient requirements	1
2.2	Types of interaction- symbiosis, mutualism, commensalism, competition, parasitism and predation.	1
2.3	Extremophile bacterial types. Types of interaction - symbiosis, mutualism, commensalism, competition, parasitism and predation plant and animal microbes interactions	2
2.4	Glycolysis, Kreb's cycle	1
2.5	β-Oxidation and Electron transport chain	1
3. Soil Microbiology		
3.1	Soil bacteria, actinomycetes, algae, fungi and protozoans and their role; Rhizosphere microbes	2
3.2	Carbon, Nitrogen, Phosphorous and Sulfur cycles	1
3.3	Biodegradation (cellulose, pectin, plastics and pesticides) and Bio-deterioration (leather).	1
3.4	Bioremediation of oil spills	1
3.4	Microbial leaching of mineral ores. Bioaccumulation and Biomagnification	1
3.5	Environmental monitoring - environmental impacts and their assessments using bio-indicators, biomarkers, biosensors and toxicity testing	2
4. Aquatic Microbiology		
4.1	Hydrological cycle, Marine, Brackish and Fresh water ecosystems	2
4.2	Water borne bacterial diseases – Cholera and typhoid	1
4.3	Microbiological analysis of water for coliform bacteria – Presumptive, Confirmed and Completed tests; IMViC test	2
4.4	Biological indicators of water pollution. Quality checking of potable water. Microbiology of sewage water treatment. Algae	2

	in water supplies – problems and control	
5. Atmospheric Microbes and Instrumentation		
5.1	Aerofungi, algae and bacteria; Microbial aeroallergens	1
5.2	Deposition of microbes in atmosphere - Gravitational setting, Surface impaction and rain and electrostatic deposition	1
5.3	Air borne microbial diseases – Pertussis, Q fever	1
5.4	Methods of air sampling – Impingement, Centrifugation, Filtration and Deposition	1
6. Instrumentation in Microbiology		
6.1	Compound and Electron (SEM and TEM) Microscopes	1
6.2	pH meter; Colorimeter; Autoclave	1
6.3	Laminar air flow chamber	1
6.4	Colony counter; Hemocytometer	1
Total		**36**

Course Designer

Dr. C. Ravi ravi_cyril@yahoo.co.in

		Category	L	T	P	Credit
14EN140	**PHYSICO-CHEMICAL TREATMENT SYSTEM**	PC	3	1	-	4

Preamble

Wastewater generated from a community must be properly treated to get rid off from its harmfulness before being disposed into any natural system either water bodies or land. Physical operations are needed for the removal of floating, suspended and colloidal matters present in the wastewater. Chemical processes like coagulation, oxidation, and neutralization are required for the conversion of the harmful chemical components amenable for physical removal subsequently.

Prerequisite

Basic knowledge on treatment of water and wastewater.

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Understand the significance of equalization and design of equalization tank and realize its impact on wastewater treatment system.	Apply
CO2.	Understand different types of settling involved in treatment and design appropriate sedimentation units to remove the suspended impurities.	Apply
CO3.	Understand the mechanisms involved and types of filtration for water/wastewater treatment and design the filtration units for the removal of finely divided colloidal and dissolved solids.	Analyze
CO4.	Identify and design chemical treatment methods for the conversion of harmful components in water/ wastewater into harmless ones or change their state amenable for subsequent physical removal.	Analyze
CO5.	Understand the theory of disinfection & adsorption and design the treatment units for the removal of dissolved organics and other undesirable compounds.	Evaluate
CO6.	Select appropriate mixing and aeration devices required for the treatment.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	S	M	-	-	M	-	M	-	M
CO2	S	M	S	M	L	-	-	-	L	-	L
CO3	S	S	S	S	M	L	-	-	M	-	M
CO4	S	S	S	S	L	L	L	-	M	M	M
CO5	S	S	S	S	L	L	-	-	M	M	M

CO6	S	M	M	M	-	M	M	-	M	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	-	-	-	-
Understand	50	30	30	30
Apply	50	50	50	50
Analyse	-	20	20	20
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the need for equalization of wastewater generated from a community.
2. Compute the volume of equalization basin required for the following flow regime.

Time (hrs)	02.00	04.00	06.00	08.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00
Flow rate(m^3/d)	7200	6400	9800	13,500	13,800	14,500	12,500	10,000	10,500	8500	8200	7700

3. Compute the flow weighted BOD from the following flow regine.

Time (hrs)	02.00	04.00	06.00	08.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00
Flow rate(m^3/d)	7200	6400	9800	13,500	13,800	14,500	12,500	10,000	10,500	8500	8200	7700
	130	110	160	220	230	245	225	220	210	200	180	160

BOD (mg/L)												

Course Outcome 2 (CO2):

1. Determine the settling velocity of a sand particle with specific gravity of 2.65 and a diameter of 1.0mm. Take Reynolds number as 275.
2. A rectangular settling tank has an overflow rate of 30 m^3/m^2d and dimensions of 2.75m deep by 6m wide by 15m long. Determine whether or not particles with diameter of 0.1mm and a specific gravity of 2.50 will be scoured from the bottom. Use f=0.03 and k=0.04.
3. The data pertaining to a settling column test performed in a 3m cylinder is given below. The initial solids concentration was 3600 mg/L. Calculate the thickener area required for a concentration C_u of 12000 mg/L with a solids flow of 1500 m^3/d.

Time min	0	10	20	30	40	50	60
Interface Height m	3.0	1.75	1.10	0.75	0.51	0.49	0.48

Course Outcome 3 (CO3):

1. Determine the headloss through a 750mm sand bed for a filtration rate 240 L/m^2 min. The sand bed is composed of spherical unisized sand with a diameter of 0.50mm and a porosity of 0.40. Kinematic viscosity is equal to 1.306×10^{-6} m^2/s. Use Rose equation.
2. Using the data given below, determine the recovery and rejection rate for the RO unit

Parameter	Unit	Value
Flow rate	m^3/d	25,000
Concentrate Flow rate	m^3/d	2500
Effluent TDS	g/ m^3	65
Concentrate TDS	g/ m^3	1500

3. Explain the different removal mechanisms postulated in depth filtration.

Course Outcome 4 (CO4):

1. Describe the method of determination of Ion-exchange capacity of a material.
2. Exhibit the particle destabilization mechanisms in chemical coagulation.
3. Illlustrate the applications of chemical oxidation in wastewater treatment.

Course Outcome 5 (CO5):

1. Explain the factors influencing chlorination process.
2. The chlorine residual measured when various dosages of chlorine were added is given below. Determine the breakpoint dosage and design dosage to obtain a residual of 1.0 mg/L free available chlorine.

Dosage mg/L	1	2	3	4	5	6	7	8
Residual mg/L	0.95	1.70	2.3	1.9	1.0	1.7	2.7	1.6

3. Using the following carbon adsorption data, determine the Frendlich capacity factor and Frendlich intensity parameters.

Carbon dose mg/L	0	5	10	25	50	100	150	200
Residual Concmg/L	27.5	24.8	24.2	18.9	11.8	2.30	1.10	0.90

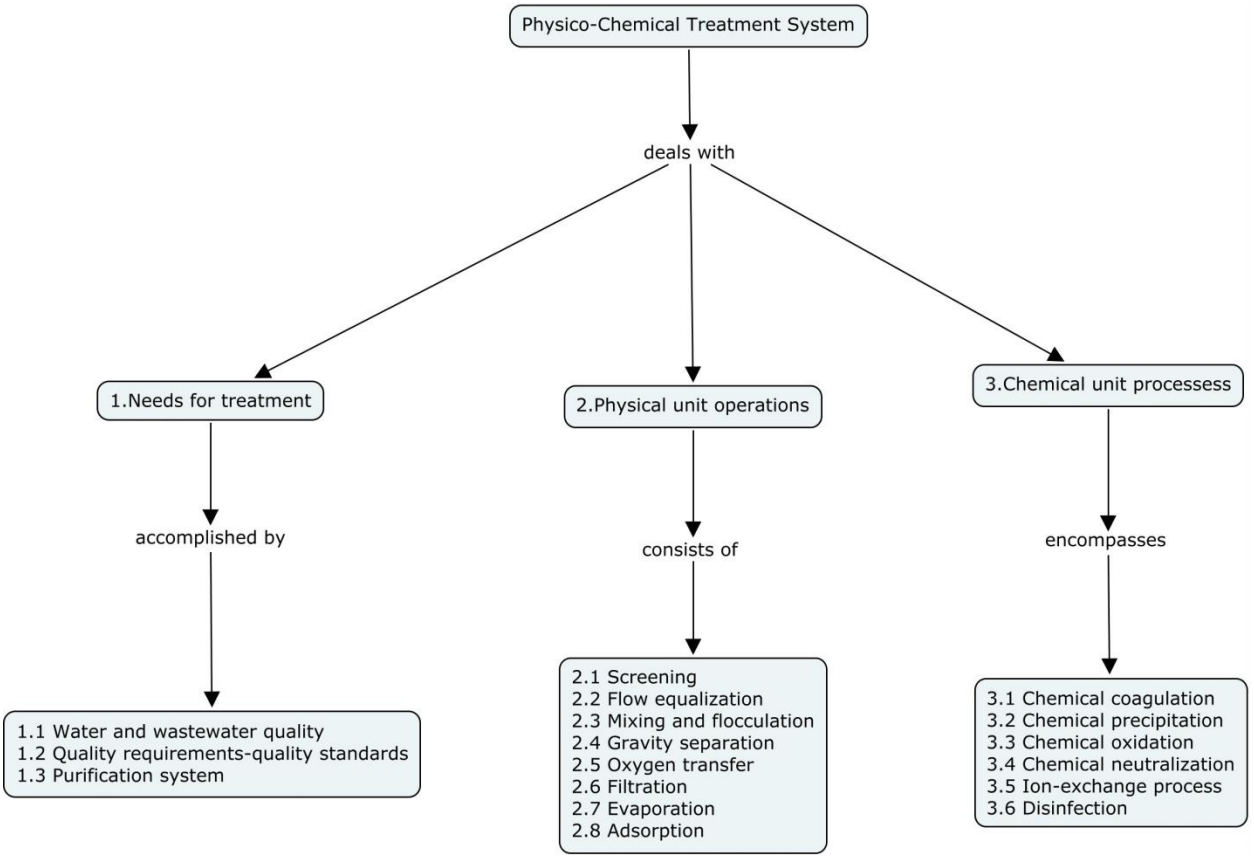
Course Outcome 6 (CO6):

1. What are the needs for mixing and flocculating devices? What are the different types of mixers is use?
2. The following data were obtained from a test program designed to evaluate a new diffused air aeration system. Using these data, determine the value of Kl.a at 20°C and the equilibrium dissolved oxygen concentration in the test tank. The test program was conducted using tap water at 24°C temp.

C mg/L	1.5	2.7	3.9	4.8	6.0	7.0	8.2
dc/dt	8.4	7.5	5.3	4.9	4.2	2.8	2.0

3. Identify the various design parameters involved in the selection of a mixing device for a said task.

Concept Map



Syllabus

Needs for treatment - Water and wastewater quality – physical, chemical and biological parameters. Quality requirements – Water quality standards – effluent standards, Water quality indices. Water purification system – physical processes and chemical processes. **Physical unit operations** – screening – classification of screens. Flow equalization – Equalization basin – design. Mixing and flocculation – types of mixers for rapid mixing and flocculation. Gravity separation – theory of sedimentation, types of settling, batch analysis, solid flux analysis- Sedimentation tanks – performances – design criteria and design. Flotation – types. Oxygen transfer – two film theory – aeration systems – types. Filtration – depth filtration – process and physical features – filtration process analysis – problems – types of filters – performances. Membrane filtration – process – operation – Application, Evaporation Techniques. Adsorption – fundamentals of adsorption – adsorption isotherms – mass transfer zone – adsorption capacity – breakthrough curve – residue management. **Chemical unit processes** – chemical coagulation – theory of colloids – chemical precipitation – chemicals used. Chemical oxidation – applications. Chemical neutralization – Ion – exchange process - Chemistry and applications. Disinfection, theory, types of

chlorination, breakpoint, process variables, chlorine dosage, dechlorination. Disinfection with ozone – disinfection by UV rays.

Reference Books

1. Casey, T.J. Unit treatment process in Water and Waste Water Engineering, John Wiley and sons, London 1993.
2. Mackenzie L.Davis, David A.Cornwell, 'Introduction to Environmental Engineering", McGraw Hill, 1998.
3. Manual on Water supply and treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi.
4. Metcalf & Eddy, "Waste water Engineering treatment, Disposal & Reuse" Tata-McGraw Hill, 2006.
5. Qasim,S.R.,"Water works Engineering, Planning, Designing&Operation, Prentice Hall(India) Ltd,2006.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Needs for treatment	
1.1	Water and wastewater quality – physical, chemical and biological parameters	1
1.2	Quality requirements – Water quality standards – effluent standards, water quality indices	1
1.3	Water purification system – physical processes and chemical processes	1
	2. Physical unit operations	
2.1	Screening – classification of screens	1
2.2	Flow equalization – Equalization basin – design	2
2.3	Mixing and flocculation – types of mixers for rapid mixing and flocculation	1
2.4	Gravity separation – settling theory – discrete particle settling	2
2.4.1	Flocculant particle settling – tube settling	1
2.4.2	Hindered settling – batch analysis – solid flux analysis.	2
2.4.3	Sedimentation tanks – performances – design criteria and design.	1
2.4.4	Flotation – types	1
2.5	Oxygen transfer – two film theory – aeration systems – types	2
2.6	Filtration – depth filtration – process and physical features	1

2.6.1	filtration process analysis – problems	2
2.6.2	Types of filters – performances	1
2.6.3	Membrane filtration – process – operation – Applications	1
2.7	Evaporation Techniques	1
2.8	Adsorption – fundamentals of adsorption	1
2.8.1	adsorption isotherms	1
2.8.2	mass transfer zone – adsorption capacity – breakthrough curve	1
2.9	Residue management	1
3. Chemical Unit Processes		
3.1	Chemical coagulation – theory	1
3.2	Chemical precipitation – chemicals used	1
3.3	Chemical oxidation – applications	1
3.4	Chemical neutralization	1
3.5	Ion –exchange process - Chemistry of ion – exchange – applications of ion – exchange	1
3.6	Disinfection – theory – types of chlorination	1
3.6.1	Chlorination – breakpoint – process variables – chlorine dosage – dechlorination	2
3.6.2	Disinfection with ozone	1
3.6.3	Disinfection by UV rays	1
	Total	**36**

Course Designer

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		Category	L	T	P	Credit
14EN150	**AIR POLLUTION CONTROL ENGINEERING**	PC	3	1	-	4

Preamble

To impart knowledge on the principles and design of control of indoor/particulate/gaseous air pollutant and its emerging trends

Prerequisite

No prerequisite

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the atmospheric process and pollutant transport mechanism	Understand
CO2	Apply modelling techniques and to determine the fate of air pollutant with respect to time and space	Apply
CO3	Prevent and control air pollution by suitable air pollution control measures	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	M	M	M	L	-	M	-	M	-
CO2	S	S	M	M	S	M	L	M	L	M	-
CO3	S	S	S	M	S	M	L	M	L	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain, how do prevailing lapse rate affect the plume behavior from a stack.
2. Explain the Gaussian dispersion model for the pollutants from a point source.
3. How do an ESP work? What are the factors governing its performances?

4. What are the control strategies in automotive pollution? Explain
5. How do scrubbers are classified? Explain them clearly
6. What are the various source reduction methods possible in the control of air pollution?
7. Explain the impacts of noise on human beings. How could it be controlled?

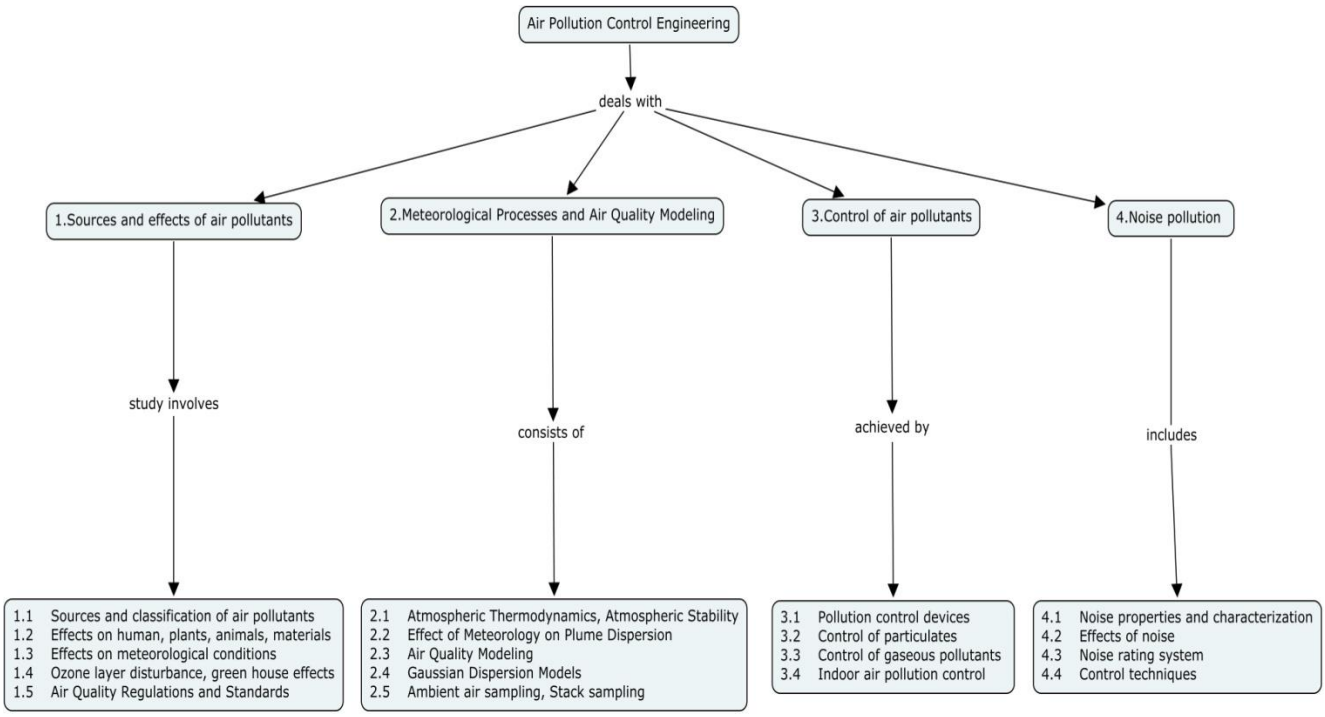
Course Outcome 2 (CO2):

1. A dumpsite fire emits 3g/s of NOx, Determine the NOx concentration at 2km downwind if the windspeed U10=5 m/s and the stability is class D. What is the maximum concentration at ground level and also at 50m above ground?
2. A 915 MW power plant with a load factor of 72.5% and efficiency of 40% uses coal as a fuel source. The coal has a 1% sulphur content and a calorific value of 30 MJ/kg. The stack tip is 200m high with a diameter of 7m. If neutral condition prevails, determine the maximum ground level concentration of SO2 at 10km from the plant. U10=4 m/s, Ts=150°C Ta=20°C and Vs=15 m/s.
3. An air conditioner generates a noise level of 75 dB for five minutes every hour. If the background noise level is 55 dB, Compute the Lequ.
4. Determine the effective height of a stack, given the following data:
   Physical stack is 170m tall with a 1.25m inside diameter Wind velocity is 5.17m/s
   Air temperature is 18°C
   Barometeric pressure is 1.0 bar
   Stack gas velocity is 8.75 m/s
   Stack gas temperature is 128°C

Course Outcome 3 (CO3):

1. Determine the size of a cyclone that will remove a 15µm particle with 50% efficiency from an air stream of 6.0 m3/min. The temperature of the air is 75°C and the specific gravity of the particle is 1.50. Assume five turns.
2. A cross flow scrubber is collecting 90% of the 3µm particle entering. The water drops are all of the same diameter, 400µm. If a new spray nozzle system is installed that make all the drops to 200µm in diameter. The flow is not changed. What will be the new collection efficiency?

Concept Map



Syllabus

Sources and effects of air pollutants: Industrial Accidents, Air Pollutants, Sources and classification of air pollutants-Effects of air pollutants – on human, plants, animals, materials -Effects of air pollutants - On meteorological conditions-Ozone layer disturbance, green house effects-Air Quality Regulations in India and USA, Air Quality Standards. **Meteorological Processes and Air Quality Modeling:** General Atmospheric Circulation, Atmospheric Thermodynamics, Atmospheric Stability, Boundary Layer Development-Effect of Meteorology on Plume Dispersion, Wind Velocity, Beaufort Scale, Wind Rose, Local Climatological Data-Air Quality Modeling: Types of Plumes, Flow Regimes of a Plume, Plume Rise, Ambient Air Concentration Modeling-Gaussian Dispersion Models, Plume Dispersion Parameters, Computer Programs, USEPA Recommended Models-Sampling – Ambient air sampling, Stack sampling. **Control of air pollutants:** General Ideas: Reduce emission by process change, pollution control devices, Resource Recovery, Ultimate fate of pollutants Fluid velocities in control equipments – Combustion - Primary and secondary particulate pollutants, Drag force and settling velocity, stokes law- Wall collection devices – Gravity settlers, Cyclone separators-Electrostatic precipitators-Surface filters-Scrubbers for particulate control-Control of gaseous pollutants – control of VOCs – control by prevention – control by concentration and recovery – control by oxidation- Control of Sulphur Oxides – recovery of SO2 – Control of NOx - Control of Motor Vehicle air pollution – IC engines – types of pollutants and emission –Alternative power plants.-

Indoor air pollution – Indoor and outdoor concentrations, models -control of indoor air quality, Radon Problem. **Noise pollution:** Noise properties of sound waves, characterization of noise, noise spectrum -Effects of noise-Noise rating system -Noise control techniques.

Reference Books

1. Lawrence K.Wang, Norman C Pererla, Yung – Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004.
2. Noel De Nevers, " Air Pollution Control Engineering" (2nd Edn.) McGraw Hill , New York 2000.
3. Wark, C.F. Warner & W.T. Davis "Air Pollution Control: its Origin and Control, Addision-Wesley, 1998.
4. Wayne R. Davis (Editor) Air & Waste Management Association, "Air Pollution Engineering Manual", 2nd Edition, Wiley Publications, 2000.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Sources and effects of air pollutants	
1.1	Industrial Accidents, Air Pollutants, Sources and classification of air pollutants	2
1.2	Effects of air pollutants – on human, plants, animals, materials	2
1.3	Effects of air pollutants - On meteorological conditions	1
1.4	Ozone layer disturbance, green house effects	1
1.5	Air Quality Regulations in India and USA, Air Quality Standards	1
	2. Meteorological Processes and Air Quality Modeling	
2.1	General Atmospheric Circulation, Atmospheric Thermodynamics, Atmospheric Stability, Boundary Layer Development	2
2.2	Effect of Meteorology on Plume Dispersion, Wind Velocity, Beaufort Scale, Wind Rose, Local Climatological Data	2
2.3	Air Quality Modeling: Types of Plumes, Flow Regimes of a Plume, Plume Rise, Ambient Air Concentration Modeling,	2
2.4	Gaussian Dispersion Models, Plume Dispersion Parameters, Computer Programs, USEPA Recommended Models	2
2.5	Sampling – Ambient air sampling, Stack sampling	1

3. Control of air pollutants		
3.1	General Ideas: Reduce emission by process change, pollution control devices, Resource Recovery, Ultimate fate of pollutants Fluid velocities in control equipments – Combustion	2
3.2	Primary and secondary particulate pollutants, Drag force and settling velocity, stokes law	1
3.2.1	Wall collection devices – Gravity settlers, Cyclone separators	1
3.2.2	Electrostatic precipitators	1
3.2.3	Surface filters	1
3.2.4	Scrubbers for particulate control	2
3.3	Control of gaseous pollutants – control of VOCs – control by prevention – control by concentration and recovery – control by oxidation	2
3.3.1	Control of Sulphur Oxides – recovery of SO2 – Control of NOx	2
3.3.2	Control of Motor Vehicle air pollution – IC engines – types of pollutants and emission – Alternative power plants.	2
3.4	Indoor air pollution – Indoor and outdoor concentrations, models -control of indoor air quality, Radon Problem	2
4. Noise pollution		
4.1	Noise properties of sound waves, characterization of noise, noise spectrum	1
4.2	Effects of noise	1
4.3	Noise rating system	1
4.4	Noise control techniques	1
Total		**36**

Course Designer

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		Category	L	T	P	Credit
14EN160	**SOLID AND HAZARDOUS WASTE MANAGEMENT**	PC	4	-	-	4

Preamble

This course work provides an in depth understanding of solid and hazardous waste characteristics and management. The students acquire proficiency in processing technologies and disposal methods for municipal solid waste and hazardous waste generated from a community.

Prerequisite

No prerequisite

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Explain the functional elements of municipal solid waste management system	Understand
CO2.	Evaluate the various processing technologies for MSW	Apply
CO3.	Analyze the various options for disposal of MSW	Analyze
CO4.	Identify and classify the hazardous wastes	Understand
CO5.	Choose the treatment, storage, and disposal options for hazardous waste	Apply
C06.	Suggest feasible remediation measures for the contaminated sites	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	-	-	M	L	-	M	-	M	-
CO2	S	S	S	S	M	M	L	M	-	M	-
CO3	S	S	S	S	M	M	L	M	-	M	-
CO4	S	M	-	-	M	L	-	M	-	M	-
CO5	S	S	S	S	M	M	L	M	-	M	-
CO6	S	S	S	S	M	M	L	M	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests	Terminal Examination

	1	2	3	
Remember	10	10	10	-
Understand	40	40	40	40
Apply	30	30	30	30
Analyse	20	20	20	30
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

4. Based on the source and type, classify the waste generated in your locality.
5. Explain the role of a transfer station in solid waste management.
6. Describe the types of containers and collection vehicles used for solid waste management.

Course Outcome 2 (CO2):

1. Analyze the current waste collection practice in your locality and choose the appropriate waste management system.
2. Analyze the environmental effects of composting and bio-gasification.
3. Assess the techno-economic viability of various processing techniques.

Course Outcome 3 (CO3):

1. Discuss the various constraints faced by municipal authorities in identifying a disposal site.
2. Do you think a sanitary landfill is possible to manage wastes in your locality? List at least three reasons to support your answer.
3. Suggest the best disposal option for the municipal solid waste generated from your locality.

Course Outcome 4 (CO4):

1. Explain are the characteristics of hazardous wastes.
2. Describe are the responsibilities of Hazardous waste generator.
3. Discuss the advantages of waste minimization in Hazardous waste management.

Course Outcome 5 (CO5):

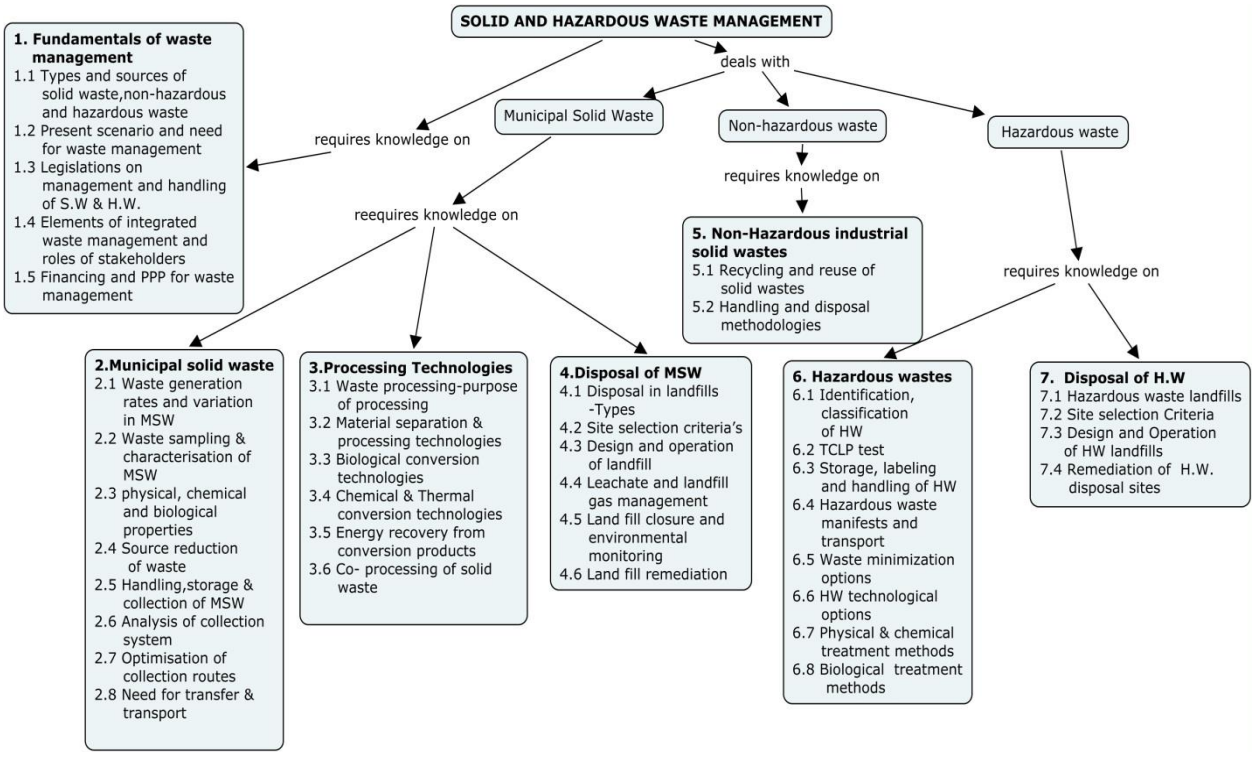
1. How will you control leachate generation from a secured landfill.
2. Discuss the issues associated with the present practice of Hazardous waste generated from electroplating industry in India.

3. Assess the various options present before implementing a source reduction policy in Hazardous waste management.

Course Outcome 6 (CO6):

1. Analyze the various remediation measures for chromium contaminated site.
2. Analyze the applications of phytoremediation for open dumping of MSW.
3. Assess the technical viability of Bioventing technology for remediation.

Concept Map



Syllabus

Fundamentals of waste management: Types and sources of solid waste, non-hazardous and hazardous waste-Present scenario and need for solid and hazard waste management- Legislations on management and handling of solid wastes**and hazardous waste** - Elements of integrated waste management and roles of stakeholders - Financing and Public Private Participation for waste management.**Municipal solid waste**: Waste generation rates and variation in MSW-waste sampling and characterization physical, chemical and biological properties of solid wastes- Source reduction of wastes- Recycling and Reuse-Handling storage and collection of MSW-Analysis of collection system-Optimization of collection routes-Need for transfer and transport – transfer station. **Processing Technologies:** Waste

processing – purposes of processing-Material separation and processing technologies-Biological conversion technologies-Chemical conversion technologies and-Thermal conversion technologies-Energy recovery from conversion products-Co- processing of solid waste. **Disposal of municipal solid waste:** Disposal in landfills –Types-Site selection criteria's-Design and operation of landfill-Leachate and landfill gas management-Land fill closure and environmental monitoring-Land fill remediation. **Non-Hazardous industrial solid wastes:** Recycling and reuse of solid wastes-Handling and disposal methodologies of high volume non-hazardous solid wastes. **Hazardous wastes:** Identification, classification of Hazardous waste-Source and characterization of hazardous waste – TCLP tests-Storage, labeling and handling of hazardous wastes-Hazardous waste manifests and transport-Waste minimization options-Hazardous waste technological options-Physical treatment methods and chemical treatment methods-Biological treatment methods. **Disposal of Hazardous waste:** Hazardous waste landfills-Site selection Criteria-Design and Operation of Hazardous waste landfills-Remediation of H.W disposal sites.

Reference Books

1. Bhide A.D and Sundaresan, B.B. "Solid Waste Management Collection, Processing and Disposal", 2001, ISBN 81-7525-282-0
2. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil "Integrated Solid Waste Management", McGraw Hill Publishers, New York, 1993.
3. "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2000.
4. Vesilind P.A., Worrell W and Reinhart, Solid Waste Engineering, Thomson learning Inc., Singapore, 2002.

Course Contents and Lecture Schedule

S. No	Topics	No. of Lectures
1.Fundamentals of waste management		
1.1	Types and sources of solid waste, non-hazardous and hazardous solid waste	1
1.2	Present scenario and need for waste management	1
1.3	Legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, plastics and fly ash	3

1.4	Elements of integrated waste management and roles of stakeholders	1
1.5	Financing and Public Private Participation for waste management	2
2.Municipal solid waste		
2.1	Waste generation rates and variation in MSW	1
2.2	Waste sampling and characterization	1
2.3	Physical, chemical and biological properties of solid wastes	1
2.4	Source reduction of wastes- Recycling and Reuse	1
2.5	Handling storage and collection of MSW	1
2.6	Analysis of collection system	1
2.7	Optimization of collection routes	1
2.8	Need for transfer and transport – transfer station	1
3.Processing Technologies		
3.1	Waste processing – purposes of processing	1
3.2	Material separation and processing technologies	1
3.3	Biological conversion technologies	1
3.4	Chemical conversion technologies and Thermal conversion technologies	2
3.5	Energy recovery from conversion products	1
3.6	Co- processing of solid waste	2
4.Disposal of municipal solid waste		
4.1	Disposal in landfills -Types	1
4.2	Site selection criteria's	1
4.3	Design and operation of landfill	1
4.4	Leachate and landfill gas management	1
4.5	Land fill closure and environmental monitoring	1
4.6	Land fill remediation	1

5.Non-Hazardous industrial solid wastes		
5.1	Recycling and reuse of solid wastes	1
5.2	Handling and disposal methodologies of high volume non-hazardous solid wastes	1
6.Hazardous wastes		
6.1	Identification, classification of Hazardous waste	1
6.2	Source and characterization of hazardous waste – TCLP tests	2
6.3	Storage, labeling and handling of hazardous wastes	1
6.4	Hazardous waste manifests and transport	1
6.5	Waste minimization options	1
6.6	Hazardous waste technological options	2
6.7	Physical treatment methods and chemical treatment methods	2
6.8	Biological treatment methods	1
7.Disposal of Hazardous waste		
7.1	Hazardous waste landfills	1
7.2	Site selection Criteria	1
7.3	Design and Operation of Hazardous waste landfills	1
7.4	Remediation of H.W. disposal sites	2
	Total	**48**

Course Designer

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		Category	L	T	P	Credit
14EN170	**ENVIRONMENTAL ENGINEERING LABORATORY**	PC	-	-	2	1

Preamble

The objective of this laboratory course is to give practical knowledge in fixing water, wastewater and air quality in order to identify the pollution status and arriving at the appropriate treatment techniques and control measures required to keep up their quality standards.

Prerequisite

Basic Knowledge on water, wastewater & air quality characteristics and treatment methods.

Course Outcomes

On the successful completion of the course, students will be able to:

(CO1) Identify the quality of water in order to fix its pollution status — Analyze

(CO2) Conduct test on wastewater to identify their characteristics so as to suggest suitable treatment methods — Analyze

(CO3) Determine the dosage of coagulants and disinfectants required for the treatment of water/ wastewater — Apply

(CO4) Measure the quality of ambient air with respect to various particulate matters — Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	S	M	S	M	M	M	---	---	M	M
CO2.	S	S	M	S	M	M	M	---	---	M	M
CO3	S	S	M	S	M	M	M	---	---	M	M
CO4	S	S	M	S	M	M	M	---	---	M	M

S- Strong; M-Medium; L-Low

List of Experiments

1. Sodium Absorption Ratio

2. Adsorption Kinetics / Isotherms
3. RSPM and TSPM in ambient air
4. Nitrate /Fluoride in water
5. COD of wastewater
6. MLSS / MLVSS / SVI of biological reactor content
7. Chlorine Dosage for disinfection of water
8. Optimum Coagulant Dosage
9. Dissolved oxygen in water / wastewater
10. Filter media characteristics – Particle size Distribution
11. Isolation and Identification of Microbes
12. Water Softening by Chemical precipitation

Demonstration Experiments

1. Atomic Absorption Spectrophotometer – Heavy metal analysis
2. Total Organic Carbon Analyzer – TOC in wastewater
3. Nitrogen Estimation – Composite Fertilizer
4. Noise measurement – Noise addition

Course Designer

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		Category	L	T	P	Credit
14EN210	**TRANSPORT OF WATER AND WASTEWATER**	PC	3	-	-	3

Preamble

Transportation of water from the source / treatment plant to the city premises and distributing it through a net work of pipes to the doorsteps of consumers at adequate pressure is a most important operation to fulfill the various water demands of the general public. Estimation and collection of storm drainage generated from the township / city areas as well as the wastewater generated by the people and conveying through a well planned sewer network to the treatment plant is also equally important to maintain the health and hygienic conditions in the urban areas.

Prerequisite

Knowledge on Pipe flow and open channel flow.

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Understand and apply the principle of hydraulics in water transportation and distribution and wastewater collection and conveyance.	Apply
CO2.	Design water supply mains taking into account all the design parameters.	Apply
CO3.	Analyze a water supply distribution network.	Apply
CO4.	Select an appropriate pipe material, necessary pipe appurtenances and able to locate the leaking mains for the water distribution system.	Analyze
CO5.	Estimate the quantity of storm drainage and design a proper storm drainage for speedy draining of storm water from the city area.	Create
CO6.	Design a sewer network for the proper disposal of the sewage generated from the city limits to treatment plant.	Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11

CO1	S	L	S	L	M	-	-	-	M	-	-
CO2	S	S	S	L	M	-	M	-	M	M	M
CO3	S	S	S	S	S	L	M	-	M	L	L
CO4	S	S	S	S	S	M	M	M	M	M	M
CO5	S	S	S	S	S	M	M	L	M	M	M
CO6	S	S	S	S	S	L	M	L	L	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	-	-	-	-
Understand	50	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	20	20	20

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A pipe 50mm diameter is 6m long and the velocity of flow of water in the pipe is 2.40 m/s. What loss of head and the corresponding power would be saved if the central 2m length of pipe was replaced by 75mm diameter pipe, the change of section being sudden? Take f=0.04 for both the pipes.
2. A rectangular notch of crest width 0.40m is used to measure the flow of water in a rectangular channel 0.6m wide and 0.45m deep. If the water level in the channel is 0.225m above the weir crest, find the discharge in the channel. Take C_d=0.63 consider velocity of approach also.
3. Explain the circumstances in which pumping of water become necessary? Also discuss the method of selection of a pump.

Course Outcome 2 (CO2):

1. Water has to be supplied to a town with one lakh population at the rate of 150 lpcd from a river, 1.8km away. The difference in elevation between the lowest

water level in the sump and service reservoir is 36m. Determine the size of the main and power of the pump required. Make suitable assumptions for any needy data.

2. A pipeline of 0.6 m diameter is 1.50 km long. To increase the discharge, another line of the same diameter is introduced parallel to the first in the second half of the length. Neglecting minor losses, find the increase in discharge if f = 0.12. The head at the inlet is 300 mm.
3. Estimate the size of supply conduit leading to a service reservoir, serving 25,000 population. Find also the hydraulic gradient at which the pipe lines are proposed to be laid. Assume any missing data suitably.

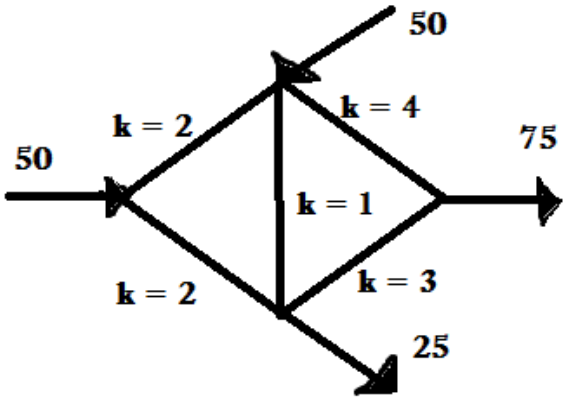
Course Outcome 3 (CO3):

1. A pipe network consists of the following pipes:

Pipe	Length M	Diameter cm	Friction factor
AB	400	30	0.014
BC	600	30	0.010
AD	500	40	0.012
DC	500	25	0.011

Inflow at 'A' is 1 m^3/sec while outflow at B, C and D are 0.3, 0.5 and 0.2 m3/sec respectively. Fing the flow in each pipe. Take two trials. Pressure at A is 100 m of water**.**

2. Determine the distribution of flow in the pipe network shown. The head loss, h_L may be assumed as KQ^n. The flow is turbulent and pipes are rough. The values of 'K' for each pipe is indicated in the figure. Use Hardy Cross method.



3. Explain the equivalent pipe method of analysing a pipe distribution network.

Course Outcome 4 (CO4):

1. Describe the various forces acting on a water supply pipe line.
2. Differentiate different types of valves used in a transmission main with respect to its purpose of use.
3. Demonstrate the steps involved in locating a leaking point on a distribution main.

Course Outcome 5 (CO5):

1. Explain the rational method of estimation of storm drainage generated from a catchment area.
2. The drainage area of one sector of a town is 12 hectares. The classification of the surface of this area is as follows:

Type of surface	% of total area	Coefficient of runoff
Hard pavement	20	0.85
Roof surface	20	0.80
Unpaved street	15	0.20
Gardens & lawns	30	0.20
Wooded area	15	0.15

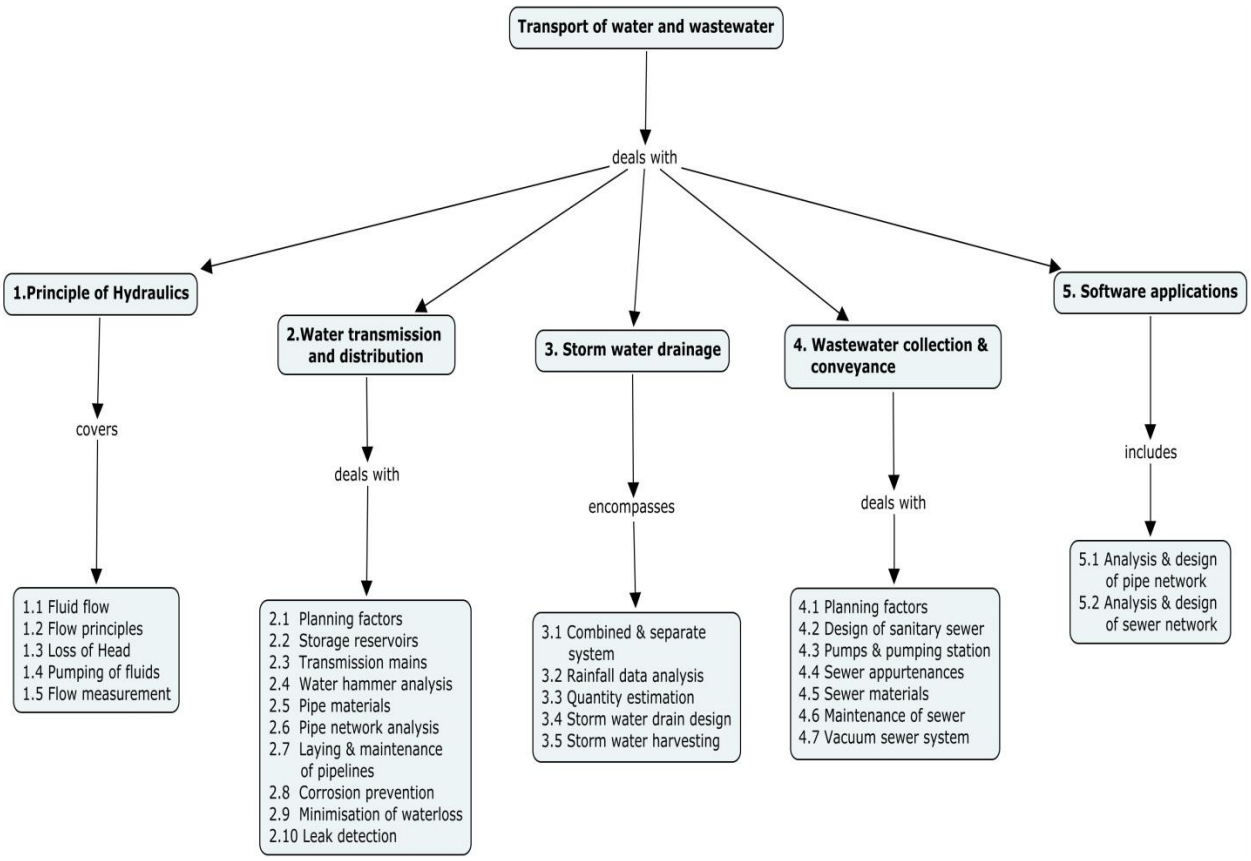
If the time of concentration for the area is 30 minutes, find the maximum run-off.

3. Design a storm drain for the following data.
   Area of catchment: 50 hectares
   Coefficient of runoff: 0.63
   Critical rainfall intensity: 20 mm/hr
   Bed slope: 1 in 500

Course Outcome 6 (CO6):

1. Determine the size of a circular sewer for a discharge of 0.60 m3/s at running half full.Take s=0.0001 and n=0.015.
2. Design an outfall sewer for the following conditions:
   Population: 1 Lakh people
   Bed slope: 1 in 500
   Sewer is running 0.70 times full during maximum flow.
   Self cleansing velocity to be maintained: 0.60 m/s.
3. A sanitary sewer is to serve a uniformly distributed population of 10000. The average ground slope is 1 in 500. Design the sewer. Give expected peak, average and minimum velocities. Make suitable assumptions and state them clearly.

Concept Map



Syllabus

Principles of hydraulics - fluid flow, continuity principle, energy principle. Loss of head – major loss - minor losses -pumping of fluids - types of pumps, selection of pumps - flow measurement - pipe flow, open channel flow. **Water transmission and distribution**- planning factors-transmission mains – design & Economizing of transmission mains – water hammer analysis - Upsurge and Down surge – pipe materials-water distribution pipe network-analysis, design of network & optimization - Laying and maintenance of pipelines. Pipe appurtenances – corrosion prevention – minimization of water losses and leak detection. **Storm water drainage** –combined and separate system, quantity estimation – rainfall data analysis – storm water drain design – storm water harvesting and roof water harvesting. **Wastewater collection and conveyance** – planning factors – design of sanitary sewer – economics of sewer design - Pumps and Pumping stations – sewer appurtenances – material, construction, inspection and maintenance of sewer, recent trends - Vacuum sewer system. **Software applications-** Water distribution- LOOP, BRANCH and EPANET- Sewer design – SEWER.

Reference Books

1. Bhave P. R , "Analysis of flow in water distribution Networks", Technomic

publishing co,U.S.A.,1991.
2. "Manual on sewerage and sewage treatment", CPHEEO, Ministry of urban affairs and employment GOI, New Delhi,2001.
3. “Manual on water supply and treatment", CPHEEO, Ministry of urban affairs and Employment GOI, New Delhi,2001.
4. “Manual on water supply maintenance and management” CPHEEO, Ministry of urban affairs and Employment GOI, New Delhi.
5. Ven Te Chow, David R Maidment, Larry W Mays "Applied hydrology", Mcgraw hill book co. 1988.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Principles of hydraulics	
1.1	Principles of hydraulics- fluid properties-	1
1.2	Continuity principle and energy principle	1
1.3	Loss of head – major loss-minor losses- estimation of losses	1
1.4	Pumping of fluids-types of pumps-selection of pumps	1
1.5	Flow measurement-pipe flow-open channel flow	1
	2. Water transmission and distribution	
2.1	Planning factors	1
2.2	Storage reservoirs- need and capacity fixing	1
2.3	Transmission mains – design & Economizing of transmission mains	1
2.4	Water hammer analysis – Upsurge and Down surge	1
2.5	Pipe materials	1
2.6	Water distribution network analysis	3
2.7	Laying and maintenance of pipelines - Pipe appurtenances	1
2.8	Corrosion of pipelines, prevention of corrosion	1
2.9	Minimization of water losses	1
2.10	Leak detection	1
	3. Storm water drainage	
3.1	Combined and separate system	1
3.2	Rainfall data analysis	1
3.3	Quantity estimation	1
3.4	Storm water drain design	2
3.5	Storm water harvesting and roof water harvesting	1

4. Wastewater collection and conveyance		
4.1	Planning factors	1
4.2	Design of sanitary sewer	3
4.3	Pumps and pumping station	1
4.4	Sewer appurtenances	1
4.5	Sewer materials and laying of sewer	1
4.6	Inspection and maintenance of sewer – recent trends	1
4.7	Vacuum sewer system- Introduction	1
5. Software applications		
5.1	Analysis of pipe network using - LOOP, BRANCH & EPANET and optimization	2
5.2	Design of sewer network using SEWER	2
Total		**36**

Course Designer

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14EN220 BIOLOGICAL TREATMENT SYSTEM

Category	L	T	P	Credit
PC	3	1	-	4

Preamble

This course work is designed to introduce the treatment of wastewater by using micro organisms. This course work deals with process kinetics and bio-kinetics which are essential inputs in the design of Biological treatment system. This course work is essentially focussed to reduce the concentration of organic and inorganic compounds of wastewater using micro organisms which are harmful to the environment. The pre-treatment concepts of some of the constituents and compounds found in industrial wastewater which are toxic to microorganisms is also dealt in here.

Prerequisite

Fundamental knowledge on microbiology and secondary treatment of wastewater.

Course Outcomes

On the successful completion of the course, students will be able to:

CO1.	Use the basic principles of process kinetics and microbial growth(bacteria)- reaction kinetics for reactor design	Apply
CO2.	Design a suspended growth treatment processes to treat municipal wastewater.	Apply & Analyze
CO3.	Design a attached growth treatment processes to treat municipal wastewater.	Apply & Analyze
CO4.	Use the basic principles of sludge process, kinetic relationship and to design a sludge treatment system	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	M	L	-	-	-	-	L	L	L
CO2	S	S	S	L	L	-	-	-	L	L	-
CO3	S	S	S	S	-	-	-	-	L	L	L
CO4	S	S	S	S	-	-	-	-	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests	Terminal Examination

	1	2	3	
Remember	20	20	-	-
Understand	30	30	30	30
Apply	30	30	30	30
Analyse	20	20	40	40
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe enzyme reactions
2. Name the fields of Microbiology that are applied to the Environmental field
3. Define half velocity constant and F/M ratio.
4. Describe the significance of BOD, COD, and Volatiles Solids?
5. Developing the mass balance relationship for each, describe the reactors used for Wastewater treatment.
6. Write arbitrary flow equation for wastewater.
7. Discuss the substrate removal when the reactor in series. Calculate & compare the volume of the reactor s required to achieve 95% reduction of a reactant in a flow of 1500m^3/d for the following conditions.
   i. Single CFSTR is used.
   ii. 5 CFSTR are used in series.

   Assume reaction rate constant is 0.6d^{-1}
8. Determine the values of biokinetic constants using the data given in table. Derived from the laboratory experiments carried out on the CFSTR model of an ASP without recycle.

Unit No	Influent substrate concentration S (mg/L)	Reactor substrat concentration S (mg/L)	Detention time (d)	Reactor biomass concentration X (mg/L)
1	250	13	3.5	130
2	250	22	2.5	128
3	250	32	1.9	132
4	250	65	1.2	120
5	250	72	1.0	115

9. Determine the volume of a reactor to carry out 95% removal of a reactant, when the flow condition is (a) plug flow and (b) complete mix flow. It is given that

i. Wastewater flow rate is 300 m^3/d
ii. First order reaction rate constant is 1.2/h

Course Outcome 2 (CO2):

1. State the classifications of waste stabilization pond?
2. List the recent trends of modifications to ASP
3. State types of oxidation ditch and Aerated lagoon?
4. Describe Kraus process?
5. Estimate the final settling tank size required for an extended aeration plant where plant inflow= 9000 m3/d, recycle flow=6000 m3/d. Other data can be assumed.
6. 2000 m3/d of wastewater with BOD=400 mg/L is treated in an activated sludge plant at 90% efficiency. Assuming net VSS production as 0.28 kg/kg of BOD removed at θ_c = 5 days, estimate the phosphorus removal.
7. Design an external aeration unit to operate as an inter-air system serving 5000 persons using parameters suitable for India. Assume that BOD = 50 g/person – day and average flow Q= 200 L/person/day. Neglect nitrification-denitrification. Take F/M=0.15 kg BOD per kg MLSS.

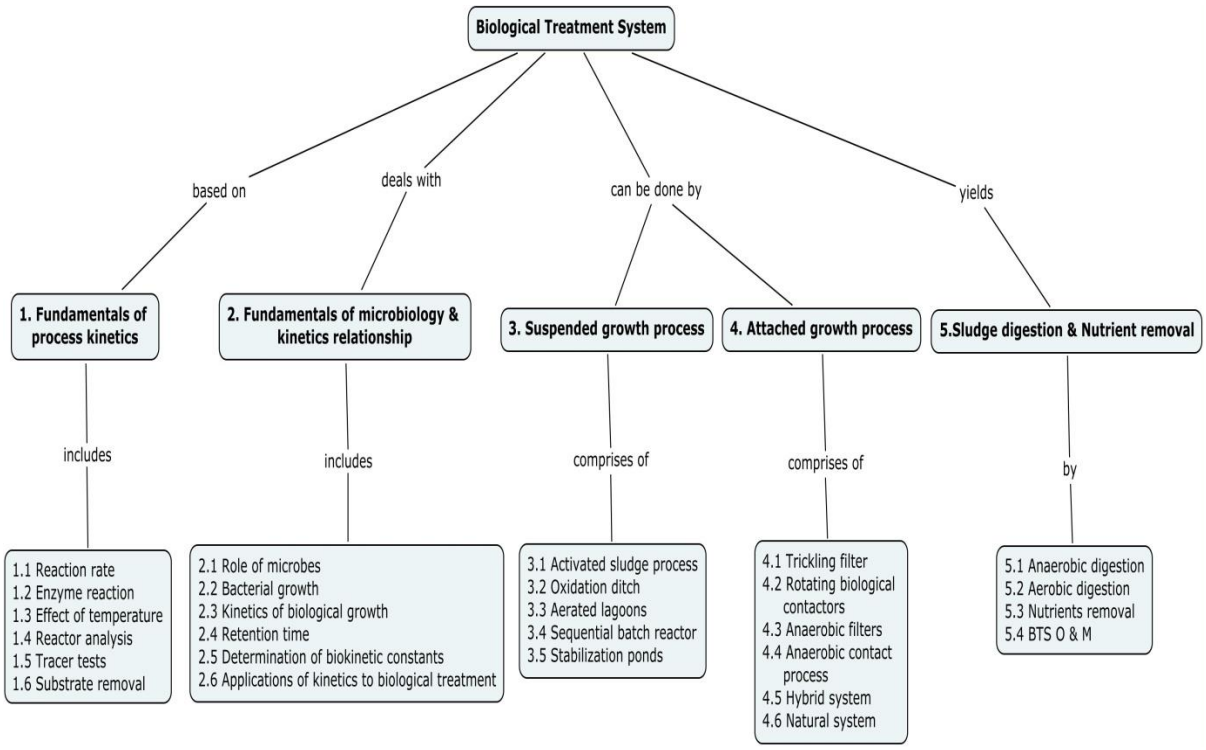
Course Outcome 3 (CO3):

1. Classify the anaerobic contact process.
2. Write Eckenfelder equation adopted for the design of Trickling Filter.
3. Design two- stage TF system to treat 5000m3/d flow of wastewater. Find the efficiency of the treatment & effluent substrate concentration. Settled influent BOD = 250 mg/L, Volume of 1st stage filter = 1000m3, Volume of 2nd stage filter = 700 m3, Filter depths = 2m, Recirculation ratio = 1.5
4. It is proposed to provide a biotower system to treat a wastewater flow of 15 MLD having BOD of 250 mg/L. The depth of modular plastic media to be used is 6m. The treatability constant determined at 20°C is found to be 0.06 min-1 & the treated effluent is to be discharged into surface water. The desired concentration of effluent BOD is 20 mg/L. Assuming a recirculation ration of 2, Design the biotowers.
5. It is proposed to provide an RBC to treat a wastewater flow of a small colony of 1500 persons. The per capita generation of flow has been taken as 200L/d. Assuming that 85% BOD removal can be achieved at an organic loading 0f 25g BOD/m^2.d by 3.0 diameter discs placed at 5cm apart, determine the effective size of tank and the volume of sludge to be wasted each day. The influent BOD size to tank is 200mg/L.

Course Outcome 4 (CO4):

1. Assuming a side water depth of 3.2m, design a flow-through type aerated lagoon proposed to design for following parameters. Flow of wastewater = 900 m3/d, Influent BOD = 175 mg/L, Desired effluent BOD = 20 mg/L, Mean cell residence time = 3d, Effluent suspended solids concentration = 90 mg/L, MLVSS = 80% MLSS, Kinetic coefficients: Y=0.6, Kd=0.06 d-1, Ks = 85 mg/L, K=6 d-1
2. The sludge production having 96% moisture content from a wastewater treatment plant is 1000 kg on dry solid basis. The solid contain 70% volatile matter with a specific gravity of 1.02 and 30% mineral matter with a specific gravity of 2.5. Determine the volume of raw and digested sludge if reduction in volatile solids is 55% during digestion and moisture content of digested sludge is 92%.

Concept Map



Syllabus

Introduction: Wastewaters – sources, nature and characteristics. **Fundamentals Of Process Kinetics:** Reaction rates - enzyme reaction - effect of temperature. Reactor

analysis - batch reactor - continuous flow stirred tank reactor, plug flow reactor. Tracer tests - estimation of dispersion coefficient. Substrate removal - reactors in parallel - reactors in series; **Fundamentals Of Microbiology And Kinetics Relationship:** Role of micro-organisms, bacterial growth and biological oxidation. Kinetics of biological growth, logarithmic growth (batch culture), substrate limited growth cell yield, biological solids retention time, F/M ratio. Determination of bio-kinetic constants, application of kinetics to biological treatment; **Suspended Growth Treatment Process:** Design of activated sludge process – modifications. Oxidation ditch, aerated lagoons, oxygen requirements, arrangement for transfer of oxygen, SBR. Stabilization ponds - classification, applications, process design; **Attached Growth Treatment Process:** Trickling Filter – Process – design based on popular design equations – rotating biological contactors, anaerobic filters. Anaerobic contact process – anaerobic up flow sludge blanket reactor. Hybrid system – MBR, MBBR and HUASB: Natural system**-** PGF, Constructed wetlands, Duckweed pond; **Sludge digestion and Nutrients removal:** sources, characteristics, quantities. Anaerobic digestion – process, kinetic relationship, gas production, design considerations. Aerobic digestion – kinetics, oxygen requirements, design considerations,

Biological removal process for Nitrogen and Phosphorus, Operation and Maintenance for biological treatment system.

Reference Books

1. Arceivala S.J., Shyam R Asolekar., "Wastewater Treatment for Pollution Control and Reuse, 3rd Edition, Tata McGraw Hill Publishers, New Delhi, 2007
2. Manual on Sewerage and sewage treatment, CPHEEO, Ministry of Urban development, GOI, New Delhi, 1993.
3. Metcalf and Eddy, "Wastewater Engineering Treatment, disposal and reuse" Tata McGraw-Hill, New Delhi 2011.
4. Qasim, S.R., Wastewater treatment plant, Planning, Design and Operation, Technomic Publications, New York, 1994.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Fundamentals of Process Kinetics	
1.1	Waste waters – sources, nature and characteristics. Reaction rates	1
1.2	Enzyme reaction	1
1.3	Effect of temperature	1
1.4	Reactor analysis - batch reactor - continuous flow stirred tank reactor, plug flow reactor	1

1.5	Tracer tests - estimation of dispersion coefficient	1
1.6	Substrate removal - reactors in parallel - reactors in series	1
2. Fundamentals of Microbiology and Kinetics Relationship		
2.1	Role of micro-organisms	1
2.2	Bacterial growth and biological oxidation	1
2.3	Kinetics of biological growth, logarithmic growth (batch culture), substrate limited growth cell yield	1
2.4	Biological solids retention time, F/M ratio	1
2.5	Determination of bio-kinetic constants	2
2.6	Application of kinetics to biological treatment	2
3. Suspended Growth Treatment Process		
3.1	Design of activated sludge process - modifications	2
3.2	Oxidation ditch	1
3.3	Aerated lagoons, oxygen requirements, arrangement for transfer of oxygen	2
3.4	Sequential Batch Reactor	1
3.4	Stabilization ponds - classification, applications, process design	1
4. Attached Growth Treatment Process		
4.1	Trickling Filter – Process – design based on popular design equations	2
4.2	Rotating biological contactors	1
4.3	Anaerobic filters	1
4.4	Anaerobic contact process – anaerobic up flow sludge blanket reactor	2
4.5	Hybrid system – MBR, MBBR and HUASB	2
4.6	Natural system - PGF, Constructed wetlands, Duckweed pond.	2
5. Sludge Digestion and Nutrient removal		
5.1	Anaerobic digestion – process, kinetic relationship, gas production, design considerations	2
5.2	Aerobic digestion – kinetics, oxygen requirements, design considerations	2
5.3	Biological removal process for Nitrogen and Phosphorus	1
5.4	Operation and Maintenance for Biological Treatment Processes	1

Total	**36**

Course Designers

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		Category	L	T	P	Credit
14EN310	**ENVIRONMENTAL IMPACT AND RISK ASSESSMENT**	PC	4	-	-	4

Preamble

Approved in BOS meeting 15.11.2014 Approved in the 49th Academic Council meeting on 4.12.2014[55]

To expose the students to the need, methodology, documentation and application of Environmental Impact Assessment and to develop the skill to prepare Environmental Management Plan.

Prerequisite

No prerequisite

Course Outcomes

On the successful completion of the course, students will be able to,

CO1.	Understand the necessity to study the impacts and risks that will be caused by projects or industries and the methods to overcome these impacts	Understand
CO2.	Describe the legal requirements of environmental and risk assessment for projects	Understand
CO3.	Prepare terms of reference for environmental impact and socio-economic impact for any developmental project	Apply
CO4.	Prepare environmental management plan and risk mitigation plan by considering environmental aspects, impacts and potential hazards respectively for any project	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	-	M	M	-	-	M	M	M	-	-
CO2	S	-	L	-	-	-	-	S	-	-	-
CO3	S	S	M	L	M	M	-	S	-	S	L
CO4	S	S	M	M	-	M	S	S	M	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests	Terminal Examination

	1	2	3	
Remember	10	10	10	-
Understand	50	50	50	60
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss the role of Public Participation in Environmental Decision Making.
2. EIA is an effective management tool : comment
3. Explain the various methodologies adapted for prediction of impacts for EIA report

Course Outcome 2 (CO2):

1. Explain the legal framework for getting environment clearance for new projects.
2. Describe the procedure for conducting the public hearing as per EIA notification 2006.
3. Explain the legal framework for handling hazardous waste generated from any industry.

Course Outcome 3 (CO3):

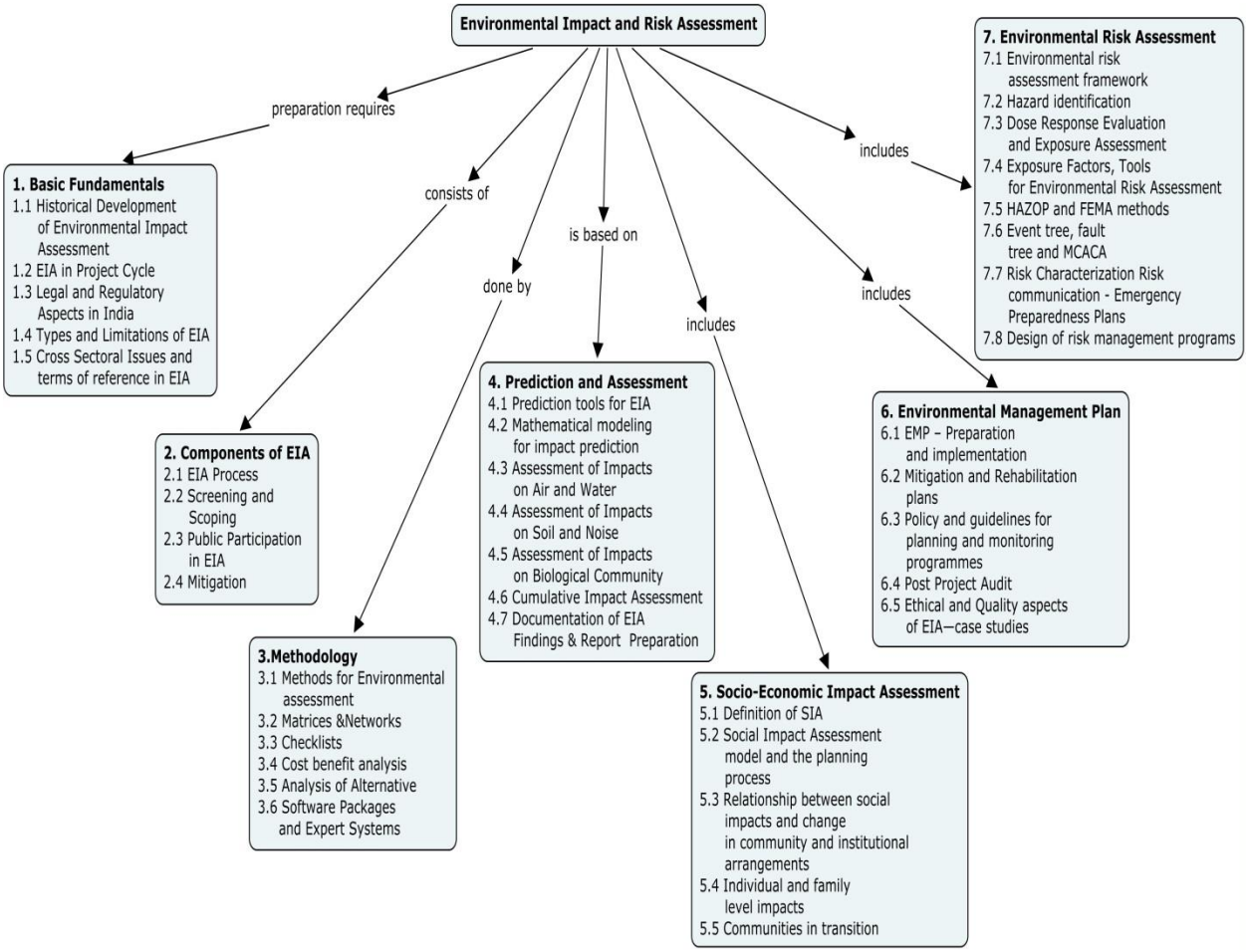
1. Prepare terms of reference for coal based Thermal Power Plant having a capacity of 2x330 MW which is located at Nagapattinam district.
2. In Madurai it is propose to develop a CETP for 20 Electroplating units. Identify the potential impacts of the project and prescribe suitable terms of reference for the project.
3. It is proposed to construct a large hydro-electric power project at the foot hills of
   Varusanaadu. Prepare terms of reference for the socio-economic impacts.

Course Outcome 4 (CO4):

1. Pudur is a town located along the OMR road. It is proposed to construct 6000 No. of residential houses in that area. Identify the potential impacts of the project and suggest a management plan to mitigate them.

2. Sabarimalai is a pilgrimage town located in Kerala state. It is proposed to develop a Greenfield airport project for the capacity to handle six new generation large aircraft. Identify the potential impacts of the project and suggest a management plan to mitigate them.
3. Prepare risk assessment report for a stand-alone distillery unit having a capacity of 50 klpd. The raw material is sugarcane based molasses. Identify the potential impacts and prepare mitigation plan for the same.

Concept Map



Syllabus

Basic fundamentals: Historical Development of Environmental Impact Assessment-EIA in Project Cycle-Legal and Regulatory Aspects in India-Types and

Limitations of EIA-Cross Sectoral Issues and terms of references in EIA**. Components of EIA environmental risk assessment**: EIA Process-Screening and Scoping-Public Participation in EIA-Mitigation. **Methodology** : Methods for Environmental assessment-Matrices &Networks-Checklists-Cost benefit analysis-Analysis of Alternative-Software Packages for EIA and Expert Systems in EIA. **Prediction and Assessment:** Prediction tools for EIA-Mathematical modeling for impact prediction-Assessment of Impacts on Air and Water-Assessment of Impacts on Soil and Noise -Assessment of Impacts on Biological Community-Cumulative Impact Assessment-Documentation of EIA Findings &Report Preparation. **Socio-economic impact assessment:** Definition of Social Impact Assessment-Social Impact Assessment model and the --planning process-Relationship between social impacts and change in community and institutional arrangements-Individual and family level impacts -Communities in transition. **Environmental Management Plan:** Environmental Management Plan – Preparation and implementation and Rehabilitation plans-Policy and guidelines for planning and monitoring programmes-Post Project Audit-Ethical and Quality aspects of Environmental Impact Assessment—case studies. **Environmental risk assessment**: Environmental risk assessment framework-Hazard identification -Dose Response Evaluation – Exposure Assessment – Exposure Factors, Tools for Environmental Risk Assessment– HAZOP and FEMA methods – Event tree, fault tree and MCACA - Risk Characterization Risk communication - Emergency Preparedness Plans –Design of risk management programs.

Reference Books

1. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York, 1996.
2. Lawrence, D.P., Environmental Impact Assessment – Practical Solutions to recurrent problems, Wiley-Interscience, New Jersey, 2003.
3. Petts, J., Handbook of Environmental Impact Assessment, Vol., I and II, Blackwell science, London, 1999.
4. World Bank – Source Book on EIA.

Course Contents and Lecture Schedule

S.No	Topics	No. of Lecture

		s
1.Basic Fundamentals		
1.1	Historical Development of Environmental Impact Assessment	2
1.2	EIA in Project Cycle	1
1.3	Legal and Regulatory Aspects in India	2
1.4	Types and Limitations of EIA	1
1.5	Cross Sectoral Issues and terms of references in EIA	1
2.Components of EIA		
2.1	EIA Process	1
2.2	Screening and Scoping	1
2.3	Public Participation in EIA	2
2.4	Mitigation	1
3.Methodology		
3.1	Methods for Environmental assessment	1
3.2	Matrices &Networks	1
3.3	Checklists	1
3.4	Cost benefit analysis	1
3.5	Analysis of Alternative	1
3.6	Software Packages for EIA and Expert Systems in EIA	1
4. Prediction and Assessment		
4.1	Prediction tools for EIA	1
4.2	Mathematical modeling for impact prediction	1
4.3	Assessment of Impacts on Air and Water	1
4.4	Assessment of Impacts on Soil and Noise	1
4.5	Assessment of Impacts on Biological Community	1

4.6	Cumulative Impact Assessment	1
4.7	Documentation of EIA Findings &Report Preparation	1
5.Socio-Economic Impact Assessment		
5.1	Definition of Social Impact Assessment	1
5.2	Social Impact Assessment model and the planning process	2
5.3	Relationship between social impacts and change in community and institutional arrangements	2
5.4	Individual and family level impacts	2
5.5	Communities in transition	1
6.Environmental Management Plan		
6.1	Environmental Management Plan – Preparation and implementation	1
6.2	Mitigation and Rehabilitation plans	1
6.3	Policy and guidelines for planning and monitoring programmes	1
6.4	Post Project Audit	1
6.5	Ethical and Quality aspects of Environmental Impact Assessment—case studies	1
7.Environmental Risk Assessment		
7.1	Environmental risk assessment framework	1
7.2	Hazard identification	1
7.3	Dose Response Evaluation and Exposure Assessment	1
7.4	Exposure Factors, Tools for Environmental Risk Assessment	1
7.5	HAZOP and FEMA methods	2
7.6	Event tree, fault tree and MCACA	2
7.7	Risk Characterization Risk communication - Emergency Preparedness Plans	1
7.8	Design of risk management programs	1

	TOTAL	**48**

Course Designer

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		Category	L	T	P	Credit
14ENPA0	**INDUSTRIAL WASTEWATER MANAGEMENT**	PE	4	-	-	4

Preamble

As a fastly growing country, India is flooded with very good numbers of small, medium and large sized industries. The liquid effluent generated from such industries would pose a great danger to the environment, if they are not managed properly. Hence, industrial wastewater management will be of great importance in maintaining the quality of the environment for sustainable living. This course work deals with characterization of industrial effluents, its impact on the environment, possible preventive measures against generation of wastes and treatment and reuse option for the generated wastewater.

Prerequisite

Knowledge on characterization of wastewater, physico-chemical treatment and biological treatment.

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Characterize the wastewater generated from a specific industry and understand the possible impacts on the environment.	Understand
CO2.	Identify the means and methods to reduce the quantity of generation of wastewater from an industrial premises by performing source reduction techniques and waste audit.	Apply/ Analyze
CO3.	Design appropriate treatment systems for the wastewater generated from the industries.	Apply/ Analyze
CO4.	Probe the possible recycling and reuse opportunities for the generated wastewater and residuals by employing suitable treatment units.	Apply/ Analyze
CO5.	Understand the feasibility and benefits of individual, common and joint treatment of industrial wastewater.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	M	L	-	-	-	-	M	M	L

CO2	S	S	S	S	L	M	M	L	M	M	L
CO3	S	S	S	S	L	L	L	-	M	M	M
CO4	S	S	S	S	L	L	M	L	M	M	M
CO5	S	S	S	S	L	M	M	L	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	-	-	-	-
Understand	50	30	30	30
Apply	50	50	50	50
Analyse	-	20	20	20
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the importance of population equivalent of an industrial effluent.
2. Describe the typical impacts of industrial wastewater on water bodies.
3. Discuss the classification of wastewater generated from an industry.

Course Outcome 2 (CO2):

1. Illustrate the good operating practices that would lead to pollution prevention.
2. Demonstrate the process of segregation and recovery of waste in waste volume reduction.
3. Perform a waste audit programme in an industry and highlight the various stages involved in it.

Course Outcome 3 (CO3):

1. Compute the volume of equalization basin required for the following flow regime.

Time (hrs)	02.00	04.00	06.00	08.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00
Flow rate(m^3/d)	8000	6000	9400	12,800	13,000	14,400	12,000	9600	11,000	8000	9000	8400

2. A wastewater is to be treated with activated carbon to remove residual COD. The following data were obtained from a laboratory adsorption study in which 1 g of activated carbon was added to a beaker containing 1 L of wastewater at selected COD values. Using these data, determine the more suitable isotherm.

Initial COD (mg/L)	140	250	300	340	370	400	450
Equillibrium COD (mg/L)	5	12	17	23	29	36	50

3. A wastewater to be desalinized by reverse osmosis using a thin-film composite membrane. Determine the required membrane area, the rejection rate, and the concentration of the concentrate system.

Flowrate	m^3/d	10,000
Influent TDS	g/m^3	2700
Effluent TDS	g/m^3	225
Flux rate coefficient k_w	/sec	1.5x 10^{-6}
Mass transfer rate coefficient, k_i	m/s	1.8x 10^{-6}
Net operating pressure	Kpa	3000
Recovery	%	86

Course Outcome 4 (CO4):

1. The sludge production having 96% moisture content from a wastewater treatment plant is 1000 kg on dry solid basis. The solid contain 70% volatile matter with a specific gravity of 1.02 and 30% mineral matter with a specific gravity of 2.5. Determine the volume of raw and digested sludge if reduction in

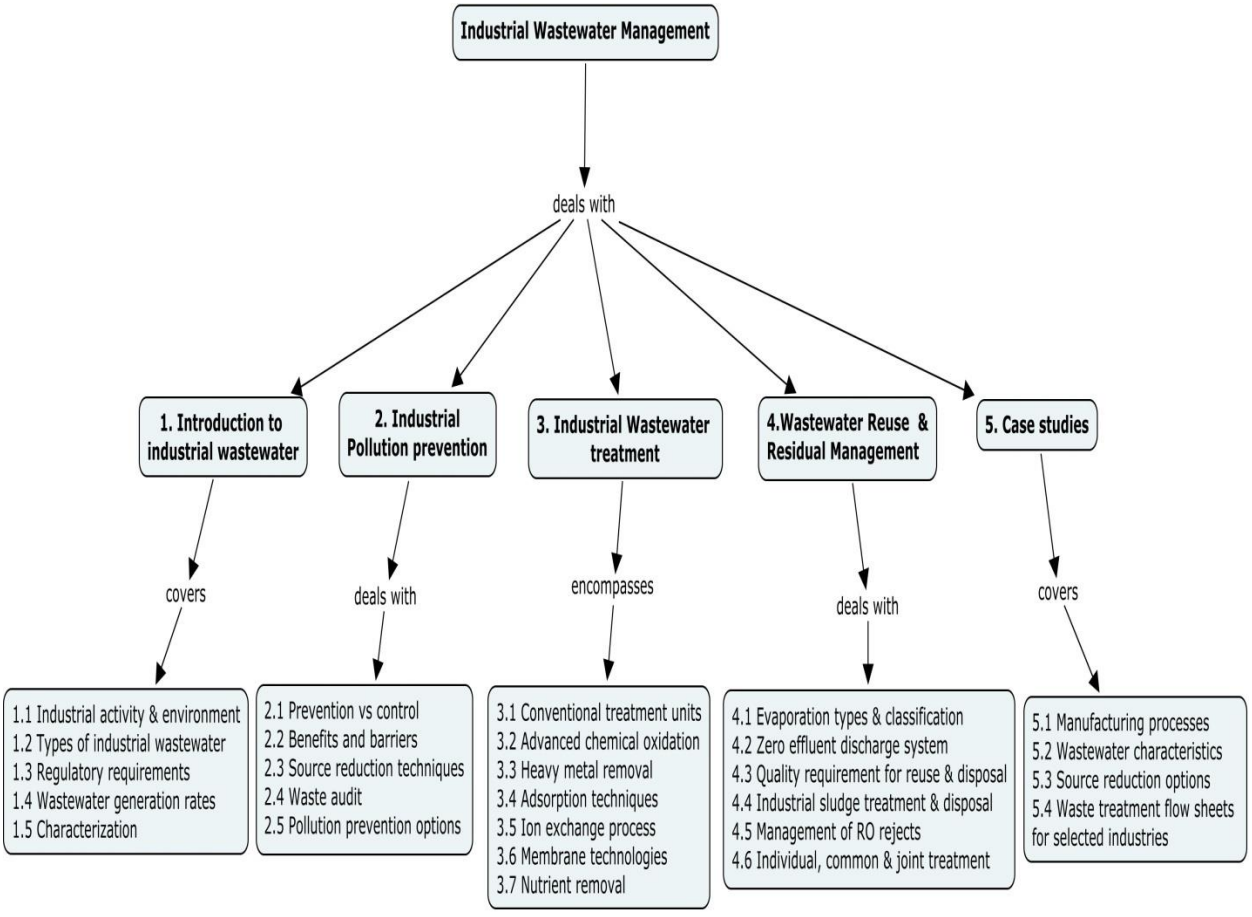
volatile solids is 55% during digestion and moisture content of digested sludge is 92%.

2. Explain the quality requirements for wastewater reuse, suggest a treatment scheme to achieve the above for an Industrial effluent.
3. Explain the role of evaporates in achieving effluent quality requirements.

Course Outcome 5 (CO5):

1. Exhibit the positives and issues in the joint treatment of industrial waste with municipal waste.
2. Identify and explain favourable factors in the common effluent treatment facility.
3. Compare individual treatment with joint treatment and identify the challenges.

Concept Map



Syllabus

Introduction to industrial wastewater: Industrial scenario in India – industrial activity and environment, uses of water by industry, sources and types of industrial wastewater. Regulatory requirements for treatment of industrial waste water, industrial waste survey, industrial waste water generation rates, characterization and variables, population equivalent. **Industrial Pollution Prevention:** Prevention Vs Control of industrial pollution – benefits and barriers. Source reduction techniques – waste audit,

evaluation of pollution prevention options, environmental statement as a tool for pollution prevention, waste minimization circles. **Industrial Wastewater Treatment:** Equalization – neutralization, oil separation, flotation, precipitation, Aerobic and anaerobic biological treatment – sequencing batch reactors, high rate reactors(Recall) Advanced Chemical oxidation – Electro chemical oxidation, wet air oxidation, ozonation, photocatalysis, Other Treatment Processes Heavy metal removal, Refractory organics separation by adsorption. ion exchange, membrane technologies, nutrient removal. **Wastewater Reuse and Residual management:** Evaporation- Evaporators types and classification. Zero effluent discharge systems - Quality requirements for wastewater reuse, industrial reuse, disposal on water and land. Residuals from industrial wastewater treatment units - quantification and characteristics of sludge – thickening, digestion, conditioning, dewatering and disposal of sludge. Management of RO rejects. Individual and common effluent treatment plants – combined treatment of industrial waste water and domestic/municipal wastewater**. Case Studies:** Industrial manufacturing process description, waste water characteristics, source reduction options and waste treatment flow sheet for textiles, tanneries, pulp and paper, metal finishing, sugar and distilleries.

Reference Books

1. Arceivala, S.J., “Wastewater Treatment for Pollution Control”, Tata McGraw Hill, 1998.
2. Eckenfelder, W.W., “Industrial Water Pollution Control”, McGraw – Hill, 2000.
3. Frank Woodard, Industrial Waste Treatment Handbook, Butterworth Heinemann, New Delhi, 2001.
4. Paul L. Bishop “Pollution Prevention: - Fundamentals and Practice”, McGraw – Hill International, 2000.
5. World Bank Group, “Pollution Prevention and Abatement Handbook – Towards Cleaner Production”, World Bank and UNEP, Washington.D.C, 1998.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
1. Introduction to industrial wastewater		
1.1	Industrial scenario in India – industrial activity and environment	1
1.1.1	Uses of water by industry	1

1.2	Sources and types of industrial wastewater	1
1.3	Regulatory requirements for treatment of industrial wastewater	1
1.4	Wastewater generation rates	1
1.5	Characterization and variables, population equivalent	2
2. Industrial Pollution Prevention		
2.1	Prevention Vs Control of industrial pollution	1
2.2	Benefits and barriers	2
2.3	Source reduction techniques	3
2.4	Waste audit	2
2.5	Evaluation of pollution prevention option	2
2.5.1	Environmental statement	1
2.5.2	Waste minimization circles – PCB Norms for water usage in industries	1
3. Industrial Wastewater Treatment		
3.1	Recall of Conventional treatment system	2
3.2	Advanced chemical oxidation- Electro-chemical oxidation	1
3.2.1	Wet air oxidation	1
3.2.2	Ozonation	1
3.2.3	Photocatalysis	1
3.3	Heavy metal removal	1
3.4	Refractory organics separation by adsorption	1
3.5	Ion exchange	1
3.6	Membrane technologies	2
3.7	Nutrient removal	1
4. Wastewater Reuse and Residual Management		
4.1	Evaporation- Types of evaporators and classification	2
4.2	Zero effluent discharge systems	2
4.3	Quality requirement for reuse and disposal	1
4.4	Quantification and characteristics of sludge	2
4.4.1	Thickening, digestion, conditioning, dewatering and disposal of sludge.	2
4.5	Management of RO reject	1

4.6	Individual, common and joint treatment	2
	5. Case Studies	
5.1	Industrial manufacturing processes, wastewater characteristics, Source reduction options and waste treatment flow sheet for textiles, tanneries, pulp and paper, metal finishing, sugar and distilleries	5
	Total Periods	**48**

Course Designers

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		Category	L	T	P	Credit
14ENPB0	**ENVIRONMENTAL POLICIES AND LEGISLATIONS**	PE	4	-	-	4

Preamble

This course work provides an in-depth understanding of the vast field of Environmental law and policy and the study would be familiar with the overall legal regime of the country as well as international obligations. To impart knowledge on the policies, legislations, institutional framework and enforcement mechanism for environmental management in India.

Prerequisite

No prerequisite

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Describe the Indian Legal System and the fundamentals of Indian Constitution	Understand
CO2	Understand the philosophy, principles and environmental justice for pollution control	Understand
CO3.	Apply the provision for legal control of industrial pollution by legislations	Apply
CO4.	Give critic comment on environmental legal framework	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	-	-	-	M	-	S	M	M	-
CO2	S	M	-	-	-	M	-	S	M	L	-
CO3	-	S	S	S	-	M	-	M	M	S	-
CO4	-	S	S	S	-	M	-	M	L	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	50	50	50	50
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Examine the Criminal Law remedies for Environmental wrong
2. Bring out the distinction between the Principles of Strict Liability & Absolute Liability
3. Describe the relevant sections of Indian Penal Code and Criminal Procedure Code for Environmental Protection

Course Outcome 2 (CO2):

1. Write short notes on Polluter Pays Principle
2. Write a note on salient features of Environment Protection Act 1986
3. Explain the provision of Municipal Solid Waste Management Rules with special reference to household hazardous waste

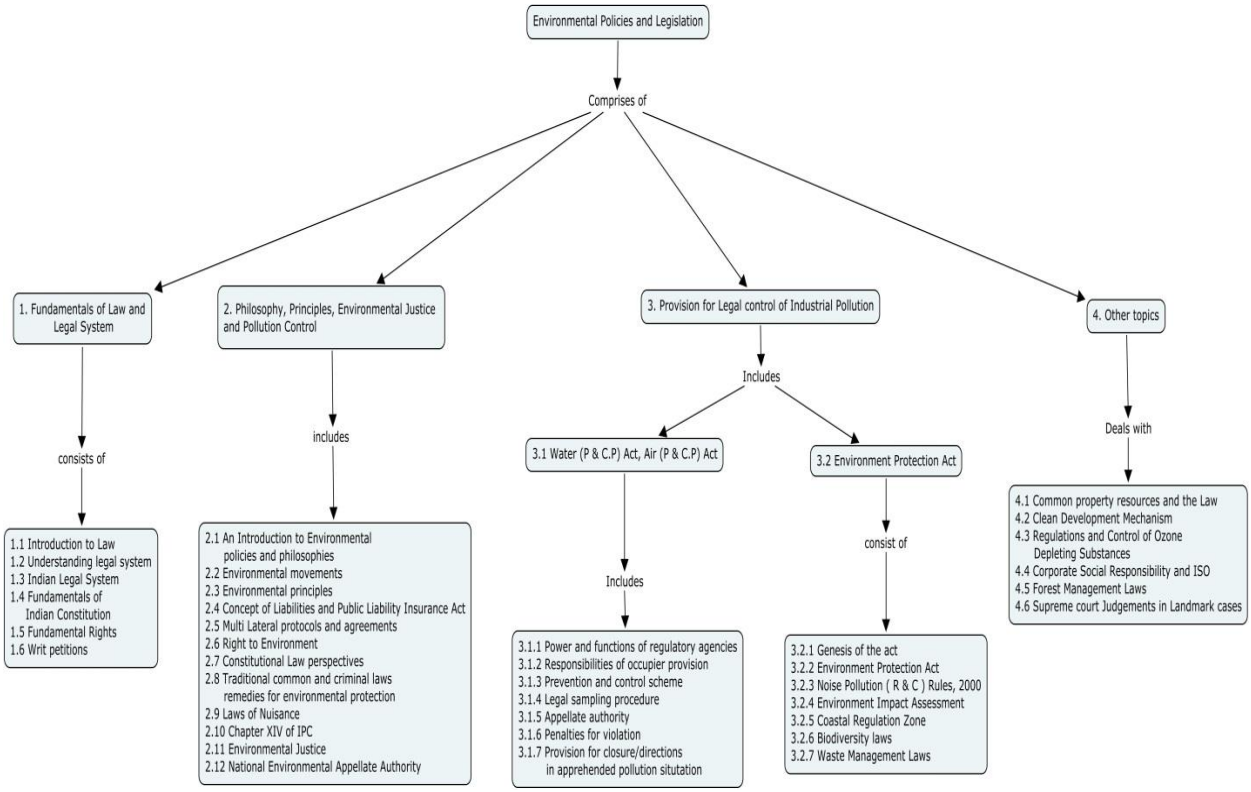
Course Outcome 3 (CO3):

1. Taking the case of Ratlam Municipal Council VsVardiChandh highlight the use of Section 133 criminal procedure code for environmental protection
2. "Nuisance by Noise pollution is a major concern in all major urban cities in India" Examine the Judicical decision on Noise pollution
3. In the light of Vellore Citizens Welfare case, highlight the role of PCB in abating pollution from tanneries.

Course Outcome 4 (CO4):

1. In India public nuisance in environmental matter can be remedied under civil law as well as criminal law-Justify
2. "Depletion & Contamination of Ground water has not been adequately addressed in environmental policy making in the country" Examine the above statement in light of the various court decisions relating to ground water management
3. With the help of decided cases, discuss the powers of magistrate to deal with environmental nuisance under sections of criminal procedure code

Concept Map



Syllabus

Fundamentals of Law and Legal system: Introduction to law – Different theories about law - Understanding legal system – Various organs of legal system -

Indian Legal system – Law enforcement in India - Fundamentals of Indian constitution – Statutes, Rules and Notification - Fundamental rights, Article 48(A) and 51-A(g) - Writ petitions – Constitutional Remedies. **Philosophy, Principles, Environmental Justice and Pollution Control:** An Introduction to Environmental policies and philosophies - Environment movements - Environmental principles – Precautionary – Polluter Pays - Concepts of Liabilities and Public Liability Insurance Act - Multi Lateral protocols and agreements – Montreal, Kyoto and Rio - Right to Environment – A basic human Right - Constitutional law perspectives – Article 21 - Traditional common and criminal laws remedies for environmental protection - Law of Nuisance : Tort Law – Public Nuisance - Chapter XIV of Indian Penal Code – Section 133 of Cr.PC - Environmental Justice – PIL and Environmental Tribunals - National Environmental Appellate authority and Green Tribunal. **Provision for Legal Control of Industrial Pollution: Water(P & C.P) Act, Air (P & C.P) Act:** Power and functions of regulatory agencies - Responsibilities of occupier provision - Prevention and control scheme – Consent to establish – Consent to operate - Legal sampling procedures - Appellate authority – State Laboratories - Penalties for violation - Provisions for closure/directions in apprehended pollution situation. **Environment Protection Act:** Genesis of the act – Delegation of Powers - EPA, 1986 – Rules and Notification - Noise Pollution (Regulation and Control) Rules, 2000 - Environment Impact Assessment - Coastal Regulation Zone - Biodiversity laws - Waste Management Laws – Municipal Solid Waste, Bio Medical Waste, Hazardous Waste. **Other Topics:** Common Property Resources and the Law (Including Water Law) - Clean Development Mechanism - Regulations and Control of Ozone Depleting Substances - Corporate Environmental Responsibility and ISO - Forest Management Laws – Indian Forest Act, 1927 – Forest Conservation Act, 1980 – Forest Regulation Act, 2006 - Supreme Court judgments in Landmark Cases.

Reference Books

1. CPCB, “Pollution Control acts, Rules and Notifications issued there under” Pollution Control
Series, Central Pollution Control Board, Delhi.
2. Greger I.Megregor, “Environmental law and enforcement”, Lewis Publishers, London, 1994.
3. Shyam Divyan and Armin Roseneranz “Environmental law and policy in India” Oxford University Press,New Delhi,2001.
4. TNPCB and YOU “A Ready Reckoner for Entrepreneurs” – Tamil Nadu Pollution Control Board 2013.

Course Contents and Lecture Schedule

S.No	Topics	No of

		Lectures
1. Fundamentals of Law and Legal system		
1.1	Introduction to law – Different theories about law	1
1.2	Understanding legal system – Various organs of legal system	1
1.3	Indian Legal system – Law enforcement in India	1
1.4	Fundamentals of Indian constitution – Statutes, Rules and Notification	1
1.5	Fundamental rights, Article 48(A) and 51-A(g)	1
1.6	Writ petitions – Constitutional Remedies	1
	2. Philosophy, Principles, Environmental Justice and Pollution Control	
2.1	An Introduction to Environmental policies and philosophies	1
2.2	Environment movements	1
2.3	Environmental principles – Precautionary – Polluter Pays	1
2.4	Concepts of Liabilities and Public Liability Insurance Act	1
2.5	Multi-Lateral protocols and agreements – Montreal, Kyoto and Rio	2
2.6	Right to Environment – A basic human Right	1
2.7	Constitutional law perspectives – Article 21	1
2.8	Traditional common and criminal laws remedies for environmental protection	1
2.9	Law of Nuisance : Tort Law – Public Nuisance	2
2.10	Chapter XIV of Indian Penal Code – Section 133 of Cr.PC	2
2.11	Environmental Justice – PIL and Environmental Tribunals	1
2.12	National Environmental Appellate authority and Green Tribunal	1
3. Provision for Legal Control of Industrial Pollution		
3.1	**Water(P & C.P) Act, Air (P & C.P) Act**	
3.1.1	Power and functions of regulatory agencies	1
3.1.2	Responsibilities of occupier provision	1
3.1.3	Prevention and control scheme – Consent to establish – Consent to operate	1

3.1.4	Legal sampling procedures	2
3.1.5	Appellate authority – State Laboratories	2
3.1.6	Penalties for violation.	2
3.1.7	Provisions for closure/directions in apprehended pollution situation.	1
3.2	**Environment Protection Act**	
3.2.1	Genesis of the act – Delegation of Powers	1
3.2.2	EPA, 1986 – Rules and Notification	2
3.2.3	Noise Pollution (Regulation and Control) Rules, 2000	1
3.2.4	Environment Impact Assessment	1
3.2.5	Coastal Regulation Zone	1
3.2.6	Biodiversity laws	1
3.2.7	Waste Management Laws – Municipal Solid Waste, Bio Medical Waste, Hazardous Waste	1
	4. Other Topics	
4.1	Common Property Resources and the Law (Including Water Law)	2
4.2	Clean Development Mechanism	1
4.3	Regulations and Control of Ozone Depleting Substances	1
4.4	Corporate Environmental Responsibility and ISO	2
4.5	Forest Management Laws – Indian Forest Act, 1927 – Forest Conservation Act, 1980 – Forest Regulation Act, 2006	1
4.6	Supreme Court judgments in Landmark Cases	2
	Total Periods	**48**

Course Designer

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		Category	L	T	P	Credit
14ENPC0	**ENVIRONMENTAL SYSTEMS ANALYSIS**	PE	3	1	-	4

Preamble

Approved in BOS meeting 15.11.2014 Approved in the 49th Academic Council meeting on 4.12.2014[75]

Environmental Systems Analysis introduces systems concept as applicable for environmental systems. This course deals with the fundamental optimization theories and modern expert tools along with their real world application potentials for environmental systems planning, design and pollution control. Introduction of operational research techniques includes: linear programming, and nonlinear programming; modern tools include ANN and Genetic algorithm. Most examples cover typical planning, design, and operation problems for environmental systems with regard to complex multidisciplinary decision-making.

Prerequisite

Knowledge on probability and optimization

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Identify environmental systems	Understand
CO2.	Formulate, integrate, and solve environmental optimization models for systems analysis and decision making	Apply
CO3.	Integrate simulation models within optimization context to confirm cost-effective principles in large-scale environmental systems	Apply
CO4.	Understand and apply the principle of soft computing for solving Environmental problems	Apply
CO5.	Design optimal environmental systems related to water, air and solid waste management satisfying conflicting constraints	Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	-	L	-	L	-	-	L	-	L
CO2	S	S	S	S	S	L	-	-	M	M	M
CO3	S	S	S	S	S	M	S	-	M	M	S
CO4	S	M	S	S	S	L	-	-	M	L	M
CO5	S	S	S	S	S	S	S	-	S	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests	Terminal Examination

	1	2	3	
Remember	-	-	-	-
Understand	50	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	20	20	20

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Distinguish simulation and optimization
2. Explain the concept of system with suitable examples. Also describe the steps involved in system modelling.
3. Sketch the diagram of solid waste generation system and identify the different input components and map the ouput.
4. Discuss the Streeter-phelps equation for modeling dissolve oxygen concentration in a river. Identify the input parameters, relationships between them and map the outputs.

Course Outcome 2 (CO2):

1. Define slack variables. Why do we need them?
2. Explain degeneracy in a linear programming problem.
3. Madurai Corporation burns 3000 tons of trash per day in three elderly incinerators. All the three has antipollution devices that are less than satisfactory. Their emission profiles differ as given in Table. At present all three incinerators are operating at full capacity. The reminder of the city's trash, another 1500 tons per day, is dumped in a sanitary landfill area. The state pollution control board has issued a temporary restraining order under which sulphur dioxide emissions must be limited to 400,000 units per day and particulate emissions to 50,000 units per day. Formulate the objectives and constraints of the LPP.
4. A company manufactures three products P1, P2, and P3. The machine hour requirements and labour hour requirements to process the three products and the maximum available labour hours per week are summarized in Table. The selling price per unit and product cost per unit are also summarized in the same table. The

company wants to limit the production volume per week of the product P3 to utmost 35 units. Formulate a LP model.

Machine	Machine hours required			Max. available hours per week
	Product P1	Product P2	Product P3	
Machine1	4	6	3	500
Machine2	3	-	2	300
Machine3	5	7	8	600
Labour	3	2	4	200
Sell. Price	500	400	550	
Product Cost	350	280	390	

5. Solve the following LPP using Simplex method
6. Maximize $Z = 3x_1 + 5x_2$

   Subject to $x_1 + x_2 \geq 2$

   i. $x_2 \leq 6$

   ii. $3x_1 + 2x_2 = 18$
7. Formulate the Kuhn-Tucker conditions for the following optimization model

   b. Minimize f(X)

   c. subject to (i) $g_j(X) \leq 0,\ j = 1,2,\cdots,m$ and (ii) $h_k(X) \geq 0,\ k = 1,2,\cdots,p$

Course Outcome 3 (CO3):

1. Madurai Corporation burns 3000 tons of trash per day in three elderly incinerators. All the three has antipollution devices that are less than satisfactory. Their emission profiles differ as given in Table. At present all three incinerators are operating at full capacity. The reminder of the city's trash, another 1500 tons per day, is dumped in a sanitary landfill area. The state pollution control board has issued a temporary restraining order under which sulphur dioxide emissions must be limited to 400,000 units per day and particulate emissions to 50,000 units per day. What is the most economical way to make the necessary cutbacks?
2. A company manufactures three products P1, P2, and P3. The machine hour requirements and labour hour requirements to process the three products and the maximum available labour hours per week are summarized in Table. The selling price per unit and product cost per unit are also summarized in the same table. The company wants to limit the production volume per week of the product P3 to utmost 35 units. Formulate a LP model to find the production volume per week of each product such that the total profit is maximized.

Machine	Machine hours required			Max. available hours per week
	Product P1	Product P2	Product P3	
Machine1	4	6	3	500
Machine2	3	-	2	300
Machine3	5	7	8	600
Labour	3	2	4	200
Sell. Price	500	400	550	
Product Cost	350	280	390	

Course Outcome 4 (CO4):

1. Distinguish feed forward and recurrent neural networks.

2. Compare binary coded and real parameter genetic algorithms.

3. Explain the working principle of genetic algorithm with neat sketches.

4. Discuss the search directions of (i) conjugate gradient method (ii) Newton Raphson method and (iii) Marquardt method.

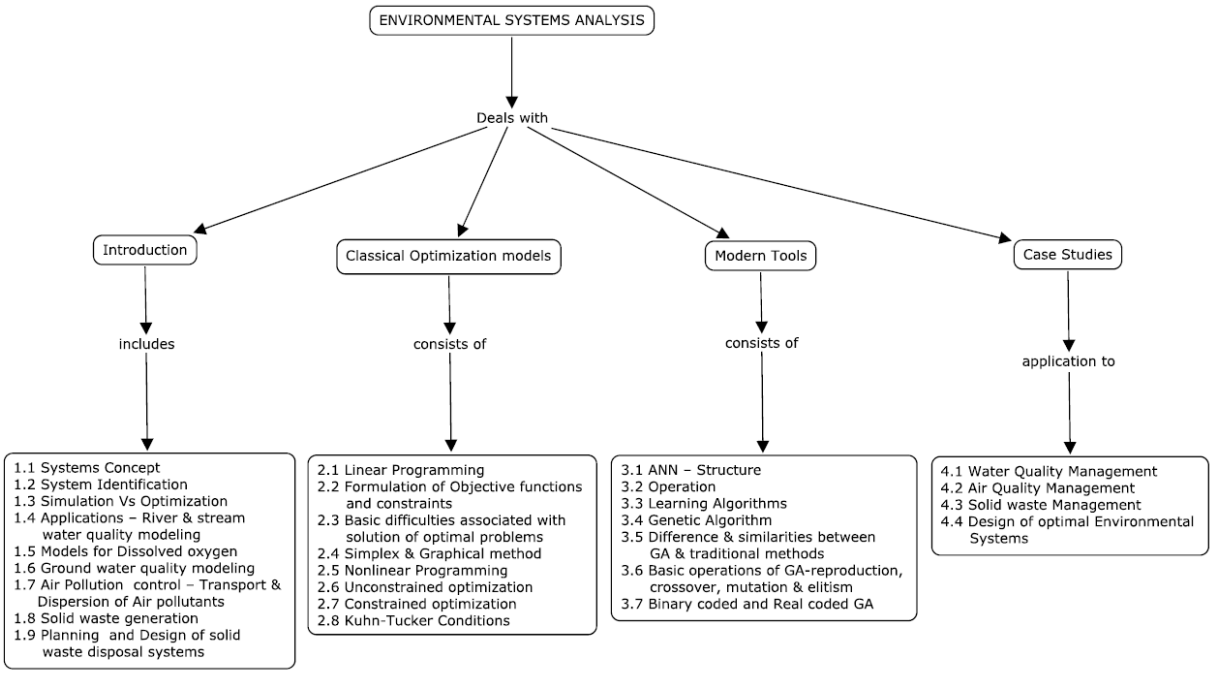
5. Draw feed forward artificial neural network architecture and demonstrate the back propagation algorithm to assess the air pollution concentration from a stack of cement manufacturing unit. Assume necessary data.

Course Outcome 5 (CO5):

1. In water treatment processes, raw-water colour is a key parameter for process control and monitoring. Therefore, the ability to predict the raw-water colour is desired to aid in the optimization of the treatment process. Using the artificial neural network (ANN) modeling technique, establish a model for forecasting the raw-water colour in a large river. Identify suitable input parameters and appropriate number of hidden neurons.

2. Formulate an objective function to minimize the cost of the water supply project, subjected to the non-negativity constraint, head constraint and assume other necessary constraints. Design an optimal water distribution system using genetic algorithm. Use real coded GA, roulette wheel selection, Single point cross-over and random mutation.

Concept Map



Syllabus

Introduction to Systems Concept – System Identification – Simulation vs Optimization – Application to Environmental Engineering Systems – River and stream water quality modeling – Models for Dissolved oxygen - Ground water quality modeling - Air Pollution control – Transport and Dispersion of Air pollutants – Solid waste generation – Planning and Design of solid waste disposal systems; **Classical Optimization methods** – Linear Programming –Formulation of Objective functions and constraints – Simplex method – Graphical method – Nonlinear Programming – Unconstrained optimization techniques, Direct search methods, Descent methods; Constrained optimization, Direct and indirect methods – Kuhn-Tucker Conditions; **Modern Tools** - ANN – Structure – Operation – Learning Algorithms – Genetic Algorithm - Difference and similarities between GA and traditional methods - Basic operations of GA – reproduction, crossover, mutation and elitism – Binary coded and Real coded GA; **Case Studies –** Water quality management, Air quality management, Solid waste management – Design optimal environmental systems.

Reference Books

1. Aliev R. A, and Aliev Rashad, "Soft Computing and its Applications", World Scientific Publications Co. Pte. Ltd. Singapore, 2001.

2. Deb, Kalyanmoy. *Optimization for engineering design: Algorithms and examples*. PHI Learning Pvt. Ltd., 2012.
3. Environmental Systems Optimization, Douglas A. Haith, John Wiley & Sons, 1982.
4. Mathews, John H., and Kurtis D. Fink. *Numerical methods using MATLAB*. Vol. 3. Upper Saddle River, NJ: Prentice hall, 1999.
5. Taha, Hamdy A. *Operations research: an introduction*. Pearson/Prentice Hall, 2007.

Course Contents and Lecture Schedule

S. No	Topic	No. of Lectures
	1. Introduction	
1.1	Systems concept	1
1.2	System Identification	1
1.3	Simulation vs Optimization	1
1.4	Applications – River and stream water quality modeling	1
1.5	Models for Dissolved oxygen	1
1.6	Ground water quality modeling	1
1.7	Air Pollution control – Transport and Dispersion of Air pollutants	1
1.8	Solid waste generation	1
1.9	Planning and Design of solid waste disposal systems	1
	2. Classical Optimization methods	
2.1	Linear Programming	1
2.2	Formulation of Objective functions and constraints	1
2.3	Basic difficulties associated with solution of optimal problems	1
2.4	Simplex method - Graphical method	2
2.5	Nonlinear Programming	1
2.6	Unconstrained optimization techniques - Direct search methods - Descent methods	2
2.7	Constrained optimization - Direct and indirect methods	2

2.8	Kuhn-Tucker Conditions	2
	3. Modern Tools	
3.1	ANN – Structure	1
3.2	Operation	1
3.3	Learning Algorithms	1
3.4	Genetic Algorithm	1
3.5	Difference and similarities between GA and traditional methods	1
3.6	Basic operations of GA - reproduction, crossover, mutation and elitism	1
3.7	Binary coded and Real coded GA	1
	4. Case Studies	
4.1	Water Quality Management	2
4.2	Air Quality Management	2
4.3	Solid waste Management	2
4.4	Design optimal environmental systems related to water, air and solid waste management satisfying conflicting constraints	2
	Total	**36**

Course Designer

Dr. D. P. Vijayalakshmi dpviji@tce.edu

		Category	L	T	P	Credit
14ENPD0	**ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES**	PE	3	1	-	4

Preamble

The goal of the course is to provide sufficient knowledge related to environmental exposure and providing a foundation for understanding the risks. To educate about the health hazards and the safety measures to be followed in the industrial environment.

Prerequisite

Basic Environmental Engineering knowledge.

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Describe environmental hazards in communities and occupational health and hygiene in work place.	Understand
CO2.	Understand safety practices and environmental issues in construction.	Understand
CO3.	Identify potential hazards and prepare a risk assessment report for highly polluting industries.	Apply
CO4.	Comply with work place safety acts and rules and establish safety systems for any industry.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	L	-	M	M	-	M	-	M	-
CO2	S	M	L	-	M	M	-	M	-	M	-
CO3	S	S	S	S	M	M	L	M	L	M	-
CO4	S	S	S	S	M	M	L	M	L	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests	Terminal Examination

	1	2	3	
Remember	10	10	10	0
Understand	50	50	50	60
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the different types of hazards associated with chemical process plants? Give brief descriptions of each of such hazards.
2. List out and explain various chemical plant control techniques to reduce the work place exposures.
3. Explain the tangible and intangible benefits of ensuring the Industrial safety.

Course Outcome 2 (CO2):

1. Explore the possible environmental issues in construction industry.
2. Explain the safety practices to be adopted in the use of hoisting apparatus and mobile cranes.
3. Discuss the relationship between quality manuals, safety policies and written risk assessments.

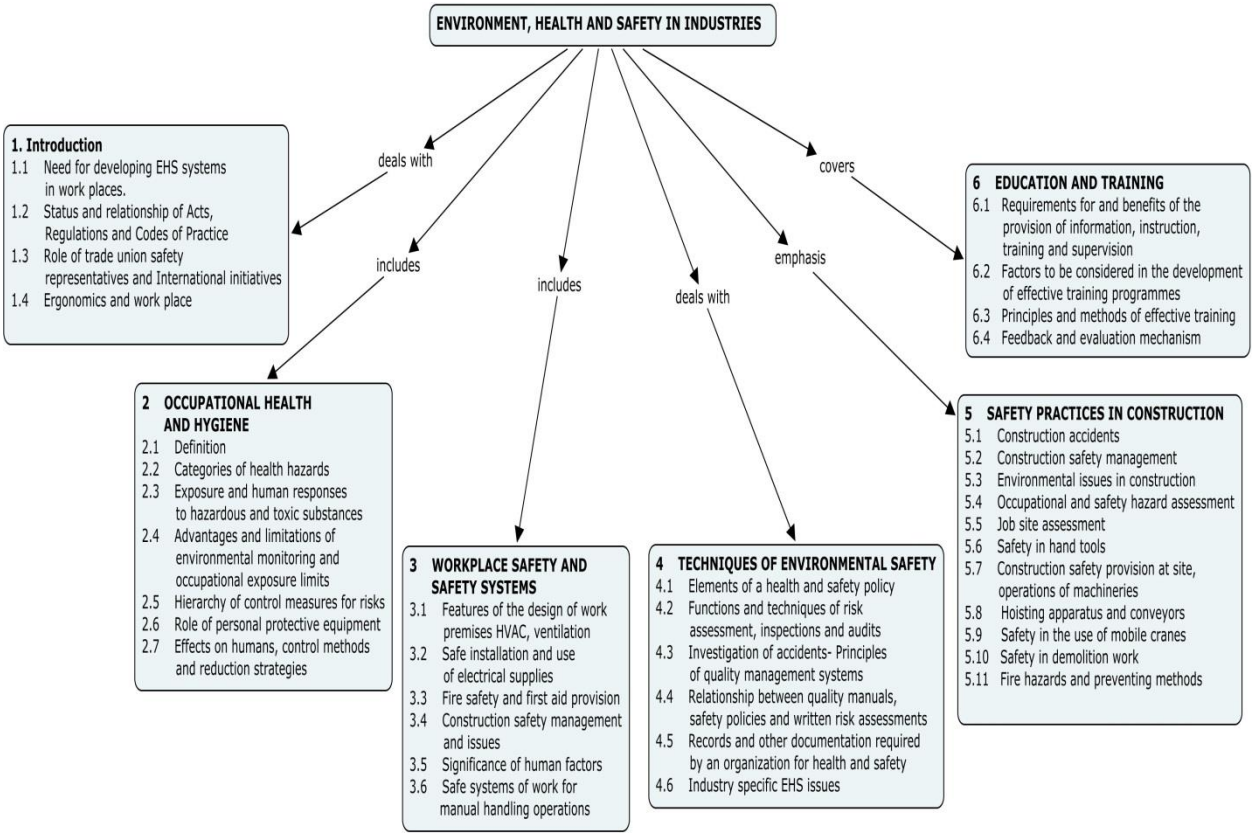
Course Outcome 3 (CO3):

1. Prepare the list of records and documents required for a secondary smelting lead industry to conduct safety audit.
2. Suggest fire safety and fire aid provision for paper and pulp industry.
3. Prepare risk assessment report for leather and hide processing industry.

Course Outcome 4 (CO4):

1. Name the applicable safety Acts and Rules for distillery industry and suggest safety system for that.
2. Specify the health and safety provisions to be made for a hazardous chemical manufacturing unit.
3. Suggest the preventive and protective construction safety provision to be adopted for the construction of a multi-storied building.

Concept Map



Syllabus

Introduction: Need for developing Environment, Health and Safety systems in work places-Status and relationship of Acts, Regulations and Codes of Practice-Role of trade union safety representatives and International initiatives-Ergonomics and work place. **Occupational health and hygiene:** Definition of the term occupational health and hygiene-Categories of health hazards-Exposure pathways and human responses to hazardous and toxic substances-Advantages and limitations of environmental monitoring and occupational exposure limits-Hierarchy of control measures for occupational health risks-Role of personal protective equipment and the selection criteria-Effects on humans, control methods and reduction strategies for noise, radiation and excessive stress, OHSAS ISO 18001 certification. **Workplace safety and safety systems:** Features of the satisfactory design of work premises HVAC, ventilation-Safe installation and use of electrical supplies-Fire safety and first aid provision – construction safety management – environmental issues in management- construction safety provision at site – significance of human factors in the establishment and effectiveness of safe systems-Safe systems of work for manual handling operations.

Techniques of environmental safety: Elements of a health and safety policy and methods of its effective implementation and review-Functions and techniques of risk assessment, inspections and audits-Investigation of accidents- Principles of quality management systems in health and safety management-Relationship between quality manuals, safety policies and written risk assessments-Records and other documentation required by an organization for health and safety-Industry specific EHS issues. **Safety Practices in Construction:** Construction accidents, Construction safety management, Environmental issues in construction, Occupational and safety hazard assessment, Job site assessment, Safety in hand tools, Construction safety provision at site, operations of machineries, Hoisting apparatus and conveyors, Safety in the use of mobile cranes, Safety in demolition work, Fire hazards and preventing methods. **Education and training:** Requirements for and benefits of the provision of information, instruction, training and supervision-Factors to be considered in the development of effective training programmes-Principles and methods of effective training-Feedback and evaluation mechanism.

Reference Books

1. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services, 2005.
2. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia , William Andrew Inc. NY, 1995
3. The Facility Manager's Guide to Environmental Health And Safety by Brian Gallant, Government Inst Publ., 2007.

Course Contents and Lecture Schedule

S.No	Topic	No.of Lectures
	1. Introduction	
1.1	Need for developing Environment, Health and Safety systems in work places.	1
1.2	Status and relationship of Acts, Regulations and Codes of Practice	1
1.3	Role of trade union safety representatives and International initiatives	1
1.4	Ergonomics and work place	1
	2. Occupational health and hygiene	
2.1	Definition of the term occupational health and hygiene	1

2.2	Categories of health hazards	1
2.3	Exposure pathways and human responses to hazardous and toxic substances	1
2.4	Advantages and limitations of environmental monitoring and occupational exposure limits	1
2.5	Hierarchy of control measures for occupational health risks	1
2.6	Role of personal protective equipment and the selection criteria	1
2.7	Effects on humans, control methods and reduction strategies for noise, radiation and excessive stress, OHSAS ISO 18001 certification	2
3. Workplace safety and safety systems		
3.1	Features of the satisfactory design of work premises HVAC, ventilation	2
3.2	Safe installation and use of electrical supplies	1
3.3	Fire safety and first aid provision	2
3.4	Construction safety management – environmental issues in management- construction safety provision at site	1
3.5	Significance of human factors in the establishment and effectiveness of safe systems	1
3.6	Safe systems of work for manual handling operations	1
4. Techniques of environmental safety		
4.1	Elements of a health and safety policy and methods of its effective implementation and review	1
4.2	Functions and techniques of risk assessment, inspections and audits	1
4.3	Investigation of accidents- Principles of quality management systems in health and safety management	1
4.4	Relationship between quality manuals, safety policies and written risk assessments	1
4.5	Records and other documentation required by an organization for health and safety	1
4.6	Industry specific EHS issues	2
5. Safety practices in construction		
5.1	Construction accidents	2
5.2	Construction safety management	1
5.3	Environmental issues in construction	2
5.4	Occupational and safety hazard assessment	1

5.5	Job site assessment	2
5.6	Safety in hand tools	1
5.7	Construction safety provision at site, operations of machineries	1
5.8	Hoisting apparatus and conveyors	1
5.9	Safety in the use of mobile cranes	1
5.10	Safety in demolition work	1
5.11	Fire hazards and preventing methods	2
6. Education and Training		
6.1	Requirements for and benefits of the provision of information, instruction, training and supervision	2
6.2	Factors to be considered in the development of effective training programmes	1
6.3	Principles and methods of effective training	2
6.4	Feedback and evaluation mechanism	1
	Total	**48**

Course Designer

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		Category	L	T	P	Credit
14ENPE0	**ENVIRONMENTAL MANAGEMENT SYSTEM AND AUDITING**	PE	4	-	-	4

Preamble

EMS educates students to become environmental managers who not only understand all aspects of the environmental industry/or corporate but also have “new work skills”, including skills in critical and analytical thinking, problem solving, project

management, interpersonal relations and team work. To impart an understanding of systems approach to Environmental Management as per ISO 14001 and skills for environmental performance in terms of legal compliance, pollution prevention and continual improvement.

Prerequisite

Basic knowledge on biotic and abiotic components of environment.

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Explain the major environmental concepts and issues confronting managers working in corporations, businesses, government, industries and non- profit groups	Understand
CO2.	Describe the strategic and operational approaches to environmental management that can be taken by business and society	Understand
CO3.	Explain the concept of regulatory compliance, recent technological changes, emergency management, health and safety management, global resource conservation and sustainable development	Understand
CO4.	Apply the concept of environmental management systems and identify the actions needed to prepare for an ISO 14000 certification audit for any industry	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	L	-	-	M	M	M	M	L	-
CO2	S	M	M	-	L	M	M	S	-	S	-
CO3	S	M	M	-	L	M	M	S	-	S	-
CO4	S	S	S	S	M	S	M	M	L	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	50	50	50	50
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the nexus between environment and development in the background of globalisation concept
2. Explain how the Corporate Social Responsibility Concept can be used to improve the society
3. Discuss the barriers and obstacles in implementation of Environmental management System for any industry

Course Outcome 2 (CO2):

1. Describe the basic steps in Environmental Auditing Process for any industry
2. Explain the various source reduction techniques to achieve cleaner production
3. Explain the different stages of developing & implementing Environmental Management Systems

Course Outcome 3 (CO3):

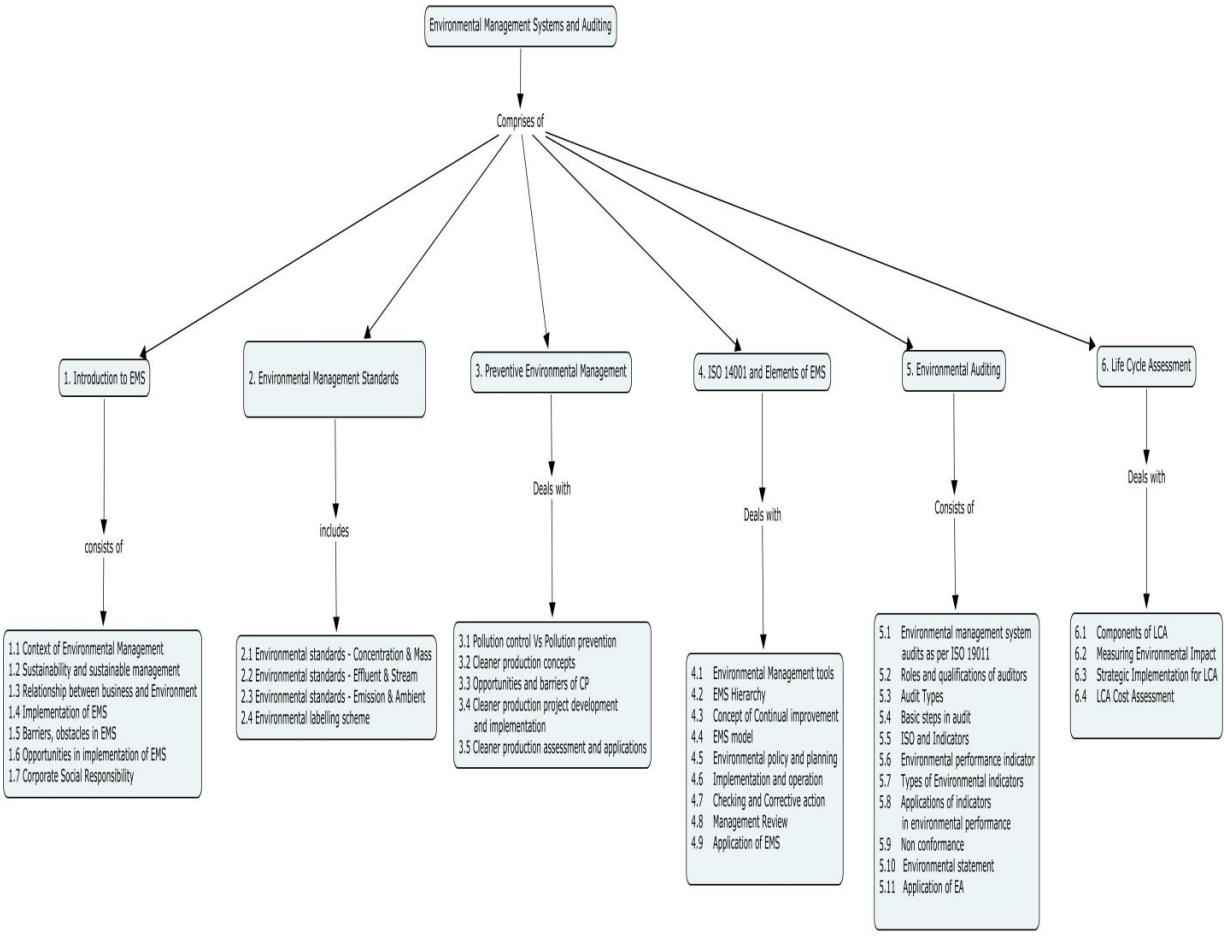
1. Discuss the purpose and benefits of Ecolabelling
2. How ISO 14001 implementation in an organization results in attaining goal of sustainable development? Briefly explain
3. Explain the basic concepts of Life Cycle Assessment for product development

Course Outcome 4 (CO4):

1. You are responsible for implementing an environmental management system for an organization, which must meet the requirements of ISO 14000. List the issues you would consider when assessing the significance of your environmental impacts.

2. You are responsible for implementing an environmental management system for an organization, which must meet the requirements of ISO 14000. List the actions you would take to prepare for an ISO 14000 certification audit.
3. Suppose your company boss is not willing to go for ISO 14001 in his organization because of legal headaches. Being an environmental engineer, how will you explain him the importance of ISO 14001 certification and what benefits company will get after implementation of ISO 14001 in his company.

Concept Map



Syllabus

Introduction to EMS: The Context of Environmental Management - Sustainability and sustainable development - Relationship between business and Environment - Implementation of EMS - Barriers, obstacles in EMS - Opportunities in implementation of EMS - Corporate Social Responsibility. **Environmental Management Standards**: Environmental standards – Concentration & Mass - Environmental standards – Effluent & Stream - Environmental standards – Emission & Ambient - Environmental labeling scheme – Certifications. **Preventive Environmental**

Management: Pollution control Vs Pollution prevention **-** Cleaner production concepts - Source reduction, Raw material substitution, Process modification, Toxic use reduction and Elimination - Opportunities and barriers of CP - Cleaner production project development and implementation - Cleaner production assessment and applications. **ISO 14001 and Elements of EMS:** Environmental Management tools - EMS Hierarchy – structure - Concept of Continual improvement - EMS model - Environmental policy and planning - Implementation and operation - Checking and Corrective action - Management Review - Application of EMS. **Environmental Auditing:** Environmental management system audits as per ISO 19011 **-** Roles and qualifications of auditors - Audit Types - Basic steps in audit - ISO and Indicators - Environmental performance indicator - Types of Environmental indicators - Applications of indicators in environmental performance - Nonconformance - Corrective and Preventive actions - Environmental statement - Application of EA. **Life Cycle Assessment:** Components of LCA - Measuring Environmental Impact - Strategic Implementation for LCA - LCA Cost Assessment

Reference Books

1. Environmental management in organizations, the IEMA Handbook edited by John Brady, Earth scan, 2005
2. Environmental Management Systems, (third edition) Christopher Sheldon and Mark Yoxon, Earth scan Publications, First South Asian Edition 2007
3. Environmental planning and management, Christian N Madu, Imperial college press, 2007
4. Hazardous waste management, M D LaGrega, P L Buckingham, J C Evans, McGraw Hill International Edition, 2001
5. Introduction to environmental engineering and science, Gilbert M Masters, Second edition, Pearson Education, 2004
6. ISO 14000 Environmental Management, David L Goetsch and Stanley B Davis, Prentice Hall, 2001

Course Contents and Lecture Schedule

S.No	Topics	No of Lectures
	1. Introduction to EMS	
1.1	The Context of Environmental Management	1

1.2	Sustainability and sustainable development	1
1.3	Relationship between business and Environment	1
1.4	Implementation of EMS	1
1.5	Barriers, obstacles in EMS	1
1.6	Opportunities in implementation of EMS	1
1.7	Corporate Social Responsibility	1
2. Environmental Management Standards		
2.1	Environmental standards – Concentration & Mass	1
2.2	Environmental standards – Effluent & Stream	1
2.3	Environmental standards – Emission & Ambient	1
2.4	Environmental labeling scheme – Certifications	2
3. Preventive Environmental Management		
3.1	Pollution control Vs. Pollution prevention	1
3.2	Cleaner production concepts - Source reduction, Raw material substitution, Process modification, Toxic use reduction and Elimination	2
3.3	Opportunities and barriers of CP	1
3.4	Cleaner production project development and implementation	2
3.5	Cleaner production assessment and applications	2
4. ISO 14001 and Elements of EMS		
4.1	Environmental Management tools	1
4.2	EMS Hierarchy – structure	1
4.3	Concept of Continual improvement	1
4.4	EMS model	1
4.5	Environmental policy and planning	1
4.6	Implementation and operation	1
4.7	Checking and Corrective action	1
4.8	Management Review	1
4.9	Application of EMS	2

5. Environmental Auditing		
5.1	Environmental management system audits as per ISO 19011	2
5.2	Roles and qualifications of auditors	2
5.3	Audit Types	1
5.4	Basic steps in audit	1
5.5	ISO and Indicators	1
5.6	Environmental performance indicator	1
5.7	Types of Environmental indicators	1
5.8	Applications of indicators in environmental performance	1
5.9	Nonconformance - Corrective and Preventive actions	1
5.10	Environmental statement	1
5.11	Application of EA	2
6. Life Cycle Assessment		
6.1	Components of LCA	1
6.2	Measuring Environmental Impact	1
6.3	Strategic Implementation for LCA	1
6.4	LCA Cost Assessment	1
	Total periods	**48**

Course Designer

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14ENPF0 CLIMATE CHANGE AND ADAPTATION

Category	L	T	P	Credit
PE	4	-	-	4

Preamble

This course work is focussed on the climate change scenario of the world due to industrialization, transportation and use of fossil fuels and to manage this scenario effectively for sustainability. The course work is designed to understand the earth's climate system, change in climate, causes for the climate change. The concept of global

warming and regional changes, the impact of climate change on society and its mitigation measures are well addressed.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Understand the earth's climate change and its system classification	Understand
CO2.	Introduce the observed changes in the climate and concept of modelling and Institutional arrangements existing for monitoring this phenomenon	Understand
CO3.	Show the impact of climate change on various sectors and its irreversibility	Understand
CO4.	Prepare the adaptation and mitigation measures of climate change on various sectors.	Apply
CO5.	Choose the clean Technology for the Fuel and energy through natural and eco friendly techniques.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	-	-	-	-	M	-	-	M	-	M
CO2	S	S	M	M	M	M	M	-	M	M	M
CO3	S	S	M	S	M	M	M	M	M	M	M
CO4	S	S	S	S	S	M	M	M	M	M	M
CO5	S	S	S	S	M	-	M	-	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	60	60	50	50
Apply	20	20	30	30
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Classify the wind systems.
2. What is El Nino?
3. What are green house gases?
4. What is Hydrological cycle.
5. Explain the components of Hydrological cycle with the help of a neat sketch.
6. Explain the reason behind green house effects.

Course Outcome 2 (CO2):

1. Explain the important aspects of Montreal protocol.
2. Explain the Global warming phenomenon & its effects.
3. Discuss the uncertainties in the projected impact of climate change.
4. Discuss the relation between global ocean circulation & climate change.
5. Discuss in detail about Climate Sensitivity and Feedback

Course Outcome 3 (CO3):

1. Discuss the role of IPCC & UNFCCC for climate change mitigation.
2. Discuss the challenges in mitigating the impact of climate change in agricultural sector
3. "Carbon capture & storage is the need of the hour" justify the statement.
4. Review the India's Policy Initiatives towards Climate Change and discuss the Recommendationsand Solutions.

Course Outcome 4 (CO4):

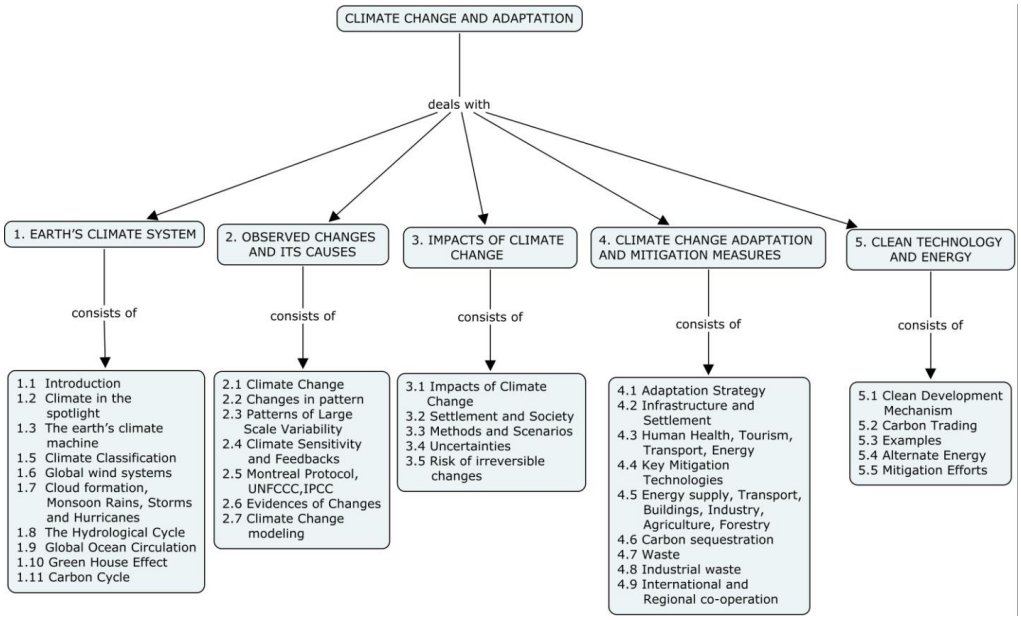
1. Illustrate & explain the different methods of carbon sequestration.
2. How Climate change affects human health in dry & arid region?

3. Consider the Water Resources and Agriculture Sector and present the Effects, Mitigation
   and adaptation in a sequential manner.
4. Propose a suitable energy alternative for our country after presenting the facts and figures in generation, consumption and economy in all aspects.

Course Outcome 5 (CO5):

1. How do you prepare flood inundation plan for your city?
2. Describe the impacts of Climate change on various sectors in Tamil Nadu.
3. Apply the Technological and Engineering Solutions to combat Climate change.
4. Propose the suitable alternate fuel as well as energy for our country after analyzing all the feasibilities (Socio, Economic and Political)
5. The consumption of fuel in India is increasing everyday and cost of it too. Propose a suitable alternate fuel for the future after analyzing the pros and cons of its implementation.

Concept Map



Syllabus

Earth's Climate System: Introduction-Climate in the spotlight-The Earth's Climate Machine – Climate Classification – Global wind systems – Trade Wind Systems – Trade Winds and the Hadley Cell – The Weserlies – Cloud formation and Monsoon Rains – Storms and Hurricanes – The Hydrological Cycle – Global Ocean Circulation – EI Nino and its Effect – Solar Radiation – The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle. **Observed Changes and Its Causes:** Observation of Climate Change – Changes in pattern of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of

Large Scale Variability – Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol – UNFCCC – IPCC – Evidences of Changes in Climate and Environment – on a Global Scale and in India – Climate Change modeling. **Impacts Of Climate Change:** Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water resources – Human Health – Industry, Settlement and Society – Methods and Scenarios – Projected Impacts for different regions – Uncertainties in the Projected Impacts of Climate Change – Risk of irreversible changes. **Climate Change Adaptation and Mitigation Measures:** Adaptation Strategy/options in various sectors – Water – Agriculture – Infrastructure and Settlement including coastal zones. Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and practices – Energy supply – Transport – Buildings – Industry – Agriculture – Forestry – Carbon sequestration – Carbon Capture and Storage (CCS) – Waste (MSW & Biowaste, Biomedical, Industrial waste – International and Regional co-operation. **Clean Technology and Energy:** Clean Development Mechanism – Carbon Trading – Examples of future Clean Technology – Biodiesel – Natural Compost – Eco-friendly Plastic – Alternate Energy – Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.

Reference Books

1. Al core 'Inconvenient Truth" – video form
2. Dash Sushil Kumar, "Climate Change – An Indian Perspective", CambridgeUniversity Press India Pvt. Ltd, 2007.
3. IPCC Fifth Assessment Report – www.ipcc.ch
4. Jan C. van Dam, Impacts of "Climate Change and Climate Variability on Hydrological Regimes", Cambridge University Press, 2003

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Earth's Climate System	
1.1	Introduction	1
1.2	Climate in the spotlight	1
1.3	The earth's climate machine	1
1.5	Climate Classification	1
1.6	Global wind systems, Trade Wind Systems and the Hadley Cell The Weserlies .	2
1.7	Cloud formation and Monsoon Rains, Storms and Hurricanes	2

1.8	The Hydrological Cycle	1
1.9	Global Ocean Circulation, EI Nino and its Effect, Solar Radiation	1
1.10	The Earth's Natural Green House Effect, Green House Gases and Global Warming	2
1.11	Carbon Cycle	1
2. Observed Changes And Its Causes		
2.1	Observation of Climate Change	1
2.2	Changes in pattern of temperature, precipitation and sea level rise – Observed effects of Climate changes	2
2.3	Patterns of Large Scale Variability – Drivers of Climate Change –	1
2.4	Climate Sensitivity and Feedbacks	2
2.5	The Montreal Protocol – UNFCCC – IPCC	2
2.6	Evidences of Changes in Climate and Environment – on a Global Scale and in India	1
2.7	Climate Change modeling	2
3. Impacts Of Climate Change		
3.1	Impacts of Climate Change on various sectors Agriculture, Forestry ,Ecosystem, Water resources , Human Health ,Industry,––	3
3.2	Settlement and Society	1
3.3	Methods and Scenarios – Projected Impacts for different regions	2
3.4	Uncertainties in the Projected Impacts of Climate Change	1
3.5	Risk of irreversible changes.	1
4. Climate Change Adaptation and Mitigation Measures		
4.1	Adaptation Strategy/options in various sectors	1
4.2	Water – Agriculture – Infrastructure and Settlement including coastal zones.	2
4.3	Human Health – Tourism – Transport – Energy	2
4.4	Key Mitigation Technologies and practices	2
4.5	Energy supply – Transport – Buildings – Industry – Agriculture –	1

	Forestry	
4.6	Carbon sequestration – Carbon Capture and Storage (CCS)	2
4.7	Waste (MSW & Biowaste, Biomedical)	1
4.8	Industrial waste	1
4.9	International and Regional co-operation.	
5. Clean Technology and Energy		
5.1	Clean Development Mechanism —— Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.	1
5.2	Carbon Trading	1
5.3	Examples of future Clean Technology – Biodiesel – Natural Eco-friendly Plastic Compost,	1
5.4	Alternate Energy Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power	1
5.5	Mitigation Efforts in India and Adaptation funding.	1
Total Periods		**48**

Course Designers

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		Category	L	T	P	Credit
14ENPG0	**ENVIRONMENTAL BIOTECHNOLOGY**	PE	4	-	-	4

Preamble

The course is aimed at providing information about micro-organisms, their interaction with contaminants and their kinetics. And also, to impart the knowledge on

mass balancing of Activated sludge process and other reactors and to biodegrade the contaminants using biotechnological means.

Prerequisite

Completion of Undergraduate level courses on Environmental engineering.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	understand the role of micro-organisms in degrading contaminants	Understand
CO2	mass balancing of reactors and activated sludge processes	Understand
CO3	application of biological processes to degrade contaminants	Apply
CO4	application of kinetics parameters in designing bio reactors	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	M	L	L	L	L	-	M	-	M	-
CO2.	S	M	L	L	L	L	-	M	-	M	-
CO3.	S	S	S	M	L	M	-	L	L	M	-
CO4.	S	S	S	M	L	M	-	L	L	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Enumerate the scope of Environmental Biotechnology?
2. Classify and explain the various types of bioremediation?
3. Differentiate in-situ from ex-situ bioremediation

Course Outcome 2 (CO2):

1. The step aeration and the contact stabilization modifications of the ASP achieve what advantages?
2. A small community uses activated sludge to treat their sewage flow of 4000 m^3/d. The system was sized to give conventional loadings for the average daily conditions Θ_x=5d, Θ =10 h, MLSS =3000 mg SS/l, R=0.30, X_r =1.3% the clarifier is 5m deep and has a surface of 130 m^2. It has a single weir around the outside. However the sewage flow is not even. During 8 h of the day the flow is 9000 m^3/d, but it averages 1500 m^3/d for the other 16 h. Explain using quantitative analysis, why this treatment plant frequently has high effluent BOD.
3. You are asked to design an activated sludge plant to treat 104 m^3/d of wastewater containing 150 mg/l of phenol. The regulatory authorities are requiring that the effluent phenol concentration from this plant not exceed 0.04 mg/l. For this problem, assume the following biological coefficients apply, that phenol inhibition can be ignored, and that X^0 =0:

   Y= 0.6 g cells/g phenol, q= 9 g phenol/ g cells-d, b= 0.15 1/d, K= 0.8 mg/l

   a) What Θ_x in d would you use for design of this plant? Be sure to list all assumptions used and show calculations that are appropriate for justifying your answer.
   b) Based upon your design Θ_x , what would be the reactor volume in m^3? Specify additional assumptions you may have to make.

Course Outcome 3 (CO3):

1. In a laboratory study of the anaerobic biological treatment of a wastewater with a biodegradable COD of 12000 mg/l, 98% removal of the COD was obtained, and 800 mg/l of biological cells were formed, Estimate the methane production resulting from this treatment in grams of methane per litre of wastewater.

2. Two anaerobic digesters are treating the same sludge, but with different organic loading. Digesters A and B have total alkalinity of 2750 mg/l as $CaCO_3$, 2000 mg/l as HAc. If both have a partial pressure of CO2 of 0.3 atm, which digester has the higher organic loading? Is it too high?

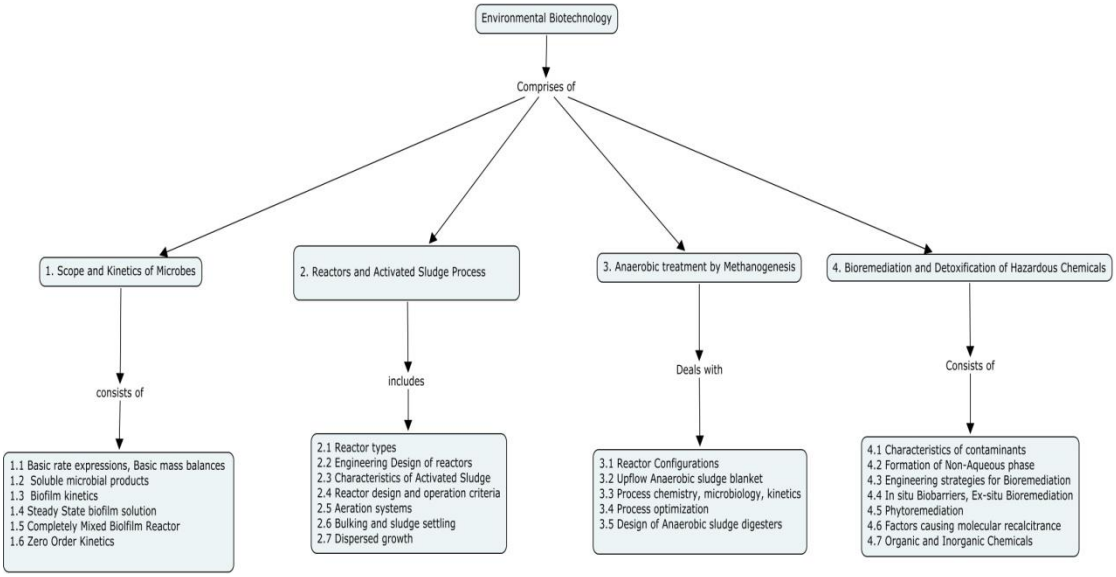
Outcome 4 (CO4):

1. From biofilm kinetics, it was found that the flux into a biofilm at steady state is 0.15 mg/cm^2-d when the bulk liquid concentration of benzoate is 2 mg/l. What reactor volume is needed to treat 100 m^3/d of wastewater containing 50 mg/l

benzoate if 96% removal is required, and if we assume completely mixed conditions and the specific surface area of the reactor is 3 cm^2/cm^3

2. In the biological oxidation of benzene by a fixed-film reactor, the flux into the deep biofilm (Sw=0) was found to be 5 mg per cm^2 of biofilm surface area per day when the benzene concentration at the biofilm surface was 15 mg/l, What do you estimate the flux will be if the benzene concentration at the biofilm surface is increased to 50 mg/l? Rate coefficients for benzene are as follows: Y =0.6 mg VS_a per mg benzene, q= 6 mg benzene per ms VS_a per day, K= 2 mg/l and b= 0.1 per day.

Concept Map



Syllabus

Scope and Kinetics of Microbes: Basic Rate Expressions-Parameter Values, Basic Mass Balances, Mass Balances on Inert Biomass and Volatile Solids -Soluble Microbial Products, Nutrients and electron Acceptors -Input Active Biomass, Hydrolysis of Particulate and Polymeric Substrates; Biofilm Kinetics : Microbial Aggregation, Importance of Biofilms, The Idealized Biofilm, The Steady-State Biofilm, The Steady-State Biofilm Solution -Estimating Parameter Values, Average Biofilm SRT -Completely Mixed Biofilm Reactor, soluble microbial products and inert biomass, Trends in CMBR performance, Normalized surface loading, Nonsteady-state biofilms. **Reactors and Activated Sludge Process:** Reactor types,Mass Balances: Biofilm Reactors, batch reactor, continuous-Flow Stirred Tank reactor with effluent recycle, plug flow reactor. – Reactor with Recycle of Settled cells, Engineering Design of Reactors. -Characteristics of Activated Sludge, Process Configurations, Design and Operation Criteria, Aeration

Systems, Bulking and Other Sludge-Settling, Activated Sludge Design. **Anaerobic Treatment by Methanogonesis:** Uses of Methanogenic Treatment, Reactor Configurations, Process Chemistry and Microbiology; Process Kinetics. **Bioremediation and Detoxification of Hazardous Chemicals:** Scope and Characteristics of Contaminants, Biodegradability -Contaminant Availability for Biodegradation, Treatability Studies, Engineering Strategies for Bioremediation, Phytoremediation, Bioremediation of Gas-Phase VOCs, Evaluating Bioremediation.

Reference Books

1. Bruce E. Rittmann, Perry L. McCarty (2001), "Environmental Biotechnology: Principles and Applications" (2001), McGraw-Hill, publications.
2. Olguin, J.E., Sanchez, G. and Hernandez, E. "Environmental Biotechnology and cleaner bioprocess", Taylor and Francis Ltd., U.S.A., 2000
3. Wainwright, M. "An Introduction to Environmental Biotechnology", 1999

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Scope and Kinetics of Microbes	
1.1	Basic Rate Expressions, Parameter Values, Basic Mass Balances, Mass Balances on Inert Biomass and Volatile Solids.	2
1.2	Soluble Microbial Products, Nutrients and electron Acceptors, Input Active Biomass, Hydrolysis of Particulate and Polymeric Substrates, Inhibition, Other Alternate Rate Expressions.	2
1.3	Biofilm Kinetics, Microbial Aggregation, Importance of Biofilms, The Idealized Biofilm, The Substrate Phenomena, The Steady-State Biofilm.	2
1.4	The Steady-State Biofilm Solution, Estimating Parameter Values, Average Biofilm SRT.	2
1.5	Completely Mixed Biofilm Reactor, soluble microbial products and inert biomass, Trends in CMBR performance, Normalized surface loading, Non steady-state biofilms.	3
1.6	Special-Case Biofilm Solutions, Deep Biofilms, Zero-Order Kinetics	1
	2. Reactors and Activated Sludge Process	
2.1	Mass Balances: Suspended-Growth reactors, Biofilm Reactors, Reactor Arrangements, batch reactor, Reactor types,	2
2.2	CSTR with settling and cell recycling, Evaluation of assumptions, Plug-Flow reactor with settling and cell recycle,	2

2.3	Characteristics of Activated Sludge, Microbiology Ecology, Oxygen and Nutrient Requirements, Impacts of Solid retention Time, Process Configurations, Physical Configurations,	3
2.4	Design and Operation Criteria, Food to Microorganism ratio, Solid Retention Time, Comparison of Loading Factors, Mixed-liquor suspended solids, the SVI, and the Recycle Ratio	2
2.5	Aeration Systems, Oxygen-Transfer and Mixing Rates, Diffused Aeration Systems, Mechanical Aeration Systems.	2
2.6	Bulking and Other Sludge-Settling Problems, Bulking Sludge Foaming and Scum Control, Rising Sludge,	2
2.7	Dispersed Growth and Pinpoint Floc, Viscous Bulking,	1
3. Anaerobic Treatment by Methanogenesis		
3.1	Uses of Methanogenic Treatment, Reactor Configurations, Completely Mixed, Anaerobic Contact, Upflow and Downflow Packed Beds, Fluidized Beds.	3
3.2	Upflow Anaerobic Sludge Blanket, Miscellaneous Anaerobic Reactors.	1
3.3	Process Chemistry and Microbiology, Process Microbiology, Process Chemistry, Process Kinetics, Temperature Effects, Reaction Kinetics for a CSTR, Complex Substrates,	3
3.4	Process Optimization, Reaction Kinetics for Biofilm Processes, Kinetics with Hydrolysis as the Limiting Factor.	1
3.5	Special Factors for the Design of Anaerobic Sludge Digesters, Loading Criteria, Mixing, Heating, Gas Collection.	2
4. Bioremediation and Detoxification of Hazardous Chemicals		
4.1	Scope and Characteristics of Contaminants, Organic Compounds, Mixtures of Organic Compounds, Mixtures Created by Co disposal, Biodegradability.	1
4.2	Contaminant Availability for Biodegradation, sorption to Surfaces, Formation of Non-aqueous Phase.	1
4.3	Treatability Studies, Engineering Strategies for Bioremediation, Site Characterization, Engineering In Situ Bioremediation, Intrinsic In Situ Bioremediation and Natural Attenuation.	1
4.4	In Situ Biobarriers, Ex Situ Bioremediation.	1
4.5	Phytoremediation, Bioremediation of Gas-Phase VOCs, Evaluating Bioremediation.	3
4.6	Factors Causing Molecular Recalcitrance, Molecular Structure, Energy Metabolism Versus Co-metabolism, Electron Donor Versus Electron Acceptor, Biodegradation of Environmental	2

	Contaminants.	
4.7	Synthetic Detergents, Pesticides, Hydrocarbons, Chlorinated Solvents and Other Halogenated Aliphatic Hydrocarbons, Chlorinated Aromatic Hydrocarbons, Explosives, General Fate Modelling for Organic Chemicals, Inorganic Elements.	3
Total Periods		**48**

Course Designer

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		Category	L	T	P	Credit
14ENPH0	**ENVIRONMENTAL REMOTE SENSING**	PE	4	-	-	4

Preamble

Remote sensing techniques are very much useful for environmental data acquisition and analysis. Geographical Information System is another important scientific tool in making decisions in environmental management issues based on the input data. This course work deals with the principles and techniques and the data processing in remote sensing, concepts of GIS, database management, GIS softwares and the applications of RS and GIS.

Prerequisite

No prerequisite

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Understand fundamental principles of Electromagnetic Radiation	Understand
CO2.	Define and appropriately use basic concepts related to Remote Sensing observations and apply basic image analysis techniques in selected environmental applications	Apply
CO3.	Have the ability to discuss the application of RS techniques to real-world environmental issues	Understand
CO4.	Investigate functions and characteristics of different satellite and airborne RS systems and evaluate remote sensing data in relation to requirements of a particular task	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	-	-	M	L	L	-	-	M	-
CO2	S	M	-	-	S	L	L	-	-	S	-
CO3	S	M	-	-	M	L	L	-	-	M	-
CO4	S	S	S	S	S	M	L	M	-	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment	Terminal Examination

	Tests			
	1	**2**	**3**	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is total radiant exitance?
2. List the significances of NIR in remote Sensing?
3. Explain EMR interaction with features such as Soil, Water and vegetation?

Course Outcome 2 (CO2):

1. Explain how Geometric Correction is applied to satellite data?
2. Explain DN and Analog to digital conversion?
3. Describe Radiometric Correction.

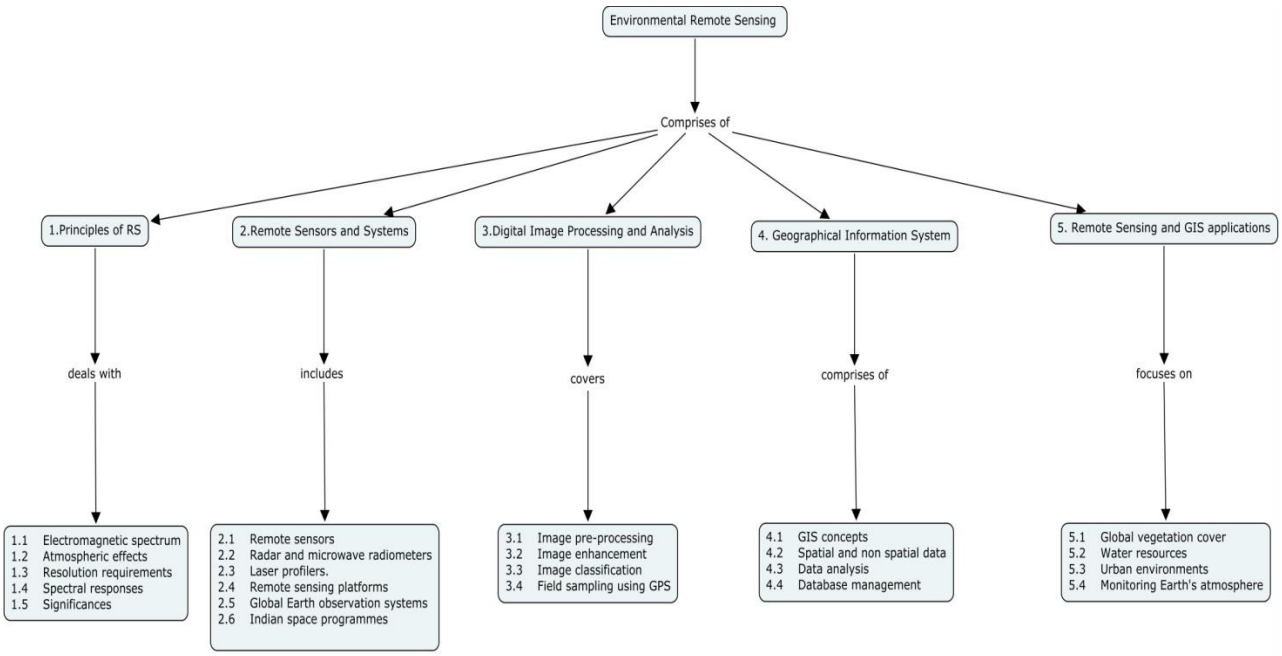
Course Outcome 3 (CO3):

1. Explain briefly the concept of “Remote Sensing of Soil Properties”
2. Explain how will you apply a GIS for Integrated Flood management?
3. Explain briefly the significances of GEOS,NOAA satellites for Environmental management?

Course Outcome 4 (CO4):

1. Explain the methodology for Land Use/ land cover mapping using Remote Sensing Techniques?
2. Explain and demonstrate with reference to a coastal zone, how LIDAR Remote Sensing techniques could be applied for Disaster management?

Concept Map



Syllabus

Principles of Remote Sensing : The electromagnetic spectrum. Reflectance and radiance**-** Atmospheric effects, Multispectral feature recognition**-** Resolution requirements**-** Energy interaction and spectral responses of earth surface features**-** Significances of Remote Sensing and Global Environmental Changes. **Remote Sensors and Systems:** Remote sensors, Multispectral satellite sensors Digital aerial cameras- Thermal infrared sensors, Radar and microwave radiometers.- Laser profilers.- Remote sensing platforms: Airborne platforms. Medium-resolution satellites, High-resolution satellites.- Global observation satellites.- The NASA Earth observing system, Global Earth observation systems: Global Climate Observing System, Global Earth Observation System, Integrated Ocean Observing system- Indian space programmes. **Digital Image Processing and Analysis**: Image data format, Image pre-processing, Image enhancement and image interpretation- Image classification. Image band selection. Error assessment. Time-series analysis and change detection.- Field sampling using GPS, Use of Geographic Information Systems. **Geographical Information System:** GIS concepts**-** Spatial and non spatial data, Vector and raster data structures**-** Data analysis**-** Database management. **Remote Sensing and GIS applications: Monitoring changes in global vegetation cover:** EM spectrum of vegetation. Vegetation indices. Biophysical properties and processes of vegetation. Classification systems. Global vegetation and land cover mapping programmes.- Application of new satellites and radar. Remote sensing of vegetation as a monitor for global change. **Surface and ground water resources:** Remote sensing of inland water quality, Remote sensing sediment load and pollution of inland waters. Remote sensing non-coastal flooding. Bathymetry of inland waters. Mapping watersheds at the regional

scale. - Remote sensing of land surface moisture. Remote sensing of groundwater.- **Remote sensing of urban environments:** Urbanization., Urban remote sensing. three-dimensional urban model generation, Stereo imaging. - LiDAR, Synthetic Aperture Radar (SAR). Microwave sensing of subsidence. Textural metrics, Monitoring city growth, Assessing the ecology of cities.- **Monitoring Earth's atmosphere:** The status of Earth's atmosphere. Atmospheric remote sensing. The 'A- Train' satellite constellation. Dancing on the A- Train.- Remote sensing atmospheric temperature. Atmospheric remote sensing of ozone. Atmospheric remote sensing of carbon dioxide. Remote sensing atmospheric dust.

Reference Books

1. Burrough, P. A. and McDonnell, R. A., Principles of Geographic Information Systems, Oxford University Press, New York, 2001.
2. John R Jensen, "Remote Sensing of the Environment: An Earth Resource Perspective (2nd Edition, 2006) Pearson Publication.
3. Pmampler and Applications of Imaging RADAR, Manual of Remote Sensing, Vol.2, ASPR, 2001
4. Samuel Purkis and Victor Klemas, " Remote Sensing and Global Environmental Change" (2011), Wiley-Blackwell, A John Wiley & Sons, Ltd. Publication.
5. Thomas Lillesand, Ralph W. Kiefer, Jonathan Chipman, "Remote Sensing and Image Interpretation, 6th Edition(2008) John Wiley & Sons, Publications.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
1. Principles of Remote Sensing		
1.1	The electromagnetic spectrum. Reflectance and radiance	2
1.2	Atmospheric effects, Multispectral feature recognition	2
1.3	Resolution requirements	1
1.4	Energy interaction and spectral responses of earth surface features	1
1.5	Significances of Remote Sensing and Global Environmental Changes	1
2. Remote Sensors and Systems		
2.1	Remote sensors, Multispectral satellite sensors Digital aerial cameras	2

2.2	Thermal infrared sensors, Radar and microwave radiometers.	2
2.3	Laser profilers.	1
2.4	Remote sensing platforms: Airborne platforms. Medium-resolution satellites, High-resolution satellites.	2
2.4.1	Global observation satellites.	1
2.5	The NASA Earth observing system, Global Earth observation systems:Global Climate Observing System,	2
2.5.1	Global Earth Observation System, Integrated Ocean Observing system	1
2.6	Indian space programmes	1
3. Digital Image Processing and Analysis		
3.1	Image data format, Image pre-processing,	1
3.2	Image enhancement and image interpretation	2
3.3	Image classification. Image band selection. Error assessment. Time-series analysis and change detection.	2
3.4	Field sampling using GPS, Use of Geographic Information Systems.	2
4. Geographical Information System		
4.1	GIS concepts	2
4.2	Spatial and non spatial data, Vector and raster data structures	2
4.3	Data analysis	2
4.4	Database management	2
5. Remote Sensing and GIS applications		
5.1	**Monitoring changes in global vegetation cover:** EM spectrum of vegetation. Vegetation indices. Biophysical properties and processes of vegetation. Classification systems. Global vegetation and land cover mapping programmes.	2

5.1.1	Application of new satellites and radar.Remote sensing of vegetation as a monitor for global change.	1
5.2	**Surface and ground water resources:** Remote sensing of inland water quality, Remote sensing sediment load and pollution of inland waters. Remote sensing non-coastal flooding. Bathymetry of inland waters.Mapping watersheds at the regional scale.	2
5.2.1	Remote sensing of land surface moisture. Remote sensing of groundwater.	1
5.3	**Remote sensing of urban environments:** Urbanization., Urban remote sensing.three-dimensional urban model generation, Stereo imaging.	2
5.3.1	LiDAR, Synthetic Aperture Radar (SAR). Microwave sensing of subsidence. Textural metrics, Monitoring city growth, Assessing the ecology of cities.	2
5.4	**Monitoring Earth's atmosphere:**The status of Earth's atmosphere. Atmospheric remote sensing.The 'A- Train' satellite constellation.Dancing on the A- Train.	2
5.4.1	Remote sensing atmospheric temperature.Atmospheric remote sensing of ozone.Atmospheric remote sensing of carbon dioxide.Remote sensing atmospheric dust	2
Total Periods		**48**

Course Designer

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14ENPJ0 RESOURCES AND ENERGY

RECOVERY FROM WASTE

Category	L	T	P	Credit
PE	4	-	-	4

Preamble

Solid waste is generated in tonnes a day throughout the world especially in urban centres. The disposal of solid waste is becoming much more complex due to toxic materials which pollutes the environment and underground water. This course work is focused to deal with recovery of resources and energy from the waste for sustainable development particularly from solid waste which includes sludge sedimented from wastewater. The process of material recovery from solid waste to recycle is dealt in this course work. The process of energy recovery in the form of Thermal, Biofuels and green manure product from the solid waste is covered in detail. The course work also covers several case studies to recycle the usable materials recovered from solid waste with its socio-economic and legal considerations.

Prerequisite

Solid Waste Management and Biological Treatment System

Course Objective

Understand and apply the recovery process of the recyclable materials and energy recovery by various transformation processes from the solid waste.

Course Outcomes

On the successful completion of the course, students will be able to:

CO1.	Understand and apply the various recovery process and volume reduction process of solid waste for sustainable development	Apply
CO2.	Develop biological process for transformation of solid waste to useful bye- products such as green manure for beneficial use	Apply & Analyse
CO3.	Develop Bio-chemical process for transformation of solid waste to useful bye- products such as bio-gas for beneficial use.	Apply & Analyse
CO4.	Develop Thermal-chemical process for transformation of solid waste to useful bye- products such as Heat energy for beneficial use	Apply & Analyse
CO5.	Apply and Analyze the recycling and recovery concepts of various solid waste and E waste practiced in the world from case studies	Apply & Analyse

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	S	S	M	M	M	-	M	M	M
CO2	S	S	S	S	L	L	L	-	M	M	M
CO3	S	S	S	S	L	L	L	-	M	M	M
CO4	S	S	S	S	L	L	L	-	M	M	M
CO5	S	S	S	M	L	M	M	-	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	50	50	30	30
Apply	30	30	30	30
Analyse	0	0	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State Sustainable Development
2. State the objectives of processing of waste
3. Describe the material and energy flow management
4. Explain the various ways of recovery of resources from waste
5. Explain the process of segregation, sorting and its conveyance
6. Describe the process of size separation and density separation
7. Explain the process of equipment selection

Course Outcome 2 (CO2):

1. Name various methods of composting
2. List the factors affecting composting
3. List the scope and importance of vermi culture
4. Name the species used for vermi culture
5. State vermi culture
6. Explain the mechanisms involved in Biological processing
7. Explain aerobic process of organic fraction

8. Design a suitable biological process of energy recovery of organic waste from vegetable markets
9. Describe the process of composting of organic waste

Course Outcome 3 (CO3):

1. State the principles of anaerobic digester
2. Name some toxic substances which affects anaerobic disgestion
3. Explain the process of methane generation by anaerobic digestion
4. Explain the process of single stage and multi stage disgestors
5. Describe the commercially available anaerobic digestor technologies
6. Explain the process of collection of gas from anaerobic digestion
7. Design a suitable biological process of methane energy recovery of organic waste from municipal solid waste

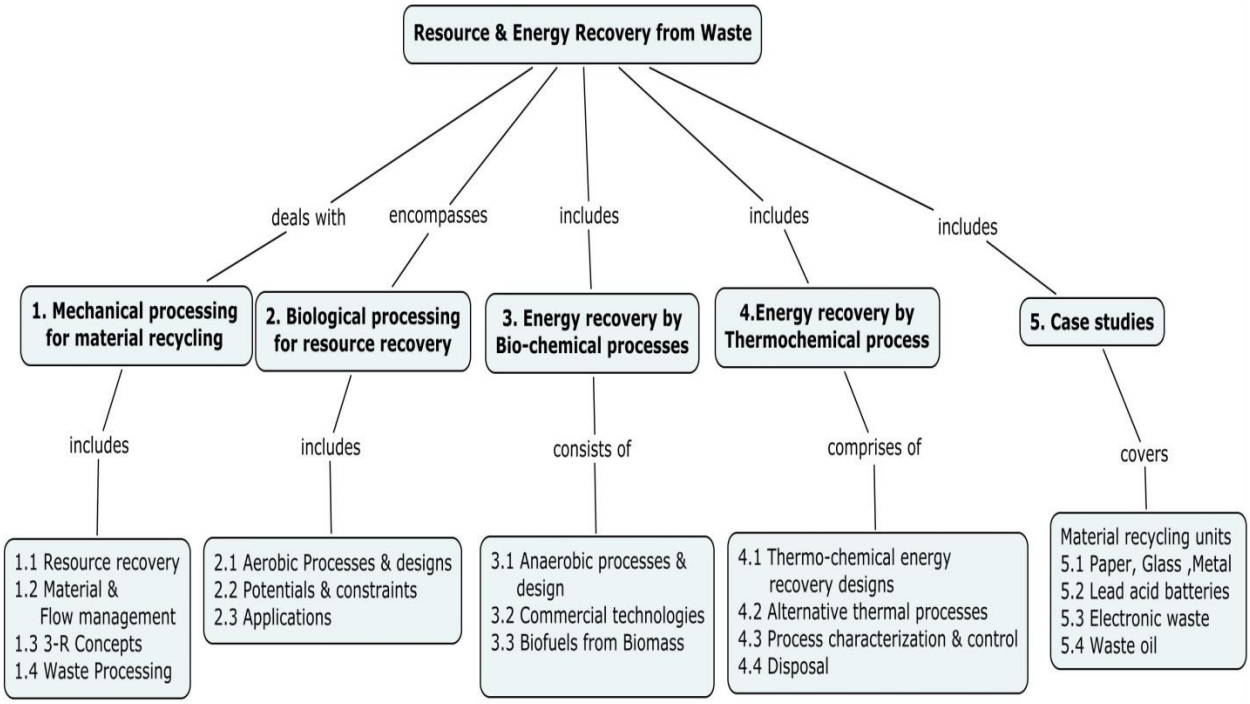
Course Outcome 4 (CO4):

1. State the principles of Thermal chemical conversion of waste to energy
2. Explain the process of energy recovery from incineration
3. Describe the process of incineration systems
4. Design a suitable Thermal chemical conversion process for energy recovery of municipal solid waste
5. Describe the procedure to determine stoichiometric air consumption
6. Explain the ways of calculating flue gas composition
7. Describe the process of pyrolysis and gasification
8. Explain the importance of cleaning of flue gases
9. Explain the treatment process of bottom ash
10. Explain utilization and disposal of bottom ash

Course Outcome 5 (CO5):

1. Explain the concept of life cycle approach
2. Explain the process of recycling technologies practiced for various materials
3. Explain the process of recycling technologies of E waste with a case study
4. Explain the process of recycling technologies of paper waste with a case study
5. Prepare a preliminary report for the resource recovery of Institutional waste from planning to the suitable transformation process. Assume the appropriate waste generated.

Concept Map



Syllabus

Mechanical processing for material recycling : Resource recovery for a sustainable development- Material and energy flow management and analysis - Systems and processes for reduction, reuse and recycling -Objectives of Waste processing-Source Segregation and Hand Sorting-Waste Storage and Conveyance – Shredding – Pulping - Size Separation by Screens- Density Separation by Air Classification –magnetic and electromechanical separation processes- Design Criteria and Equipment selection**. Biological processing for resource recovery :** Mechanisms of Biological Processing – Aerobic Processing of Organic fraction - Composting methods and processes- factors affecting- Design of Windrow Composting Systems- In Vessel Composting- Compost Quality Control- Vermiculture: definition, scope and importance – common species for culture - Environmental requirements - culture methods- Applications of vermiculture- Potentials and constraints for composting in India-Largescale and decentralized plants. **Bio-chemical conversion of waste to energy :** Principles and Design of Anaerobic Digesters – Process characterization and control**-** The biochemistry and microbiology of anaerobic treatment - Toxic substances in anaerobic treatment -Methane generation by Anaerobic Digestion- Anaerobic reactor technologies – Commercial anaerobic Technologies- Single stage and multistage digesters- Digester design and performance- Gas collection systems-Methane Generation and Recovery in Landfills – Biofuels from Biomass**. Thermo-chemical conversion of waste to energy:** Principles and Design of

Energy Recovery Facilities -Types and principles of energy conversion processes - Incinerator design - Mass Burn and RDF Systems- Composition and calorific value of fuels and waste, Determination of the stoichiometric air consumption, Calculation of the flue gas composition - grate firing designs, boiler design, removal of bottom ash, heat recovery- Emission Controls – flue gas cleaning, de-dusting, flue gas scrubbers, DeNOx processes, dioxins and furans - Alternative thermal processes: co-incineration, pyrolysis, gasification, plasma arc – Process characterization and control- waste heat recovery- Bottom ash: Quantity, quality, treatment, utilization, disposal- Facility design- decentralized mobile plants- Planning and construction of incineration plants**. Case studies:** Recycling technologies for paper, glass, metal, plastic – Used Lead Acid Battery Recycling –End of Life Vehicle Recycling – Electronic Waste Recycling – Waste Oil Recycling.

Reference Books

1. Aarne Veslind and Alan E Rimer (1981), “Unit operations in Resource Recovery Engineering
“, Prentice Hall Inc., London.
2. Charles R Rhyner (1995),Waste Management and Resource Recovery, Lewis Publishers
3. Chiumenti, Chiumenti, Diaz, Savage, Eggerth, and Goldstein *, Modern Composting Technologies* , JG Press October 2005.
4. Gary C. Young (2010)Municipal Solid Waste to Energy Conversion Processes: Economic,
Technical, and Renewable Comparisons , John Wiley & Sons
5. Manser A G R, Keeling A A (1996). Practical handbook of processing and recycling on
municipal waste. Pub CRC Lewis London, ISBN 1-56670-164.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
1. Mechanical processing for material recycling		
1.1	Resource recovery for a sustainable development	1
1.2	Material and energy flow management and analysis	1
1.3	Systems and processes for reduction, reuse and recycling	1
1.4	Objectives of Waste Processing-Source Segregation and Hand Sorting	1
1.4.1	Waste Storage and Conveyance – Shredding – Pulping	1
1.4.2	Size Separation by Screens- Density Separation by Air	1

	Classification –magnetic and electromechanical separation processes	
1.4.3	Design Criteria and Equipment selection	2
2. Biological processing for resource recovery		
2.1	Mechanisms of Biological Processing – Aerobic Processing of Organic fraction	2
2.1.1	Composting Methods and processes- factors affecting	2
2.1.2	Design of Windrow Composting Systems- In Vessel Composting- Compost Quality Control	2
2.2	Potentials and constraints for composting in India-Largescale and decentralized plants.	2
2.3	Vermiculture: definition, scope and importance – common species for culture -	1
2.3.1	Environmental requirements - culture methods- Applications of vermiculture	2
3. Bio-chemical conversion of waste to energy		
3.1	Principles and Design of Anaerobic Digesters – Process characterization and control	2
3.1.1	The biochemistry and microbiology of anaerobic treatment - Toxic substances in anaerobic treatment	1
3.1.2	Methane generation by Anaerobic Digestion	1
3.2	Anaerobic reactor technologies – Commercial anaerobic Technologies	1
3.2.1	Single stage and multistage digesters- Digester design and performance	2
3.3	Gas collection systems-Methane Generation and Recovery in Landfills – Biofuels from Biomass	1
4. Thermo-chemical conversion of waste to energy		
4.1	Principles and Design of Energy Recovery Facilities	1
4.1.1	Types and principles of energy conversion Processes	1
4.1.2	Incinerator design - Mass Burn and RDF Systems- Composition and calorific value of fuels and waste,	2
4.1.3	Determination of the stoichiometric air consumption, Calculation of the flue gas composition -	2
4.1.4	grate firing designs, boiler design, removal of bottom ash, heat recovery	2

4.1.5	Emission Controls – flue gas cleaning, de-dusting, flue gas scrubbers, DeNOx processes, dioxins and furans	1
4.2	Alternative thermal processes: co-incineration, pyrolysis, gasification, plasma arc	1
4.3	Process characterization and control- waste heat recovery- Bottom ash: Quantity, quality,	2
4.4	Bottom ash treatment, utilization, disposal- Facility design- decentralized mobile plants	2
4.4.1	Planning and construction of incineration plants	1
5. Case studies		
Material recycling units		
5.1	Recycling technologies for paper, glass, metal, plastic	2
5.2	Used Lead Acid Battery Recycling –End of Life Vehicle Recycling	2
5.3	Electronic Waste Recycling	1
5.4	Waste Oil Recycling – Solvent Recovery	1
Total		**48**

Course Designers

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		Category	L	T	P	Credit
14ENPK0	**SURFACE AND GROUND WATER QUALITY MODELLING**	PE	3	1	-	4

Preamble

Modelling is a very useful tool in studying and forecasting the environmental quality parameters. The mathematical models would be of great support in taking managerial decisions towards the mitigation and remedial measure against the environmental degradation. This course work addresses the modelling techniques for surface and ground water quality

Prerequisite

Completion of Undergraduate level courses on Environmental engineering.

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Gain an understanding of water and ground quality processes such as reaction kinetics, diffusion and eutrophication.	Understand
CO2.	Apply and evaluate the results of water and groundwater quality models such as QUAL2K, and USGS models such as MODFLOW	Apply
CO3.	Learn the basics of modeling stratified lakes and reservoir and passive turbulent diffusion plum modeling	Understand
CO4.	Sharpen problem solving skills including model calibration, validation, and verification	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	L	L	M	M	-	M	L	M	-
CO2	S	S	S	S	M	M	L	M	L	M	-
CO3	S	S	L	L	M	M	-	M	L	M	-
CO4	S	S	S	S	M	M	L	M	L	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the processes that occur as the effluent discharged into a natural stream.
2. Distinguish Deterministic and Stochastic Models
3. Describe the basic mechanism by which solute moves in groundwater?
4. Relate point estimation in water quality modeling.

Course Outcome 2 (CO2):

1. Determine velocity, area of cross section, mean depth for the river whose mean width=20 m, flow=2000 cubic metre/sec. A reach of 2 Km is considered and a dye injected in the stream travelled for 3.2 hours to pass over the reach.
2. Assume a leather industry away from Madurai, discharges its effluent at the side of vaigai river, having the characteristics of width=35m, depth=1.20m, velocity=0.8m/s and slope=0.0003. Determine (i) The length of stream needed for complete mixing and if Manning's equation holds and the channel is roughly rectangular, (ii) What is the stream's roughness and (iii) determine the longitudinal dispersion coefficient.

Course Outcome 3 (CO3):

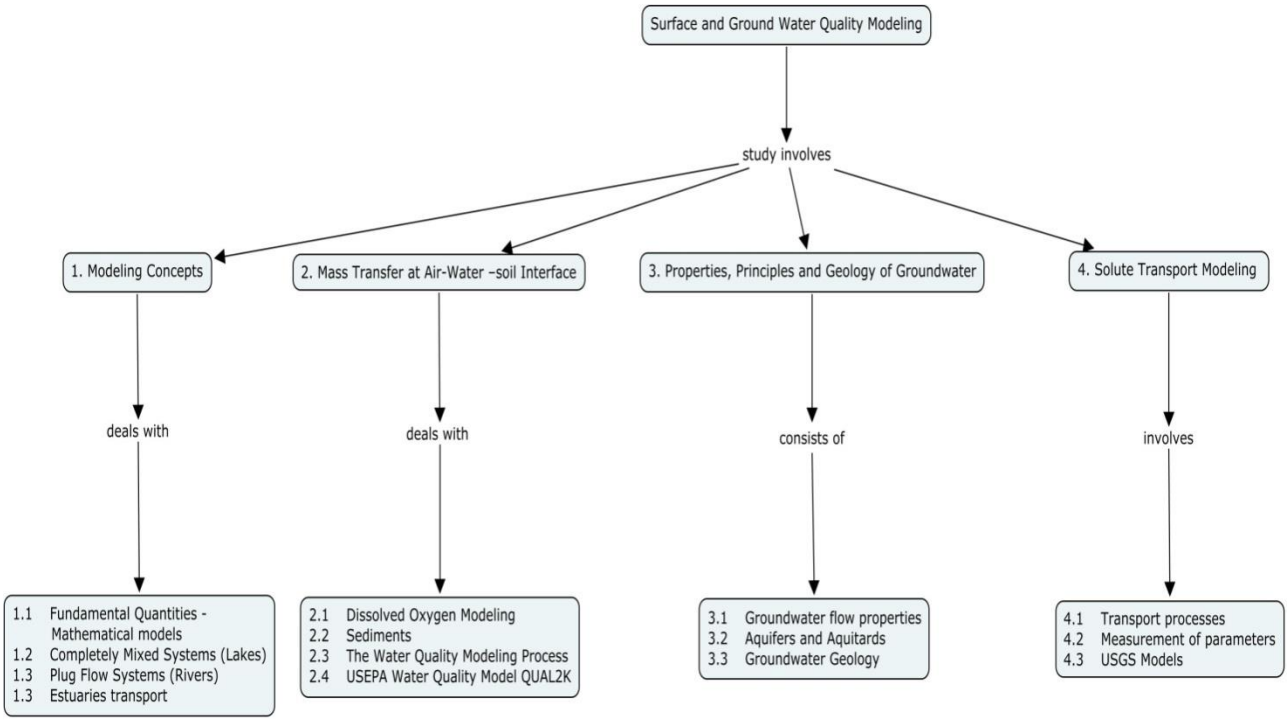
1. Explain the challenges that an Estuary poses to a water quality modeler
2. Describe Lake Morphometry
3. Demonstrate how the Monte Carlo Analysis is used in simulations?

Course Outcome 4 (CO4):

1. A metal ion is removed in groundwater by an approximately zero order precipitation reaction. If $k=2.35*10^{-8}$ mol/m^3.s and $D=10^{-8}$ m^2/s, estimate the vertical concentration profile resulting from an interface concentration of 0.75 mol/m^3 determine the acceptable loading rate for the lake.

2. A conservative contaminant is accidentally discharged to an upper lake. Assuming complete mixing estimate the time required for the concentrations entering the lower lake to reach 10 and 90 percent of the concentrations in the upper lake. Assume cross sectional area= 60 sq.m, head loss =41m, length of flow path=2200m, K=0.001m/s, porosity =0.41, Initial concentration=110g/m^3, hydrodynamic dispersion= 10^{-6} m^2/s and assume that the concentration in the upper lake remains constant, k=0.001/d.

Concept Map



Syllabus

Modeling Concepts: Introduction: Water Quality-Fundamental Quantities-Mathematical models, Historical Development of Water-Quality Models.- Basic modeling concepts - Reaction Kinetics**-**Reaction fundamentals-Analysis of Rate Data-Stochiometry-Temperature Effects**.-** Completely Mixed Systems (Lakes)- Mass Balance , Applied Loadings, Step Input, Impulse Input**.-** Plug Flow Systems (Rivers): Types, Hydrogeometry- Low-flow Analysis**.** Dispersion and Mixing -Flow, Depth and velocity-Routing and Water Quality.**-** Estuaries: Estuary transport-Net Estuarine Flow-Estuary Dispersion coefficient-Vertical Stratification. **Mass Transfer at Air-Water –soil Interface:** Dissolved Oxygen Modeling-Reaeration-Carbonaceous BOD, Nitrogenous

BOD, Photosynthesis/Algal Respiration, Benthal Demands**.-** Sediments: Sediment transport overview-Suspended Solids-the Bottom Sediments-Simple Solids Budgets-Bottom Sediments as a Distributed Systems-Resuspension**.-** The Water Quality Modeling Process- Model Sensitivity.**-** Presentations of Case Study information and USEPA Water Quality Model QUAL2K. **Properties, Principles and Geology of Groundwater:** Hydraulic head and fluid potential, Hydraulic Conductivity and Permeability, heterogeneity and Anisotropy of hydraulic Conductivity-porosity, void ratio, unsaturated flow and water table**.-** Aquifers and Aquitards-Steady state flow and Transient flow-Transmissivity and Storativiy, Equation of ground water flow-Limitation of Darcian Approach-Hydrodynamic dispersion**.-** Groundwater Geology: Lithology, Stratigraphy and Structure, FluvilalDeposits, Aeolian Deposits, Glacial Deposits, Sedimentary Rocks. **Solute Transport Modeling :** Transport processes: Non-reactive constituents in homogenous and heterogeneous media –Governing equations.-Hydrochemical behavior of contaminants-Nitrogen, trace metals organic substances.-Measurement of parameters: Determination of Velocity, Dispersivity and chemical partitioning -sources of contamination Presentation of case study-USGS Models.

Reference Books

1. Allen Free R. and John A. Cherry, " Groundwater" Printice Hall Inc. 1979
2. Steven C.Chapra, Surface Water Quality Modelling, The McGraw-Hill Companies, Inc., New Delhi, 1997.

Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
	1. Modeling Concepts	
1.1	Introduction, Water Quality-Fundamental Quantities-Mathematical models, Historical Development of Water-Quality Models.	2
1.1.1	Basic modeling concepts - Reaction Kinetics**-**Reaction fundamentals-Analysis of Rate Data-Stochiometry-Temperature Effects	2
1.2	Completely Mixed Systems (Lakes)- Mass Balance , Applied Loadings, Step Input, Impulse Input	2
1.3	Plug Flow Systems (Rivers): Types, Hydrogeometry- Low-flow Analysis	2
1.3.1	Dispersion and Mixing -Flow, Depth and velocity-Routing and	2

	Water Quality.	
1.4	Estuaries: Estuary transport-Net Estuarine Flow-Estuary Dispersion coefficient-Vertical Stratification	2
2. Mass Transfer at Air-Water –soil Interface		
2.1	Dissolved Oxygen Modeling-Reaeration-Carbonaceous BOD, Nitrogenous BOD, Photosynthesis/Algal Respiration, Benthal Demands	2
2.2	Sediments: Sediment transport overview-Suspended Solids-the Bottom Sediments-Simple Solids Budgets-Bottom Sediments as a Distributed Systems-Resuspension.	2
2.3	The Water Quality Modeling Process- Model Sensitivity.	2
2.4	Presentations of Case Study information and USEPA Water Quality Model QUAL2K	4
3. Properties, Principles and Geology of Groundwater		
3.1	Hydraulic head and fluid potential, Hydraulic Conductivity and Permeability, heterogeneity and Anisotropy of hydraulic Conductivity-porosity, void ratio, unsaturated flow and water table	2
3.2	Aquifers and Aquitards-Steady state flow and Transient flow-Transmissivity and Storativity, Equation of ground water flow-Limitation of Darcian Approach-Hydrodynamic dispersion	2
3.3	Groundwater Geology: Lithology, Stratigraphy and Structure,	1
	FluvilalDeposits, Aeolian Deposits, Glacial Deposits, Sedimentary	1
4. Solute Transport Modeling		
4.1	Transport processes: Non-reactive constituents in homogenous and heterogeneous media –Governing equations.	2
	Hydrochemical behavior of contaminants-Nitrogen, trace metals organic substances	1
4.2	Measurement of parameters: Determination of Velocity, Dispersivity and chemical partitioning -sources of contamination	2
4.3	Presentation of case study-USGS Models	3
Total Periods		**36**

Course Designer

Dr.S.Kaliappan drkaliappan@gmail.com

Category	L	T	P	Credit
PE	3	1	-	4

14ENPL0 FATE AND TRANSPORT OF CONTAMINANTS IN THE ENVIRONMENT

Preamble

To expose the fundamentals of pollutant transport mechanism to the students of environmental engineering and familiarize to chemical and thermal equilibrium at Environmental Interfaces.

Prerequisite

Completion of Undergraduate level courses on Environmental engineering.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the fundamental phenomenon of transport of pollutants in the environment specifically at the interfaces between air-water-soil.	Understand
CO2	Quantify the concentrations of pollutants at the interfaces between air and water-water and soil-air and soil.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	M	L	M	M	-	M	-	M	-
CO2	S	S	S	S	M	M	L	M	L	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

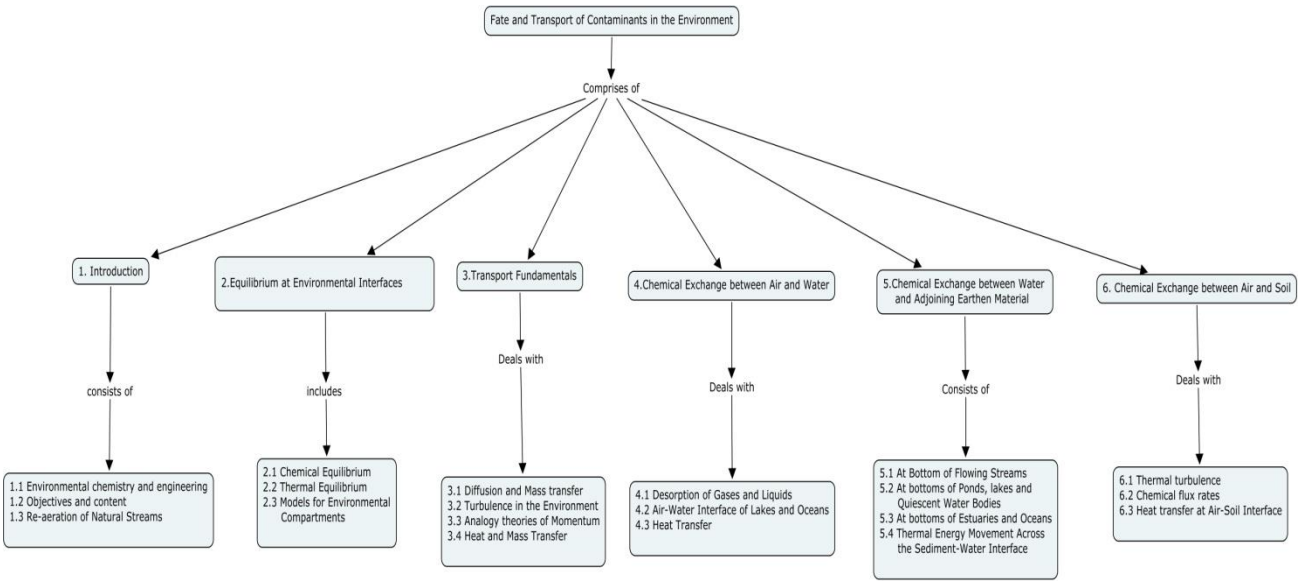
Course Outcome 1 (CO1):

1. Rederive the O_2 organic matter fate model accounting for bottom sediment oxygen demand (SOD) as a constant rate process; n A_3 in g $O_2/m^2.s$
2. Estimate the equilibrium concentration of benzene in the water filled pore space within a landfill cell containing an oily sludge with 1400 ppm (wt) benzene at 25 degree Celsius. Assume that M_4=111 g/mol, since benzene probably forms an ideal solution in the sludge.

Course Outcome 2 (CO2):

1. Estimate the solubility (g/m^3) of ethane in water at 25 degree Celsius if it is present above water as a pure gas at 1 atm pressure?
2. Calculate the equilibrium concentrations in water (mg/l) for the gas mixture; 75 vol % vinyl chloride 25% ethane at 25 degree Celsius. The solubility of vinyl chloride is 30.6 mg/l at 25 degree Celsius. Is the water mixture a dilute solution?

Concept Map



Syllabus

Introducion: Introduction to environmental chemistry and engineering-Illustration of objectives and content: Reaeration of Natural Streams. **Equilibrium at Environmental Interfaces:**Chemical Equilibrium at Environmental Interfaces- Thermal Equilibrium at Environmental Interfaces- Chemical Equilibrium models for Environmental Compartments. **Transport Fundamentals** :Diffusion and Mass transfer - turbulence in the Environment-Fundamentals of Heat Transfer. Analogy theories of

Momentum, Heat and Mass Transfer-Particles and Porous Media.**Chemical Exchange between Air and Water** :Desorption of Gases and Liquids from Aerated Basins and Rivers- Exchange of Chemicals Across the Air-Water Interface of Lakes and Oceans-Heat Transfer Across the Air-Water interface. **Chemical Exchange between Water and Adjoining Earthen Material:** Chemical Transport at Bottom of Flowing Streams-Chemical Movement at bottoms of Ponds, lakes and Quiescent Water Bodies- Chemical Movement at bottoms of Estuaries and Oceans-Thermal Energy Movement Across the Sediment-Water Interface. **Chemical Exchange between Air and Soil**: Thermal turbulence Above Air-Soil Interface- Chemical flux rates Through upper layer of Earthen material-Heat transfer at Air-Soil Interface.

Reference Books

1. Clark, M. M. “Transport Modeling for Environmrntal Engineers and Scientist” John Wiley & SonsInc., New York.,1996
2. Louis J. Thibodeaux “Environmental Chemodynamics: Movements of Chemicals in Air, Water and Soil” John Wiley & Sons, Inc. New York., 1996

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
1. Introduction		
1.1	Introduction to environmental chemistry and engineering	1
1.2	Illustration of objectives and content	1
1.3	Re-aeration of Natural Streams	1
2. Equilibrium at Environmental Interfaces		
2.1	Chemical Equilibrium at Environmental Interfaces: Air-water;	2
2.1.1	Water-soil; soil-Air	1
2.2	Thermal Equilibrium at Environmental Interfaces: Air-water;	2
2.2.2	Water-soil; soil-Air	1
2.3	Chemical Equilibrium models for Environmental Compartments	2
3. Transport Fundamentals		
3.1	Diffusion and Mass transfer	1
3.2	Turbulence in the Environment-Fundamentals of Heat Transfer	2
3.3	Analogy theories of Momentum	2
3.4	Heat and Mass Transfer-Particles and Porous Media	1
4. Chemical Exchange between Air and Water		
4.1	Desorption of Gases and Liquids from Aerated Basins and Rivers	2
4.2	Exchange of Chemicals Across the Air-Water Interface of	2

	Lakes and Oceans	
4.3	Heat Transfer Across the Air-Water interface	1
5. Chemical Exchange between Water and Adjoining Earthen Material		
5.1	Chemical Transport at Bottom of Flowing Streams	2
5.2	Chemical Movement at bottoms of Ponds, lakes and Quiescent Water Bodies	2
5.3	Chemical Movement at bottoms of Estuaries and Oceans	2
5.4	Thermal Energy Movement Across the Sediment-Water Interface	2
6. Chemical Exchange between Air and Soil		
6.1	Thermal turbulence Above Air-Soil Interface	2
6.2	Chemical flux rates through upper layer of Earthen material	2
6.3	Heat transfer at Air-Soil Interface	2
Total		**36**

Course Designer

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		Category	L	T	P	Credit
14ENPM0	**AIR QUALITY MODELLING**	PE	3	1	-	4

Preamble

To expose the students in the field of air quality modelling and understand the fundamentals of meteorology and dispersion phenomena of air in the environment and to develop the skill for modelling with different plume dispersion models.

Prerequisite

Basic course on air pollution control engineering.

Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Understand the meteorology and its relationship with transport of air pollutants.	Understand
CO2.	Develop or formulate governing equation for atmospheric pollutant transport processes.	Apply
CO3.	Apply air quality models such as ISC-3,CALINE for point source and line source air pollutants dispersion and simulate its concentration	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	L	L	M	M	-	M	-	L	-
CO2	S	S	S	S	M	M	L	M	-	-	-
CO3.	S	S	S	S	S	M	-	M	L	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List the important aspects of Air pollution meteorology?
2. Describe Aloft pressure and aloft pressure surface.
3. Outline the factors affecting the dispersion of atmospheric pollutants and the merits and demerits of Gaussian model that predicts pollutant dispersion.

Course Outcome 2 (CO2):

1. Determine the centre line concentration of SO_2, at distances 750m, 1.50 km, 3.5 km and 5 km downwind, emitted from a power plant whose effective height is 160m and burns about 15 tons of coal containing 4% of sulfur for the following conditions,
    a. Time=8.00 am.
    b. Surface Wind Speed=2.9m/s
    c. Sun Angle=21 degrees
    d. Cloud Condition=clear
2. Estimate the concentration of carbon monoxide at the downwind edge of a city. The city may be considered to consist of three parallel strips, located perpendicular to the wind. For all of the strips the wind velocity *u* equals 3 m/s. The properties of each of the strips are described in the following table:

Name of strip	Length, km	Emission rate, q, g/s · km^2	Mixing height, H, m
Upwind suburbs	5	100	400
Downtown	2	500	500
Downwind suburbs	5	100	400

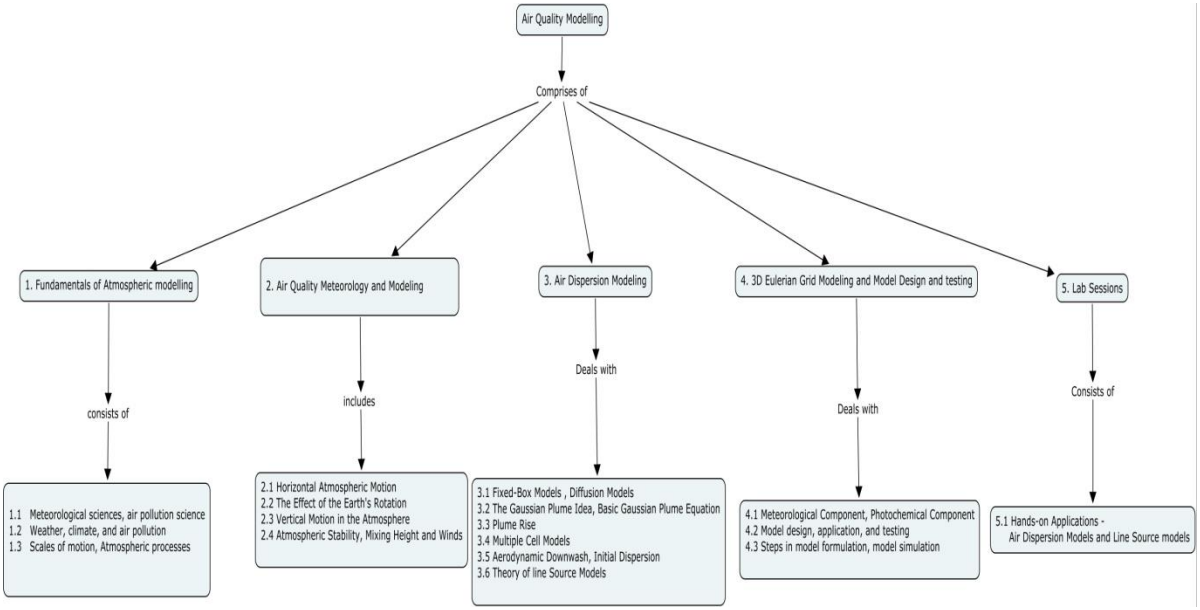
Assume that the fixed-box model applies to each of the strips. The background concentration *b* in the air entering the upwind suburbs is I mg/m^3.

3. A ground-level source (H = 0) is emitting pollutants at an unknown rate. At 1 km directly downwind of the source the measured ground-level concentration of the pollutant is I 0 µg/m^3 the stability category is A. Estimate the emission rate of this source.

Course Outcome 3 (CO3):

1. A terrorist releases 1000 g of nerve gas as a single instantaneous emission at ground level at point $x = y = z = 0$, at time $t = 0$. The wind speed is 3 m/s and the stability class is C and the mixing height, *L,* is 2000 m. Estimate the maximum instantaneous value of the nerve gas concentration that would be observed at a point *5* km directly downwind of the emission point (x = *5* km, $y = z = 0$).
2. A power plant emits 100 g/s of NO, from a stack with physical stack height 100 m and plume rise 150m. The stability category is C and the wind speed 2 m/s.
   (a) What is the estimated maximum ground-level concentration of NO, due to this source?
   (b) How far downwind of the source does the maximum occur?
   (c) If the wind speed is not necessarily fixed at 2 m/s but is taken as a variable, then there is some wind speed that causes the highest estimated ground-level concentration of NO, What is that wind speed?
3. A smelter is located near an airport. The smelter stack is 300m high and has a plume rise of 100 m. It is emitting 5000 gls of SO_2 Assume that the stability class is always C, and that the wind speed is always 3 m/s.
4. The flight path for the airport is perpendicular to the plume and 5 km downwind of the smelter. The airport safety office has determined that it is unsafe for planes to go through any portion of the plume that has an average SO_2 concentration higher than 500 11g/m^3. They have also decided that flying under the plume is unsafe, so the planes must always fly over it. What is the minimum altitude at which they can fly under these circumstances and not be exposed to SO_2 concentrations greater than or equal to 500 µg/m^3?

Concept Map



Syllabus

Fundamentals of Atmospheric Modeling: Brief history of meteorological sciences-Brief history of air-pollution science- The merging of air-pollution and meteorological sciences-Weather, climate, and air pollution-Scales of motion-Atmospheric processes **Air Quality Meteorology and Modeling:** The Atmosphere-Horizontal Atmospheric Motion -Equatorial Heating, Polar Cooling -The Effect of the Earth's Rotation-The Influence of the Ground and the Sea-Vertical Motion in the Atmosphere -Air Density Change with Temperature and Humidity -Air Density Change with Pressure -Atmospheric Stability-Mixing Height-Moisture -Winds -Velocities -Wind Direction. **Air Dispersion Modeling:** Fixed-Box Models -Diffusion Models -The Gaussian Plume Idea -Gaussian Plume Derivation Some Modifications of the Basic Gaussian Plume Equation -Plume Rise -Long-Term Average Uses of Gaussian Plume Models -Pollutant Creation and Decay in the Atmosphere -Multiple Cell Models -Receptor-Oriented and Source-Oriented Air Pollution Models -Other Topics -Building Wakes -Aerodynamic Downwash -Transport Distances -Initial Dispersion EPA-Recommended Models-theory of line Source Models-BLP-CALINE3-CAL3 CTDMPLUS-OCD. **3D Eulerian Grid Modeling and Model Design and testing:** Meteorological Component - Photochemical Component- Application and Analysis.Model design, application, and testing:Steps in model formulation-Example model

simulation. **Lab Sessions:** Hands-on Applications for real World Problems Using USEPA Air Dispersion Models and Line Source models.

Reference Books

1. Mark Z. Jacobson, "Fundamental of Atmospheric Modeling" Gambridge University Press,2005
2. Noel de Nevers, " Air Pollution Control Engineering, 2nd ed.2000
3. Paolo Zannetti, EnviroComp/A&WMA, "Air Quality Modeling Vol.I-III

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
1. Fundamentals of Atmospheric Modeling		
1.1	Brief history of meteorological sciences, air pollution science	1
1.2	The merging of air-pollution and meteorological sciences-Weather, climate, and air pollution	2
1.3	Scales of motion, Atmospheric processes	2
2. Air Quality Meteorology and Modeling		
2.1	The Atmosphere, Horizontal Atmospheric Motion , Equatorial Heating, Polar Cooling	2
2.2	The Effect of the Earth's Rotation, The Influence of the Ground and the Sea	1
2.3	Vertical Motion in the Atmosphere , Air Density Change with Temperature, Humidity and Pressure	2
2.4	Atmospheric Stability, Mixing Height, Moisture, Winds Velocities Wind Direction.	2
3. Air Dispersion Modeling		
3.1	Fixed-Box Models , Diffusion Models	1
3.2	The Gaussian Plume Idea, Gaussian Plume Derivation Some Modifications of the Basic Gaussian Plume Equation	2
3.3	Plume Rise , Long-Term Average Uses of Gaussian Plume Models, Pollutant Creation and Decay in the Atmosphere	2
3.4	Multiple Cell Models, Receptor-Oriented and Source-Oriented Air Pollution Models, Other Topics, Building Wakes	2
3.5	Aerodynamic Downwash, Transport Distances, Initial Dispersion, EPA-Recommended Models	1
3.6	Theory of line Source Models-BLP-CALINE3-CAL3-	2

	CTDMPLUS-OCD.	
4. 3D Eulerian Grid Modeling and Model Design and testing		
4.1	Meteorological Component, Photochemical Component, Application and Analysis.	2
4.2	Model design, application, and testing	2
4.3	Steps in model formulation, Example model simulation	2
5. Lab Sessions		
5.1	Hands-on Applications for real World Problems Using US-EPA Air Dispersion Models and Line Source models.	8
Total		**36**

Course Designer

Dr.S.Kaliappan drkaliappan@gmail.com

		Category	L	T	P	Credit
14ENPN0	**SUSTAINABLE MANAGEMENT OF URBAN ECOLOGY**	PE	4	-	-	4

Preamble

This course provides an overview of, and engagement with, various theoretical perspectives, debates and research practices in urban ecology, urban ecosystems, and urban sustainability. At the intersection of increasing urbanization and ecological crises, there has been an intense theoretical debate on how to understand and research urban nature and urban ecology in a sustainable manner. This course work covers the concept of sustainable management especially in the urban environment. It also explains the various environmental issues in an urban scenario and its impacts on ecology. It provides exposure to various issues in the management of urban water resources and wastewater. The future of Urban ecosystems and managing the climate change through the concept of future proofing is also addressed in the course work.

Prerequisite

Basic knowledge on Ecology, Environment, Water resources and wastewater engineering.

Course Outcomes

On the successful completion of the course, students will be able to:

CO1	Understand the concept of sustainable development in the urban perspective	Understand
CO2	Introduce the concept of urban ecology and its framework	Understand
CO3	Apply the Urban water management tools and models	Apply
CO4	Understand the present scenario and introduce eco friendly techniques to manage the wastewater	Understand
CO5	Design the future urban ecosystems keeping the climate change as a constraint	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	S	L	L	S	M	L	M	S	M
CO2	S	S	S	M	M	M	M	L	M	S	M
CO3	S	S	S	S	S	S	M	M	M	S	S
CO4	S	S	S	S	S	S	M	M	M	S	S
CO5	S	S	S	S	S	S	S	M	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	80	50	50	50
Apply	-	30	30	30
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the Principles of Sustainable Development.
2. List the Millennium Development Goals.
3. Discuss the economic dimensions of Urban sustainability.
4. Explain the Ecological Foot Print.

Course Outcome 2 (CO2):

1. Discuss the various theories of Urban Ecology.
2. Describe concept of Ecocity
3. Distinguish: Smart City and Compact city
4. Demonstrate the Urban Ecological Framework with a case study .

Course Outcome 3 (CO3):

1. Draw the Urban Water Cycle.
2. Define: IWRM
3. List the applications of IWRM
4. Apply the concept of IWRM to your city and comment on the outcome.
5. Solve the Interstate water disputes using IWRM concept.

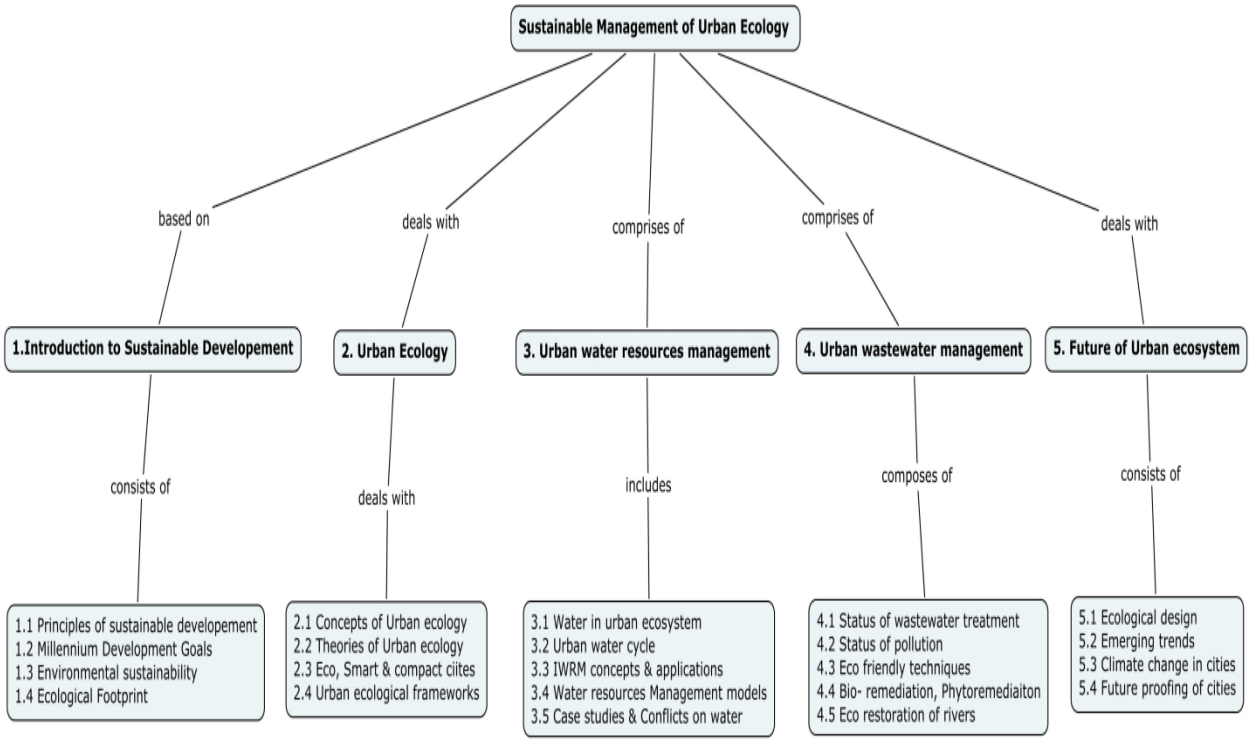
Course Outcome 4 (CO4):

1. Sequence the status of wastewater generation, collection, treatment and disposal
2. in the country.
3. Describe the impacts of improper disposal sewage on eco system
4. Differentiate: Bio Remediation and Phytoremediation.
5. Illustrate a Eco restoration of river project in India.

Course Outcome 5 (CO5):

1. Discuss the emerging trends and Technologies in Urban ecology.
2. Produce the results of Future Proofing Cities done for Madurai city and comment on it.
3. How to adapt the climate change impacts in Cities?
4. Write components of Ecological Design.

Concept Map



Syllabus

Introduction to Sustainable Development: Definitions and principles of Sustainable Development –Environment and Development linkages –Millennium Development Goals **Environmental Sustainability:** Planning, Measuring Sustainability - Carrying Capacity and its limits - Social Capital and its limits- Urban sustainability, Social, Economic , Ecological dimensions, Concept of Ecological Foot print **Urban Ecosystem** Concepts and theories of urban ecology**-** Linkages with sustainable urbanism – Concepts of Eco cities, smart cities, compact cities- Urban Ecosystem Challenges and opportunities – Urban areas and ecological services, Urban Ecological Frameworks **Urban water resources management:** Water in urban ecosystem – Urban Water Cycle - storm water management practices – Water harvesting Structures – IWRM concepts and applications to Urban Water management - Integrated urban water

planning– Water Resources management models and Water policy of Developed nations- National water Policy -Conflicts on water between Interstate and country – water Pricing – Case studies **Urban wastewater management:** Status of Wastewater treatment and disposal, pollution in India – Impacts on ecosystem, Eco friendly treatment systems- concept of decentralization – Bio remediation, Phytoremediation- Wastewater management policy and models of Developed nations– eco restoration of rivers – Case studies. **Futures of Urban Ecosystems** Scenario Planning and Adaptive Management, Ecological Design, Emerging Trends and Technologies, Integrated Models, Climate modifications and managing climate change challenges in cities, Adaptation and mitigation measures to make cities resilient Future proofing of cities.

Reference Books

1. Neil S. Grigg., "Urban Water Infrastructure Planning – Management and Operations", John Wiley and Sons, 1986.
2. Philip James, Jari Niemelajurgen H . Breuste "Urban Ecology: Patterns, Processes and Applications", OUP Oxford, 2011.
3. Tracer Strange and Anne BAley ,"Sustainable Development –Linking economy,Society , environment" , StatLink from OECD Publishing 2008.
4. UNU/IAS Report ,"Defining an Ecosystem Approach to Urban Management and Policy Development" March 2003 .
5. Zhifeng Yang "Eco- Cities: A Planning Guide (Applied Ecology and Environmental Management)" CRC Press, 2012.

Course Contents and Lecture Schedule

S.No	Topics	No of Lectures
1. Introduction to Sustainable Development		
1.1	Definitions and principles of Sustainable Development	2
1.2	History and emergence of the concept of Sustainable Development	1
1.3	Environment and Development linkages	1
1.4	Globalization and environment- Millennium Development Goals: Status (global and Indian)	1
1.5	Environmental Sustainability Planning Measuring Sustainability - Carrying Capacity And its Limits	1
1.6	Social Capital And its Limits	1
1.7	Introduction to urban sustainability	1
1.8	Social dimensions, Economic dimensions, Ecological dimensions	1
1.9	Physical aspects	1
1.10	Concept of Ecological Foot print.	2

2. Urban ecology		
2.1	Concepts and theories of urban ecology and linkages with sustainable urbanism	2
2.2	Concepts of Eco cities, smart cities, compact cities etc.	2
2.3	Urban Ecosystem Challenges and opportunities of urban, rural and periurban growth,	2
2.4	Processes in human population growth, urbanization and implications for urban ecology	2
2.5	Urban areas and ecological ecosystem services	1
2.6	Urban Ecological Frameworks, the principles and frameworks of ecology	1
2.7	Environmental perspectives on Urban master plans	1
2.8	Institutions working on Water, Environment- National/International levels	1
3. Urban water resources management		
3.1	Water in urban ecosystem	1
3.2	Urban Water Cycle	1
3.3	Urban water resources planning and organization aspects	1
3.4	Rainfall- runoff- Groundwater Recharge in urban regions	1
3.5	Storm water management practices storage capacity of urban components	1
3.6	Water harvesting Structures	1
3.7	IWRM – concepts and applications to Urban Water management and Distribution	1
3.8	Integrated urban water planning	1
3.9	Water Resources management models and Water policy of Developed nations	1
3.10	Case studies -Conflicts on water- Interstate/ country – water Pricing	1
4. Urban wastewater management		
4.1	Status of Wastewater treatment and disposal on India/ developed nations	1
4.2	Status of pollution	1
4.3	Eco friendly treatment systems-concept of decentralization	2
4.4	Bio remediation, Phytoremediation	1
4.5	Wastewater management policy and models of Developed nations- Case studies	1
4.6	Case study on restoration of rivers	1

5. Futures of Urban Ecosystems		
5.1	Scenario Planning and Adaptive Management	1
5.2	Ecological Design, Emerging Trends and Technologies	2
5.3	Integrated Models, Climate modifications and managing climate change challenges in cities,	2
5.4	Adaptation and mitigation measures to make cities resilient Future proofing of cities	2
	Total periods	**48**

Course Designer

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