International Association Of Certified Practicing Engineers	IACPE INTERNATIONAL ASSOCIATION OF CERTIFIED PRACTICING ENGINEERS **Knowledge, Certification, Networking** **www.iacpe.com**	**Page : 1 of 90** **Rev: 01** **Rev 01-May 2016**
	INTRODUCTION TO ENVIRONMENTAL ENGINNERING **CPE II TRAINING MODULE**	

The International Association of Certified Practicing Engineers is providing the introduction to the Training Module for your review.

We believe you should consider joining our Association and becoming a Certified Practicing Engineer. This would be a great option for engineering improvement, certification and networking.

This would help your career by

1. **Providing a stands of professional competence in the practicing engineering and management field**
2. **Identify and recognize those individuals who, by studying and passing an examination, meets the standards of the organization**
3. **Encorage practicing engineers and management professionals to participate in a continuing program of personal and professional development**

www.IACPE.com

TABLE OF CONTENT

INTRODUCTION 5

Scope 5

General Design Consideration 6

DEFINITIONS 19

NOMENCLATURE 22

THEORY OF THE DESIGN 23

Water Pollution 23

Air Pollution 33

Mitigating air and water pollution 43

Solid Waste Management 46

Noise Pollution 56

Hazardous Waste Management 65

Industrial Waste Management 73

REFEREENCES 86

LIST OF TABLE

Table 1: The pollutant levels of the national primary and secondary ambient air quality standards 11

Tabel 2: Overview of environmental burdens and major impact categories 12

Table 3: Gaseous Composition of Unpolluted Air (dry basis) 33

Table 4: Air Pollution Emissions and Controls: Petrochemical Processes 39

Table 5: Comparison of Particulate Removal Systems 41

Table 6: Ultimate Waste Disposal Methods 44

Table 7: Typical waste sources and types 46

Table 8: Common physical and chemical characteristics of solid wastes 47

Table 9: Noise Levels from Common Sources 57

Table 10: Range of community noise levels 58

Table 11: Range of industrial plant noise levels at operator's position 58

Table 12: The typical sound pressure levels 60

Table 13: Applications of Noise Control Techniques 65

Table 14: Major contaminants—industrial source and effect 73

Table 15: Major physical, chemical, and biological treatment unit operations and processes used for liquid treatment 76

Table 16: Summary of industrial wastes from major food industry 79

Table 17: Summary of industrial wastes from several major operations in pulp and paper industry 80

Table 18: Summary of industrial wastes from several major chemical industries 82

Table 19: Summary of wastes generated from various oil refinery operations 83

Table 20: Origin, characteristics, and treatment of wastes in four major metal industries 84

LIST OF FIGURE

Figure 1: Waste minimization techniques 9
Figure 2: Waste minimization assessment procedures 10
Figure 3: The hydrologic or water cycle 24
Figure 4: Block diagram of a complete wastewater treatment plant 30
Figure 5: Waste water treatment plant overview 33
Figure 6: Wet-wall electrostatic precipitator with tubular collection electrodes for air control 42
Figure 7: Venturi scrubber system 43
Figure 8: Integrated management of municipal solid wastes 48
Figure 9: The flow of incineration process 54
Figure 10: Sanitary Landfill 56
Figure 11: Simplified hazardous waste characterization logic diagram 68
Figure 12: Features of a deep-well injection system 72

INTRODUCTION

General Design Consideration

Environmental engineering is the application of science and engineering principles to protect and utilize natural resources, control environmental pollution, improve environmental quality to enable healthy ecosystems and comfortable habitation of humans.

Environmental engineering is essential for development of facilities for protection of the environment and for the proper management of natural resources. The environmental engineer places special attention on the biological, chemical, and physical reactions in the air, land, and water environments and on improved technology for integrated management systems, including reuse, recycling, and recovery measures. Environmental engineering is based on multiple disciplines including geology, hydrology, biology, chemistry, physics, medicine, engineering, management, economics, law, and others.

Environmental engineering activities involve water supply, waste water management, solid waste management, air pollution control, noise pollution control, radiation protection, environmental sustainability, public health issues, environmental impact assessment, hazardous-waste management, treatment of contaminated land, hazard prevention and mitigation, climate change adaptation and mitigation, renewable energy, and others.

Environmental engineering is divided into two types: natural environment and built environment. The natural environment encompasses all living and non-living things occurring naturally in the area. The built environment refers to the human-made surroundings that provide the setting for human activity (e.g., buildings, parks, cities and supporting infrastructure such as transport, water supply and energy supply).

The principal environmental engineering specialties are well established: air quality control, water supply management, wastewater disposal, storm water management, solid waste management, and hazardous waste management. Other specialties include industrial hygiene, noise control, oceanography, and radiology.

There are four spheres on the Earth that are of interest to environmental engineering, which are referred to as the lithosphere (the rigid outermost shell of the earth), the hydrosphere (water on, under, and over the surface of the Earth), the atmosphere (a layer of gases surrounding the Earth), and the biosphere (sum of living organisms on the Earth).

They are combined to become the ecosphere and can be remembered easily as corresponding to rocks, water, air, and life.

Sustainable engineering is the design of man-made systems to ensure the current uses of natural resources do not lead to diminished quality of life of future generations. For engineers, ‘design’ is the key word’ here. Green engineering is to design, discover and implement engineering solutions with an awareness of potential benefits and problems in terms of environment, economy and society (three pillars of sustainability) throughout the design lifetime. The goal is to minimize adverse impacts (e.g., water use inefficiency, depletion of finite materials and energy resources, urban congestion, water and air pollution, degradation of environment) while simultaneously maximizing benefits to the economy, society and environment.

The principles of green engineering as outlined by Anastas and Zimmerman include

1. Inherent Rather Than Circumstantial (Designers need to strive to ensure that all materials and energy inputs and outputs are as inherently nonhazardous as possible);
2. Prevention Instead of Treatment (It is better to prevent waste than to treat or clean up waste after it is formed);
3. Design for Separation (Separation and purification operations should be designed to minimize energy consumption and materials use);
4. Maximize Efficiency (Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency);
5. Output-Pulled Versus Input-Pushed (Products, processes, and systems should be “output pulled” rather than “input pushed” through the use of energy and materials);
6. Conserve Complexity (Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition);
7. Durability Rather Than Immortality (Targeted durability, not immortality, should be a design goal);
8. Meet Need, Minimize Excess (Design for unnecessary capacity or capability (e.g., “one size fits all”) solutions should be considered a design flaw);
9. Minimize Material Diversity (Material diversity in multicomponent products should be minimized to promote disassembly and value retention);

10. Integrate Material and Energy Flows (Design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows);
11. Design for Commercial “Afterlife” (Products, processes, and systems should be designed for performance in a commercial “afterlife”);
12. Renewable Rather Than Depleting (Material and energy inputs should be renewable rather than depleting).

Waste minimization (pollution prevention) practices are not only intended to protect and improve human health and the environment but also are means to reduce costs, build community relations, demonstrate environmental leadership, and reduce the impacts of state and federal requirements.

Waste minimization consists of source reduction and recycling, which consist of a number of practices and approaches, as illustrated in Figure 1. Source reduction usually is preferable from an environmental protection perspective. The waste minimization assessment procedure, illustrated in Figure 2

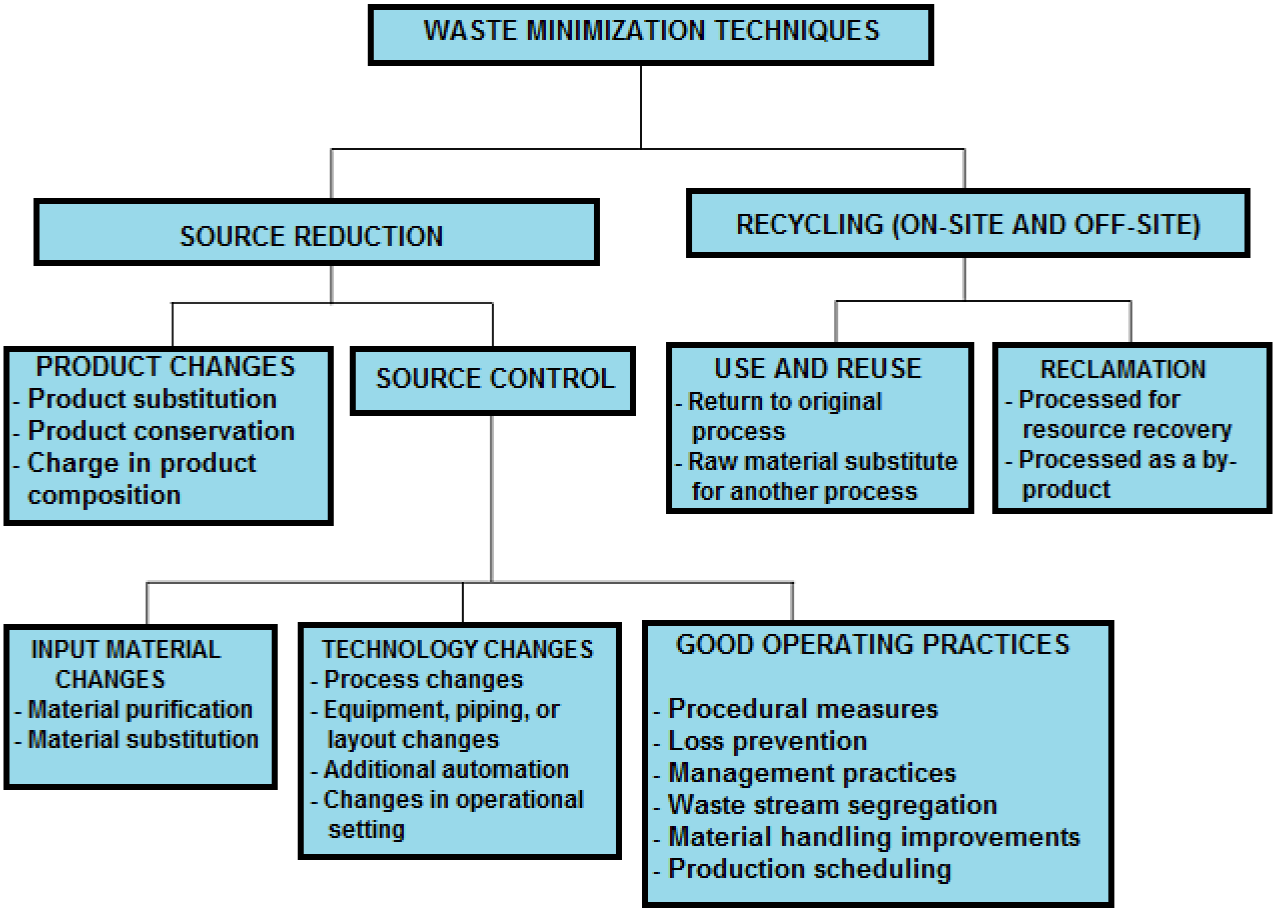

Figure 1: Waste minimization techniques (Corbitt, 2004)

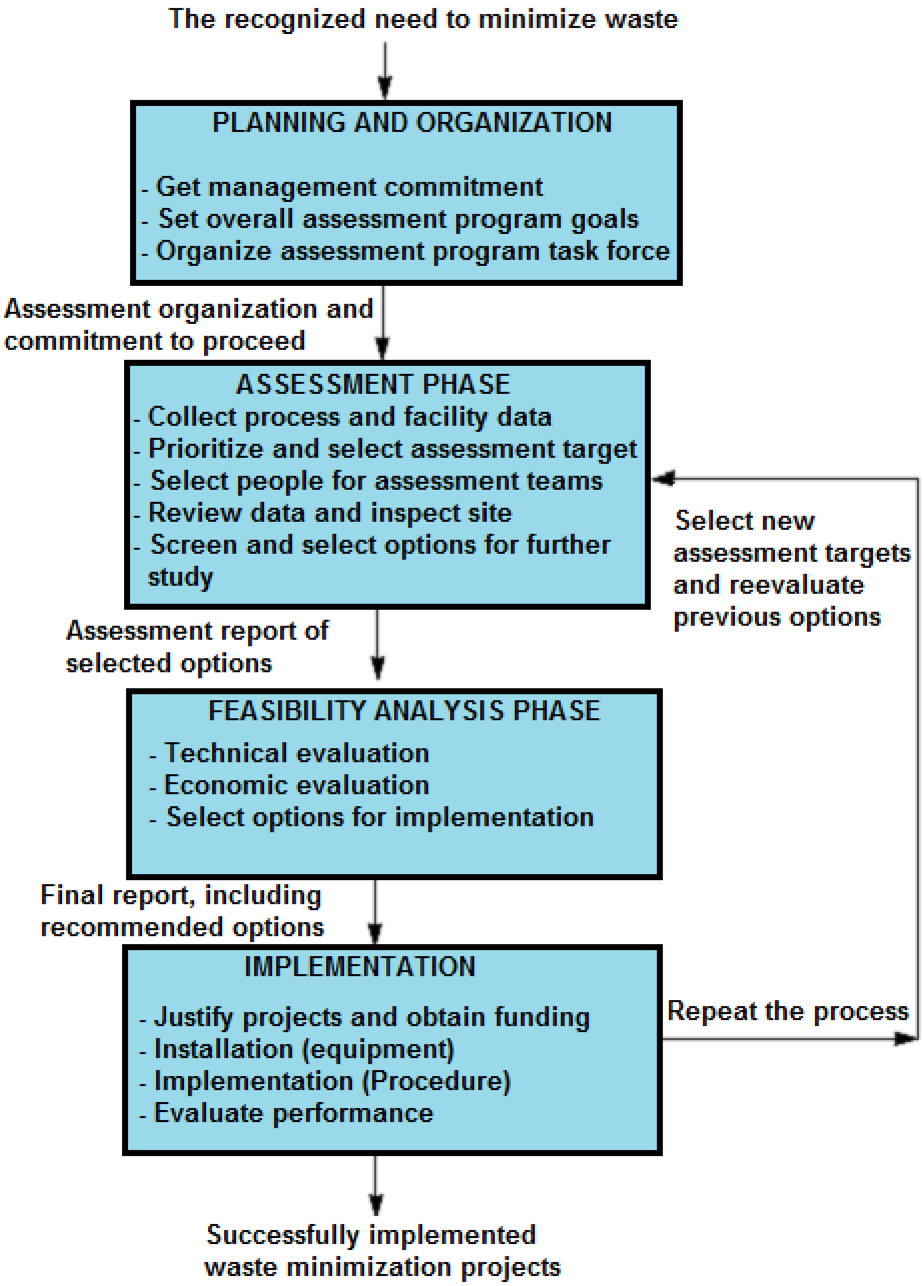

Figure 2: Waste minimization assessment procedures (Corbitt, 2004)

Air Quality Standard

The United States Congress mandated that the USA EPA promulgate national ambient air quality standards as maximum levels of selected pollutants that would lead to unacceptable air quality. These numerical standards were to be based on background studies that included control technology, costs, energy requirements, emission reduction benefits, and environmental impacts. The national primary ambient air quality standards are judged necessary, with an adequate margin of safety, to protect public health. Secondary standards were developed to protect the public welfare from any known or anticipated adverse effects of a pollutant, such as impaired vision or damage to buildings and lifeforms. The pollutant levels of the national primary and secondary ambient air quality standards are presented in Table 1. The reference condition for these standards is a temperature of 25°C and a pressure of 760 mmHg.

Table 1: The pollutant levels of the national primary and secondary ambient air quality standards (Corbitt, 2004)

Pollutant	Air Quality Standard		
Sulfur Dioxide			
Primary	80 μg/m³	0.03 ppm	Annual arithmetic mean
	365 μg/m³	0.14 ppm	Maximum 24-h concentration not to be exceeded more than once per year
Secondary	1300 μg/m³	0.5 ppm	Maximum 3-h concentration not to be exceeded more than once per year
Particulate Matter			
PM2.5	150 μg/m³	-	Annual arithmetic mean, 3-year averaging, spatial averaging
	65 μg/m³	-	24-h 98th percentile, 3-year averaging, at each monitor
PM10	50 μg/m³	-	Annual arithmetic mean
	150 μg/m³	-	24-h 99th percentile, averaged over 3 years
Carbon Monoxide			
Primary and secondary	10,000 μg/m³	9 ppm	8-h average concentration not to be exceeded more than once per year
	40,000 μg/m³	35 ppm	1-h average concentration not to be

Pollutant	Air Quality Standard		
			exceeded more than once per year
Ozone Primary and secondary	157 µg/m³	0.08 ppm	8-h average concentration, 3-year average of annual fourth-highest daily maximum 8-h average
Nitrogen dioxide Primary and secondary	100 µg/m³	0.53 ppm	Annual arithmetic mean
Lead Primary and secondary	1.5 µg/m³	-	Maximum arithmetic mean averaged over a calendar quarter

Table 2: Overview of environmental burdens and major impact categories (Kreider 1999)

Burdens	Impacts						
	Extent		Environment				
	Space	Time	Climate	Health	Natural	Agricultural	Man-made
Primary air-pollutants							
CO2	G	P, F	X				
CH4	G	P, F	X				
Other greenhouse gases	G	P, F	X				
Particulates	R	P		X			X
SO2	R	P		X	X	X	X
NOx	R	P		X	X	X	X
CO	R	P		X			
Heavy metals (Pb, Hg, Cd, É)	R	P, F		X	X		
Toxic organic compounds (e.g., dioxins)	R	P, F		X	X		
VOC (volatile organic compounds, etc.)	R	P		X			
Secondary air pollutants							
O3 (from NO + VOC)	R	P	X	X	X		
Acid rain (from NO, SO)	R	P		X	X	X	X
Aerosols (from NO, SO, etc.)	R	P	X	X	X	X	X
Liquid residues							
Heavy metals (Pb, Hg, Cd, É)	L, R	P, F		X	X		

Burdens	**Impacts**						
	Extent		**Environment**				
	Space	**Time**	**Climate**	**Health**	**Natural**	**Agricultural**	**Man-made**
Toxic organic compounds (e.g., dioxins)	L, R	P, F		X	X		
COD (chemical oxygen	L, R	P, F		X	X	X	
demand)	L, R	P, F		X	X	X	
BOD (biological oxygen demand)	L	P, F		X	X		
Solid residues	L	P					
Other	L	P					
Thermal							
Noise, odor							

Impacts:
X = potentially important; blank = usually not important.
Extent:
L = local (up to tens of kilometers); P = present generation; R = regional (hundreds to thousands of kilometers); G = global; F = future generations.

The first step in evaluating the environmental impact of a project's alternatives is to inventory factors that may be affected by the proposed action. Existing conditions are measured and described, but no effort is made to assess the importance of a variable. Any number and many kinds of variables may be included, such as:

1. the "ologies": hydrology, geology, climatology, anthropology, and archaeology;
2. environmental quality: land, surface and subsurface water, air, noise, and transportation impacts;
3. plant and animal life;
4. economic impact on the surrounding community: number of jobs, average family income, etc.;
5. analysis of the risks to both people and the natural environment from accidents that may occur during the life of the project; and
6. other relevant socioeconomic parameters, like future land use, expansion or diminution of the population of urban areas and exurbs, the impacts of nonresident populations, and environmental justice considerations.

The American Public Health Association Committee on the environment proposed the following program areas and also the planning considerations, and methods to implement programs.

- Environmental Program Area: Wastes (Air, Sewage and liquid, Solid), Water Supply, Housing and Residential Environment, Food and Drugs, Radiation, Noise, Accidents, Occupational and Institutional Hazards, Vectors, Recreation
- Planning Considerations: Health, Economic, Demographic and Land Use, Social, Esthetic, Resource Conservation (Also manpower, facilities, and services.)
- Methods and Technics: Research, Demonstration, Education, Standards, Legislation, Inspection, Enforcement, Planning, Evaluation, Incentives, Systems Analysis

Human society and the environment interact with each other. Human impacts (i.e., anthropogenic impacts) on the environment refer to the impacts of human activities on biophysical environments, biodiversity and other resources.

Those activities include (Han 2012);

1. agricultural practices (deforestation, genetically modified food, agricultural chemicals, soil degradation, agricultural plastics),
2. fishing (overfishing, ecological disruption, by-catch),
3. irrigation (soil salination, reduced river discharge, evaporation, withdraw of groundwater, drainage),
4. livestock production (pollution, fossil fuels, water and land consumption),
5. energy industry (climate change, biofuel use, fossil fuel use, electricity generation, renewable energy),
6. manufacturing (cleaning agents, nanotechnology, paint, pesticides, pharmaceuticals and personal care products),
7. mining (erosion, sinkholes, loss of biodiversity, contamination of soil, contamination of groundwater and surface water),
8. transport (use of fossil fuels, air pollution, emission of carbon dioxide, traffic congestion, invasion of natural habitat and agricultural lands)

Water Quality Standards

Standards of stream water quality were required to be established while considering their use and value for public water supplies; propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other legitimate uses. The ideal drinking water quality standards should be based on health and risk assessment information (i.e., how much of the contaminant may be present with no adverse health effects). However, costs and availability of technology are usually considered for legally enforced standards (cost benefit analysis and available technology). The purposes of water quality standards are to protect the public health or welfare and enhance the quality of water consistent with the designated water uses.

Water quality standards are usually based on one of two primary criteria: stream standards or effluent standards. Stream standards are based upon receiving-water quality concentrations. These standards are determined from threshold values of specific pollutants. The waste being discharged into a stream must not cause the pollutant concentration to exceed the threshold value.

Effluent standards establish the concentration of pollutants that can be discharged (the maximum concentration of a pollutant, mg/L or the maximum load, lb/day) to a receiving water or upon the degree of treatment required for a given type of wastewater discharge, no matter where in the United States the waste originates. These effluent limitations are related to the characteristics of the discharger, not to that of the receiving stream.

It should be noted that the water quality to be attained is not static but is often subject to modification with a changing municipal and industrial environment. For example, as the carbonaceous organic load is removed by wastewater treatment, the detrimental effect of nitrification may also become a serious problem. These considerations may require an upgrading of the degree of treatment provided for waste discharges over time and suggest that the assessment of water quality conditions and water quality demands must be an ongoing process, i.e., it is time variant or time dependent (Reynold et al, 2002).

General Water Quality Criteria. The waters of the State at all times shall be free from (Corbitt, 2009):

1. Substances attributable to sewage, industrial waste, or other waste that will settle to form sludge deposits that are unsightly, putrescent, or odorous to a degree as to create a nuisance, or that interfere directly or indirectly with water uses;
2. Floating debris, oil, grease, scum, and other floating materials, attributable to sewage, industrial waste, or other waste in amounts sufficient to be unsightly to a degree as to create a nuisance, or that interfere directly or indirectly with water uses;
3. Materials attributable to sewage, industrial waste, or other waste which produce taste, odor, or change the existing color or other physical and chemical conditions in the receiving waters to a degree as to create a nuisance, or that interfere directly with water uses; and
4. High-temperature, toxic, corrosive, or other deleterious substances attributable to sewage, industrial waste, or other waste in concentrations or combinations which interfere directly or indirectly with water uses, or which are harmful to human, animal, plant, or aquatic life.

Criteria for water contact recreation and aquatic life (Corbitt, 2009):

1. Bacteriological. There may not be any sources of pathogenic or harmful organisms in sufficient quantities to constitute a public health hazard. A public health hazard will be presumed if the fecal coliform density exceeds a log mean of 200 per 100 ml, based on a minimum of not less than 5 samples taken over any 30-day period, or if 10 percent of the total number of samples taken during any 30-day period exceed 400 per 100 ml, unless a sanitary survey approved by the Department of Health and Mental Hygiene disclosed no significant health hazard.
2. Dissolved Oxygen. The dissolved oxygen concentration shall be not less than 5.0 mg/liter at any time.
3. Temperature. For all discharges of heat, the maximum temperature outside the mixing zone may not exceed 90°F (32°C) or ambient temperature of the receiving waters, whichever is greater. In addition, a discharge of heat may not create thermal barriers that adversely affect aquatic life.
4. pH. Normal pH values may not be less than 6.5 or greater than 8.5.

5. Turbidity. Turbidity may not exceed levels detrimental to aquatic life. Turbidity in the receiving water, resulting from any discharge may not exceed 150 NTU (nephelometer turbidity units) at any time or 50 NTU as a monthly average. NTU are equivalent measures to FTUs (formazin turbidity units) and JTUs (Jackson turbidity units).
6. Toxic Materials. The toxic materials listed here may not exceed these designated limits at any time:
    i. Polychlorinated Biphenyls (PCBs)—0.001 µg/liter:
    ii. Endrin—0.004 µg/liter;
    iii. Toxaphene—0.005 µg/liter;
    iv. DDT—0.001 µg/liter;
    v. Benzidine—0.1 µg/liter;
    vi. Aldrin-Dieldrin—0.003 µg/lite

Environmental Risk

Environmental risk due to various environmental hazards is an important topic for environmental engineers to recognize and understand in order to protect human society and ecosystems from harms or damages at local, regional or global scales. A hazard is a threat to life, health, property, or ecosystems, i.e., it involves something that could potentially be harmful. Hazards may be broadly classified into two groups (Han, 2009):

- Man-made hazards (also called anthropogenic hazards): created by humans due to human intent, negligence, or error, such as crime, terrorism, war (sociological hazards), industrial hazards, power outage, hazardous materials (technological hazards), etc.
- Natural hazards: caused by a natural process with a negative effect on people or the environment, such as volcanoes, floods, earthquakes, etc. Many natural and man-made hazards are interrelated (e.g. earthquakes may cause tsunamis which in turn damage nuclear power plants to release radioactive waste).

Hazard' and 'Risk' are different terms. In environmental engineering, risk is defined as the expected outcome of an environmental hazard (human injury, disease, death, economic losses or ecosystem damages). Generally, the risk is a function of hazard and its exposure

$$\text{Risk} = f\,(\text{Hazard, Exposure})$$

The meaning and unit of the formula vary depending on the specific hazards. Risk can be reduced by lowering either hazard or exposure, or both. The risk to the health of human due to harmful carcinogenic chemicals is expressed as.

$$\text{Risk} = \text{Risk per unit dose} \times \text{Exposed dose}$$

where

risk = the probability of a person suffers from the adverse effect of the hazards
risk per unit dose = the harm caused by a unit exposure of a hazardous material
exposed dose = the contact of a human and the chemical

For the risk linked with natural hazards (e.g., floods), it is defined as

$$\text{Risk} = \text{Probability} \times \text{Expected adverse consequences}$$

where

risk = the expected losses from the hazard event
probability = the likelihood of the hazard event
expected adverse consequences = the result of the event (in economic loss or deaths)

Risk assessment is an important component in risk management. Risk assessment is the determination of risk related to a hazard. Methods for assessment of risk may differ between sectors and whether it pertains to environmental or public health risk assessment.

For natural hazards, risk assessment involves (Han, 2009):

1. hazard identification: to identify the potential hazards in the investigation site. Some hazards are conjoint or causal (e.g., an earthquake may trigger landslides);
2. hazard probability: to derive the probabilities of the hazard magnitudes based on instrumental records, historical records or palaeo records.
3. consequence analysis: to work out expected losses from the realization of the hazards.

Risk management is the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities. Once risks have been identified and assessed, all techniques to manage the risk fall into one or more of these four major categories (Han, 2009).

1. Avoidance: this includes not performing an activity that could carry risk
2. Reduction: this involves reducing (or eliminating) the severity of the loss or the likelihood of the loss from occurring. There are two main measures on risk reduction: soft engineering measures (forecasting, land planning, policies) and hard engineering measures (e.g., structures).
3. Sharing: the burden of loss from a risk can be shared with another party, such as insurance firms.
4. Retention: the risk loss is accepted. This may be acceptable if the chance of a significant loss is rare and the cost to mitigate for the hazard is great

An environmental impact assessment is an assessment of the possible positive or negative impact that a proposed project (e.g., reservoir, wastewater treatment plant, highway) may have on the environment considering the environmental, social and economic aspects. Environmental impact assessment is divided into four steps: acquisition of information, analysis of information, communication of conclusions and selection of appropriate actions.

DEFINITIONS

Aerobic - a life or a process that occurs in the presence of oxygen.

Anaerobic - a life or a process that occurs in the absence of free oxygen.

Biodegradable - A quality of organic matter meaning that it can be metabolized by biological means.

BOD (Biochemical Oxygen Demand) - a measure of oxygen consumed in biological processes that break down organic matter in water.

Composting - The biological degradation and transformation of organic solid waste under controlled conditions designed to promote aerobic decomposition. Natural decay of organic solid waste under uncontrolled conditions is not composting.

Degradable - The quality certain substances or compounds have of gradually decomposing by physical, chemical or biological means.

Disposal/Deposition - The discharge, deposit, injection, dumping, leaking, or placing of any solid waste into or on any land or water.

Dissolved Oxygen (DO) - the amount of free oxygen in solution in water, or wastewater effluent. Adequate concentrations of dissolved oxygen are necessary for fish and other aquatic organisms to live and to prevent offensive odors.

Effluent - the treated liquid that comes out of a treatment plant after completion of the treatment process.

Energy Recovery - The recovery of energy in a useable form from mass burning or refuse-derived fuel incineration, pyrolysis or any other of using the heat of combustion of solid waste that involves high temperature (above twelve hundred degrees Fahrenheit) processing.

Incineration - Reducing the volume of solid wastes by use of an enclosed device using controlled flame combustion.

Industrial Solid Wastes - Solid waste generated from manufacturing operations, food processing, or other industrial processes.

Landfill - A disposal facility or part of a facility at which solid waste is permanently placed in or on land including facilities that use solid waste as a component of fill.

Leachate - Water or other liquid within a solid waste handling unit that has been contaminated by dissolved or suspended materials due to contact with solid waste or gases. The liquid produced mainly by rain filtering through the cover material and percolating through the layers of garbage, carrying significant concentrations of decomposing organic matter and other contaminants. Other factors that contribute to leachate generation are the moisture content typical of wastes, the water from decomposition, and the seepage of groundwater.

Mitigation - approaches should be identified to minimise or avoid adverse environmental impacts as a result of the proposed project (e.g., monitoring, landscaping, site management, alternative hours of operation). The remaining or residual impacts should be assessed and dealt with if possible

Municipal Solid Waste (MSW) - A subset of solid waste which includes unsegregated garbage, refuse and similar solid waste material discarded from residential, commercial, institutional and industrial sources and community activities, including residue after recyclables have been separated. Solid waste that has been segregated by source and characteristic may qualify for management as a non-MSW solid waste, at a facility designed and operated to address the waste's characteristics and potential environmental impacts.

Oxidation – process that involves aerobic bacteria breaking down organic matter and oxygen combining with chemicals in sewage.

Pretreatment - proses that involves treatment of wastes or wastewater by industries performed prior to the discharge to the sewer system.

Primary Treatment - the initial stage of wastewater treatment that removes floating material and material that easily settles out.

Reuse - This is the return of a good or product to the economy to be used in the same way as before, with no change in its shape or nature.

Secondary Treatment - the second stage in most wastewater treatment systems in which bacteria consume the organic matter in wastewater. Federal regulations define secondary treatment as meeting minimum removal standards for BOD, TSS, and pH in the discharged effluents from municipal wastewater treatment facilities.

Sewage Sludge - Solid, semisolid, or liquid residue generated during the treatment of domestic sewage in a treatment works. Sewage sludge includes, but is not limited to, domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment processes; and a material derived from sewage sludge. Sewage sludge does not include ash generated during the firing of sewage sludge in a sewage sludge incinerator or grit and screenings generated.

Solid Waste - All putrescible and non putrescible solid and semisolid wastes including, but not limited to, garbage, rubbish, ashes, industrial wastes, swill, sewage sludge, demolition and construction wastes, abandoned vehicles or parts thereof, contaminated soils and contaminated dredged material, and recyclable materials.

Solid Waste Handling - The management, storage, collection, transportation, treatment, use, processing or final disposal of solid wastes, including the recovery and recycling of materials from solid wastes, the recovery of energy resources from such wastes or the conversion of the energy in such wastes to more useful forms or combinations thereof.

Treating - The physical, chemical, or biological processing of solid waste to make such solid wastes safer for storage or disposal, amenable for recycling or energy recovery, or reduced in volume.

Trickling Filter - a fixed film process that involves a tank, usually filled with a bed of rocks, stones or synthetic media, to support bacterial growth used to treat wastewater.

Wastewater Treatment Plant - a facility involving a series of tanks, screens, filters, and other treatment processes by which pollutants are removed from water.

NOMENCLATURES

λ = wavelength (m),
f = frequency (Hz)
c = speed (m/s)
P = sound pressure (Pa)
L_P = sound pressure level (dB)
risk = the probability of a person suffers from the adverse effect of the hazards
risk per unit dose = the harm caused by a unit exposure of a hazardous material
exposed dose = the contact of a human and the chemical

probability = the likelihood of the hazard event
expected adverse consequences = the result of the event (in economic loss or deaths)
TSS = high in suspended solid
TDS = high in dissolved solid
BOD = Biochemical oxygen demand
COD = Chemical oxygen demand