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CHAPTER 1:

INTRODUCTION TO ENVIRONMENTAL ENGINEERING.

Engineering:

Engineering is a profession that applies mathematics and science to utilize the properties of matter and sources of energy to create useful structures, machines, products, systems and processes.

Engineer:

Engineers are professionals who invent, design, analyze, build and test machines, structures & system applying their field knowledge, creativity, and knowledge.

Environmental Engineering:

Environmental engineering is the application of engineering principles, under constraint, to the protection and enhancement and ~~prod~~ protection of public health and welfare.

(*): Focus of ENE:

(i): Controlling water, soil, atmospheric and sound pollution.
(ii) To design, build and operate waters and wastewater treatment plants.

(iii) To build and operate solid waste collection, transportation and disposal system.
(iv) To carry out environmental assessment of projects and products {EIA = Environmental Impact Assessment}
(v) To provide inputs in decision making regarding the environmental issues of development sector and welfare of people.

Engineering Projects:

Engineering projects is a product being designed or a service to be provided that encompasses series of decisions made by engineers for its implementation.

Engineering projects may be large or small and most engineering projects improve human civilization, protect the global environment and enhances integrity of the profession.

*) Projects in my Province:

1: Fast track — Cost: Rs 213 billion
Length: 72·5 km.

2: Nagdhunga Tunnel — Cost: Rs 22·14 billion.
{NEA govt: 5·85 billion
JICA: 16·5 billion.}
Length: 2680 m
(8·3 m high, 9·5 m wide)

Engineering Decision:

Engineering decision is a choice made by the engineer to solve the problem presented. While making engineering decisions, the following aspects have to be considered:

i) Technical Analysis
ii) Cost effective Analysis
iii) Cost Benefit Analysis
iv) Risk Analysis
v) Environmental Impact Analysis
vi) Ethical Analysis.

i) Technical Analysis:

The technical decisions made by engineers for solving a given problem must be quantifiable {suitable technical solutions}.
The technical decision can also be evaluated and checked by other professional engineers.

If we don't have complete data for during analysis, we make assumptions to build the best decision technically.

(ii): Cost Effective Analysis:

Engineering decisions must also consider cost effectiveness. Engineers must decide on the lowest total cost alternative.
Annual cost or present worth ~~is~~ are most ~~aff~~ accepted ways for comparing alternate action courses.

→ IRR: Internal Rate of Return.

IRR is an indicator that reflects profits of projects.
While deciding on final engineering decision on projects that have same investment cost, the highest IRR is considered better.

iii) Cost Benefit Analysis:

Cost Benefit analysis is checked by comparing the ratio of benefit with cost during engineering decision.

If (Benefit / Cost) = > 1.0, this means that the benefit of the project is greater than the initial loss caused by its cost. Hence, project is considered worthwhile.

iv) Risk Analysis:

Any engineering decision must inculcate risk analysis on different sectors of environment, human life, professions, etc.
Factors that are considered during risk analysis are : source of pollutants, type of pollutants, expose to health problems, expense on reducing risks, etc.

(v): Environmental Impact Analysis:

Any engineering decision must consider its impact upon the environment that could happen in planning, implementation and operational phase.

EIA is done through many methods of assessment.

If any engineering projects contribute more negative impact on the environment ~~during~~ overtime and which cannot be reversed, than the decision is not considered viable.

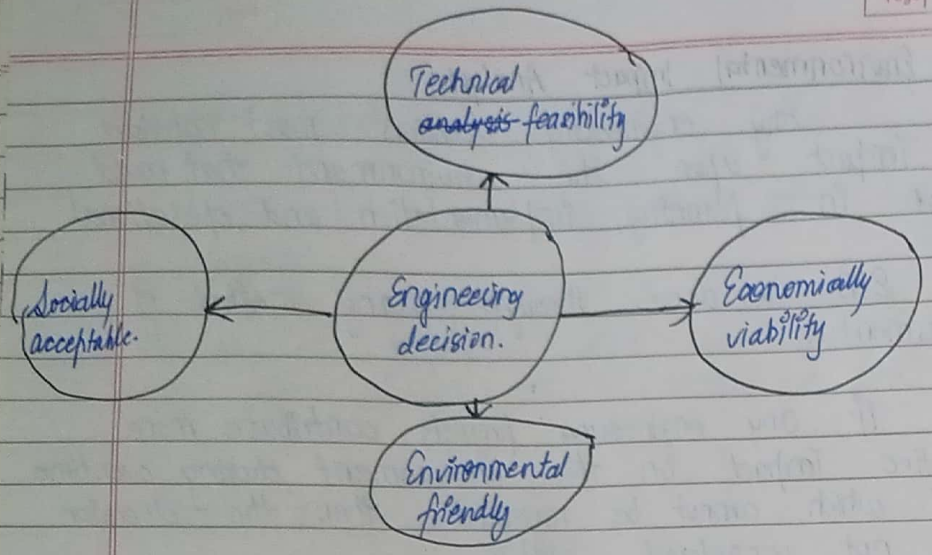
Hence, projects overally must not deteriorate the condition and negatively impact environmental conditions.

(vi): Ethical Analysis:

Any engineering decisions must also consider social impacts of the projects.

Hence, the projects impact on local communities, public health, cultural heritage, overally quality of life with understanding the needs of the people. So, decisions must be ethical and not violate ethics of society.

Thus, engineering decisions must consider all the above mentioned factors for viability and sustainability of any engineering projects.



<Q>: A town with 4000 residents wants to establish a municipally owned and operated garbage collection program. They can purchase one of the following trucks with capacities.

Truck A: $8\ m^3$
Truck B: $6\ m^3$
Truck C: $4\ m^3$

If truck collects truck everyday and is only allowed one trip per day, which truck is best and sufficient?

Sol^n:

Here, we don't have data on waste generation and the amount of waste truck can compact.

Thus, these values need to be assumed.

Given,

truck A = $8\ m^3$
truck B = $6\ m^3$
truck C = $4\ m^3$

Let us assume the per capita waste generation is 0.8 kg per person per day.

Then,

total waste generation of town = Total population x Per capita waste generation

$= 4000 \times 0.8$ kg
$= 3200$ kg/day

Let us assume the truck can compact waste upto 450 ~~385~~ kg/m^3.

Thus, the required truck capacity = $\frac{\text{Total waste generated}}{\text{Compact waste capacity}}$

$= \frac{3200}{\cancel{385}\ 450}$
$= 7.11\ m^3/\text{day}$

Conclusion: Thus, based on given assumptions, we can see that the truck A is the truck technically feasible.

Environmental Laws of and Regulation

Environmental laws and regulations in Nepal are as follows:

(i) Environment Protection Act (EPA), 2076
(ii) Environment Protection Rules (EPR), 2077
(iii) Solid Waste Management Act, 2068
(iv) Water Resources Act, 2049

(v): Different policies, standards, guidelines and standards for pollutants, emission, quality.
(vi): Climate Change Policy.

Levels of Environmental Study in Nepal

As per project size, these are three levels of environmental study in Nepal. They are as follows:

i) Brief Environmental Study (BES)
ii) Initial Environmental Examination (IEE)
iii) Environmental Impacts Assessment (EIA)

i) Brief Environmental Study (BES)

→ Performed as guided by schedule 1 of EPR

Eg: (i): Hospitals with 16-25 beds
(ii) Hotels or resort from 25-50 beds.
(iii) Bridges upto 250 m.
(iv) ~~Hurup~~ Municipal or urban roads
(v) upto 5 MLD water supply projects with treatment plant and sewer.

(ii) Initial Environmental Examination (IEE)

→ Performed as guided by schedule 1 of EPR

Eg: (i) Hospitals with 25-100 beds
(ii) Hostel/Resorts with 51-100 beds.
(iii) Bridges above 250 m
(iv) New road upto 25 km long.
(v) Upgrading ~~for~~ roads from 10-50 km.
(vi) Acquisition of forest area from 1-5 ha.
(vii) Solar power plant upto 5MW - 50MW hydropower.

(iii) Environmental Impact Assessment (EIA)

→ Performed as guided by schedule 1 of EPR

Eg: (i): Hospital/Hotels above 100 beds.
(ii): Projects acquiring National parks/conservation area/forests above 5 ha.
(iii) Hydropower production above 50 MW.

Engineering Institutions in Nepal

(i): Nepal Engineering Council

→ Nepal Engineering Council Act, 2055
→ First executive ~~committe~~ Council formed in 2056
→ Nepal Engineering Council Rules, 2057
→ NEC act amended twice in 2076 B.S & 2079 B.S.

X) Scope:

→ Licensing on the basis of exam.
→ Produce and monitor the professional code of conduct
→ Registration of Engineer.
→ Authorization of certificates
→ Recognition of Academic Institutions.

(ii) Nepal Engineers Association (NEA) (2015968/2024 BS)

→ To promote development of engineering, science and technology in Nepal.

→ To promote followship, goodwill and cooperation ~~association~~ assistance among the Nepalese engineers and safeguard their rights and interests.

→ To continuously enhance the highest professional ideals among the members and widen it.

(iii): Nepal Environment Society (NES)

Institution including all the environmental professionals of Nepal.

(iv) Society of Public Health Engineers, Nepal (SOPHEN)

→ Registered in 1990 AD (2047 BS)

→ Independent professional organization of Nepalese engineers.

(v): Society of Environmental Engineers, Nepal (SEEN)

→ Institute established by Environmental Engineers of Nepal.

→ Governed by Executive Committee of 7 members and elected by general members of society.

x) Scope:

→ Enhancement of technical and professional competencies of its members.

→ Works for protection of basic professional rights

→ To support the government and other agencies in formulation of policies and strategies in related fields.

→ To carry out various professional activities that are intended to bring qualitative results to improve the sanitary and environmental conditions of country.

Values, Units, Dimensions

Values give the quantity of measurement. Units describes what the quantity is about.

Dimension is a descriptive unique quantity that describes a basic characteristics of the measurement.

Quantity	Prefix	Symbol	Quantity	Prefix	Symbol
10^{-12}	pico	p	10^{-9}	nano	n
10^{-6}	micro	μ	10^{-3}	milli	m
10^{-2}	centi	c	10^{-1}	deci	d
10	deca	da	10^{2}	hecto	h
10^{3}	kilo	k	10^{6}	mega	M
10^{9}	giga	G			

* Substance and sizes:

i) Bacteria: 1 μm ii) Sand: 1 mm

iii) Gravel: 1 cm iv) 32" TV: 1 m

Density: Mass per unit volume is called density.

Mathematically,

$$S = \frac{M}{V}$$ Unit = kg/m^3

Concentration: Mass per unit volume of the solution.

Mathematically,

$$C_A = \frac{M_A}{V_A + V_B}$$

C_A = Concentration of A

M_A = Mass of A

V_A = Volume of A

V_B = volume of B.

Unit = kg/m^3

<Q>: Plastic beads with a volume of $0.04 m^3$ and mass of 0.48 kg are placed in container and 100 litres of water is poured into the containes. What is concentration of plastic beads.

Let A = beads B = water.

Given,

$M_A = 0.48$ kg

$V_A = 0.04 m^3$ ~~each~~.

$V_B = 100$ litres.

$= 100 L \times \frac{1 m^3}{1000 L}$

$= 0.1 m^3$

So,

$C_A = \frac{M_A}{V_A + V_B} = \frac{0.48}{0.04 + 0.1} = 3.42 kg/m^3$

$C_A = 3.42 kg/m^3 = 3.42 \frac{kg}{1 m^3} \times \frac{1 m^3}{1000 L} \times \frac{10^6 mg}{1 kg}$

$= 3420 mg/L$

$\therefore C_A = 3420 mg/L$

Units of Concentration:

1) ppm = parts per million $= 10^{-6}$
2) ppb = parts per billion $= 10^{-9}$
3) 1% = 10^{-2}
4) $\mu g/L$ = microgram per litre
5) mg/L = milligram per litre

*) Relationships: (For water)

1): $\frac{1 mg}{L} = \frac{1 mg}{L} \times \frac{1 L}{1 g} \times \frac{1 g}{10^3 mg}$

$= 10^{-6} = 1 ppm$ [$\because 1 ml = 1 g$ if density doesn't change]

$\therefore 1 mg/L = 1 ppm$

2) $\frac{1 \mu g}{L} = \frac{1 Mg}{L} \times \frac{1 L}{1 gL} \times \frac{1 g}{10^6 Mg}$ [$\because 1 ml = 1 g$]

$= \frac{1 \times 10^{-6} g}{1 L} \times \frac{1 L}{1000 ml} = \frac{10^{-6} g}{1 L} \times \frac{1 L}{1000 g}$

$\therefore 1 Mg/L = 10^{-9} = 1 ppb.$

~~3): 1 ppm = 1000 ppb~~ 3) $1 ppm = 10^{-3} ppb.$

4) $1\% = 10^{-2}$

$= \frac{1}{10^2} \times \frac{10^4}{10^4} = 10^4 ppm = 10000 ppm$

and

$= \frac{1}{10^2} \times \frac{10^7}{10^7} = 10^7 ppb$

$\therefore 1\% = 10^4 ppm = 10^7 ppb$

5): $1\% = 10^4 mg/L$

<Q7: (Soil:) A kg sample of soil is analyzed for the chemical TCE. The analysis indicates sample contains 5 mg of TCE. find conc of TCE in ppm_m and ppb_m?

Soln:

Given,

$$C = 5\ mg/kg$$

$$= \frac{5\ mg}{1\ kg} \times \frac{1\ kg}{1000\ g} \times \frac{1\ g}{1000\ mg}$$

$$= \frac{5}{10^3 \times 10^3} = 5 \times 10^{-6}$$

$\therefore 5\ mg/kg = 5\ ppm_m$.

$$= \frac{5}{10^6} \times \frac{10^3}{10^3} = \frac{5}{10^6} \times \frac{10^3}{10^3}$$

$$= \frac{5 \times 10^3}{10^9} = 5 \times 10^3\ ppb_m$$

$\therefore 5\ mg/kg = 5\ ppm_m = 5000\ ppb_m$.

<Q>: (Water): One litre of water is analyzed and found to contain 5.0 mg TCE. What is TCE concentration in mg/L and ppm_m? If drinking water standard for TCE is 5 µg/L, is the TCE above limits?

Soln:

Given limit,

$$\frac{5\ \mu g}{1\ L} = \frac{5\ \mu g}{1\ L} \times \frac{1\ L}{1000\ g} \times \frac{1\ g}{1000\ \mu g \times 10^6\ \mu g}$$

$$= \frac{5}{10^9} = 5\ ppb_m$$

$\therefore$ The TCE limit is $5\ ppb_m$

Now,

the sample $= \frac{5\ mg}{L} = \frac{5\ mg}{1\ L} \times \frac{1\ L}{1000\ g} \times \frac{1\ g}{10^3\ g}$

$$= \frac{5}{10^6} = 5\ ppm_m$$

Then,

$$5\ ppm_m = \frac{5}{10^6} \times \frac{10^3}{10^3} = 5000\ ppb_m$$

Since, $5000 > 5$, the TCE is above limits.

Concentration in Air

Concentration of chemicals in air is measured by units mass per unit volume of air.

Eg: $\frac{mg}{m^3}$, $\frac{\mu g}{m^3}$

to use ppm and ppb for air pollutants by using conversion factor. but we have to consider temperature and pressure.

Air pollutants are particulate matter of oxides of nitrogen, carbon and sulphur. They are TSP (total suspended particles, PM 10 (<10M), PM 2-5 (<2-5 M)

x) Conversion:

[Q]: Convert 10^3 μg/m³ to ppm for CO. The gas is at 290 K and 2 atm.

Sol^n:

We know, Molwt of CO = 28 gm/mol

Now,

$$= \frac{10^3\ \mu g}{1\ m^3} \times \frac{1\ m^3}{1000\ L} \times \frac{1\ mole\ of\ CO}{28\ g} \times \frac{1\ g}{10^6\ \mu g} \times \frac{22.4\ L}{1\ mole\ of\ CO_2}$$

$$= 0.8 \times 10^{-6} = 8 \times 10^{-7}$$

$$\therefore 10^3\ \frac{\mu g}{m^3} = 0.8\ ppm = 800\ ppb$$

Now, if we need to convert to STP case,

∴ TCF (Temperature correction coefficient factor) = $\frac{\text{given temp}}{\text{standard temp}}$

$$= \frac{290}{273.15} = 1.061$$

∴ Pressure correction factor (PCF) = $\frac{\text{given atm standard pressure}}{\text{standard atm given pressure}}$

$$= \frac{1}{2} = 0.5$$

So, correct value

$$= 0.8 \times \frac{1}{TCF} \times \frac{1}{PCF} = 0.8 \times \frac{1}{1.061} \times \frac{1}{0.5}$$

$$= 1.508\ ppm$$

(*): For any component i,

i) $ppm_v = \frac{V_i}{V_{total}} \times 10^6$

ii) $ppm_v = \frac{moles_i}{moles\ total} \times 10^6$

Flow/Discharge Rate:

a) Volume flow rate:

$$Q_v = \frac{V}{T} = \frac{\text{volume of liquid}}{\text{time taken}}$$

Unit: m^3/s, L/s, LD, MLD

Note: $1\ m^3 = 1000$ litres

$1\ MLD = 10^6$ litres.

(b): Mass flow Rate:

Q_m = $\frac{M}{T}$ = $\frac{\text{mass of liquid}}{\text{time taken}}$

Unit: mg/s , kg/day

We know,

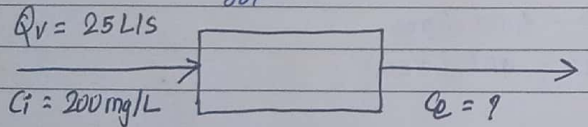
$$C = \frac{Q_m}{Q_v}$$

or, $Q_m = C \times Q_v$

Influent: It means incoming flow
Effluent: It means outgoing flow.

<Q7: A stream can have a sediment load of upto 200 mg/L in rainy reason. The stream water has been divested using a dam and is supplied to treatment plan. The tapped flow is 25 L/s.
i) Find mass flow rate of sediment in influent pipe/day.
ii) If 90% of suspended solids can be remove, find concentration of sediments in the effluent of treatment plant.

Soln:



(i): We know,

$$C = \frac{Q_m}{Q_v}$$

or $Q_m = Q_v \times C = \frac{25\,L}{1s} \times \frac{200\,mg}{1L}$

$$= \frac{25\,\cancel{L}}{1\cancel{s}} \times \frac{200\,\cancel{mg}}{1\cancel{L}} \times \frac{86400\,\cancel{s}}{1\,day} \times \frac{1\,kg}{1000\,\cancel{g}} \times \frac{1\,\cancel{g}}{10^3\,\cancel{mg}}$$

$$= \frac{25 \times 200 \times 86400}{10^6}$$

$\therefore Q_m$ = 432 kg/day

(ii): Now, according to question,

$C_e = C_i - 90\%\ \text{of}\ C_i$

$= 200 - \frac{90}{100} \times 200$

$\therefore C_e$ = 20 mg/L.

Hydraulic Retention Time

Retention time is the time an average particle of the fluid spends in the container through which the fluid flows.

Mathematically,

HRT = $\frac{V}{Q_v}$ = $\frac{\text{volume of tank}}{\text{volumetric flow rate.}}$

<Q>: The Helamchi project has 170 MLD flow rate. Water analysis say the water must be retained for 4 to 6 hours to get rid of suspended particles. Design a sedimentation tank for this purpose.

Sol^n:

Given,
volumetric flow rate (Q_V) = 170 MLD
HRT = 6 hrs
volume of tank (V) = ?

We know,

$$HRT = \frac{V}{Q_V}$$

or, $V = Q_V \times HRT$

$$= \frac{170\ ML}{1\ day} \times 6\ hrs$$

$$= \frac{170 \times 10^6\ L}{1\ day} \times \frac{1\ day}{4\ 24\ hrs} \times 6\ hrs$$

$\therefore V = 425 \times 10^5\ L$

$= 425 \times 10^2\ m^3$

<Q>: A lagoon has volume of $1500\ m^3$, and the flow into the lagoon is $3\ m^3/h$. What is retention time into the lagoon.

Sol^n:

Given,
$V = 1500\ m^3$
$Q_V = 3\ m^3/h$

Now,

$$HRT = \frac{V}{Q_V}$$

$$= \frac{1500\ m^3}{3\ m^3} \times \frac{1\ hr}{}$$

$\therefore HRT = 500$ hours

Approximation in Engineering Calculations

For any starting of a project, a engineer must provide tentative estimation.

Eg: Cost of constructing new wastewater treatment plant for the Dhulikhel population.

If the population is 30k and per capita domestic wastewater flow is 100 L/day.
This means the treatment plant capacity must be 300000 L/day or 3 MLD for domestic purpose.

The engineer almost calculates 1 MLD for industrial effluents, storm inflow, infiltration of groundwater. Then, the final treatment capacity is 4 MLD.

For 1 MLD treatment plan, the estimated cost is 25 crore. So, the total estimated cost of project will be 1 Arab (100 crore).

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<Q>: The wastewater treatment plan in Guheswori receives $0.20\ m^3/s$ of wastewater. The plant is established to directly serve a population of 2×90^5 in Gokarna and Chahabil area. The cost estimated was 1/2 billion NRs.

(a): Calculate NRs / MLD

(b): NRs / individual benefitted.

Sol^n:

Given,

$$Q_v = 0.20\ m^3/s$$

$$= \frac{0.20\ m^3}{1\ s} \times \frac{1000\ L}{1\ m^3} \times \frac{86400\ s}{1\ day}$$

$$\therefore Q_v = 17.28\ MLD$$

Cost estimate = Rs. 500 million.

Population = 2×10^5.

(a): $\frac{NRs}{MLD} = \frac{500\,000\,000}{17\,280\,000}$

$= 28.93$ million NRS / MLD

(b): $\frac{NRs}{Individual} = \frac{500000000}{2 \times 10^5} = \frac{5 \times 10^3 \times 10^5}{2 \times 10^5}$

$= 2500$ NRs / individual.