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Handout of

ENVIRONMENTAL ENGINEERING
WATER SUPPLY ENGINEERING

CLASSROOM HANDOUT

~ Session : 2024-25 ~

Faculty : Sagar Dodeja (Ex. IES)

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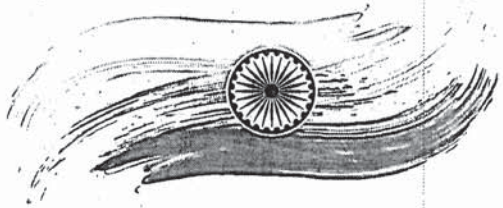


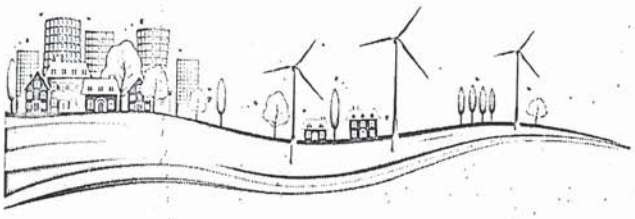
5 RULES OF PREPARATION

1. Jaan Laga Do Ya Jaane Do
2. Practice & Revise Not Until You Are Right, Do It Until You Cannot Get It Wrong
3. The Key to Effective Time Utilisation is to Follow The Teacher As It Is
4. A Systematic Approach Is Always The Right Approach
5. Pray Daily

Class rules :-

1) Ask doubt when the topic completes. Mean while write the doubts.
2) Do not be late in the class.
3). Do not talk with each other.

JAI HIND



ENVIRONMENTAL ENGINEERING

BY
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INSTRUCTIONS

These are interactive notes for Made Easy Classroom Students and Made Easy Online Students. These notes contain basic knowledge only and classes need to be attended thoroughly for in-depth explanations and solving WorkBook Questions.

All the blank spaces are intentionally left for the students to write during the lectures.

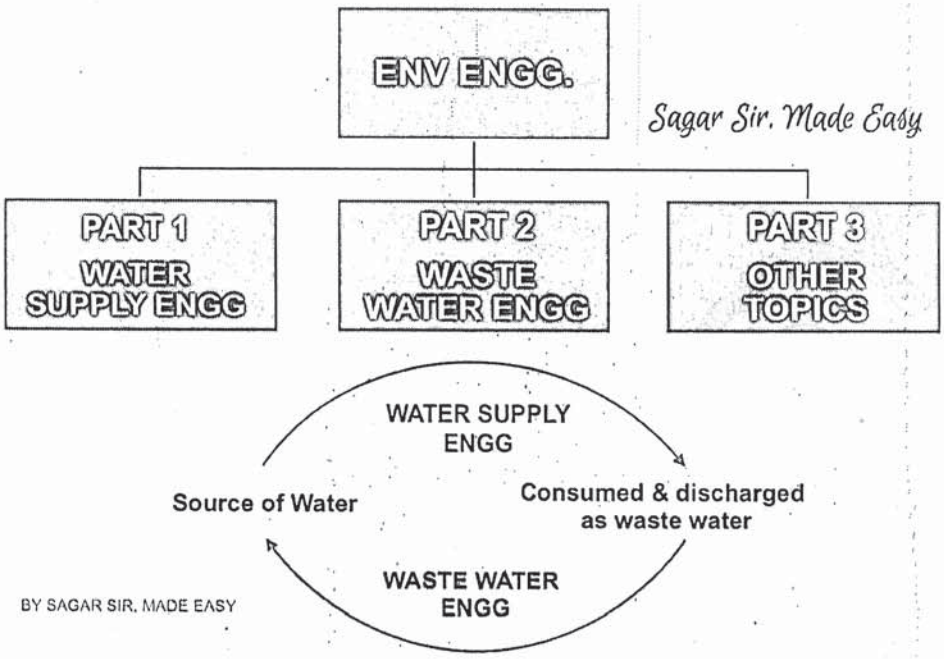
Students should keep a separate copy of 200 pages with them at all times to solve all WorkBook questions.

These notes are already tried and tested successfully on thousands of students and the notes provided have ensured maximum output from them.

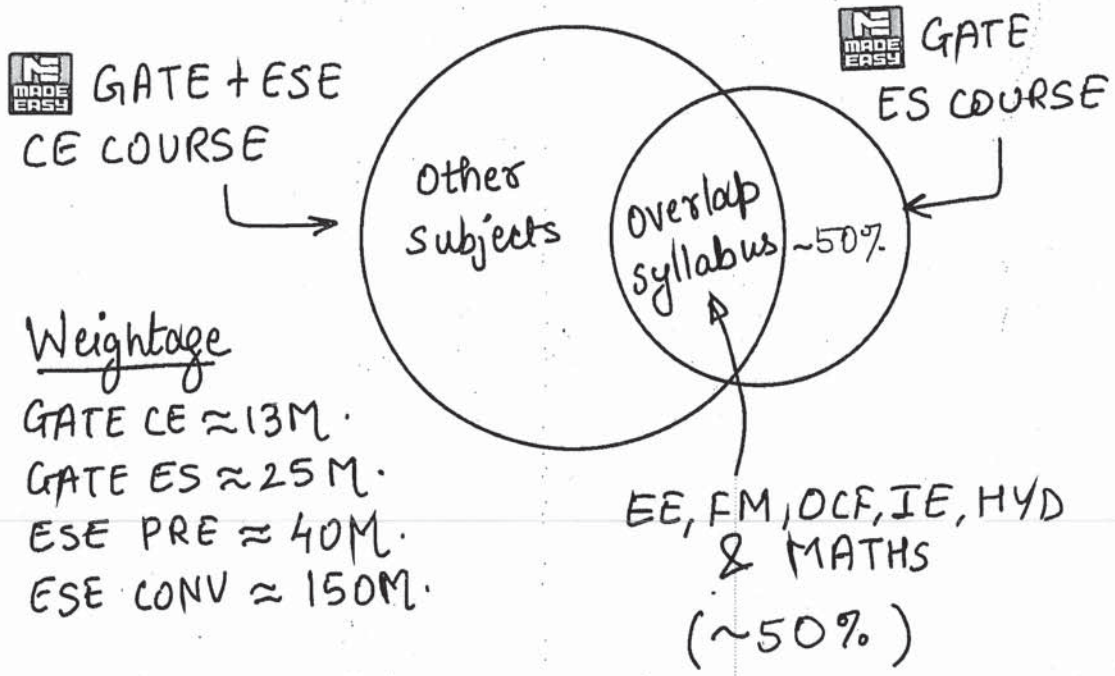
With these notes, students can focus entirely on concept building and developing problem solving skills as basic theory, diagrams and facts are already written clearly in the notes. This also minimises errors during writing.

Let's Begin

INTRODUCTION



SYLLABUS OF GATE CE AND ES COURSE



ADDITIONAL PAGE

Environmental Engineering is a multi-disciplinary branch of engineering which relates the biotic or the living factors with abiotic or non-living factors.

The biotic factors include all plants, animals & micro-organisms.

The abiotic factors include water, air & soil.

The primary objective of environmental engineering is to ensure sustainable development without causing harm to the environment.

In India, environmental engineering started with water act of 1974. The agencies like Central Pollution Control Board (CPCB), Central Public health & Environmental engineering organisation (CPHEEO), National Environmental Research Institute (NEERI) were formed as a result.

The air act as introduced in 1981 & an umbrella act, called as Environmental protection act (EPA) was enacted in 1986 and emended in 1991.

As per EPA, the agencies are responsible for developing the guidelines related to environmental engineering & also ensure its enforcement. These guidelines are updated from time to time.

APPENDIX

I. Useful Elements, Atomic Numbers & Masses.

Element	Atomic Number	Atomic Mass	Element	Atomic Number	Atomic Mass
Aluminium	13	27	Nitrogen	7	14
Boron	5	11	Oxygen	8	16
Calcium	20	40	Phosphorus	15	31
Carbon	6	12	Potassium	19	39
Chlorine	17	35.5	Silicon	14	28
Copper	29	63.5	Silver	47	108
Fluorine	9	19	Sodium	11	23
Hydrogen	1	1	Sulphur	16	32
Iodine	53	127	Zinc	30	65
Iron	26	56			
Magnesium	12	24			
Manganese	25	55			

II. SI Units

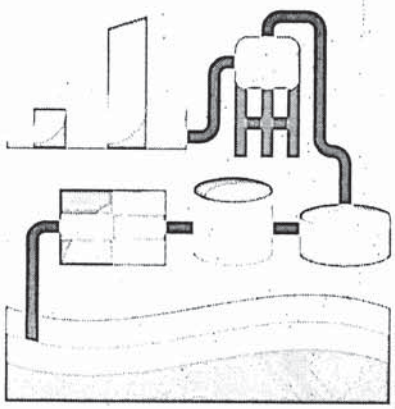
1. Length – m
2. Mass – kg
3. Time – s
4. Electric current – A (Ampere)
5. Temperature – K
6. Amount of substance – mol (mole)
7. Force – N ($kg\text{-}m/s^2$)

8. Pressure - Pa ($kg/m\text{-}s^2$)
9. Energy or work - J ($\frac{kg\text{-}m^2}{s^2}$ or N-m)
10. Power - W ($\frac{kg\text{-}m^2}{s^3}$ or J/s)
11. Electric charge - C (A-s)
12. Dynamic Viscosity - Pa-s or $\frac{N\text{-}s}{m^2}$
13. Kinematic Viscosity - $\frac{m^2}{s}$

III. Some Standards

1. $g = 9.81\ m/s^2 = 32.174\ ft/s^2$
2. $1\ bar = 10^5\ N/m^2$
3. $1\ atm = 101.325\ kN/m^2$
   $= 101.325\ kPa$
   $= 1.013\ bar$
   $= 10.333\ m$ of water
4. $1\ HP = 746\ W$
   $1\ W = 0.0013\ HP$
5. $1\ ha = 10^4\ m^2$
6. $1\ acre = 4046.86\ m^2$
7. $1\ kW\text{-}h = 3600\ kJ$
8. $1\ Cal = 4.184\ J$
9. $1\ MLD = 10^6\ l/d$
10. $1\ MGD = 3.785 \times 10^6\ l/d$

(MGD: gallons)



START OF

WATER SUPPLY ENGINEERING

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CHAPTER 1
WATER DEMAND

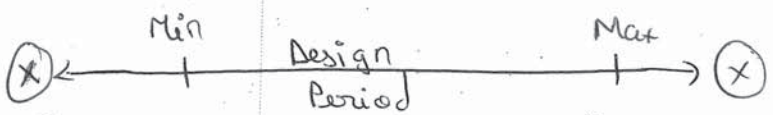
Introduction

- Water Demand implies water quantity estimation.
- The quantity of water required for municipal uses (↳ Nagar Nigam) for which the water supply scheme has to be designed requires the following data :-
  1. Forecasted Population → Future population
  2. Rate of consumption usually expressed in lpcd - per person per day [litres per capita per day or l/c/d or $\frac{l}{c \times d}$) (LPCD) per head per person
- Unit of Water Demand is MLD usually. (1 MLD = 10^6 l/d) (1 Million litres per day)

Design Period

- The quantity of water is worked out with due provision for requirement of future,
- The future period for which the water supply scheme is designed to cater for the future population is referred as DESIGN PERIOD.
- Design Period should always be in a range.

Note :-



To ensure the economy of investments & to avoid repeated investments

To ensure the suitability of material

census → 1st
vs
survey

The water (Prevention & control of pollution) act enacted in the year and was 1974

PART 1

Population Forecasting → Mathematical Methods
Population Forecasting → Graphical Methods.

(Forecasting ↳ estimate something)

Mathematical Methods

1. Arithmetic Increase Method
2. Geometric Increase Method
3. Incremental Increase Method
4. Decreasing Rate of Growth Method

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ARITHMETIC INCREASE METHOD (AIM)

- Assumption → population increases at a constant rate.
- It is used for those cities which are sufficiently large and are already established.

Process :-

Qus Find the avg. increase / decade

Year	Population	Increase in Population ($\bar{x}$)
1981	60000	—
1991	130000	70000
2001	250000	120000
2011	500000	P_0 250000

$$\bar{x} = \left(\frac{70+120+250}{3}\right) \times 10^3$$

$$= 146666.67$$

Let last known population $= P_0$

Population after 1 decade
from $P_0 = P_1$
$P_1 = P_0 + \bar{r}$

Similarly,
$P_2 = P_1 + \bar{r} = P_0 + 2\bar{r}$
$P_3 = P_0 + 3\bar{r}$
$\vdots$
$P_n = P_0 + n\bar{r}$

∵ data given is in decades, n should be taken in decades

$P_{2054} = 500000 + 4.3 \text{ decades} \times (146666.67)/\text{decade}$
$= 1130666.67$
≈ 1130667 (Round off to the next integer always)

Ex

Bank A	Bank B
₹ 100	₹ 100
₹ 110	110
104	104
108	108.1
112	112.5
AIM	GIM

GEOMETRIC INCREASE METHOD (GIM)

- **Assumption** → The percentage growth rate is assumed to be constant
- Applicable to young and developing cities.

Process :-

Year	Population	% increase in Population (r)
1981	60000	
1991	130000	$\frac{70000}{60000} \times 100 = 116.67\%$
2001	250000	$\frac{120000}{130000} \times 100 = 92.31\%$
2011	500000	$\frac{250000}{250000} \times 100 = 100\%$

$\bar{r}$ will be found by geometric mean.

$\bar{r} = (r_1 \times r_2 \times r_3)^{1/3}$
$= 102.49\%$

$P_1 = P_0 + \left(\frac{\bar{r}}{100} \times P_0\right) = P_0\left(1 + \frac{\bar{r}}{100}\right)$
$P_2 = P_1 + \left(\frac{\bar{r}}{100} \times P_1\right) = P_1\left(1 + \frac{\bar{r}}{100}\right)$
$= P_0\left(1 + \frac{\bar{r}}{100}\right)^2$

$$P_n = P_0\left(1 + \frac{\bar{r}}{100}\right)^n$$

$P_{2054} = 500000\left(1 + \frac{102.49}{100}\right)^{4.3} = 10387365.18$
$\approx 1,03,87,366$

INCREMENTAL INCREASE METHOD (Improve of AIM)

→ The trend of increase is called increment.

- Also called as Method of Varying Increments.
- For population in India, this method gives values somewhere in between AIM & GIM. (upto 2011 census)

Process :-

Year	Population	x	Increment over increase
1881	60000	—	—
1991	130000	70000	—
2001	250000	120000	+50000
2011	500000	250000	+130000

Incremental Increase method

Increment means the trend of increase for India :-

$$P_n = P_0 + n\bar{x} + \frac{n(n+1)}{2}\bar{y}$$

$\bar{y}$ → average of increments over increase

Mathematically, $\bar{y}$ can be ⊕, ⊖ or even zero.

Ex

$\bar{x} = 146666.67$

$\bar{y} = \frac{50000 + 130000}{2}$

$= 90000$

specifically used in mumbai population

$P_{2054} = 500000 + (4.3 \times 146666.67) + \left(\frac{4.3(5.3)}{2} \times 90000\right)$

$= 2156216.6 \approx 21,56,217$

DECREASING RATE OF GROWTH METHOD (Improve of GIM)

- Used when the percentage increase in population is consistently decreasing.
- It cannot be used for long term forecasting.

Process :-

Quiz

$$P_1 = P_0 + \left(\frac{x_1}{100}\right)P_0$$

$$P_2 = P_1 + \left(\frac{x_2}{100}\right)P_1$$

$$P_3 = P_2 + \left(\frac{x_3}{100}\right)P_2$$

$x_1 > x_2 > x_3$

Year	Population	% increase	Decrease in % increase
1960	55.5	—	—
1970	63.7	14.77%	—
1980	71.3	11.93%	2.84%
1990	79.5	11.5%	0.43%

Avg. decrease in % increase $= \frac{2.84 + 0.43}{2}$

$= 1.635\%$

$P_{2000} = 79.5 + \left[\left(\frac{11.5 - 1.635}{100}\right) \times 79.5\right]$

$= 87.34$

$P_{2010} = 87.34 + \left[\left\{\frac{11.5 - (2 \times 1.635)}{100}\right\} \times 87.34\right] = 94.53$

$P_{2020} = 94.53 + \left[\left\{\frac{11.5 - (3 \times 1.635)}{100}\right\} \times 94.53\right] = 100.76$ thousands

Ex $P_{2014} = 94.53 + \left[\frac{(100.76 - 94.53)}{10} \times 4\right] = 97.02$ thousand

1) By interpolation

Note :-
If no method or type of city is given, then use geometric increase method as it provides the highest value of forecasted population. However if % increase is consistently decreasing, then use decreasing rate of growth method

GRAPHICAL METHODS

1. Simple Graphical Method.
2. Comparative Graphical Method.
3. Logistic / Growth / S – Curve Method.

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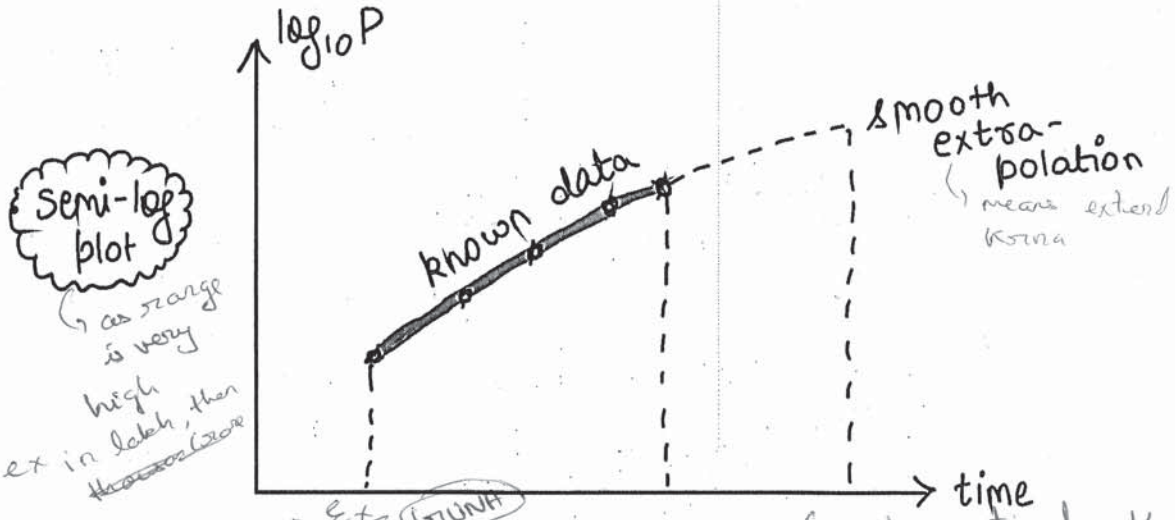
SIMPLE GRAPHICAL METHOD

- Provides highly approximate results and its use is very limited.
- A long duration past record must be available in order to extend it for a short duration.
- It cannot analyze the change in population trend in future.



semi-log plot
(as range is very high ex in lakh, then)

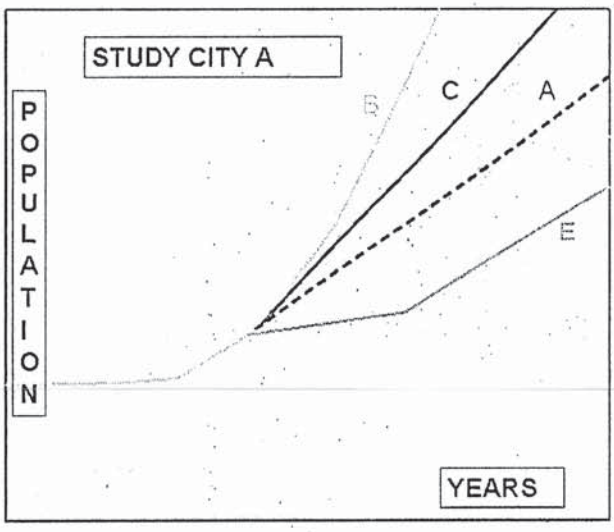
COMPARATIVE GRAPHICAL METHOD

(Most practical method as it observed method not assumed)

(Choose city ka compare hogu baaki city se)

- Cities with similar initial population growth are selected which have grown in similar manner as concerned city A. Their graphs are plotted and superimposed along with the graph of city A.
- The mean of all these graphs is taken as the proposed graph of City A.
- This method gives quite satisfactory results because of its practical nature.

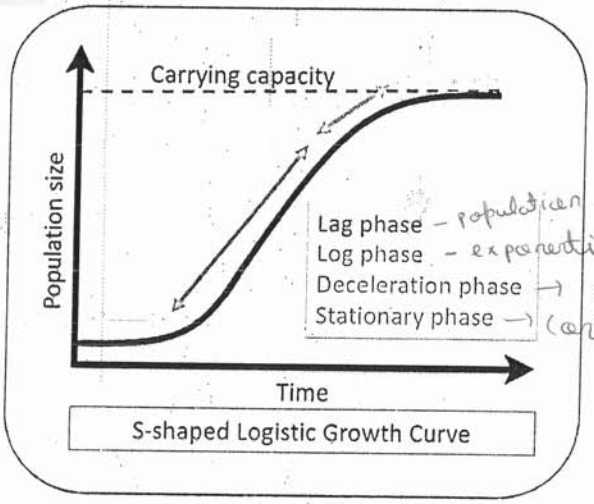
* This method cannot be used for large cities



LOGISTIC CURVE METHOD

- The 3 major factors responsible for population change are births, deaths and migrations. This method states that there is a maximum population which can be carried by a city called as SATURATION POPULATION (P_s). This is because every city has limited space and limited economic opportunities.

* This is the ideal logistic curve obtain under ideal condition
* The effect of natural calamities is not considered



- It is also known as S – Curve.
- Logistic Curve :–