

GUJARAT TECHNOLOGICAL UNIVERSITY

4th Semester Civil Engineering – PDDC

Subject Code & Name : X40601 - Environmental Engineering

Assignment - 1 (Water Demands)

Date : 02-02-2015

Theory :

1. What is water demand? What are the different types of water demand.
2. Explain in details “Per Capita Demand”.
3. What are the affecting rate of demand.
4. What is the design period and explain influencing the section of design period.
5. What is population forecasting? List & explain method of population forecasting.

Example :

1. Following data have been noted from the Census Department.

Year	Population
1981	20,000
1991	22,000
2001	28,000
2011	40,000

Calculate the Parabolic Population by different Four method for Year 2031, 2041 & 2051.

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- 1 What is water demand?
What are the different types of water demand?

The total quantity of water can be estimated by estimating the water required for different purpose. The water requirement is generally expressed in terms of average number of litres of water per capita per day (lpcd) throughout the year.

The various types of water demands which a city/town may have can be divided into following classes.

- (1) Domestic or residential
- (2) Industrial
- (3) Institutional and commercial
- (4) Fire demand
- (5) Demand for public uses
- (6) Water required to compensate losses in waste and theft.

1 Domestic or Residential Water Demand

There are number of activities in daily life where water is needed. e.g. drinking, bathing, cooking, washing of utensils, clothes, cleaning of house, vehicles etc. The water demand depends on population, living standard and habits of community, season of the year, climate of the places etc.

The environmental hygiene committee suggested certain rates based on population IS. 1172-1983 on water supply.



2

and drainage and sanitation suggested minimum 135 liters of water per day for every persons or capita (lpcd), for Economically weaker section and LIG colonies and 200 lpcd for a town or a city with full flushing system is not available in every house, generally in India 135 lpcd taken for design purpose as the bare minimum rate of consumption. In developed countries like USA, this figure may goes as high as 300 lpcd.

Given minimum water demand for domestic purpose per capita per day (lpcd) for weaker sections and LIG colonies in Small Indian towns and cities.

Table-1.1

Use	water requirement in liters per capita per day)
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing of utensils	10
Washing and cleaning of houses and residences	10
Flushing of water closet	39
Total	135 lpcd

Table-1.2

It gives minimum domestic water consumption for Indian towns and cities with full flushing system

(contd)



Use	Water Requirement (in liters per capita per day)
Drinking	5
Cooking	5
Bathing	75
Washing of clothes	25
Washing of Utensils	15
Washing and cleaning of houses and residences	15
Lawn watering and gardening	15
Flushing of water closets	45
Total	200 lpcd

2 Industrial Water Demand :

The industrial demands represent the water demand of industries, which are existing or are likely to be started in the future, in the city for which water supply is being planned. This demand depends on the number and types of the industries.

There are different uses of water in industries. It may be for process use like, chemical industry needs water as a solvent. Non process uses like cooling, washing of machine floors, working staff needs etc. Some industries needs huge quantities of water while some may need very little.

Example.

A paper industry needs 200-400 l

per unit per ton of paper and

Petroleum refinery needs 1 to 2 kl

per ton of crude refined.

Water Demands for certain Important Industries

Sl. No.	Industry	Unit of Production	Water requirement in Kilolitre per unit of Production
1	Automobiles	Vehicle	40
2	Distillery	Kilolitre (Culcohol)	152-175
3	Fertilizers	Tonne	80-200
4	Leather	Tonne	40
5	Paper	Tonne	200-400
6	Special Quality paper	Tonne	400-1000
7	Straw board	Tonne	75-1000
8	Petroleum refinery	Tonne (crude)	1-2
9	Steel	Tonne	200-250
10	Sugar	Tonne (crushed cane)	1-2
11	Textile	Tonne (goods)	80-150

3 Institutional And commercial water Demand:

The water requirement for different institute is different depending upon the type and function of the institute. For example:

- Approximately 450 lit/day is required per bed in a hospital.

Similarly water requirement for Hotels, Restaurants, schools, colleges are different.

On an average per capita demand of 20 lpcd is usually considered to be enough to meet institutional and commercial demands.



Water for Institutional Needs

Sr. NO	Institution/ type of unit	Water requirement in litres/ head/ day.
1	Office	45-90
2	Factories	
	(a) where bathrooms are provided	45-90
	(b) where no bathrooms are provided	30-60
3	Schools	
	(a) day scholars	45-90
	(b) Residential	135-225
4	Hostels	135-180
5	Hotels	180 (Per bed)
6	Restaurants	70 (Per seat)
7	Hospitals (including laundry)	
	(a) number of bed not exceeding 100	360 (Per bed)
	(b) number of bed exceeding 100	450 (Per bed)
8	Nurses homes and medical clinics	135-225
9	Railway Stations	
	(a) Junction and intermediate stations where mail and express trains stop	45 (with bathing facilities) 15 (without bathing facilities)
	(b) Intermediate stations where mail and express trains do not stop	45 (with bathing facilities) 25 (without bathing facilities)
10	Airports - International and domestic	70
11	Cinema halls and Theatres	15

4 Demand for Public uses.

This includes the quantity of water required for public utility purposes, such as watering of public parks, gardening, washing and sprinkling on roads, use in public fountains etc. For the most of the water supply schemes in India, these needs are not considered. Usually 10 lpcd is added for this demand while computing the total demand. Show Table. the water consumption for some of the public uses.

Water requirement for public use

Purpose	Water consumption
Public parks	1.4 litres per sq. meter per day
Road watering	1-1.5 litre per sq. meter per day
Sewer cleaning	4.5 litres per hectare per day

5 Fire Demand :

The demand of water for extinguishing fire is very small in a year but the rate of consumption is large. The water supply scheme should provide the necessary peak demand of water for fire fighting.

The water requirement for extinguishing fire depends on bulk, congestion and fire resistance of buildings. The minimum limit of fire demand is the amount and rate of supply that is required to extinguish the largest probable fire that may occur in town. The following empirical formula may be used where C_f is demand in litres per minute and P is the population in thousands.



11) Knichling's formula: $Q = 3182 UP$

12) Freeman's formula: $Q = 1135 \left(\frac{P}{5} + 10 \right)$

13) National Board of Fire Underwriters Formula:

$$Q = 4637 UP \{ 1 - 0.01 \cdot OP \}$$

The formula mentioned above do not take into account the probability of fire occurrence and its duration. An approximate relationship.

$$Q = \frac{43.607}{(t + 12)^{0.75}}$$

is used to take into account the duration and frequency of fire occurrence.

where

Q = discharge in litre per minute.

t = duration of fire in minute

T = frequency of fires in years.

6 Water Required to Compensate losses in waste and thefts:

This includes the water lost in leakage due to bad plumbing or damaged meters, stolen water due to unauthorized water connections and other losses and wastes. These losses should be taken into account while estimating the total requirements. These losses can be reduced by careful maintenance and universal metering. Even in the best managed water works, this amount may, however, be as high as 15% of the total consumption.



7 Per Capita Demand:

If the daily demand on average basis of a town or city is required to be calculated, we should find out the water required by a person considering all the above mentioned demand per day and for knowing the total average daily demand of the city the total population of the city is multiplied with this total demand. If Q is the total quantity of water supplied to a town yearly then per capita demand of that city is

$$= \frac{Q}{CP \times 365} \text{ litres/capita.}$$

It is expressed as l.p.c.d.

For average Indian condition, the requirement of water in terms of lpcd for town can be expressed as

(i) Domestic demand	135 lpcd.
(ii) Industrial demand	50 lpcd.
(iii) Public use	10 lpcd
(iv) Commercial use	20 lpcd
(v) Losses and thefts	55 lpcd
Total	270 lpcd.

2. Explain in detail "Per capita demand".

→ If the daily demand on average basis of a town or city is required to be calculated, we should find out the water required by a person considering all the above mentioned demand per day and for knowing the total average daily demand of the city the total population of the city is multiplied with this total demand. If Q is the total quantity of water supplied to a town yearly then per capita demand of that city is

$$= \frac{Q}{(P \times 365)} \text{ litres/day/capita}$$

It is expressed as l. P.C.D.

For average Indian condition, the requirement of water in terms of l.P.C.D for town can be expressed as

(i) Domestic demand	135 l.P.C.D
(ii) Industrial demand	50 l.P.C.D
(iii) Public use	70 l.P.C.D
(iv) Commercial use	20 l.P.C.D
(v) Losses and thefts	55 l.P.C.D

3 What are the factors Affecting
Size of demand?

→ The annual average demand considerably varies from different town or cities. This figure generally ranges between 100-180 lpcd for Indian conditions. Such variation depends upon a number of factors which are summarized below:

1 Size and type of community :

O The per capita demand for big cities is generally large as compared to that for smaller towns. This is because of the fact that in big cities, huge quantities of water are required to maintain clean and healthy environment. Commercial and industrial activities are also more in big cities.

2 Standard of living :

O Higher the standard of living, higher is the demand. More water will be consumed in air conditioners, bath tubs etc. which are the symbols of higher living standards.

3 Climatic condition :

At hotter and dry places, the consumption of water is generally more because more of bathing, cleaning, air conditioning, sprinkling in lawns, garden etc. etc. are involved. Similarly in extremely cold countries more water may be consumed because the



People may keep their taps open to avoid freezing pipes, and there may be more leakage from pipe joints since the metal contracts at lower temperature.

4 Quality of water:

If the quality of water supplied is good higher will be the consumption as people will not use any alternative source like private bore etc.

5 Pressure in the supply:

Higher pressure results in increased consumption of water as people living in higher storey will also get water freely. Also as pressure is higher more will be wastage of water and more will be the losses from the fittings.

6 Developments of sewage facilities:-

The water consumption will be more if the city is provided with flush system and shall be less if the old conservation system of latrines is adopted.

7 Metering of water:

Use of water decreases if the supplies are metered. If the water tax are based upon the amount of water used, the consumption would decrease.

8 Cost of water:

Higher is the cost, lesser will be the consumption.



9 System of Water supply:

Water supply may be continuous (24 hours) or intermittent. Generally, intermittent supply will reduce rate of demand.

10 Industrial and Commercial activities

More of these activities will result in increase in the water consumption.

4. What is design period and explain factors influencing the selection of design period.

→ A water supply scheme requires lot of investment. Lot of public money is used for it, so it is the duty of an engineer to use this money in such a way that investment can give returns for a long period of time. A water supply project includes many units like dams, reservoirs, treatment works, pipe networks and pumps with peripherals which cannot be replaced or increased in their capacities, easily and conveniently. For example water mains and the pipes used in distribution system are laid underground and cannot be replaced or added easily without digging the roads or disrupting the traffic.

In order to avoid these future complications of expansions as well as to give proper justification of the invested public money, various components of water supply scheme are designed larger than what is required for present, so as to satisfy the needs for a reasonable number of years to come. This future period or number of years for which provision is made in designing the capacities of the various components of the water supply scheme is known as **design period**.

A scheme which is designed for say x years is supposed to serve satisfactorily up to the end of x years.

The reasonable design period is 30 years. Also the design period should not exceed the useful life of the component structure.



Factors Influencing the selection of Design period.

- 1 Useful life of the component structures and their chances of becoming old and obsolete. Design period cannot be greater than those respective values.
- 2 Availability of finance in present as well as in future. Lesser is the available finance smaller is the design period.
- 3 The rate of interest on the borrowings. If the interest rates are lower, longer designed period can be selected.
- 4 Anticipated rate of population growth. For lesser rate of population growth longer design period can be selected and vice-versa.
- 5 Ease and difficulty that is likely to be faced in expansions, if undertaken at future dates. More difficult the expansion, higher will be the design period.



5 What is Population forecasting List : and explain method of population forecasting.

As water supply scheme is design for 20-30 years (design period), it is very important to predict the population for the future i.e. population to be served by the end of design period. Exact prediction for the future population is almost impossible but various methods are available for population forecasting using which future population can be predicted. For predicting future population it is very important to have the present as well as the past population data.

The data about the present as well as past population data of a city under question can always be obtained from the records of the municipality or civic body.

It can also be available from the census department.

The increase in population of a city depends upon several factors such as birth rate, death rate, migration, living conditions of the city.

Following are some of the important methods of population forecasts or population projections:

- i) Arithmetical increase method
- ii) Geometrical increase method
- iii) Incremental increase method
- iv) Decrease rate of growth method
- v) Graphical extension method
- vi) Graphical comparison method
- vii) Zoning method
- viii) Ratio and correlation method
- ix) Growth and composition analysis method

Arithmetical Increase Method :

In this method, the rate of growth of population is assumed to be constant. The rate of change of population with time is constant. It is like a simple interest calculation.

Mathematically,

$$\frac{dp}{dt} = \text{constant} = k$$

$$\int_{P_0}^{P_t} \frac{dp}{dt} = \int_0^t k dt$$

$$P_t = P_0 + k t$$

Where: $\frac{dp}{dt}$: rate of change of population

P_t = Population at sometime in the future

P_0 = Present population

t = Period of the projection in decades

k = Population growth rate (constant)

The future population P_n after 'n' decades (time) is thus given by

$$P_n = P + n I$$

Where P_n = future population at the end of n decades.

P = Present population

I = average increment for a decade



ii Geometrical Increase method or Uniform increase method.

In this method, the percentage growth rate (γ) [the per decade percentage increase] is assumed to be constant, and the increase is compounded over the existing population every decade. This method is therefore, also known as uniform increase method. It is like a compound interest calculation. This method is suitable for a rapidly developing new city.

The geometric increase can be expressed as :

$$\begin{aligned}
 P_1 &= \text{Population after 1 decade} \\
 &= P_0 + \frac{\gamma}{100} P_0 \quad (\because \gamma \text{ is in percent}) \\
 &\therefore P_0 \left(1 + \frac{\gamma}{100}\right)
 \end{aligned}$$

Similarly,

$$\begin{aligned}
 P_2 &= \text{Population after 2 decades} \\
 &= P_1 + \frac{\gamma}{100} P_1 \\
 &= P_1 \left(1 + \frac{\gamma}{100}\right)
 \end{aligned}$$

$$P_2 = P_0 \left(1 + \frac{\gamma}{100}\right)^2$$

Proceeding in this way, we can write

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

where P_0 = Initial population i.e. the population at the end of last known census

P_n = Future Population after n decades

γ = Assumed growth rate (%)



(iii) Incremental increase method:

This method combines both the arithmetic average method and the geometrical average method. From the census data for the past several decades, the actual increase in each decade is first found. Then the increment in increase for each decade is found. From these an average increase is found.

The population in the next decade is found by adding to the present population the average increase plus the average incremental increase per decade. The process is repeated for the second future decade, and so on. Thus the future population at the end of n decade is given by:

$$P_n = P + nI + \frac{n(n+1)}{2}r$$

where

P = Present population

I = average increase per decade

r = average increment increase

n = number of decades.

(iv) Decade rate of growth method or Logistic curve method.

This method has an S-shape combining a geometric rate of growth at low population with a declining growth rate as the city approaches some limiting population.

A logistic projection can be based on the equation:

$$P_t = \frac{P_{sat}}{1 + e^{at + bt^2}}$$

P_t = Population at some time in the future.

P_0 = base population

P_{sat} = Population at saturation level.

$$= \frac{(2P_0 P_1 P_2 - P_1^2 (P_0 + P_2))}{P_0 P_2 - P_1^2}$$

$$a = \log_e \frac{P_{sat} - P_2}{P_2}$$

$$b = \frac{1}{n} \log_e \frac{P_0(P_{sat} - P_1)}{P_1(P_{sat} - P_0)}$$

P_1, P_2 = Population at two time periods

n = time interval b/w successive censuses.

t = no. of years after base year.

V. Graphical Extension Method

In this method, a curve is drawn between the population P and time T with the help of census data of previous few decades, so that the shape of the population curve is obtained up to the present period.

The curve is then carefully extended from the present to the future decades. From the extended part of the curve, the population at the end of any future decade is approximately determined.

(V) Graphical comparison Method

This method is a variation of the previous method. It assumes that



the city under consideration will develop as similar cities developed in the past. The method consisting of plotting curves of cities that, one or more decades ago, had reached the present population of the city under consideration.

Thus are shown in fig. the population of city A under consideration is plotted up to 1970 at which its population is 20000. The city B having similar conditions, reached the population of 62000 in 1930 and its curve is plotted from 1930 onwards. Similar curves are plotted for other cities C, D, and F, which reached the population of 62000 in 1925, 1935 and 1920 respectively.

VII Zoning Method (Master Plan Method)

The master plan prepared for a city is generally such, as to divide the city in various zones and thus to separate the residential, commerce and industry in various zones and thus to separate the residence, commerce and industry from each other. The population densities are also fixed. Say for example there may be 5 persons living in a residential plot and there may be 5000 plots in a zone.

Common Population Densities

Area Type	Persons per hectare (Population density)
Residential single family units	15-80
Residential - multiple family units	80-250
Apartments	250-2500
Commercial areas	60-75
Industrial areas	15-40



VIII Growth composition Analy.

The change in population of a city is due to three reasons:

(1) Birth

(2) Death and

(3) Migration from villages or other towns.

The population forecast may be made by proper analysis of these three factors. The difference bet'w birth rate and death rate gives the natural increase in the population. Thus,

$$P_n = P + \text{Natural increase} + \text{migration}$$

The estimated natural increase is given by the following expression:

$$\text{Natural increase} = T (T_B - I_D)$$

Where. T = design period

P = present population

T_B = Average birth rate per year

I_D = Average death rate per year



Example

Year	Population	Increase Population	% Increases in Population
1981	20,000	-	
1991	22,000	2000	$\frac{2000}{20000} \times 100 = 10$
2001	28,000	6000	27.27 $\frac{6000}{22000} \times 100$
2011	40,000	12,000	42.86
Total	201,000		80.13
Average	$\frac{201000}{3} = 66666.67$		$\frac{80.13}{3} = 26.71$

a) Arithmetic Increase method:

For 2031

$$P_n = P_0 + nI$$

P_0 = Present population = 40,000

n = no. of decades = 3 = $\frac{(2031 - 2011)}{10}$

I = Average Increase = 6666.67

$$P_{2031} = 40,000 + 3 \times 6666.67 \\ = 60,000.01$$

For 2041 $n=4$



$$\begin{aligned}
 P_{2041} &= 40,000 + 4 \times 6666.67 \\
 &= 66666.68 \\
 &= 66667. \text{ Ans}
 \end{aligned}$$

For 2051

$$n = 5$$

$$\begin{aligned}
 P_{2051} &= 40,000 + 5 \times 6666.67 \\
 &= 73,333.35 \\
 &= 73,334. \text{ Ans}
 \end{aligned}$$

O b Geometric Increase method:

For 2031

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

where $n = \text{no. of decades}$

$\gamma = \text{Average rate of increase}$
 $= 26.71\%$

Taking $\gamma = 26.71\%$.

$$\begin{aligned}
 P_{2031} &= 40,000 \left(1 + \frac{26.71}{100}\right)^3 \\
 &= 40,000 (1 + 0.2671)^3 \\
 &= 40,000 (1.2671)^3 \\
 &= 40,000 \times 2.034 \\
 &= 81375.31 \\
 &= 81376. \text{ Ans}
 \end{aligned}$$

For 2041

$$\begin{aligned}
 P_{2041} &= 40,000 \left(1 + \frac{26.71}{100}\right)^4 \\
 &= 40,000 (1.2671)^4 \\
 &= 40,000 \times 2.577 \\
 &= 103110.66 \\
 &= 103111. \text{ Ans}
 \end{aligned}$$

For 2051



$$P_{2057} = 10,000 \left(1 + \frac{26.71}{100}\right)^5$$

$$= 10,000 (1.2671)^5$$

$$= 10,000 \times 3.26528$$

$$= 1,30,651.5$$

$$\therefore 1,30,652. Ans$$

c Incremental increase method.

$$P_n = P + nT + \frac{n(n+1)}{2} \cdot j$$

$$P_n = P_{2031}, P_{2051}, P_{2071}$$