WATER SUPPLY ENGINEERING

(QUANTITY OF WATER)

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The design of water supply system for any community requires the determination of the quantity of water required for various purposes. The sources that fulfill the demand of the water are examined. Multiple sources are determined if the water from a single source cannot fulfill the demand of the community. For estimating the quantity of water required following three factors needs to be known.

- Per capita Demand of water
- Base and design period
- Population

### 3.1 Per Capita Demand of Water

It is also termed as the rate of demand. It is defined as the total annual average daily consumption including all demands of water for a person. It is expressed in liters per capita per day (lpcd). In Nepalese context, for rural water supply system per capita demand is taken as 40 – 45 lpcd and for urban water supply system per capita demand is taken as 100-160 lpcd. If Q be the quantity of water required per year by community with population P, then per capita demand of water is given as:

\[
\text{Per capita demand of water} = \frac{Q}{(P*365)}
\]

### 3.2 Base and Design Periods

#### Base Period:

Base period is the period required for survey, design and construction of water supply system. Usually, base period of two to three years is adopted.

#### Design Period:

Design period is defined as the future period for which a provision is made while planning and designing the water supply programs. Usually, 15 to 20 years is adopted as design period. For developing community where population growth rate is high, the population estimation may not be accurate so a low design period is taken. For the developed community where population growth rate is low, high design period can be taken.

#### 3.2.1 Typical Base and Design Periods:

For rural water supply system with the high population growth rate base period of 2-3 years and design period of 15 years is taken whereas for rural water supply system with low population growth rate base period of 2-3 years and design period of 20 years is taken. For urban water supply system base period of 2-3 years and design period up to 30 years is taken.
3.2.2 Base Year:

After the completion of the water supply system, water is delivered to the community. The year in which the water is delivered to the community is called the base year.

Base year = Survey year + Base Period

3.2.3 Design Year:

Design year is defined as that year for which the water supply system is designed for. It depends on the base year and the design period and is given as:

Design Year = Base year + Design Period

3.2.4 Selection Basis of Design Period

Design period must be selected in such a way that it is neither too long nor too short. Shorter design period may lead to an uneconomical project whereas a longer design period may result in the financial burden on the present population as the components need to be of high capacities. Following are the selection basis of design period:

1. Fluid Available:

The fluid available at the water source must be able to fulfill the needs and demands at the design year. Higher the fluid available longer can be the design period and the design period would be shorter if the fluid available is low.

2. Development of community:

For the developing communities, higher will be the population growth rate due to migration from the community with poor infrastructures. So the estimation of the population may not be accurate so a short design period is selected whereas the case is just reverse for the developed community where population growth rate is low.

3. Population Growth rate:

Due to migration and other natural phenomenon as birth and death the population cannot be accurately determined so the design period is taken shorter for high population growth rate.

4. Availability of funds and rate of interest:

If the fund available for the water supply system is adequate (not limited), the system with higher capacity can be constructed for which a longer design period can be taken. Shorter design period is taken when the fund is limited. If the interest on the money borrowed for the construction of water supply project, a longer design period can be taken and vice-versa.
5. **Useful life of components:**

Every component used in the water supply system (pipe, valves, fittings, etc) has their useful life. The design period should not exceed the useful life of such components.

### 3.3 Types of Water Demand:

Depending upon the water used for various purposes water demand are classified as:

#### 3.3.1 Domestic Demand (DD)

The domestic demand includes water used for drinking, bathing, cooking, house washing, utensils washing, cloth wasting, latrine, gardening and so on.

- 112 lpcd for fully plumbed houses
- 45 lpcd for partly plumbed houses
- 45 lpcd for rural areas served by public stand posts.

As per WHO guidelines, 135 lpcd is recommended for domestic demand.

#### 3.3.2 Livestock Demand (LD)

Livestock demand includes the quantity of water consumed by domestic animals and birds as cows, buffalos, horses, sheep, goat, pigs, chicken, ducks, etc.

- 45 lits/animal/day for big animals as cows, horses, etc.
- 20 lits/animal/day for medium sized animals as pigs, sheep, goats, etc.
- 20 lits/100birds/day for birds such as chicken ducks, etc.

The livestock demand should not exceed 20% of the total domestic demand. The livestock demand in the urban area is much lower as compared to the domestic demand and can be neglected.

#### 3.3.3 Commercial Demand (CD)

Commercial Demand includes the demand of water by offices, restaurants, schools, colleges, hospitals, hotels and other institutions.

- 500-1000 lits/day for offices (Depending upon the size)
- 500 lits/bed/day for hospitals with the bed.
- 2500 lits/day for hospitals without bed and health clinics.
- 200 lits/bed/day for hotels with the bed.
- 500 - 1000 lits/day for hotels without the bed.
- 500 – 1000 lits/day for restaurants and tea stalls.
- 10 lpcd for day scholars.
- 65 lpcd for boarders.
3.3.4 Public/Municipal Demand (PD)

Public Demand includes the quantity of water required for watering of public parks and gardening purposes. It includes cleaning of roads and sewers. This demand is taken into consideration in urban communities only. 5-10% of the total consumption is made for public/municipal demand.

3.3.5 Industrial Demand (ID)

Water consumed by industries is included within the industrial demand. The consumption depends upon the size and type of industries. 20-25% of the total consumption is made for industrial demand.

3.3.6 Fire Demand (FD)

The quantity of water that is required for firefighting purposes is included under fire demand. For cities and towns provision of fire, demand should be included in the water supply scheme. Following are the empirical formulas to determine the fire demand:

**Indian Water Supply Manual and Treatment Formula**

\[ Q = 100 P^{1/2} \]

Where, \( Q \) = Quantity of water for fire demand in kilolitres/day.

\( P \) = Population in thousands.

**Buston’s Formula**

\[ Q = 5663 P^{1/2} \]

Where, \( Q \) = Quantity of water for fire demand in liters/min.

\( P \) = Population in thousands.

**Kuichling’s Formula**

\[ Q = 3182 P^{1/2} \]

Where, \( Q \) = Quantity of water for fire demand in liters/min.

\( P \) = Population in thousands.

**Freeman’s Formula**

\[ Q = 1136 ((P/5)+10) \]
National Board of Fire Underwriters’ Formula

\[ Q = 4637 \, P^{1/2} (1-0.01P^{1/2}) \]

Where, \( Q \) = Quantity of water for fire demand in liters/min.

\( P \) = Population in thousands.

3.3.7 Loss and Wastage (LW)

There is always a loss and wastage during the supply of water. The actual amount of water wasted cannot be determined. So 15% of the total supply is taken as loss and wastage. The loss of water may be due to leakage in valves, mains, unauthorized connections, fittings, etc.

3.3.8 Total Water Demand

The sum of all the various types of demand is known as water demand.

Total water Demand = DD + LD + CD + PD + ID + FD + LW

3.4 Variation in Demand of Water

The water consumption varies from day to day, season to season and hour to hour. As the water consumption is not uniform they are studied as:

1. Seasonal Variations:

The rate of demand of water varies from season to season. During summer, more quantity of water is required for drinking, bathing, washing of clothes. It is due to the hotter climatic condition during summer. During winter, due to cool weather the consumption of water is less. In Nepalese context, the seasonal variation is low and can be neglected.

Maximum Seasonal Demand = Seasonal Peak Factor * Annual average demand

The seasonal peak factor is 1 in Nepal.

2. Daily Variations:

The rate of demand of water also varies from day to day. The consumption of water during special occasion and function is more than in any other normal day. Water is consumed more during Dashain, Tihar, wedding ceremony and other festivals. In Nepalese context, water is consumed more on Saturday.
Maximum Daily Demand = Daily Peak Factor * Annual average demand

The daily peak factor is 1 in Nepal.

3. **Hourly Variations:**

The rate of demand of water also varies from hour to hour. The demand of water is high in the morning from 5 AM to 7 AM as more amount of water is consumed for cleaning and sanitary purposes. The demand is also high during the period of cooking. The water demand remains less during day time and increases from 5 PM to 7 PM. From midnight to 5 AM in the morning, the demand remains almost zero.

Maximum Hourly Demand = Hourly Peak Factor * Annual average demand.

The hourly peak factor is 3 in Nepal.

3.5 **Peak Factor**

Peak factor is the factor which is used to match the maximum demand as per fluctuation of daily water demand as well as seasonal from average.

It is the ratio of maximum demand to that of average annual demand of water.

Maximum demand = Peak factor * Annual average demand

Peak factor = Seasonal peak factor * Daily Peak Factor * Hourly Peak factor.

For continuous system: Peak factor of 2 – 4 is adopted.

For intermittent System: Peak factor 4 – 6 is adopted.

3.6 **Factors Affecting Demand of Water**

- **Size and type of community:**

The rate of demand of water demand depends on the size and type of community. If the community is large with more municipal and other types of demand, the demand of water is high and for the small community, the demand of water is also less.

- **Climatic conditions:**

During summer, the water consumption is high as water is required in more quantity for drinking, washing and bathing purposes. During winter due to cool climate, the rate of water demand is also less.

- **Standard of living:**
Higher the standards of living higher would be the demand of water as people with high standards can afford the luxury and use of more water.

- **Quality of water:**

  The demand for water increases if the quality of water supplied is good as consumers feel safe to consume the provided water. The demand decreases when the quality of water decreases.

- **System of Supply:**

  The rate of demand of water depends upon the system of supply. If the system of supply is continuous the demand is more and the demand is less when the system of supply is intermittent.

- **Sewerage System:**

  If the community or a society is provided with sewerage system. More water is required for flushing sanitary units.

- **Metering and Cost:**

  For metered water supply the demand is less and for the unmetered system of supply, the demand is high. If the cost is high, the demand is less and the demand increases for the low cost.

**Other factors:**

- Pressure in the distribution system
- Industrial and commercial activities
- Public and Private connections
- Distance of tap stand
- Dominating age group

### 3.7. Population Forecasting

Water demand for the community is given by the product of per capita demand of water and the population of the community. The population needs to be known for the design and construction of water supply system. So, population forecasting needs to be done.

Methods of Population Forecasting:

1. **Mathematical Method:**
   - Arithmetical increase Method

   In this method, the increase in population from decade to decade is assumed to be constant.

   \[ P_n = P_0 + nC \]
Where,

\( P_0 \) = Population at the base year

\( P_n \) = Population at the \( n^{th} \) decade

\( n \) = no of decades

\( C \) = average increase in population for a decade.

- **Geometrical Increase Method**

In this method, the percentage increase in population per decade remains constant for each future decade.

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

Where,

\( P_0 \) = Population at the base year

\( P_n \) = Population at the \( n^{th} \) decade

\( n \) = no of decades

\( r \) = average percentage increase in population per decade

- **Incremental Increase Method**

\[
P_n = P_0 + nC + \frac{(nC'(n+1))}{2}
\]

Where,

\( P_0 \) = Population at the base year

\( P_n \) = Population at the \( n^{th} \) decade

\( n \) = no of decades

\( C \) = average increase in population for a decade

\( C' \) = average incremental increase in population for decade.

- **Decreased Rate of Growth/Changing Rate of Increase Method**

\[
P_n = P_0 \left(1 + \frac{r_n - r'}{100}\right) \left(1 + \frac{r_n - 2r'}{100}\right) \ldots \left(1 + \frac{r_n - nr'}{100}\right)
\]
Where,

\( P_0 \) = Population at the base year

\( P_n \) = Population at the \( n^{th} \) decade

\( n \) = no of decades

\( r_n \) = percentage increase in population in the last decade

\( r' \) = average decrease in percent increase in population per decade

- Saturation Limit Method
- Logistic Curve Method (S - curve Method)

2. Graphical Method:

- Extension Method
- Comparison Method

3. Miscellaneous Method:

- Master Plan Method

Bibliography:
