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ENVIRONMENTAL ENGINEERING

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Head Office:

HYDERABAD

GATE MASTER'S ACADEMY

3rd Floor, S.S. Towers, Beside Kamala Hospital,

Dilsukhnagar, Hyderabad.

Tel: 040-6662 3032

Mobile:+91 8125303032

GM Publications

Address : #303, 3rd Floor, SS Towers, Beside Kamala Hospital,
Dilsukh Nagar, Hyderabad - 60

Phone : 040-66623032

Mobile : +91 8125303032

e-mail : info.gmpublication@gmail.com

web : www.gatemasterspublication.com

Authors

Subject Experts of Gate Master's Academy, Hyderabad.

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INDEX

Environmental Engineering

TSPSC AEE SYLLABUS

Water supply : objectives, rate of demand, population forecasts; Analysis of water –classification, design of coagulation, sedimentation, filtration, disinfection and softening processes; Methods of layout of distribution pipes – Hardy cross method; *Waste water engineering* : systems of sewerage, hydraulic formulae and design of sewers, BOD, COD, self purification of natural streams, methods of sewage disposal; *Treatment of sewage* : principles and design of grit chamber, sedimentation tanks, trickling filters, activated sludge process, sludge digestion tanks, septic tanks; *Municipal solid waste* : characteristics, collection and transportation of solid wastes; *Air Pollution* : types and sources of pollutants, air quality standards; Noise pollution – Impacts and permissible limits, measurement and control of noise pollution.

APPSC AEE SYLLABUS

Water Supplying Engineering: Sources of supply, Yields, Design of intakes and conductors, Estimation of demand. Water quality standards, Control of waterborne diseases. Primary and secondary treatment. Conveyance and distribution systems of treated water, Leakages and control. Rural water supply. Institutional and industrial water supply.

Waste Water engineering: Urban rain water disposal, Systems of sewage collection and disposal. Design of sewers and sewerage systems, Pumping Characteristics of sewage and its treatment. Disposal of products of sewage treatment. Plumbing systems. Rural and semi-urban sanitation.

Solid Waste Management: Sources and effects of air pollution, Monitoring of air pollution, Noise pollution, Standards, Ecological chain and balance. Environmental assessment

SSC-JE SYLLABUS

Quality of water, source of water supply, purification of water, distribution of water, need of sanitation, sewerage systems, circular sewer, oval sewer, sewer-appurtenances, sewage treatments. Surface water drainage. Solid waste management – types, effects, engineered management system. Air pollution – pollutants, causes, effects, control. Noise pollution – cause, health effects, control

1 POPULATION FORECASTING & WATER DEMANDS

WATER DEMAND

- Whenever an engineer is given the duty to design a water supply scheme for a particular section of the community, the first study is to consider the demand and then the second requirement is to find sources to fulfil that demand.Total quantity of water required for designing the water supply scheme for a town or city.

Types of Demands

Domestic Water Demand :

- It is the quantity of water required for domestic use of community.
- In India on an average the domestic consumption of water under normal condition is about 135 lpcd (for LIG colonies) as per IS:1172-1993.
- In developed countries this figure may be as high as 350 lpcd.
- Total consumption in this demand, generally amounts to 55 to 60% of total demand.

Average domestic water consumption in an Indian community		
Use	Consumption	
	LIG (lpcd)	HIG (lpcd)
Domestic Purpose	135	200
Industrial Purpose	40	40
Public use	25	25
Fire Demand	15	15
Losses, Wastage & Theft	55	55
Total	270	335

Note : LIG - Lower Income Group, HIG - Higher Income Group.

Commercial and Industrial Demand :

Industrial water demand is 50 lpcd under ordinary conditions. Commercial water demand is 20 lpcd, although this demand may be as high as 50 lpcd for highly commercial cities

Type of Building	Consumption
Offices	45 lpcd
Day Schools	45-90 lpcd
Boarding schools	135 lpcd
Restaurants	70 lit/seat
Hotels (Per Bed)	180 lpcd
Hostels	135 lpcd
Hospitals (Per Bed)	
› No. of beds not exceeding 100	340 lts
› No. of beds exceeding 100	450 lts
Cinema halls (Per Seat)	15 lts
Bus stations & Railway stations	70 lpcd
Airports	100 lpcd

S.No.	Classification of Towns/Cities	Recommended Maximum water Supply levels (lpcd)
01.	Town provided with piped water Supply without sewerage system	70
02.	Cities provided with piped water supply where sewerage system is existing/contemplated	135
03.	Metropolitan and Mega cities provided with piped water supply where sewerage system is existing/contemplated	150

Demand for Public Use :

- To meet the water for public use, provision of 5% of the total consumption is made while designing the water works for a city.

Fire Demand :

- The minimum water pressure available at fire hydrants should be of the order of 1 to 1.5 kgf/cm^2 and should be maintained even after 4 to 5 hours of constant use of fire hydrant.

Quantity of water required for fire demand:

- National Board of Fire Underwriter's formula :

$$Q = 4637\sqrt{P}\,(1-0.01\sqrt{P})$$

Q = Quantity of water in lpm;

P = Population in thousands.

- Freeman's Formula :

$$Q = 1136\left[(P/5)+10\right]$$

- Kuichling's formula :

$$Q = 3182\sqrt{P}$$

- Buston's formula :

$$Q = 5663\sqrt{P}$$

Compensate Losses Demand :

Generally allowances of 15% to 20% of the total quantity of water is made to compensate losses, thefts and wastage of water.

Per Capita Demand :

Per Capita Demand

$$= \frac{Q}{P \times 365} \frac{\text{Litres}}{\text{Person-day}} (\text{Lpcd})$$

FACTORS AFFECTING PER CAPITA DEMAND	
Factor	**Relation with per capita demand**
› Size of city	› Directly proportional
› Climatic Condition	› Hotter and dryer the climatic condition, higher is the demand.
› Gentry and habit of people	› Higher class communities use more water
› Industrial and commercial activities	› More is the activity more is the demand
› Quality of water supply	› Better the quality of water, more is the water demand
› Pressure in distribution system	› Directly proportional
› Type of sewerage facilities	› For sewerage facility with "Flush system" consumes more water than a facility with conventional system.
› System of supply	› For 24x7 supply, consumption is more than, intermittent supply system
› Cost of water	› Inversely proportional
› Policy of metering and charging method	› Reduces consuption, hence reduces water demand

Design Period :

The number of years for which the design of the water works have been done is known as design period. Mostly water works are designed for a design period of 20 to 30 years.

Units	Design Discharge	Design Period
Water treatment unit	Maximum daily demand	15 Years
Main supply pipes	Maximum daily demand	30 Years
Well and tube wells	Maximum daily demand	30-50 Years
Demand reservoir at ground level (or) Over Head	Maximum daily demand	50 Years
Distribution system	Maximum of maximum hourly demand and coincident draft	30 Years

Fluctuations in Demand of Water :

Water demand does not remain uniform throughout the year but it varies from season to season, even from hour to hour.

- Maximum daily consumption= **1.8**×Avg. daily consumption.
- Maximum hourly consumption=**1.5**× Max daily consumption

$$= \mathbf{1.5}\left[1.8 \times \frac{Q_{avg}}{24}\right]$$

$$= \mathbf{2.7} \times \frac{Q_{avg}}{24} \ (\because \text{Expressed in lit/hour})$$

- Maximum weekely demand=**1.48**×Avg weekely demand
- Maximum monthly demand=**1.28**×Avg monthly demand
- The maximum daily demand when added to the fire demand for working out draft is known as **Coincidence Draft.**

Coincidence Draft = Max daily consumption + Fire demand.

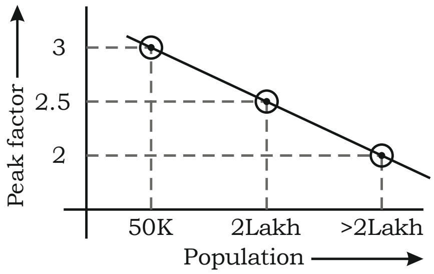
- The total draft is the coincidence draft or the maximum hourly demand whichever is more.

$$\text{Total Draft} = \left.\begin{matrix}\text{Coincidence Draft} \\ \text{Maximum hourly demand}\end{matrix}\right\} \text{Whichever is more}$$

Peak factor :

- It is the ratio of maximum daily demand to the average daily demand.

Population	Peak factor
50,000	3
50,000 - 2,00,000	2.5
>2,00,000	2
For rural water supply scheme	3



Population Forecasting :

The following are the standard methods by which the forecasting of population is done.

- Arithmetical Increase method.
- Geometrical Increase method.
- Incremental Increase method.
- Decreasing rate method.
- Simple graphical method
- Comparative graphical method.
- Master plan method
- Logistic curve method.

Arithmetical Increase Method :

- Suitable for **old and settled cities** and small towns with no industrial growth
- Rate of change of population with time is constant.

$$\frac{dP}{dt} = C$$

Population after 'n' decades can be determined by the formula :

$$\boxed{P_n = P_0 + n\bar{x}}$$

where

P_n = Population after 'n' decades

P_0 = Population data (latest known)

n = No. of decades.

$\bar{x}$ = Average increased population per decade (assumed)

Geometrical Increase Method :

- Suitable for rapidly progressing communities **(young cities)**
- This method is based on the assumption that the percentage increase in population from decade to decade remains constant.
- The forecasted population after 'n' decades is given by

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

where

P_0 = Latest known population

n = No. of decades

P_n = Population after 'n' decades

$\bar{r}$ = assumed population growth rate

$$\boxed{\bar{r} = (r_1.r_2.r_3.......r_x)^{\frac{1}{x}}}$$

$$r_i = \frac{\text{increment in population}}{\text{original population}} \times 100$$

Incremental Increase Method :

- Suitable for any type of city whether **old (or) new.**
- This method is an improvement over the above two methods. The average increase in the population is determined by the arithmetical method and to this added the average of the net incremental increase once for each future decade.
- Population after 'n' decades will be

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

where

P_0 = Latest known population

$\bar{x}$ = Average increase population per decade (assumed)

n = No. of decades

P_n = Population after 'n' decades

$\bar{y}$ = Average of the net incremental increase.

Decreasing Rate Method :

- In this method, the average decrease in the percentage increased is worked out and is then subtracted from latest percentage increase for each successive decade.

$$P_n = P_0 + \left(\frac{r_0 - n.r}{100}\right) \times P_0$$

where

P_0 = Population at last known census

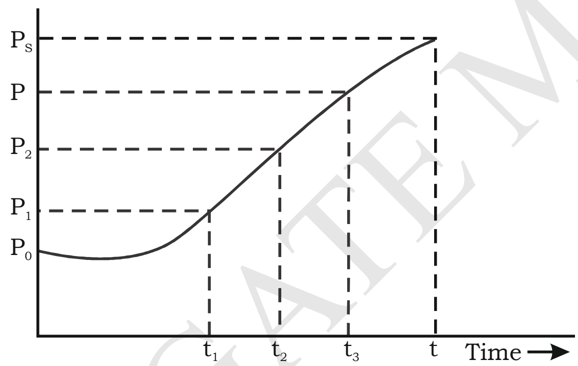
P_n = Population after next "n" decades from last known census.

r_0 = Growth rate at last known census

r = Average decrease in growth rate.

Applicable to those cases, where the rate of growth shows a downward trend.

The Logistic Curve Method:



P-Population at beginning of census record

P_1 = Population after t_1 years

P_2 = Population after t_2 years

P_s = Saturation population

Population after any time t from start,

$$P_t = \frac{P_s}{1 + m\log_e^{-1}(nt)}$$

Where,

$$m = \frac{P_s - P_0}{P_0} = \text{constant}$$

$$P_s = \frac{2P_0P_1P_2 - P_1^2(P_0 + P_2)}{P_0P_2 - P_1^2}$$

$$n = \frac{1}{t_1}.\log_e\left[\frac{P_0(P_s - P_1)}{P_1(P_s - P_0)}\right] = \frac{2.3}{t_1}\log_{10}\left[\frac{P_0(P_s - P_1)}{P_1(P_s - P_0)}\right]$$

Applicable to those regions where the rate of increase or decrease of population varies with time and also population growth is likely to reach an ultimate saturation limit.

Simple Graphical Method :

In this method the population of last few decades are correctly plotted to a suitable scale on the graph with respect to decade. The curve is smoothly extended to forecast the future population.

Comparative Graphical Method :

In this method, the cities having conditions and characteristics similar to the city whose future population is to be estimated are selected. It is then assumed that the city under consideration will develop as the selected similar cities have developed in the past.

The Master Plan Method :

The master plans are prepared for the development of the cities for 20 to 30 years. The population densities for various zones (such as residence, commercial & industry) of the towns to be developed are also fixed. The future development of the water works is also designed on the basis of the master plan.

CLASSWORK

1. Per capita water demand is calculated in litres
   a) Per person per day
   b) Per person per month
   c) Per person per year
   d) None of the above

2. Water demand of a city includes
   a) Domestic water demand
   b) Commercial and industrial demand
   c) Fire and public-use demand
   d) All the above

3. Under normal conditions, the average domestic consumption in India per person per day in litres is
   a) 105 b) 135 c) 180 d) 215

4. The total domestic consumption in a city as compared to total demand of the city is
   a) 20% b) 30% c) 60% d) 75%

5. Industrial and commercial water demand in a city as compared to total demand of the city is
   a) 10 to 15% b) 15 to 20%
   c) 20 to 25% d) 30 to 40%

6. As per norms, 45 litres of water per person per day is provided in case of
   a) Hotels b) Hospitals
   c) Office buildings d)Public places

7. Per capita consumption will be higher if
   a) Pressure in distribution system is more
   b) Quality of water will be good
   c) The living standard of people is higher
   d) All the above are correct

8. The fire demand of a city is generally calculated by
   a) Under writer's formula
   b) Freeman's formula
   c) Kuichling's formula
   d) All the above

9. If p is the population of a place in thousands then the fire demand of water in liters per minute, according to kuichling formula, is given by
   a) $5663\sqrt{p}$ b) $3182\sqrt{p}$
   c) $4640\sqrt{p}$ d) None of the above

10. Water demand for public use as compared to total demand, kept in design of water work for a city is
   a) 5% b) 10% c) 20% d) 25%

11. Maximum consumption of water is noticed in
   a) Paper factory b) Steel plant
   c) Automobile industry d) Foundry

12. The ratio of the maximum daily consumption to the average daily demand is
   a) 1.2 b) 1.5 c) 1.8 d) 2.7

13. The ratio of maximum hourly consump tion and average hourly consumption of the maximum day is
   a) 1.2 b) 1.5 c) 1.8 d) 2.7

14. If the average daily consumption of a city is 10^5 m^3,the maximum daily consumption on peak hourly demand will be
   a) $1.2x10^5$ m^3 b) $1.5x10^5$ m^3
   c) $1.8x10^5$ m^3 d) $2.7x10^5$ m^3

15. The distribution mains in water supply system are designed for
   a) Maximum daily demand
   b) Peak hourly demand
   c) Average daily demand
   d) Maximum hourly demand on maximum consumption day

16. The accurate method for predicting population for a sound and rapidly increasing city is

a) Arithmetical increase method

b) Geometrical increase metod

c) Incremental increase method

d) Graphical method

17. The population figures in a growing town are as follows:

Year	Population
1970	40,000
1980	46,000
1990	53,000
2000	58,000

The predicted population in 2010 by arithmetic progression method is

a) 62,000 b) 63,000

c) 64,000 d) 65,000

18. The average minimum domestic water consumption per capita per day for an Indian city, as per IS:1172-1993, may be taken as

a) 135 lpcd b) 240 lpcd

c) 270 lpcd d) 180 lpcd

19. Water-supply projects are designed on the rate of water consumption per capita and expected population growth at the end of the design period of :

a) 5 to 10 years b) 10 to 15 years

c) 15 to 20 years d) 25 years

Practice Questions

Level - 1

1. In the case of public water supply system, the requirement of water supply system, for fire demand is generally taken as a direct function of **(AEE-2004)**

a) Number of multistoreyed buildings

b) Population of the city

c) Area of the city

d) Industrial area

2. The requirement of water is the highest for **(AEE-2004)**

a) Livestock

b) Irrigation

c) Domestic needs

d) Nuclear power plant

3. Water losses in a supply system are assumed as **(AEE-2004)**

a) 15 % b) 7.5% c) 10% d) 22.5%

4. For water supply to a medium town, what is the daily variation factor ?

a) 1.5 b) 2.5 c) 3 d) 3.5

5. The design period adopted for designing a water distribution system is generally **(AEE-2006)**

a) 1year b) 30year c) 100year d) 500year

6. The percapita consumption of water of a locality is affected by **(AEE-2007)**

a) Climatic condition and quality of water

b) Quality of water and distribution pressure

c) Distribution pressure and climatic condition

d) Climatic condition, quality of water and distribution pressure

7. Coincidence draft of water during fire fighting is represented by **(AEE-2007)**

a) Maximum hourly demand of water

b) Maximum daily demand of water + fire fighting

c) Average hourly demand of water

d) Average daily demand of water

8. The suitable method of forecasting population for a young and rapidly increasing city is **(AEE-2007)**

a) Arithmetical increase method

b) Geometrical increase method

c) Incremental increase method

d) Graphical method

9. Water losses in a water supply system are assumed as **(AEE-2007)**

a) 5 to 10% b) 10 to 20%

c) 20 to 30% d) 30 to 40%

10. The distribution mains in a water supply scheme are designed for **(AEE-2007,08)**

a) Average daily demad

b) Maximum hourly demad

c) Maximum daily demand+fire demand

d) Greater of (b) and (c)

11. If 'V' is total consumption of water in liters for 'N' individuals, the per capita consumption (Q) **(Managers-2013)**

a) Q=V/15N b) Q=V/20N

c) Q=V/30N d) Q=V/365N

12. The formula $P_n = P_0\left(1+\frac{r}{100}\right)^n$ is used for forecasting population by **(TSPSC AE-2015)**

a) Arithmetical increase method

b) Geometrical increase method

c) Incremental increase method

d) Graphical mehtod

13. A water supply distribution system for an averagely populated township to be designed for **[ESE:2016]**

a) Maximum daily demand

b) Maximum hourly demand and fire demand

c) Average demand

d) Maximum daily demand and fire de mand, or maximum hourly demand, whichever is higher

14. As per code, water required per head per day for average domestic consumption is **(AEE-2004, AEE Prelims-2016)**

a) 60liters b) 80liters

c) 100liters d) 135 liters

15. The recommeded maximum water supply needs as per CPHEEO guidelines for metropolitan and megacities where sewerage system is existing or contemplated, in litres per capita per day (*l*pcd), is

(APPSC AEE Prelims-2016)

a) 45 b) 70 c) 136 d) 150

16. The peak factor suggested by CPHEEO for computing carrying capacity in the design of sewers for the contributory population of 20,000 is **(APPSC AEE Prelims-2016)**

a) 2.00 b) 2.25 c) 2.50 d) 3.00

17. The Freeman's formula to estimate the quantity of water required to meet the fire demand (Q) of a city with a population of P (in thousands) is___

(AE (ENV) Mains-2017)

a) $3861\sqrt{P}\left(1-0.01\sqrt{P}\right)l\text{pm}$

b) $5663\sqrt{P}\,l\text{pm}$

c) $1136.5\left(\frac{P}{5}+10\right)l\text{pm}$

d) $2650\left(\sqrt{P}\right)l\text{pm}$

18. **Statement (I):** Both the Empirical formulae given by American insurance Association and buston for the determination of fire demand of water are not suitable for Indian conditions.

Statement (II) : Kuchling's formula estimates lesser value of fire water demand.

[IES-2021]

19. The various types of water demand, which a city may have, may be broken down into which of the following classes ?

1. Domestic water demand

2. Industrial water demand

3. Demand for public uses

Select the correct answer using the code given below:

(a) 1 and 2 only (b) 2 and 3 only

(c) 1 and 3 only (d) 1, 2 and 3

20. For water supply scheme design of a town or a city, the suitable method of estimating future population by the end of the design period is

(a) Increasing rate method

(b) Decreasing rate method

(c) Exponential curve method

(d) Incremental decrease method

21. Which one of the following forecasting methods for population is also known as uniform increase method?

a) Arithmetic increase method

b) Decreasing rate method

c) Geometric increase method

d) Simple geographical method

Level - 2

1. The population of a town in three consecutive years is 5000, 7000 and 8400 respectively. The population of the town in the fourth consecutive year according to geometrical increase method is

[TSPSC RWS : 2018,Obervers-2013]

a) 9500 b) 10920 c) 10100 d) 9800

2. The population of a city in the year 2000 was 82,300. If average percent increase in population per decade in 35%, the population of the city in the year 2020 estimated geometrical increase will nearly be **[ESE:2015]**

a) 100000 b) 125000

c) 150000 d) 175000

3. If the average of the population increase in known decades is 5000 and the average incremental increase is 600. Calculate the population after 3 decades from the present known population of 50,000.

[TSPSC FRO:2017]

a) 65000 b) 66800

c) 68600 d) 65600

Level - 1

KEY

01. b 02. b 03. a 04. b 05. b 06. d 07. b 08. b 09. b 10. d

11. d 12. b 13. d 14. d 15. d 16. d 17. c 18. b 19. d 20. c

21. c

Level - 2

KEY

01. b 02. c 03. c

2 SOURCES OF WATER

WATER SUPPLY

The selection of a water source depends mainly on the quantity of water which it can yield to cater the needs of the community.

These can broadly classified as

Surface Sources	Subsurface Sources
› Streams	› Springs
› Rivers	› Infiltration galleries
› Lakes	› Infiltration wells
› Ponds	› Wells
› Impounded Reservoirs/Oceans	

Surface Sources

- **Streams :**

  Streams are formed by run off. The quantity of water in streams is more in rainy season than that in other season. The quality of water in streams is normally good. The impurities may be in suspended form or dissolved form.

- **Rivers :**

  Rivers originate in the hills where the quantity of water remains small but as they move forward, more and more streams combine in it and increases its discharge. They are polluted by dilution of sewage from the communities. River water has self purification capacity. In rainy season run off water makes river as too turbid water.

- **Lakes :**

  Lakes are natural basins formed with impervious beds formed in hilly areas and receive water from springs and streams. The suspended type impurities in lakes settle down in the bottom but in the lake bed, weeds and organic growth take place which produce bad smell, taste and colour in water.

- **Ponds :**

  These are depressions in plains in which water is collected during rainy season.

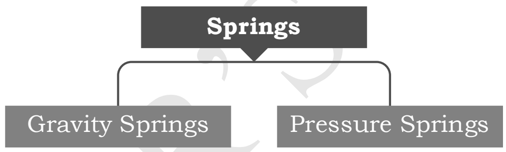
- **Impounded Reservoirs :**

  Water stored in the river by constructing weir or a dam across the river forming a reservoir.

Subsurface Source (Ground Water)

- **Spring :**

  Spring is a natural out cropping of ground water along the slopes of hills or river banks.



- **Infiltration Galleries :**

  Infiltration galleries are tunnel like structures constructed near the banks of rivers or streams. These are constructed in masonry or concrete with arch roof along the length of the river bank.

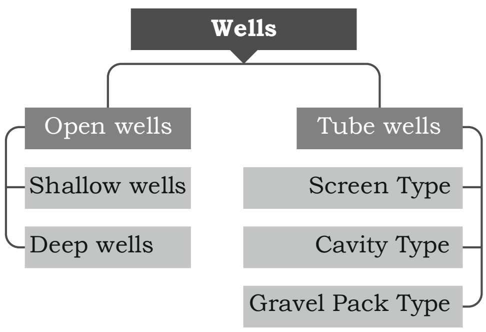
- **Infiltration Wells :**

  These are wells constructed in series or rows under the soil along the river banks to trap the underground water passing in the rivers. Series wells are connected by radial Porous pipes with each other and finally connected to a sump well called *Jackwell*. Water collected in the jackwell is pumped out to treatment plant for further process.

- **Wells :**

  Vertical holes excavated into the water bearing stratum are known as wells

Classification of wells:



According to the Aquifer Tapped :

- ***Shallow wells :***

  Constructed in the upper most aquifer of the earth (generally unconfined aquifer)

- ***Deep wells :***

  Constructed to a larger depth into the confined aquifer of the earth to get larger and reliable water.

Note :

> - The nomenclature of the shallow and deep well is purely technical and has nothing to do with actual depth of the well.
> - A shallow well might be having more depth than a deep well.

According to condition of flow :

- ***Gravity wells :***

  Constructed in top unconfined aquifer.

- ***Pressure (or) Artesian wells :***

  Wells constructed in confined aquifer.

Note :

> In certain cases of artesian wells the water flows out of the wells on to the ground surface due to high pressures. Such wells are called as "flowing wells".

According to the size of the well :

- ***Open wells :***

  Diameter may vary from 1 to 9m.

- ***Tube wells :***

  These are mostly taken into the bottom of confined aquifers of the earth to draw large quanties of water. Diameter of tubewells vary from 25 to 90 cm

According to the type of construction :

- Dug wells
- Sunk wells
- Driven wells
- Bored wells
- Drilled wells

INTAKES FOR COLLECTING SURFACE WATER

Whenever the water is withdrawn from surface source such as a lake or river and the entrance of the withdrawl conduit is not an integeral part of a dam or any other related structure, then an intake structure must be constructed at the entrance of the conduit.

Submerged Intake

- A simple submerged intake consist of a simple concrete block or a rock filled timber crib supporting the intake end (with a bell-mouth) of the withdrawl pipe.
- This type of intake is cheap and there is no obstruction to navigation.

Tower Type Intakes

- They are also known as exposed intakes
- Used for tapping water from reservoirs, lakes and most commonly from rivers.
- In case of reservoirs, sometimes an exposed intake is provided.
- Depending upon the water tapping source they are classified as river intake or reservoir intakes.
- River intakes are classified into four types
- **Intake well**
  - They are circular masonry or concrete tower of two to six meter diameter
  - The water flows into the intake well through the penstocks located at different level.
- **Pipe intake**
  - When a small quantity of water is to be drawn the pipe intakes are economical.
- **Weir intakes**
  - Water is drawn from the weir through a channel into a sump well.

- **Floating pantoon intake**
  - In case of wide rivers with great fluctuations in flow, weir intake are not economical. In such case floating intakes with a strained bell mouth are provided.

Canal intakes

- It consists of a pipe intake placed at the canal bed and enclosed in a concrete well.
- The end of the pipe is provided with a bell mouth with fine screens.
- They are similar to submerged intakes.

Lake intake

- Lake intakes are also of tower type intakes.
- Special precaution is to be taken while locating the intakes so that polluted shores water may not enter into the intake conduit.
- To avoid entry of sediments, wet wells may be provided with a blow off valve.

CLASSWORK

1. Which source of water among the follow ing is not a surface source ?

a) River b) Well c) Lake d) Ocean

2. Which source of water, among the following, is not a sub surface source ?

a) Spring

b) Well

c) Storage reservoir

d) Infiltration gallery

3. The natural out flow of subsurface water at the surface is termed as

a) Lake b) Spring

c) Infiltration gallery d) Tube well

4. A well constructed in the upper most water bearing stratum is called

a) Infiltration well b) Tube well

c) Shallow well d) Jack well

5. An infiltration gallery is

a) A tube well with horizontal arms

b) A horizontal well under the ground surface

c) An artesion well

d) A shallow well

6. A well consisting of RCC rings placed on a curb, sunk in the bed of a river is called

a) Infiltration well b) Jack well

c) Deep well d) Artesion well

7. Ground water is

a) Free from suspended solids but contain dissolved solids

b) Free from harmful bacteria but may contain harmless bacteria

c) Free from floating impurities but may have suspended solids

d) Free from dissolved solids but may have colloidal solids

8. A good source of water requiring practically the least treatment is

a) A perennial river

b) An impounded reservoir

c) A deep well

d) An elevated lake

9. The most commonly used type of tube well in India is

a) Cavity type b) Strainer type

c) Slotted type d) Perforated pipe type

10. As compared to shallow wells, deep wells have

a) More depth

b) More discharge

c) More depth and more discharge

d) More depth but less discharge

11. The quantity of water available from an infiltration gallery depends on

a) Size of the gallery

b) Yield of the surrounding aquifer

c) Length of the gallery and yield of the surrounding aquifer

d) Neither size of the gallery nor yield of the surrounding aquifer

Practice Questions

Level - 1

1. A tube-well that supplies water to a surface canal during non-monsoon season is known as **(AEE 2003)**

   a) Direct irrigation tube-well

   b) Stand-by tube-well

   c) Augmentation tube-well

   d) Indirect irrigation tube-well

2. For the least effect on the water table, the location of tubewells should be one per every **(AEE 2004)**

   a) 0.50 sq km b) 0.75 sq km

   c) 1.50 sq km d) 2.50 sq km

3. The highest yield of water can be expected from **(AEE 2004)**

   a) Gravity springs

   b) Surface springs

   c) Artesian wells

   d) Aquifuge

4. Perched aquifers are found **(AEE 2004)**

   a) At ground surface

   b) Below ground surface but above water table

   c) Below ground water table

   d) At ground water table level

5. Underground water is obtained from **(AEE 2004)**

   a) Rivers b) Lakes

   c) Reservoirs d) Springs

6. The horizontal tunnels constructed at shallow depths along the banks of a river to intercept ground water tables are called **[APPSC-AE-2022]**

   a) Canals b) Infiltration galleries

   c) Springs d) Lakes

Level - 1

KEY 01. d 02. c 03. c 04. b 05. d 06. b

3 QUALITY & CHARECTERSTICS OF WATER

INTRODUCTION

The primary objective of water treatment and purification is to collect water from best available source and subject it to processing which will ensure water of good physical quality, free from unpleasant taste or odour and contain nothing which might be detrimental to health. It is not possible to find absolutely pure water in nature. Chemically pure water is the one which contains two parts of hydrogen and one part of oxygen.Supplies of water may be obtained by drawing directly from rivers,lakes, or springs.

- **Pure Water :**
  Water which contains only two parts of hydrogen and one part of oxygen by volume.
- **Wholesome Water :**
  Water which is not chemically pure, but does not contains anything harmful to human health.
- **Potable water :**
  Water which is tasteful for drinking and aesthetically pure.
- **Palatable water:**
  Water which has characterstics of both, “Wholesome water” and “Potable water”.
- **Polluted Water :**
  Water which consists of undesirable substances which make it unfit for drinking and domestic use.
- **Contaminated Water :**
  Water containing pathogenic organisms.

Common Impurities in water :

- **Suspended Impurities :**
  - Suspended impurities include clay, algae, fungi, organic and inorganic matters and mineral matter etc.,
  - These all impurities are macroscopic and cause turbidity in the water.
  - The size of suspended impurities range from **10^{-1}mm to 10^{-3}mm**

Note : Size > 10^{-1}mm → Particulates *Eg:* dust.

- **Colloidal Impurities :**
  - Finely divided dispersion of particles in water
  - Colloidal impurities generally associated with organic matter containing bacteria and they are chief source of epidemics.
  - Most of the colour of the water is due to colloidal impurities.
  - Size of impurities may range from **10^{-3} mm to 10^{-6} mm.**
- **Dissolved Impurities :**
  - Impurities are dissolved in water in the form of solids, liquids and gases
  - Dissolved impurities may be organic or inorganic in nature.
  - Concentration of dissolved impurities is expressed in ppm.
  - Size may range from **10^{-6}mm to 10^{-8}mm**

Examination of water :

The parameters which help in asserting the quality of raw water are called “Water Quality Parameters”.

These parameters are classified as :

Classification of Water Quality Parameters

PHYSICAL	CHEMICAL	BIOLOGICAL
Temperature	Dissolved Solids	Bacteria
Colour	pH	Virus
Turbidity	Alkalinity	Protozoa
Taste & Odour	Hardness	Helminths
Suspended Solids	Nitrogen Chlorides Fluorides, etc.,	

Total Solids = Suspended solids + Dissolved solids

PHYSICAL TESTS

- **Temperature :**
  - Temperature of water is measured by thermometers.
  - The most desirable temperature for public supply is 10^0C.
  - Temperature above 26^0C is undesirable and above 35^0C is unfit for public supply, because it is not potable.
  - Temperature affects the chemical and biological reactions.
  - An increase in 10^0C in temperature almost double the biological activity.
  - For water supply, the temperature should be in between 10^0C to 25^0C
  - **Beyond Upper Limit** $\rightarrow$ Rate of biological reaction increased.
  - **Below Lower Limit** $\rightarrow$ Not easily consumable.
- **Colour :**
  - Colour of water is usually due to presence of organic matter in colloidal condition, but sometimes it is also due to mineral and dissolved organic and inorganic impurities.

> 1 TCU= The colour produced by one milligram of platinum cobalt ion as a chloroplatinate mixed in one litre of distilled water.

  - The permissible colour for domestic water is 20ppm on platinum cobalt scale (Burgess Scale).
  - Colour caused by **suspended** and **dissolved matter** in water referred as *apparent colour.*
  - After suspended matter causing colour is removed by **filtration, centrifugation etc.,** the colour obtained is called *true colour.*

Effects :

- Coloured water is not suitable for dyeing purpose.
- Organic compounds causing colour may exert chlorine demand and hence reduces the effectiveness of disinfection by chlorine.
- Phenolic compounds with chlorine produces taste and odour.
- Some colour causing organic compounds with chlorine becomes carcinogenic.

Measurement :

- Measurement of colour is done by colour matching techniques using *Nesslers* tubes

  (instrument used is **Tintometer**)

Turbidity :

- It is caused due to presence of suspended and colloidal impurities in the matter.
- Turbidity is the measure of extent to which light is either absorbed or scattered by suspended material in water, however it is not a direct quantitative measure of SS (Suspended Solids).

> **Note :** SS depends upon concentration where as turbidity depends on both concentration and fineness of particles in water.

- Ground water produces less turbidity on one milligram of finely divided silica scale by turbidimeters.

Effects :

- Disinfection of turbid water is difficult because the SS may partially shield the organisms from disinfectant. So efficiency of disinfection decreases.
- In natural bodies, turbidity interferes with light penetration and hence with the photosynthetic reactions (which gives oxygen to the water).

MEASUREMENT OF TURBIDITY