WATER QUANTITY & QUALITY

SEC-A

NOTES

BY

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Content…

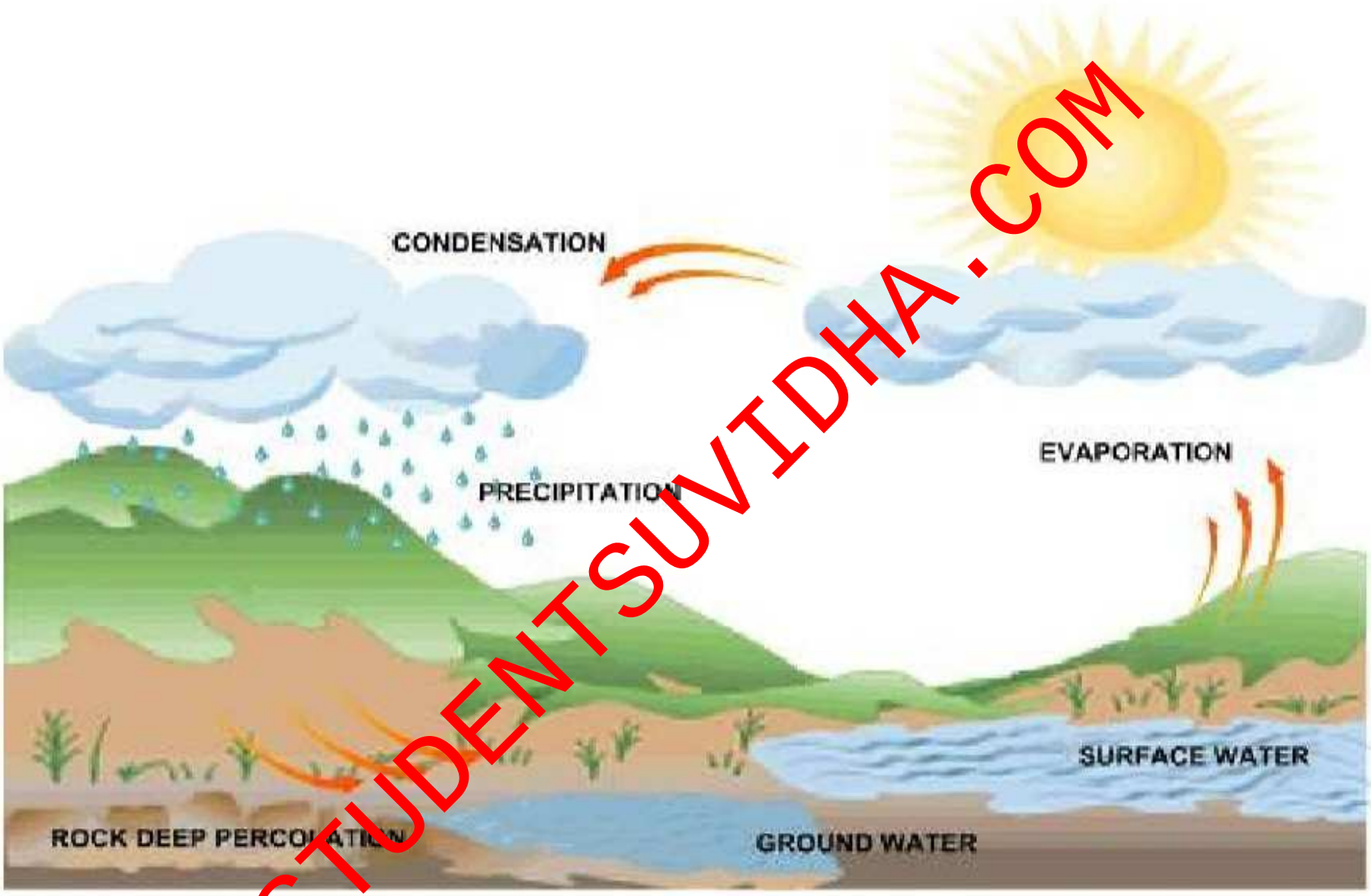
Sources of water, Assessment of domestic and industrial requirement, Impurities in water, Indian standards for drinking water, Water borne diseases and their control.

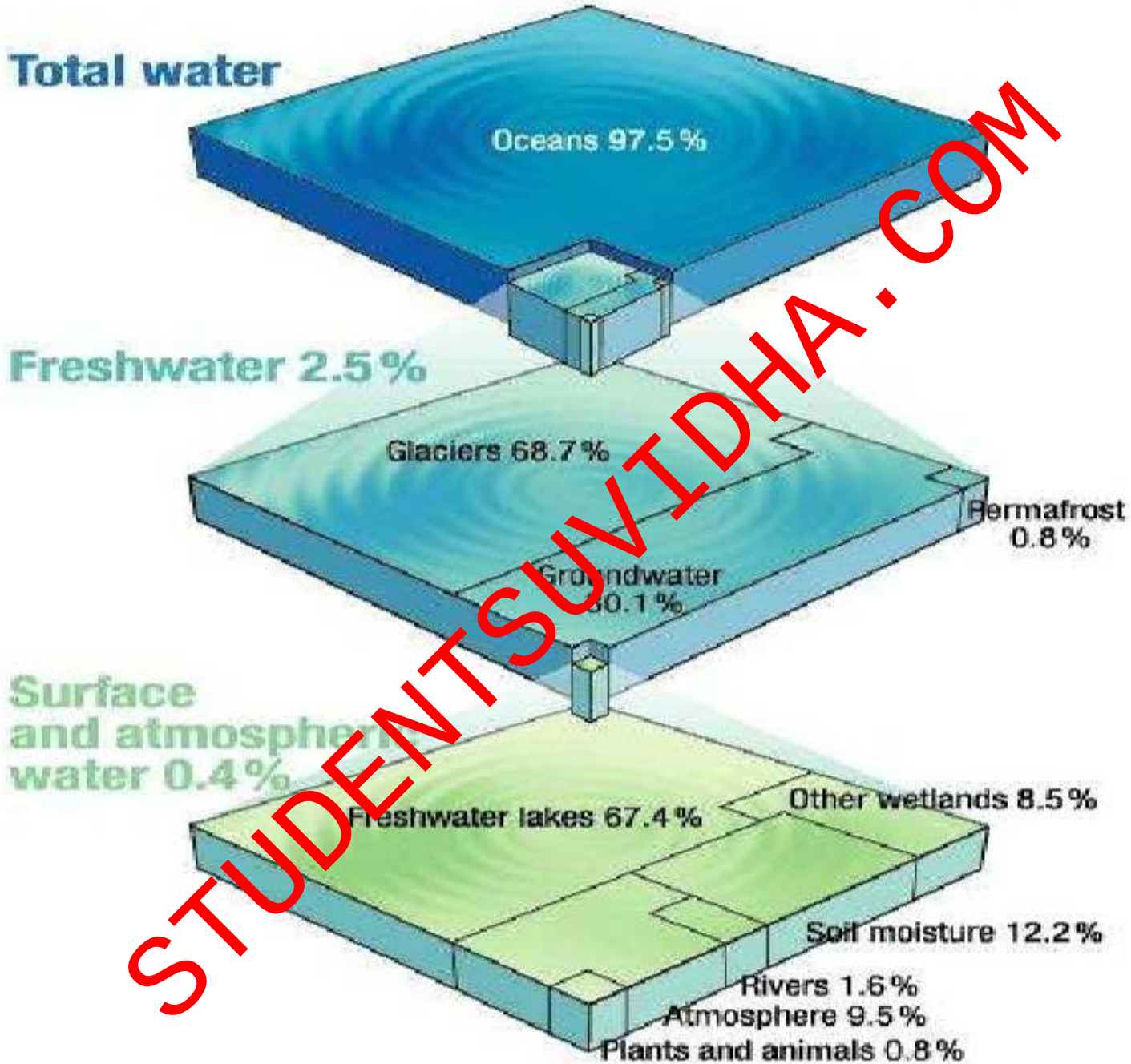
Water…

- Vital natural resources which forms basis of life.
- is a chemical substance with the chemical formula H_2O
- found in 3 states liquid, solid and gases
- 97% earth surface covered by water
- animals and plants have 60-65% water in their body

- Water keeps on cycling endlessly through environment "Hydrological cycle"

- evaporation or transpiration
- precipitation
- condensation
- runoff





Source selection of water

Selecting site for the source of water-

- Location
- Elevation of intake point
- Quantity of water
- Quality of water

Sources of water..

FIGURE 1
Water use by source

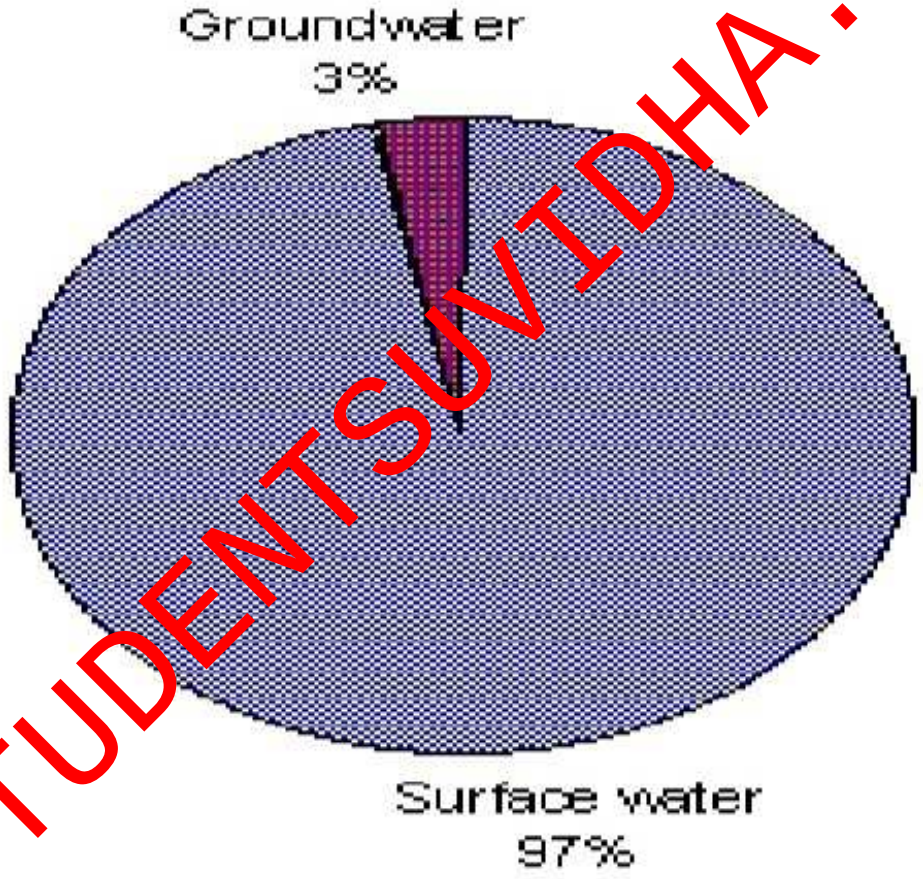
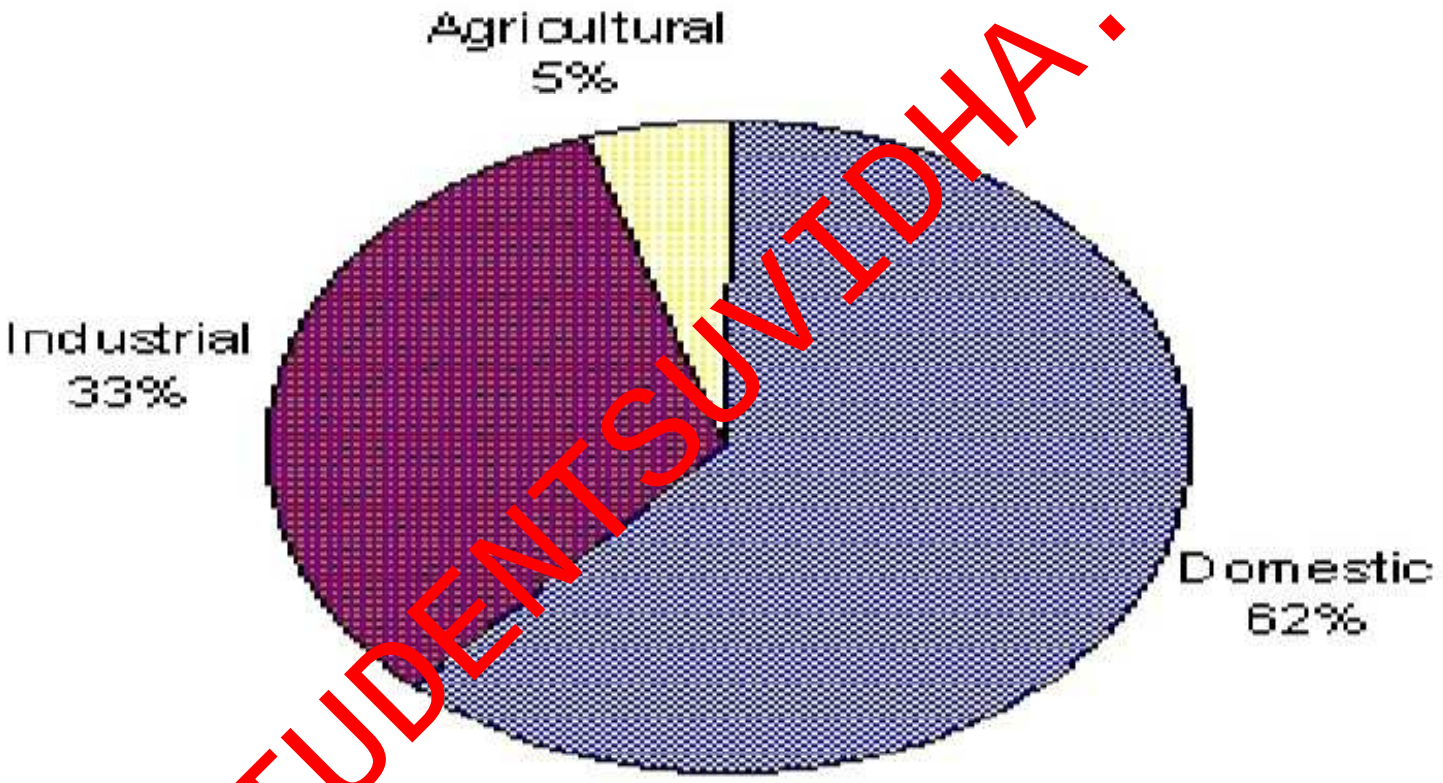
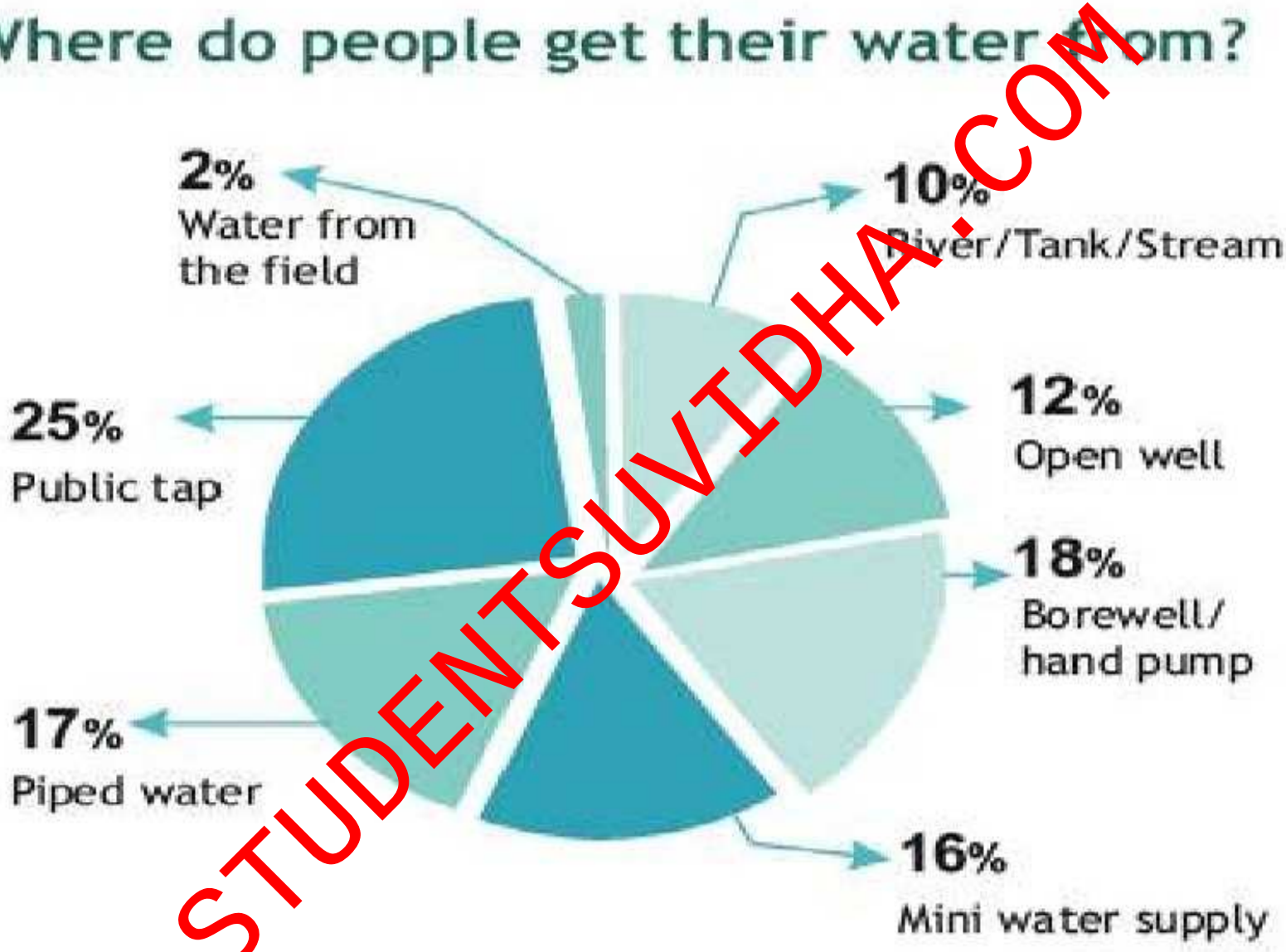


FIGURE 2

Groundwater utilization by sector





Characteristics of surface water

- Physical and chemical character vary.
- Contain lot of sand.
- Lot silt and clay.
- Contain oxygen, algae, bacteria and other microbes.
- Proper treatment needed before use.

Characteristics of ground water

- Rich in mineral content.
- High iron content.
- Harder than surface water.
- Almost no treatment or only disinfection may require.

Water requirements

Determination of total water requirements involves-

- Water consumption rate *(Per Capita Demand in litres per day per head)*
- Population to be served.

- *Quantity = Per capita demand x Population*

Water Consumption Rate

- Very difficult to assess the quantity of water demanded by the public, since there are many variable factors affecting water consumption.

- There are various types of water demands in a city.

- Domestic water demand
- Industrial demand
- Institution and commercial demand
- Demand for public use
- Fire demand
- Loses and wastes

Domestic water demand

- water required in the houses for drinking, bathing, cooking, washing etc.
- mainly depends upon the habits, social status, climatic conditions and customs of the people.
- As per IS: 1172-1963, under normal conditions, the domestic consumption of water in India is about 135 litres/day/capita.

The details of the domestic consumption are

a) Drinking ----- 5 litres

b) Cooking ----- 5 litres

c) Bathing ----- 55 litres

d) Clothes washing -----20 litres

e) Utensils washing ----10 litres

f) House washing----- 10 litres

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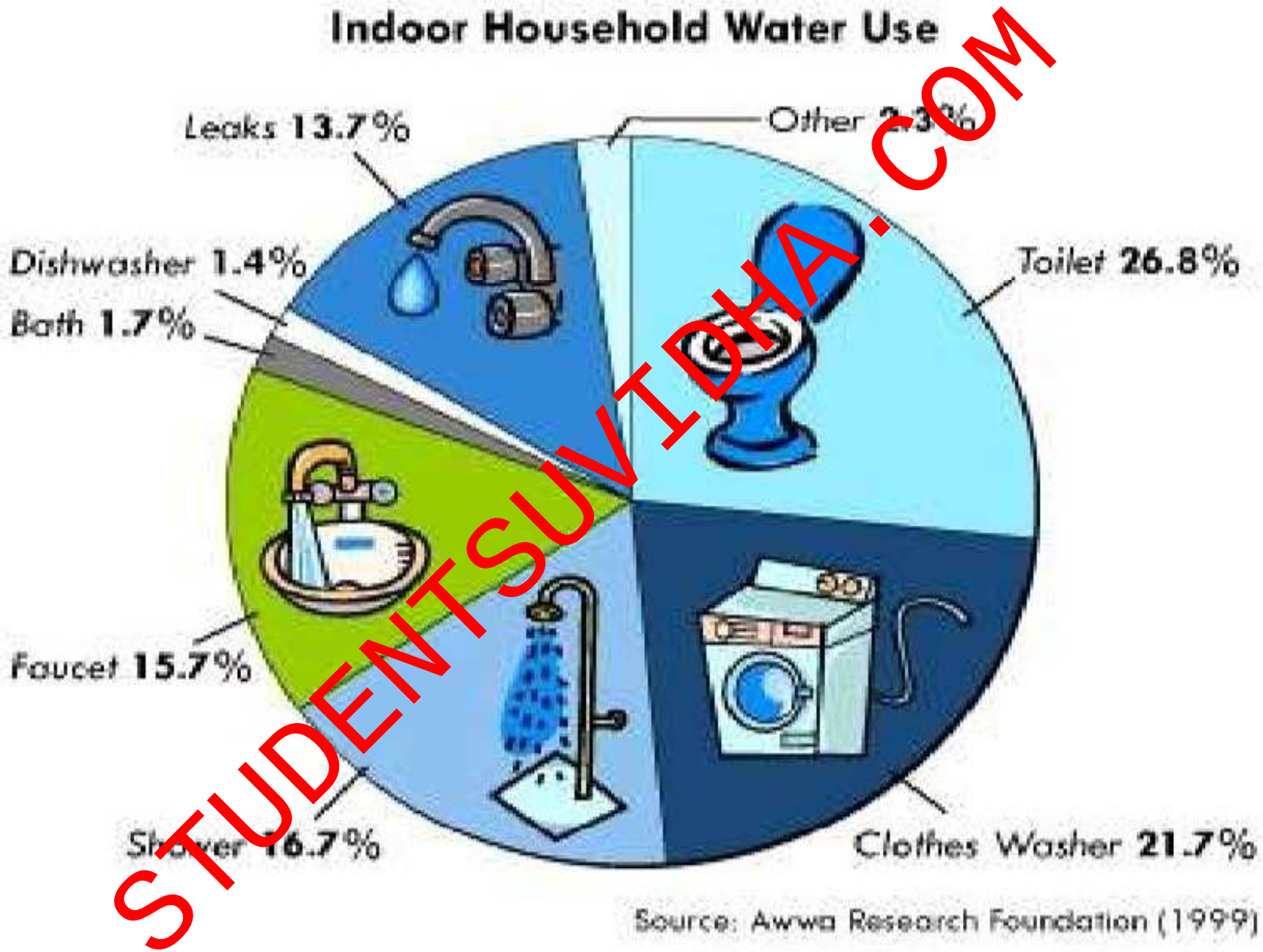
135 litres/day/capita



Industrial demand

- The water required in the industries mainly depends on the type of industries, which are existing in the city.
- The water required by factories, paper mills, Cloth mills, Cotton mills, Breweries, Sugar refineries etc. comes under industrial use.
- The quantity of water demand for industrial purpose is around 20 to 25% of the total demand of the city.

Institution and commercial demand

- Universities, Institution, commercial buildings and commercial centres including office buildings, warehouses, stores, hotels, shopping centres, health centres, schools, temple, cinema houses, railway and bus stations etc comes under this category.

Demand for public use

- Quantity of water required for public utility purposes such as for washing and sprinkling on roads, cleaning of sewers, watering of public parks, gardens, public fountains etc. comes under public demand.
- To meet the water demand for public use, provision of 5% of the total consumption is made designing the water works for a city.

The requirements of water for public utility shall be taken as...

Sl.No.	Purpose Water	Requirements
1	Public parks	1.4 litres/m2/day
2	Street washing	1.0-1.5 litres/m2/day
3	Sewer cleaning	4.5 litres/head/day

Fire demand

- During the fire breakdown large quantity of water is required for throwing it over the fire to extinguish it, therefore provision is made in the water work to supply sufficient quantity of water or keep as reserve in the water mains for this purpose.

- The quantity of water required for fire fighting is generally calculated by using different empirical formulae.
- For Indian conditions kuiching's formula gives satisfactory results.

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

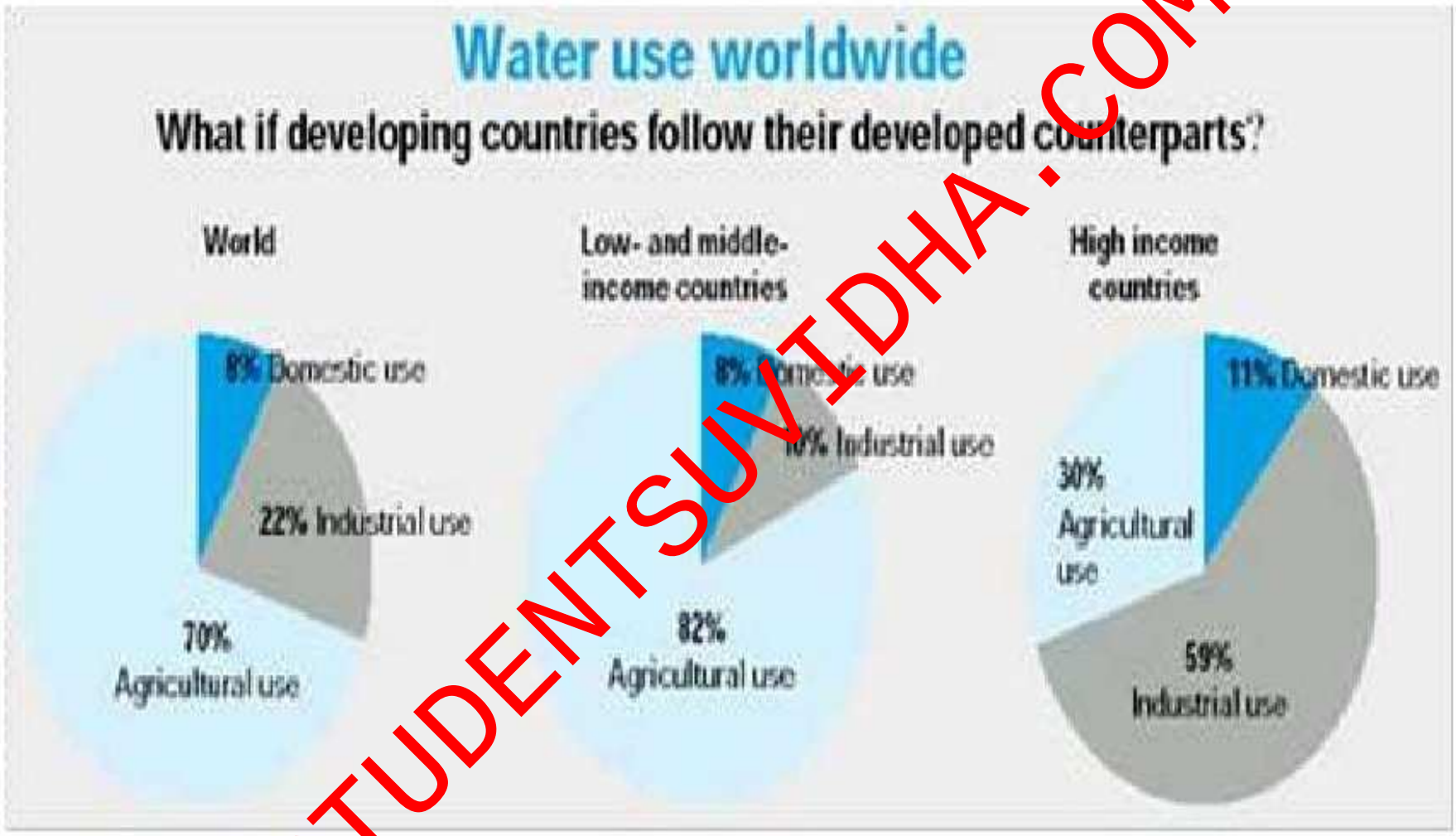
- Where 'Q' is quantity of water required in litres/min
- 'P' is population of town or city in thousands

Loses and wastes

- Losses due to defective pipe joints, cracked and broken pipes, faulty valves and fittings.
- Losses due to, continuous wastage of water.
- Losses due to unauthorised and illegal connections.
- While estimating the total quantity of water of a town; allowance of 15% of total quantity of water is made to compensate for losses, thefts and wastage of water.

Water Consumption for Various Purposes

	Types of Consumption	Normal Range (lit/capita/day)	Average	%
1	Domestic Consumption	65-300	160	35
2	Industrial and Commercial Demand	45-450	135	30
3	Public Uses including Fire Demand	20-90	45	10
4	Losses and Waste	45-150	62	25



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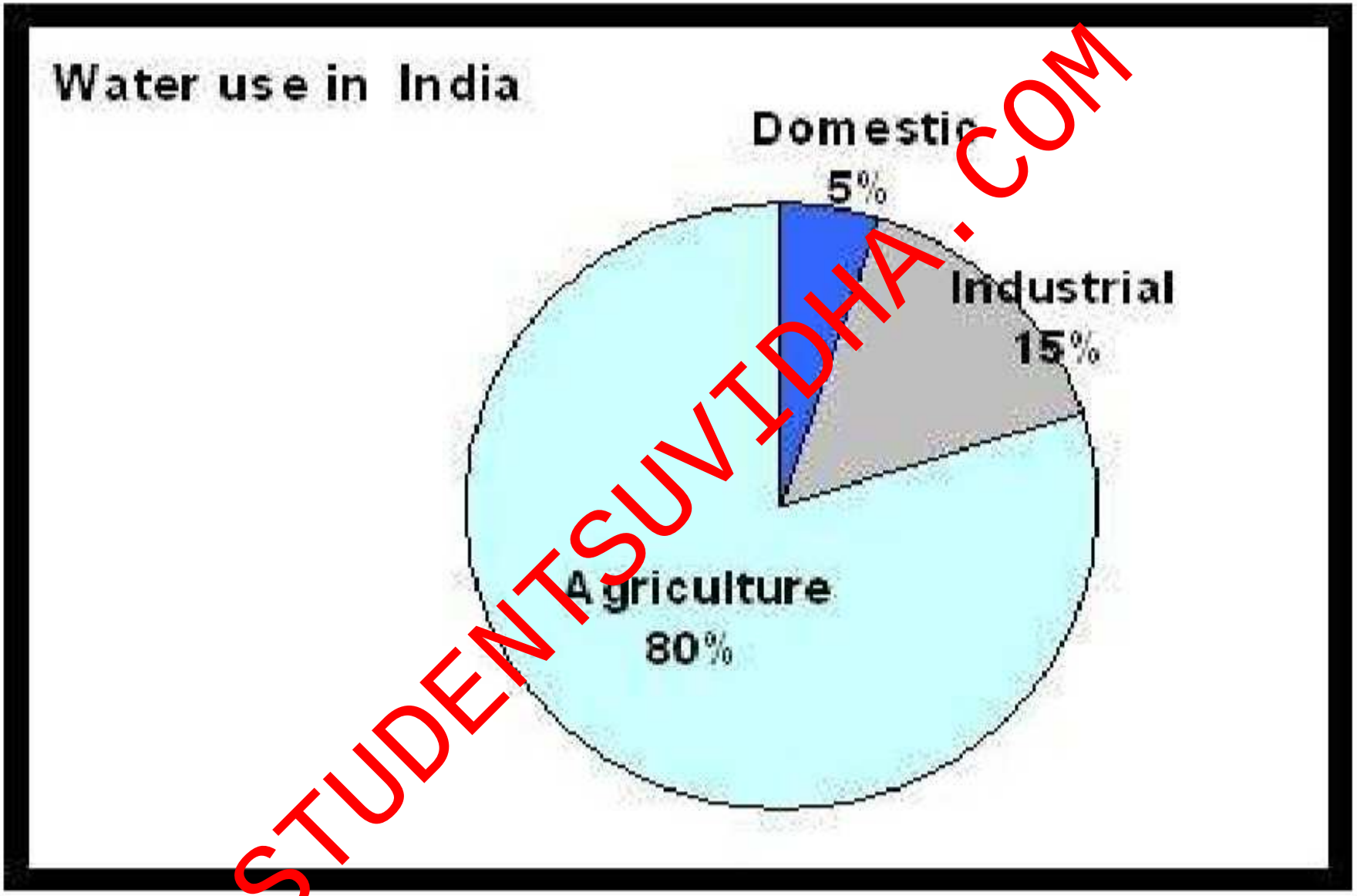

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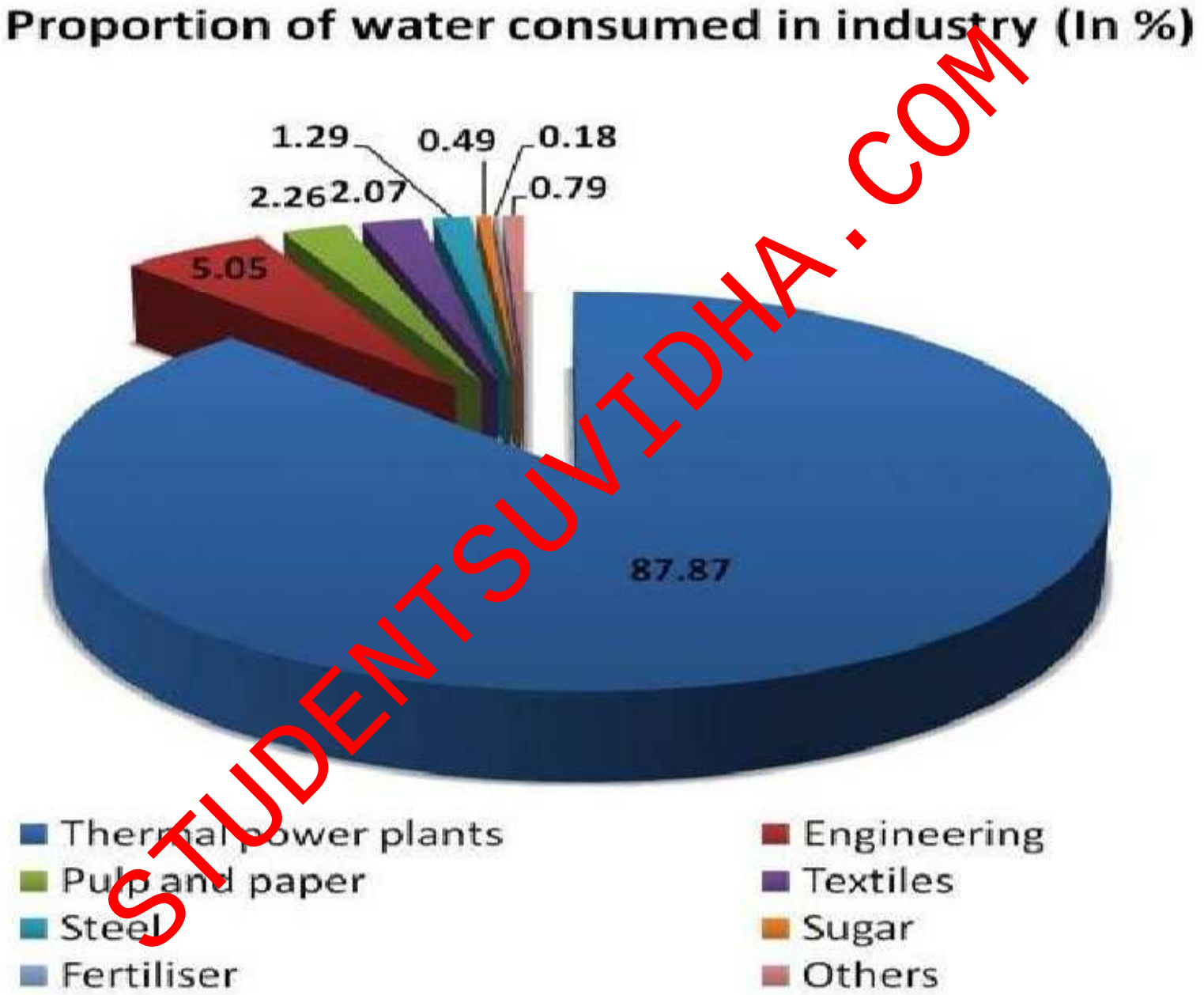


Factors affecting rate of demand

- Size and type of community
- Standard of living
- Climatic conditions
- Quality of water
- Pressure in the supply

- Development of sewage facility
- Metering of water
- Cost of water
- Industrial and commercial activities
- System of water supply

Variation in rate of demand

Several types of variations:-

- Seasonal variation
- Daily variations
- Hourly variations

Per capita demand

- If 'Q' is the total quantity of water required by various purposes by a town per year and 'p' is population of town, then per capita demand will be

- Per capita demand = $\frac{Q}{P \times 365}$ litres/day

- Per capita demand of the town depends on various factors like standard of living, no. and type of commercial places in a town etc.
- For an average Indian town, the requirement of water in various uses is as under-

Domestic purpose -------	135 litres/c/d
Industrial use -------	40 litres/c/d
Public use -------	25 litres/c/d
Fire Demand -------	15 litres/c/d
Losses, Wastage and thefts -------	55 litres/c/d

Total :	270 litres/capita/day

Fluctuations in Rate of Demand

- Average Daily Per Capita Demand
  = Quantity Required in 12 Months/ (365 x Population)

- If this average demand is supplied at all the times, it will not be sufficient to meet the fluctuations.

- Maximum daily demand = 1.8 x average daily demand

- Maximum hourly demand of maximum day i.e. Peak demand

  = 1.5 x average hourly demand
  = 1.5 x Maximum daily demand/24
  = 1.5 x (1.8 x average daily demand)/24
  = 2.7 x average daily demand/24
  = 2.7 x annual average hourly demand

Population Forecasting Methods

- The various methods adopted for estimating future populations .

- The particular method to be adopted for a particular case or for a particular city depends largely on the factors discussed in the methods, and the selection is left to the discretion and intelligence of the designer.

- Arithmetic Increase Method
- Geometric Increase Method
- Incremental Increase Method
- Decreasing Rate of Growth Method
- Simple Graphical Method
- Comparative Graphical Method
- The master plan method

Arithmetic Increase Method

- This method is based on the assumption that the population is increasing at a constant rate.
- The rate of change of population with time is constant. The population after 'n' decades can be determined by the formula

$$Pn = P + n.c$$ where

- P → population at present
- n → No. of decades
- c → Constant determined by the average of increase of 'n' decades

Geometric Increase Method

- This method is based on the assumption that the percentage increase in population from decade to decade remains constant.
- In this method the average percentage of growth of last few decades is determined.
- The population at the end of 'n' decades is calculated by- $Pn = P\{1+IG/100\}$ where
- P → population at present
- C → average percentage of growth of 'n' decades

Incremental Increase Method

- This method is improvement over the above two methods.
- The average increase in the population is determined by the arithmetical method and to this is added the average of the net incremental increase once for each future decade.

Basic terms in water

- Potable water- treated or disinfected drinking water
- Palatable water- at a desirable temp. i.e. free from objectionable tastes, odor, color and turbidity
- Contaminated water- pathogenic bacteria
- Polluted water- undesirable substances

Impurities in water

- Rain is the principal sources.
- Rain water passes atmosphere and dissolved with different gases,
- When reaches ground mix with particles of silt and mud,
- Flows towards stream passes through decaying vegetative matter and organic acids.

Classification of impurities

Mainly classified as -

1. Physical
2. Chemical and
3. Biological impurities

Potable water properties

- Colorless
- Odorless
- Good taste
- Not contain harmful microbes

Physical quality parameters

- Temperature
- Color
- Taste and odor
- Turbidity
- Conductivity

- **Temperature**- around 10°c desirable, above 25°c objectionable.
- **Color-** pure water colorless, color mainly due to suspended matter (apparent color), due to dissolved solids (true color)
- Color measured in Hazen unit, instrument named tintometer, desirable limit 5, permissible limit 25.

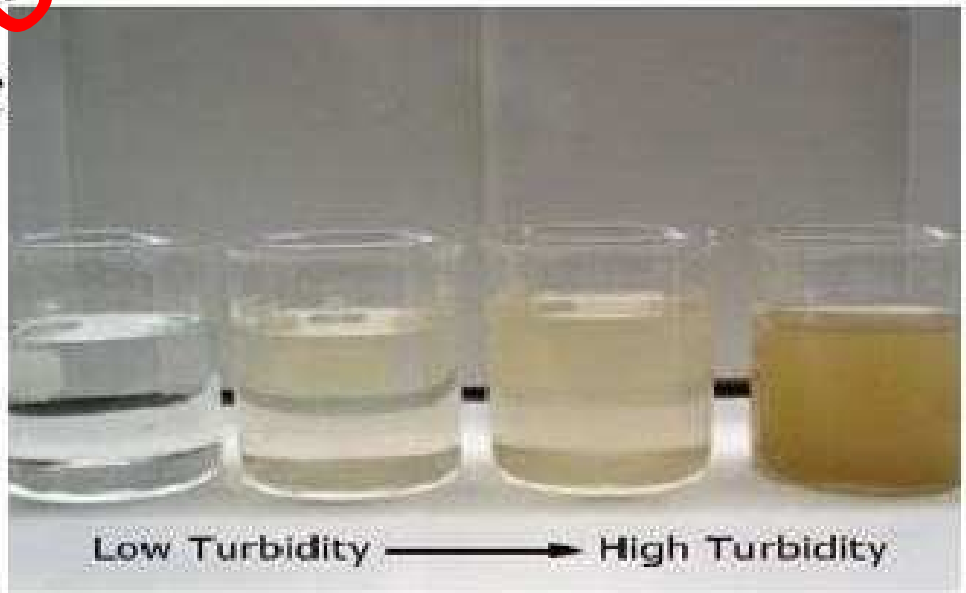
- **Taste and odor-** pure water odor and taste less.
- Taste and odor due to dissolved gases.
- Odor measured by threshold odor number (TON).

  TON = (A+B)/ A

  A= Volume of sample in ml

  B= Volume of distilled water
- For public supply TON below 3.
- Osmoscope used for odor test.

- **Turbidity-** cloudiness caused by colloidal material such as clay, silt, rock fragments and microbes.
- Measured light is either absorbed or scattered by suspended matter.
- Instrument is Turbidity meter.
- Unit is Nephelometric turbidity unit (NTU)
- 10 NTU is desirable.



- **Conductivity-** gives idea about dissolved solids in water
- More solids more conductivity
- Measured by conductivity meter.
- Avg. value of conductivity of potable water less than 2 mho/cm.

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Chemical quality parameters

- Total solids
- Chlorides
- Hardness
- pH
- Alkalinity
- Acidity
- Nitrogen and its compounds
- Metals and other chemical substances
- Dissolved gases

- **Total solids-** suspended as well as dissolved solids.
- Permissible limit 500 ppm and 1000 ppm in case of industrial uses.
- Water is filtrated through fine filter paper, material retained on filter is dried and weighed.
- Indirectly measured by conductivity meter.

- **Chlorides-** mainly present in form of Na chloride.
- Due to leaching of marine sedimentary deposits, pollution from sea water, industrial and domestic water.
- 250 mg/L permissible limit.
- High quantity of chloride indicate pollution of water due to sewerage and industrial waste.
- Determining by titration with standard silver nitrate solution using potassium dichromate.

- **Hardness-** caused by bicarbonates, carbonates, sulphates, chlorides, and nitrates of calcium and magnesium.
- Prevents the formation of soap formation.
- Two types- temporary or carbonate hardness
- Permanent or non carbonate hardness.
- Temporary due to carbonates and bicarbonates of Ca and Mg.
- Permanent due to presence of sulphates, chlorides and nitrates of Ca and Mg.

- Hardness usually expressed in ppm of Ca carbonate.
- 75 ppm consider as soft, 200 ppm are considered as hard.
- Under ground water harder than surface water.
- Determined by versanate method using EDTA solution for titration and Erio chrome black T as indicator.
- Ground water more hard than surface water.

- **pH-** reciprocal of hydrogen ion concentration.
- Indicator of acidity and alkalinity of water.
- Acidic water 0-7, alkaline water 7-14.
- Neutral water 7.
- Measured in pH meter.

- Permissible limit 6.5 to 7.5.
- Acidic water causes corrosion, alkaline causes sedimentation deposits.

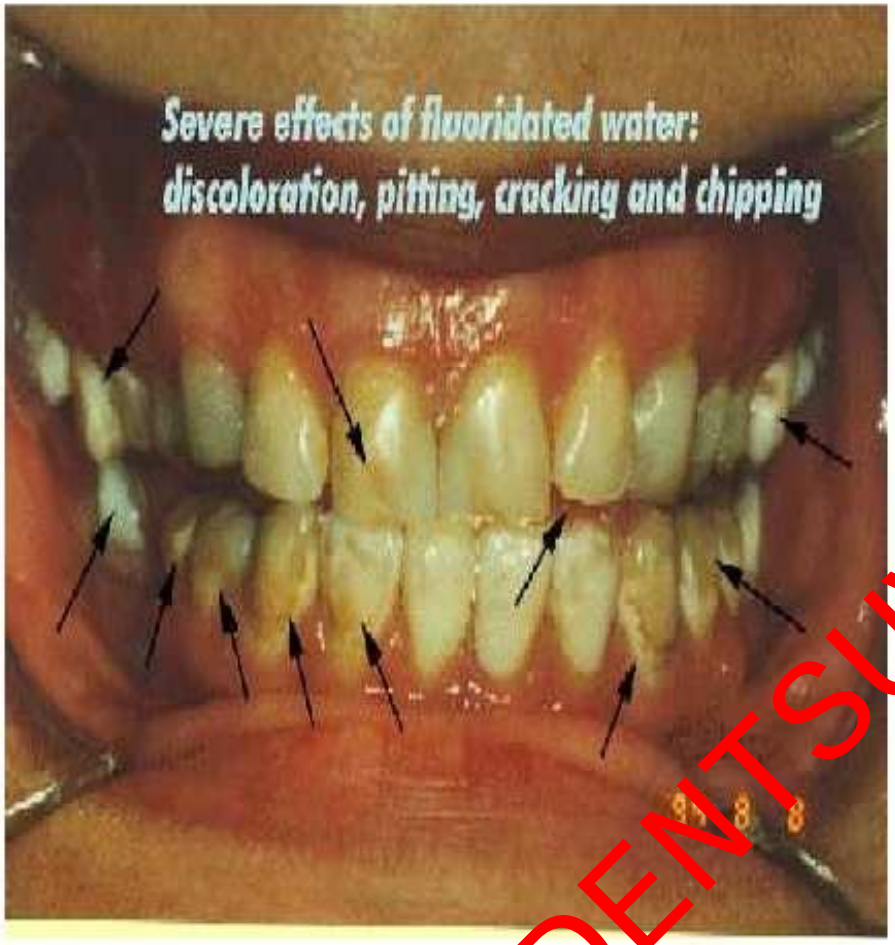
- **Alkalinity-** caused by carbonates, bicarbonates and hydroxides of Na, Ca and Mg.
- Excessive alkalinity causes bitter taste, sedimentation deposits in pipes.
- Expressed in terms of mg/L.
- Determined by titrating the sample against standard acid (H_2SO_4) using methyl orange indicator.

- **Acidity-** due to presence of mineral acids, free carbon dioxide, sulphates of iron, and aluminum in water.
- Expressed in mg/L of calcium carbonate.
- Determined by titration with standard

- **Nitrogen and its compounds-** presence of Nitrogen indicates presence of organic matter.
- Occur as- free ammonia, organic nitrogen, nitrites, nitrates.

- Free ammonia first stage of decomposition, organic nitrogen before decomposition, nitrites partly decomposed and nitrates fully oxidized.
- For potable water free ammonia limit 0.15 mg/L, organic nitrogen 0.3 mg/L, nitrates very dangerous so limit is zero.
- Nitrate conc. in domestic water supply limit 45mg/L.
- Mathemoglobinemia- more nitrate conc.

- **Metals and other chemical substances-** Fe, Mn, Cu, Pb, Cd, Cr, As, F etc. present in water.
- The amount should be under permissible limit.
- Fe and Mn- should not exceed 0.3 ppm and 0.05 ppm in public water supply respectively.
- Impart color of the water
- Fluoride- less than 0.8 – 1.0 ppm causes dental caries due to formation of cavity.
- Higher than 1.5 ppm cause skeletal fluorosis.
- Limit should be 1.0 to 1.5 ppm.



Dental fluorosis

Skeletal fluorosis

- **Dissolved gases-** Dissolved Oxygen, Carbon dioxide, Hydrogen sulphide.

- DO- from atmosphere or due to activity of algae. DO related to temp. High temp. low DO.
- Minimum 4mg/L necessary for fish.
- At 20 °c 9.2 mg/L and at 30 °c 7.6 mg/L.
- More DO increase corrosivity.

- CO_2- dissolved from atmosphere, from decomposing organic matter.
- Higher CO_2 makes water acidic so corrosivity increases.
- Higher CO_2 imparts taste and odor.

- H_2S- found in ground water, produced by reduction of sulphate, or by decomposition of organic matter.
- If present gives rotten egg smell.

Biological quality parameters

- Thousands of biological species found on water sources.
- Phytoplankton, diatom, dynoflagellate,
- Zooplankton
- Water plant
- Water Insect
- Protozoa
- Bacteria (e.g. nitrifying bacteria)
- Fungi

Indian standards for drinking water (IS-10500:1991)

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Permissible Limit
Essential characteristics			
1	Colour, (Hazen units), Max	5	25
2	Odour	Unobjectionable	--
3	Taste	Agreeable	--
4	Turbidity (NTU), Max	5	10
5	pH Value	6.5 to 8.5	No Relaxation
6	Total Hardness (as $CaCo^3$) mg/L, Max	300	600
7	Iron (as Fe) mg/L, Max	0.3	1.0
8	Chlorides (as Cl) mg/L, Max.	250	1000
9	Residual, free chlorine, mg/L, Min	0.2	--
10	Fluoride (as F) mg/L, Max	1.0	1.5

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Permissible Limit
Desirable characteristics			
11	Dissolved solids mg/L, Max	500	2000
12	Calcium (as Ca) mg/L, Max	75	200
13	Magnesium (as mg) mg/L, Max	30	100
14	Copper (as Cu) mg/L, Max	0.05	1.5
15	Manganese (as Mn)mg/L, Max	0.10	0.3
16	Sulfate (as SO^4) mg/L, Max	200	400
17	Nitrate (as NO^3) mg/L, Max	45	No Relaxation
18	Phenolic Compounds (as C^6H^5OH) mg/L, Max	0.001	0.002

19	Mercury (as Hg) mg/L, Max	0.001	No relaxation
20	Cadmium (as Cd) mg/L, Max	0.01	No relaxation
21	Selenium (as Se) mg/L,Max	0.01	No relaxation
22	Arsenic (as As) mg/L, Max	0.01	No relaxation
23	Cyanide (as CN) mg/L, Max	0.05	No relaxation
24	Lead (as Pb) mg/L, Max	0.05	No relaxation
25	Zinc (as Zn) mg/L, Max	5	15
26	Anionic detergents (as MBAS) mg/L, Max	0.2	1.0
27	Chromium (as Cr^{6+}) mg/L, Max	0.05	No relaxation

28	Mineral Oil mg/L, Max	0.01	0.03
29	Pesticides mg/L, Max	Absent	0.001
30	Radioactive Materials i. Alpha emitters Bq/L, Max ii. Beta emitters pci/L, Max	-- --	0.1 1.0
31	Alkalinity mg/L, Max	200	600
32	Aluminium (as Al) mg/L, Max	0.03	0.2
33	Boron mg/L, Max	1	5

Bacteriological Examination

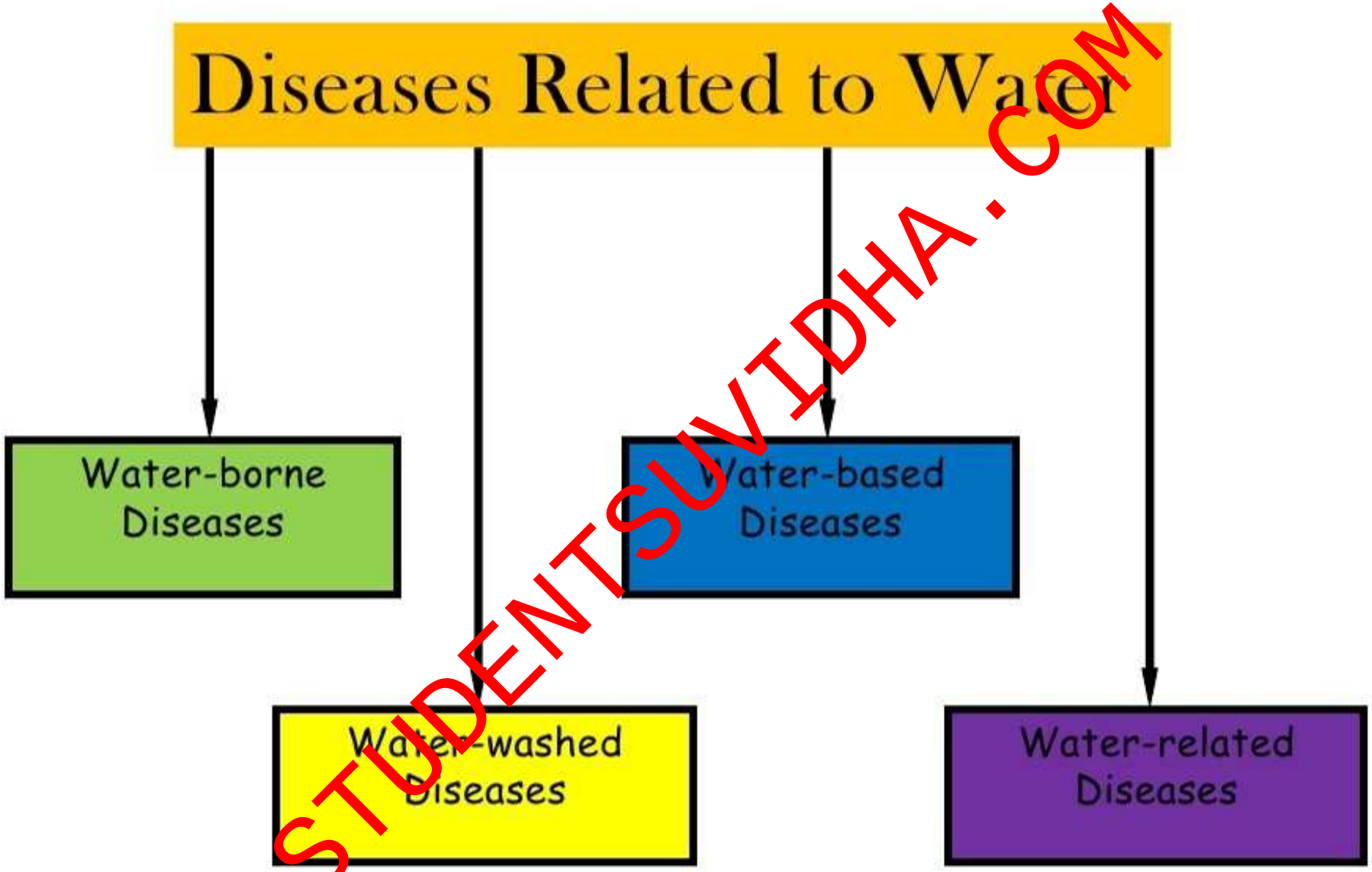
- Water in the distribution system

- Ideally, all samples taken from the distribution system including consumers' premises, should be free from coliform organisms.

- In practice, this is not always attainable, and the following standard of water collected in the distribution system is therefore recommended when tested in accordance with IS 1622:1981.

- Throughout any year, 95 percent of samples should not contain any coliform organisms in 100 mL;
- No sample should contain E coli in 100 mL;
- No sample should contain more than 10 coliform organism per 100 mL; and
- Coliform organism should not be detectable in 100 mL of any two consecutive samples.

Water borne diseases



Water-borne Diseases

Diseases caused by ingestion of water contaminated by human or animal excrement, which contain pathogenic microorganisms.

- Include cholera,
- typhoid,
- amoebic and bacillary dysentery and
- other diarrheal diseases

Diarrheal Diseases

- Giardiasis (Protozoan)
- Cryptosporidiosis (Bacteria)
- Campylobacteriosis (Bacteria)
- Shigellosis (Bacteria)
- Viral Gastroenteritis (Virus)
- Cyclosporiasis (Parasite)

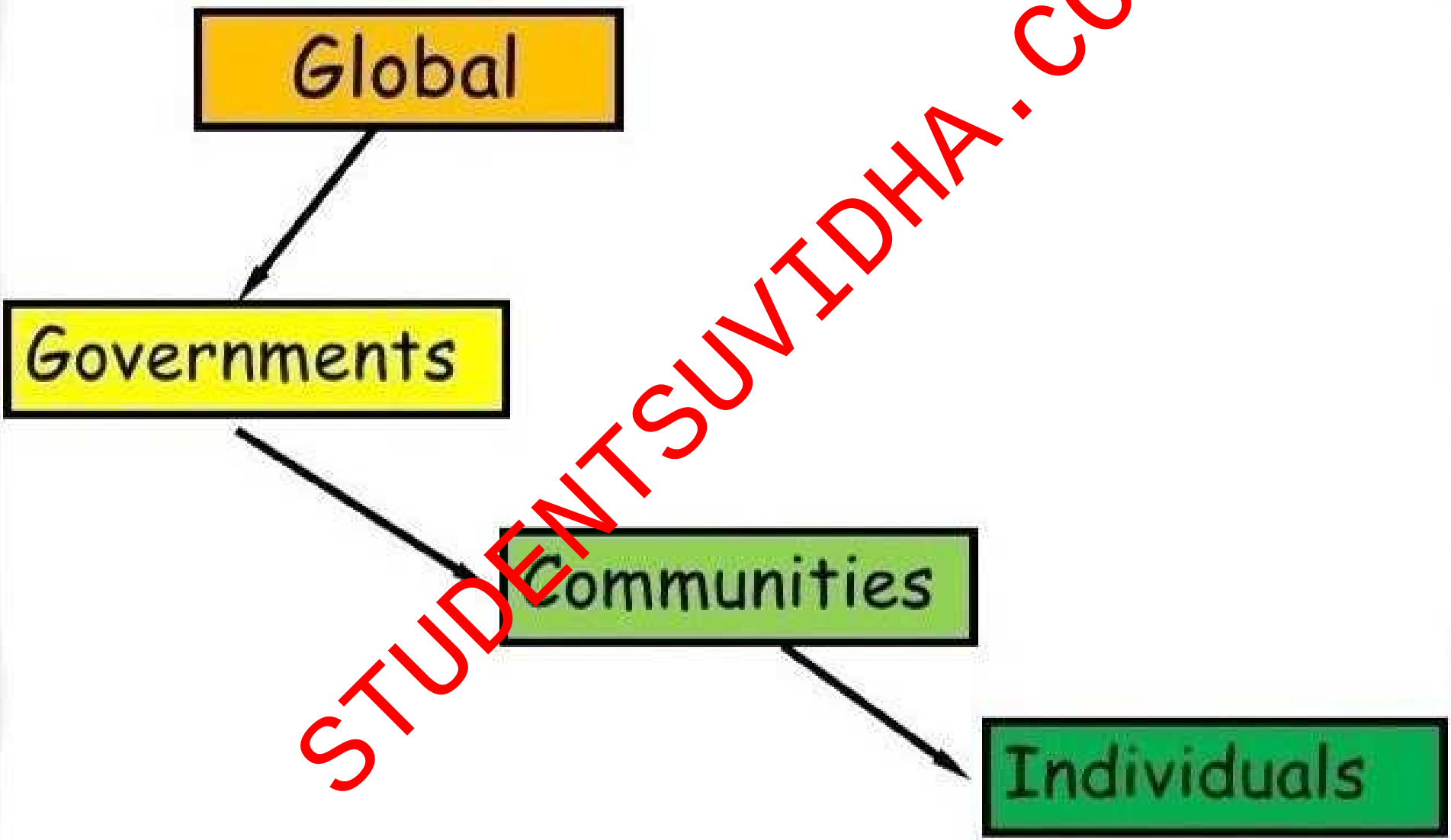
In addition, water-borne disease can be caused by the pollution of water with chemicals that have an adverse effect on health

- Arsenic
- Fluoride
- Nitrates from fertilizers
- Carcinogenic pesticides (DDT)
- Lead (from pipes)
- Heavy Metals

The Problem

- ~80% of infectious diseases
- > 5 million people die each year
- > 2 million die from water-related diarrhea alone
- Most of those dying are small children

Control & Prevention



Education Issues

- Hygiene education
- Good nutrition
- Improvements in habitation and general sanitation
- Higher education training in water-related issues

Global Surveillance

- Public health infrastructure
- Standardized surveillance of water-borne disease outbreaks
- Guidelines must be established for investigating and reporting water-borne diseases

General Guidelines

- Properly treatment of water before drinking.
- Water should be properly disinfected.
- Chlorine commonly used for disinfection.
- Some household methods used for control of water borne disease like boiling of water, reverse osmosis, uses of chlorine tablets.
- Proper disposal and treatment of domestic and medical waste helps in controlling the disease.

- Water line should be frequently tested, checked and inspected, so to detect any leakage, or possible source of contamination..
- Designing water distribution system , attempt should be made to keep sewer lines and water lines as far as possible.
- Habit of cleanness must be followed among the people. Sufficient number of public urinals and latrines should be constructed.

- All water borne disease are infectious, the person attending the such patients should wash his hands with soap and water every time.

- The fly nuisance in the city should be checked and reduced minimum by general cleanliness and using insecticides.

How do people treat their water before drinking?

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