Water Hygiene

Introduction

يقول ربنا تبارك وتعالي ” **وجعلنا من الماء كل شئ حي**“
. صدق الله العظيم.

Introduction

- **Water represent:-**

1. 85% of young animal's body Wt .
2. 55-60 of adult animal's body Wt .
3. 66 % of poultry egg wt.
4. >96 % of the blood wt.
5. > 90 % of the fetus body wt.
6. 80 % of cell components
7. It represents 18% of fatty tissues; 13% of bones; 0.2% of teeth.

Introduction

- Water deprivation for short period have negative adverse effects of performance and livability.

1. 10 % loses of body water causes serious physiological disorders. Moreover, 20% loses leads to death (animal's body can lose 98% of its fat, 50% of protein and still survive).

Water function

1. Moving the feed through the digestive system.
2. Help in mastication, digestion and absorption.
3. Transfer the nutrients to different organs through the blood.
4. Play a great role in the metabolism and all vital functions and body reactions.
5. Removing wastes and toxic substances.
6. Joint lubrications.
7. Regulation of the body temperature (28% evaporation from skin, 20% lungs,50 urination and defecation and 2% other sources,.
8. Water is the main constituents in saliva, gastric juice, bile, intestinal juice, hormones, enzymes. And so on.

What happens if animal deprived from water

- If so:-

1. Loss in their appetite for solid food.
2. Difficult mastication, swallowing, digestion, absorption and assimilation.
3. Waste products are remain too long.
4. Blood thickening.
5. Increase body temperature.

- Loss of 10% cause restlessness while loss 20%, causing death.

Sources of water for animal

1. Water consumption as it is.
2. Partially from food as in green forages.
3. From food assimilation, oxidation of H2 atom (in carbohydrates and proteins). It was found that oxidation of 100 lbs of cellulose or starch, 55.5 lbs of water get liberated.
4. **fats yield more water than starch while protein yield less than carbohydrates. So, food rich in crude protein, a great demand for water than starch food.**

Classification of water according to their palatability

Class	Source	Palatability
I. Wholesome	●Spring water ●Deep well water ●Rain water	Very palatable
II. Suspicious	●Water from cultivated lands	Moderately palatable
III. Dangerous	●River water ●Shallow well water	Palatable

Some technical terms

1. **Safe palatable water**: water used for drinking should be clean, clear, tasteless, colorless, odorless and free from harmful materials.
2. **Polluted water**: Is water which has received any foreign materials, organic, inorganic or biological, constituting some hazards to consumers.
3. **Contaminated water**: Is one, which is Contaminated with human or animal waste and which may transfer infection.

- Both polluted and contaminated water requires purification before its consumption by animal or human.

Some technical terms

- **Soft water**: Water than can be used for both human and animal as drinking. It should be free or contain less amount of hardness salts. It has the capability to form foam with soap.
- **Very soft water**: Water soften by atomic energy and completely free from salts. it was recorded that consumption of such water, causing some cardio-vascular diseases (miscellaneous cause).
- **Hard water**: Contain high amount of salts, making it unpalatable and fail to form foam with soap. Animal obligate to drink such water, leading to some gastro-intestinal troubles.

Hygienic requirements of water

- Water performed for animals and those used for animal branches which have a direct contact with public health (dairies, abattoirs etc..), should fulfill all sanitary requirements in drinking water for man. So water should be:-

1. Palatable.
2. Sufficient in quantity.
3. Free from causes of diseases.

1- Palatable

- Water to be palatable should be free from:-

1. **Colour**:
2. **Decay or mouldy taste and odors:** Some industrial wastes contain strong smelling chemicals, when discharged to rivers and streams, water gets unpleasant taste and odor. **The main sources of taste and odors are algae, iron, manganese, free chlorine, hydrogen, sulphide and phenol.** Public health hazards my be represented by such water.

1- Palatable

3. **Marked turbidity and coarse impurities**: turbidity of water originated mainly from industrial wastes, very finally suspended matters and colloidal matters and bacterial contaminants. Due to turbidity, water become:-

- Undesirable appearance.
- Reduction of light penetration, which affects plant life.

1- Palatable

4. Water temperature is not suitable: **water used for drinking should be cold enough to refresh the animal. The most suitable temp. is 10-12 ºC.** Water of higher temp. has the following effects:-

- **Decrease DOD (dissolved oxygen demand)** due to activation of the biological life.

2- Sufficient in quantity

- For watering, washing, cleaning of the stables, cleaning of the udder and milking equipments and so on. The water amount required/animal differ according to:-

1. Milk production.
2. Environmental Temp.
3. Type of ration.
4. Salt concentration in the food.

Water consumption rate in various classes of beef cattle with reference to environmental temperature.

	Water Consumption (Litres per Day at Different Temperature)					
Weight (kg)	4.4° C	10° C	14.4° C	21.1° C	26.6° C	32.2° C
Growing Cattle						
182	15.1	16.3	18.9	22.0	25.4	36.0
277	20.1	22.0	25.0	29.5	33.7	48.1
364	23.0	25.7	29.9	34.8	40.1	56.8
Finishing Cattle						
273	22.7	24.6	28.0	32.9	37.9	54.1
364	27.6	29.9	34.4	40.5	46.6	65.9
454	32.9	35.6	40.9	47.7	54.9	78.0
Wintering Pregnant Cows						
409	25.4	27.3	31.4	36.7		
500	28.7	24.6	28.0	32.9		
Lactating Cows						
409	43.1	47.7	54.9	64.0	67.8	81
Mature Bulls						
636	30.3	32.6	37.5	44.3	50.7	71.9
727	32.9	35.6	40.9	47.7	54.9	78.0

Differences in water intake in dairy cows of similar weight, but differing in milk production.

Lactating Cows (600 kg) Milk Yield (kg/day)	Water Intake at Temp 10°C	Water Intake at Temp 32°C
15	59	89
30	92	146
45	124	203

Examples of water intake by various classes of ruminant livestock

	Approximate Water Consumption Levels (Litres per Day)
Beef	26-66
Feeder calves	18-27
Steers	36-45
Dairy	28-110
Dairy (maintenance)	55-68
Dairy (lactating)	68-114
Calves (4-8 weeks)	4.5-6.8
Calves (12-20 weeks)	9.1-20
Calves (26 weeks)	17-27
Heifers (pregnant)	32-45
Lambs (weaned)	3.5-4.0
Ewes (dry)	4.0-5.0
Ewes (lactating)	4.0-12.0
Goats	3.0-15

Approximate water consumption for poultry (gallons/100 birds/day)

Approximate water consumption for poultry (gallons/100 birds/day)

Type of poultry	Normal ambient temperature (68°F/20°C)		Hot weather (89.6°F/32°C)
	Average (growing)	Mature birds	Mature birds
Layer pullets	2.64	3.43	5.28
Breeder pullets	3.17	4.23	6.60
Layer hens		5.55	10.57
Broiler breeders		7.93	15.85
Broiler chickens	4.23	6.60	13.21
Roaster chickens	5.28	7.93	15.85
Broiler turkey	7.66	14.27	26.42
Heavy female turkeys	10.04	16.91	31.70
Heavy male turkeys	14.53	26.42	47.55

3- Free from causes of diseases

- **Causes of diseases could be transmitted via water may be:-**

1. **Chemical poisons.**
2. **Pathogenic M.Os.**
3. **Animal parasites.**

1- Chemical poisons

- **Dissolved impurities may contain organic and/or inorganic compounds, gases etc. The amount of solids dissolved normally expressed in ppm.**

1- Chemical poisons

1. Lead poisoning:

- Originated from :-

A. **lead pipes,** specially when water contain high amounts of O2 and CO2, humus acid, and nitrates. On the other hand, chlorides and water hardness may hinder dissolving of lead.

B. **Throwing of factories waste materials**.

C. **Insecticides containing lead**

- The problem of lead is its cumulative effect, causing lead poisoning **(Plumlism)** which frequently observed in horses, cattle, goats, dogs, fowls and fish. The MPL of lead should be extremely low and **should not increase than 0.1 ppm.**

1- Chemical poisons

2. **Arsenic poisoning:** The main source of arsenic is the insecticides containing it. Arsenic also has a cumulative effect.
3. **Copper:** usually copper poisoning occurs:-

- in pet animals when allowed to drink from rusty copper vessels.
- Water sources get polluted by wastes of factories dealing with copper.
- Cooper compounds used to eradicate snails.

II-pathogenic micro-organisms

- Water sources specially surface water get Contaminated by pathogenic M.Os. From different sources.
- **Domestic water used for human or animal industry should be free from any pathogenic organisms.** The main sources of water pollution and contamination will be described in details.

III- animal parasites

- Water plays an important role in distribution of animal parasites including nematodes, cestodes , Trematodes or even coccidiosis of poultry and other large animals.
- Stagnant water is a main source.
- Transmission of cercaria of liver flukes by water causing heavy losses among animals grazing in the infested areas.

Standard quality of water

- **Drinking water should fulfils a standard quality for chemical and biological parameters as following :-**

Selected Primary Maximum Contaminant Levels in Potable Water for Human Determined by the USEPA, the Equivalent Limits and Recommended Guideline Values Set by the EU Directive (98/83/EC), and the WHO

Contaminant	USEPA	EU	WHO
	Inorganic Chemicals		
Antimony	0.006	0.005	0.020
Arsenic	0.05	0.01	0.01 (P)[a]
Asbestos	7 MFL[b]	n.l.[c]	n.l.
Barium	2	n.l.	0.7
Beryllium	0.005	n.l.	n.l.
Cadmium	0.005	0.005	0.003
Chromium (total)	0.1	0.05	0.05 (P)[a]
Cyanide	0.2	0.05	0.07
Fluoride	4	1.5	1.5
Lead	0.015	0.01	0.01
Mercury (inorganic)	0.002	0.001	0.006
Nitrate	10	50	50

Note: Numbers indicate levels in mg/L unless specified.

a Provisional guideline value.

b MFL, million fibers per liter.

c n.l., no limit was stated however treatment techniques may be required.

d Less than 5% of tested samples should be positive.

e NTU, nephelometric turbidity units.

Microbial Factors			
Total coliform	<5% +[d]	0 cells/100 mL	0 cells/100 mL
Turbidity	n.l.	1 NTU[e]	5 NTU
Organic Chemical Pesticides			
Alachlor	0.002		0.02
Atrazine	0.003		0.002
Carbofuran	0.04	Limits total pesticides as 0.0005 mg/L and pesticides by 0.00001 mg/L measured in supplies over 10,000 m^3/day	0.007
Chlordane	0.002		0.0002
2,4-D	0.07		0.03
Dibromochloropropane	0.0002		0.001
1,2-Dichloropropane	0.005		0.04 (P)[a]
Endrin	0.002		0.0006
Lindane	0.0002		0.002
Methoxychlor	0.04		0.02
Silvex (Fenoprop; 2,4,5-TP)	0.05		0.009
Simazine	0.004		0.002
Other Organic Contaminants			
Arylamide	n.l.	0.0001	0.0005
1,2-Dichloroethane	0.005	0.003	0.03
Epichlorohydrin	n.l.	0.0001	0.0004 (P)[a]
Total trihalomethanes	0.1	0.1	0.01

Recommended Upper Safe Levels of Water Contaminants for Horses. Column with values recommended for other classes of livestock is included for comparison.

Water Contaminant	Horses (mg/L)*	Livestock (mg/L)**
Arsenic	0.2	0.025
Cadmium	0.05	0.08
Calcium	500	1000
Chloride	3000	NA
Chromium	1	0.05
Cobalt	1	1
Copper	0.5	0.5 to 5.0
Cyanide	0.01	None
Fluoride	2	1 to 2
Hardness	200	NA
Hydrogen Sulphide	0.1	NA
Iron	0.3***	NA
Lead	0.1	0.1
Magnesium	125	NA
Manganese	0.05***	NA
Mercury	0.01	0.03
Nickel	1	1
Nitrate	400	100
Nitrate nitrogen	100	23
Nitrite nitrogen	10	3
Potassium	1400	NA
Selenium	0.01	0.05
Silver	0.05	NA
Sodium	2500	NA
Sulphate	2500	1000
TDS	6500	3000
Vanadium	0.1	100
Zinc	25	50

* Adapted from Lewis, 1995;

Total Dissolved Solids	Comments
<1000 ppm	Excellent for all livestock classes.
1000 - 2999 ppm	Satisfactory for most livestock, may cause decreased gain or death with poultry.
3000 - 4999 ppm	Satisfactory for some livestock, may cause decreased gain or death with poultry.
5000 - 6999 ppm	Acceptable. Do not use for pregnant or lactating livestock. Unacceptable for poultry.
>7000 ppm	Unacceptable for all livestock use.

ppm NO_3-N	Comments
<100	No harm to livestock and poultry.
100 - 300	No harm when used alone on livestock and poultry. Use caution when feeds also contain nitrates.
>300	Nitrate poisoning occurs.

Poultry water quality standards and treatment options

Water Quality Indicator	Levels Considered Average	Maximum Acceptable Level	Maximum Acceptable Levels Indicate	Treatment Options/Comments
Total bacteria (TPC)	0 CFU/ml	1,000 CFU/ml	Dirty system, may taste bad and could have pathogens in the water system	Clean the system between flocks with approved sanitizing cleaners, and establish a daily water sanitation system when birds are present Shock chlorinate, as well
Total coliforms	0 CFU/ml	50 CFU/ml	Water with >50 total coliforms or any fecal coliform has been in contact with feces	
Fecal coliforms	0 CFU/ml	0 CFU/ml		
pH	6.5–7.8	5–8	Below 5—metal corrosion Above 8—water sanitizers work poorly; "bitter" taste	Raise pH with soda ash, lime, or sodium hydroxide Lower pH with phosphoric acid, sulfuric acid, and hydrochloric acid (strong alkalinity); citric acid or vinegar (weak alkalinity)
Alkalinity	100 mg/l	300 mg/l	Associated with bicarbonate, sulfates, and calcium carbonate Can give water a bitter taste that is undesirable to the birds Difficult to lower pH at high levels Can be corrosive to cool cell pads	Acidification Anion exchange dealkalizer Can be reduced by removing free carbon dioxide through aeration.
Total hardness	Soft 0–75mg/l CaCO2 Somewhat hard 76–150 Hard 151–300 Very hard >300		Hardness causes scale, which reduces pipe volume and makes drinkers hard to trigger or leak (main factors are calcium and magnesium, but iron and manganese contribute a small amount)	If water is high in sodium, do not use water softener unless potassium chloride is used instead of sodium chloride. Polyphosphates will tie up hardness and keep in solution Water acidification to pH below 6.5
Calcium (Ca)	60 mg/l		No upper limit; if values are above 110 mg/l, may cause scaling	Treatment same as for hardness
Magnesium (Mg)	14 mg/l	125 mg/l	May cause flushing because of laxative effect if high sulfate is present	Treatment same as for hardness
Iron (Fe)	0.2 mg/l	0.3 mg/l	Birds tolerant of metallic taste Drinkers may leak from Fe deposit Can promote bacteria growth (*E. coli* and *Pseudomonas*)	Treatment: addition of chlorine, chlorine dioxide, or ozone, then filtration removal with proper sized mechanical filtration

Manganese (Mn)	0.01 mg/l	0.05 mg/l	Can result in black grainy residue on filters and in drinkers	Similar to iron; can be more difficult to remove due to slow reaction time Chlorination followed by filtration most effective in 8.5 pH range; needs extended contact time with chlorine before filtration unless using Iron X media
Chloride (Cl)	50 mg/l	150 mg/l	Combined with high NA levels, can cause flushing and enteric issues Can promote Enteroccoci bacterial growth	Reverse osmosis; mix with non-saline water, keep water clean, and use daily sanitizers such as hydrogen peroxide or iodine to prevent microbial growth
Sodium (Na)	50 mg/l	150 mg/l	Can cause flushing in combination with high Cl levels Can promote Enteroccoci bacterial growth	Treatment same as chloride
Sulfates	15–40 mg/l	200 mg/l	Can cause flushing Hydrogen sulfide (rotten egg smell) indicates sulfur-loving bacterial growth; can cause flushing and air locks in water system Sulfides can gas off, so test results may underestimate actual levels present	Aerate water into holding tank to gas off sulfur Anion exchange (chloride based) Treat with oxidizing sanitizers, then filtration If rotten smell is present, shock chlorination of well is recommended, plus daily water sanitation while birds are present
Nitrates	1–5 mg/l	25 mg/l	Poor growth and feed conversion May indicate fecal contamination; test for coliform bacteria	Reverse osmosis Anion exchange
Lead (Pb)	0 mg/l	0.05 mg/l	Can cause weak bones and fertility problems in broiler and turkey breeders	Not naturally occurring. Check for pipes, fittings, or solder that contain lead Can be reduced by water softeners and activated carbon
Copper (Cu)	0.002 mg/l	0.6 mg/l	High levels may cause oral lesions or gizzard erosion	Most likely results from corrosion of pipes or fittings
Zinc (Zn)		1.5 mg/l	Growth may be reduced at high levels	Water softener and activated carbon will reduce adsorption

II- Biological standards

1. **For water in the distribution System:**

- Viable bacterial count at 35 ºC :< 100/ml
- Coliform count: zero
- E. coli count: Zero and if the count is 10 organism/100 ml, re-sampling should be done. If the count still 10 or more/100 ml, there is an urgent need to look for the source. Eliminate the source and treat the water.

2. **For individual or small community supplies:**

- Coliform count: < 3/100 ml
- E. coli count/100 ml: Zero

Sources of water

- **There are 3 distinct groups of water:-**

1. **Rain water**
2. **Surface water**
3. **Ground water**

1- Rain water

- Pollution:- high rain is commonly pure, but low rain at distance away from surface of ground by 30 m is polluted by:-

1. Gaseous impurities as CO_2
2. Dust particles floating in air (organic and/or inorganic.
3. Pollen grains, plants, hair, yeast, faecal parts.
4. Smokes of industrial effluents .

2- Surface water

- **As rivers, sea, lakes, ponds and stream**.
- Quality of surface water is liable to wide variation of pollution from soil, addition from inhabited regions adding a lot of chemical and biological impurities.

How surface water get polluted - contaminated

1. Immersion of secreta and excreta of diseased animals (urine, pus, etc..).
2. Outlets and drains of slaughter houses, veterinary hospitals etc..
3. Throwing of animal carcasses into water ways.
4. Burying dead animals close to river banks. Due to water movement, the carcasses become uncovered and easily reach the water stream.

5. Bad habits of farmers as micturation in water channels.
6. Washing of polluted equipments with insecticides.
7. Effluents of vegetation which is polluted with chemical fertilizer.
8. Effluents from chemical factories.
9. Sewer from human building living along side the water ways.

Fate of these carcasses may be:-

A. Float along water stream for long distances carrying infection to other sites.
B. Stop by river banks among vegetation.
C. Flushed upon the cultivated fields.
D. Considered as a focus of infection for animals gaining access to such contaminated water for watering, bathing, or grazing.
E. May be ingested by carnivorous animals. These animals may become ill or carries.

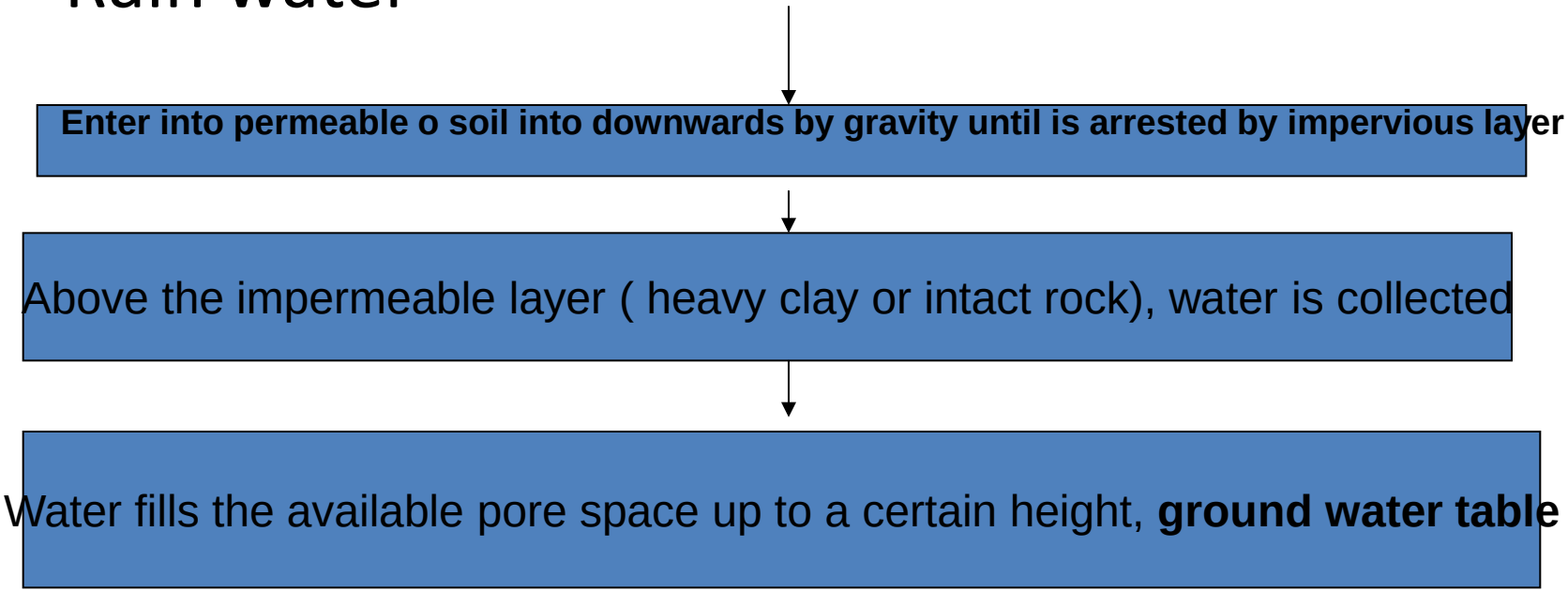
How animals get infected from polluted - contaminated water.

1. Drinking of contaminated water.
2. Grazing in contaminated fields.
3. Animal and birds swimming in this water.
4. Remnants of carcasses

Ground water

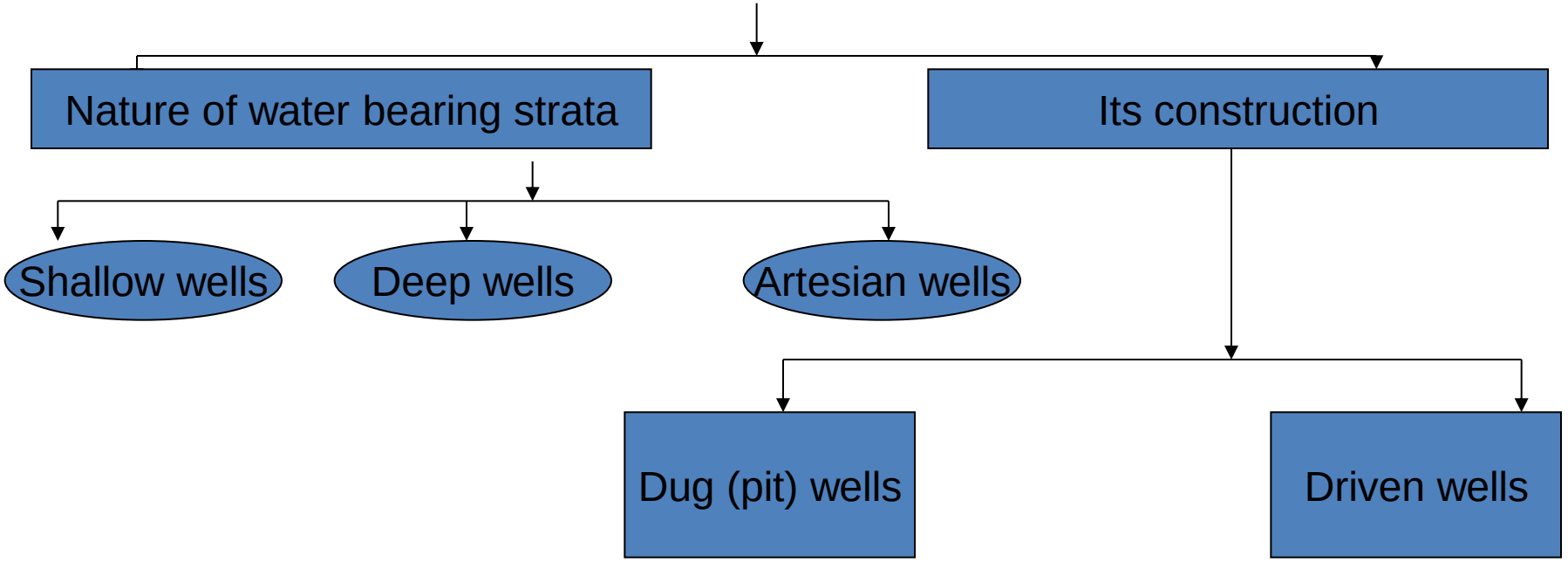
- Rain water which penetrate the soil strata and collected on impermeable surface. 1/3

Rain water



Wells

- Artificial means of getting ground water. Wells may classified according to:-



How ground water get polluted - contaminated

- Well water may become contaminated with pathogenic bacteria through:-

1. Throwing of small animal carcasses and/or birds.
2. Surface or side contamination, specially when wells are constructed close to a source of infection.
3. Contamination with chemicals and insecticides if the containers and utensils are washed in it.

Prevention of water pollution - contamination

1. Prevent diseased or suspected diseased animals from gaining access to water sources.
2. Prevent animals from drinking directly from water sources.
3. Slaughter houses, animal hospitals, animal infirmaries, etc.. Must be located down stream.
4. Waste products of biological nature should sterilized before its evacuation into water streams or before their use as an agriculture fertilizers.
5. Prevent discharges of animal excreta from gaining access to water sources.
6. Human vices as micturation and defecation in water sources should be stopped.
7. Prevent throwing animal carcasses into water streams. Animal carcasses should be buried or incinerated under veterinary supervision.

8. Remove vegetation firstly before application of copper sulphate (in case of eradication of snails in ponds and ditches).
9. Prevent washing of polluted equipments with insecticides.
10. Contraindicate to drain directly the effluents of vegetation (which is polluted with chemical fertilizer) and/or effluents from chemical factories.
11. Prevent the direct drainage of sewer from human building living along side the water ways directly to water ways.

Water hardness

- Hard water: which form a foam difficulty with soap, it needs more soap.
- Cause: **presence of calcium and magnesium salts. These salts reacts with fatty acids to form insoluble gelatinous materials difficult to be removed.** So needs more soap.
- **Total hardness= Permanent + temporary**

Temporary hardness

- Presence of **bicarbonate of calcium and or magnesium.**
- These salts splits by boiling into insoluble carbonate and carbon dioxide
- $Ca(HCo_3)+ H_2O$ 

Permanent hardness

- Presence of dissolved **sulphates** of **Calcium or Magnesium**. **Nitrate or chloride** may be involved in this case. This ***hardness can't be removed by boiling but require chemical treatment for its softening***.

Hygienic and economical significance of hardness

- **Economic significance**: economically the hardness may cause:-

1. Formation of fur in the kettle and boilers which is due to ppt of carbonates of calcium and magnesium on heating water.
2. Formation of boiler scales due to ppt of sulphates of Ca and Mg.

- The fur and scales are bad conductor to heat So, there are some economic losses.

3. **Hard water hinders the solubility of disinfectants and animal dips**.

Hygienic and economical significance of hardness

- **Hygienic significance**: Hardness has the following draw backs:-

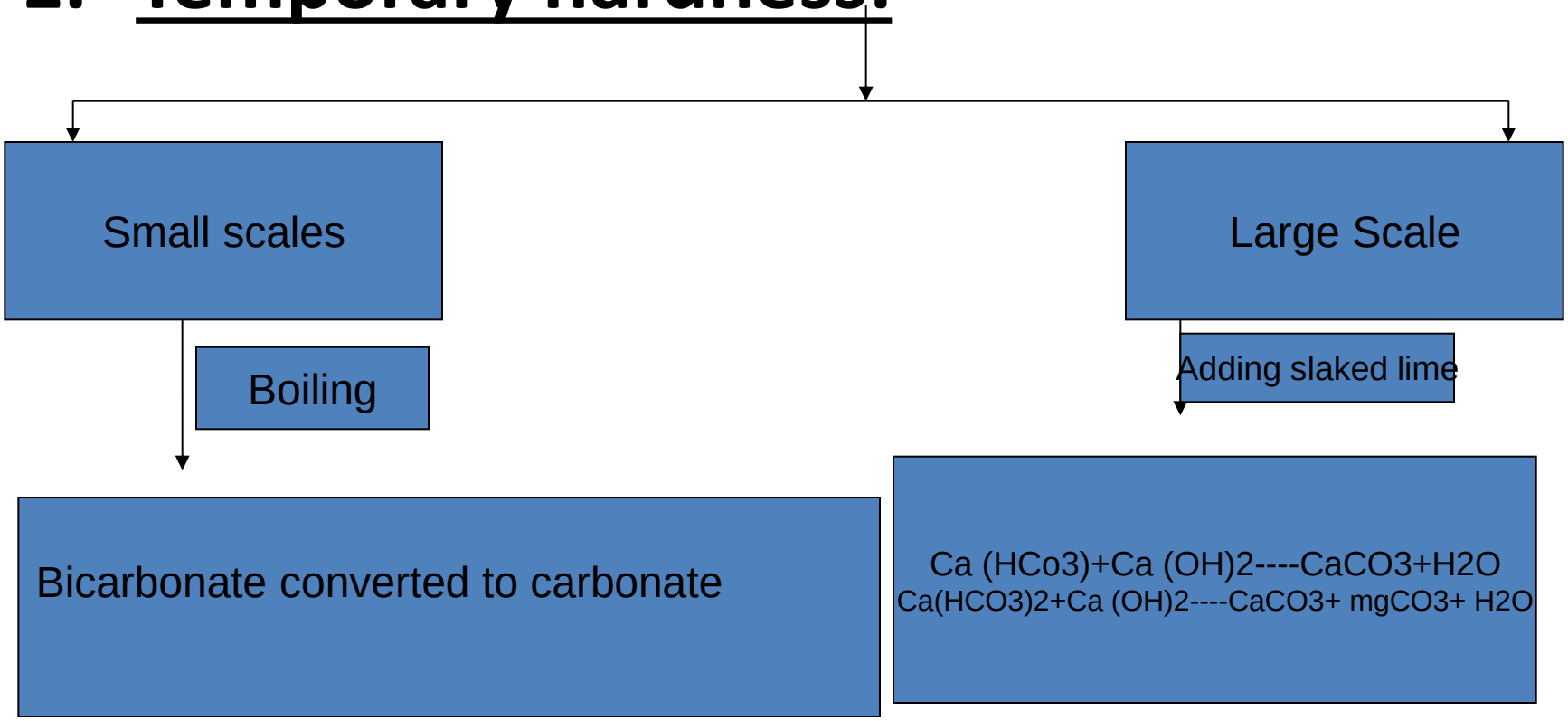
1. Some physiological disturbances as goiter, renal and bile calculi, dyspepsia, and reduce calcification of children teeth.
2. It increase the pesticide toxicity to fish.
3. High calcium level, reduce absorption of iron causing anemia.
4. Decrease the body weight.
5. Indigestion and mal-nutrition.
6. Causing dry coat and dyspeptic in horses.

Disadvantages of very soft water

1. it was recorded that consumption of such water, causing some cardio-vascular diseases
2. Reduction of hardness to zero, accelerate pipe corrosion.
3. Lead dissolve rapidly, increase lead poisoning.

Removal of hardness

1. Temporary hardness:



Removal of hardness

- **Permanent hardness:**

1. By adding **Sod. Carbonate** (Na_2Co_3) to **replace Ca or Mg** radical **by Na** radical to form **Sod. Sulphate** which is **not a salt of hardness**:-

- $Ca\ SO_4 + Na_2Co_3$ -------$CaCO_3 + Na_2SO_4$
- $Mg\ SO_4 + Na_2CO_3$------$MgCO_3 + Na_2SO_4$

Removal of hardness

- **Permanent hardness:**

2. **Base-exchange process " Permutite process"**

- By passing hard water through zeolite bed composed of silica, aluminum and sodium (**Sod. aluminum silicate**). It also can remove the temporary hardness.
- Zeolite is slowly exhausted on repeated use.
- To restore it to its original sate, add strong solution of Sod. Chloride then wash it by clean water to remove excess sod. Chloride.

Removal of hardness

- **The softening of water by Zeolite and restoring zeolite to its original state is reversible.** So, if Ca or Mg salts are high------The reaction is proceed from left to right **(softening process)**. On the other hand, **replacing all Na salt in Zeolite by Ca or Mg---leading to stop softening and Zeolite need to be treated with strong sol. Of Sod. chloride to convert the calcium Zeolite back to its original condition as Sod. Zeolite**.

Improvement and treatment of water

- **Water in nature should be purified before its use for human and animal consumption in order to remove the harmful bacteria and to eliminate unpalatable or objectionable materials.**

- **<u>This includes:-</u>**

1. **Self-purification.**
2. **Mechanical purification**
3. **Chemical treatment.**

Self or Spontaneous purification

- **Bacteria in water sources are subjected to a number of unfavorable conditions. These factors tend to eliminate most of these bacteria get contaminate water. Examination of any water stream at various points below a source of contamination (outlet of a sewer), will show a rapid reduction of the contaminants as the distance below the sewer outlet increase. The following are factors of self or spontaneous purification:-**

1- Physical factors

- **<u>This includes:-</u>**

1. Dilution
2. Agitation
3. Sedimentation

2- Biological factors

- **<u>Biological factors are include:-</u>**

1. Oxidation.
2. Temperature.
3. Light
4. Food supply.
5. Antagonistic action of other m.os.
6. Osmotic pressure and toxic salts.

Dilution

- **Addition of contaminated materials into huge water stream, result in reduction of the DBA in such water/ml. Moreover, constant addition of pure water which is relatively free from bacteria to a polluted stream will result in a gradual reduction of the bacterial burden per ml.**

Agitation

- **Agitation of water was reported to be destructive to most bacteria specially those of vegetative forms. Moreover, vigorous agitation and vibration will destroy to most bacterial forms, eggs and larvae of helminthes.**

Sedimentation

- **Reduction of bacterial No. in stored water is largely attributed to sedimentation. It was reported that, 80-90% of suspended bacteria in water is decreased within 24 h. when kept stationary in flask.**
- **Rate of sedimentation is influenced by:-**

1. **Time.**
2. **Viscosity and temperature.**
3. **No. of bacteria originally present.**
4. **Size of the suspended particles.**

2- Biological factors

- **<u>Biological factors are include:-</u>**

1. Oxidation.
2. Temperature.
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6. Osmotic pressure and toxic salts.

1-Oxidation

- **Oxidative changes of chemical and biological origin-------reduce the conc. Of organic impurities------ make conditions unfavorable for bacterial growth.**

2-Temperature

- **Generally the water temp. usually below the optimum temp. required for most bacteria.**
- **Elevation of water temp., speeds up the metabolic activity of bacteria until their optimum temp.**

3-Light

- Direct sunlight is injurious to many m.os. Through:-

A. Shorter visible rays are more injurious to m.os than blue or green rays.

B. Thermal (solar) radiation possess a much higher germicidal efficiency than most visible rays (UV-rays).

4- Food supply

- **Water free from food supply, usually contain low No. or even free from bacteria.**

5- Antagonistic action of other m.os

- **Protozoa and lower form metazoa live primarily upon bacteria. So bacterial No. sharply decreased.**

6- Osmotic pressure and toxic salts

- This is minor role as the bacterial cells may be not influenced by the osmotic pressure as those in higher plants or animal cells. Even under **high salt conc**. In water, **plasmolysis of bacterial cells** is of doubtful.
- Discharges of certain industrial wastes into water streams may contain toxic compounds responsible for reduction of bacterial count in such water.
- **Note: Self purification is of little value in providing domestic animals with hygienic water.**

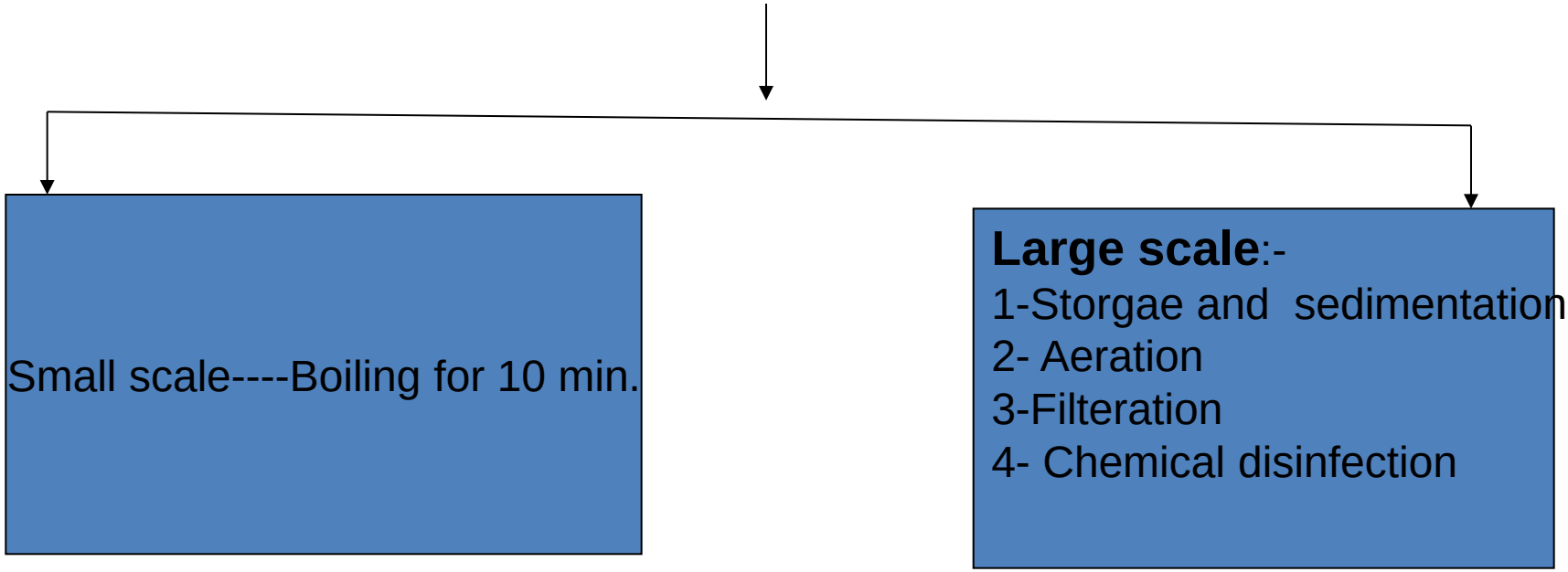
Mechanical purification of water

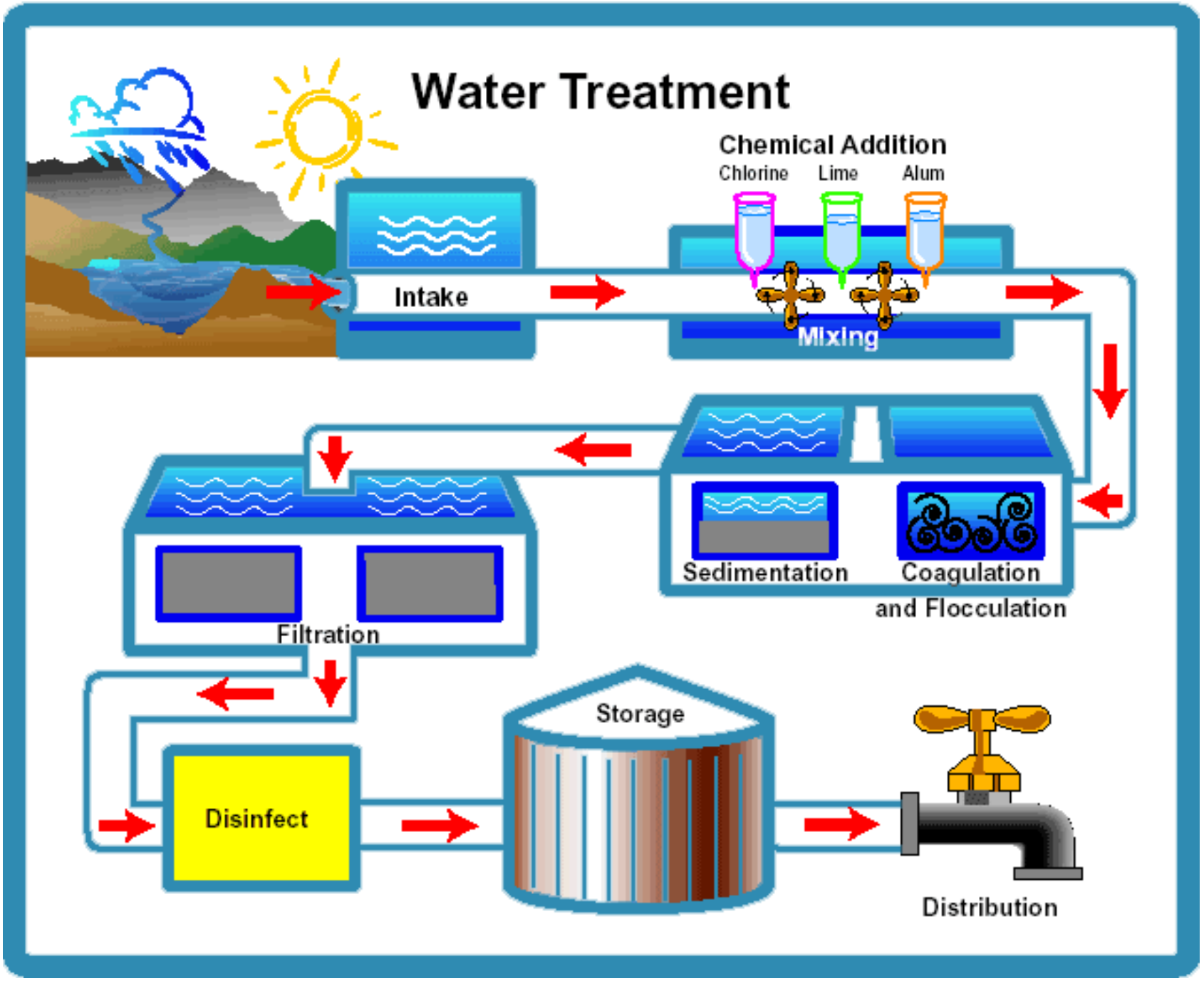
- **Objects:-**

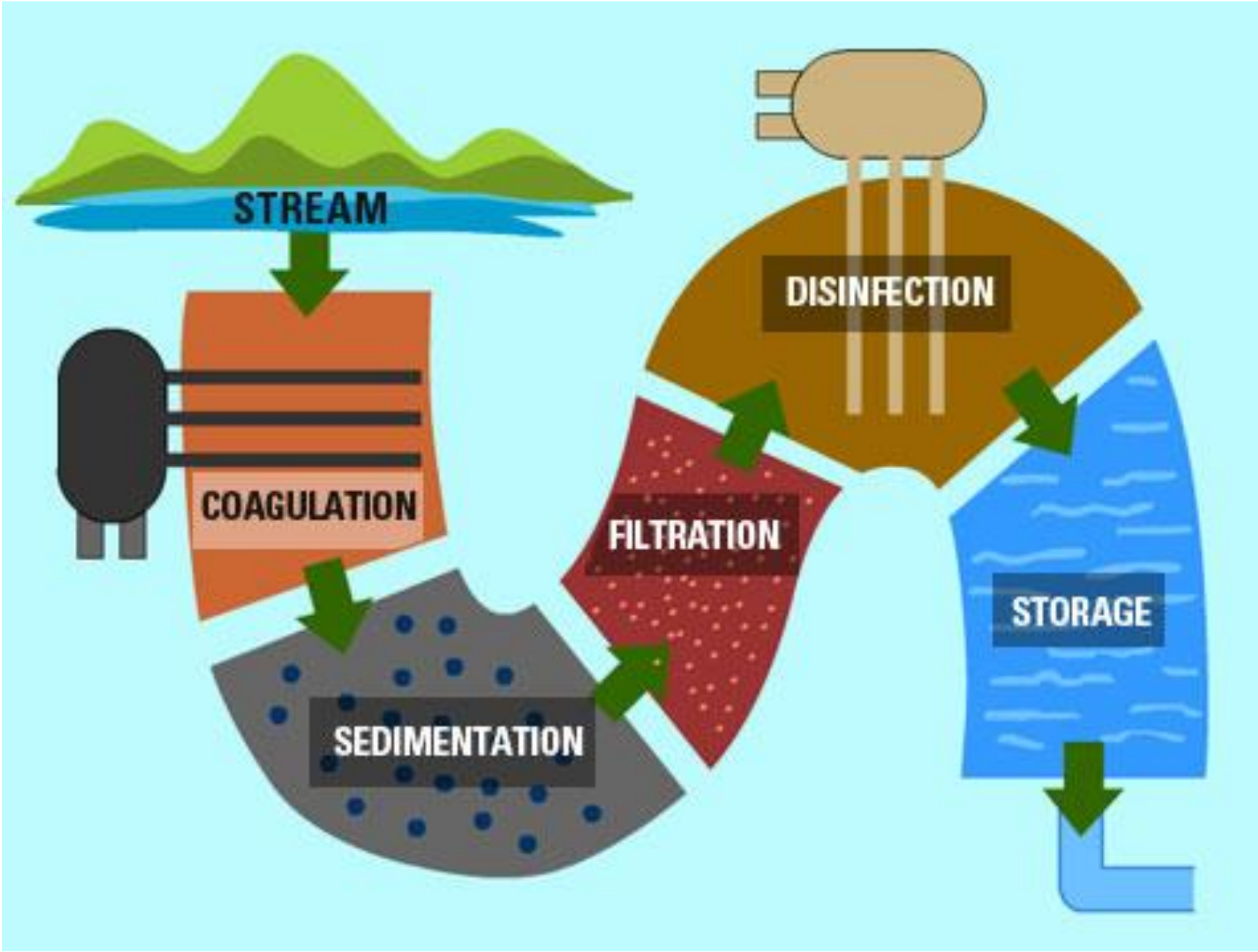
1. **To remove coloured and dissolved gasses.**
2. **To remove objectionable odour and taste.**
3. **To remove corrosive properties.**
4. **To kill pathogenic bacteria.**
5. **To make water safe for domestic uses.**

Methods of mechanical purification

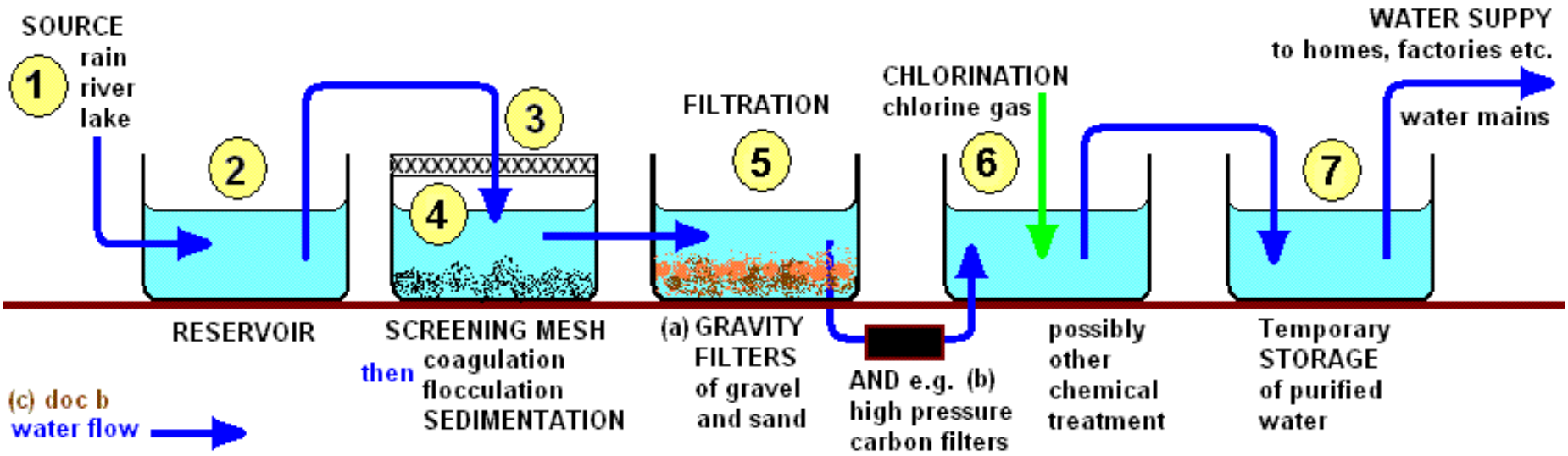
- Methods



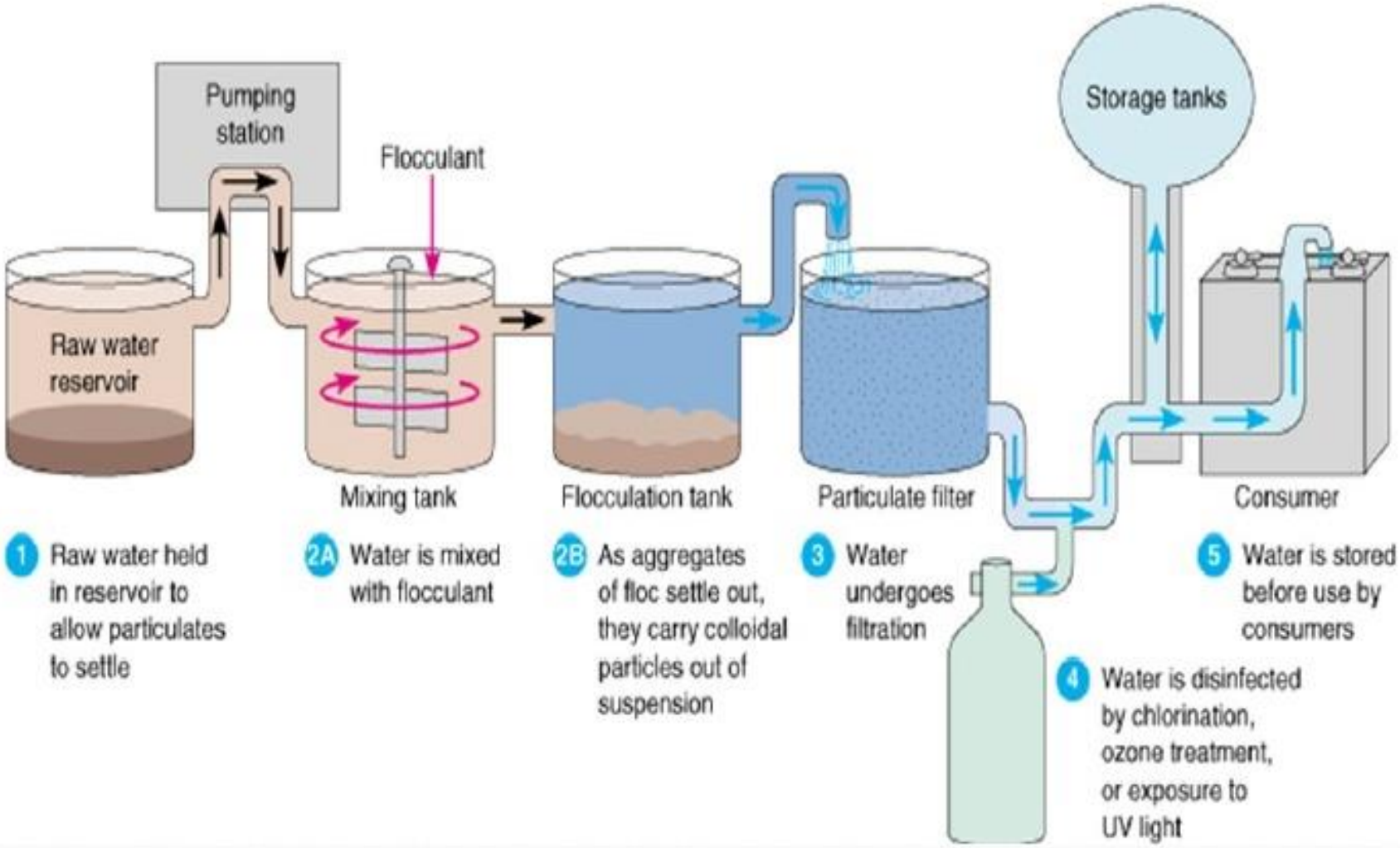

Water Treatment
Chemical Addition
Chlorine
Lime
Alum
Intake
Mixing
Sedimentation
Coagulation
and Flocculation
Filtration
Storage
Disinfect
Distribution


STREAM
COAGULATION
SEDIMENTATION
FILTRATION
DISINFECTION
STORAGE

Simplified 'FLOW' diagram of some of the ways water is treated and purified for domestic and industrial consumption



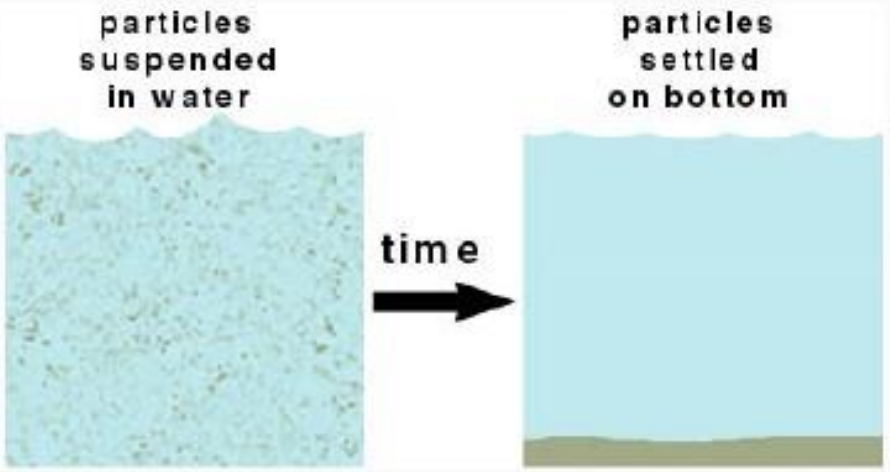
Municipal Water Purification Plant



Initial Stages

1. **Screening** - removal of any coarse floating objects, weeds, etc.
2. **Aeration** - dissolving oxygen into the water
   - removes smell and taste
   - promotes helpful bacteria growth
3. **pH correction** - preparing for coagulation and to help precipitate metals.

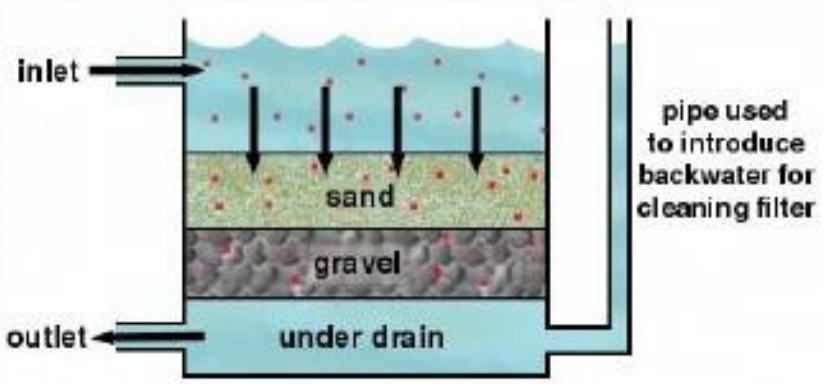
- **Sedimentation –**
  - Floc settles out and is scraped and vacuumed off the bottom of large sedimentation tanks.
  - Clarified water drains out of the top of these tanks in a giant decanting process.



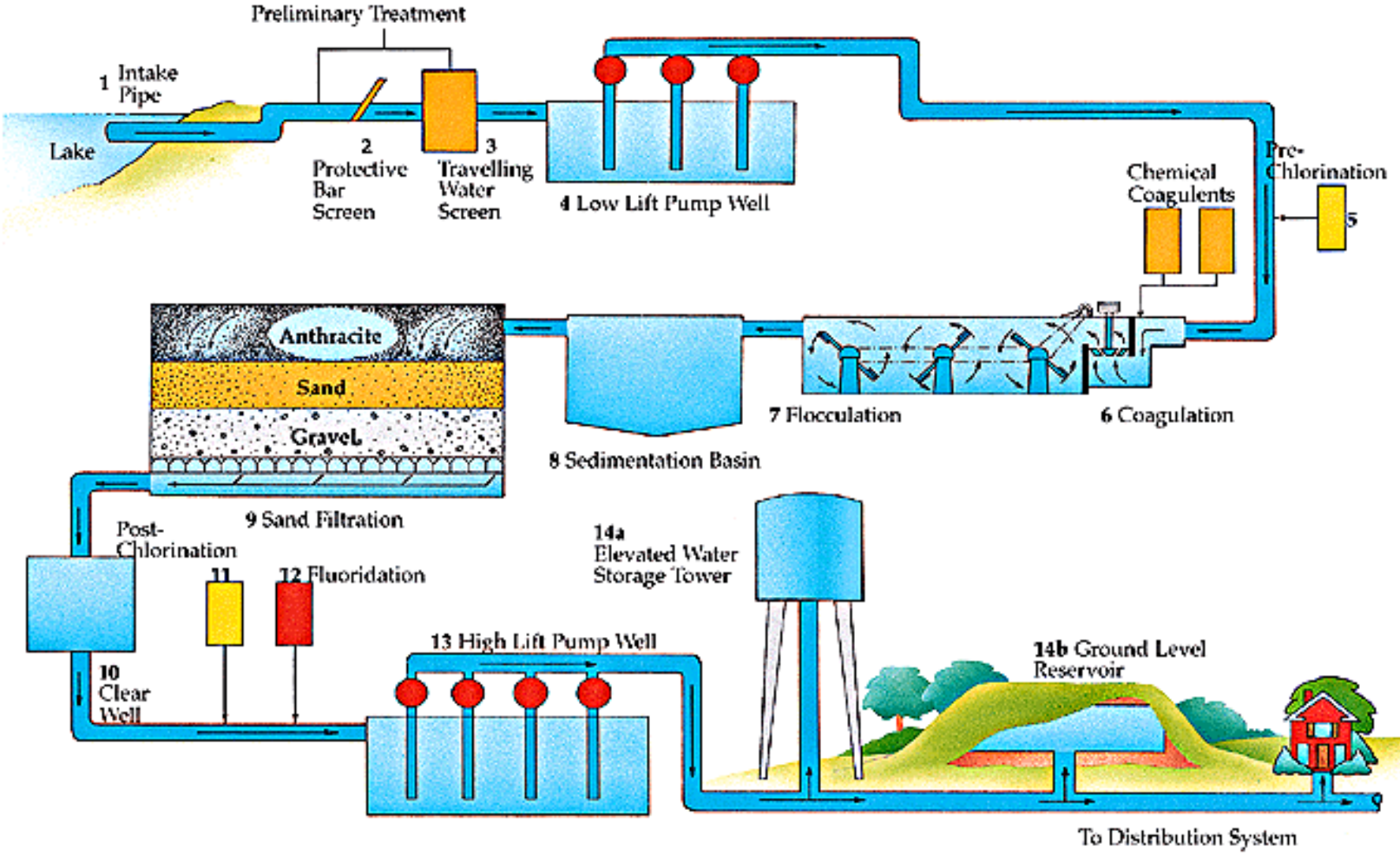
6. **Pre-chlorination and dechlorination** - mostly to kill algae that would otherwise grow and clog the water filters. Also kills much of the remaining bacteria

Filtering Out What's Left

7. **Filtration** (depends on size of plant/volume of water considerations)
   - Rapid-sand filters force water through a 0.45-1m layer of sand and work faster, needing a smaller area. But they need frequent back-washing
   - Slow-sand filters require a much larger area but reduce bacteriological and viral levels to better due to the biofilm layer. The top 1 inch of biofilm must be periodically scraped off and the filter occasionally back-washed



WATER TREATMENT PLANT
SURFACE WATER SUPPLY



Mechanical purification

- **Water intake:-** Site should satisfy the following:-

1. Sufficient water intake.
2. Site up stream to city and any other source of pollution.
3. Should be protected from pollution source (500 m up stream and 150 m down stream).
4. Pipes should extended to the center of water source; should open below surface of water.

Mechanical purification

1. **Storage and sedimentation:**

Water is kept in concrete tanks of 1/40 to 1/80 sloped bottom to allow frequent removal of precipitate by the action of gravity.

Efficiency of sedimentation is influenced by:-

- Period of storage.
- No. of bacteria
- Amount of suspended matter.

Storage and sedimentation

- During storage, No. of bacteria is reduced by the time due to:-

❖Change in food supply, temp.

❖Germicidal effect of UV rays of sunlight (can penetrate up to 3 M depth in water.

❖Protozoa and other predator consuming bacteria.

Types of sedimentation

1. **Long storage sedimentation:** Storing water for about 4 weeks. This will eliminate 99% of pathogenic bacteria. It is not used in our country because the hot climate favors growth of algae in water during storage.
2. **Short storage sedimentation:** Water is stored in tanks for 4-6 hrs. Sedimentation is helped by addition of aluminum sulphate or ferric or ferrous sulphate (coagulate like alum)

- Co_3 or HCo_3 in water reacts with aluminum sulphate forming **aluminum hydroxide** which **precipitated to the bottom as a flocculent** deposits to the bottom of the tank.
- This **process is called Coagulation and flocculation**. **Alum is added at a dose of 1 ppt.**
- If water **containing objectionable odour or taste**, **black alum** (containing 5% activated carbon) to be coagulated .

$Al_2 (So_4) + 18\ H_2O + Ca(OH)_2 \text{-----} 2Al(OH)_3 + 3\ CaSo_4 + 18\ H_2O.$

Or

$FeSo_4 + 7\ H_2O + ca(OH)_2 \text{------} Fe(OH)_2 + CaSo_4$

Time required for this process is **15-60 min**. during which **about 85% of impurities are removed.**

2- Aeration

- **Water may be aerated to remove excess gasses, reduce Co_2 and retain O_2 level**.
- This water become less corrosive to metals. This water become more palatable.
- **Aeration help in the removal of iron salts as ferrous bicarbonate or sulphate**.

3-Filteration

- **Water is allowed to pass through layers of sand and gravel to be filtered. This process is aimed to:-**

1. To remove any suspended matter.
2. Limitation of the formation of slime in water and distribution system

- Filtration may be inadequate to remove all m.os and so water should be chemically treated before its domestic use.

Types of filters

- Types

Gravity filters including:-
A- Slow sand filter
B- Rapid sand filter

Closed pressure filters: used for purification of smaller quantities of water as swimming pools

Gravity filters
1- Slow sand filter

- **<u>Construction</u>**:

A. **Base material (gravel): its depth of 30-75 cm in 3-5 layers of varying thickness from 10-15 cm/each.**

- Lowest layer…….15cm thickness
- I/M first layer…….15 cm thickness
- I/M second layer……15 cm thickness
- Top most layer……..15 cm thickness
- Total……60 cm thickness

Slow sand filter

B. **Filter sand (filter media): Sand is laid over the top of the gravel (Base layer).**

- **Thickness: 75-100 cm**.
- The sand should be fine, washed and their **size from 0.2-0.35 mm.**
- More fine sand, more pure water (free from bacteria, other impurities).

Slow sand filter: suspended matter including bacteria is removed at the surface or within the first few mms of the surface by **a gelatinous biological film which is composed of finely suspended materials, blue, green algae, organic matter. To this film, bacteria, protozoa and other m.os. Become imbedded in their gelatinous matrix.**

- On **using a new sand filter**, **water** should be **allowed to stand quietly for 2-3 days to form this gelatinous membrane.**
- Highly turbid waters will form a thick layer of gelatinous film which hinder the filteration quickly so, very turbid water should be stored for some time to allow suspended matter to be settle down.

Slow sand filter

- **Rate of filtration: 100-150 l/h/m^2** .
- **Efficiency:** The filter is not suitable for water having **turbidity above 50ppm.**
- Bacteria efficiency: slow sand filter is 98-99%.
- Odour, taste (of algae and other plankton) are completely removed.
- **Filter cleaning**: The surface of the filter require cleaning at interval varying **from 1-3 months**.
- Method: passing compressed air through the filter in the reverse direction of the water flow and by agitation.

Rapid sand filter

- Water to be filtered should be:-

A. Preliminary coagulation followed by,

B. Sedimentation

C. Finally filtered through rapid sand filter.

- Object of coagulation: to give the chance for several colloidal particles to be collected together to form bigger sized flock, which is easily settle down.

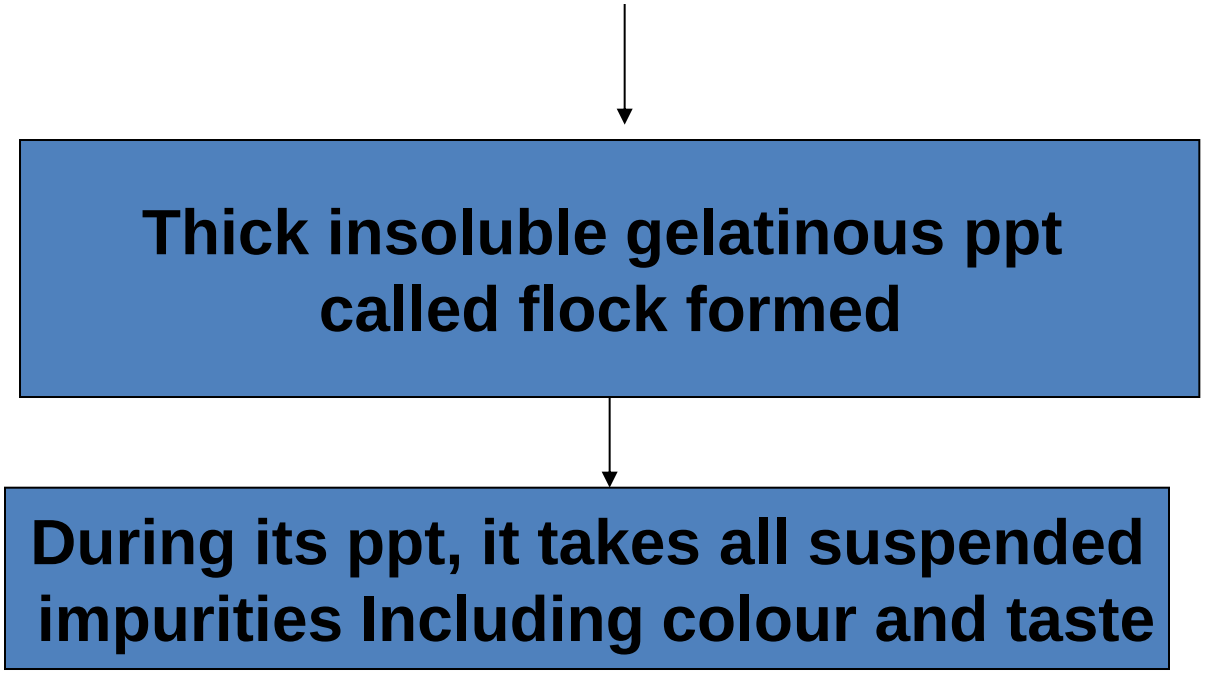
Coagulation principals

- Coagulation can be done either by:-

1. Flock formation.
2. Electrical charge

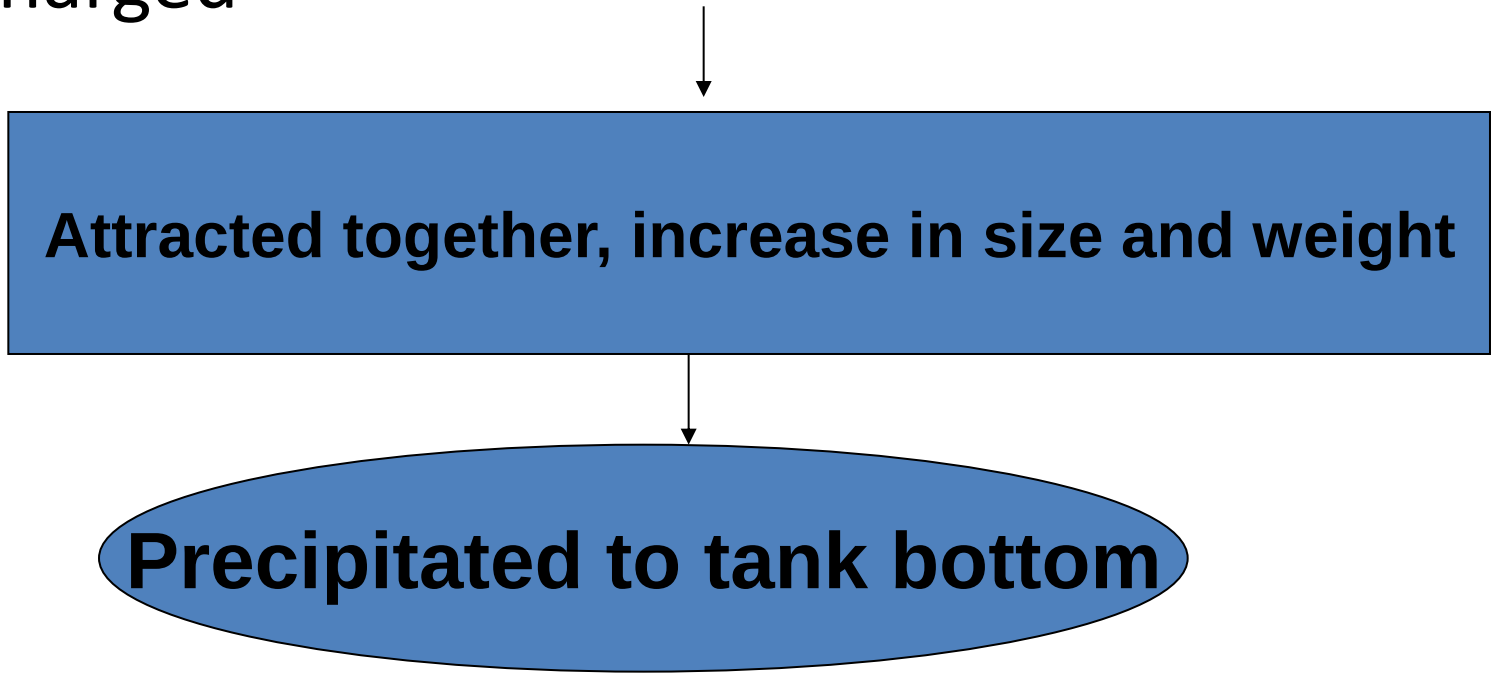
Flock formation

- Add coagulant, thoroughly mixed



Electrical charge

- Idea: Floc ions are positively charged, while colloidal (coagulant) particles are negatively charged



Coagulant used

1. Aluminum sulphate.
2. Ferrous sulphate and lime.
3. Sod. Aluminates.
4. Chlorinated coppers.
5. Mag. Carbonate.

Aluminum sulphate (Alum- filter alum)

- **It is the most common coagulant used due to:-**

1. **Very cheap.**
2. **Reduce turbidity, taste and colour.**
3. **It produce clean water.**
4. **Very efficient.**
5. **Flocs formed are very stable and heavy.**
6. **Not harmful to health.**

- **<u>Black alum</u>: Aluminum sulphate + 4% active carbon. Usually used in water having taste and odours.**

Aluminum sulphate (Alum- filter alum)

- This coagulant work well at alkaline pH. So, lime or sod. Carbonate must be added if water pH is not alkaline. Aluminum hydroxide (floc), calcium sulphate and carbon dioxide are formed as following:-

- $Al_2(So_4)_3+18H_2O+3Na_2Co_3$---**$2Al(OH)_3$**$+3Na_2So_4+18H_2O+3Co_2$
- $Al_2(So_4)_3+18H_2O+3Ca(HCo_3)_2$---**2Al(OH)3**$+3CaSo_4+18H_2O+6Co_2$
- $Al_2(So_4)_3+18H_2O+3Ca(OH)_2$---**2Al(OH)3**$+3CaSo_4+18H_2O$.

- **<u>Dose</u>**: **7-20 mg/l (14 mg/L)** which is depend on turbidity, colour, taste, pH, temp.
- **Aluminum hydroxide form an insoluble floc and remove the fine suspended and colloidal impurities.**