قسم الهندسة المدنية

المرحلة الرابعة

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Dr Ameer Badr Khudhair

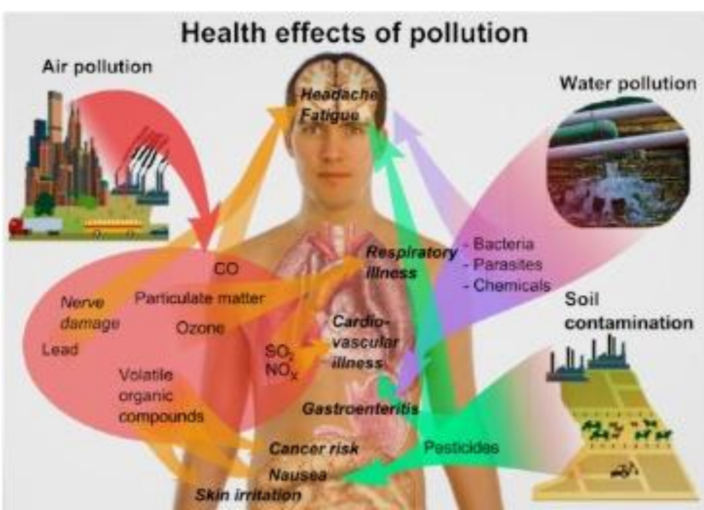
Ministry of Higher Education and Scientific Researches
Al-Mansour University College
Department of Civil Engineering
Sanitary and Environmental Engineering

Water Pollution

Dr Ameer Badr Khudhair

Pollution

- Pollution is the introduction of a contaminants/ pollutants into the environment. It is created by industrial and commercial waste, agricultural practices, everyday human activities that cause adverse change to human health and environment.
- Pollution can take the form of biological creatures, chemical substances or energy, such as noise, heat and radiation.



The are three types of pollution:

- Land Pollution
- Air Pollution, Ex: London Great Smog 1952
- Water Pollution, Ex: London Great Stink 1858



Type of wastes according to its sources

- Domestic waste: food residual, human waste, grease, oil, detergents.
- Industrial waste: to the industry such as petroleum from oil well.
- Agricultural pesticide, herbicide
- Hospital waste: mainly viruses, bacteria

Waste source

- Point Source: discharge of pollutants from single point. Factories, power plants, sewage treatment plants, oil wells.
- Non-point Source: sources of water pollution that are scattered or diffuse, not having a specific location. Farm fields, cities, roads, clear-cut forests, mines.



Water pollution

- Water is considered polluted if some substances or condition is present to such a degree that the water cannot be used for a specific purpose.
- Water pollution is the presence of excessive amounts of a hazard (pollutants) in water in such a way that it is no long suitable for drinking, bathing, cooking or other uses.
- Physical, chemical, biological changes in water quality that adversely affect living organisms, human and environment.

Types of water pollution

- Color
- Taste and Odor
- Temperature
- pH scale (acid & base)
- Sediment (Particulates)
- Microorganisms: Infectious Agents
- Inorganic Pollutants
- Organic Chemicals (non domestic waste)
- Oxygen-Demanding Wastes (domestic waste)
- Radiation

Color

- Color in water is caused by substances in solution, known as true color, and by substances in suspension, mostly organics, known as apparent or organic color.
- Iron, copper, manganese, and industrial wastes all can cause color.
- Color is aesthetically undesirable, and it stains fabrics and porcelain bathroom fixtures.
- Water color is determined by comparison with standard platinum/cobalt solutions or by spectrophotometric methods.
- The IS value for treated water is 5 to 25 cobalt units.

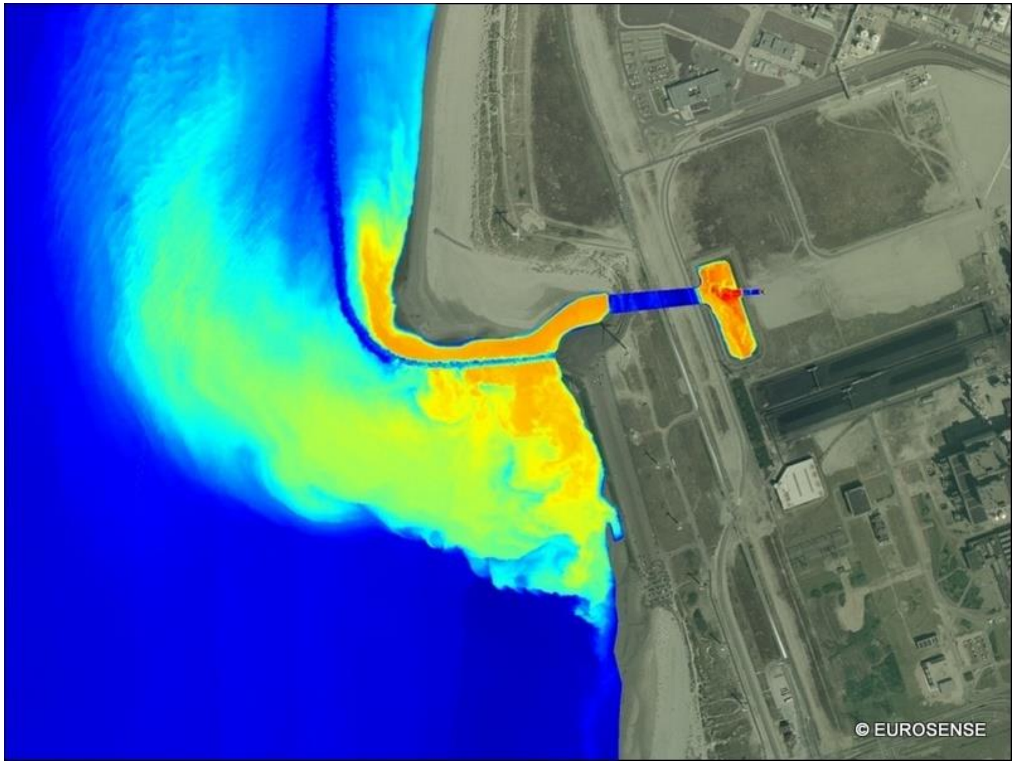
Taste and Odor

- Odor depends on the contact of a stimulating substance with the appropriate human receptor cell.
- Most organic and some inorganic chemicals, originating from municipal or industrial wastes, contribute taste and odor to the water.
- Tas ed in term odor intensity or threshold values.
- A new method to estimate taste of water sample has been developed based on flavor known as “ Flavor Profile Analysis” (FPA).
- The character and intensity of taste and odor discloses the nature of pollution or the presence of microorganisms.

Temperature

- The increase in temperature decreases palatability, because at elevated temperature carbon dioxide and some other volatile gases are expelled.
- The ideal temperature of drinking water is 5 to 12˚C, above 25˚ C water is not recommended for drinking.

- Thermal Pollution: an increase in water temperature
- Source: Nuclear power plants, coal power plants, industrial effluents, domestic sewage.
- Can cause: thermal shock to aquatic life.

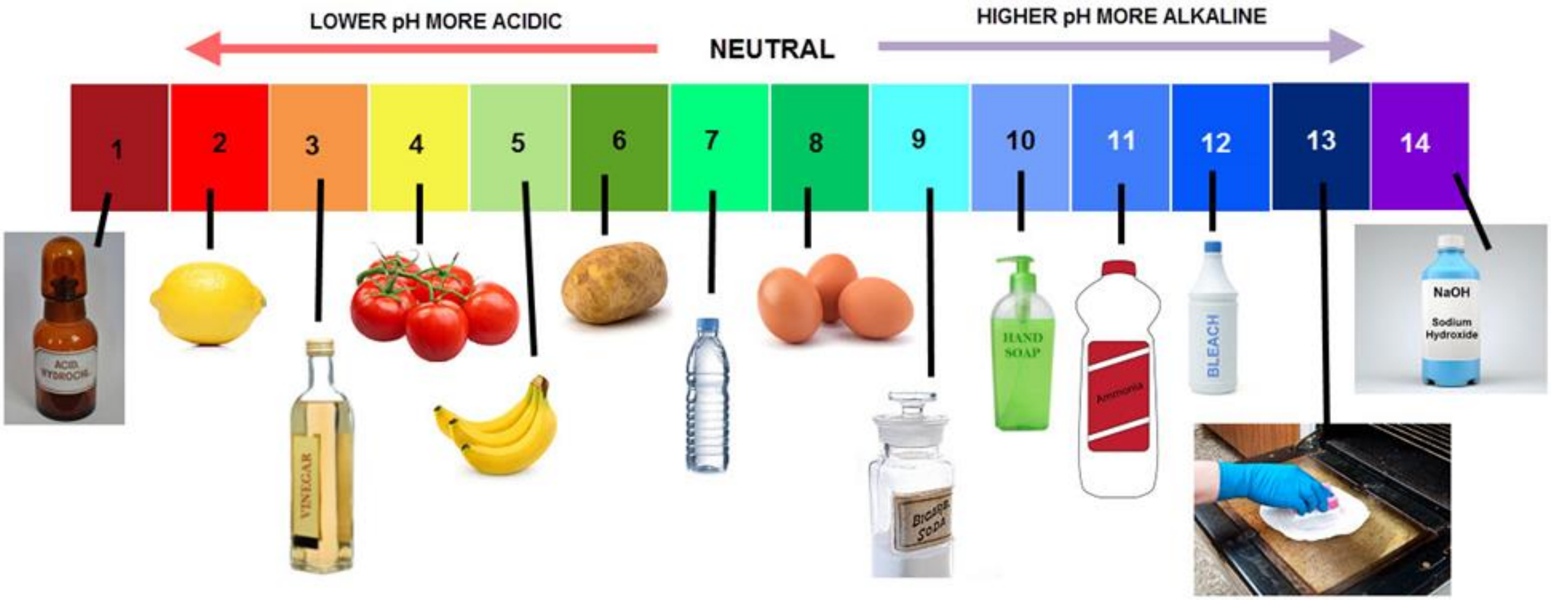


Acid and base

- Affect the degree of corrosion of metals as well as disinfection efficiency
- The pH of the water entering the distribution system must be controlled to minimize the corrosion of pipes in household water systems. Failure to do so can result in the contamination of drinking-water and in adverse effects on its taste, odor.

- *Acid rain* describes a mixture of wet and dry atmospheric deposition containing higher than normal amounts of nitric and sulphuric acids.
- The chemical compounds of acid rain result from both natural sources, such as volcanoes and decaying vegetation, and from manufactured sources, primarily sulphur dioxide (SO_2) and nitrogen oxide (NOx) emissions from fossil fuel combustion.
- Acid rain is associated with the acidification of soils, lakes, and streams, accelerated corrosion of buildings and monuments, and reduced visibility.
- In the United States, about two-thirds of all SO_2 and one-quarter of all NOx come principally from coal burning power plants.
- Acid rain occurs when SO_2 or NOx gases react in the atmosphere with water, oxygen, and other chemicals to form mild solutions of sulphuric or nitric acid.

- pH is a way of expressing the hydrogen-ion concentration of a solution. As acids and bases in solution dissociate to yield hydrogen ions [H+] and hydroxyl ions [OH^-] respectively, pH is the acidic or alkaline condition of a solution.
- pH =-log[H]

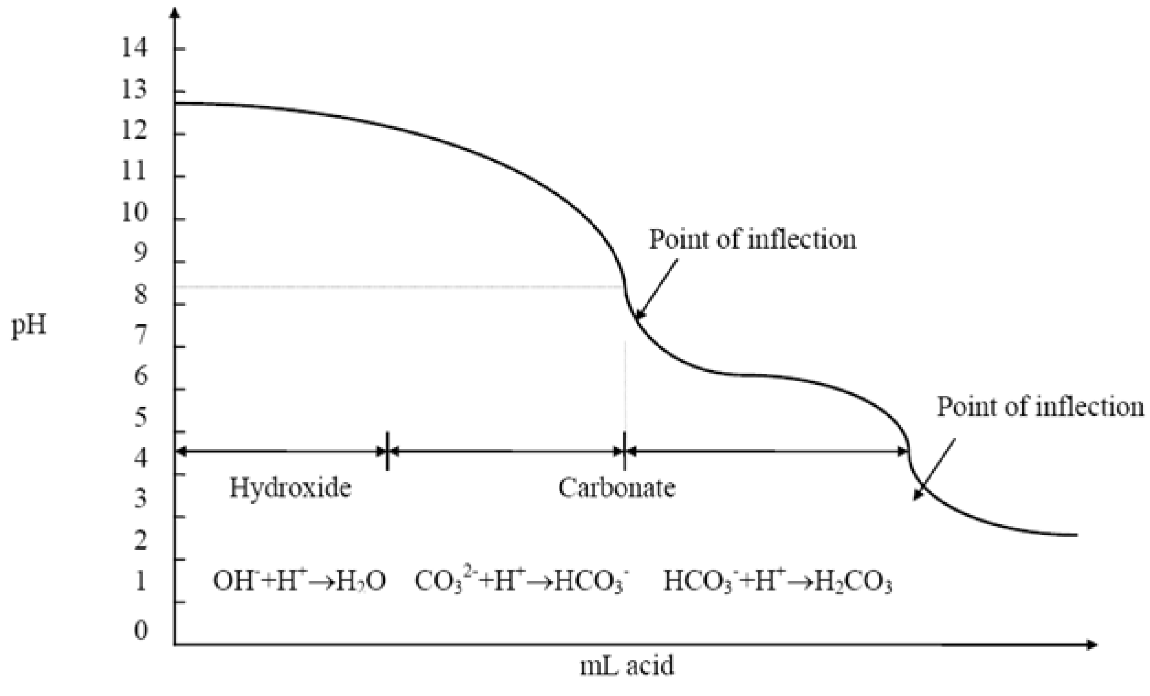


- The alkalinity of water is its quantitative capacity to neutralize acids. The three major forms of alkalinity ranked in order of their association with high pH values are

(1) hydroxide $[OH^-]$

(2) carbonate, $[CO_3^{-2}]$

(3) bicarbonate $[HCO_3^-]$



Type of Impurities in Water

- **Suspended**
  - **Soil**
    - Sand
    - Silt
    - Clay
    - Colloidal
  - **Microorganisms**
    - Bacteria
    - Algae
    - Fungi
    - Protozoa
    - Viruses
- **Dissolved**
  - **Salts**
    - **Cation**
      - Ca
      - Mg
      - Mn
      - Fe
      - Na, K
      - Pb, Hg
    - **Anion**
      - HCO_3
      - CO_3
      - SO_4
      - Cl
      - F
      - NO_3, NO_2
  - **Gases**
    - O_2
    - CO_2
    - H_2S
    - CH_4
    - N_2
    - NH_3
  - **Organic Matter**

Suspended Impurities	Causes
Bacteria	Disease
Algae	Odor, Color, Turbidity
Protozoan	Disease
Viruses	Disease
Silt	Murkiness & Turbidity
Clay	Murkiness & Turbidity
Colloids	Color, Murkiness & Turbidity

Gases	Causes
Oxygen	Corrosive, Oxidizing agent
Carbon Dioxide	Acid
Hydrogen Sulfide	Acid, Reducing agent
Ammonia	Caustic

Salts-Cations	Causes
Calcium	Hardness
Magnesium	Hardness
Iron	Hardness, Color
Manganese	Hardness, Color
Others	Dissolved Solids

Salts-Anions	Causes
Bicarbonate	Alkalinity
Carbonate	Alkalinity
Sulfate	Laxative
Chloride	Taste
Fluoride	Tooth Mottling
Organics	Color, Taste, Odor, Toxicity

Impurities of water may be divided into two classes:

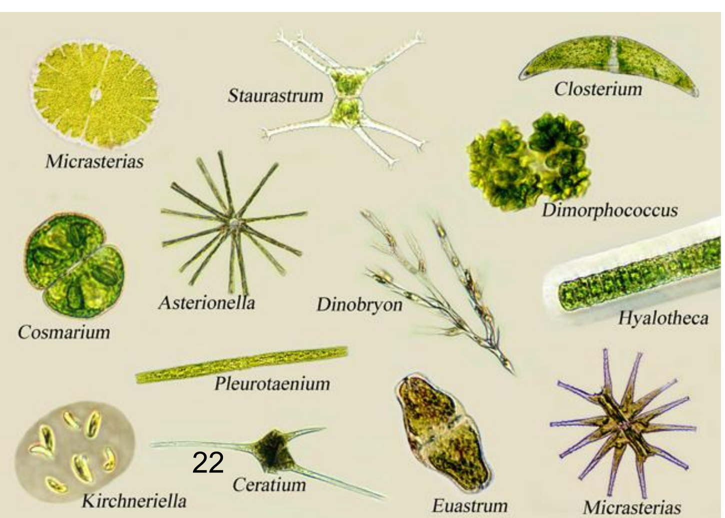
1. Suspended Impurities:

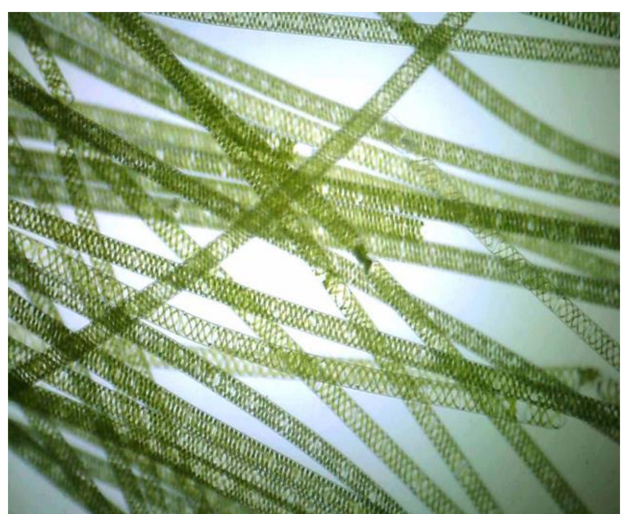
- Microorganisms: they may get into water from air with dust, etc., as r only when soil polluted with human and animal wastes washed into the water source.
- The latter type of impurities in water is the most dangerous one because a good number of microorganisms are pathogenic and cause diseases.
- Microorganisms such as bacteria, algae, fungi, etc.

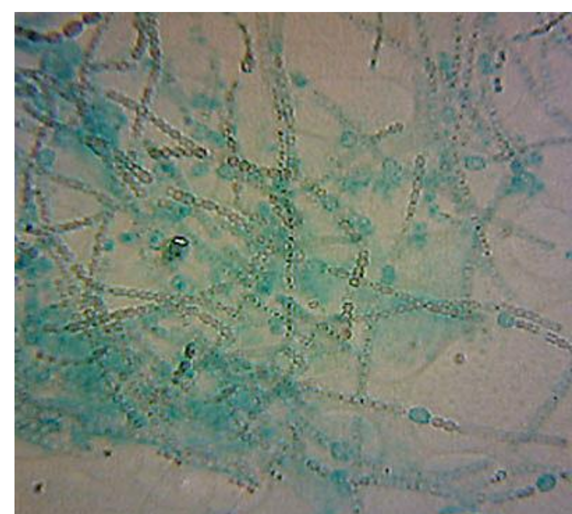
- Algae: Algae are minute plants that grow in still or stagnant water. Some algae are green, brown or red, and their presence in water causes taste, color and turbidity.
- Some species of algae could be poisonous both for aquatic animals and humans.

There are different types of algae found in water:

- Asterionella: gives water an unpleasant odor.
- Spirogyra: is a green scum found in small ponds and polluted water. It grows in thread. It is slippery and non-toxic.
- Anabaena: is blue- green and occurs in fishponds, pools, reservoir and clogs filter

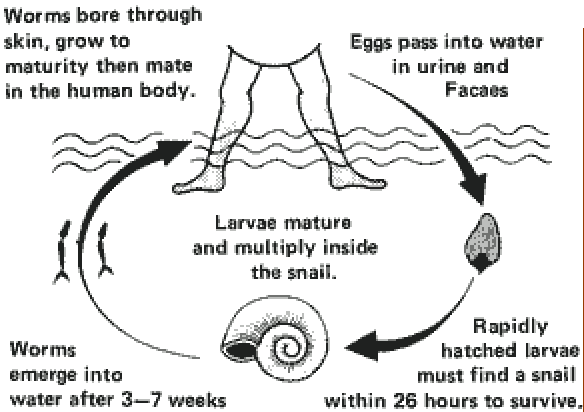


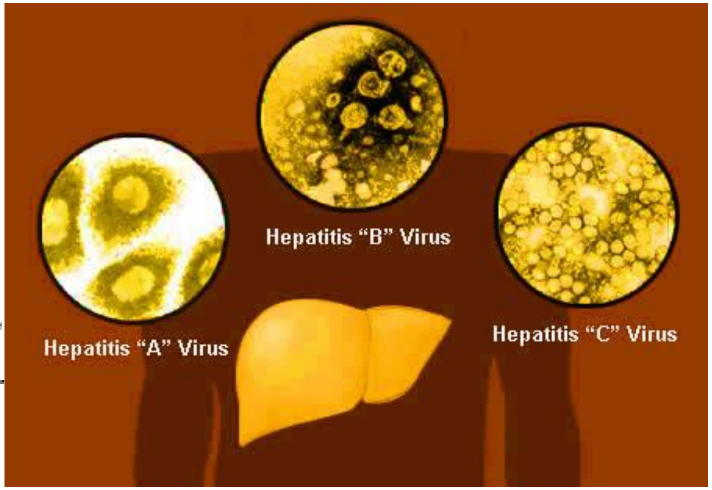




Infectious Agents: Bacteria

- Infectious Agents : pathogenic organisms. Water-borne diseases include typhoid, cholera, bacterial and amoebic dysentery, infectious hepatitis, guinea worm and bilharzia.
- Due to lack of sanitation, analyze coliform bacteria (E. coli). Presume if coliform bacteria are present, infectious pathogens are also present.





Some human diseases transmitted by polluted water

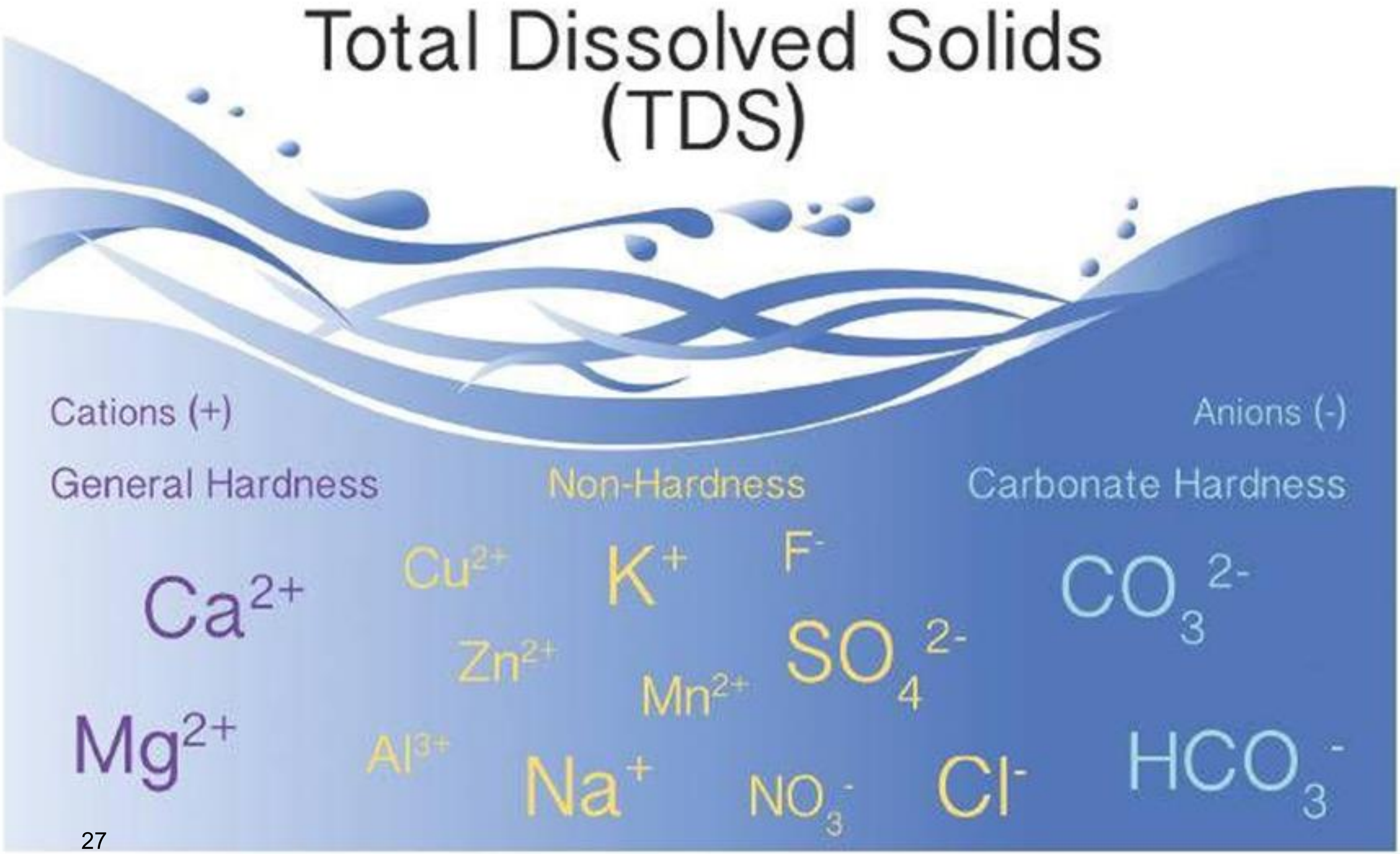
Disease	Infectious Agent	Type of Organism	Symptoms
Cholera	*Vibrio cholerae*	Bacterium	Severe diarrhea, vomiting; fluid loss of as much as 20 quarts per day causes cramps and collapse
Dysentery	*Shigella dysenteriae*	Bacterium	Infection of the colon causes painful diarrhea with mucus and blood in the stools; abdominal pain
Enteritis	*Clostridium perfringens*, other bacteria	Bacterium	Inflammation of the small intestine causes general discomfort, loss of appetite, abdominal cramps, and diarrhea
Typhoid	*Salmonella typhi*	Bacterium	Early symptoms include headache, loss of energy, fever; later, a pink rash appears along with (sometimes) hemorrhaging in the intestines
Infectious hepatitis	Hepatitis virus A	Virus	Inflammation of liver causes jaundice, fever, headache, nausea, vomiting, severe loss of appetite; aching in the muscle occurs
Poliomyelitis	Poliovirus	Virus	Early symptoms include sore throat, fever, diarrhea, and aching in limbs and back; when infection spreads to spinal cord, paralysis and atrophy of muscles
Cryptosporidiosis	*Cryptosporidium* sp.	Protozoon	Diarrhea and cramps that last up to 22 days
Amoebic dysentery	*Entamoeba histolytica*	Protozoon	Infection of the colon causes painful diarrhea with mucus and blood in the stools; abdominal pain
Schistosomiasis	*Schistosoma* sp.	Fluke	Tropical disorder of the liver and bladder causes blood in urine, diarrhea, weakness, lack of energy, repeated attacks of abdominal pain

Sediment

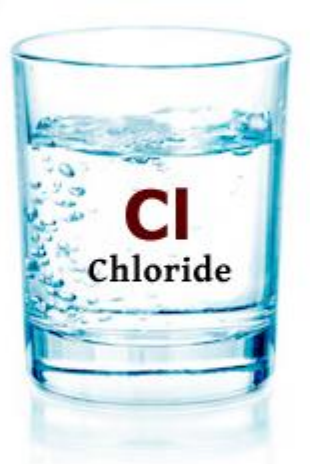
- Sediment is the loose sand, clay, silt and other soil particles that settle at the bottom of a body of water.
- Source: soil erosion and runoff, decomposition nd animals.
- Cause: obstructs shipping channels, clogs pipes, purification more costly, disinfection process is not efficient.

- Turbidity is caused by suspended materials which absorb and scatter light, such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms.
- These materials are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand). Turbidity can affect the color of the water.
- These colloidal and finely dispersed turbidity-causing materials do not settle under quiescent conditions and are difficult to remove by sedimentation.
- Turbidity is a key parameter in water supply engineering, because turbidity will both cause water to be unpleasant and cause problems in water treatment processes, such as filtration and disinfection.
- Turbidity is also often used as indicative evidence of the possibility of bacteria being present.

2. Dissolved Impurities:



- Chlorides (Cl^-): may be present in combination with one or more of the cations of calcium, magnesium, iron and sodium.
- Chlorides of these minerals are present in water because of their high solubility in water.
- Each human being consume about 6 to 8 grams of sodium chloride (NaCl) per day, a part of which is discharged through urine.
- Thus excessive presence of chloride in water indicates sewage pollution.
- IS value for drinking water is 250 to 1000 mg/l.



- Sulphates (SO_4^{-2}): occur in water due to leaching from sulphates mineral and oxidation of sulphide.
- Sulphates are associated generally with calcium, magnesium and sodium ions.
- Sulphate in drinking water causes a laxative effect and leads to scale formation in boilers.
- It also cause odor and corrosion problems under aerobic conditions.
- Desirable limit for drinking water is 150 to 400 mg/l.

- Iron (Fe): is found on earth mainly as insoluble ferric oxide.
- When it comes in contact with water, it dissolves to form ferrous bicarbonate under favorable conditions. This ferrous bicarbonate t bad taste to the water, causes discoloration in clothes.
- IS value for drinking water is 0.3 to 1 mg/l.

- Nitrates (NO_3^-): in surface water occur by the leaching of fertilizers from soil during surface run-off and also nitrification of organic matter.
- Presence of high concentration of Nitrates is an indication of pollution.
- Concentration of nitrates above 45 mg/l causes a disease methemoglobin. IS value is 45 mg/l.

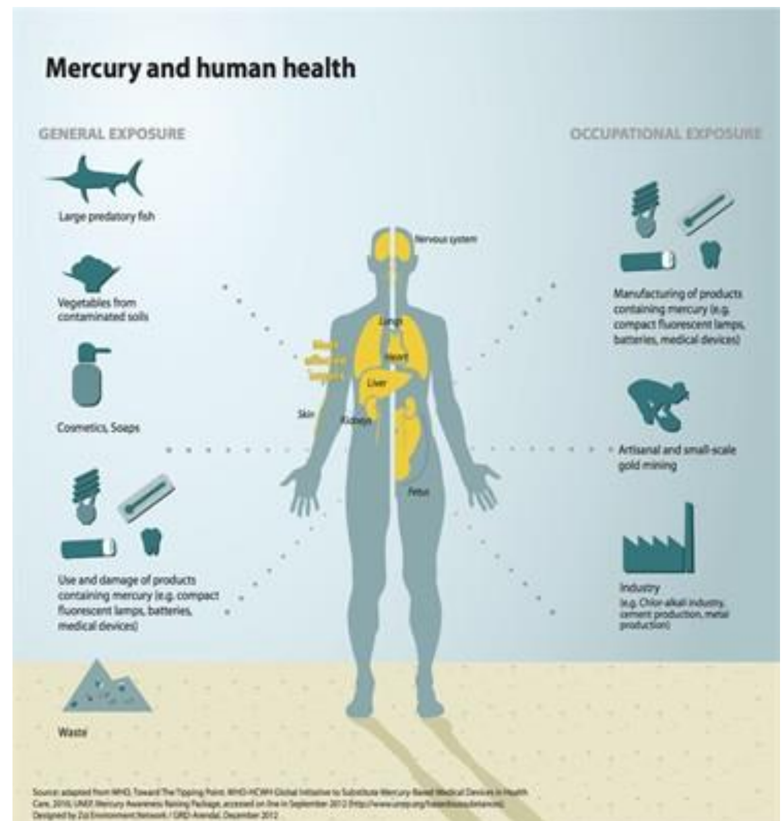
Mercury (Hg^{+2}) Cation, metallic:

Source:

- Industry such as (fluorescent light bulbs), cement and steel
- Coal-fired power plants,
- Incineration,
- Natural sources, such as volcanoes

Causes:

- Damage to the nervous system
- Development delays
- kidney disorders



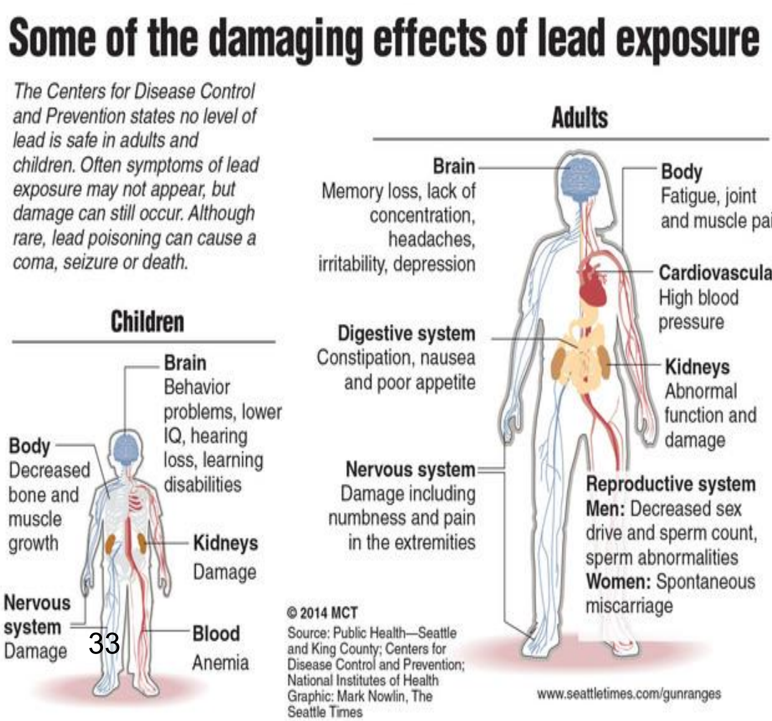
Lead (Pb^{+2}) Cation, metallic:

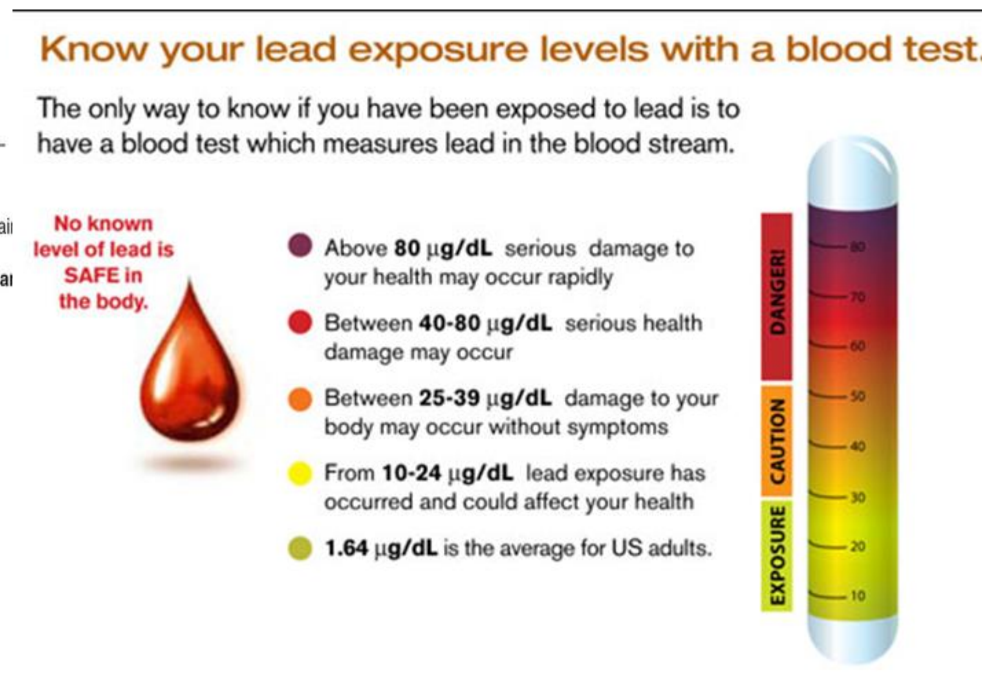
Source

Incineration, pipes, solder, gasoline

Causes:

Nervous system, anemia, abortion, Hearing los

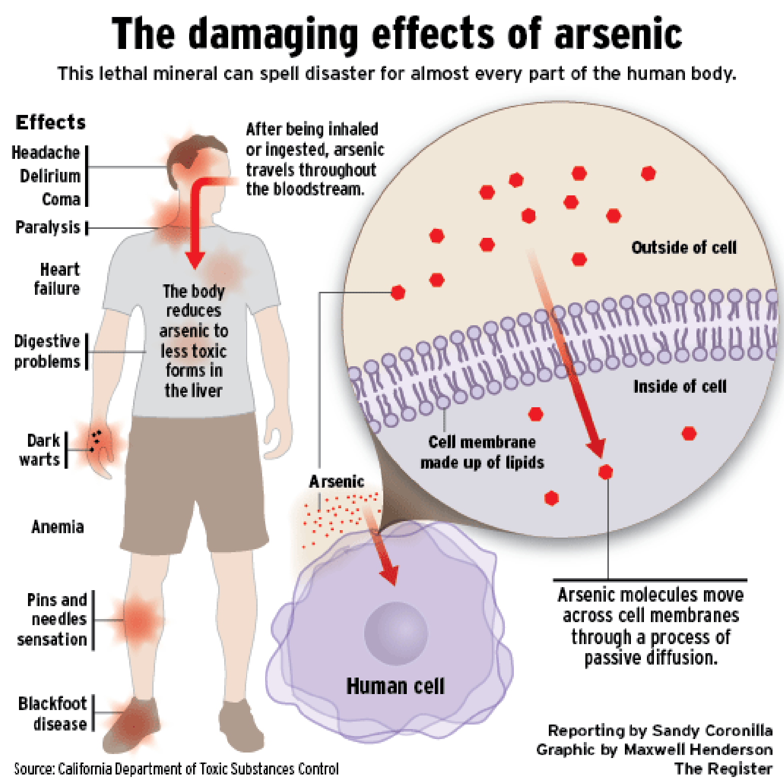




Arsenic (As^{+3}) cation, Non metal:

Source: Industries, mining, pesticides, ground water

Causes: anemia, cancer



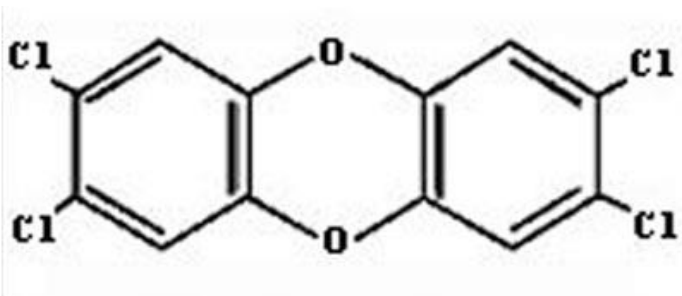
Hardness

- If water consumes excessive soap to produce lather, it is said to be hard.
- Hardness is caused by divalent metallic cations.
- The principle hardness causing cations are calcium, magnesium, strontium, ferrous and manganese ions.
- Major anions associated with these cations are sulphates, carbonates, bicarbonates, chlorides and nitrates.
- Total hardness of water is defined as the sum of calcium and magnesium concentration, both expressed as **calcium carbonate**, in mg/l.
- Hardness are of two types, temporary or carbonate hardness and permanent or non-carbonate hardness.
- Temporary hardness is one in which bicarbonate and carbonate ion can be precipitated by prolonged boiling.
- Non-carbonate ions cannot be precipitated or removed by boiling
- IS value for drinking water is 300 mg/l as $CaCO_3$.

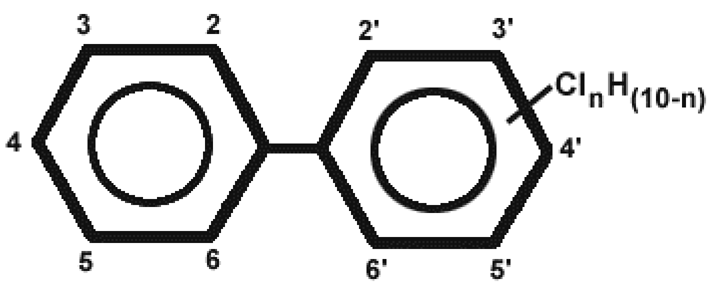
Organic Pollutants

- Such as pesticides, solvents, pharmaceuticals, and industrial chemicals
- In 1995, the United Nations Environment Programme Governing Council investigated. Initially the Convention recognized only 12 POPs for their adverse effects on human health and the environment, placing a global ban on these particularly harmful and toxic compounds and requiring its parties to take measures to eliminate or reduce the release of POPs in the environment. Such as Dioxin, PCB, DDT.
- Since 2001, this list has been expanded to include certain polycyclic aromatic hydrocarbons (PAHs) and other compounds.

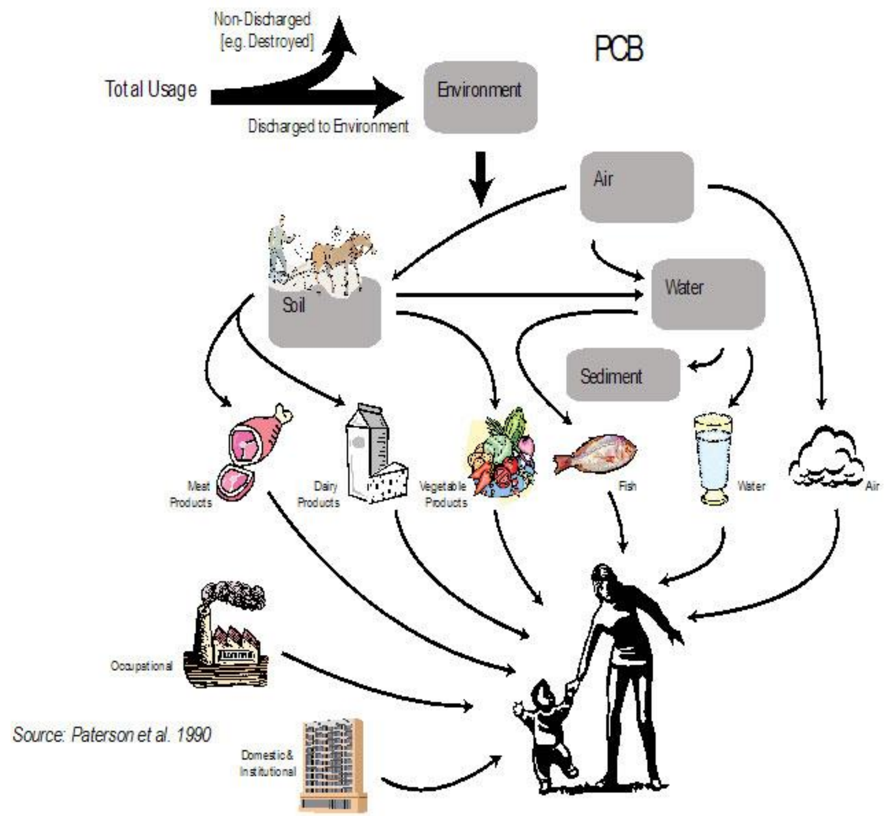
- Dioxin : Stable; slow to degrade
- Generated from : Burning wood, coal, oil, household trash, and chlorine bleaching of paper.
- Causes : Damage the immune system, interfere with hormones and also cause cancer.



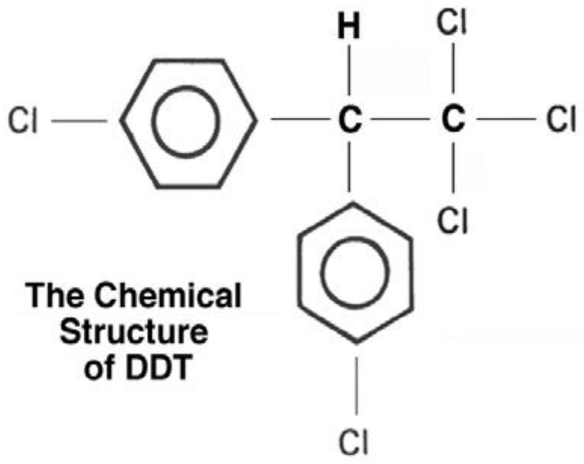
- Polychlorinated Biphenyl (PCBs) : stable, non-flammable, high boiling points.
- Does not conduct electricity well, so used in electr Accumulates in fat of animals
- Causes: hormonal and reproductive disruptions, cancer.



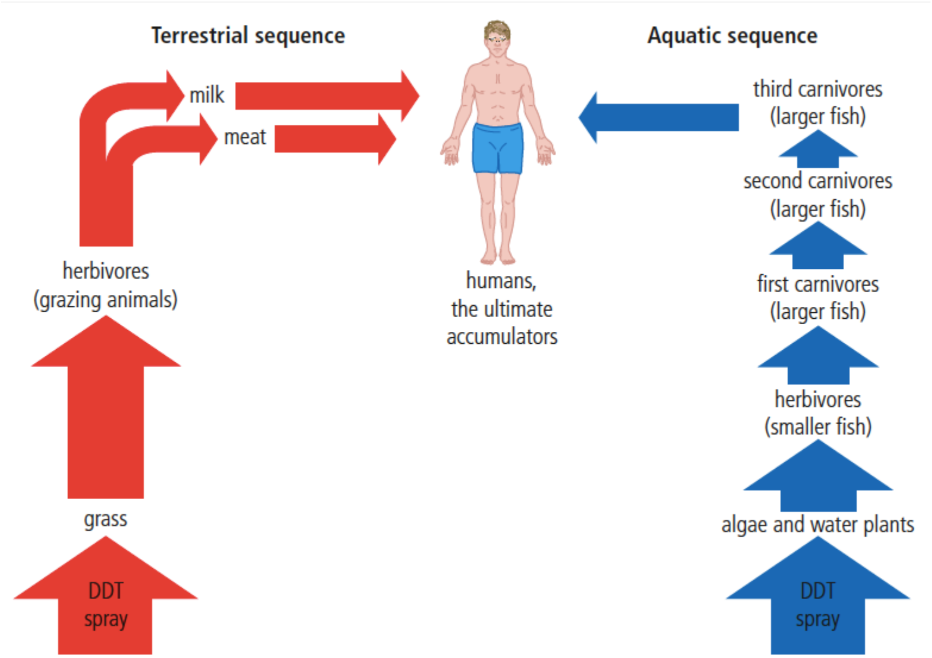
Polychlorinated Biphenyl (PCB)



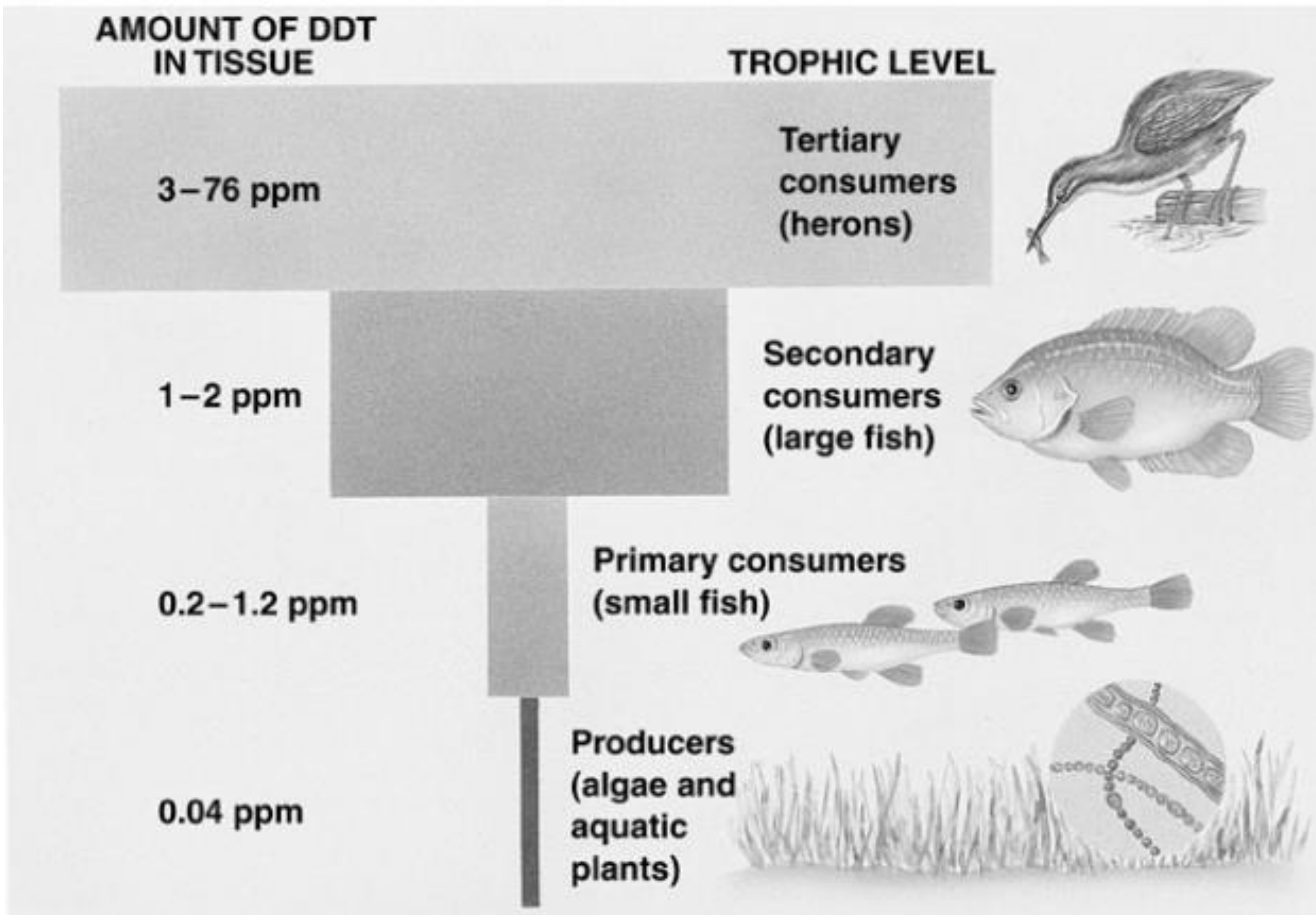
- DDT : insecticide; stable and slow to degrade.
- Paul Muller won the Nobel Prize in 1948 for developing it. Benefits: Controlled spread of malaria; Provided crop protection.
- Cause: decreased mental function, male infertility, cancer



The Chemical Structure of DDT

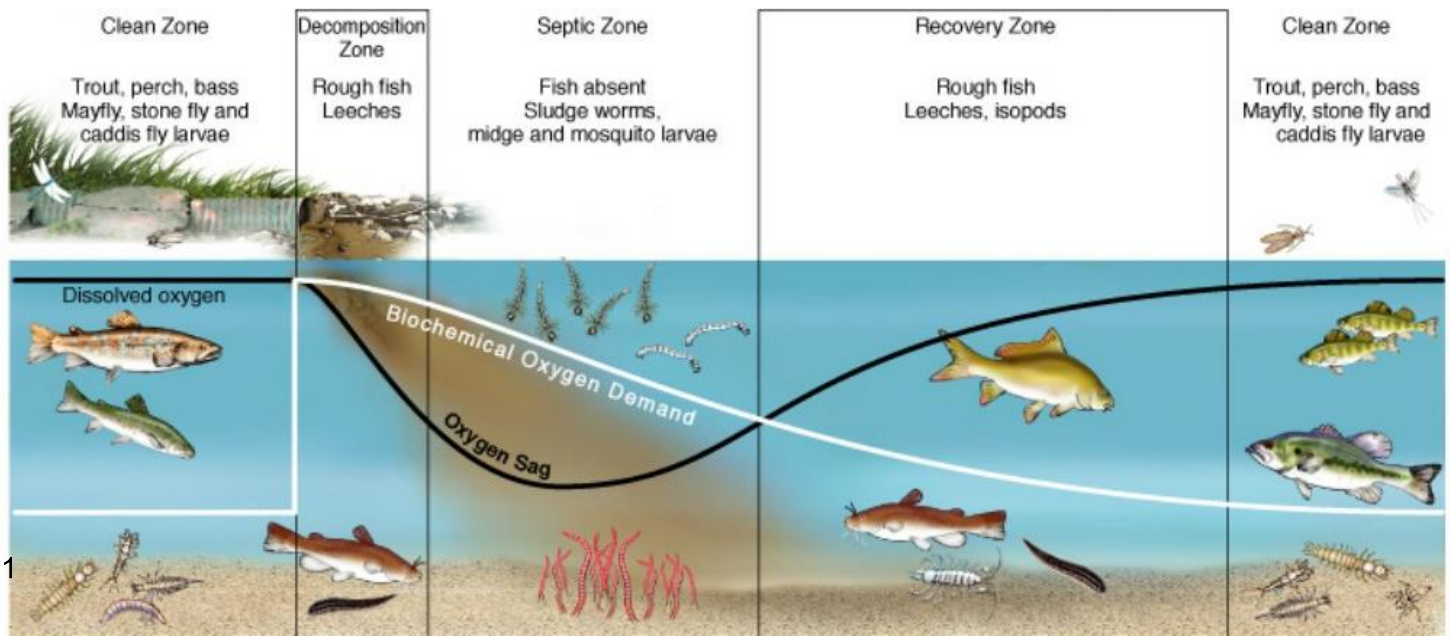


- Problems with DDT: DDT is not metabolized very rapidly by animals; instead, it is deposited and stored in the fatty tissues bioaccumulation.



Oxygen-Demanding Wastes

- Oxygen dissolved in water is indicator of water quality. 6 part per million (ppm) of O_2 or more supports desirable aquatic life.
- BOD: Biochemical oxygen demand : measures the amount of dissolved oxygen consumed by aquatic microorganisms.
- Sewage or food wastes can cause an Oxygen sag, where few fish survive.



Biochemical oxygen demand (BOD)

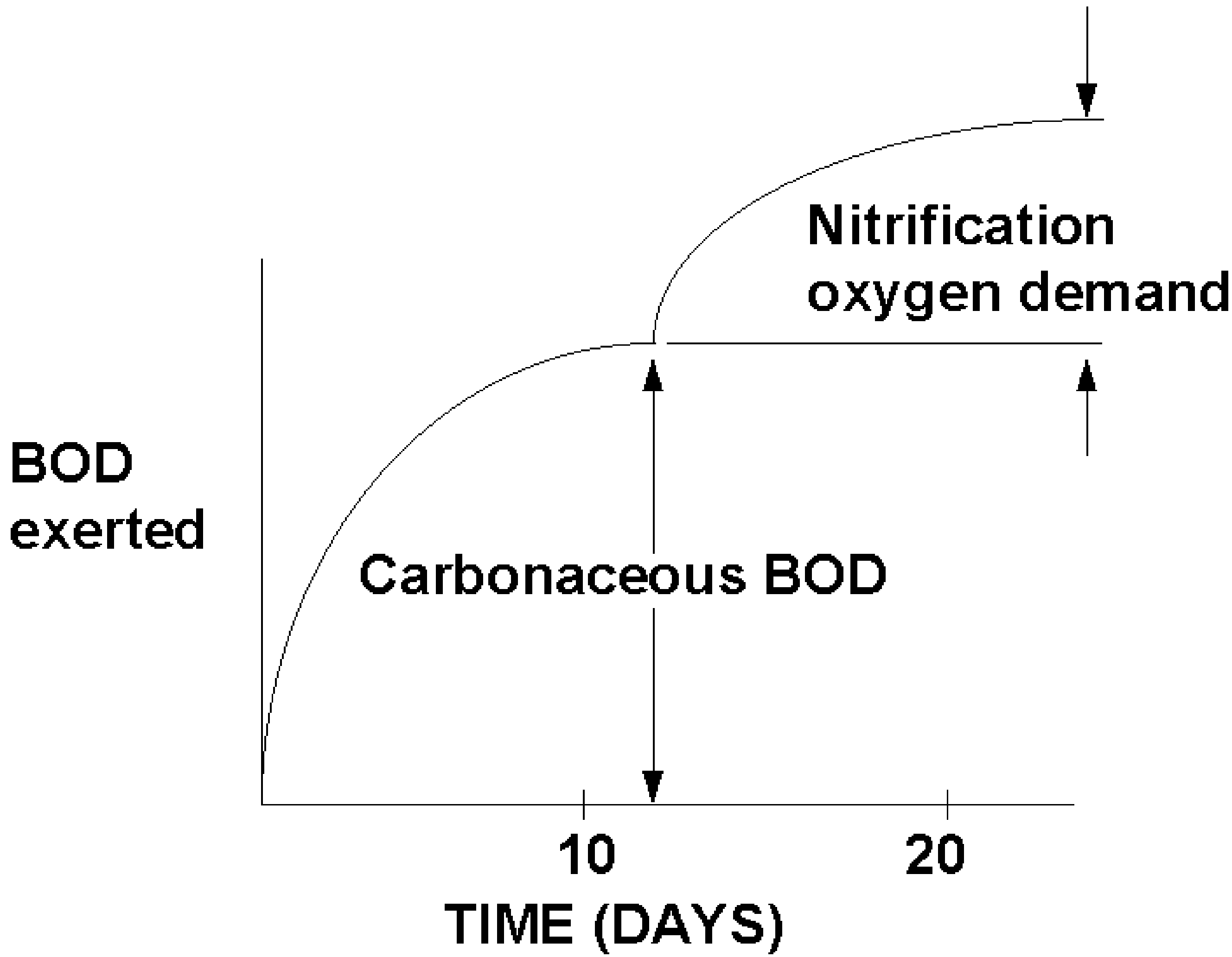
- BOD is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period depending on temperature, nutrient concentrations, and the enzymes available to indigenous microbial populations.
- The BOD value is most commonly expressed in milligrams of oxygen consumed per liter (mg/l) of sample during 5 days of incubation at 20 °C and is often used as a indicator of the degree of organic pollution of water and effectiveness of wastewater treatment plants.
- BOD is similar in function to chemical oxygen demand (COD), in that both measure the amount of organic compounds in water. However, COD is less specific, since it measures everything that can be chemically oxidized, rather than just levels of biologically active organic matter.

- Most natural waters contain small quantities of organic compounds. Aquatic microorganisms have evolved to use some of these compounds as food.
- Microorganisms living in oxygenated w ic community can produce.
- Fish and aquatic insects may die when oxygen is depleted by microbial metabolism.

Organic matter + O_2 + bacteria → CO_2 + H_2O + new cells of bacteria

Organic nitrogen + O_2 + bacteria → Ammonia-nitrogen

NH_3-N + O_2 → Nitrate- nitrogen (NO_3-N) (nitrification)



- Dissolved oxygen (DO) depletion is most likely to become evident during the initial aquatic microbial population explosion in response to a large amount of organic material.
- Most rivers will have a 5-day carbonaceous BOD below 1 mg/L.
- Moderately polluted rivers may have a BOD value in the range of 2 to 8 mg/L.
- Municipal sewage that is efficiently treated averages around 600 mg/L in Europe and as low as 200 mg/L in the U.S., or where there is severe groundwater or surface water Infiltration/Inflow. The generally lower values in the U.S. derive from the much greater water use per capita than in other parts of the world.

Typical values of k & BOD ultimate (L) for various waters for default temperature of 20°C

Water Type	K (Day^{-1})	L_0 (mg/l)
Tap water	<0.1	0 – 1
Surface water	0.1 – 0.23	1 – 30
Weak municipal waste water	0.35	150
Strong municipal waste water	0.40	250
Treated effluent	0.12 – 0.23	10 – 30

$$BOD_t = BODu(1 - e^{-k.t})$$

Where:

BOD_t: BOD at any time (mg/l)

BOD_u: BOD ultimate (mg/l)

e: exponential

t: Time (day)

K: reaction constant (1/day), depend on temperature

$$K_{temp} = K_{20C}.\, \theta^{temp-20}$$

ɵ = 1.135 for 4 < Temp ≤ 20°C

ɵ = 1.056 for Temp > 20°C

BOD_5 is calculated by:

Unseeded BOD_5 = $\frac{DO_i - DO_5}{p}$

Seeded BOD_5 = $\frac{(DOi - DO_5) - (BOi - BO_5).f}{p}$

where:

DO_i is the dissolved oxygen (DO) of the diluted solution after preparation (mg/l)

DO_5 is the DO of the diluted solution after 5 day incubation (mg/l)

p is the decimal dilution factor

BO_i is the DO of diluted seed sample after preparation (mg/l)

BO_5 is the DO of diluted seed sample after 5 day incubation (mg/l)

f is the ratio of seed volume in dilution solution to seed volume in BOD test on seed

- 60- 70 % of the oxidation/ degradation of organic pollutants in 5 days
- 95- 99% oxidization in 20 days

Example: Determine BOD_1 & BOD_u for waste water where BOD_5 at 20˚C is 200 mg/l, k= 0.23 d^{-1}

Example: Water sample has 0.02 dilution factor (1 ml from sample diluted in 50 ml distilled water), the initial dissolved oxygen (DO) is 10 mg/l, after 5 days the DO is 6 mg/l. Calculate BOD_5

Thomas Graphical Method (McGhee 1991): This is an approximate method. It is based on the following equation:

$$(t/y)^{1/3} = \quad 1/(2.3\ kL_0)^{1/3} \quad + \quad [(2.3\ k)^{2/3}/6\ L_0^{1/3}]\ .\ t$$

$$Z = a + b.\ t$$

Where:

a: intercept with y axis

b: line slop (dy/dx)

Sample calculation

Step 1: calculate $(t/y)^{1/3}$

Time (t)	BOD_t (y)	$(t/y)^{1/3}$
0	0.00	---
1	1.60	0.855
2	3.0	0.873
3	3.86	0.919
4	4.74	0.945
5	5.14	0.991
6	6.86	0.956
7	7.74	0.967

step 2: Plot $(t/y)^{1/3}$ versus "t" and found slope and intercept

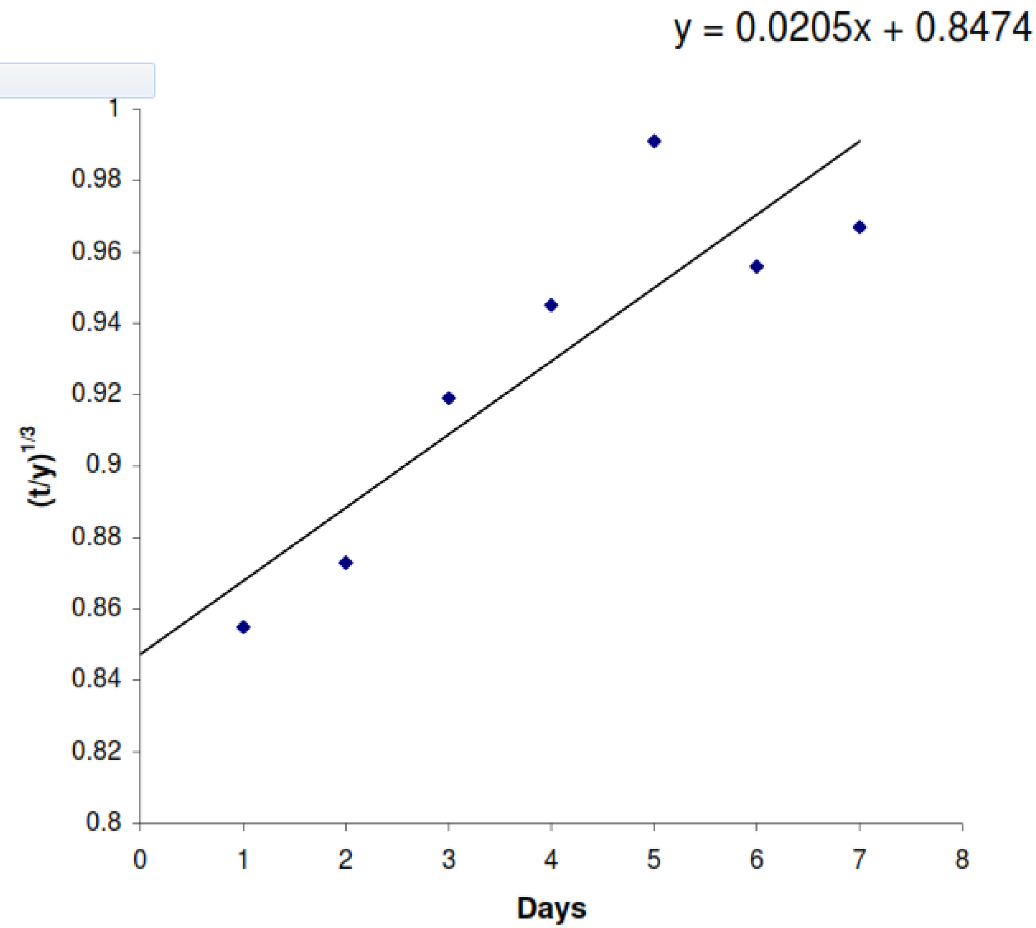
Slope = 0.0205

Intercept = 0.8474

Step 3: k and L

$$K = 2.61\,\frac{slope}{intercept} = 0.063/\text{day}$$

$$L = \frac{1}{2.3 * k * intercept^3} = 11.34\ \text{mg/l}$$



HW: Compute the value of k & BOD_u for the data given below

Time (day)	BOD_t (mg/l)
2	11
4	13
6	22
8	24
10	26

Treatment evaluation

$$\text{Efficiency (BOD)} = \frac{\text{BOD}_{\text{inf}} - \text{BODeff}}{\text{BOD}_{\text{inf}}} \times 100$$

BOD: Biological oxygen demand

inf: Influent (flow in)

eff: Effluent (flow out)

Example: the plant efficiency of treatment plant are 50% for BOD & 70% for suspended solid (SS), BOD & SS of wastewater enter the plant are 40 & 55 mg/l, respectively. Can we dispose the flowing out from the treatment plant to the river? Why?

Radiation

- *Radon* is a radioactive noble gas formed by the natural decay of uranium, which is found in nearly all soils.
- Radon is considered a health hazard amination inside of homes is of particular concern and cannot be remedied once detected.
- Radon concentrations in the air are typically expressed in units of picocuries per liter (pCi/L) of air. Concentrations can also be expressed in *working levels* (WL) rather than picocuries per liter (1 pCi/L = 0.004 WL).

	مواصفات هيئة الصحة العالمية	مواصفات الاتحاد الأوربي	المواصفات الكندية	المواصفات الأمريكية	المواصفات الروسية
اللون TCU	15	20	15	15	-
المواد الصلبة الذائبة	1000	-	500	500	-
المواد الصلبة المعلقة	-	-	-	-	-
العكارة NTU	5	4	5	1 – 5	-
الاس الهيدروجينى PH	6.5 – 8.5	6.5 – 8.5	8.5 – 6.5	8.5-6.5	-
الأكجسين المذاب	-	-	-	-	4
عسر الماء	500	-	-	-	-
نيتروجين نشادرى (امونيا)	-	-	-	-	2
الأمونيوم	-	0.5	-	-	2
نترات معين بالنيتروجين	10	-	10	10	-
النترات	-	50	-	-	10
نتريت معين بالنيتروجين	-	-	1	-	1
النتريت	-	0.1	-	-	1
الفوسفور P	-	5	-	-	-
حدود الاكسجين الحيوي BOD	-	-	-	-	2
الصوديوم Na	200	-150 175	-	-	-

	مواصفات هيئة الصحة العالمية	مواصفات الاتحاد الأوربي	المواصفات الكندية	المواصفات الأمريكية	المواصفات الروسية
الصوديوم Na	200	-150 175	-	-	-
الكوريد CI	250	25	250	250	250
كبريتات So_1	400	25	500	250	500
كبريتيد So_1	-	-	0.05	-	-
فلوريد F	1.5	-1.5 [5](0.7)	1.5	2	1.5
بورون B	-	1	5	-	-
سيانيد CN	0.1	-	0.2	-	0.1
الومنيوم AI	0.2	0.2	-	-	-
ارسنك AS	0.05	0.05	0.05	0.05	-
باريوم Ba	-	0.1	1	1	-
كادميوم Cd	0.005	0.005	0.005	0.01	0.001
كروميوم Cr	0.05	0.005	0.05	0.05	0.1 8(0.5)
كوبلت Co	-	-	-	-	0.1
نحاس Cu	1	1(0.1)	1	1	1
حديد Fe	0.3	0.3	0.3	0.3	0.5

	مواصفات هيئة الصحة العالمية	مواصفات الاتحاد الأوربي	المواصفات الكندية	المواصفات الأمريكية	المواصفات الروسية
رصاص Pb	0.05	0.05	0.05	0.05	0.03
منجنيز Mn	0.1	0.05	0.05	0.05	-
زئبق Hg	0.001	0.001	0.001	0.002	0.0005
نيكل Ni	-	0.05	-	-	-
سلينيوم Se	0.01	0.01	0.01	0.01	-
زنك Zn	5	0.1 – (3)	5	5	1

الملوثات العضوية	مواصفات الصحة العالمية	مواصفات الاتحاد الاوربي	المواصفات الكندية	المواصفات الامريكية	المواصفات الروسية
Oil & Petroleum Products	-	0.01	-	-	0.3
Total Pesticides	-	0.5	0.1	-	-
Individual Pesticides	-	0.1	-	-	-
Aldrin & Dieldrin	0.03	-	0.7	-	-
DDT	1	-	30	-	-
Lindane	3	-	4	0.4	-
Methoxychlor	30	-	100	100	-
Benzene	10	-	-	5	-
Hexachlorobenzene	0.01	-	-	-	-
Pentachlorophenol	10	-	-	-	-
Phenols	-	0.5	2	-	1
Detergents	-	0.2	-	12(0.5)	0.5

قسم الهندسة المدنية

المرحلة الرابعة

Al-Mansour University College

Civil Eng. Dept.

4th. Stage

Sanitary Engineering

2022 - 2023

الهندسة الصحية

Lec.3

Dr Ameer Badr Khudhair

Ministry of Higher Education and Scientific Researches
Al-Mansour University College
Department of Civil Engineering
CE 405 Sanitary and Environmental Engineering

Water Treatment Plant

Intake
Rapid mix
coagulation
Flocculation

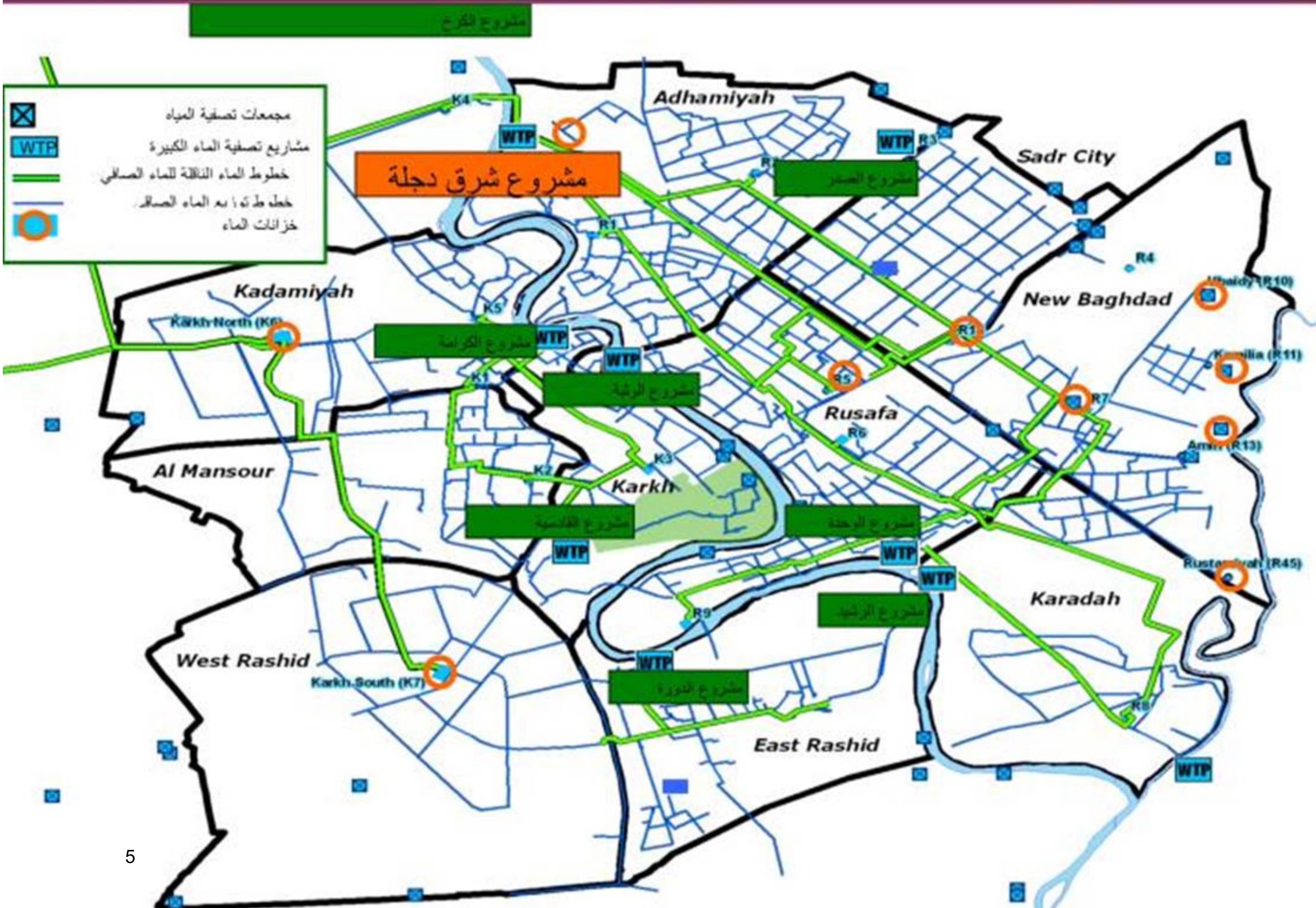
Dr Ameer Badr Khudhair

https://docs.google.com/spreadsheets/d/1PqH8FA3o_fSA4wGRTSj57zPqY91_JTqzMSd26b_8kGA/edit?pli=1#gid=543764524

مقدمة

- ✓توجد في مدينة بغداد 8 وحدات رئيسة لمعالجة مياه الشرب
- ✓ تبلغ مجموع طاقتها التصميمية حوالي 2.5 مليون م^3/يوم تقريبا، منها 1.900 مليون م^3/يوم في الكرخ، و 0.656 مليون م^3/يوم في الرصافة
- ✓وفي أحدث دراسة قامت بها شركة (سافيج) الفرنسية عام 2002 قدرت فيه وتتوزع هذه المشاريع على نهر دجلة كفاءة محطات معالجة المياه بحوالي 67%
- ✓في جانبي الكرخ والرصافة، ويضم جانب الكرخ مشاريع الكرخ، والدورة، والكرامة والقادسية
- ✓أما جانب الرصافة فيضم مشاريع شرق دجلة، والوثبة، والرشيد، والوحدة

مشاريع تصفية المياه الرئيسية في بغداد



((الطاقات الفعلية لمشاريع أنتاج الماء الرنيسية))

ت	أسم المشروع	موقع المشروع	الطاقة الفعلية 1000 متر مكعب / يوم	المناطق المجهزة بالماء
1	ماء الكرخ	الطارمية	1150	خزان التاجي ، خزان ابو غريب ، الخزان الشمالي ، الخزان الجنوبي ، خزان 2B ، مشروع شرق دجلة + منطقة الطارمية
2	ماء شرق دجلة عدا محطة الـ 2B	سبع ابكار	579	جانب الرصافة :- حي المهدي ، حي البساتين ، حي الشعب ، حي تونس ، حي الربيع ، حي البيضاء ، حي جميلة ، حي القاهرة ، الوزيرية ، حي المستنصرية ، مدينة الصدر ، حي المغرب ، حي النضال .... حي 9 نيسان والمحلات التابعة لها والمناطق المجاورة أي جانب الرصافة عدا المناطق المخدومة
3	ماء الكرامة	العطيفية	155	يجهز منطقة العطيفية والكاظمية وجزء من جانب الكرخ الشمالي للمحلات (407 ، 409 ... 413 ، 206 ، 208)
4	ماء القادسية	القادسية	90	منطقة القادسية والمناطق المحيطة بها المحلات (604 ، 606 ، 610 ، 616 ، 612 ، 614 ، 205 ، 211 ، 213 ، 215)
5	ماء الدورة	حي الأثوريين	100	يجهز اغلب مناطق الدورة للمحلات (823 ، 821 ... 833 ، 820 ، 822 ... 840 ، 846 ، 848 ، 802 ، 804 ، ... 818 ، 850 ، 852 ، 856 ، 858)
6	ماء الوثبة	العيواضية	76	يجهز مركز الرصافة وجزء من الأعظمية للمحلات (104 ، 108 ، ... 122 ، 107 ، 109 ، ... 119)
7	ماء الوحدة	الكرادة	72	يجهز منطقة الكرادة المحلات(902 ،903 ، 904 ،905 ، 906 ، 908 ، 910)
8	ماء الرشيد	معسكر الرشيد	45	يجهز منطقة الزعفرانية للمحلات (949 ، 951 .... 961 ، 977 ، 979)
9	ماء الصدر	كسرة وعطش	95	يجهز محلات مدينة الصدر
10	ماء الجادرية	الجادرية	58	يجهز محلات الكرادة (901، 911 ، 913 ، 929)
	المجموع		2420	مليونان واربعمائة وعشرون الف متر مكعب / يوم

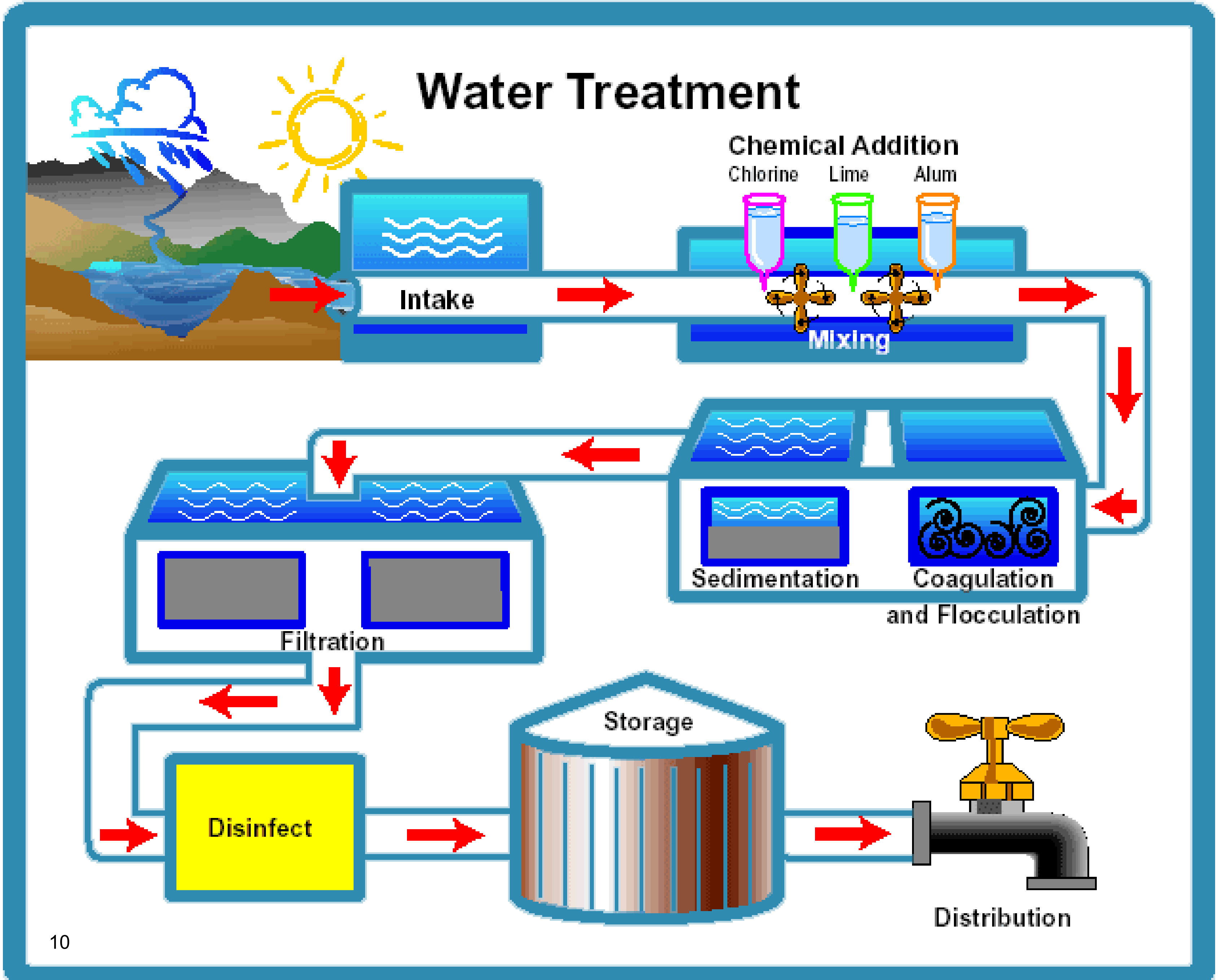
Water treatment plant

- The prime goal of the design of water treatment plants is to provide of **safe water**. Ideally, appealing water is one that is **clear** and **colorless**, **pleasant** to the **taste**, and **cool**.
- It is non-staining, and is neither corrosive nor scale forming.

- Treatment process used depends on the **raw water source** and the **quality of finished water** desired.
- Many chemicals are employed in the treatment. The specific chemicals selected for treatment are based on their effectiveness to perform the desired reaction and cost.
- Natural water polluted either by human activity or by nature, is likely to contain dissolved organic and inorganic substances; biological forms, such as bacteria and plankton; and suspended inorganic material.

The principal water treatment units processes employed to remove these substances are as follows:

- Water resource
- Intake
- Rapid mixing
- Coagulation and flocculation, Sedimentation
- Filtration
- Advanced treatment: Softening, Ion exchange, Adsorption, Reverse osmosis, Aeration.
- Disinfection/ Chlorination
- Ground storage
- Water network system



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

Intakes

- Intakes are structures constructed in or adjacent to lakes, reservoirs, or rivers for the purpose of withdrawing water from the source to the water treatment plant.
- They consist of an opening with a strainer through which the water enters, and a conduit to conduct the water by gravity to a pumping station.
- The water is pumped from the pumping station to the water treatment facility. Schematic diagrams of lake and river intake systems are shown in Figures 1 and 2.

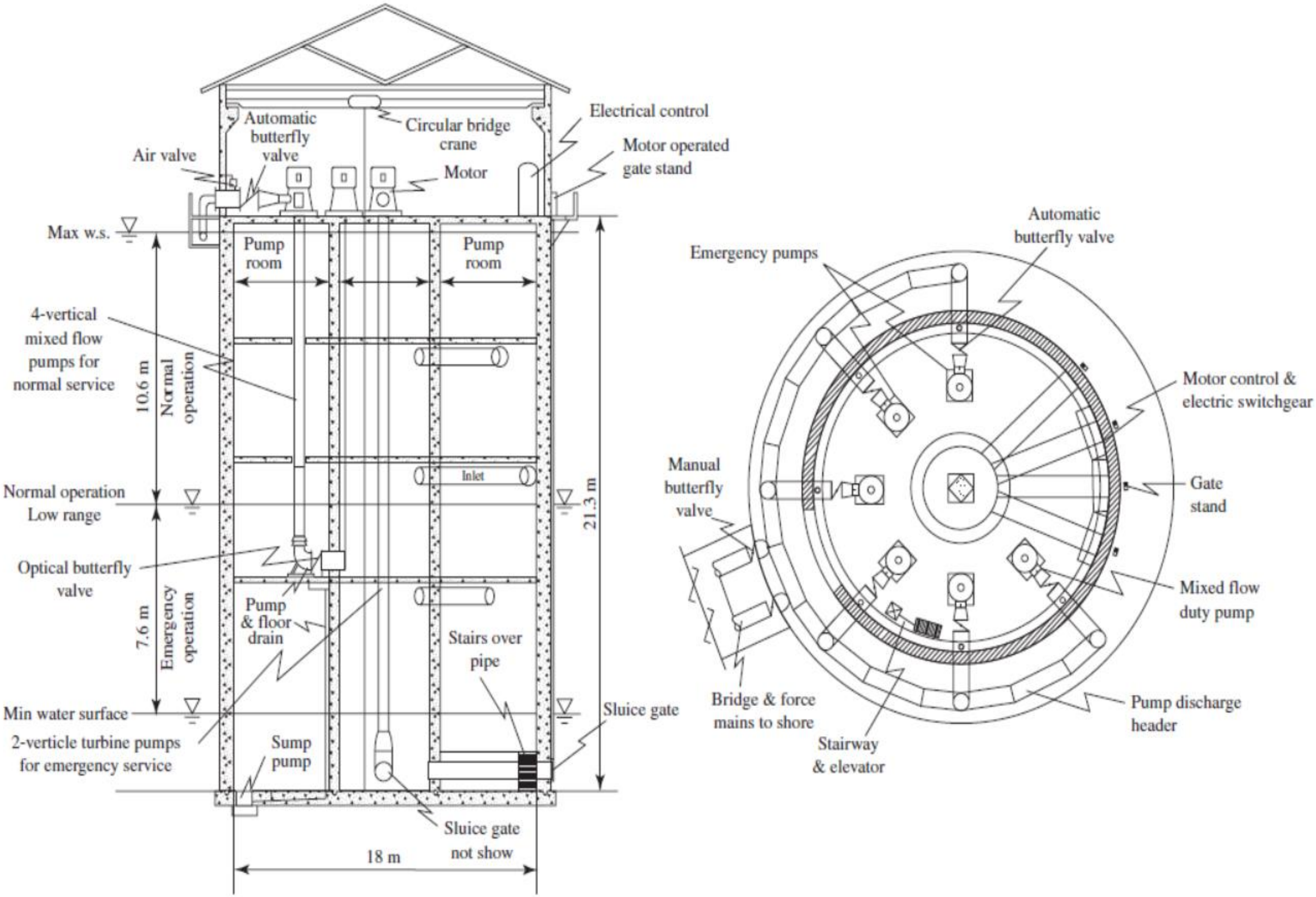


Figure 1: tower intake in a lake (water surface).

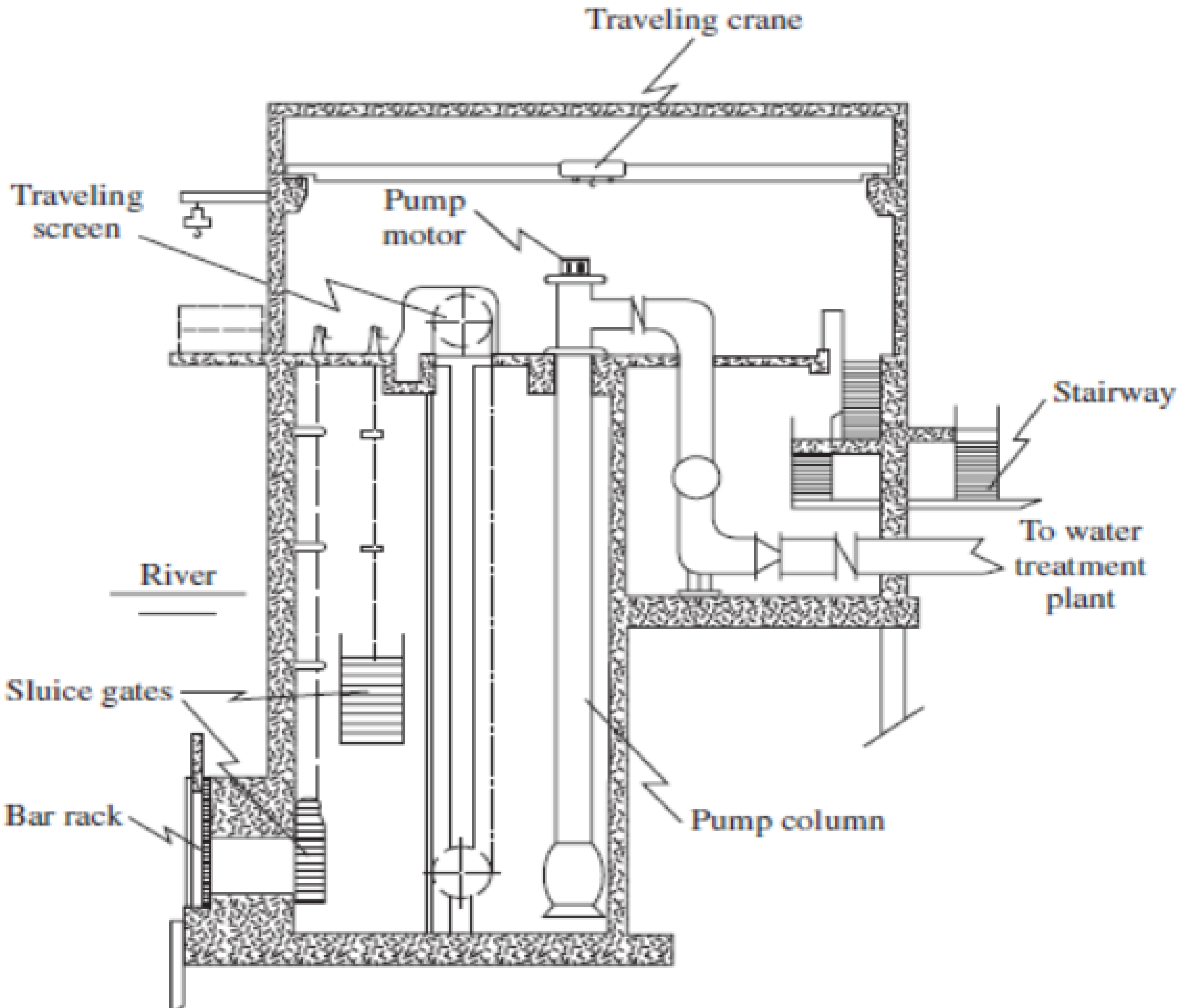


Figure 2: river intake.

Type of Intake

Intake structures may be classified into two categories:

- **Direct intake**: directly from the river.
- **Indirect intake**: take from well beside the river.

Many varieties of these types have been used. The selection of the type of intake is highly dependent on local circumstances. Because the circumstances are fundamentally different, the systems are often classified as either river intakes or lake/reservoir intakes as shown in figure 1, 2.

The key requirements of the intake structures are that they are:

- Adequate size to provide the required quantity of water.
- Located to obtain the be damage to aquatic life.
- Located to minimize navigational hazards.

Intake design elements

- Water level variation: NPSH in site ≥ NPSH pump; NPSH: net positive suction head
- Water quality: Use to remove objects to enter to system through strainer
- Detention time in the well: range from **15-30 minutes**, so the pumps do not work continuously.
- Bottom of the well: the bottom of the well must reduce no more than **1 m** from the river bottom.
- The distance between the entrance pipe and the bottom of the well is almost **0.6 m**

Strainer design elements

- Entrance velocity for strainers **0.15 - 0.3** m/s.
- Area for strainer holes **≤ 50%** of the gross area of the strainers.
- Velocity for gravity pipe **0.6 -1.5** m/s.
- Discharge for the washing pipe = **1/3** discharge for the gravity pipe.
- Flow velocity for the washing pipe = **3** m/s.

Example: It is required to design a strainer with imperforated top and 0.6 m height. Find the strainer, gravity pipe and wash pipe diameter, the dimensions of the well. If the flow required is 10 m^3/min. The water surface elevation is 252 m, river bed elevation is 249 m.

Note: Use 2 units. Flow velocity (entrance to the strainer) = 0.15 m/s, gross area of strainer = twice effective area. Velocity in gravity pipe =1.5 m/s. Use Q for the washing pipe = 1/3 Q for the gravity pipe. Velocity = 3m/s. Detention time in the well = 20 min. Use cylindrical well.

Strainer

$Q = Q_t / 2 = 10/2 = 5\ m^3/min$

Flow velocity (entrance to the strainer) = 0.15 m/s

$A = Q/v = 5/(0.15*60) = 0.55\ m^2$ = Effective area

Gross area = $0.55*2 = 1.1\ m^2$

Strainer area = $\pi.d.h$

Strainer diameter = $1.1/(\pi*0.6) = 0.6$ m

Gravity pipe

$v = 1.5$ m/s

Gross sectional area = $1.67/(3*60) = 0.009\ m^2$, Pipe diameter = $(4*0.009/\pi)^{0.5} = 0.11$ m

Size of the well

Detention time = 20 min

Effective volume = Q *time = 5*20 = $100\ m^3$

Effective well depth = 252 - 249 + (1-0.6) = 3.4 m

Cylindrical well

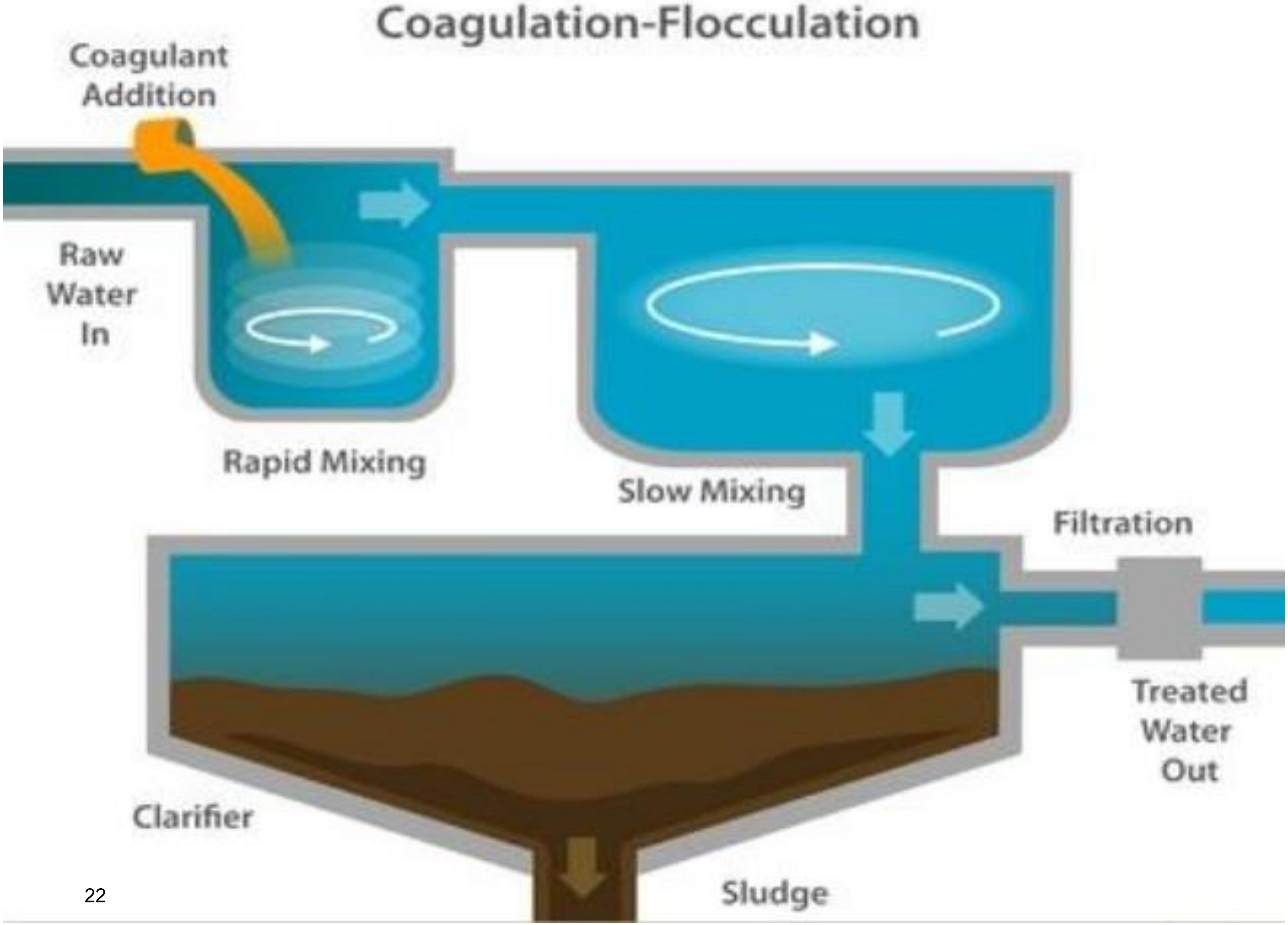
Effective volume = area* effective depth

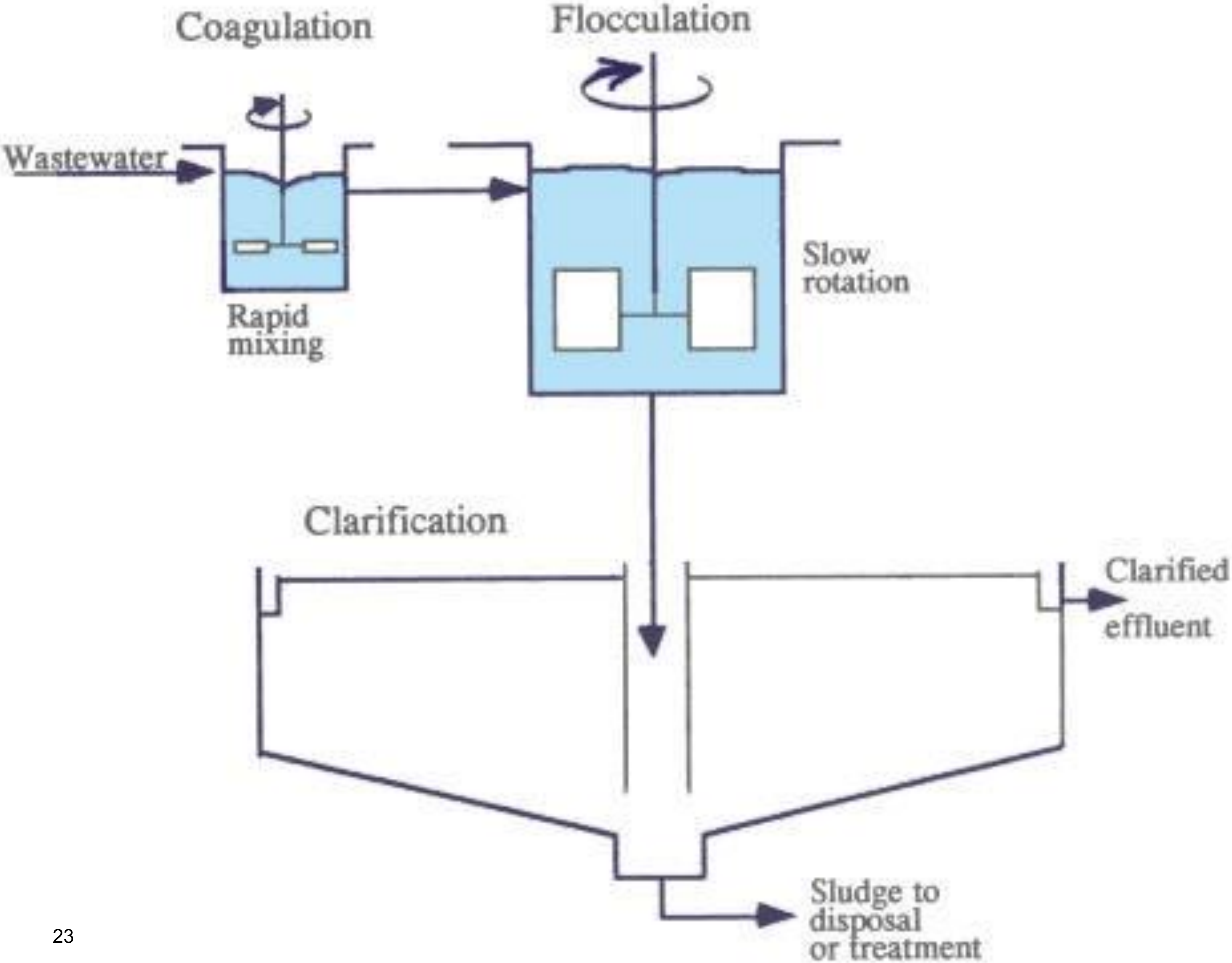
Area (sectional area) = 100/3.4 = $29.4\ m^2$

Well diameter = $(4*29.4/\pi)^{0.5} = 6.1$ m

Rapid mix

- Rapid mix, or flash mix or quick mix is the process by which a **coagulant** is rapidly and uniformly dispersed through the mass of the water.
- The process usually occurs in a small basin called '**coagulation basin**'.
- This process is used to generate a homogeneous mixture of raw water and coagulants which result in the **destabilization** of the colloidal particles in the raw water to **enable coagulation**.
- Mixing is provided by pumps, venture flumes, air jets or rotating **impellers** (paddles, turbines, or propellers).


Coagulation-Flocculation
Coagulant Addition
Raw Water In
Rapid Mixing
Slow Mixing
Filtration
Treated Water Out
Clarifier
Sludge



Coagulation
Flocculation
Wastewater
Slow rotation
Rapid mixing
Clarification
Clarified effluent
Sludge to disposal or treatment

Mixing types

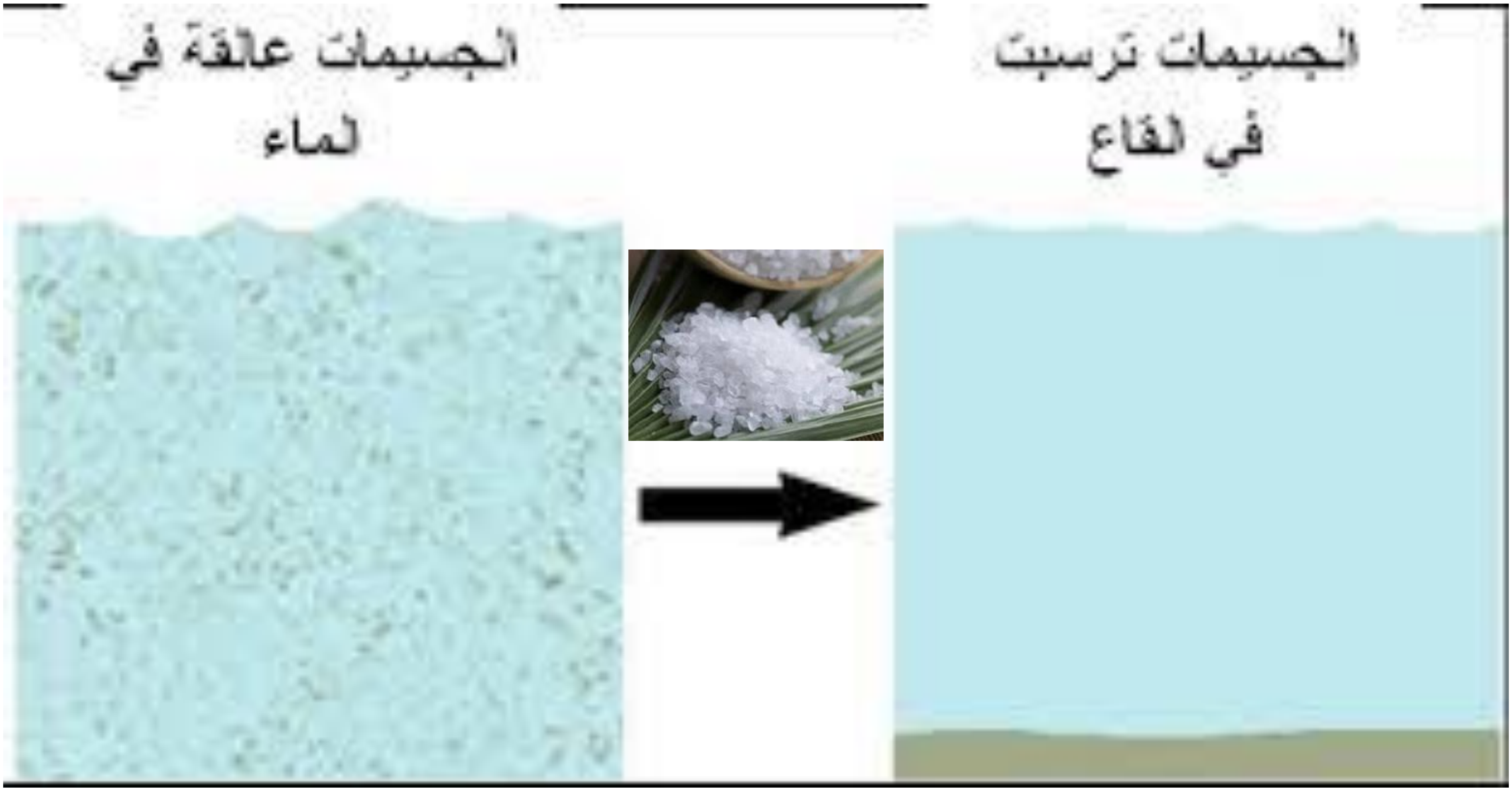
- Hydraulic mixing: such as Baffle mixing, mixing using obstacles. Head loss between 0.5- 1m.
- Air mixing: by using compressed air, at the same time of mixing oxygen react with iron (Fe^{+2}) and Manganese (Mn^{+2}) pollutants that exist in the raw water.
- Mechanical mixing: use propellers, turbines paddles. It is more efficient than other mixing type.

Design parameters

- Detention time: 30- 60 sec
- Basin dimensions: 3 – 10 ft
- Mixing intensity: 700- 100 1/sec
- Power: 0.25 – 1.0 hp/MGD

Coagulation

- Coagulation is the widely used process to **remove** the substances producing turbidity in water.
- Coagulation is a **chemical process** in which particle charge is satisfied while flocculation is a **physical process** which agglomerates particles that are too small for gravity settling so that they may be successfully removed during the process.
- Coarser components oved from water by plain sedimentation in tanks having ordinary dimensions.
- So they must be flocculated to produce larger particles that are **settleable**.
- The process of coagulation may find use in the **softening** of hard water with **lime** or lime and **soda ash** and removal of color producing substances such as colloidal metallic hydroxides or organic compounds having a much smaller particle size.


الجسيمات عالقة في
الماء
الجسيمات ترسبت
في القاع

Coagulation treatment depends upon many factors such:

- Water quality
- Water quantity
- Chemical composition of the water
- Temperature
- pH
- ions
- Turbidity
- Type of coagulant
- Detention time

- Coagulation should be carried out within the optimum pH range for the particular water.
- For certain waters it may be necessary to adjust the pH with acid, or lime, or soda ash, etc.
- The selection of type and dosage of the chemical coagulant must be made by experimentation, most commonly with jar tests.
- Commonly used coagulants (table 1) include those which are iron or aluminum-based, lime, and polymers. Aluminum sulfate, commonly known as Alum, is effective for pH values of 5.5 to 8.0.

Table 1: some of commonly used coagulants

Coagulant	Chemical formula	Molecular weight, g/mole
Aluminum sulfate	$Al_2(SO_4)_3 \cdot 14H_2O$	594
Sodium aluminate	$Na_2Al_2O_4$	164
Aluminum chloride	$AlCl_3$	133.5
Polyaluminum chloride	$Al_w(OH)_x(Cl)_y(SO_4)_z$	Variable
Polyaluminum sulfate	$Al_w(OH)_x(Cl)_y(SO_4)_z$	Variable
Polyiron chloride	$Fe_w(OH)_x(Cl)_y(SO_4)_z$	Variable
Ferric chloride	$FeCl_3$	162.5
Ferric sulfate	$Fe_2(SO_4)_3$	400

The reason for using Alum frequently in Iraq

1. Low cost
2. Easy to store (do not oxidize in the air) and transport.
3. Available
4. Can used as solid or fluid
5. Keep its properties over time

Coagulants shape

- Dry feeding: powder or grains
- Wet feeding : liquid

Jar test

This test represents coagulation and flocculation processes but in small scale. It is used to find the **optimum dose**. It is divided into three steps:

- Rapid mix (1- 2 minutes) the coagulation process starts.
- Slow mix (20 minutes) the flocculation process starts
- Settling Without mixing (30 -40 minutes) to settle the flocs.
- Then measuring the water turbidity and draw a chart then find the optimum dose of coagulant.

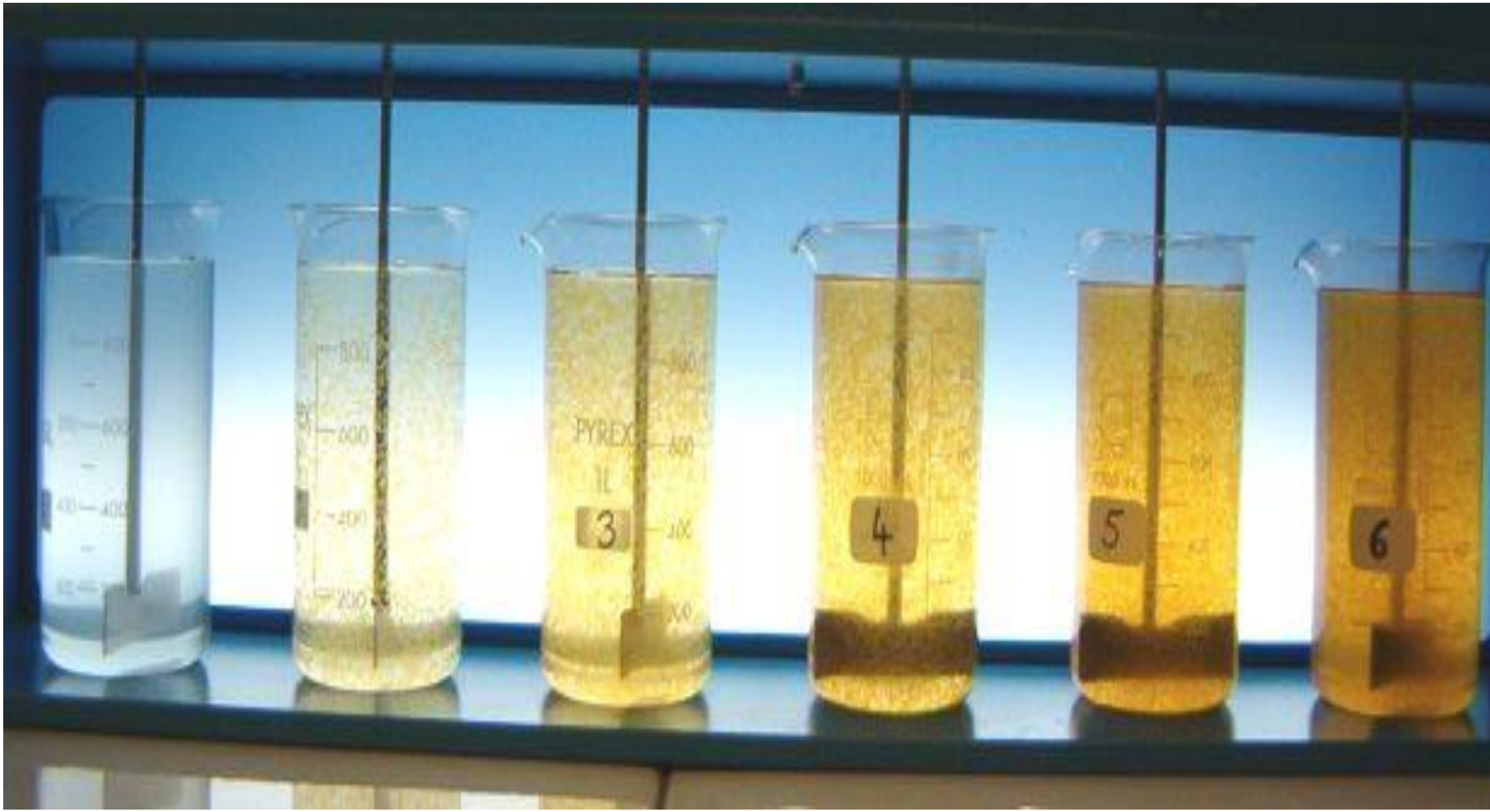
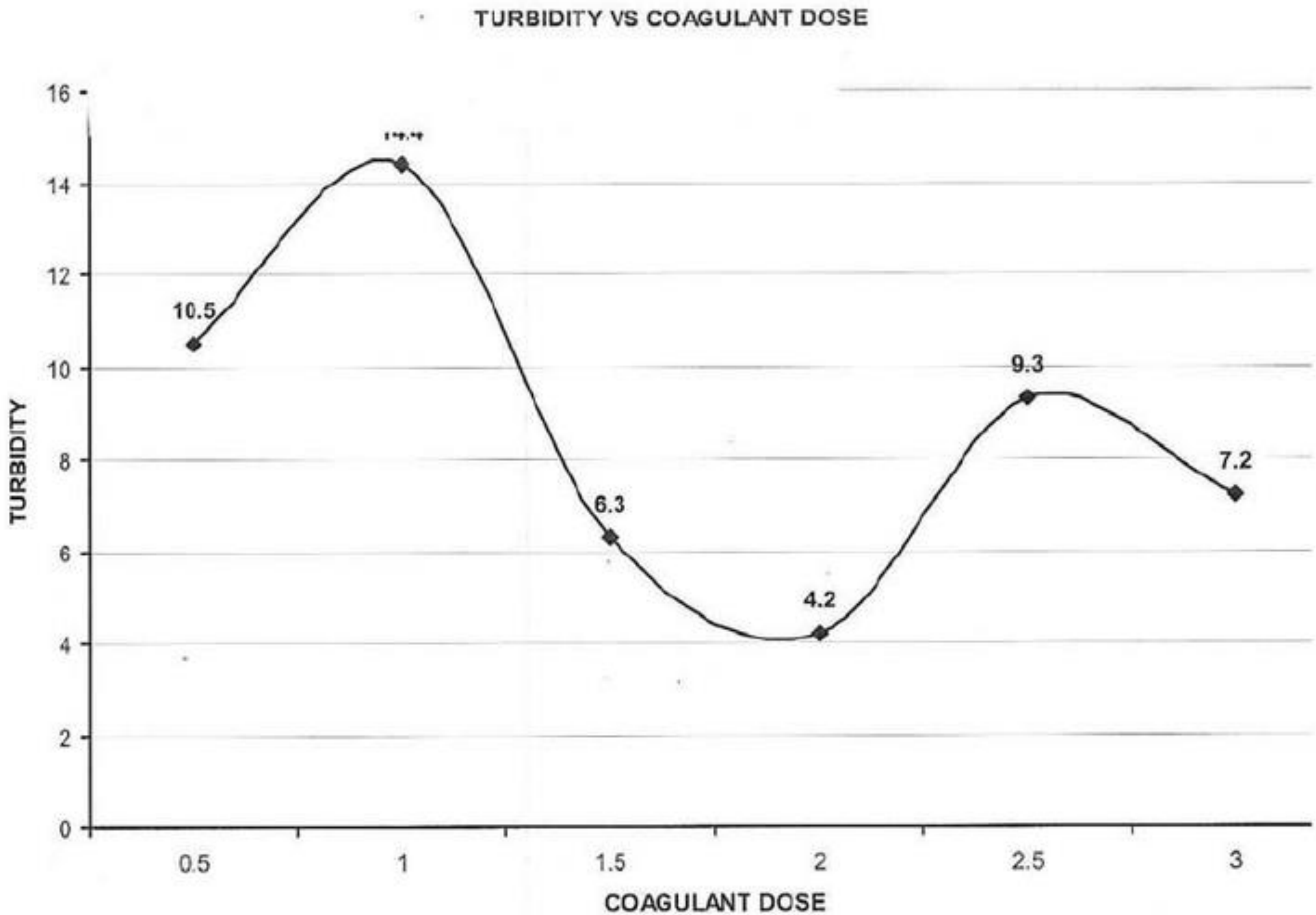


Figure 1: Jar test device


TURBIDITY VS COAGULANT DOSE
16
14
12
10
8
6
4
2
0
TURBIDITY
10.5
6.3
4.2
9.3
7.2
0.5
1
1.5
2
2.5
3
COAGULANT DOSE

Example: Find the quantity of alum used per day. The dose of alum = 5 mg/l and Q =100 m^3/day.

Total quantity = Q* dose

=100 /day = 0.5 kg/day

Example: Find out the quantity of alum required to treat 18 million liters of water per day. The dosage of alum is 14 mg/L. also work out the amount of CO_2 released per liter of treated water.

Solution:

Quantity of alum/day = 14*18 = 252 kg

The chemical reaction is as follows:

$Al_2(SO_4)_3.18H_2O + 3Ca(HCO_3)_2 \longrightarrow 2Al(OH)_3 + 3CaSO_4 + 18H_2O + 6CO_2$

Molecular wt. of Alum = 2* 27+3(32+16*4) + 18(1*2+16) = 666 g/mol

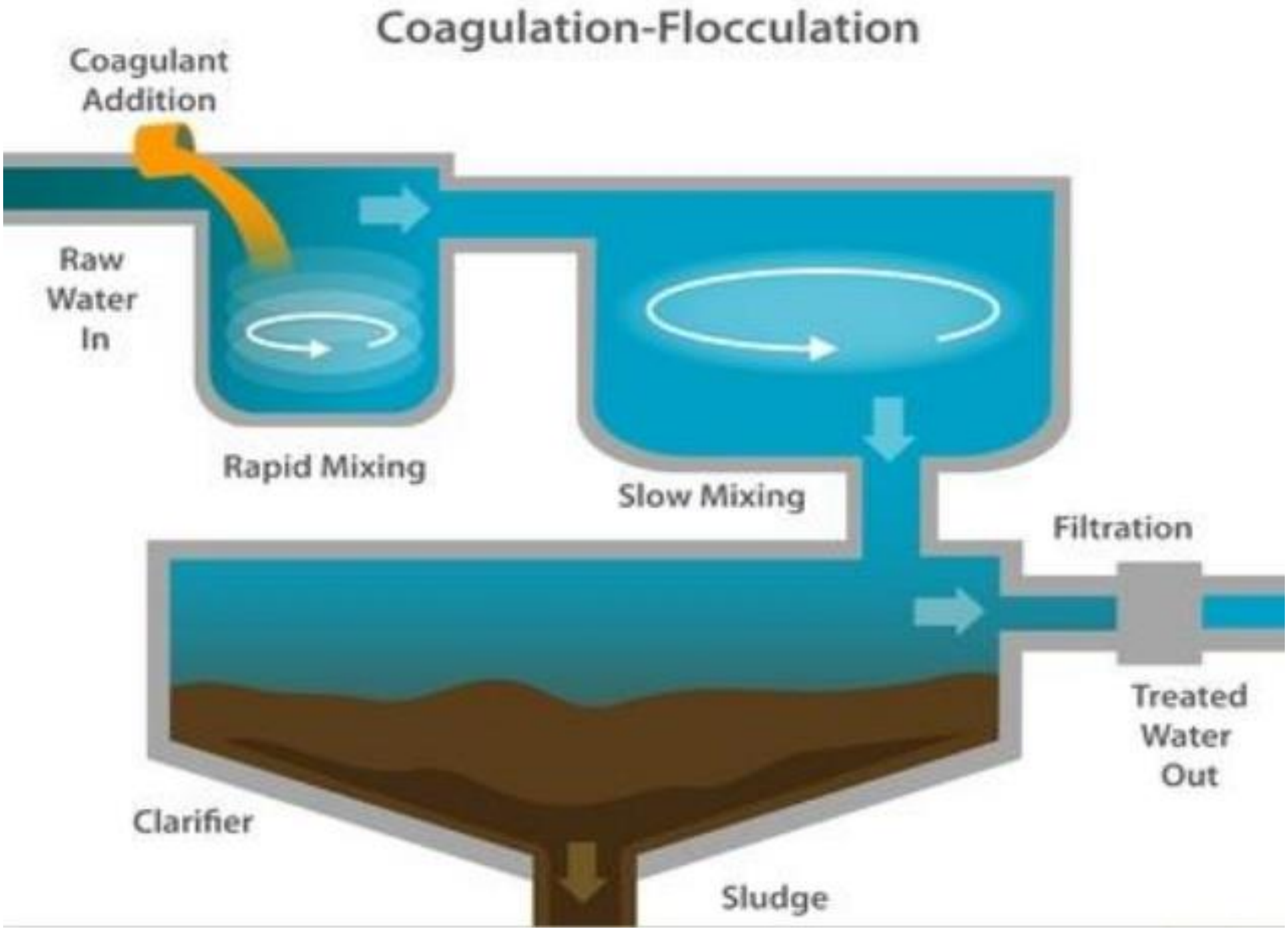
Molecular wt. of CO_2 = (1*12)+(2*16) = 44 g/mol

666 mg of alum release 6*44 mg of CO_2

The amount carbon dioxide would release per day = (6*44/666)* 252 = 100.8 kg of CO_2/day

Flocculation

- During flocculation, slow-moving paddle mixers gently stir a mixture of water and coagulant to generate floc.
- The common mechanical mixing devices are paddle flocculators, flat-bed turbines, and vertical-turbine mixers.
- These mixing devices are shown in next figure. Flocculation chamber is built as close to sedimentation tank as possible.


Coagulation-Flocculation
Coagulant Addition
Raw Water In
Rapid Mixing
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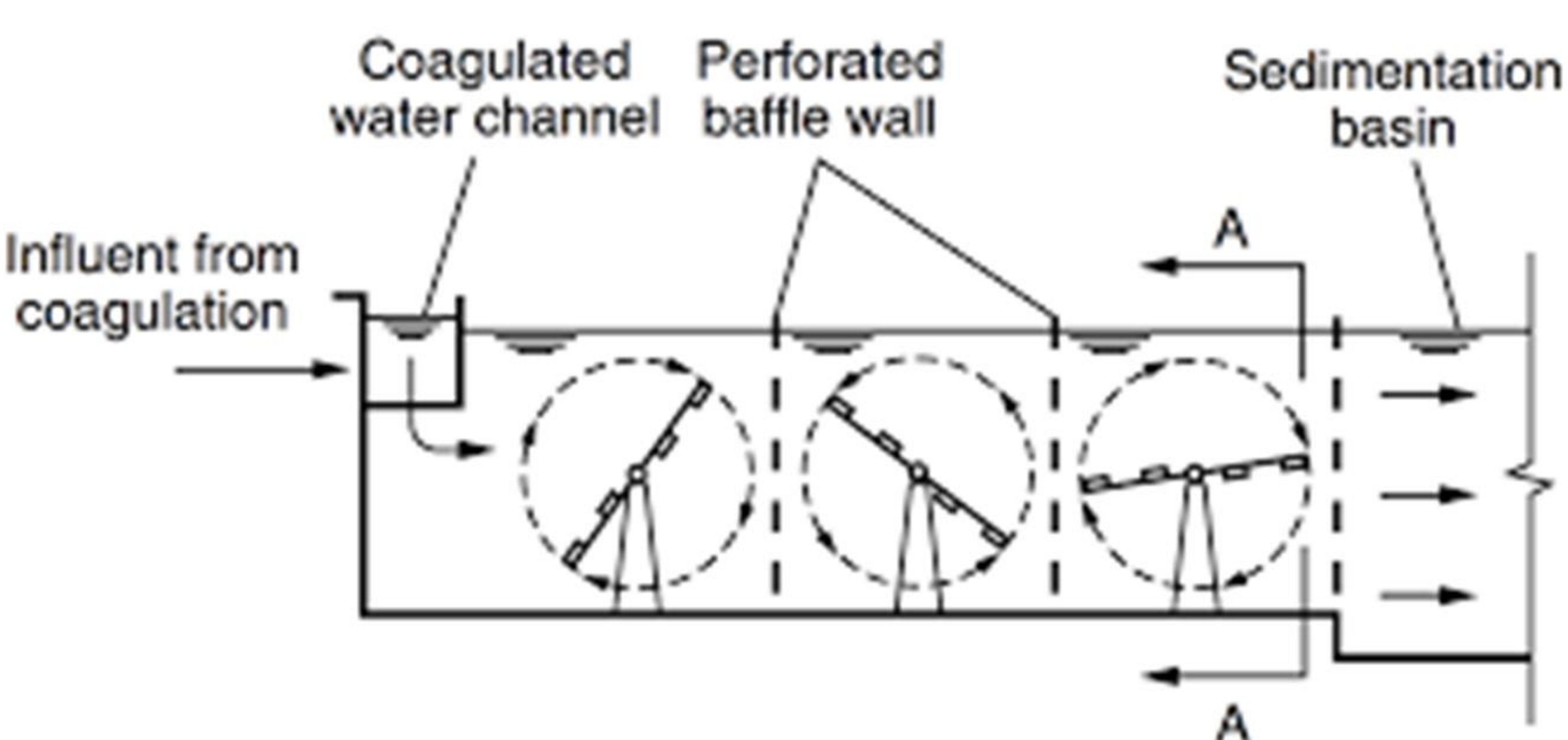
Filtration
Treated Water Out
Clarifier
Sludge

Type of flocculator:

- Mechanical flocculator; horizontal or vertical
- Hydraulic flocculator



Design criteria

Detention time (20-30) minutes

Velocity gradient G (20 -50) 1/sec; $G = \sqrt{\frac{P}{\mu.V}}$

GT =G.T; 20,000 - 200,000

- P: power input (watt); watt = r density (1000 kg/ m^3)
- A: total area of paddles
- V: floccualtor volume (m^3)

- μ: dynamic viscosity ($N.s/m^2$), ($Pa \cdot s$);

if not mentions in the question use ($1.312 * 10^{-3}$ $N.s/m^2$)

- r: effective radius (m)
- n: rpm
- v: relative velocity (v)

= absolute velocity (vi) - velocity of water in paddles

$v = (1-k) * 2\pi.r.n/60$

$vi = 2\pi.r.n/60$

- k: relative velocity between water and abs velocity of paddles

= velocity of water in paddles/ abs velocity (vi)

Example 1: For a flocculator tank, the following data are given: Q =300 m^3/min, D.T. =20 min, P =2KW/unit of flow, L= 3D, W =2D, D =depth of the tank, v=75% vi peddles, ρ =1000 kg/m^3, Cd =1.2, find:

1. L, W, D of the flocculator tank.
2. Total area of paddles knowing that three rows are used in this flocculator along its length and the area for one row is 10% W.D.
3. RPM of the paddles in flocculation tank. Use r = 4.5 m

Solution:

Volume = Q*D.T. =300*20 = 6000 m^3

Volume = L.W.D = 3D. 2D.D= 6D^3; D =10 m; w = 20 m; L =30m

Area of one raw of paddles is equal to W* P=2kw for each unit of flow

P_{total}= 2*300 = 600 kw = 600,000 watt

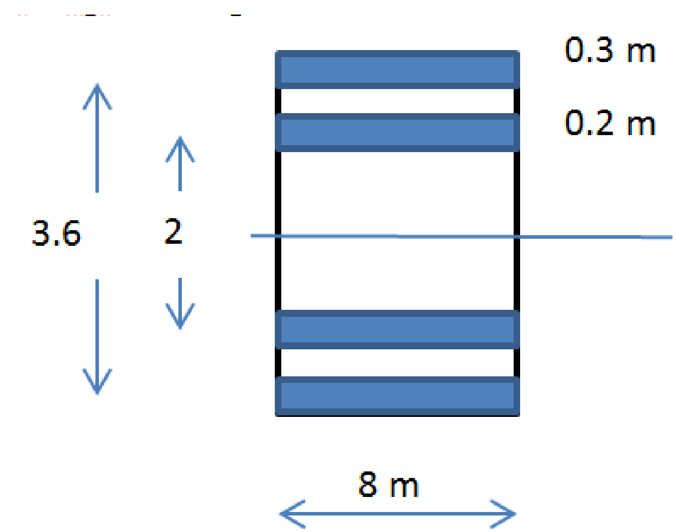
v= 2.56 m/s

v =0.75*vi; vi = 3.413 m/s

vi =2π.r.n/60; r = 4.5 m

n=7.24 rpm

Example 2: A flocculator with L=8m, w =10m, depth =6m and designed with one rotating paddle of blades as shown in figure below. Knowing that D.T. =20 min and cd =1.2, μ =1.3 cp, rpm =2, ρ =1000 kg/m^3, v =0.75*vi, find: (1 *cp* = 10^{-3} Pa·s = 1 mPa·s) (cp= centipoise). Power input in N.m/sec; G in 1/s



Solution:

$P= 0.5* Cd.\rho.A.v^3$

There are two blades

$A_1= 0.3*8*2= 4.8\ m^2$

$A_2=0.2*8*2 =3.2\ m^2$

$r_1= 3.6/2 =1.8$ m; $r_2= 2/2=1$ m

vi =2π.r.n/60

vi1= 2*3.14*2*1.8/60 =0.377 m/s

vi2= 2*3.14*2*1/60 = 0.21 m/s

v = 0.75 vi, vi = vp

$v_1=0.75*0.377 = 0.282$ m/s

$v_2=0.75*0.21 =0.157$ m/s

$p =0.5*1.2* 1000* (A_1.v_1^3+A_2.v_2^3) = 72$ N.m/sec

$G = \sqrt{\frac{P}{\mu.V}} = (72/ (1.3*10^{-3})*(10*8*6))^{0.5} = 10.74\ s^{-1}$

Not in range (20 – 50) sec^{-1} then not ok.

Example 3: A flocculator tank is designed to treat 1 m^3/sec have a length 30 m and 12 m width and 4.5 m depth, it is equipped with paddles 0.3m width and 12m length, which are set in pins on four shafts rotation =2.5 rpm. The shafts are at the mid depth of the tank and the distance from the half to the center line of paddle is 2 ity =1.312* 10^{-3} N.s/ m^2, find: detention time, power input, G and G.T.

Solution:

Volume= 30*12*4.5 =1620 m^3
D.T.= Vol./Q =1620/ 1 =1620 sec = 27 min
P= 0.5* Cd.ρ.A.v^3
If Cd is not mention in the question use 1.8
No. of paddles = 2*4 =8 paddles
A total = area of one paddle* no. of paddles = 0.3*12*8 =28.8 m^2 1000 *28.8*$(0.392)^3$ = 1561.3 watt

$G = \sqrt{\frac{P}{\mu.V}}$ =27.1 sec^{-1} , G =20-50 sec^{-1} ; then ok
G.T = G. D.T =27.1* 1620 = 4.3902 * 10^4; GT = (2* 10^4-2*10^5); then ok