Drinking Water Treatment

El-Hassan A. El-Sadek

2018

Agenda

This Presentation will cover :

- Water in Egypt
  - Multiple Barrier Approach
  - Current situation of water in Egypt
- Drinking Water Treatment Process

Drinking Water in Egypt

Do You Know...????

How long can humans live without water?

We can live 30+ days without food, but **only 4-7 days** without water

How much of the human body is made of water?

The human body is about **60%** water

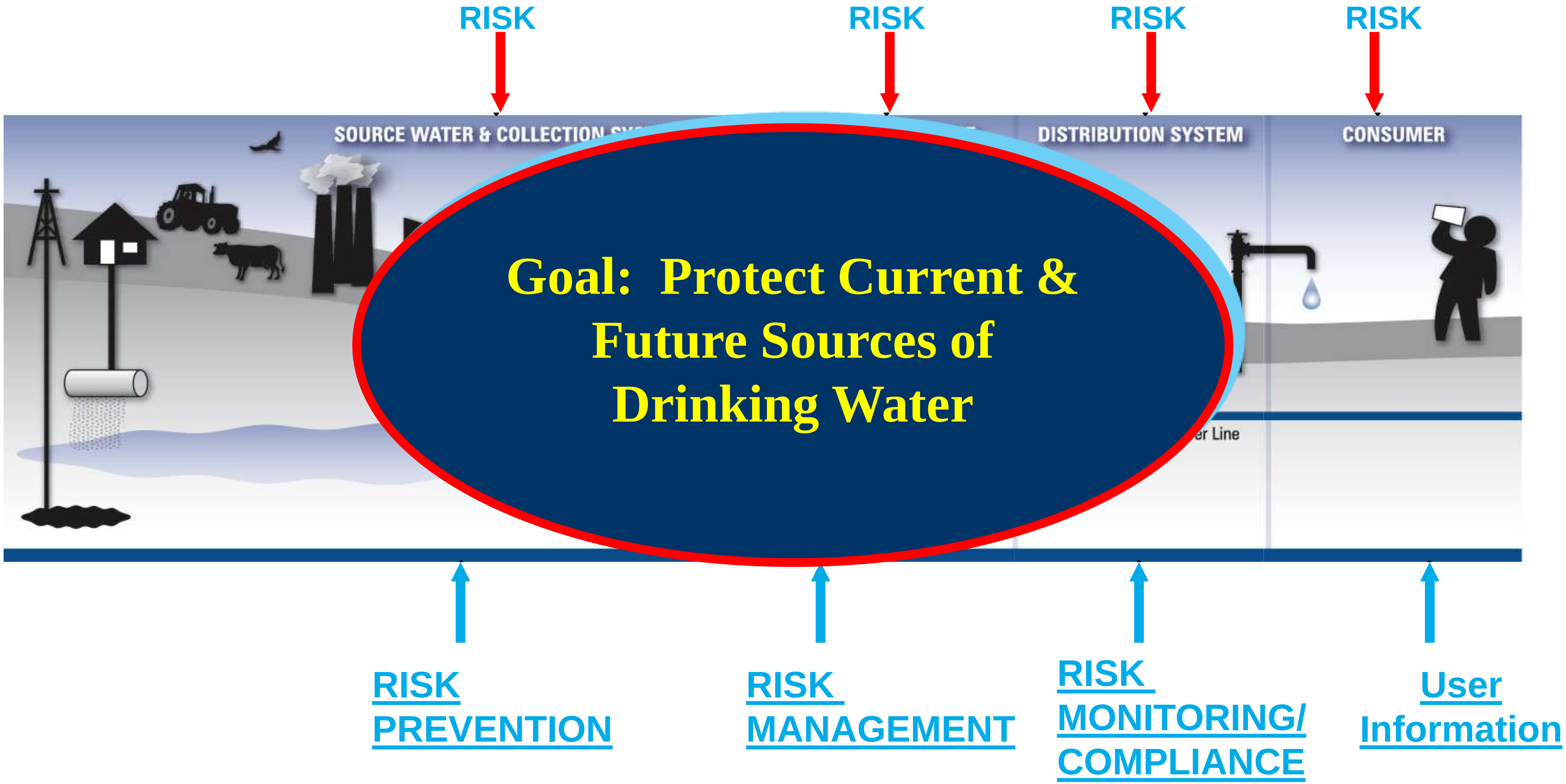
How much water should humans drink each day?

We must drink at least **6-8 glasses** of water each day

Multiple Barrier Approach

??

Multiple Barrier Approach to Public Health Protection



منظومة مراقبة جودة مياه الشرب بالجمهورية

منظومة جودة مياه الشرب على مستوى شركات المياه

Water shortage in Egypt

- The current water shortage in Egypt is 13.5 Billion cubic meter per year (BCM/yr) and is expected to continuously increase.

- water shortage in 2025 would be 26 BCM/yr in case of continuation of current policies.

Source Water + Treatment =

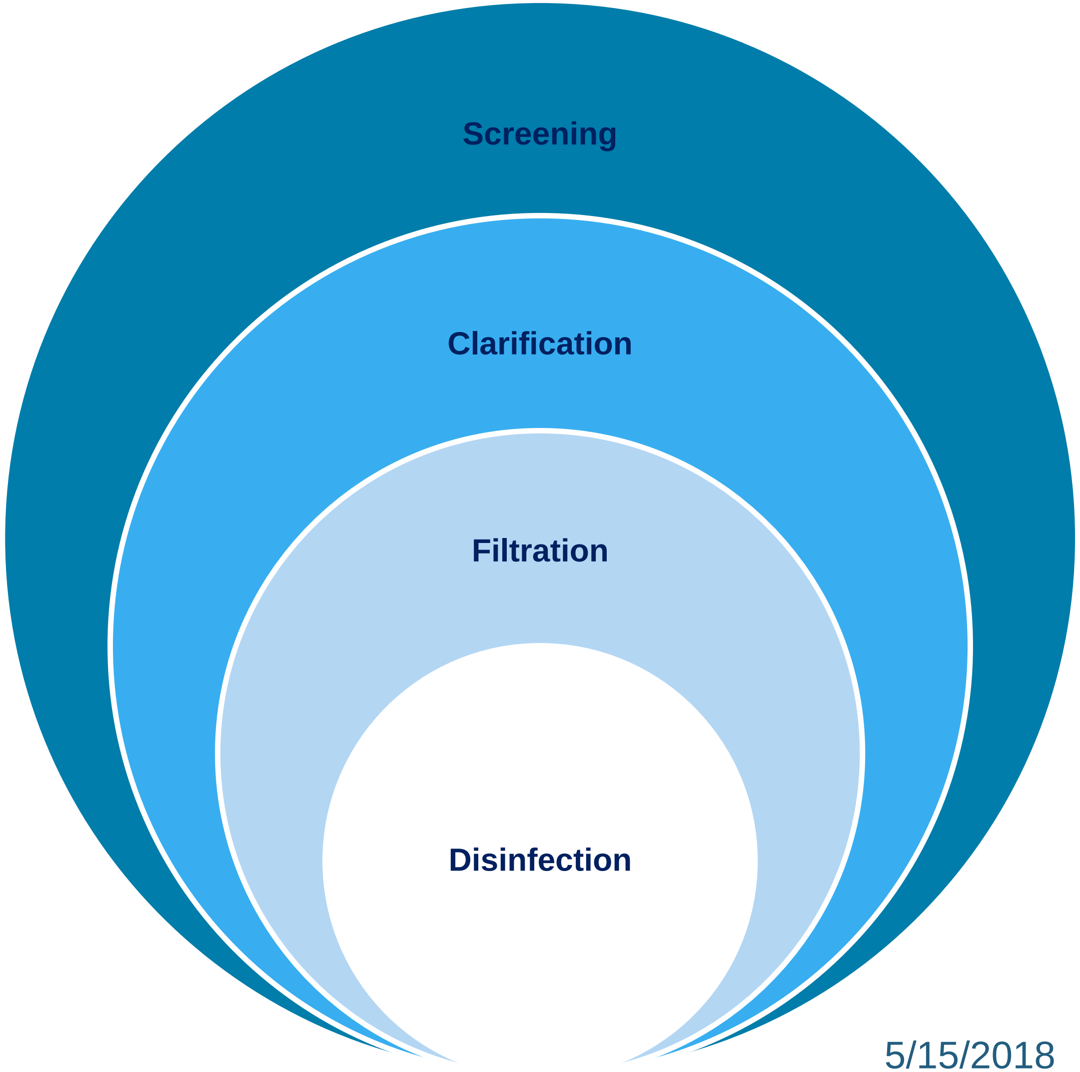
Contaminants:
Particles (clay, silt)
Natural organic matter
Microcontaminants
(e.g., pharmaceuticals)
Bacteria , Protozoa.

Tap Water

Water Treatment Process

Water Teratment Process

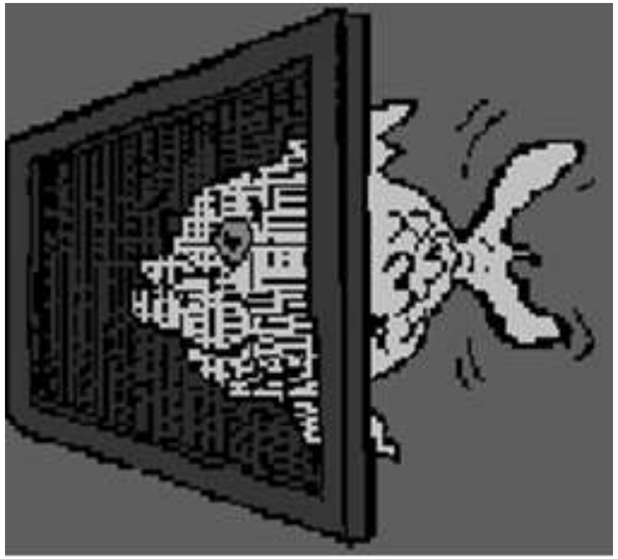
1. Screening (المأخذ) الفحص
2. Clarification الترويق
3. Filtration الترشيح
4. Disinfection التطهير



Screening

Screening

- Removes large solids
  - logs
  - branches
  - rags
  - fish



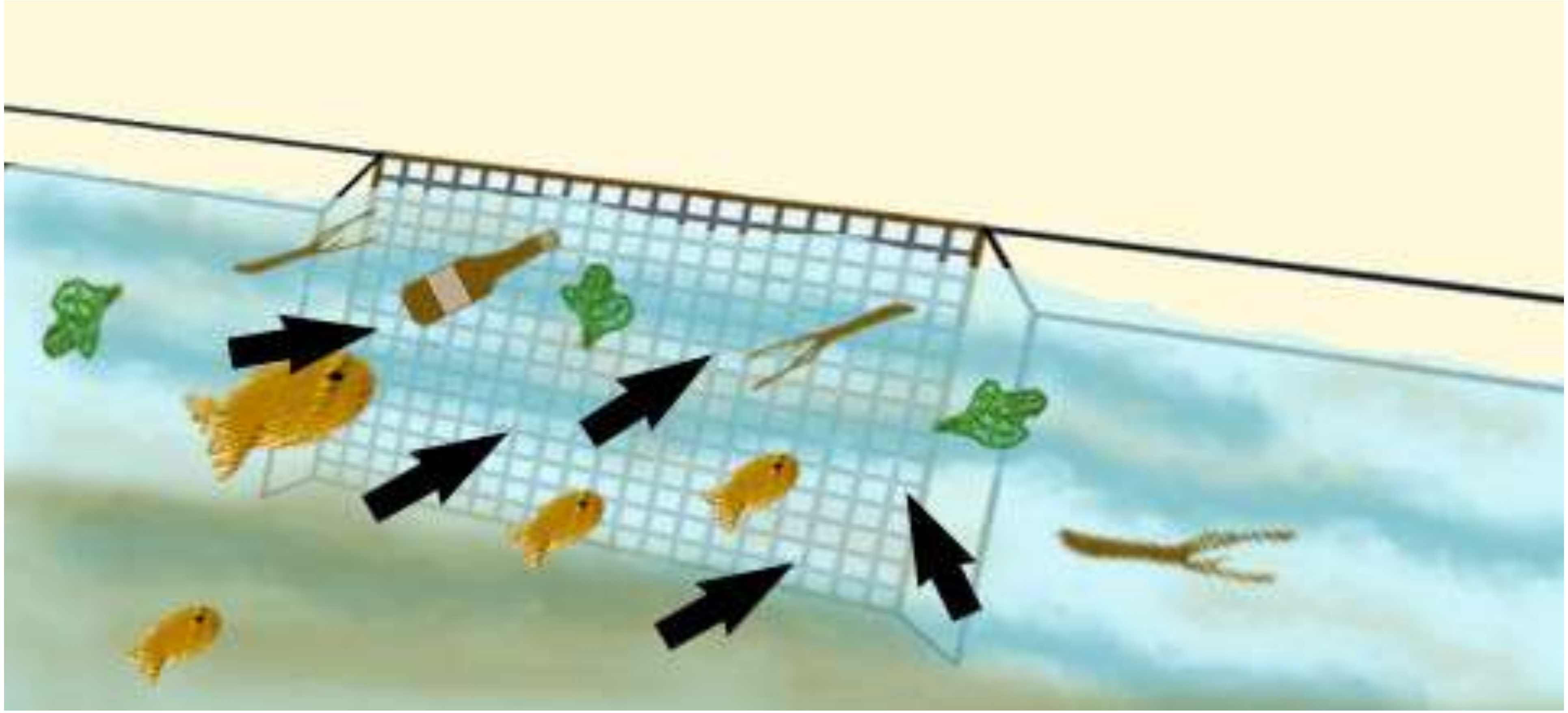
- Protects pumps and pipes in WTP

Screening

- Screens should be easily removable or have automatic cleaning devices

- Steel or metal screens should be corrosion resistant.

-Screening (Manual)



-Screening (Automatic)


ecomacchine

عنبر طلمبات رفع المياه الخام (النيل)

Maintenance of Screens

1. Clean and validity of screens
2. Clogging and corrosion are biggest problem
3. All screens must be inspected
4. Periodic maintains of pumps

Clarification

Do You Know...????

من اين تأتى عكارة المياه ؟

Nature of Particles:

Particles in water are a result of :

- soil
- decay of plant material
- industrial contamination
- animal wastes, etc.

Type of Particles

Particles

Particles

NOT Able to perception

غير قابلة للترسب

Particles

Able to perception

قابلة للترسب

قابلية ترسيب الجسيمات في المياه

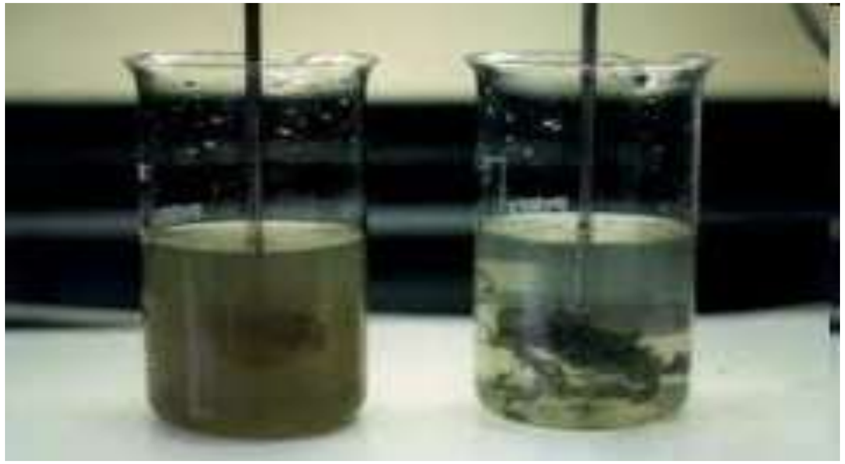
قطر الحبيبات (مم)	النوع	زمن الترسيب *	القابلية للترسيب
10	حصي	1 ثانية	قابلة
1	رمل	10 ثواني	قابلة
0.1	رمل ناعم	2 دقيقة	قابلة
0.01	طمي / طحالب	2 ساعة	غير قابلة
0.001	بكتريا	8 يوم	غير قابلة
0.0002	مواد غروية	سنتين	غير قابلة
0.00002	فيروسات	20 سنة	غير قابلة

* زمن الترسيب هو القدرة التقريبية للرسوب لمسافة 1 م في المياه تحت تأثير الجاذبية فقط

.

Clarification

Clarification

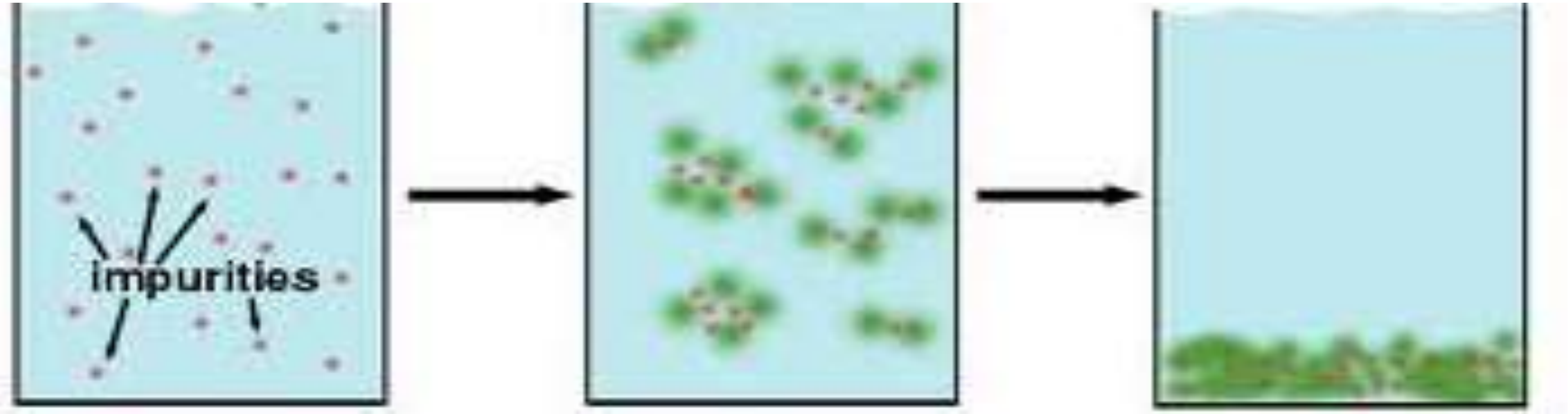


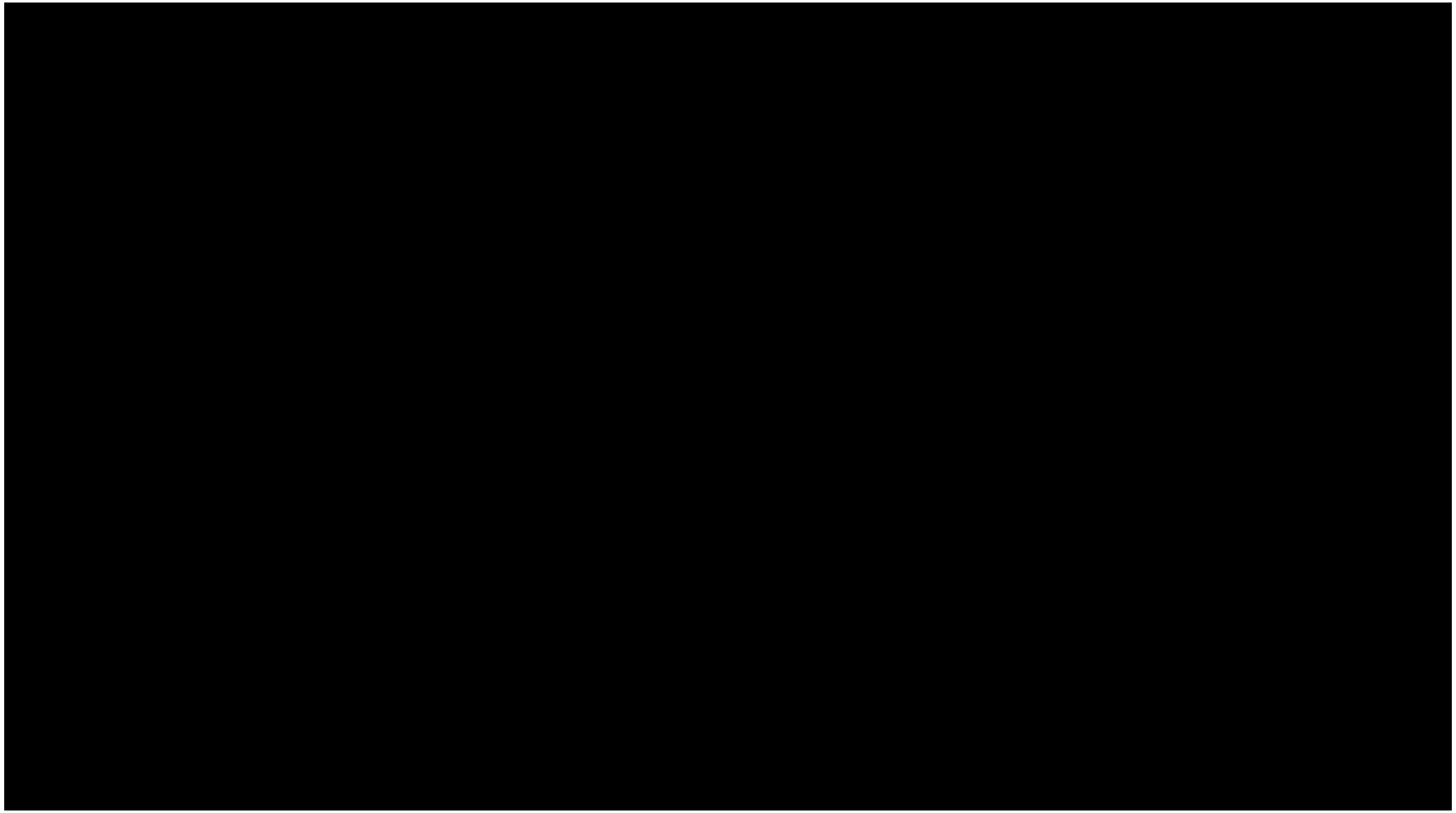
Clarification stages

Coagulation
ترويب

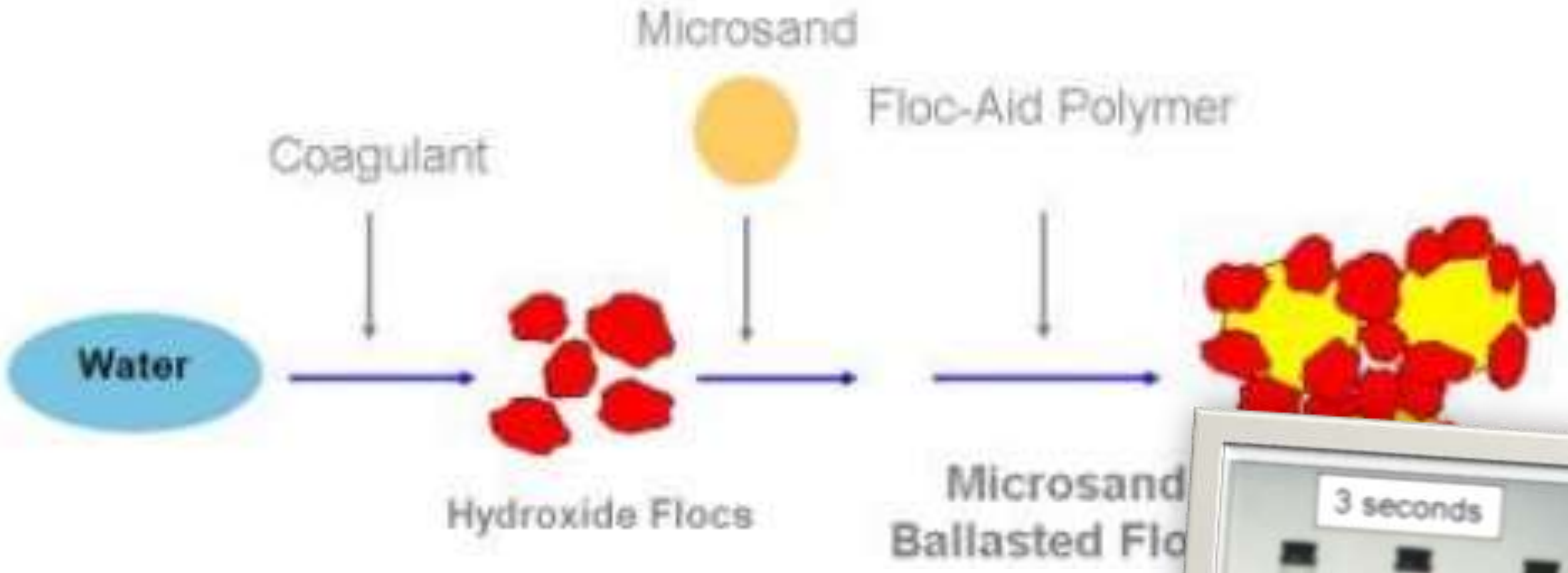
Flocculation
تنديف

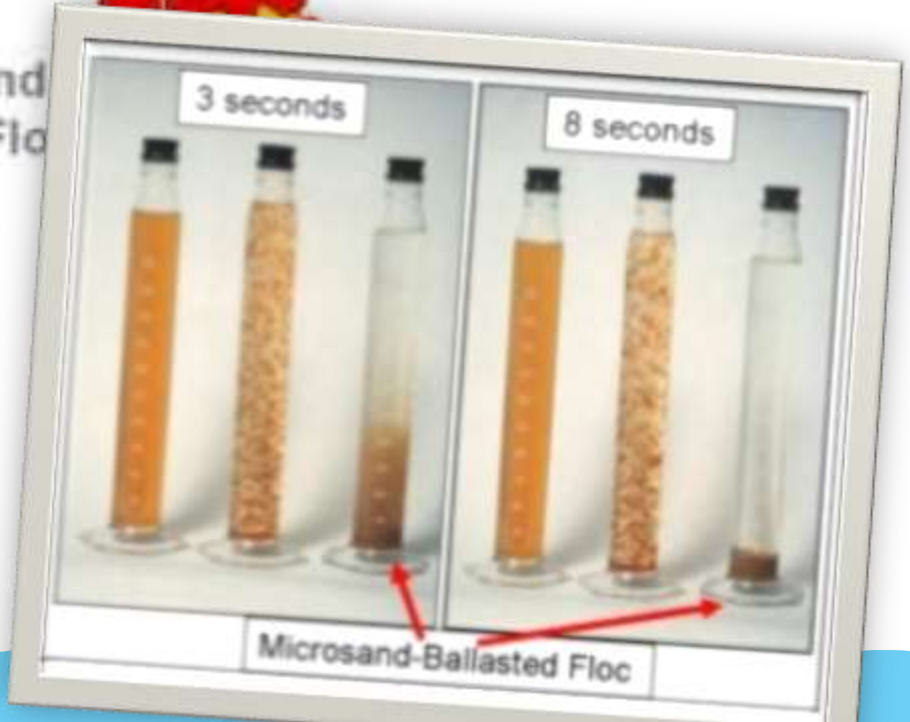
Sedimentation
ترسيب

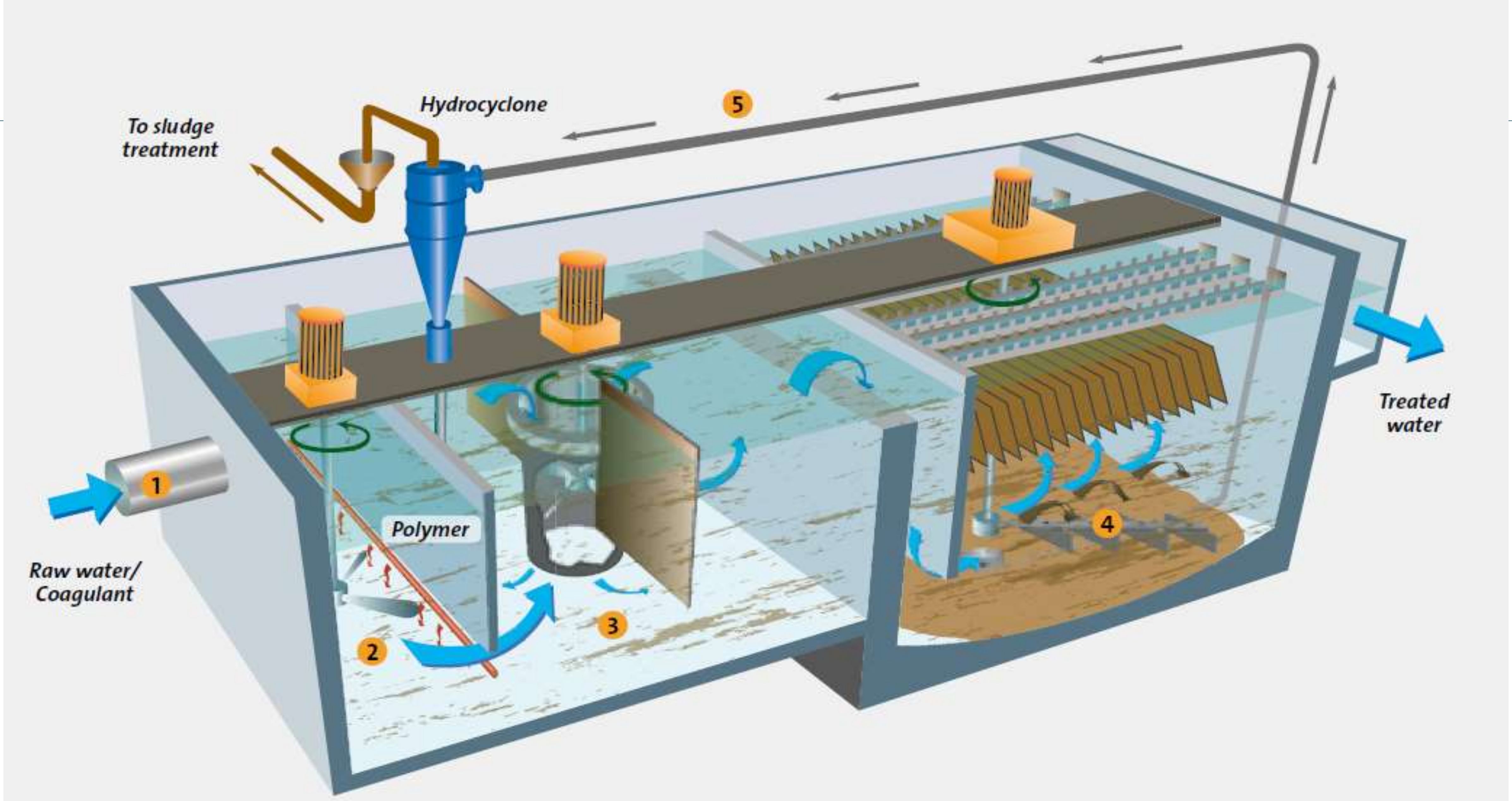




Microsand ballasted technology






Hydrocyclone
To sludge treatment
5
1
Raw water/ Coagulant
Polymer
2
3
4
Treated water

نموذج لشكل المروقات الدائرية

نموذج لشكل المروقات الدائرية

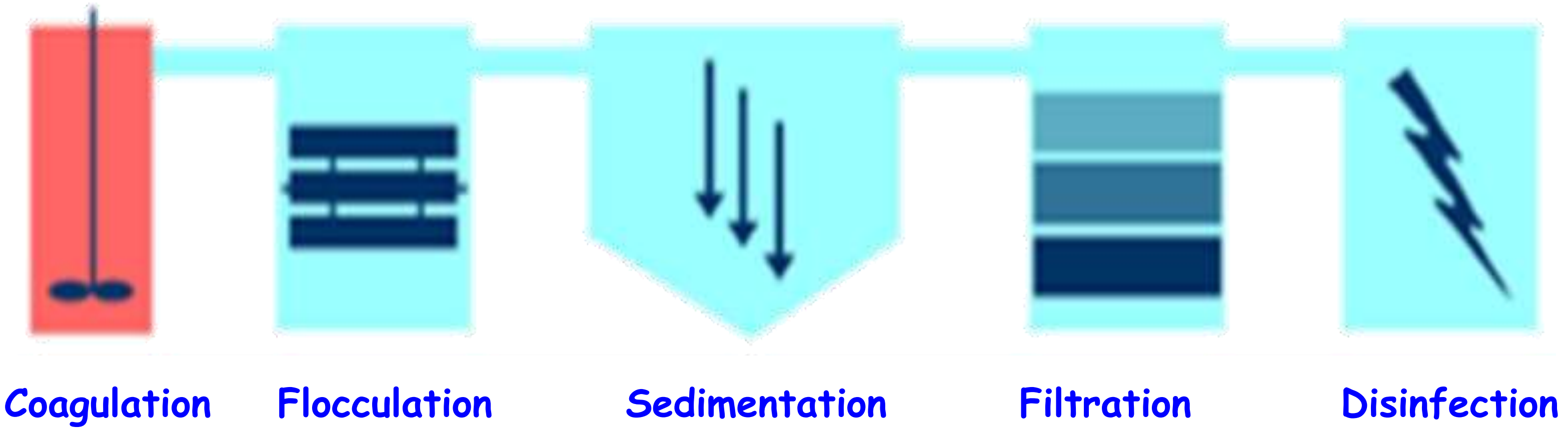
نموذج لشكل المروقات الدائرية

نموذج لشكل المروقات المستطيلة

نموذج لشكل المروقات المستطيلة

Clarification stages

1. Coagulation



Coagulation

- Surface water usually has a lot of suspended and dissolved matter

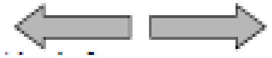
- These solids must be removed to ensure that the water is safe for consumption

- The coag/floc process facilitates the removal of small, suspended and dissolved matter

Natural Forces Between Particles

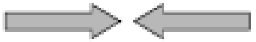
1- Zeta potential

- Preventing force between any two particles of like Charge



2- Van der Waals force

- Attraction force between particles pulling them together



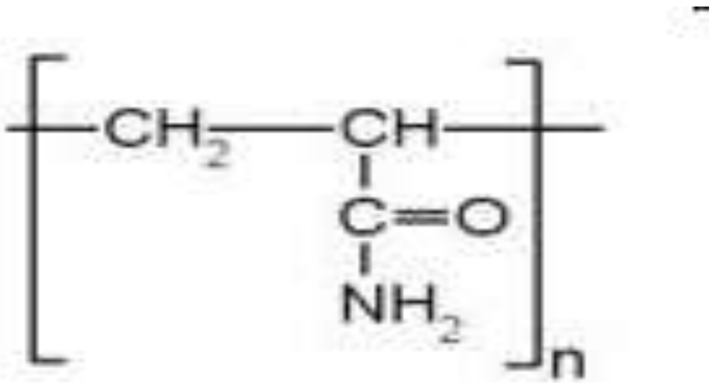
- Particles will stay in suspension :

  zeta potential > van der Waals force

Coagulant agent

Alum

Magnesium chloride



Polyacrylamide

Moringa oleifera

Chemical Feed Equipment

Flash Mixers

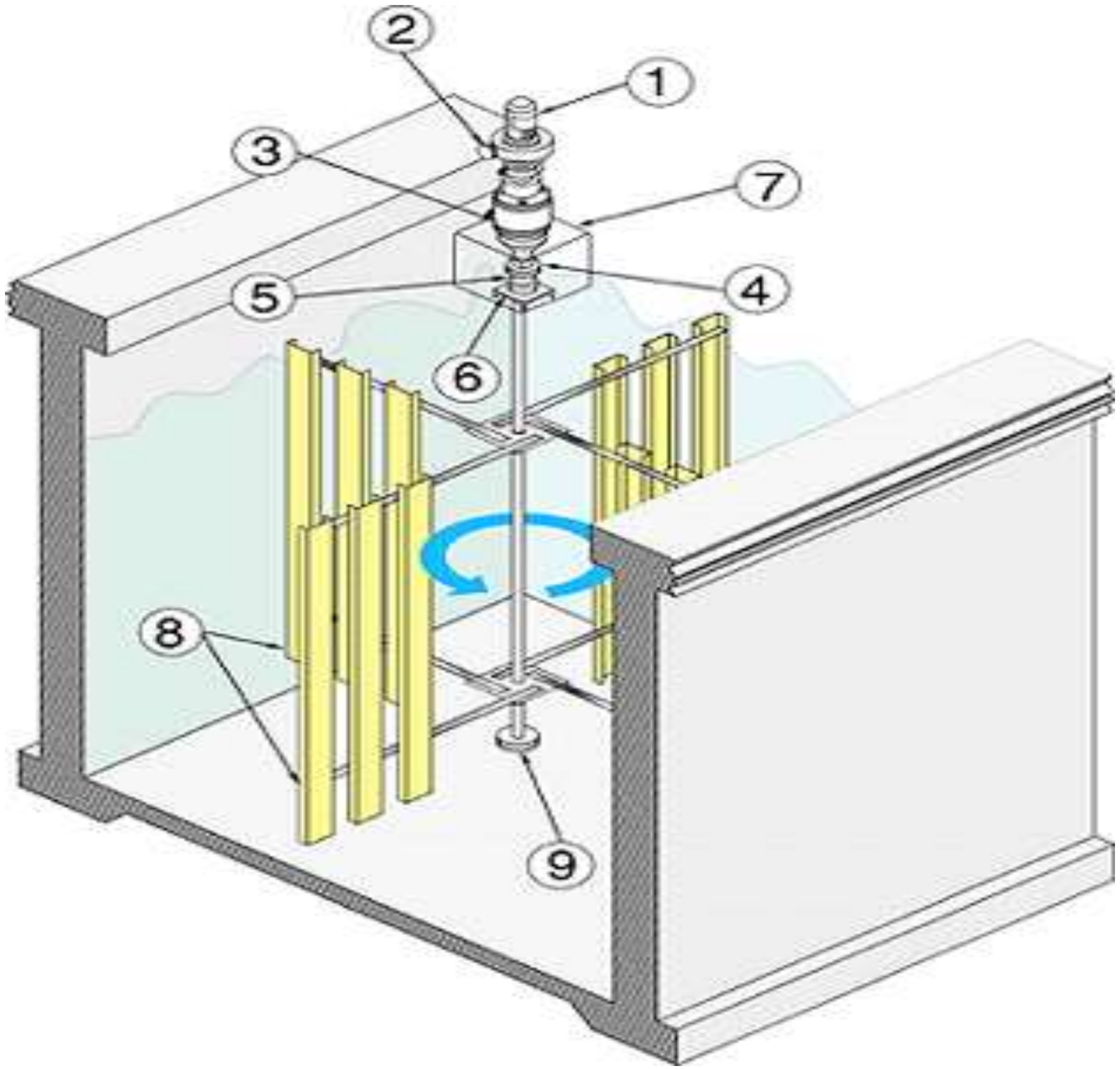
 Provide agitation to evenly mix coagulant through water
 Add chemicals to center of mixing chamber
 Coagulation occurs in less than 1-2 seconds
 This stage determines the success of coagulation
 Detention time should not exceed 30 seconds (Design Criteria)

Flash Mixers

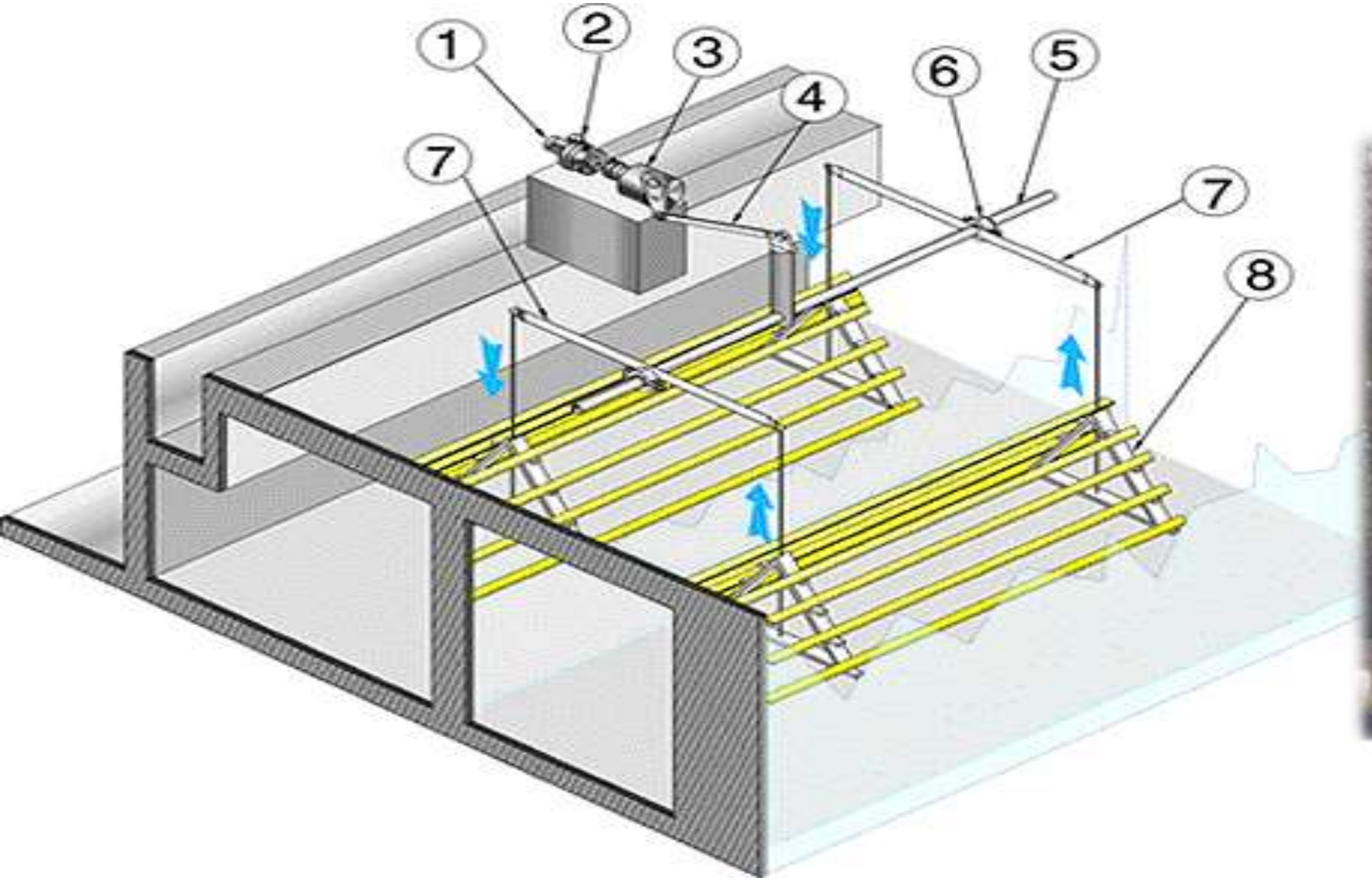
Types of Flash Mixers

- Mechanical mixers
- Static mixers
- Pumps and conduits
- Baffled chambers

Mechanical mixers



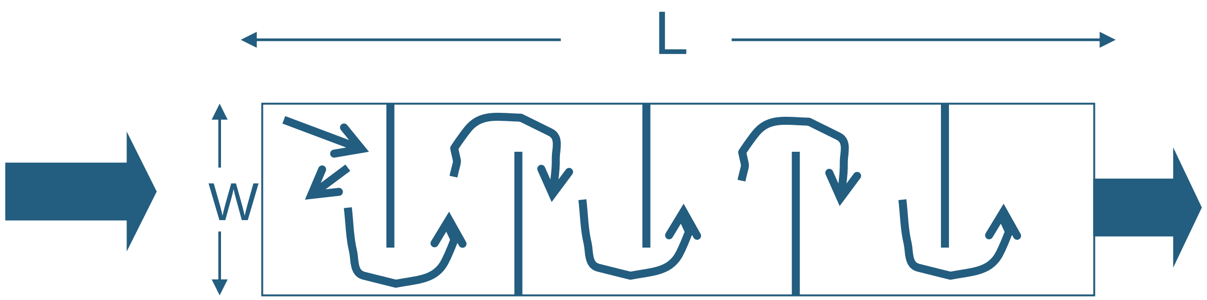
Mechanical mixers



Baffled chambers

- *Horizontally baffled tank*

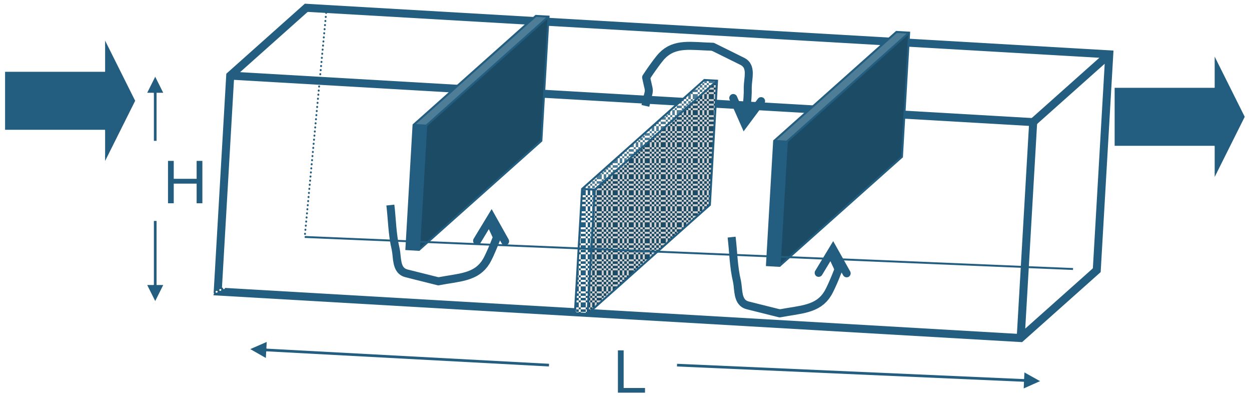
  The water flows horizontally.
  The baffle walls help to create turbulence and thus facilitate mixing



Plan view (horizontal flow)

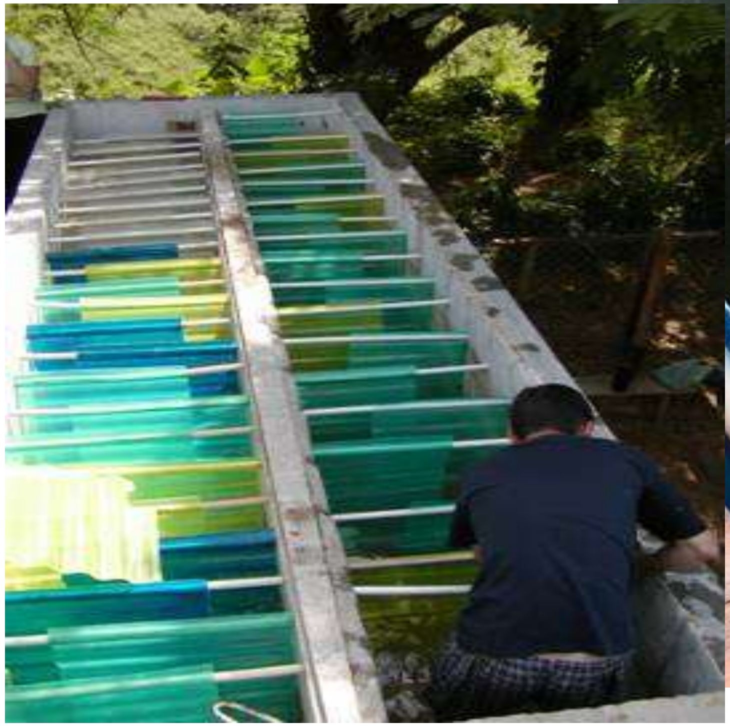
- *Vertically baffled tank*

  The water flows vertically.
  The baffle walls help
  to create turbulence and
  thus facilitate mixing



Isometric View (vertical flow)

Baffled chambers

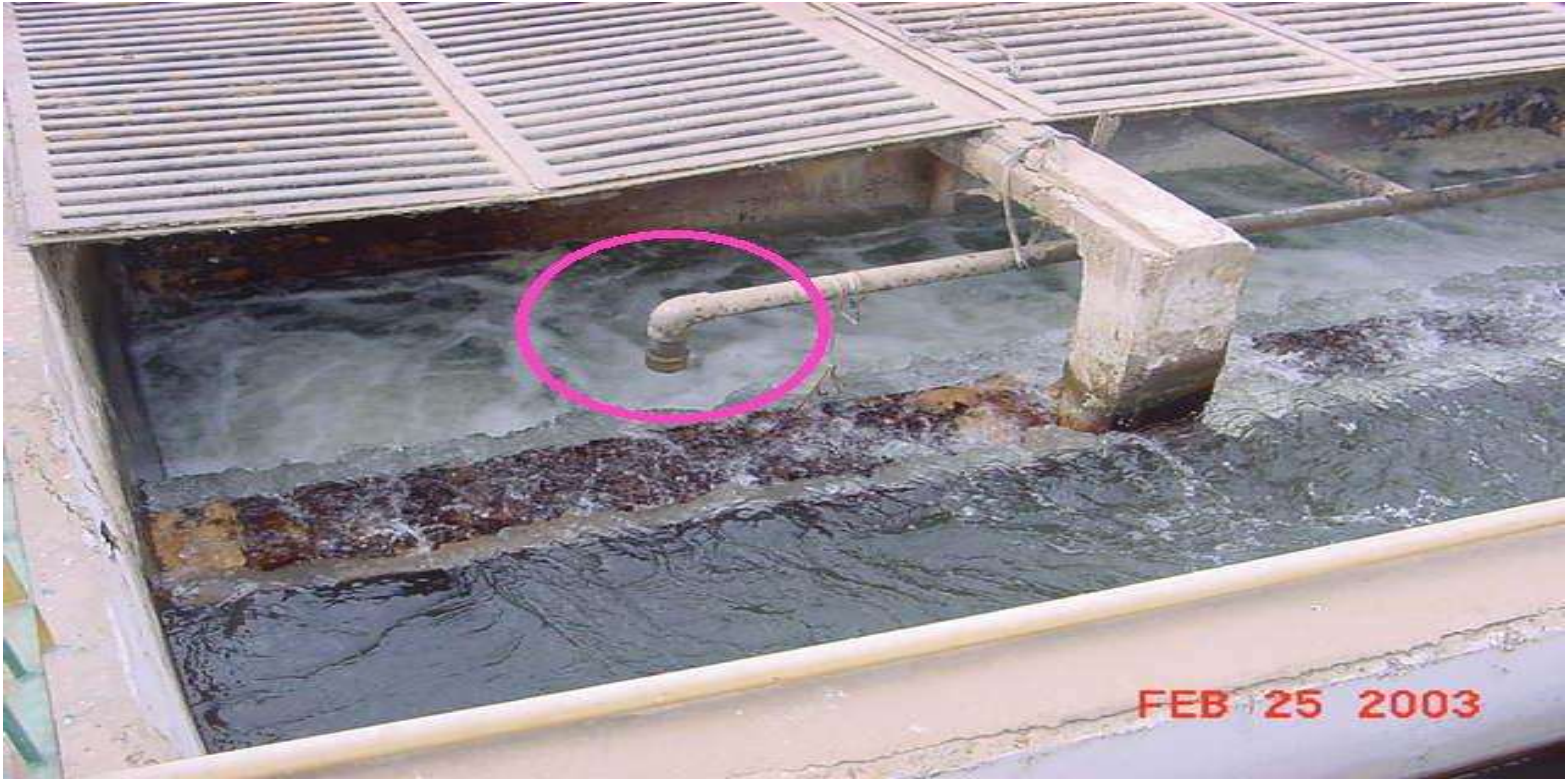



FEB 25 2003


FEB 25 2003

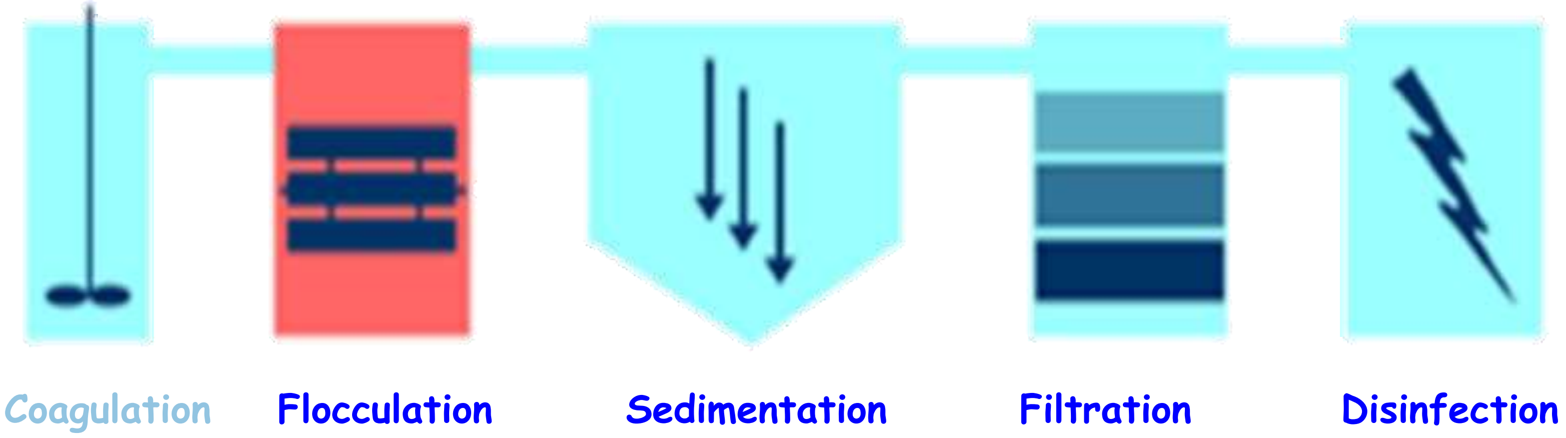

FEB 25 2003


FEB 25 2003

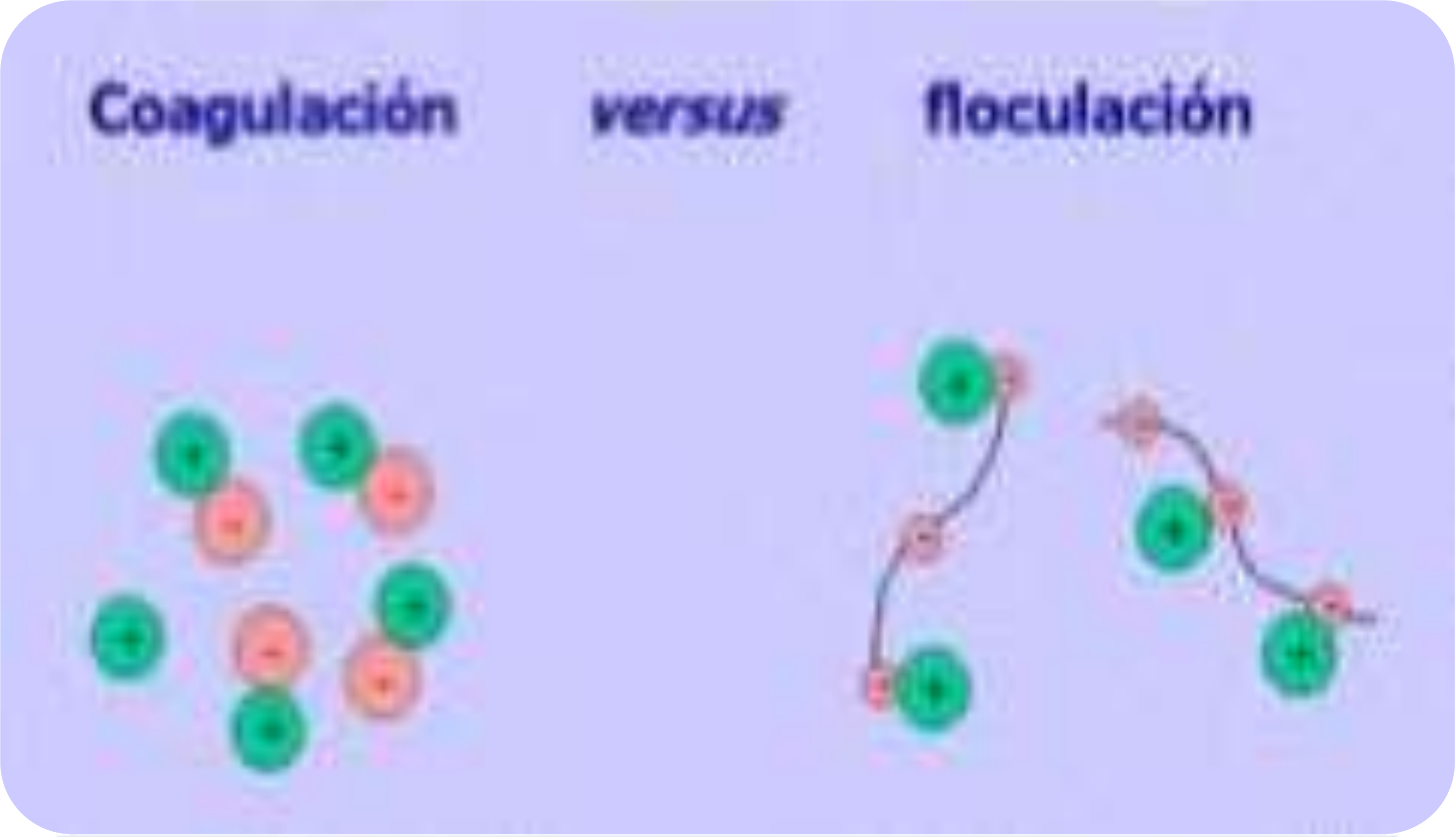

FEB 25 2003

Clarification stages

2. Flocculation



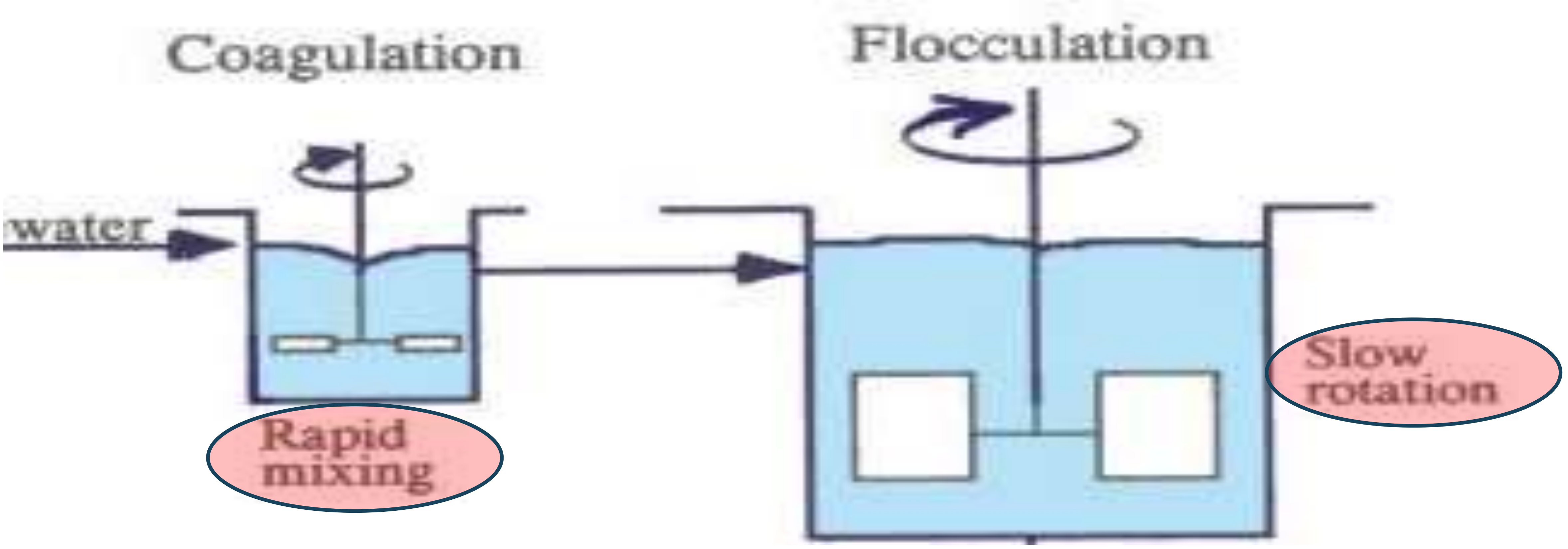
Coagultion Vs. Flocculation



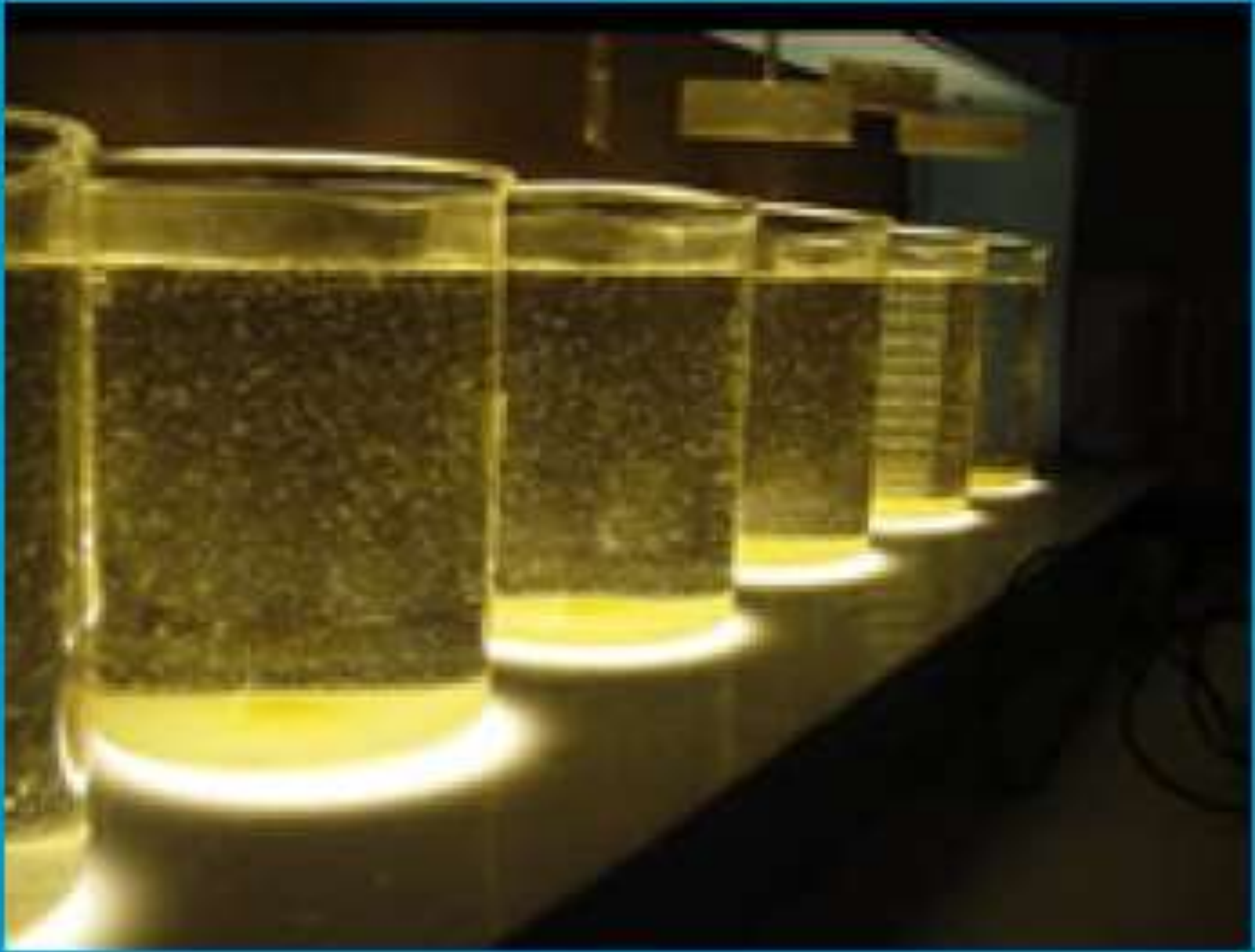
Flocculation

- Follows coagulation
- Provides gentle agitation to build floc
- Mixing energy must be low so floc will not be sheared
- Floc should not be allowed to settle in floc basin
- Detention time must be at least 30 minutes, with 45 minutes recommended (Design Criteria)

Coagultion Vs. Flocculation



Flocculation: theory



Inorganic Coagulant Reactions

ALUM

$Al_2(SO_4)_3$	+	$3\ Ca(HCO_3)_2$	------------->	$2\ Al(OH)_3$	+	$3CaSO_4$	+	$6\ CO_2$
Aluminum Sulfate	+	Calcium Bicarbonate (already in the water to treat)	gives	Aluminum Hydroxide	+	Calcium Sulfate	+	Carbon Dioxide

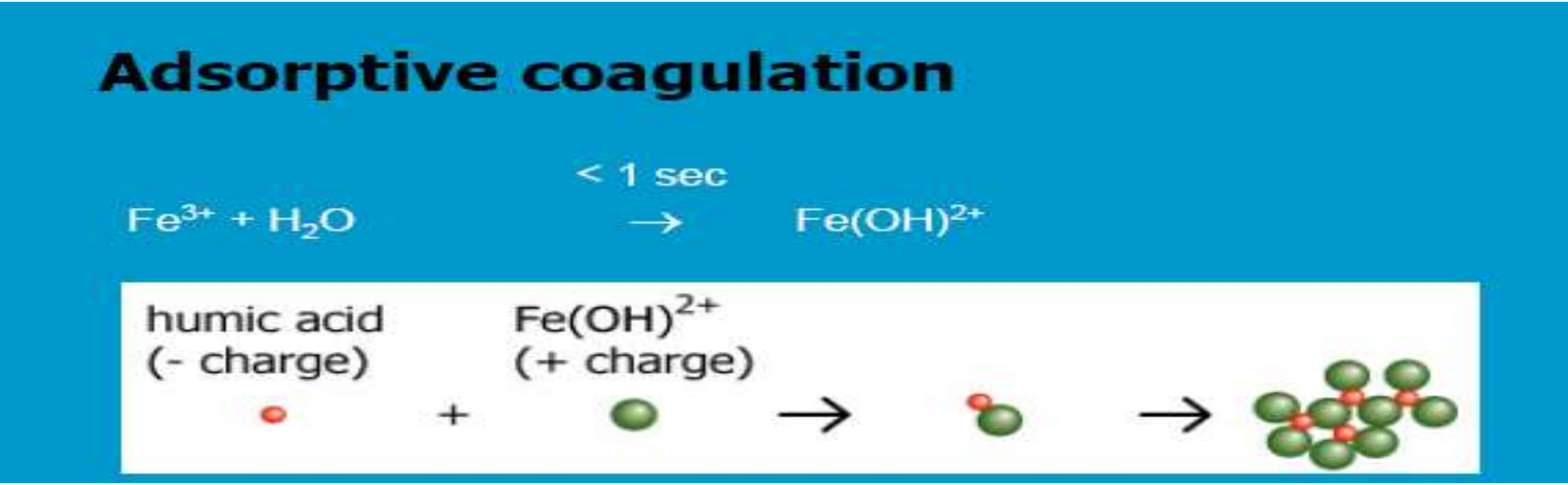
FERRIC SULFATE

$Fe_2(SO_4)_3$	+	$3\ Ca(HCO_3)_2$	------------->	$2\ Fe(OH)_3$	+	$3CaSO_4$	+	$6\ CO_2$
Ferric Sulfate	+	Calcium Bicarbonate (present in the water to treat)	gives	Ferric Hydroxide	+	Calcium Sulfate	+	Carbon Dioxide

FERRIC CHLORIDE

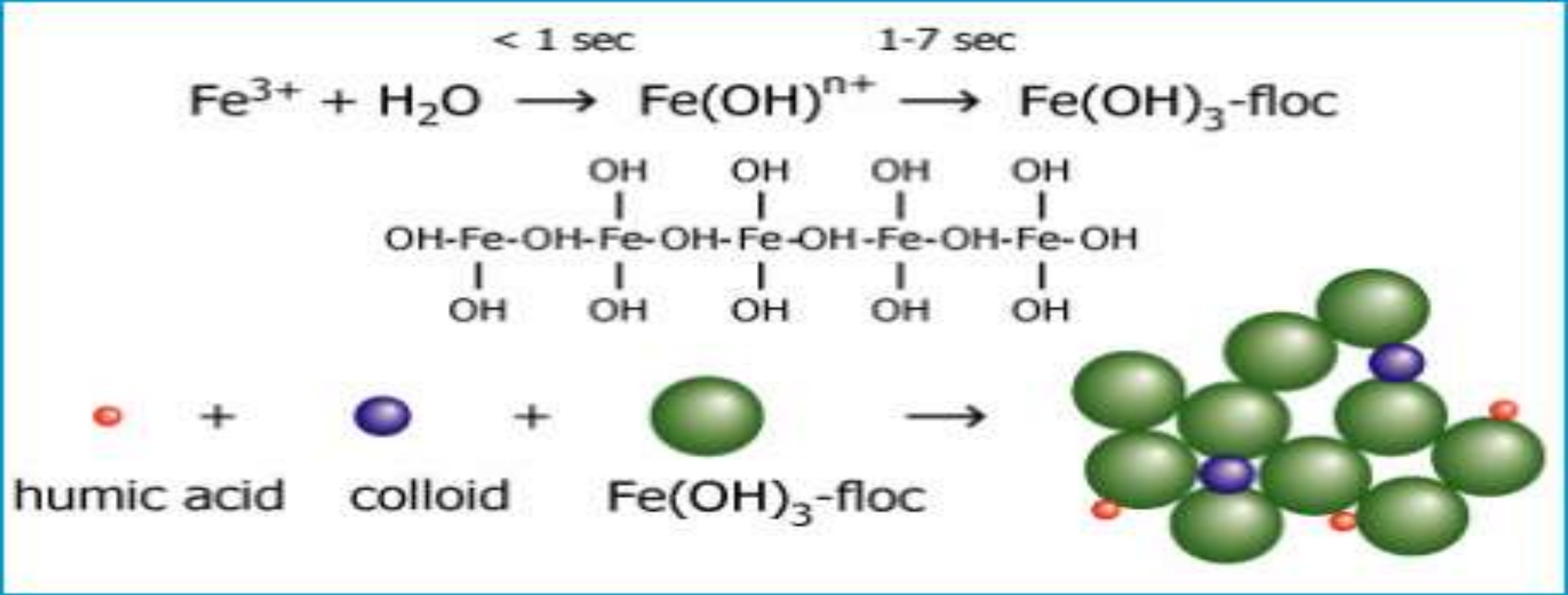
$2\ Fe\ Cl_3$	+	$3\ Ca(HCO_3)_2$	------------->	$2\ Fe(OH)_3$	+	$3CaCl_2$	+	$6CO_2$
Ferric Chloride	+	Calcium Bicarbonate (present in the water to treat)	gives	Ferric Hydroxide	+	Calcium Chloride	+	Carbon Dioxide

Flocculation Mecanisam



Flocculation Mecanisam

Precipitation (sweep) coagulation



Flocculation

Operating Factors That Affect Floc Development

- Inadequate flash mixing
- Improper flocculation mixing
- Inadequate flocculation time
- Incorrect chemical dose

Choosing a Coagulant

- Begin by using the **jar test** with various chemicals
  - Dose
  - Mixing speed
  - Chemical combination
  - Full-scale plant operation may not match jar test results
  - Indication of improper flash mixing, coagulant
  - Pinpoint floc
  - High settled turbidity
  - Frequent filter backwash

Control Tests

Tests that are used to optimize the coagulation and flocculation processes:

□ **Jar test**

- allows you to test different chemicals or dosages before you try them in your plant

Control Tests

Tests that are used to optimize the coagulation and flocculation processes:

- **pH**
  - ensures proper pH range for coag/floc process
- **Turbidity (settled)**
  - success of sedimentation process
- **Turbidity (finished)**
  - overall process success

Control Tests

Tests that are used to optimize the coagulation and flocculation processes:

- Zeta potential meter
- measures charge of water
- Streaming current monitor
- measures overall charge after coagulant is added
- Particle counter
- measures size and concentration of particles in finished water

Control Tests

Visual inspection of floc in floc basins:

- size and distribution of floc
- Visual inspection of how floc settles in sedimentation Basin
- Calibrate feeder equipment at least once per shift
- Use in-line monitors to measure water quality

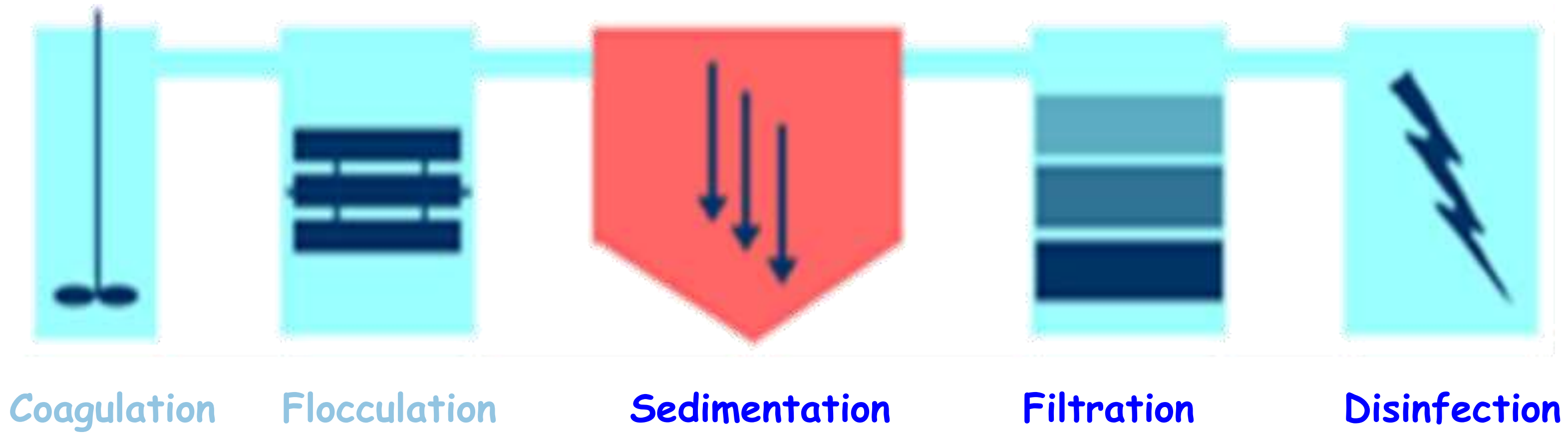
Common Operating Problems

- Low water temperature
  - As temp drops, water becomes more viscous
  - Solutions: operate near optimal pH, increase coagulant dose, add weighting agent or coagulant aid

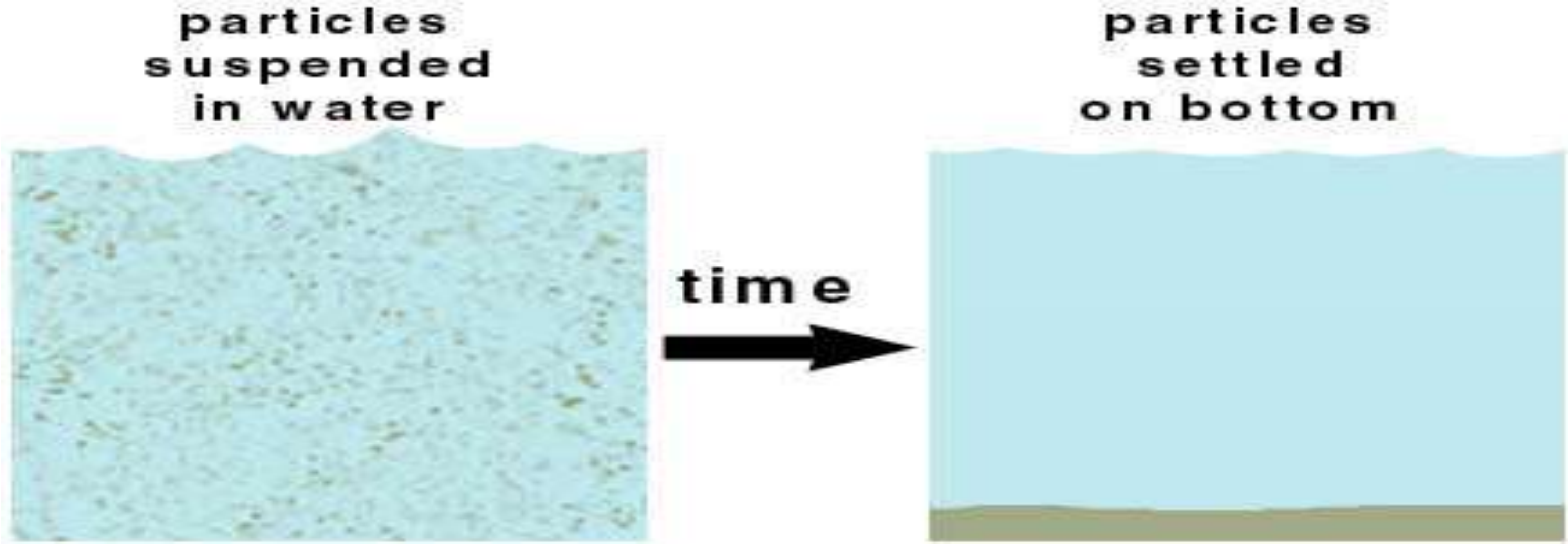
- Weak floc
  - Passes through filters
  - Slow floc formation
  - Often caused by low turbidity or insufficient alkalinity
  - Solutions: add weighting agent or increase alkalinity

Clarification stages

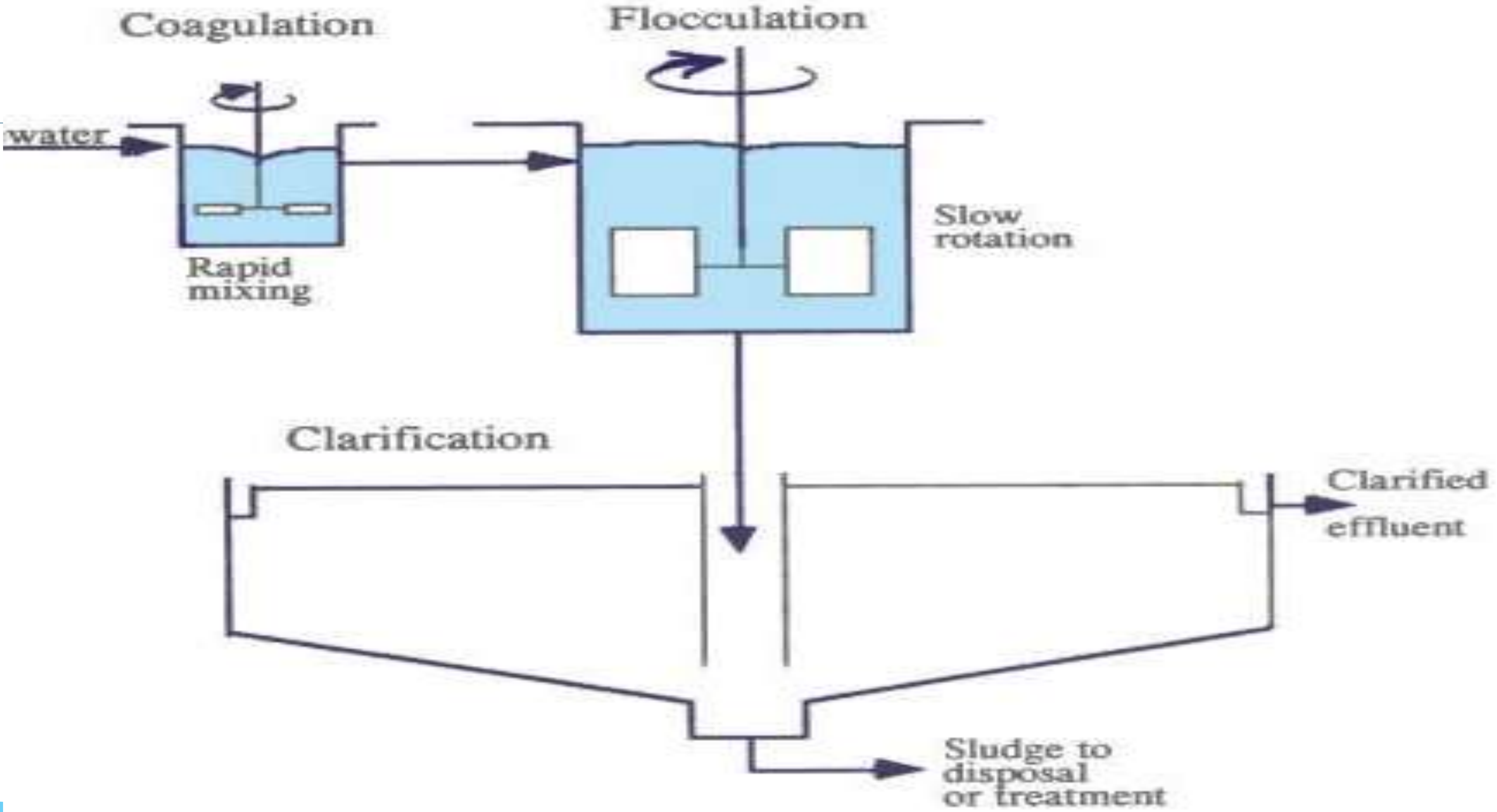
3. Sedimentation



Sedimentation



Rachel Casiday, Greg Noelken, and Regina Frey, Washington University



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

Sedimentation

 Occurs following flocculation and before filtration

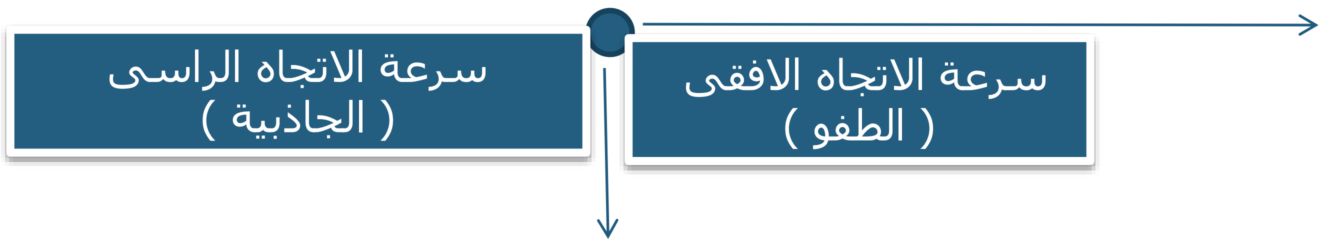
 Decreases the solids loading on filters and other treatment processes

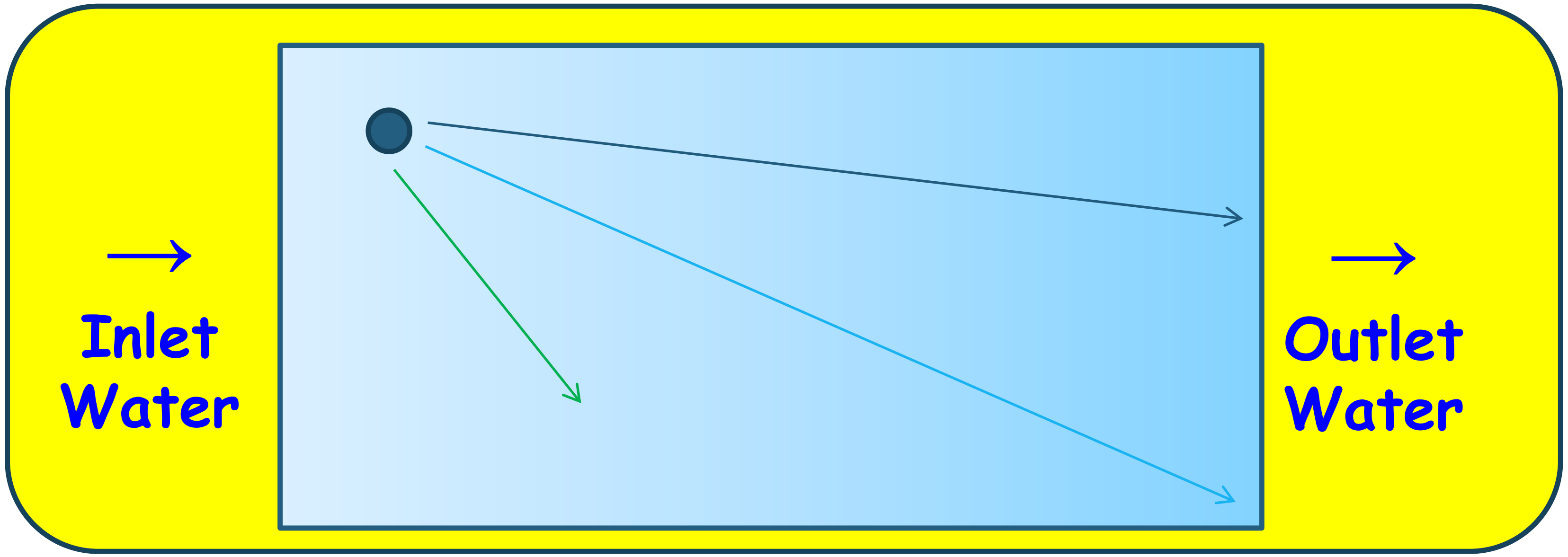
 The decreased loading can result in

- longer filter runs
- reduced filter maintenance

SEDIMENTATION BASIN OPERATION

- Goals of Sedimentation
  - To produce settled water with the lowest possible Turbidity
  - To reduce the concentration of organics which can cause color or form DBP’s (disinfection by products)


سرعة الاتجاه الراسى
(الجاذبية)
سرعة الاتجاه الافقى
(الطفو)


Inlet
Water
Outlet
Water

سلوك الجزئيات عند الترسيب

$$\frac{\text{سرعة الطفو}}{\text{سرعة الهبوط}} = \frac{ع_{أ}}{ع_{هـ}} = \frac{ل}{ق} \qquad \frac{\text{الطول}}{\text{العمق}}$$

$$\therefore \quad ع_{هـ} = \frac{ق}{ل} \times ع_{أ}$$

وحيث أن

$$ع_{أ} = \boxed{\frac{ك}{ض \times ق}} \qquad \frac{\text{معدل التدفق (تصرف المياه)}}{\text{مساحة المقطع (العرض x القاع)}}$$

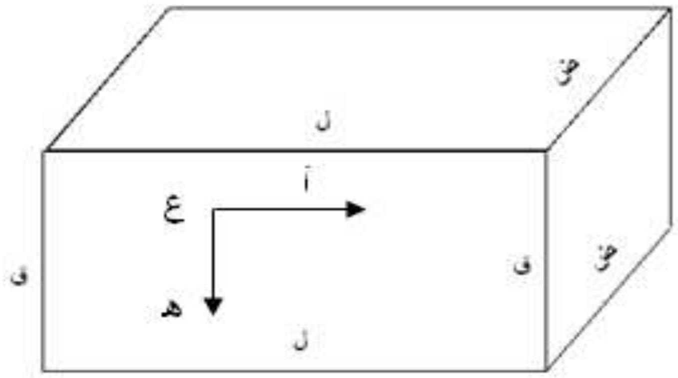
$$\therefore \quad ع_{هـ} = \frac{ق}{ل} \times \boxed{\frac{ك}{ض \times ق}} = \frac{ك}{ض \times ل}$$

أى أن:

$$\text{سرعة الهبوط الرأسية للحبيبات} = \frac{\text{معدل التدفق (التصرف)}}{\text{المساحة السطحية لحوض الترسيب}}$$

(عمق حوض الترسيب (ق))

العرض x الطول

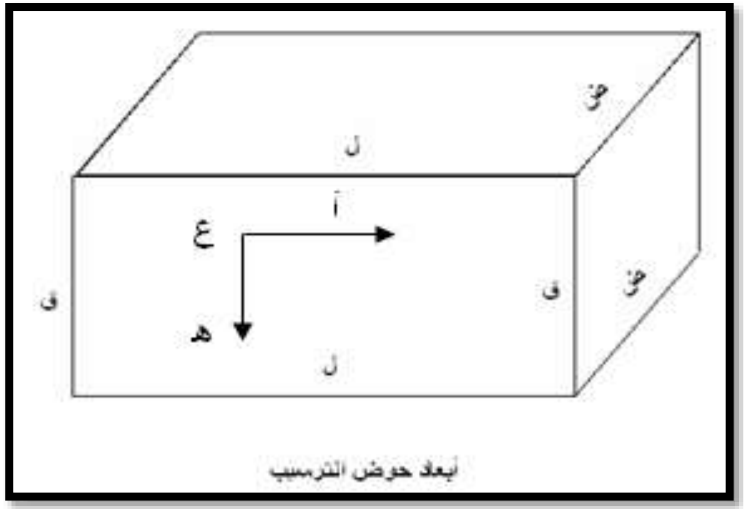


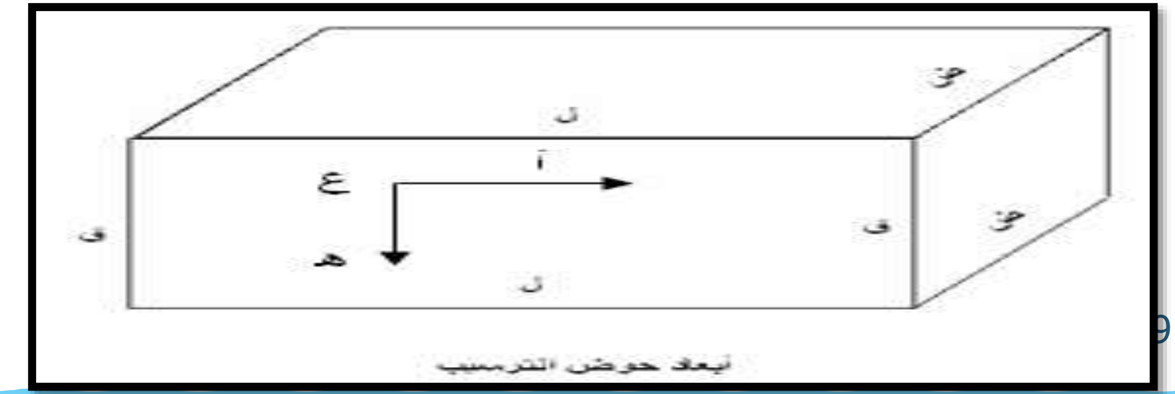
أبعاد حوض الترسيب

[ل] طول حوض الترسيب (م)
[ض] عرض حوض الترسيب (م)
[ق] عمق حوض الترسيب (م)

[ع أ] سرعة الطفو الافقية(م / س)
[عهـ] سرعة هبوط رأسية (م / س)

اى احواض الترسيب افضل ؟



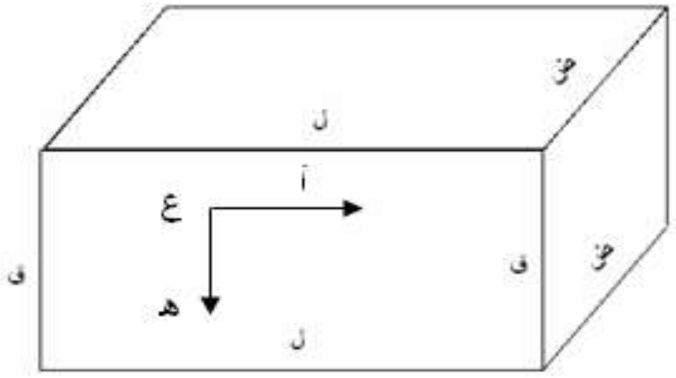


اى احواض الترسيب افضل ؟!!

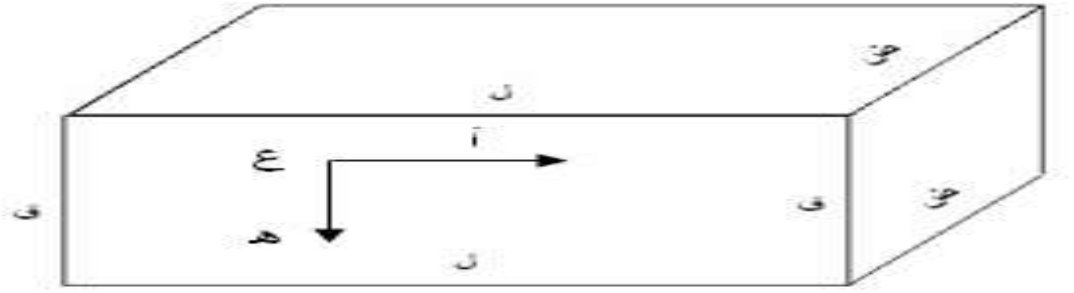
معدل التدفق (تصرف) المياه

سرعة الهبوط الرأسية للجزيئات = ________________________

مساحة المقطع (الطول x العرض)



أبعاد حوض الترسيب



أبعاد حوض الترسيب

يتضح من المعادلة السابقة أن المواد العالقة التى لها سرعة هبوط رأسية مساوية أو أكثر من "عهـ" يتم ترسيبها فى الحوض .
وعلى العكس لا ترسب المواد إذا كانت سرعتها الرأسية أقل من "عهـ" .

ومن ذلك نرى أن المساحة السطحية لحوض الترسيب (الطول × العرض) لها تأثير مباشر على كفاءة الترسيب
فكلما زادت المساحة السطحية قلت "عهـ" والتى تقابل عمق حوض الترسيب (ق) زادت كفاءة الحوض .

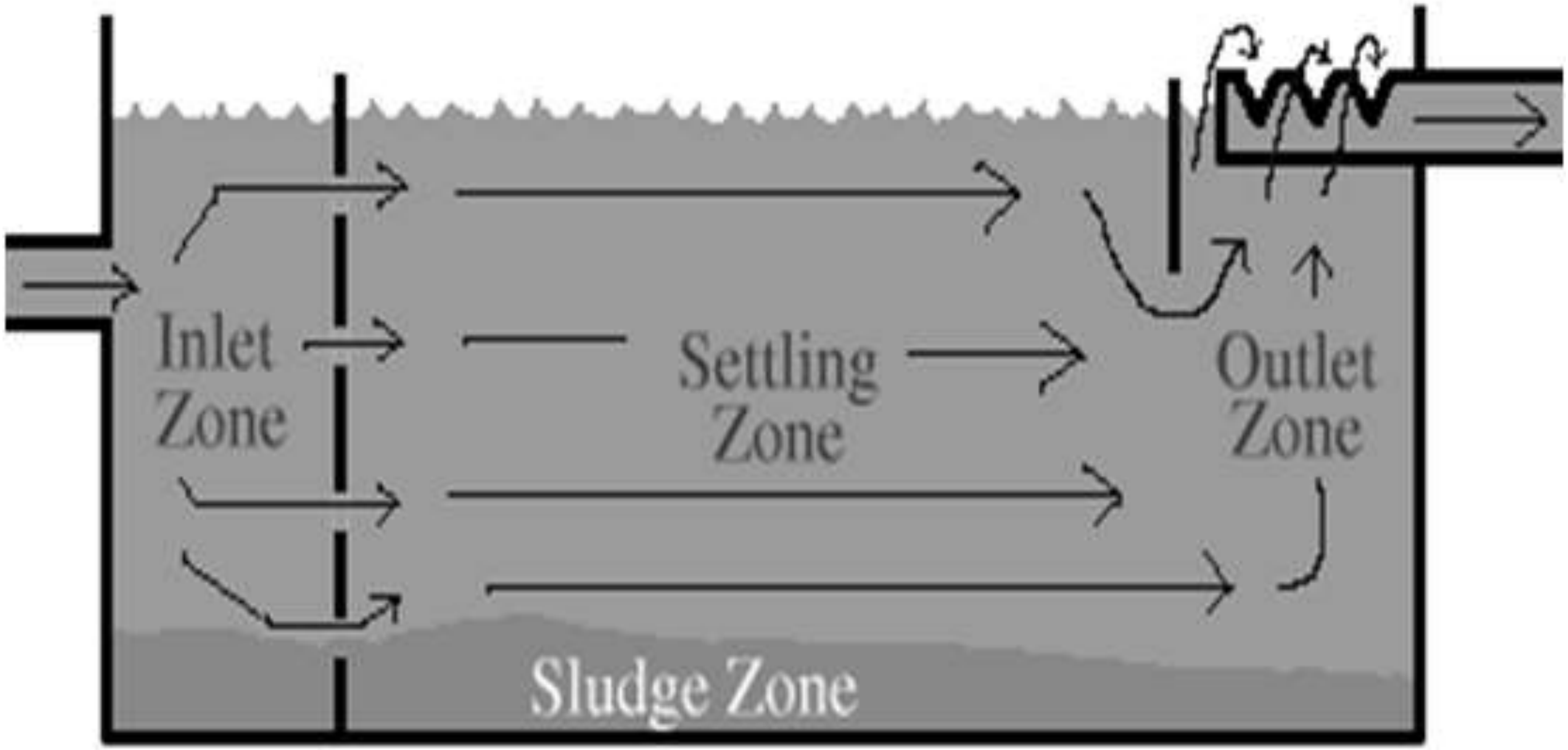
وتسمى "عهـ" بمعدل التحميل السطحى لحوض الترسيب وتُتخذ كأساس من أسس التصميم لهذه الأحواض وتكون وحدتها م^{3} / م^{2} / س .

Ideal sedimentation tanks

The conditions must be done to be an ideal sedimentation tank:

1. *The flow is laminar flow.*
2. *There are no dead zones.*
3. *The horizontal velocity is constant.*
4. *Good arrangement of inlet and outlet weirs.*

ZONES OF A SEDIMENTATION BASIN



ZONES OF A SEDIMENTATION BASIN

 Influent Zone (inlet)

- Decreases the velocity of incoming water from flocculation
- basin
- Distributes it evenly across the basin

 Settling Zone

- Provides the calm area for the suspended material to settle
- Largest zone
- Effluent Zone

 Provides smooth transition from settling zone to effluent
flow area

 V-notch weirs enable flow to be evenly distributed

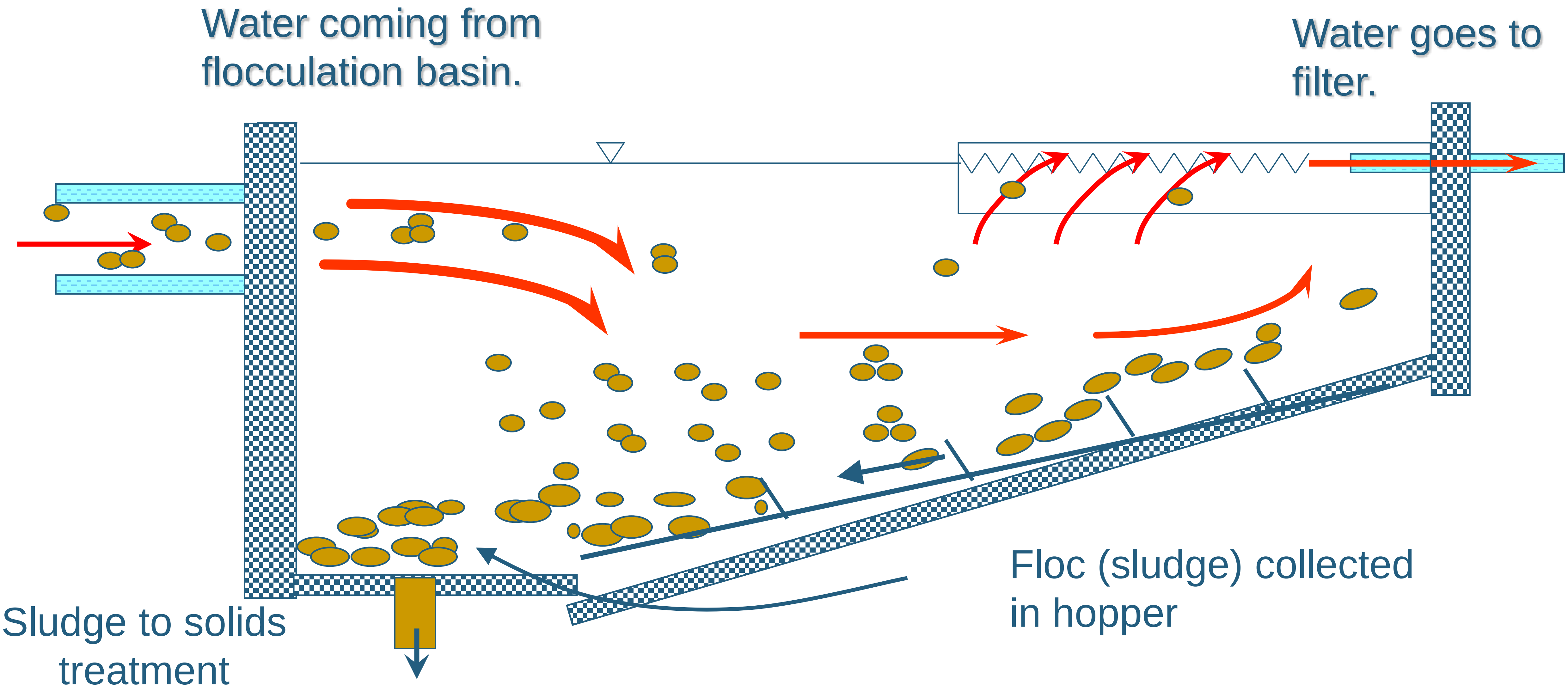
 Sludge Zone

 Area where solids collect as they settle

SEDIMENTATION BASIN OPERATION

- Factors Affecting Sedimentation
  - Temperature
  - Colder water = slower settling
  - Particle size, shape, and weight
  - Electrical charge of particles
  - Wind and rain
  - Coagulant dose and type
  - Basin hydraulics

Sludge removal



OPERATING PROBLEMS

- **Poorly Formed Floc**
- Doesn’t settle properly
- Characterized by smaller loosely held particles that do not settle & are carried out of the settling basin
- Can be caused by
  - improper mixing
  - dosage
  - type of coagulant
  - changes in raw water
  - Solutions
  - increase mixing energy
  - perform jar tests
  - use coagulant aid

OPERATING PROBLEMS

- **Short Circuiting :**
  - Water bypasses normal flow and reaches outlet without proper amount of DT
- Can be caused by
  - poor inlet baffling (main cause)
  - wind driven currents
  - density currents
  - when the influent contains more suspended solids than the water in the basin
  - when the influent is colder than the water in the basin

OPERATING PROBLEMS

- Algae and Slime Growth
- Outdoor, uncovered basins
- Causes taste and odors
- Can detach and clog filters or weirs
- Can create slick, hazardous surfaces
- Solutions
- can be controlled with a mixture of copper sulfate and lime or other chemicals
- drain basin and apply mixture to problem areas with a brush

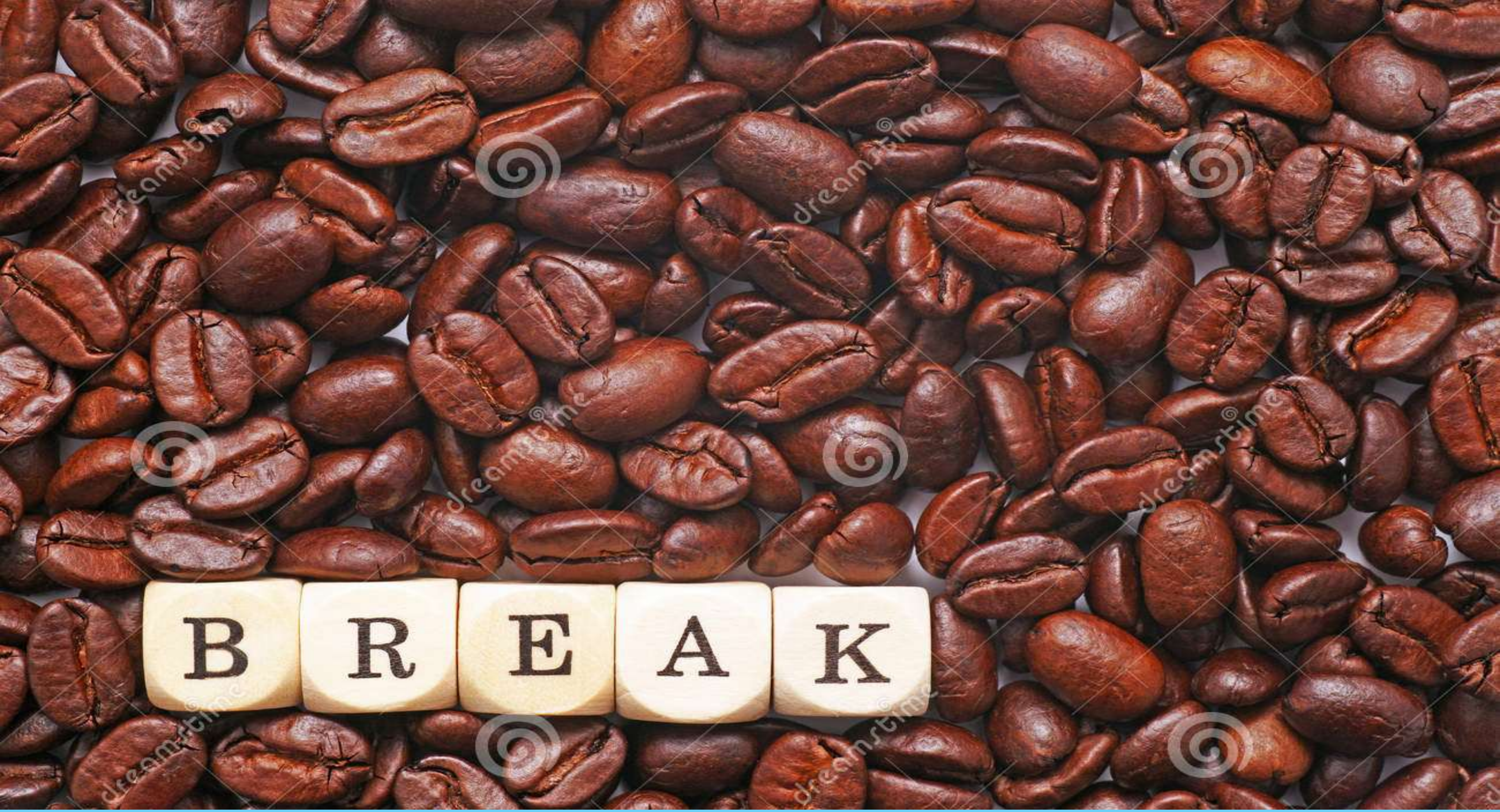
التقييم المبدئى لاداء محطات تنقية مياه الشرب

المروقات :

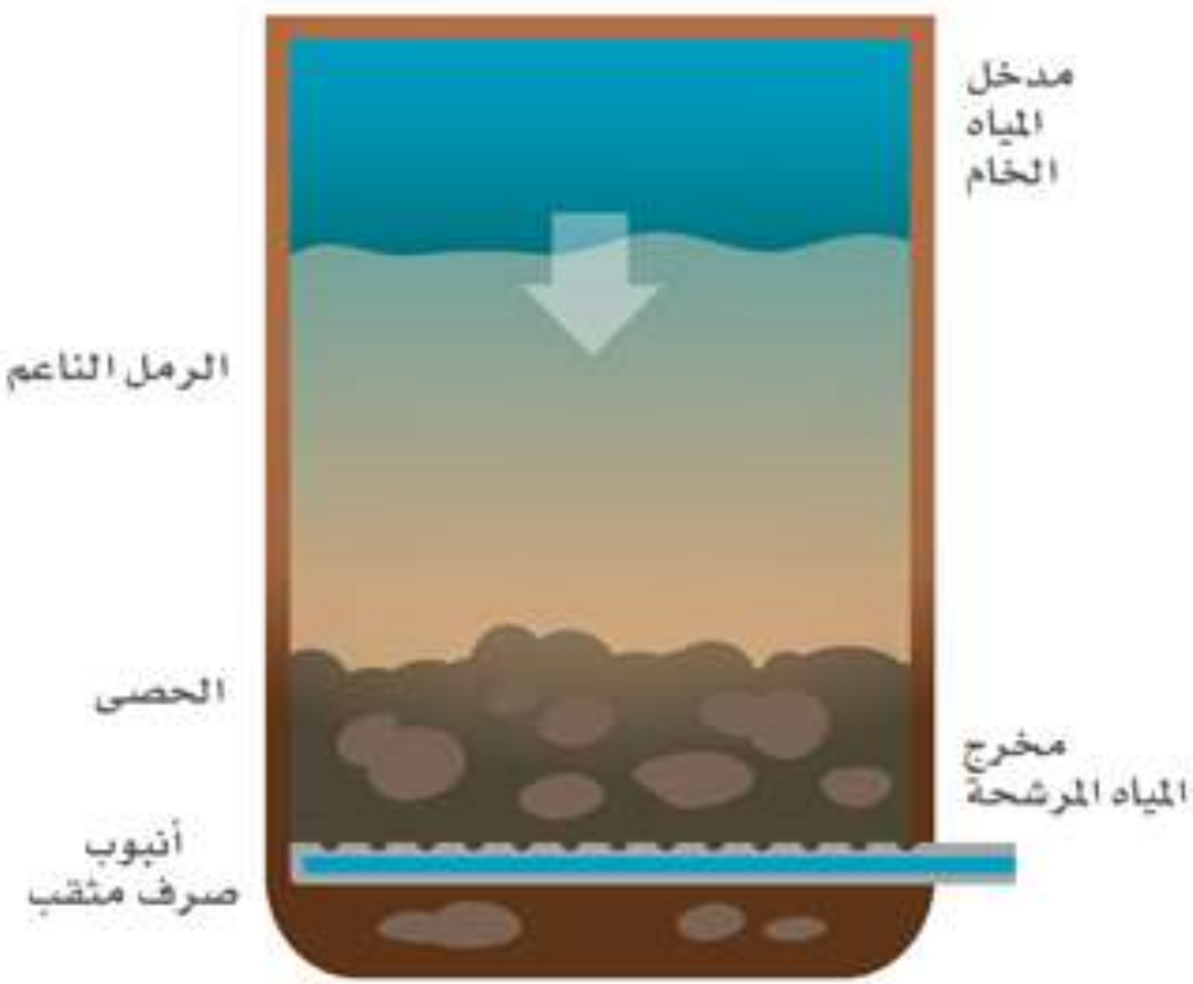
- مقارنة الشفافية والعكارة لمياه المأخذ ومياه الخروج .
- ملاحظة وجود ندف كبيرة Flocks لتدل على كفاءة عالية للمحطة
- ملاحظة دفع الطلمبة وتركيز الشبة 10% وحقن الشبة (جرعة الشبة المضاف (25 – 30 جرام/م^3)
- ملاحظة جرعة الكلور المبدئية (3-5 كيلو/1000م3) صيفا و (2-3 كيلو/1000م^3) شتاءا
- مراقبة وملاحظة مخرج الروبة طبقاً للمعدل المطلوب

التقييم المبدئى لاداء محطات تنقية مياه الشرب

العوامل	الموقع	التكرارية	الإجراءات التى يمكن اتخاذها
١- ملاحظة أداء العملية وتقييم جودة المياه			
• العكارة • درجة الحرارة	• المياه الداخلة والخارجة • المياه الداخلة	• مرة كل ساعتين على الأقل • على فترات	١. زيادة معدل تكرار أخذ العينات عند تغير نوعية المياه ٢. إجراء اختبار الكأس ٣. إجراء التغييرات اللازمة: • تغيير المادة المروبة • ضبط جرعة المروبات • ضبط شدة الخلط والمزج • زيادة معدل إزالة الروبة ٤- التأكد من التجاوب السريع مع المتغيرات
٢. الملاحظة البصرية	الموقع	التكرارية	الإجراءات التى يمكن اتخاذها
• خصائص ترسيب الندف • توزيع الندف • عكارة (شفافية) المياه المروقة	• النصف الأول من الحوض • مدخل الحوض • هدار الخروج أو قناة المياه المروقة	• مرة على الأقل فى الوردية ٨ ساعات • مرة على الأقل فى الوردية • مرة على الأقل فى الوردية ٨ ساعات	١. إجراء اختبار الكأس عند اللزوم ٢. إجراء التغييرات اللازمة: • تغيير المادة المروبة • ضبط جرعة المروبات • ضبط شدة الخلط والمزج • زيادة معدل إزالة الروبة ٣- التأكد من التجاوب السريع مع المتغيرات


BREAK

Filtration



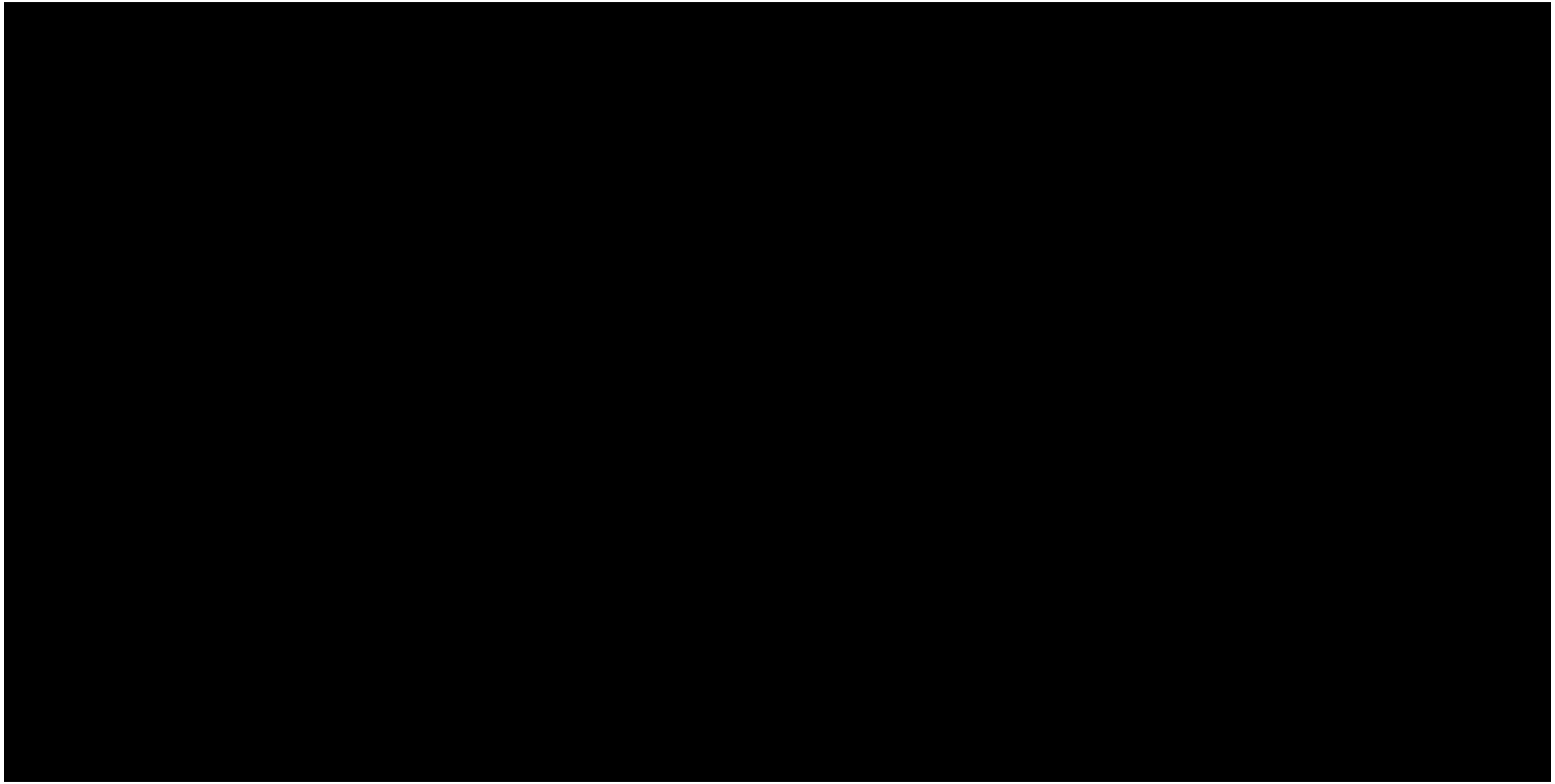
مدخل
المياه
الخام
الرمل الناعم
الحصى
مخرج
المياه المرشحة
أنبوب
صرف مثقب

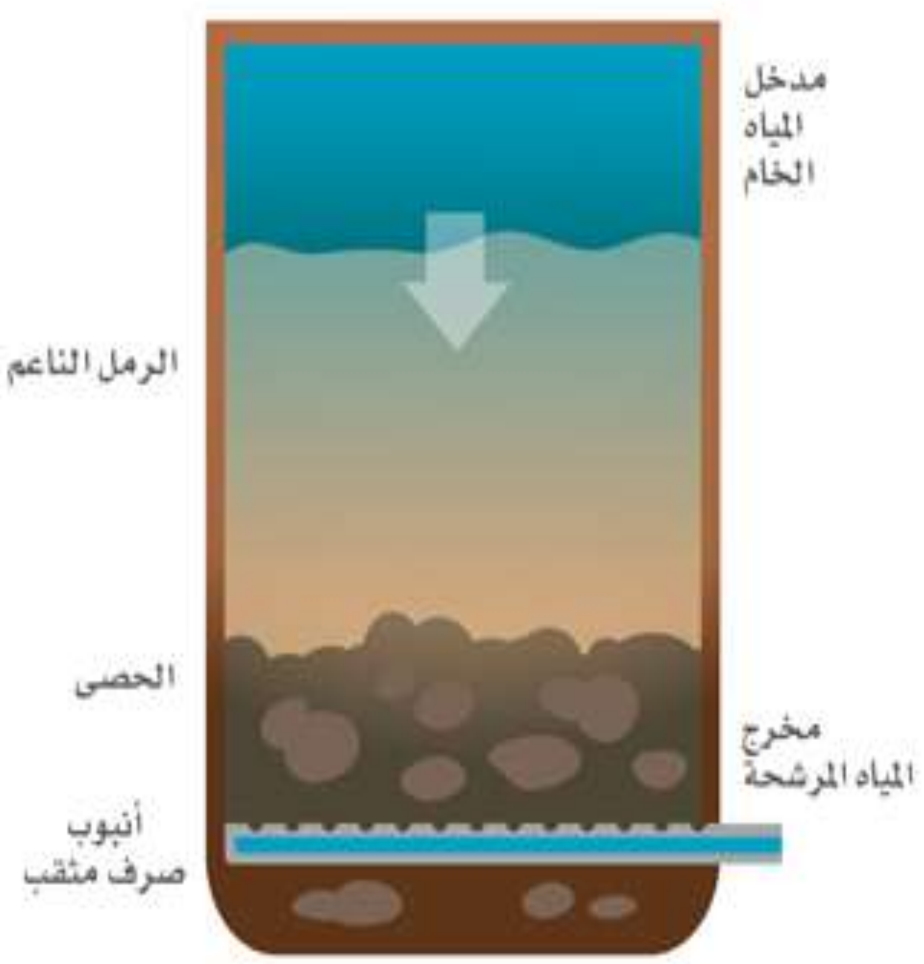
PURPOSE OF FILTRATION

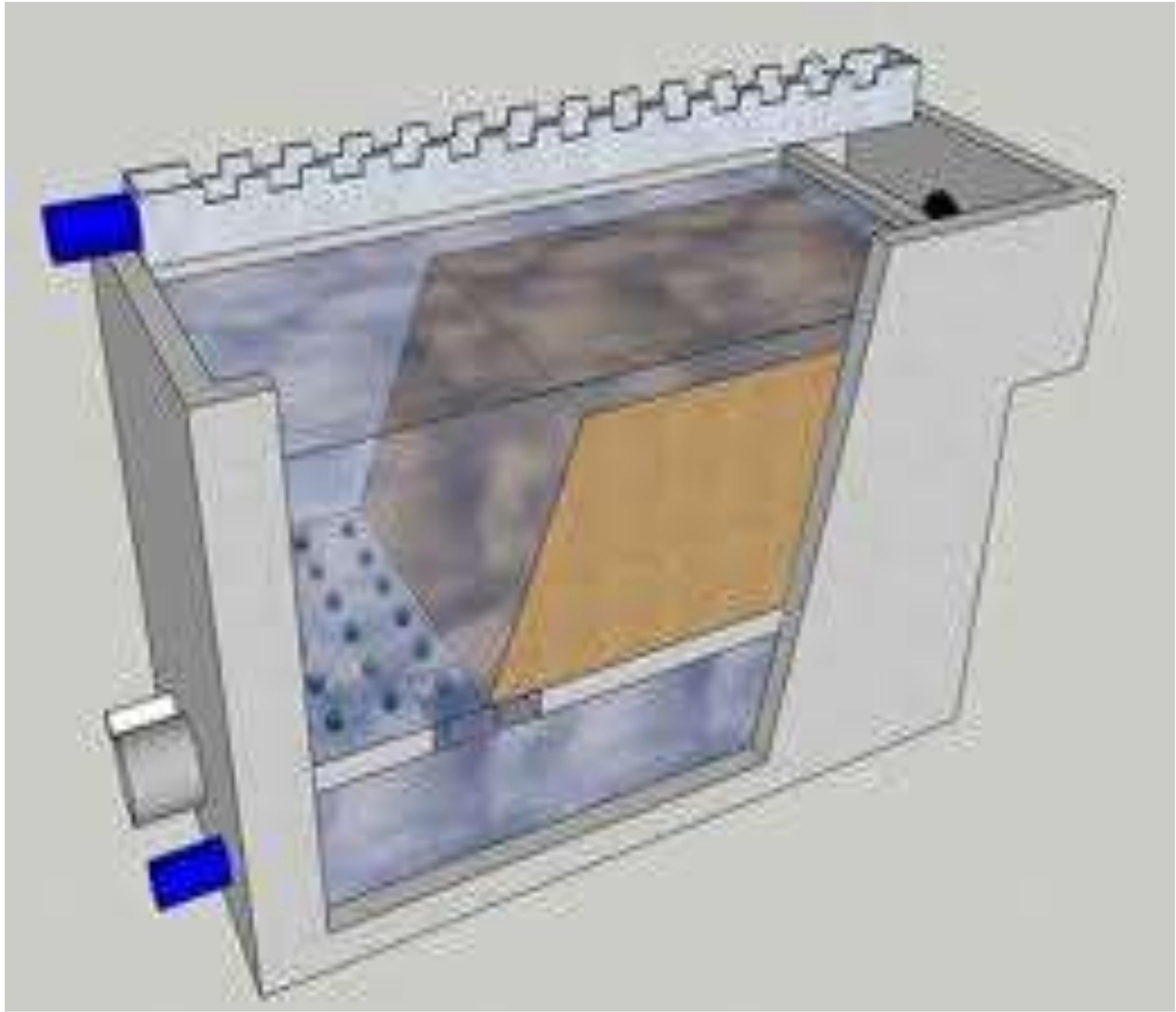
 Removal of particulate impurities and floc

- Aesthetics – minor reason
- Rremoves microorganisms - main reason

فيديو نموذج لمرشح

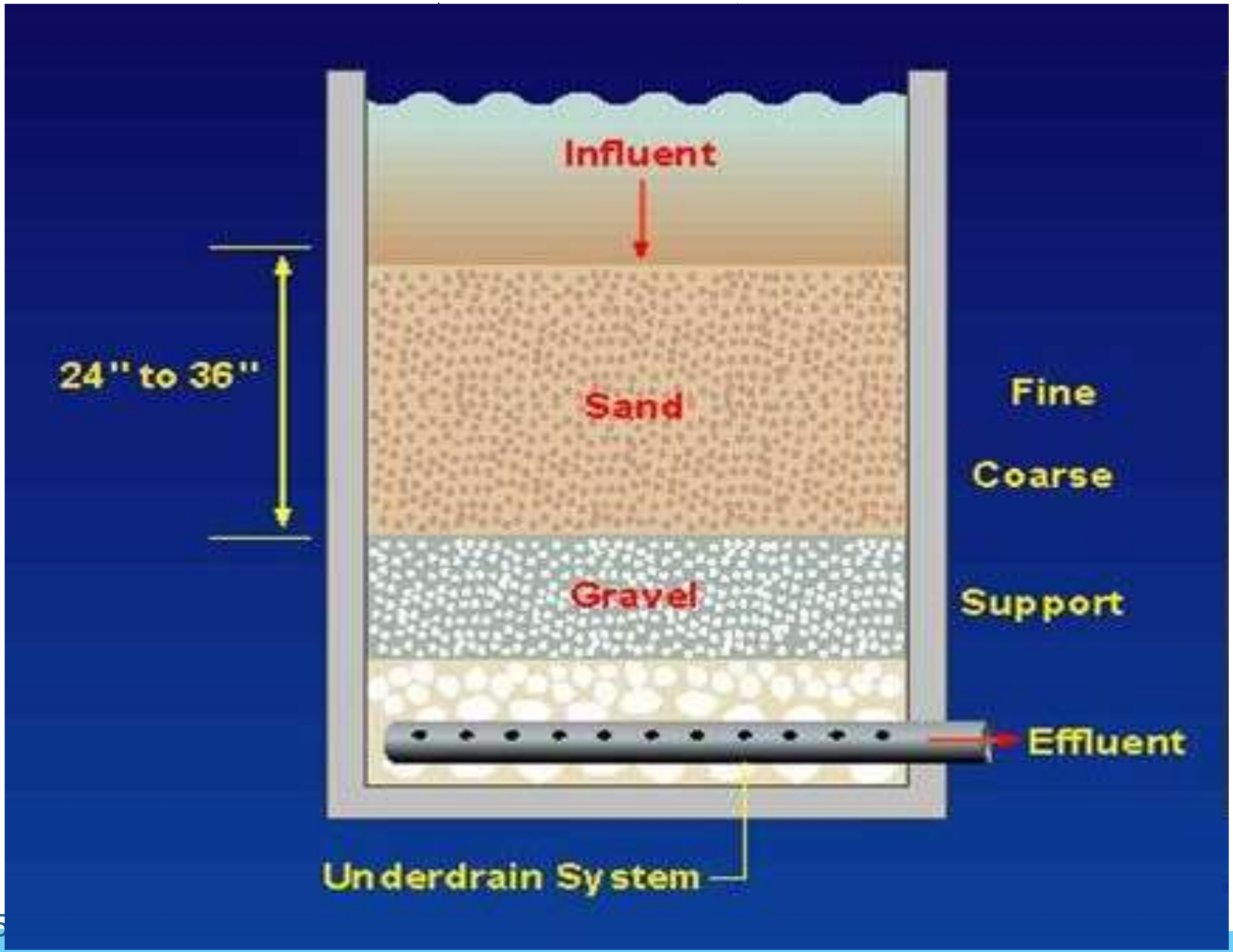


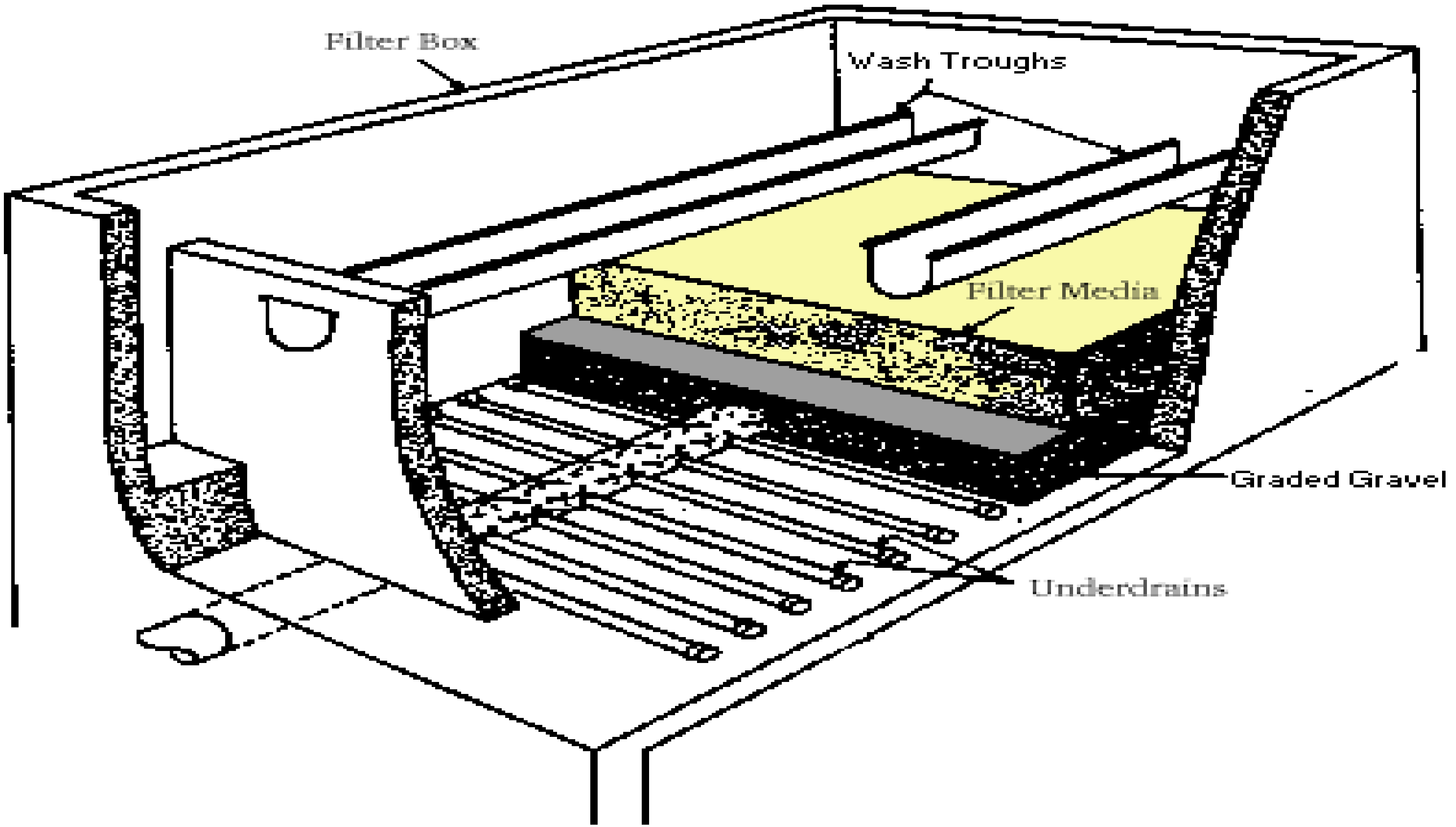

مدخل
المياه
الخام
الرمل الناعم
الحصى
مخرج
المياه المرشحة
أنبوب
صرف مثقب




GRAVEL:D=2-4mm
thickness=75mm
SAND:D=0.7-1.0mm

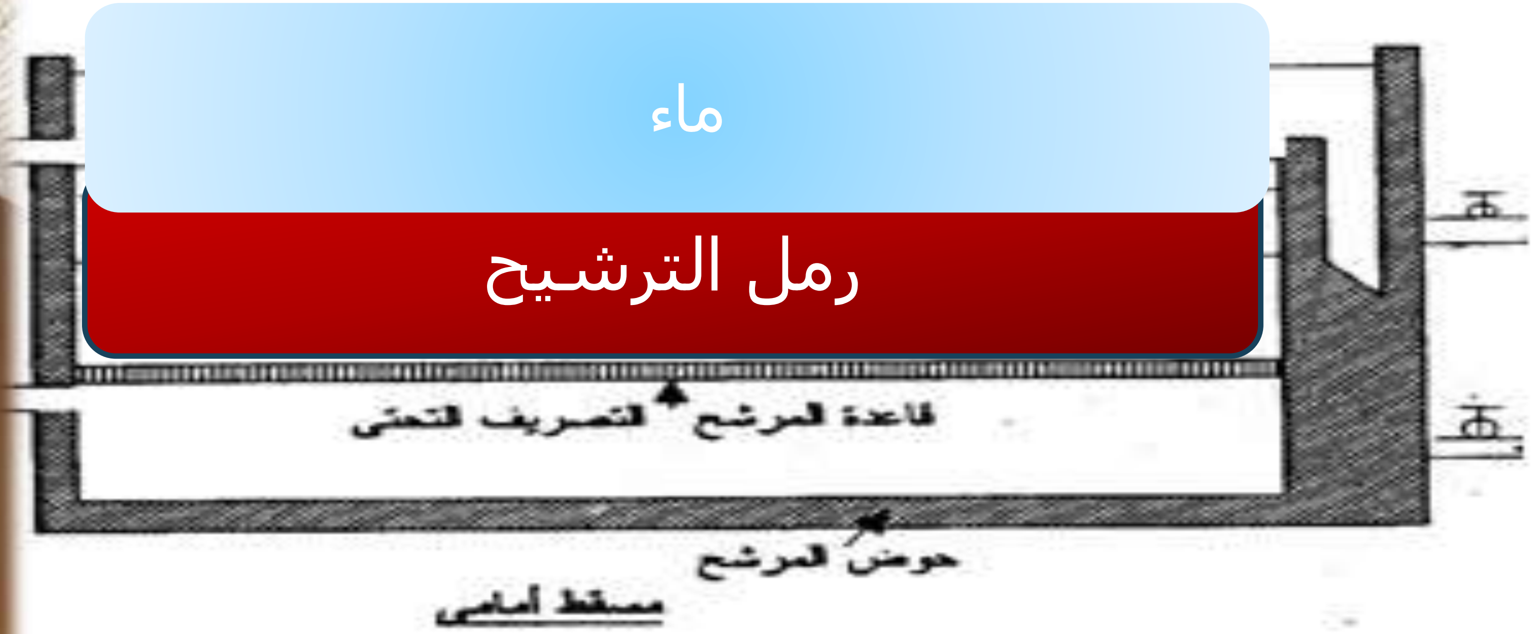

SAND:D=0.7-1.0mm
GRAVEL:D=2-4mm
thickness=75mm
GRAVEL:D=2-4mm
thickness=75mm
GRAVEL:D=4-6mm
thickness=75mm
GRAVEL:D=4-6mm
thickness=75mm
GRAVEL:D=6-13mm
thickness=75mm
GRAVEL:D=13-20mm
thickness=75mm


Influent
24" to 36"
Sand
Fine
Coarse
Gravel
Support
Effluent
Underdrain System

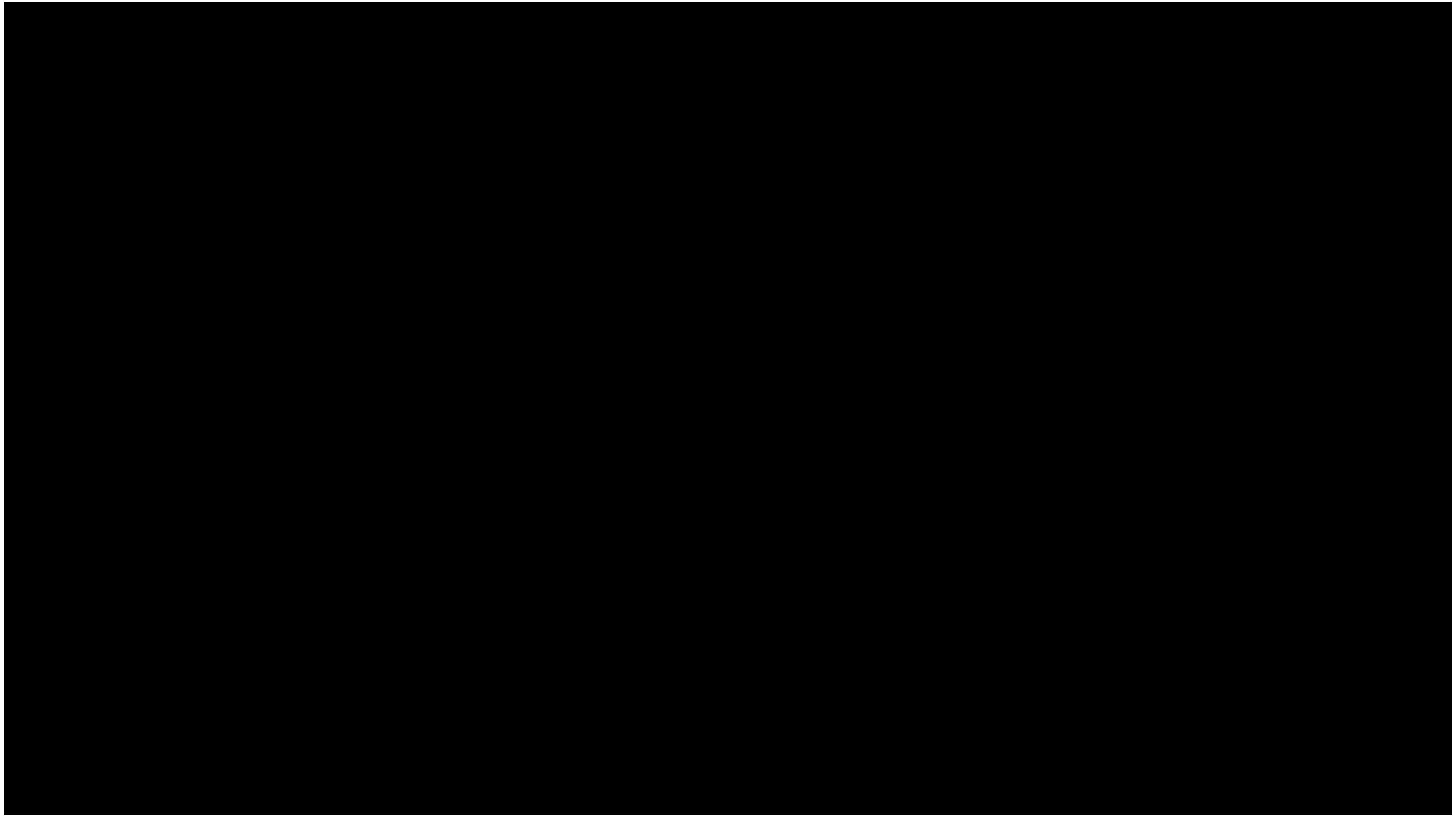

Filter Box
Wash Troughs
Filter Media
Graded Gravel
Underdrains

البلاطات الخرسانية ذات الفواني :

تصنع البلاطات عادة من الخرسانة وتحتوي علي فتحات تركب فيها الفواني وتصنع الفواني من الصلب الذي لا يصدأ أو من البلاستيك وتحتوي علي مشقبيات رفيعة لا تسمح بمرور الرمل الخشن فيها .



Biosand filter

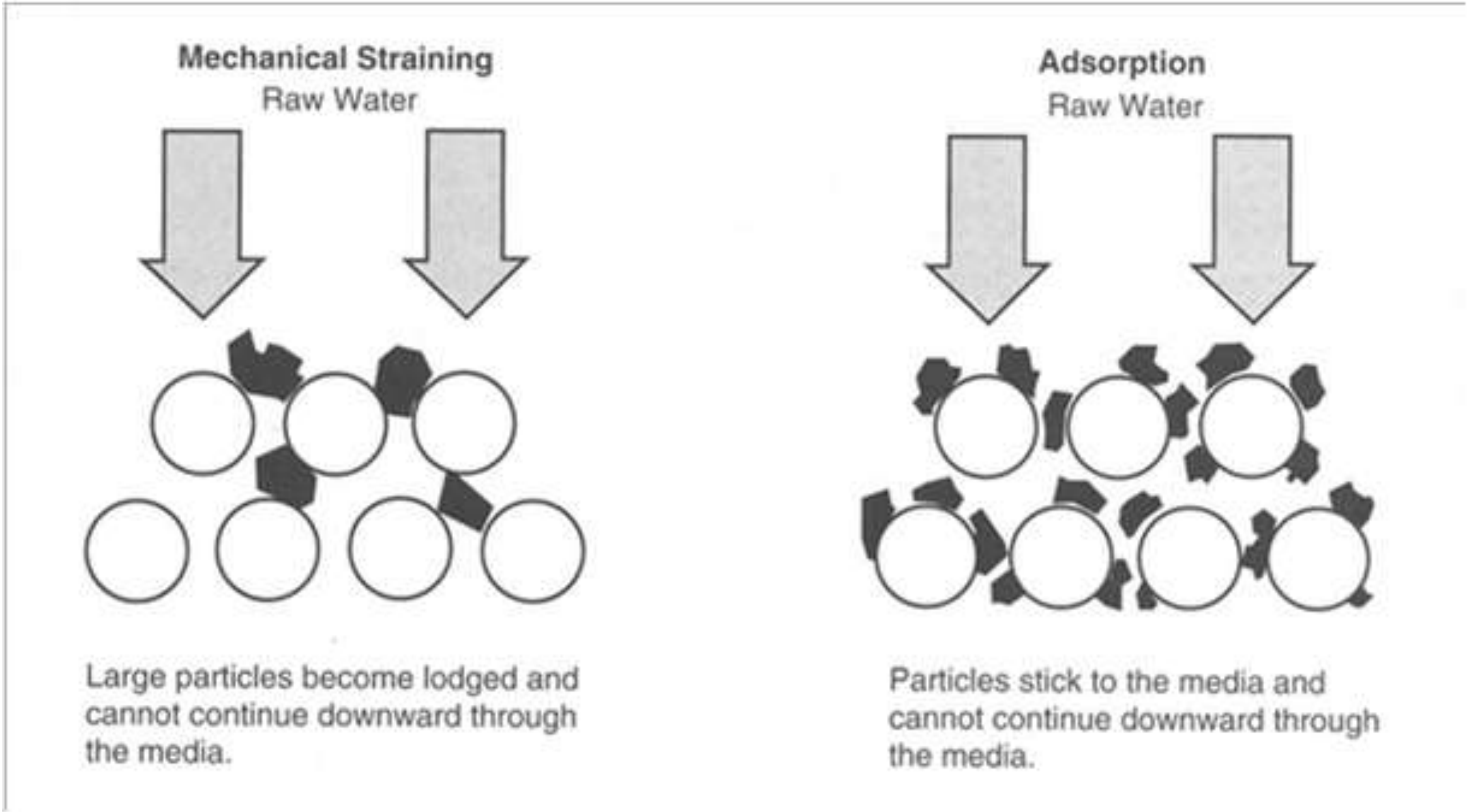



rapid sand filtration
slow sand filtration

PURPOSE OF FILTRATION

- Sedimentation on media (very important) :
- **Adsorption**
  - stick to surface, adhere
- **Absorption**
  - penetration of substance into structure of another substance, like a sponge
- **Straining**

PROCESS DESCRIPTION



BACKWASHING

BACKWASHING

Solids trapped by adsorption and straining :

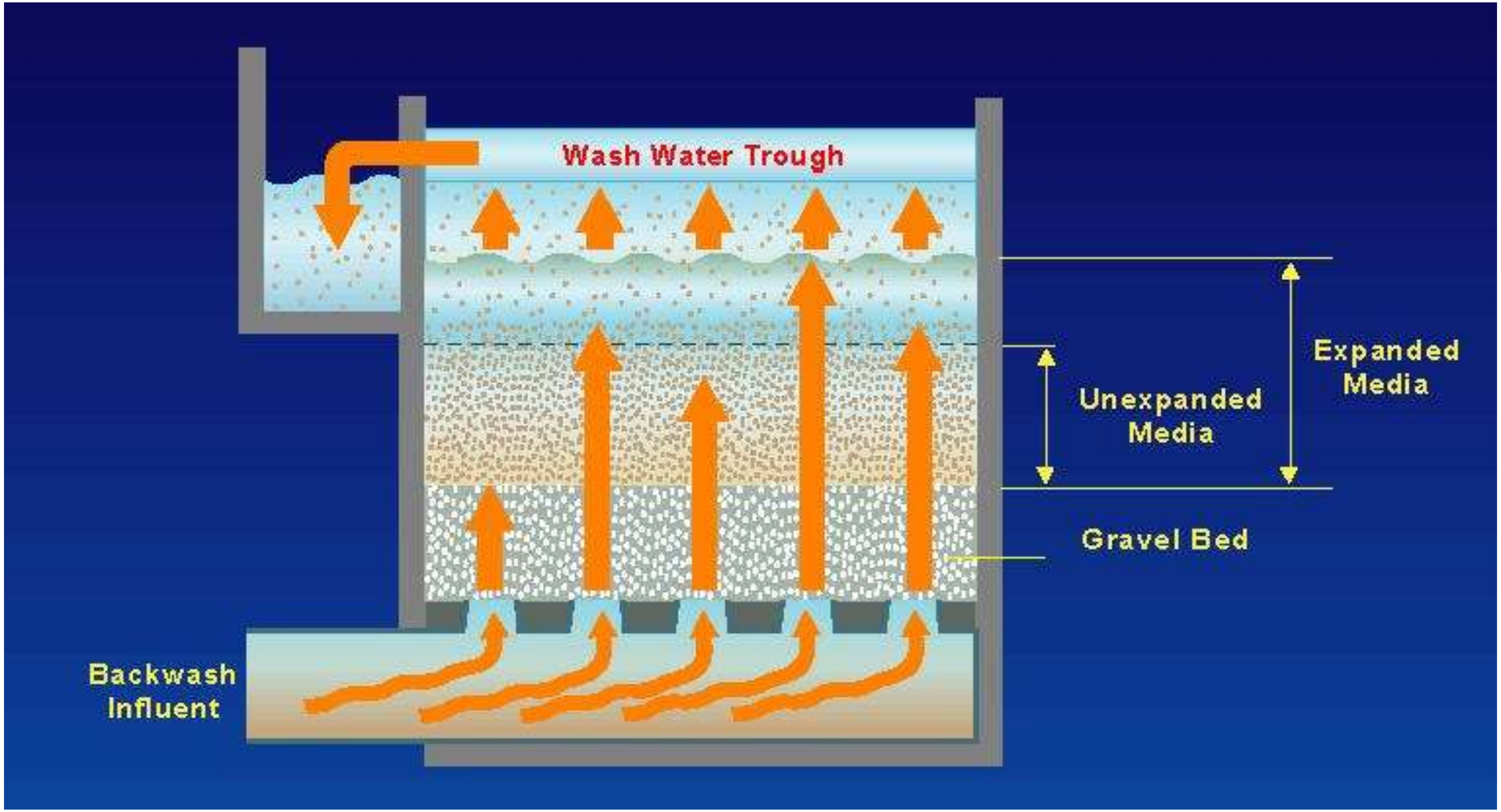
- Solids clog openings through the filter
- turbidity can occur



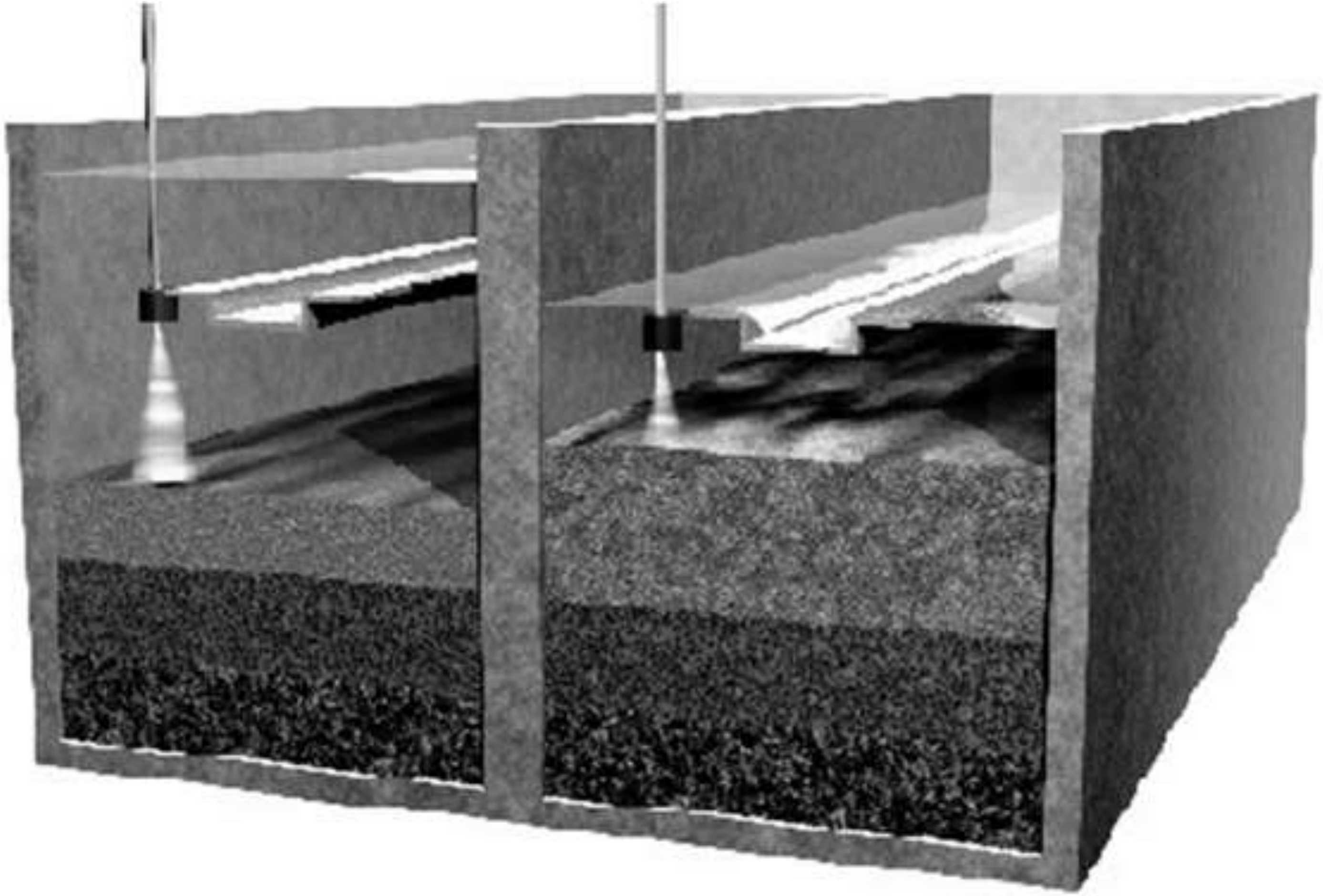
عملية غسيل المرشحات

المرحلة	المادة المستخدمة في الغسيل	الهدف
1	هواء أو ماء	بدء دخول المادة المستخدمة في الغسيل في الاتجاه المعاكس
2	هواء + ماء	عمل احتكاك لفصل الجزيئات العالقة
3	ماء يزداد تصرفة تدريجيا	طرد الهواء من الوسط الترشيحي
4	ماء فقط	طرد المواد العالقة
5	ماء يقل تصرفه تدريجيا	لتعود الجزيئات كل الي مكانة حسب الحجم والكثافة

BACKWASHING

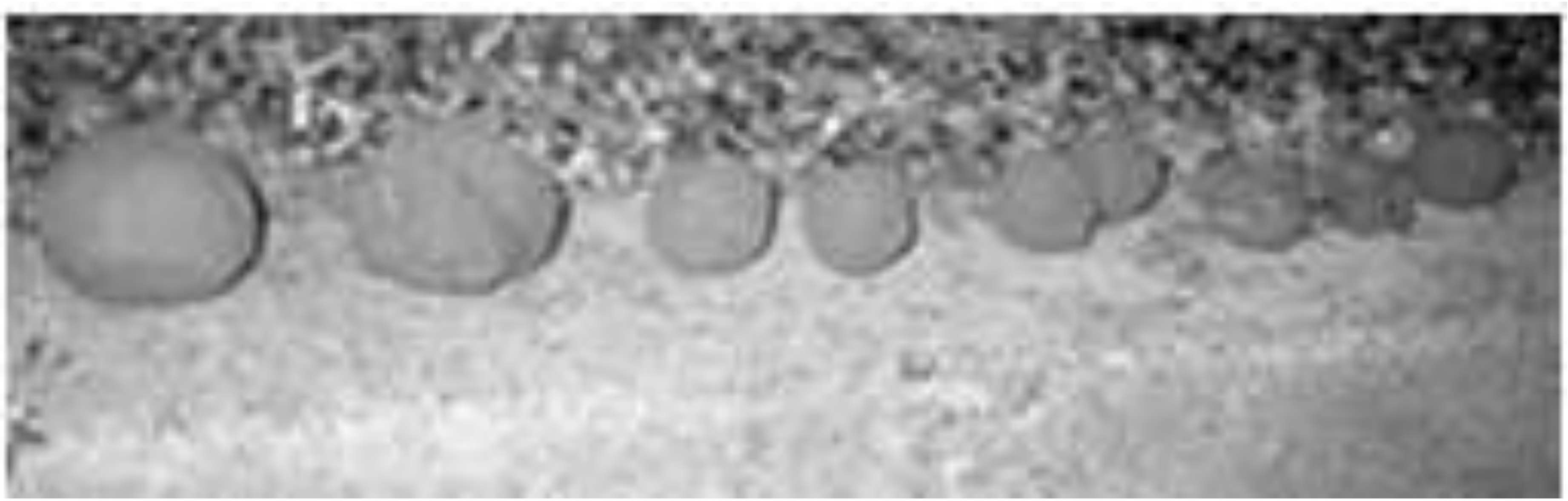


BACKWASHING



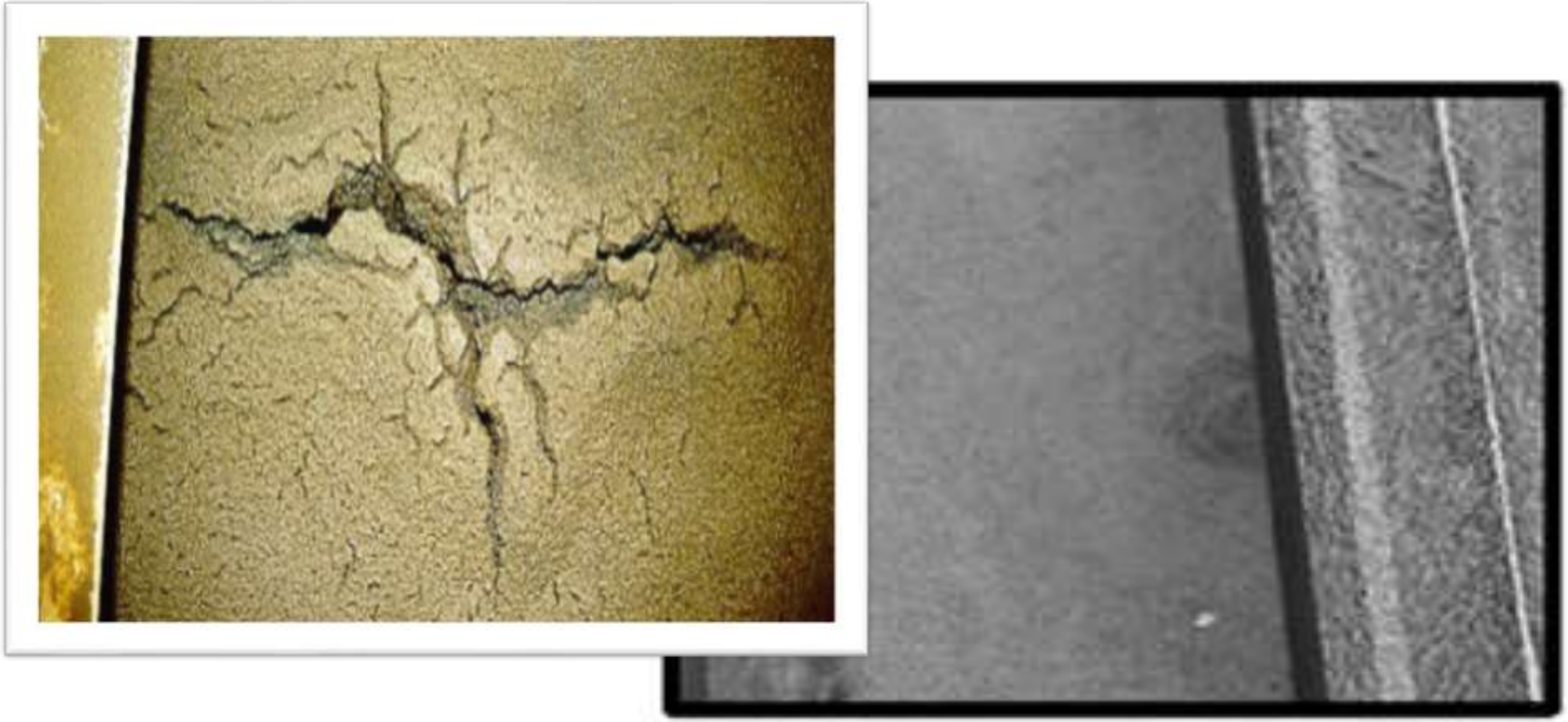
Abnormal Conditions

Mudball in media



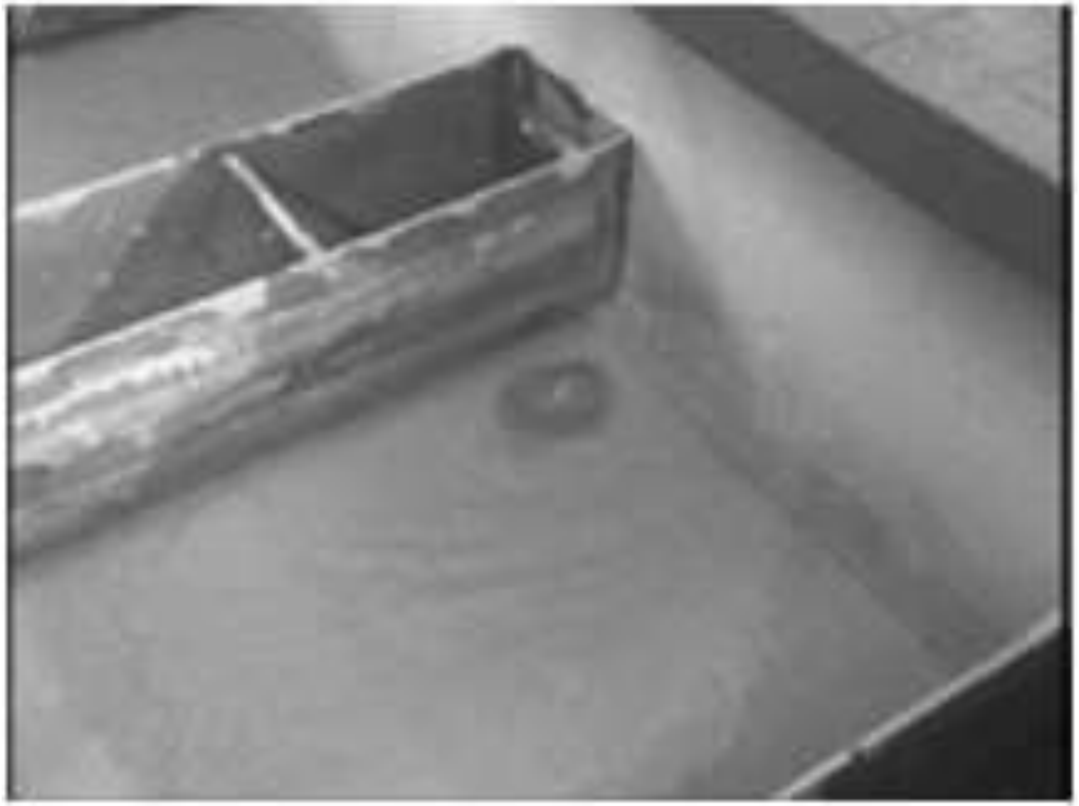
Abnormal Conditions

Media cracked or shrinkage



Abnormal Conditions

Media boils during backwashing



التقييم المبدئى لاداء محطات تنقية مياه الشرب

المرشحات :

- رؤية رمل الترشيح بوضوح (شفافية المياه)
- ملاحظة الطفو الزائد over flow
- ملاحظة نظافة الحوض
- ملاحظة ندرة كور الطمى mud ball
- ملاحظة قلة الندف حيث ان 90% منها يجب أن يكون بالمروقات .
- انتظام الغسيل العكسى للمرشح

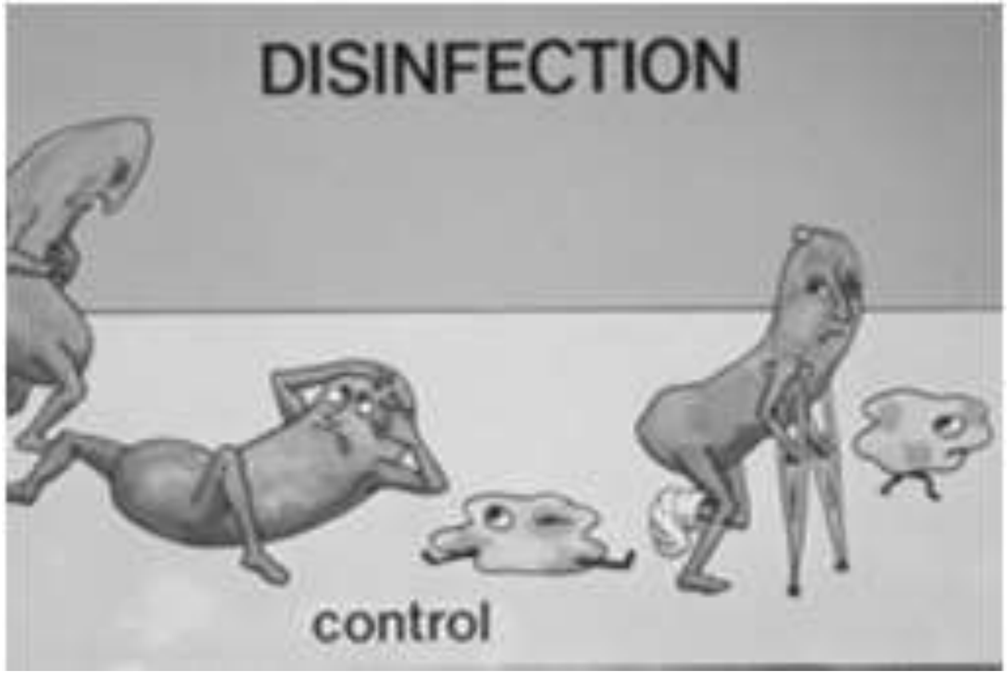
Disinfection

Disinfection or Sterilization !!

Disinfection

□ Disinfection – the destruction of **pathogenic organisms**

- To prevent waterborne disease outbreaks
- Destroys only disease-causing organisms

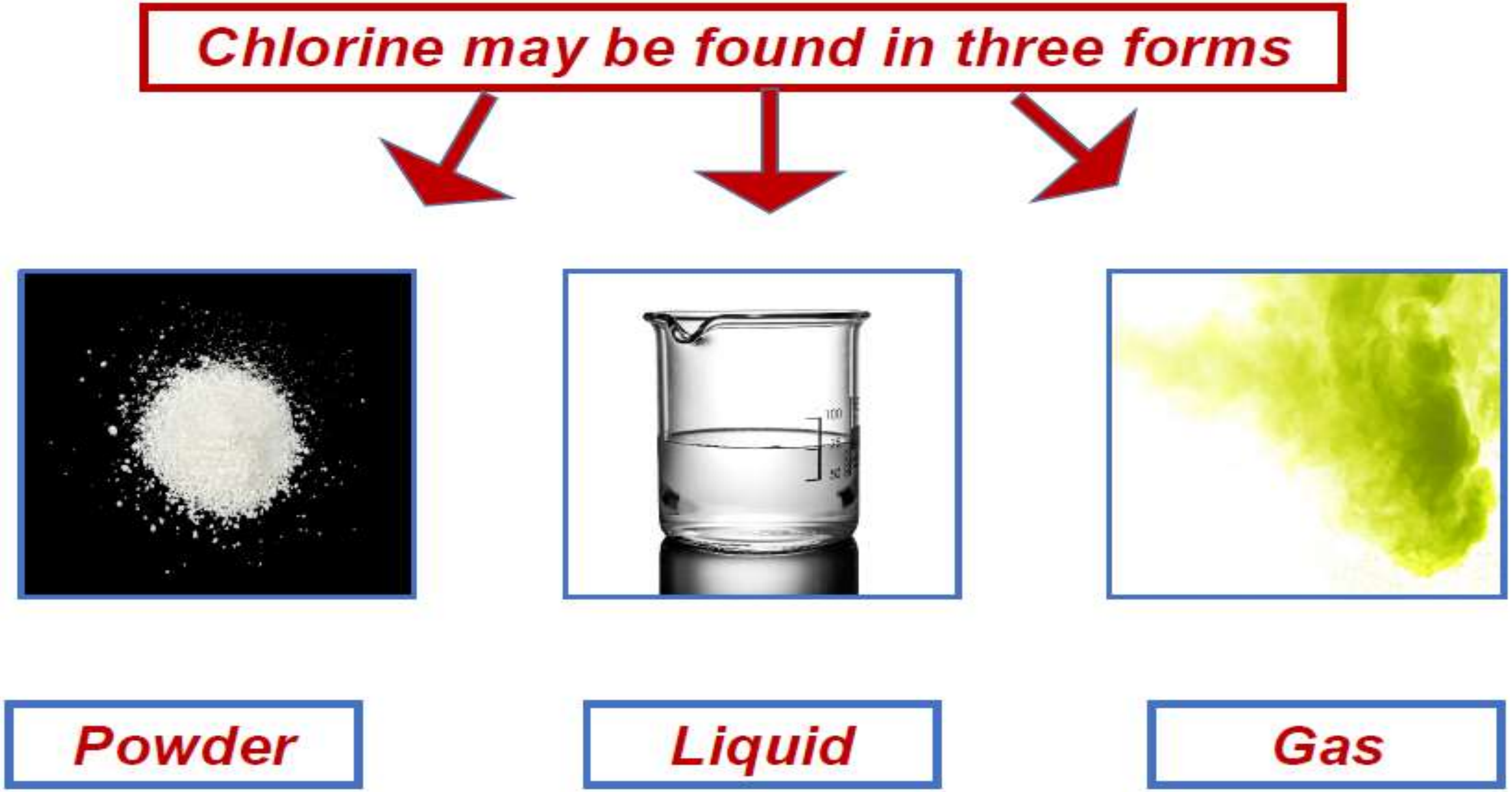


Sterilization

□ Sterilization :

- the destruction of **all organisms** in the water
- Not all microorganisms are bad!

Chlorine



How to express the strength of chlorine

- Chlorine **gas** typically contains **pure chlorine**

- Chlorine powder and liquid do not contain pure chlorine
  - are mixed with other substances (e.g., calcium, sodium or water)

- The strength of chlorine in chlorine powder or chlorine liquid is referred to:
  - as the Concentration of chlorine in that substances.

    (**percentage (%) of active chlorine present**)

Chlorine (Gas)

Chlorine Gas (Cl2):

- Greenish-yellow color
- 2.5 times as dense as air
- Pungent, noxious odor
- Highly irritating to eyes,nasal passages, and respiratory tract
- **Strength**: Approx. 100 % active chlorine
- **Stability**: Most stable

Chlorine (Liquid)

Hypochlorite (Liquid)

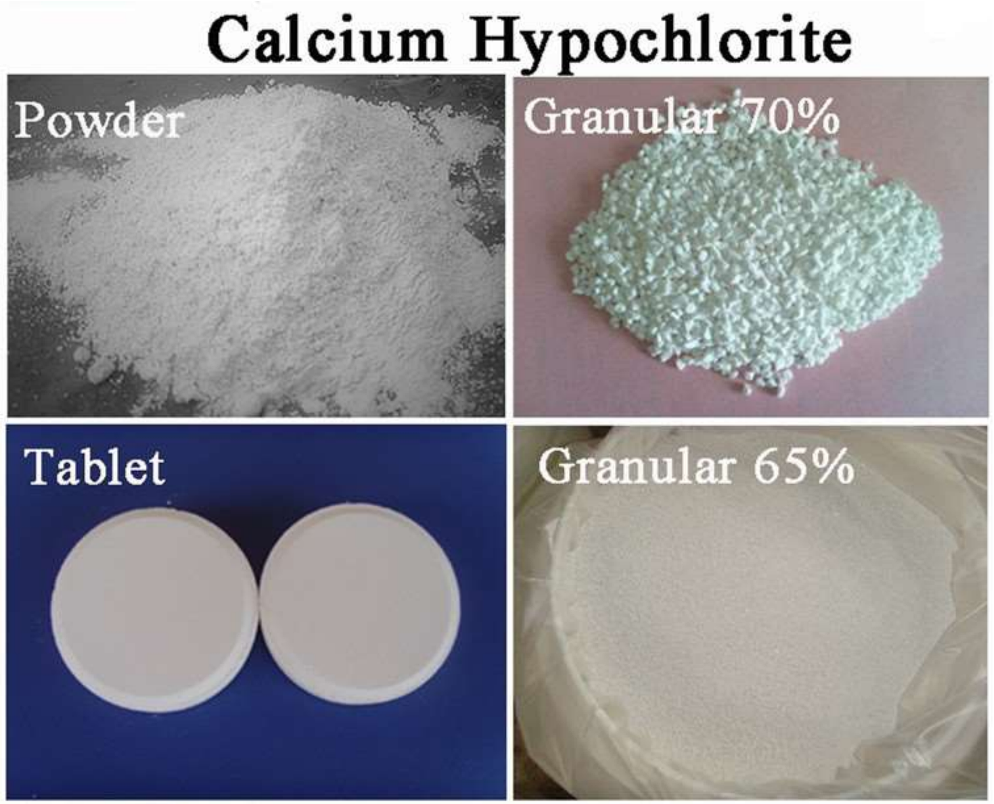
- **Sodiuim hypochlorite (NaOCl)**
- Bleach
- Clear, light-yellow color
- Costs 3 times as much as chlorine gas
- Shelf life of 60-90 days
    - 5.25% chlorine : Clorox
    - 12.5% chlorine : Pool bleach

Chlorine (Solid)

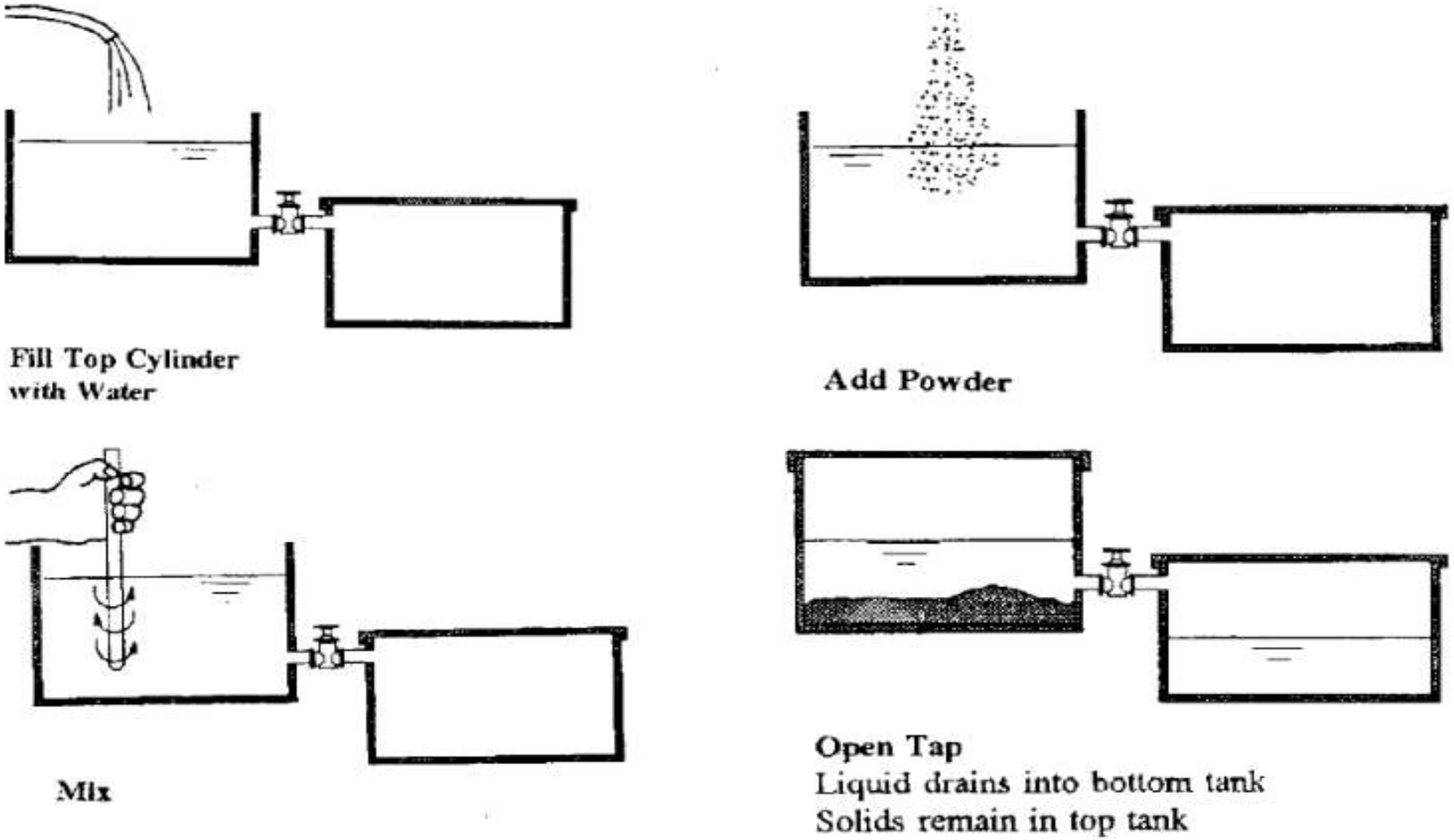
Hypochlorite (Solid) :

- **Calcium hypochlorite [$Ca(OCl)_2$]**
- Solid, granular or tablet
- White or yellow-white in color
- Most dangerous – fire hazard
- 65% pure – High Test Hypochlorite (HTH)

- **Strength:** Typically 30 to 70 % active chlorine
- **Stability:** May lose strength over time;



Preparing chlorine liquid from chlorine powder



Powder & liquid chlorine may lose strength over time

Chlorine liquid solutions are generally less stable than chlorine powder (i.e., lose strength more quickly)

Type of chlorine (approx. % active chlorine concentration)		Loss of initial active chlorine concentration (%)[1, 2, 3]
Chlorine powder	Bleaching powder (35 %)	5 to 18 % after 40 days
	High test hypochlorite (70 %)	
Chlorine liquid	Sodium hypochlorite (15 %)	50 % after 100 days
	Sodium hypochlorite (10 %)	50 % after 220 days
	Sodium hypochlorite (5 %)	50 % after 790 days

How to calculate the required amount of chlorine powder

Weight of chlorine powder (mg/L) =

$$\frac{1\,000 \times \text{Volume of chlorine liquid required (L)} \times \text{Desired chlorine liquid concentration (\%)}}{\text{Active chlorine concentration in the chlorine powder (\%)}}$$

Example:

$\Rightarrow$ **Require 500 L of chlorine liquid solution**

$\Rightarrow$ **Require chlorine liquid concentration to be 2 % active chlorine**

$\Rightarrow$ **Using bleaching powder (35 % active chlorine), then using Eq. 4:**

$$\text{Weight of chlorine powder (mg/L)} = \frac{1\,000 \times 500\ \text{L} \times 2\ \%}{35\%}$$

$$= 28\,571\ \text{g (or 28.6 kg) per 500 L of water}$$

Chlorine dose rate

‘Chlorine dose rate’ means how much chlorine liquid solution you are adding to the water over time .

May be measured in various ways

⇒ **mL** per second

⇒ **mL** per minute

⇒ **L** per hour

How to calculate the chlorine dose rate

$$\text{Chlorine Dose Rate (mL/h)} = \frac{\text{Required chlorine dose (mg/L)} \times \text{Treated water flow rate (m}^3\text{/h)}}{\text{Chlorine liquid concentration (\%)} \div 100}$$

Example:

⇒ **Require 3 mg/L chlorine dose (see Eq. 3)**

⇒ **Flow rate at the water treatment plant is 100 cubic meters per hour (100 m^3/h)**

⇒ **Chlorine liquid concentration is 2 %**

$$\text{Chlorine Dose Rate (mL/h)} = \frac{3\ \text{mg/L} \times 100\ \text{m}^3\text{/h}}{2\ \% \div 100}$$

$$= 15\,000\ \text{mL/h (or 250 mL/min)}$$

How to calculate the actual chlorine dose

Actual Chlorine Dose (mg/L) =

$$\frac{[\text{Chlorine dose rate (mL/h)} \times \text{Chlorine liquid concentration (\%)}] \div 100}{\text{Flow rate } (m^3/h)}$$

Example:

⇒ **Chlorine dose rate is 6 000 mL/h**

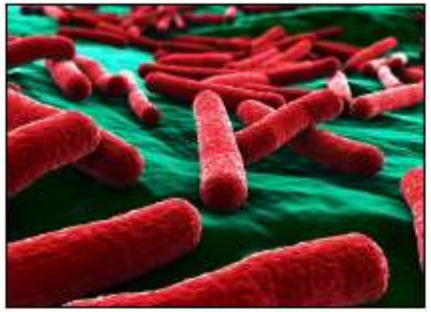
⇒ **Chlorine liquid concentration is 2 % (see Eq. 4)**

⇒ **Flow rate at the water treatment plant is 100 cubic meters per hour (100 m^3/h)**

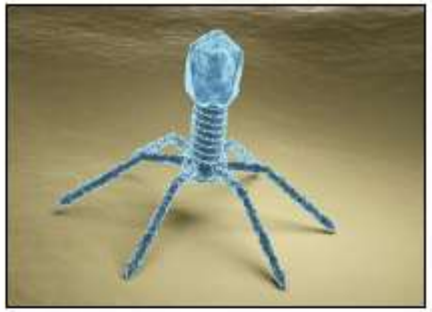
Actual Chlorine Dose (mg/L) $= \dfrac{(6\,000 \text{ mL/h} \times 2\ \%) \div 100}{100\ m^3/h}$

$= 1.2$ **mg/L**

Relative effectiveness of chlorine



BACTERIA



VIRUSES

PROTOZOA

MOST EFFECTIVE EFFECTIVENESS OF CHLORINE LEAST EFFECTIVE

Chlorine dose

- Usually expressed as milligrams per litre (**mg/L**).

- for example,
  - if drinking water has a chlorine concentration of **1 mg/L**,
  - this means that there is **1 milligram** of chlorine present in **1 litre of water**

Chlorine chemical reactions

$Cl_2 + H_2O \leftrightarrow HOCl + HCl$

(chlorine gas) (water) (hypochlorous acid) (hydrchloric acid)

$NaOCl + H_2O \leftrightarrow HOCl + Na(OH)$

(sodium hypochlorite) (water) (hypochlorous acid) (sodium hydroxide)

$CaOCl + H_2O \leftrightarrow 2HOCl + Ca(OH)$

(calcium hypochlorite) (water) (hypochlorous acid) (calcium hydroxide)

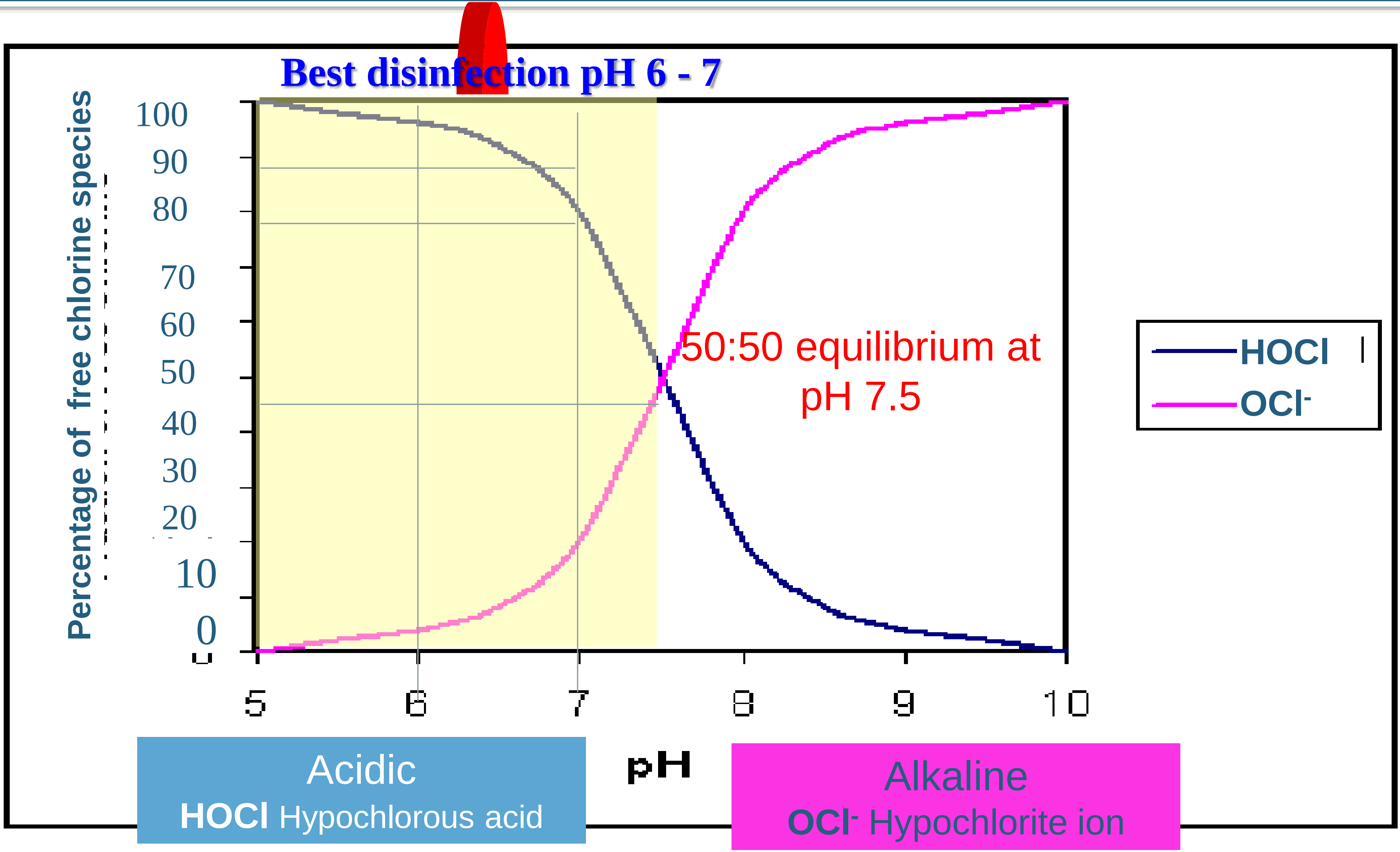
Chlorine chemical reactions

Under normal water conditions, hypochlorous acid will also chemically react and break down into a hypochlorite ion (**OCl^-**):

$$\underset{\text{(hypochlorous acid)}}{HOCl} \leftrightarrow \underset{\text{(hydrogen)}}{H^+} + \underset{\text{(hypochlorite ion)}}{OCl^-}$$

The **hypochlorite ion** is a much weaker than **hypochlorous acid**, about 100 times less effective.

Hypochlorous acid (HOCl) VS hypochlorite ion (OCl^-)



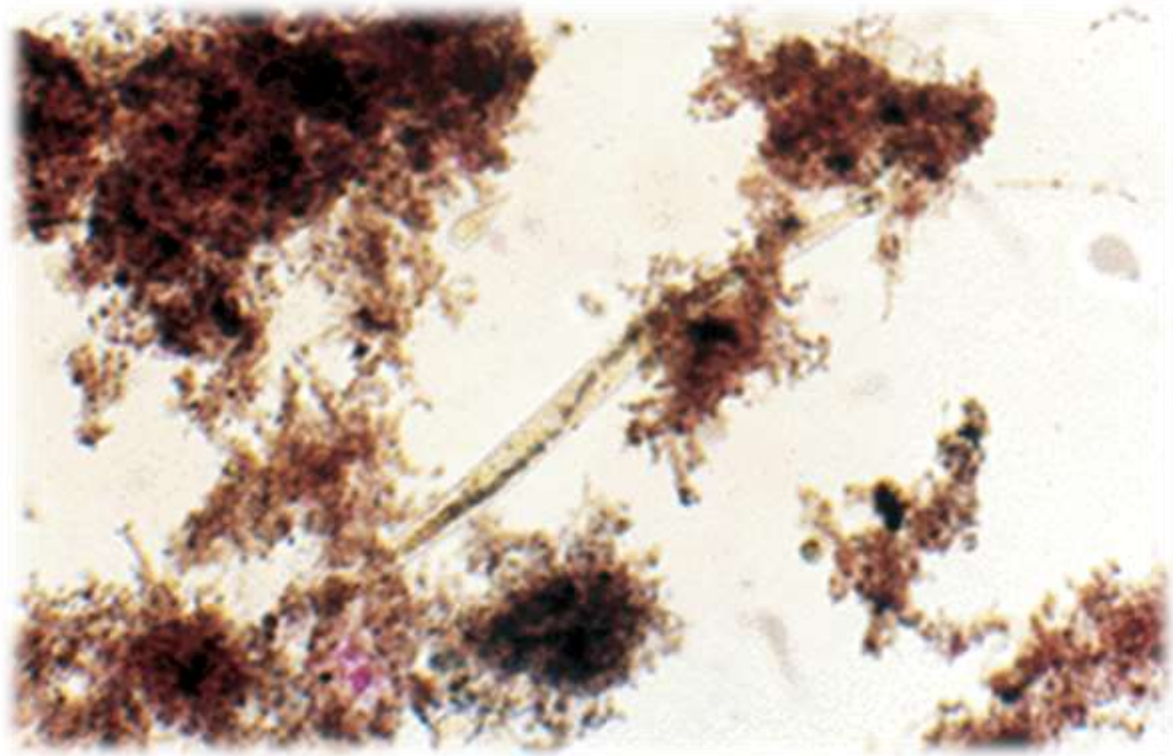
Understanding Chlorination Process

Understanding Chlorination Process

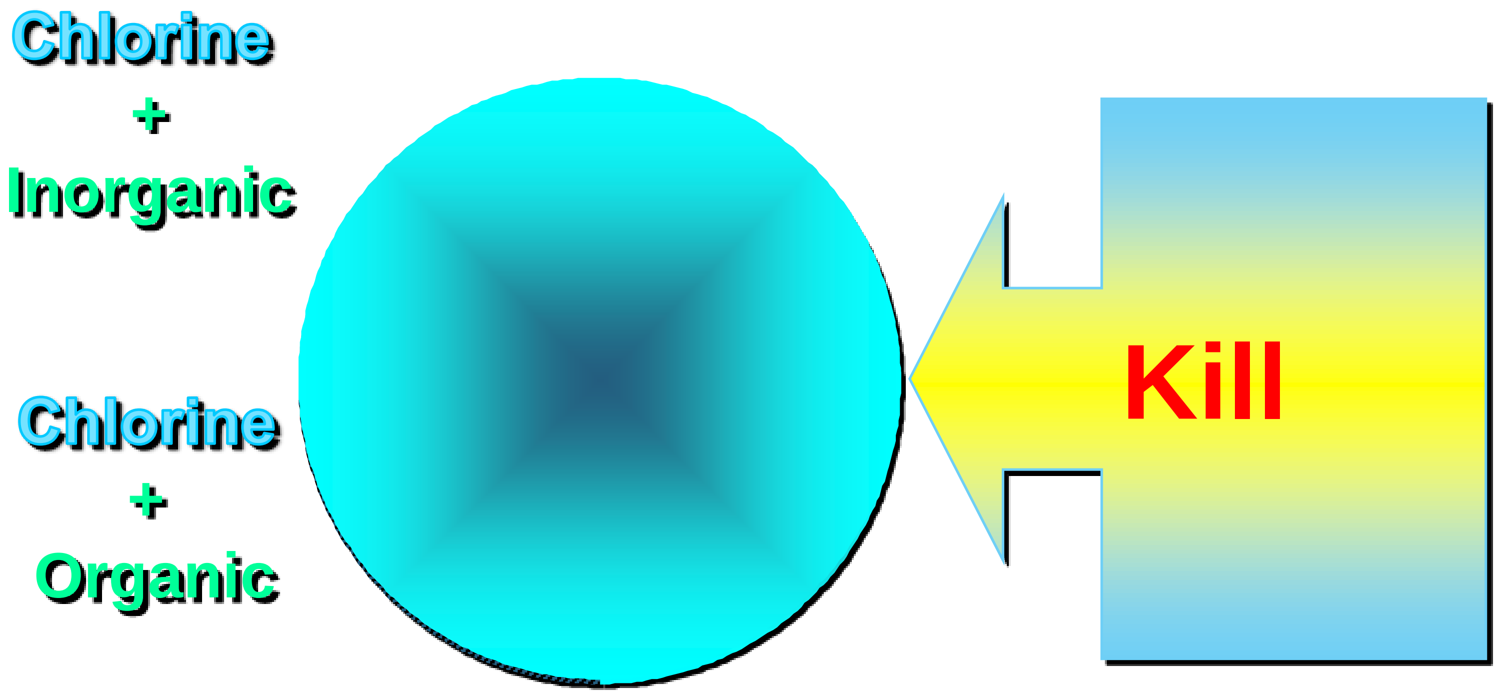
الماء فى الحقيقة :

Inorganic

Organic



Understanding Chlorination Process

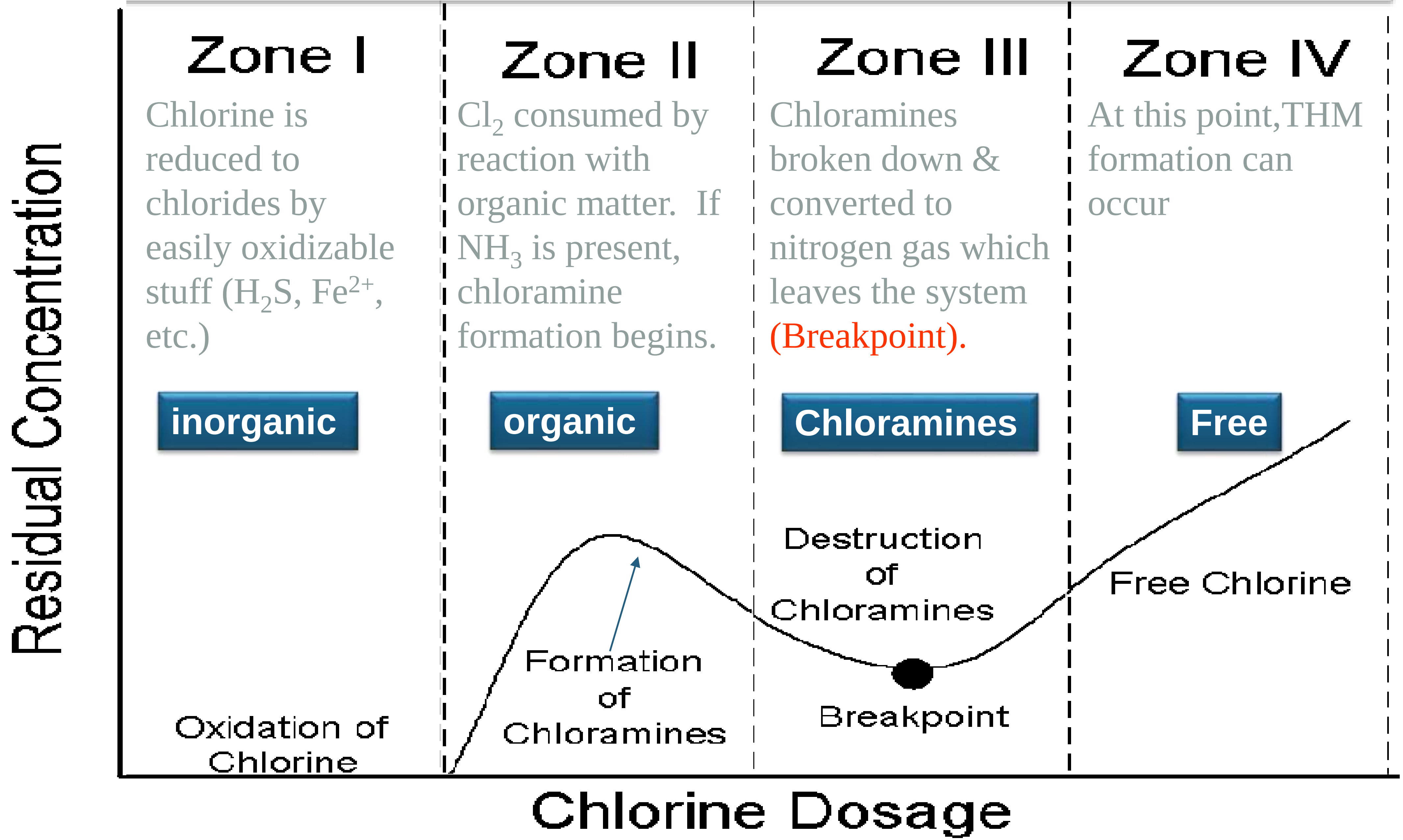


Chlorine Dosage (total added)

1. **Chlorine Demand** (Inorganic)
2. **Combined Residual Chlorine** (Organic)
3. **Free Residual Chlorine**

The “Breakpoint”

The “Breakpoint”



The “**Chloramines**”

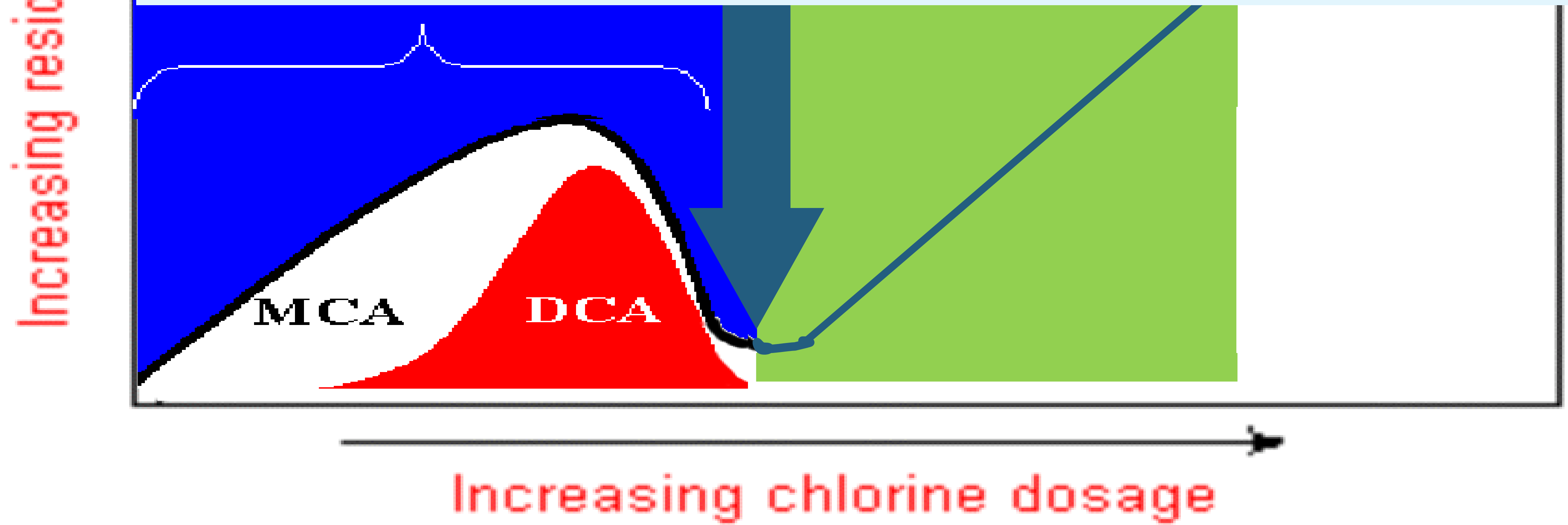
The "Chloramines"

$NH_3 + HOCl \rightarrow NH_2Cl + H_2O$ $(4 < pH < 6)$ ….. (1)

NH_2Cl (mono) $+ HOCl \rightarrow NHCl_2 + H_2O$ $(4 < pH < 6)$ ….. (2)

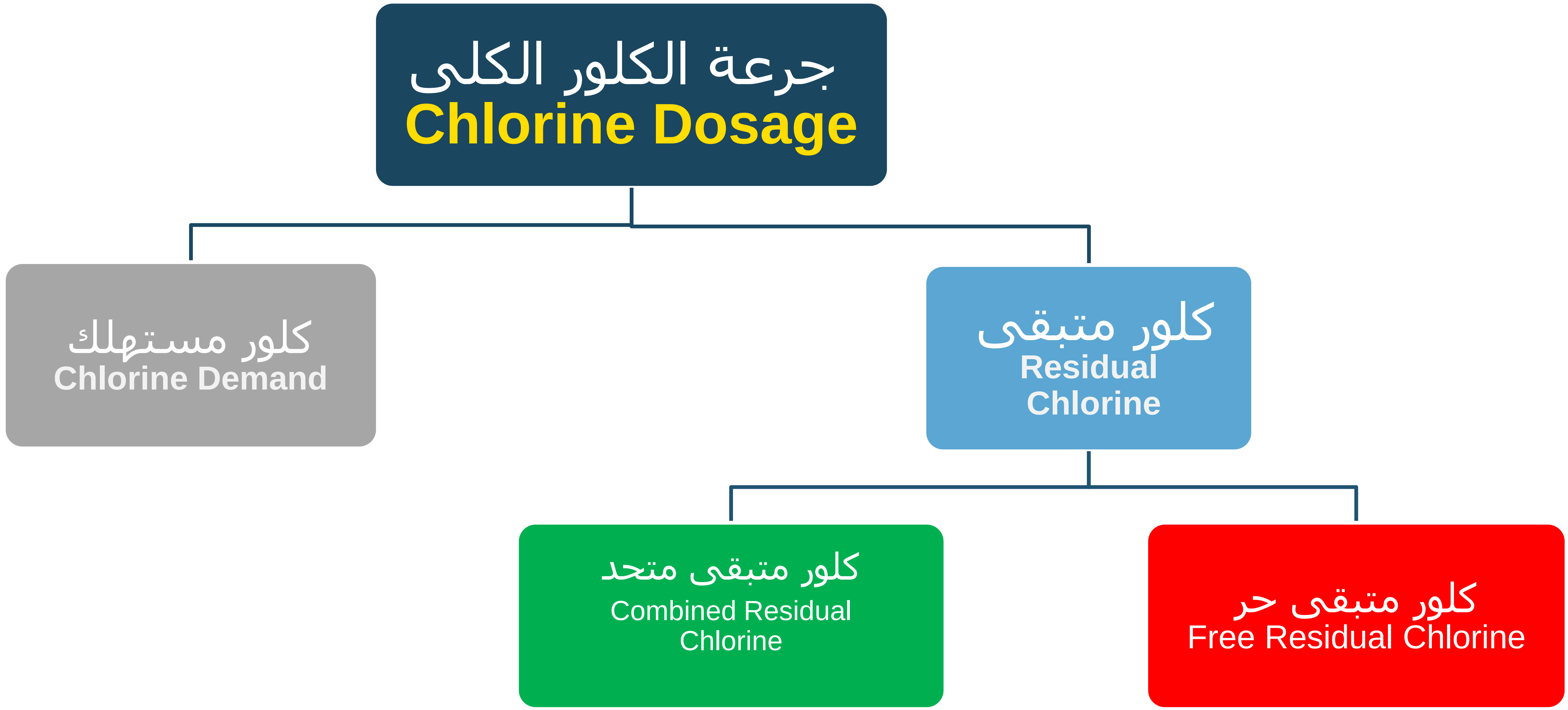
$NHCl_2$ (di) $+ HOCl \rightarrow NCl_3 + H_2O$ $(pH < 3)$ ….. (3)

$2NH_2Cl$ (Tri) $+ HOCl \rightarrow N_2$ (غاز النتروجين) $+ 3\,HCl + H_2O$ ….. (4)

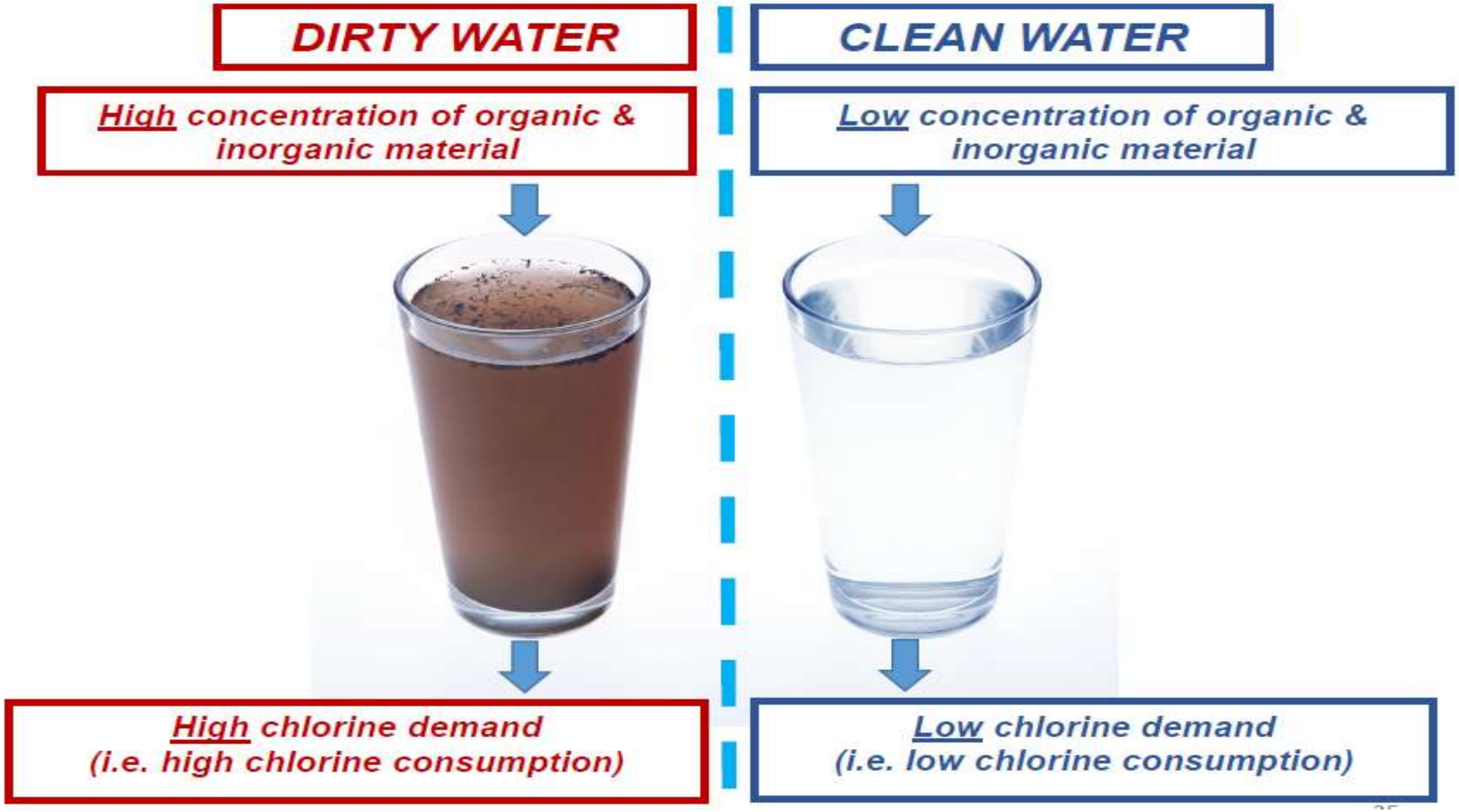


Chlorine Terms

Chlorine Terms مصطلحات الكلور



Relationship between : chlorine demand & chlorine dose



Factors to success of chlorination

Factors to success of chlorination

- Chlorine concentration (C)
- Contact time (T)
- Water temperature
- Water pH
- Foreign substances in water

Ct concept for disinfection

“kill” is proportional to C x T

- Destruction of organisms depends on the

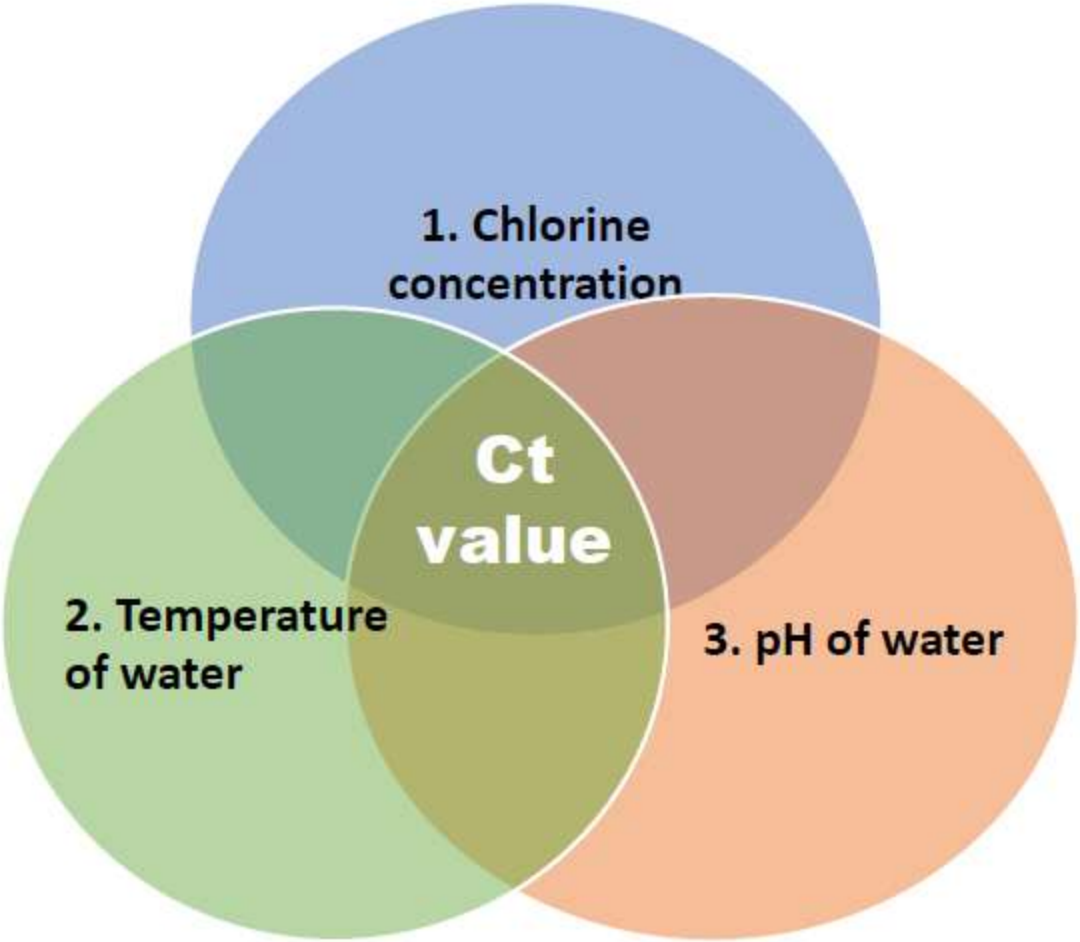
  concentration of chlorine added (C)

  and

  the contact time with the organisms (T)

- If one is decreased, the other must be increased

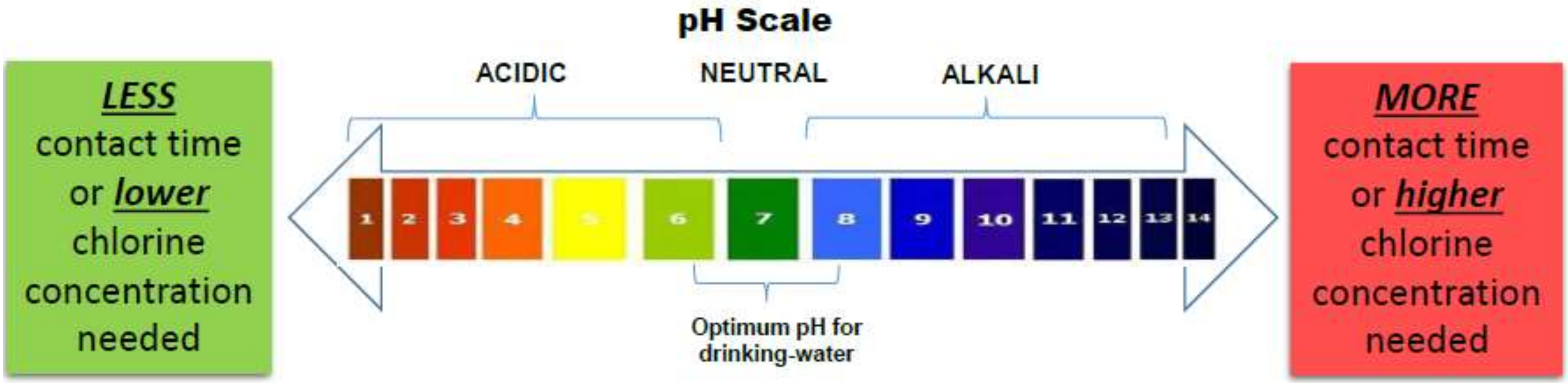
Factors influencing the Ct value



Influence of chlorine concentration

Influence of water temperature

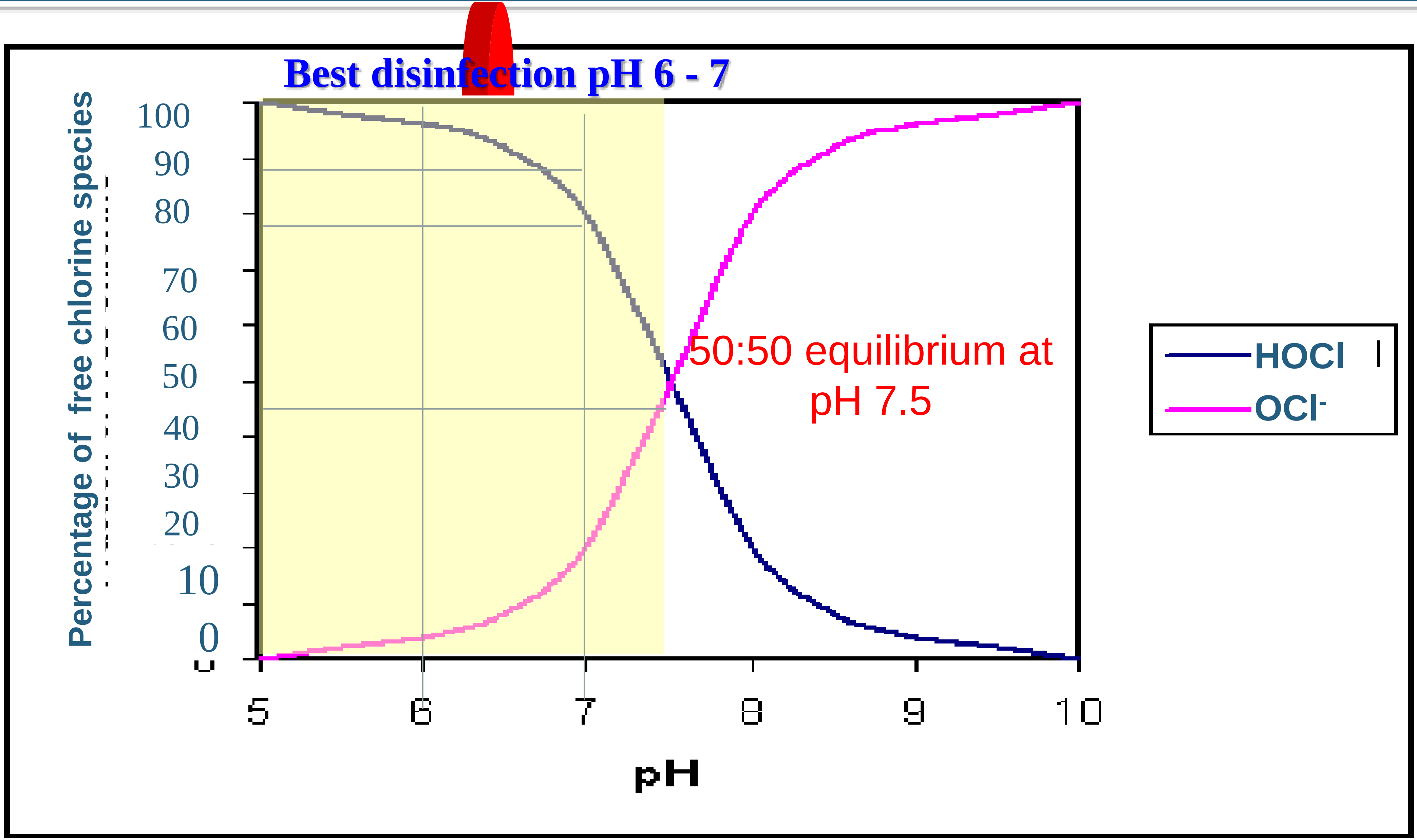
Influence of pH



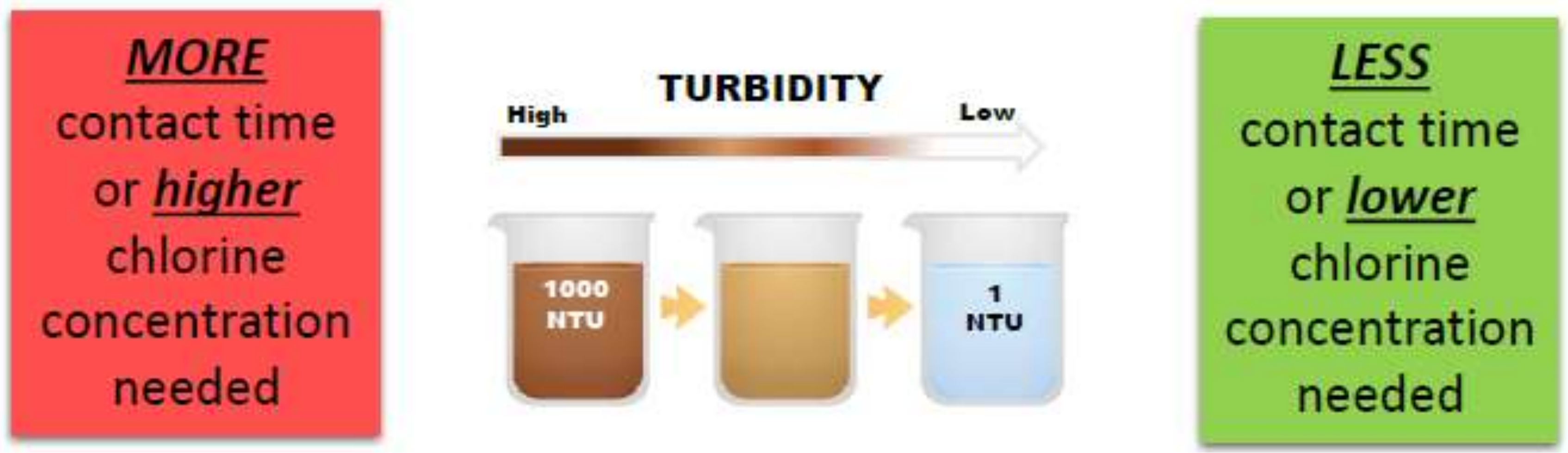
- For effective chlorination, the pH of the water should be **< pH 8.0**

- Where water is >pH 8.0,
  higher chlorine concentrations or **More** contact time will be required!

Free Chlorine Distribution with pH

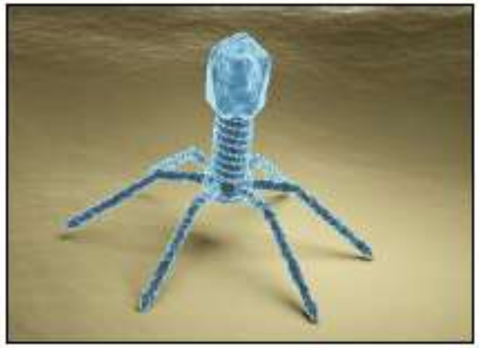


Influence of Turbidity



Influence of microorganisms

BACTERIA



VIRUSES

PROTOZOA

__LESS__ contact time or ***__lower__*** chlorine concentration needed

MOST EFFECTIVE → LEAST EFFECTIVE

__MORE__ contact time or ***__higher__*** chlorine concentration needed

Minimum required contact time for effective disinfection

For effective disinfection, the WHO recommends

*at **least 30 minutes contact time**,*

where the residual chlorine concentration is
≥0.5 mg/L** and the pH of the water is **<pH 8.

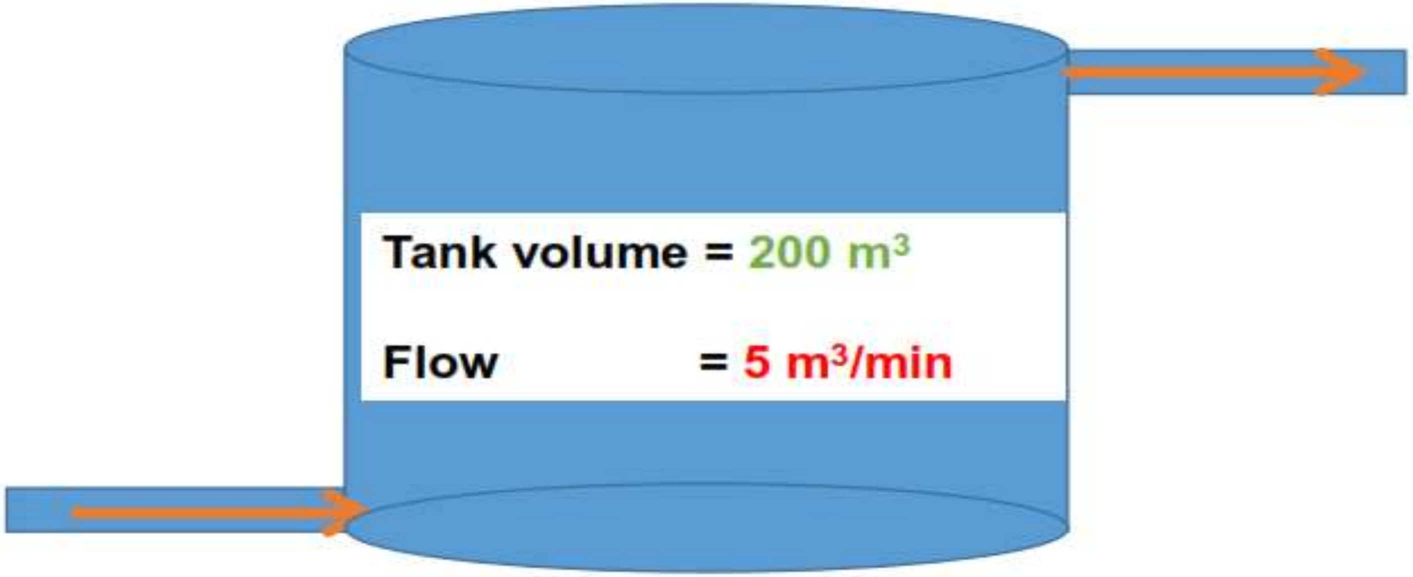
Calculate the Ct value

How to calculate the Ct value

1. calculate the detention time for a storage
2. calculate the Ct value

How to calculate the detention time for a storage

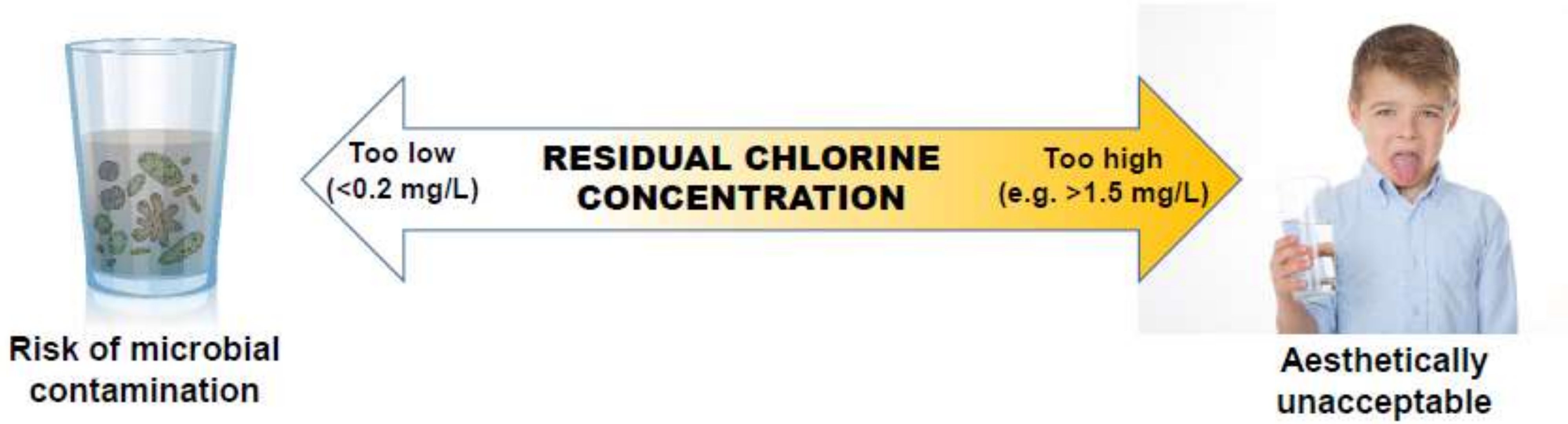
Detention time (min) = Storage volume (m^3) ÷ Flow (m^3/min)



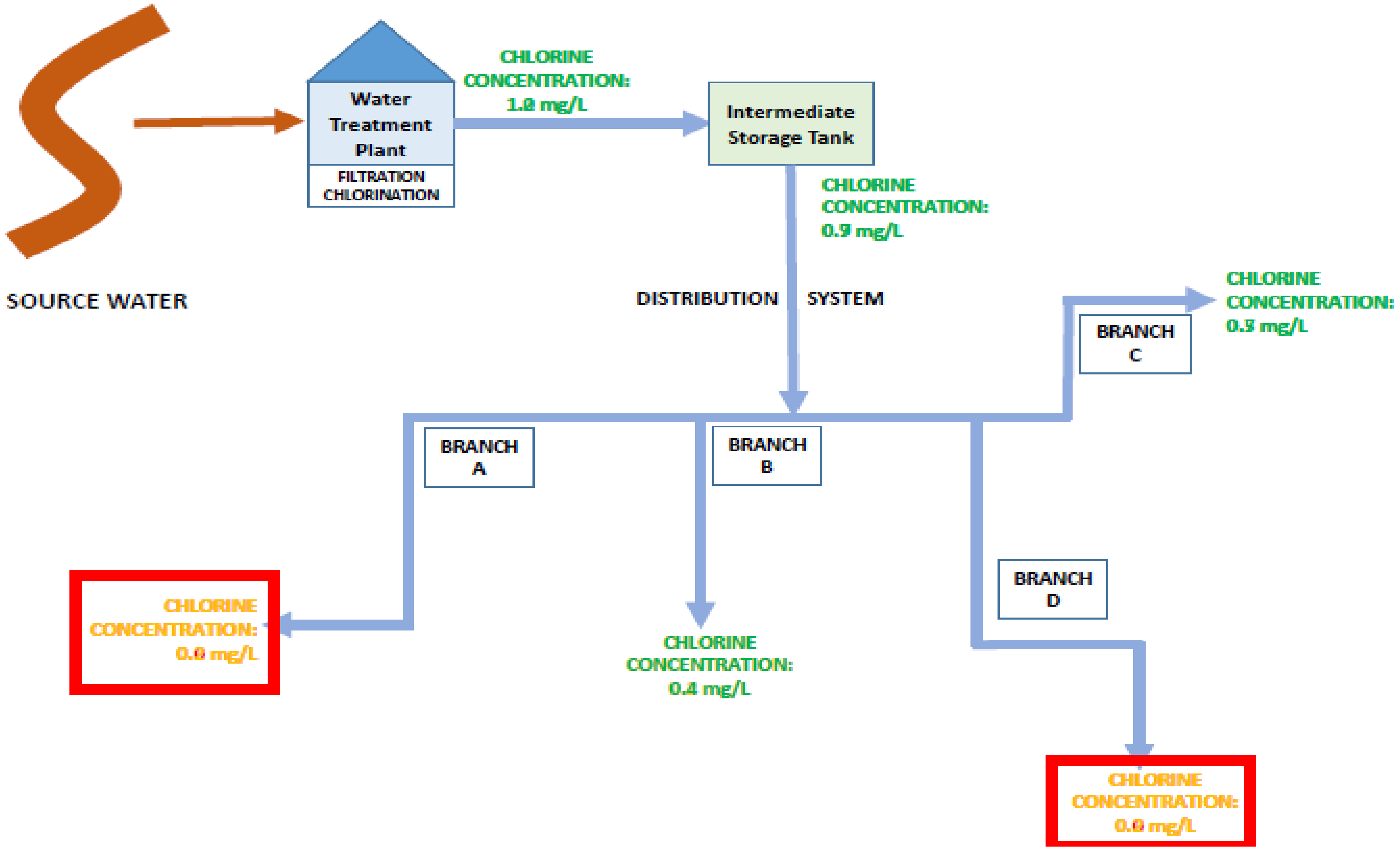
Detention time = 200 m^3 ÷ 5 m^3/min

= 40 min

Optimizing the chlorine dose



Optimizing the chlorine dose



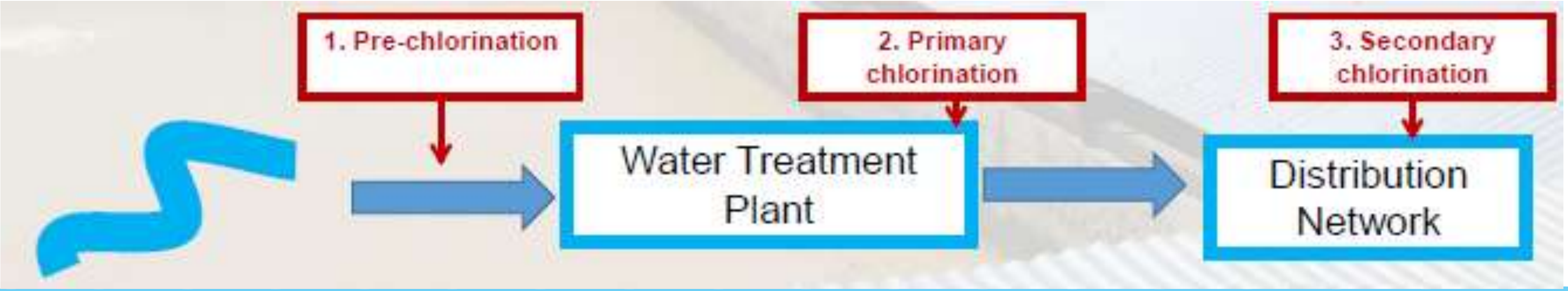
Application Points


PALANDEH AB
FORCE FLOW

Application Points

Chlorine may be added:

1. **Pre -chlorination** (before water treatment plant)
2. **Post-chlorination** (after water treatment process)
3. **Secondary chlorination** (during distribution)
4. **Groundwater systems**



Application Points

Pre-chlorination (*source water chlorination*)

- Begins process of killing or inactivating pathogens
- Minimizes biological growth throughout process
- Oxidizes minerals, gases, organics, etc.
- Increases contact time
- May improve coagulation
- High potential for DBP production

Application Points

Post-chlorination (*terminal disinfection*)

Application of chlorine to treated water

Required to meet state and federal requirements for residual

Applied at or immediately before clearwell

Clearwell must minimize short circuiting to meet C x T values

Application Points

Distribution system (Secondary chlorination)

Some systems may require booster chlorination

Added at storage tank discharge

 Additional application points

 Feeding 2 or more types of disinfectants at different points may help meet requirements

Oxidants other than chlorine can be used early in treatment process to reduce DBPs

Application Points

Groundwater systems

- Often require no treatment other than chlorination
- Apply chlorine just past wellhead

trihalomethanes (THMs)

Organic material + Cl2 = trihalomethanes (THMs) :

- Organics found in all surface and groundwaters
- Humic and fulvic acids from decomposing plant material
- THMs are potential **carcinogens**
- Current MCL for total THM = **0.08 mg/L**

Control Tests

Chlorine residual

- Presence of residual
- Free or combined
- Concentration
- By amperometric titration (most accurate, not affected by color or turbidity) or DPD method
- Bacteriological test
- Indicates fecal contamination

التقييم المبدئى لاداء محطات تنقية مياه الشرب

مياه الخروج

- ملاحظة عدم زيادة جرعة الكلور عن 1.5-3 جرام / لتر فى النهائى.
- راجع وقت التلامس عن طريق مستوى المياه في خزان المياه، مع عمل تقييم للـ " C*T"
- التحكم في الجرعة (كجم/ ساعة) والاستهلاك الشهري
- الكلور الحر المتبقي عند مخرج خزان المياه .... الهدف: الحد الأدنى 0,5 مليجرام/ لتر- الحد الأقصى 1,5 مليجرام/ لتر عند العملاء الموجودين في أول الخط
- ملاحظة الفرق أن يكون الكلور المتبقى فى أول الشبكة وأبعد نقطة فى الشبكة فى حدود 0.5 ملليجرام / لتر.

Water Storage

Water Storage

Purpose

- Equalizing supply and demand
- Increasing operating convenience
- Leveling out pumping requirements
- Decreasing power costs

any
questions...

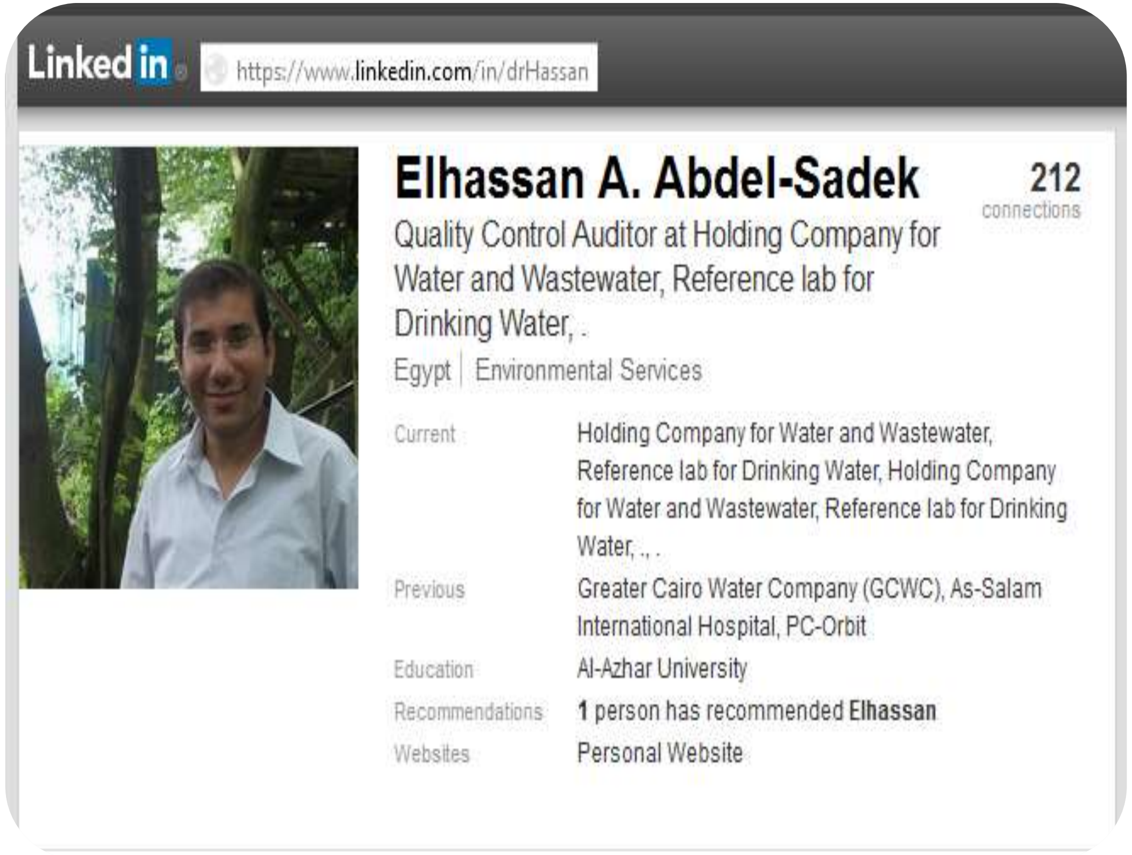
من أقوال الحسن البصري :

" من عمل بما علم ورثه الله علم ما لم يعلم
ووفقه فيما يعمل حتى يستوجب الجنه ،
ومن لم يعمل بما يعلم تاه فيما يعلم
ولم يوفق فيما يعمل حتى يستوجب النار " .

وَاتَّقُوا اللَّهَ ۖ وَيُعَلِّمُكُمُ اللَّهُ ۗ

Thank you

keep in touch:



Linkedin :

https://www.linkedin.com/in/**drHassan**

Facebook: Elhassan Elsadek

Facebook Page: ميكروبيولوجيا المياه – الحسن الصادق