هذه الورقة تحتوي تلخيص شامل

Chapter #24 : B : Drinking water treatment

- Primary goal → Prevention of disease
- Secondary goal → good taste, color, odor / ↓ hardness / meet irrigation & fire protection

[A] Surface water treatment

primary : remove suspended (turbidity) / color
eliminate pathogenic elements
Largely based on coagulation & flocculation
① Direct filtration plant
② Membrane filtration plant.

coagulation - flocculation - sedimentation
screen exist

[B] Ground water treatment

primary : remove hardness / minerals
eleminate pathogenic elements
Largely on chemical precipitation.
* There is aeration

rxn basin - settling tank - recarbonation
no screen

[A] Surface Water

→ Coagulation (0.001 - 1) μm, negatively charged particles → stable suspension (must be oxid. to Fe^{3+} pH 7-8.5)
- ↳ Common coagulants :- Alum ($Al_2(SO_4)_3 \cdot 14H_2O$), $FeCl_3$, $FeSO_4 \cdot 7H_2O$
- ↳ good coagulants :- ↓toxic, inexpensive, insoluble, trivalent, ↓need ↑conc. [metals]
- ↳ Al chemistry optimum pH 5.5 - 6.5 $Al_2(SO_4)_3 + 6HCO_3^- \leftrightarrow \cdots$
- ↳ Fe chemistry optimum pH 4.5 - 5.5 $FeCl_3 + 3HCO_3^- \leftrightarrow Fe(OH)_3 + 3CO_2 + 3Cl^-$

→ Flocculation, slow mixing
- ↳ Flocculation chemical (coagulant-acids) :- ① inorganic : poly(Al) chloride
  ② synthetic acrylic ③ naturally starch, jojoba, protein, gums < sodium arginate
- ↳ Flocculation units : < rpm, water velocity 0.5 - 1.5 ft/s, at least 20 min - detention

→ Determining coagulant dose & optimum pH : Jar test (for both)
by plotting turbidity remaining with pH or coagulant dose to get the optimum point.
it simulate coagulation & flocculation processes.

→ Sedimentation → Flocs : scraped and vaccumed off the bed of large sedimentation tank.
- effluent 1 - 10 NTU
- clarified water : drains out in a giant decanting process

→ Filtration → Desired effluent < 0.3 NTU
- ↳ Slow sand Filter (depends on plant size / water volume) dp 0.15 - 0.35 mm ↓bacteria & viral to greater degree, (occasionally) back wash, top 1" scraped
- ↳ rapid sand Filter 0.45 - 1m layer dp 0.4 - 1.2 mm, frequent back wash, fast, ↓ area
- Typical gravity filter

→ Disinfection, by chlorine OR (now) chloramine OR ozone.
- residual disinfectant is left to prevent reinfection.
- chlorine → can form harmful by products
  has the following functions : taste & odor control like oxidizing agent / oxidation of Fe^{2+} Mn^{2+} / ammonium removal / slime, biofouling control.
  in ground water, in domestic water

↳ Disinfectants → Cl_2 gas → common, advant.: provide residual, disadv.: byproduct
- ClO_2 → no by products (no trihalomethanes).
- $Ca(ClO_2)$ → safer than Cl_2
- ozone → generated on site
- UV lamps

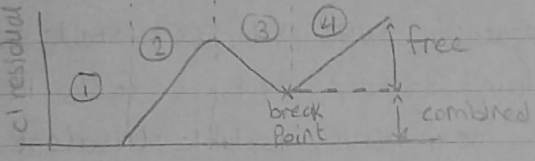
↳ chemistry of chlorine in water $Cl_2 + H_2O \rightarrow H^+ + Cl^- + HOCl$ (weak acid)

↳ free available chlorine $\{HOCl, OCl^-\}$

chloramines ← combined available chlorine $\{NH_2Cl, NHCl_2, NCl_3\}$ weaker disinfectants but are desired residual chlorine to go to distribution system

- small amount of ammonium NH_4^+ is added, not excessive because it consume excess demand of Cl_2.

↳ chlorine demand or breakpoint chlorination.



① chlorine removing by reducing organic
chloroorganic & chloramine → formation ② destruction ③
④ formation of free chlorine

↳ Disinfection CT* concept [CT] = (mg/L)·min → concentration * contact time
inactivation is a function of contact time, conc., pH, temperature

CT = 0.9847 C* 0.1758 pH * 2.7519 temp * − 0.1467

- ↓ contact time if: ↓pH ↑temp. ↑concentration
- The weaker the disinfectant the higher CT needed to inactivate a microorganism
- Insteed of CT (min.) → IT (sec.) for UV light I & light intensity mW/cm² → IT & mJ/cm²

B → Ground water softening

↳ principal cations and anions in decreasing order of abundance in natural H_2O
- cations Ca^{2+} Mg^{2+} Sr^{2+} Fe^{2+} Mn^{2+}
- anions HCO_3^- SO_4^{2-} Cl^- NO_3^- SiO_3^{2-} (non carbonate)

Ion exchange softening

↳ Total, carbonate, non carbonate hardness
Temporary (Ca^{2+}) Permanent

→ Water softening methods (hardness removal)

↳ ion exchange ↳ reverse osmosis ↳ chemical precipitation (common)

↳ chemical precipitation → by Lime Soda [$Ca(OH)_2$ - Na_2CO_3] process

↳ lime only process (present just as carbonate)

$Ca(HCO_3)_2 \rightarrow CaCO_3$ $Mg(HCO_3)_2 \rightarrow MgCO_3 \rightarrow Mg(OH)_2$

↳ lime soda process, CO_2 will also consume lime

$MgSO_4 \rightarrow Mg(OH)_2 + CaSO_4 \rightarrow CaCO_3$

↳ benifits: removal of other metals / excess flouride / prevention of corrosion / inactivation / reduction of solid, turbidity, TOC (total organic carbon).

→ Distillation process

chlorine removing by reducing org

chloroorganic & chloramine ⇒ formation

destruction

formation of free chlorine

ng/L). min → concentration * contact

ne, conc., pH, temperature

np * - 0.1467

centration

CT needed to inactivate a microo

ght intensity mW/cm² → LT s mJ/c

ng order of abundance in natural

↳ softening reaction

$Na_2R + Ca(HCO_3)_2 \leftrightarrow$

$CaR + 2NaHCO_3$

↳ Regeneration reaction

$CaR + 2NaCl \leftrightarrow$

$Na_2R + CaCl_2$

CHAPTER #5 : Conventional Waste water / Biosolids treatment and management

CHAPTER #5 A : Conventional waste water treatement

- main objective : reduce pollutent to a level such that → returned without stress, quality
  → reused for regulated purpose
- process block diagram
- design methods
  loading criteria, impirical equations, derived equat

considerations for WWT plants
The final slide in 5A

- preliminary operations
  - ↳ bar racks : cleaned mechanically or manually, spacing 0.5 - 3.4 cm
  - ↳ grit removal by gravity settling, grit chambers are relatively small, ↓V effective tank & thus treatment effectiveness
- primary sedimentation collected in hoppers and removed
  1/3 BOD5, 2/3 SS usually removed in conventional primary sedimentation.
  - ↳ rectangular clarifier
  - ↳ circular clarifier
- secondary treatment organic matter ($C_cH_hN_n$) + O_2 + enzymes → $CO_2 + H_2O + NH_3$ + biomass cells
  objective is to allow the BOD to be exerted in the treatment plant rather than in the stream

↳ Aerobic conditions	↳ Anoxic conditions	↳ Anaerobic conditions
aerobic respiration	anaerobic respiration	Fermintation
e^- acceptor $O_2 \rightarrow H_2O$	e^- acceptor $NO_3^- \rightarrow NO_2^-$ → $N_2 + H_2O$	e^- acceptor → generated by microorgan.
good for → large V waste water → < 500 mg BOD/L		good for concentrated waste (> 1000 mg BOD/L)
more stable end product		complex → L.M.W fatty acids → $CH_4 + H_2O + CO_2$
↑ growth rate, ↑ sludge production	relatively ↑ sludge production	↓ sludge production

- Common aeration techniques & equipments
  1. Diffused bubble 2. Mechanical / surface 3. Floating accelerator 4. brush accelerat
- Basic ingredients & conditions in bioreactor
  ↑ conc. of microorganisms, good contact, ↑ aeration, optimum growth conditions, ∝ toxic
- Biological growth types
  - ↳ Dispersed (suspended) growth
    bacteria in suspension by mixing
    sludge age is controlled < reactor volume / biomass recycle
    e.g. on processes: Activated sludge, aerated lagoons, stabilization / Facultative ponds (natural aeration)
  - ↳ Fixed (attached) growth
    bacteria are attached or entrapped
    long sludge age at low HRT which is good
    trickling filters, rotating biological contactors (RBC), membrane biological reactor (MBR)

Activated sludge schematic process :-
microbal growth Functions : oxidize waste water, assimilate most colloidal & soluble organics.

- The activated sludge process (الوحدة المنشأة)

Biosolids treatment and management

waste water treatement

such that → returned without stress, quality
↓
reused for regulated purpose

1. Flow rate & composition
2. domestic & municipal
3. distance from residential areas
4. agricultural usage
5. Pathogens presence
6. space
7. standards
8. experience d design engineering
9. cost
   - capital
     - purchase
     - installation
   - operation & maintanance including energy

• final (secondary) settling ترسيب ورقة الثانوية

- Functions : 1. clarification 2. settling

- filamentous bulking as ↑MLSS ↓SVI ↑better settling (e.g strong bacteria (90x) ✓ SI

mixing is not good

slow settling. Causes: ↓ F/M ↓nutrients ↓dissolved O_2 ↑sulfide Treatment: chlorine, hydrogen peroxide

→ Variations of ASP

1. conventional activated sludge plant
2. completely mixed activated sludge flow
3. extended aeration activated sludge
4. contact stabilization activated sludge.

it improves the efficiency of primary tank but may deprive biological process.

Phosphorus Removal

→ Waste water treatment

↳ oxidation detch ↓rate, suspended growth, intermittently / continuously, small communities, high space

↳ aerated lagoons suspended growth, completely mixed, no recycle, time related to θ, effluent quality lim

↳ ~~fallative~~ ponds facultative — common for small communities, popular because long θ with no effect on effluent quality, capital & operating & maintainance cost are less

bottom → top

↳ anaerobic layer — does not required O_2 — use chemical species — acid fermentation $C_xH_yO_z$ → CH_3COOH — methane fermen. CH_3COOH → $CO_2 + CH_4$

↳ Facultative zone — available not all the time — natural aeration & algae role — aerobic → daylight, anaerobic → darkness

↳ aerobic zone — present at all times — oxygen supplies from 2 region — limited → diffusion — majority → algal photosythesis

↳ attached growth systems Biofilm is used in TF & RBC (biological slime layer ...)

↓ Trickling Filters (packed bed) (Packed tower) named for plastic media / Englan 1893

Plastic media: larger surface area, lighter than rock

- consist of → rotating arm: sprays wastewater → water is collected at the bottom of filter for further treat.
- Filter medium < rock / plastic
- plug flow mode, design based on specific surface area, aeration by < induced / forced draft
- under high organic loading, the slime growth can plug the filter in rock trickling filter
- classified by < hydraulic ($m^3/m^2.day$) / organic (Kg BOD5/m^3.day) loading.

- Recirculation to: ↑contact efficiency, ↑DO by mixing, damper variation in loading.

↓ RBC, RBD

- drum diameter 3-4m, 1.5rpm speed, ∅ recycle, maybe several stages, requires piloting.
- shaft: 8m with 7.5 by media - media: HDPE - drive system: mechanical drive
- typical side water 1.5 m depth 40% submerged - settling tank similar to TF
- operating problems: shaft failure, media breakage, bearing failure, odor problems.

→ membrain bioreactor in WWT

↳ P removal

↳ N control ① nitrification / denitrification (Bio.)

② ammonia stripping (chemically)

② by ↑pH (adding lime)

$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$

lime produce $CaCO_3$ - premove period.

NH_3 can be stripped by passing large quantities of air through water

Nitrogen control

ttling ارجوك ورقة القوانين

ation 2- settling

as ↑MLSS ↓SVI ↑better settling (e.g strong bacteria (low ox)

FM ↓nutrients ↓dissolved O_2 ↑sulfide Treatment < chlorine hydrogen

- Phosphorus found as HPO_4^{-2}
- removal of phosphorus to ↑ Prevent reduce eutrophication by chemically precipitation ↑ $FeCl_3$ / $Al_2(SO_4)$ / $Ca(OH)_2$
- $FeCl_3$ & Al_2SO_4 → ↓pH → 5.5-7 pH
  $Ca(OH)_2$ → ↑ pH → if not enough alkanity
- precipitation requires ↑ rxn basin / settling tank
- $FeCl_3$ & Al_2SO_4 may be added to aeration tank but not possible with $Ca(OH)_2$ since the high pH required to form precipitate is detrimental to organisms
- $FeCl_3$ & Al_2SO_4 in sometimes added before primary sedimentation tank

ed sludge plant

ivated sludge flow

activated sludge

activated sludge.

ent

rate, suspended growth,

spended growth, completely

common for small com

on effluent quality,

layer

wired

species

thane fermen.

$_3COOH$

$CO_2 + CH_4$

available not all the time — present at all time

natural aeration & algae role — oxygen supplies from 2

↑ aerobic → daylight — limited ↔ majority

anaerobic → darkness — diffusion algal ph

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DO by mixing, dampen variation in loading.

maybe
cle, several stages, requires piloting.
: HDPE - drive system: mechanical drive
emerged - settling tank similar to TF
a breakage. bearing failure odor problems.

- can be in any form (except N_2)
- removed to help algae growth
- ammonia → toxic to fish
  exert oxygen demand

① maybe in ASP but θ_c > 15 day or mor
- nitrifying bacteria is required
  $NH_4^+ + O_2 \rightarrow NO_3^- + H_2O + 2H^+$
- if nitrogen level → not of concern → discharge after settling
  of concern → anoxic denitrification bacteria
- organic matter for denitrification (energy) & some times to rapid nitrification.
  organic matter → raw settled sewage → effect quality
  methanol