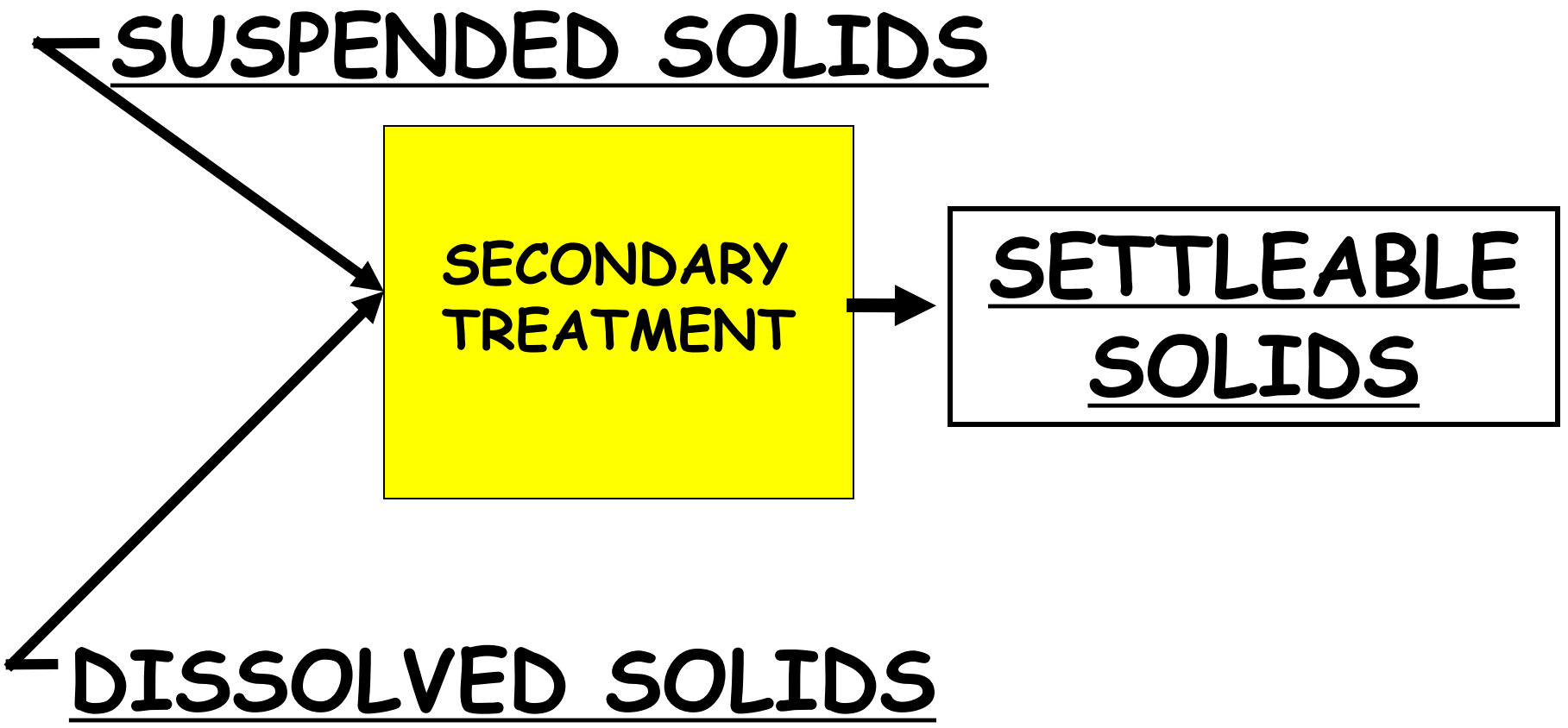
ROTATING BIOLOGICAL CONTACTORS

REVIEW


SUSPENDED SOLIDS
SECONDARY TREATMENT
SETTLEABLE SOLIDS
DISSOLVED SOLIDS

SECONDARY TREATMENT

- WASTE TREATMENT PONDS
- TRICKLING FILTERS
- ROTATING BIOLOGICAL CONTACTORS (RBCs)
- ACTIVATED SLUDGE

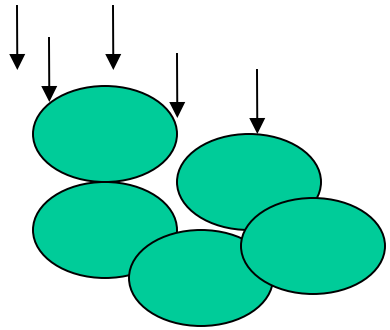
RBCs ARE FAIRLY RECENT TECHNOLOGY- SINCE THE 1970's

OVER 6,000 ROTATING BIOLOGICAL CONTACTORS IN SERVICE

15,000 gpd to >30 MGD

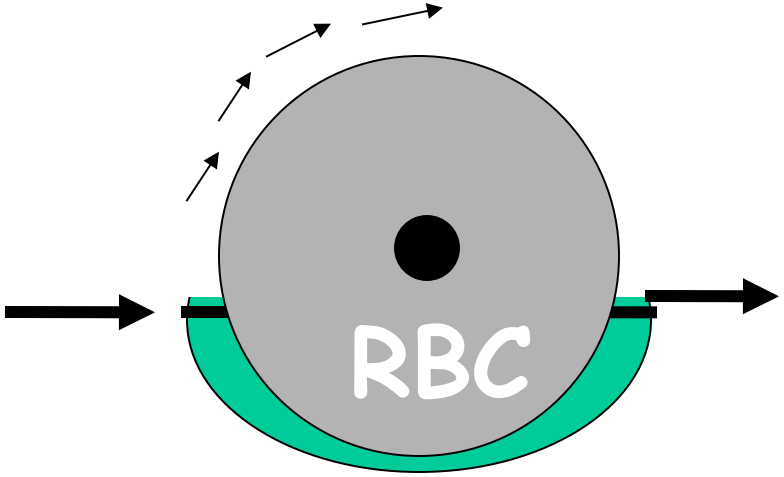
TRICKLING FILTER vs RBC

WASTEWATER



TRICKLING FILTER

Wastewater is passed thru the media



Media is passed thru the wastewater

PRELIMINARY TREATMENT (SCREENS, GRIT REMOVAL) and PRIMARY TREATMENT SHOULD PRECEED ROTATING BIOLOGICAL CONTACTORS TO PREVENT PROBLEMS WITH SOLIDS

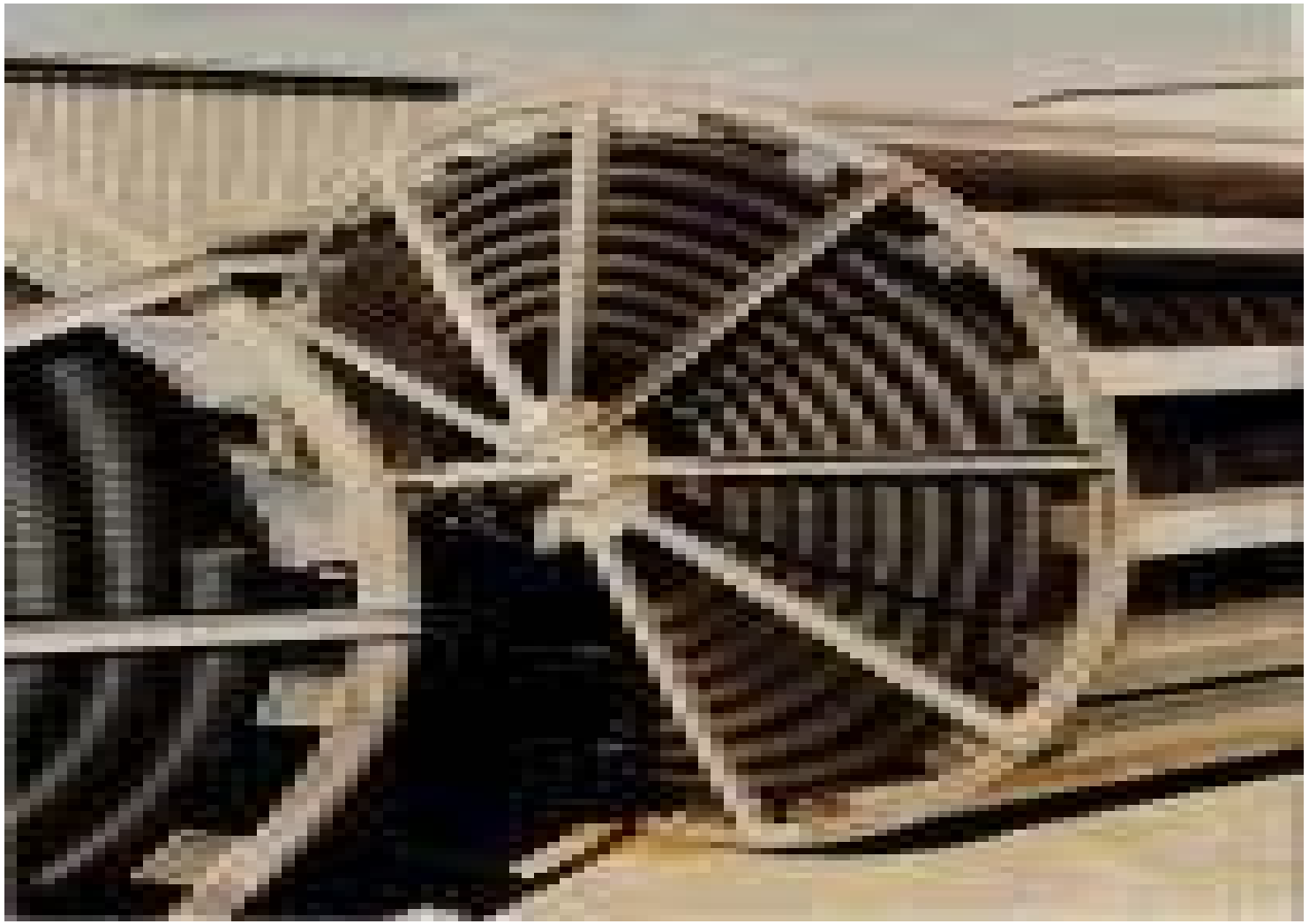
DESCRIPTION OF AN RBC

- ROTATING SHAFT (UP TO 25 ft LONG)
- ROUND PLASTIC DISKS (USUALLY 12 ft DIAMETER

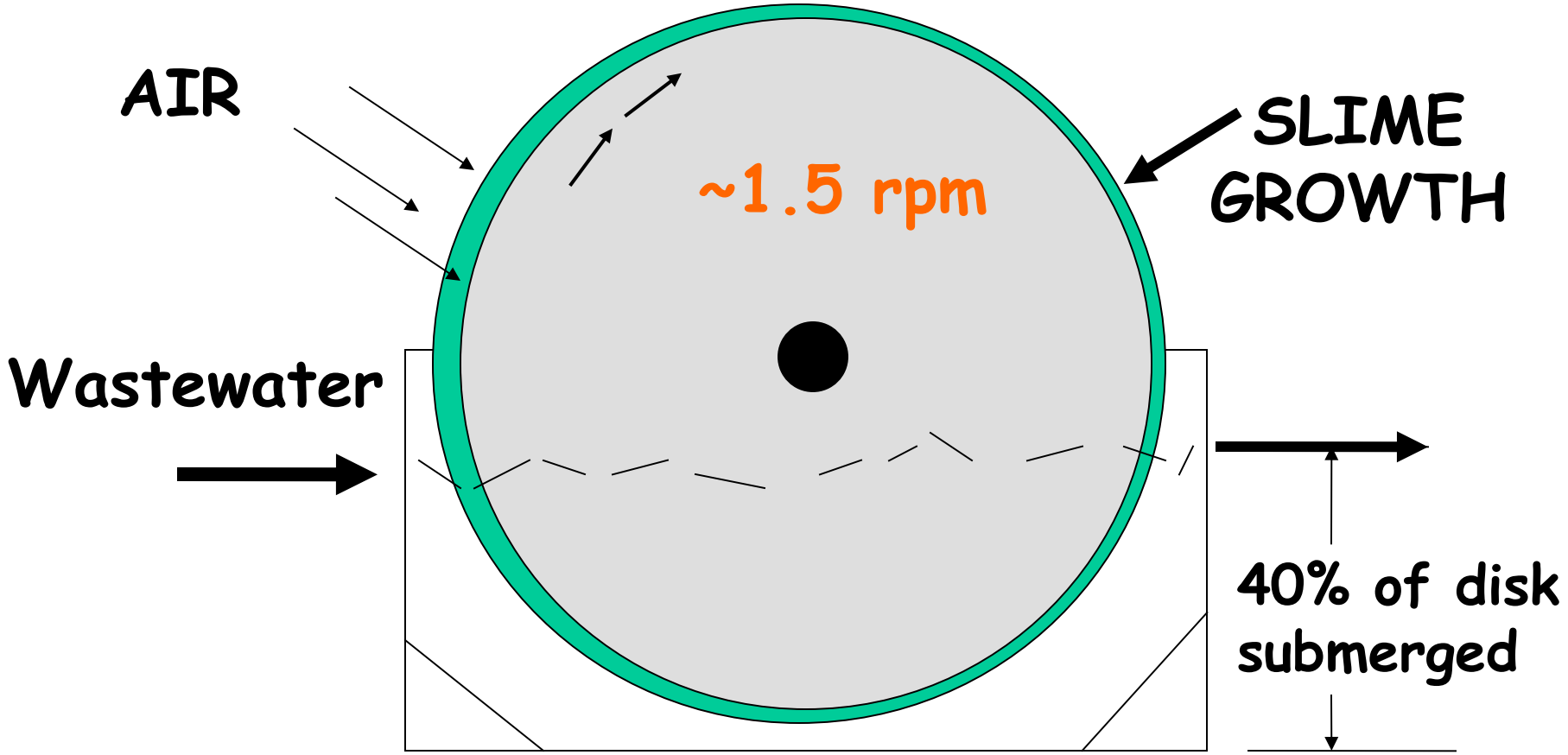
MEDIA IS AVAILABLE AS STANDARD, MEDIUM OR HIGH DENSITY

A CONVENTIONAL RBC WITH STANDARD MEDIA, 25-ft LONG by 12-ft DIAMETER = >110,000 ft^2 of media surface area!

(high density >165,000 ft^2)



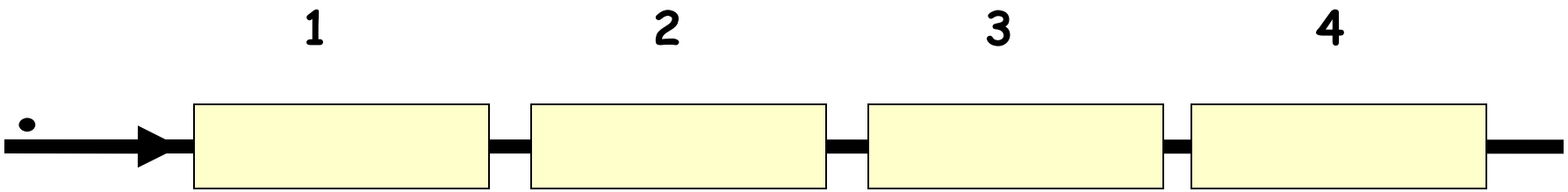
COMBINATION OF SHAFT AND MEDIA IS CALLED A "DRUM"



USUALLY A "ONCE THRU" OPERATION—NO RECIRCULATION

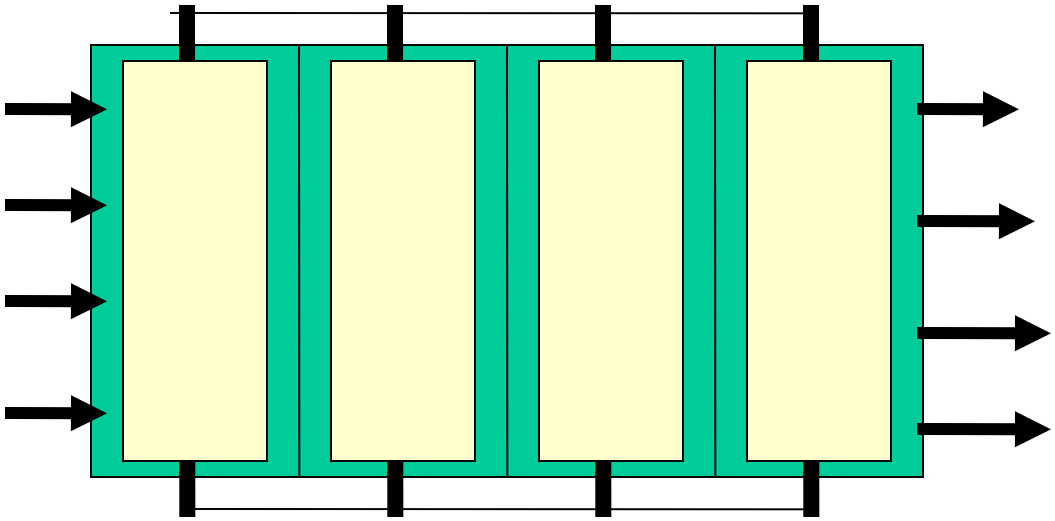
DIRECTION OF FLOW

A.

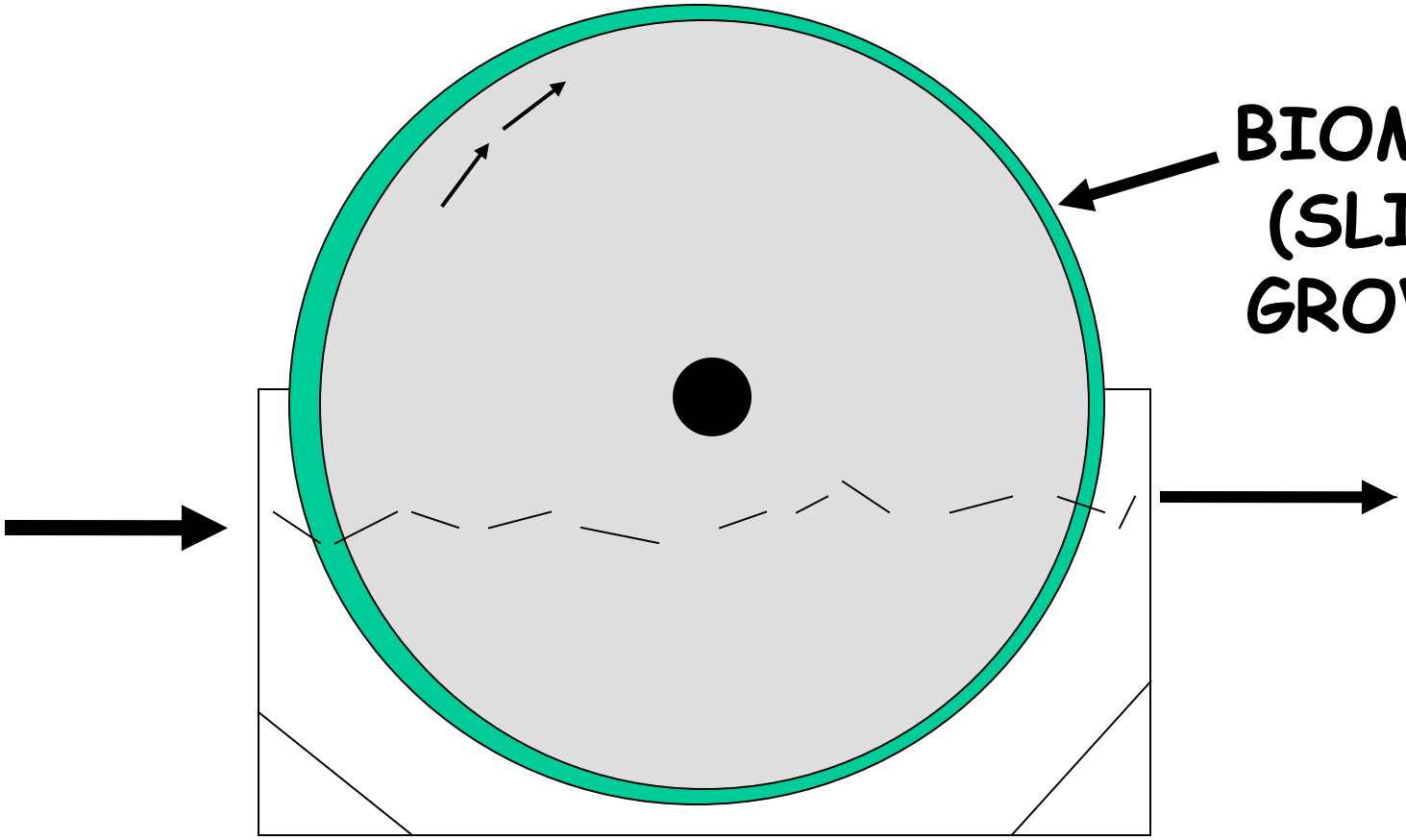


FLOW IS PARALLEL TO SHAFT

B.

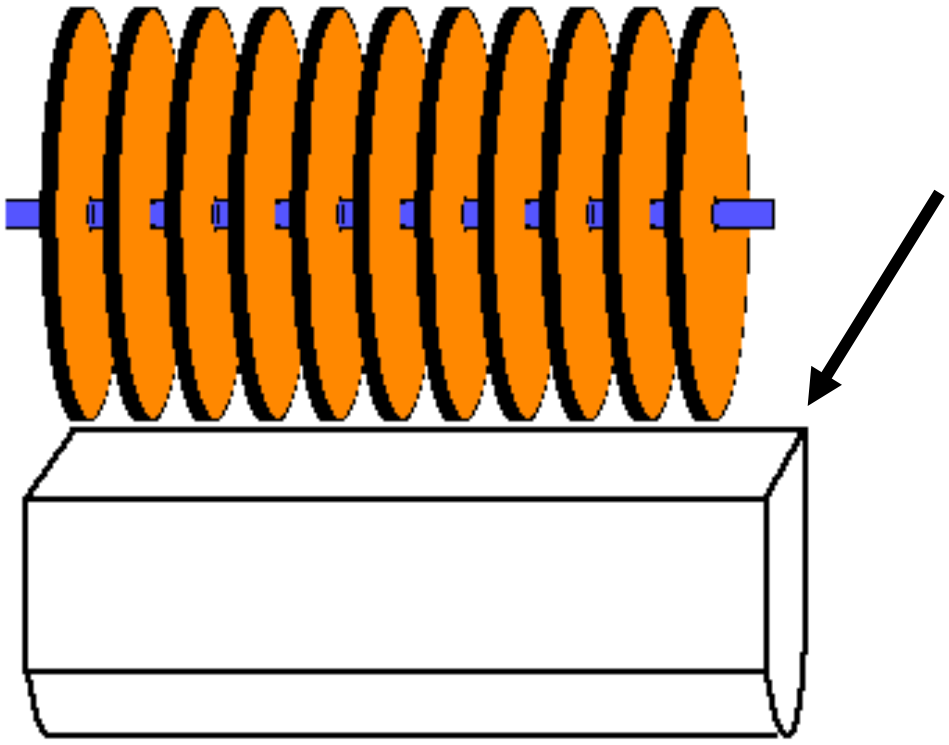


FLOW IS PERPENDICULAR TO THE SHAFT



BIOMASS THICKNESS RANGES FROM <1 to 3 mm

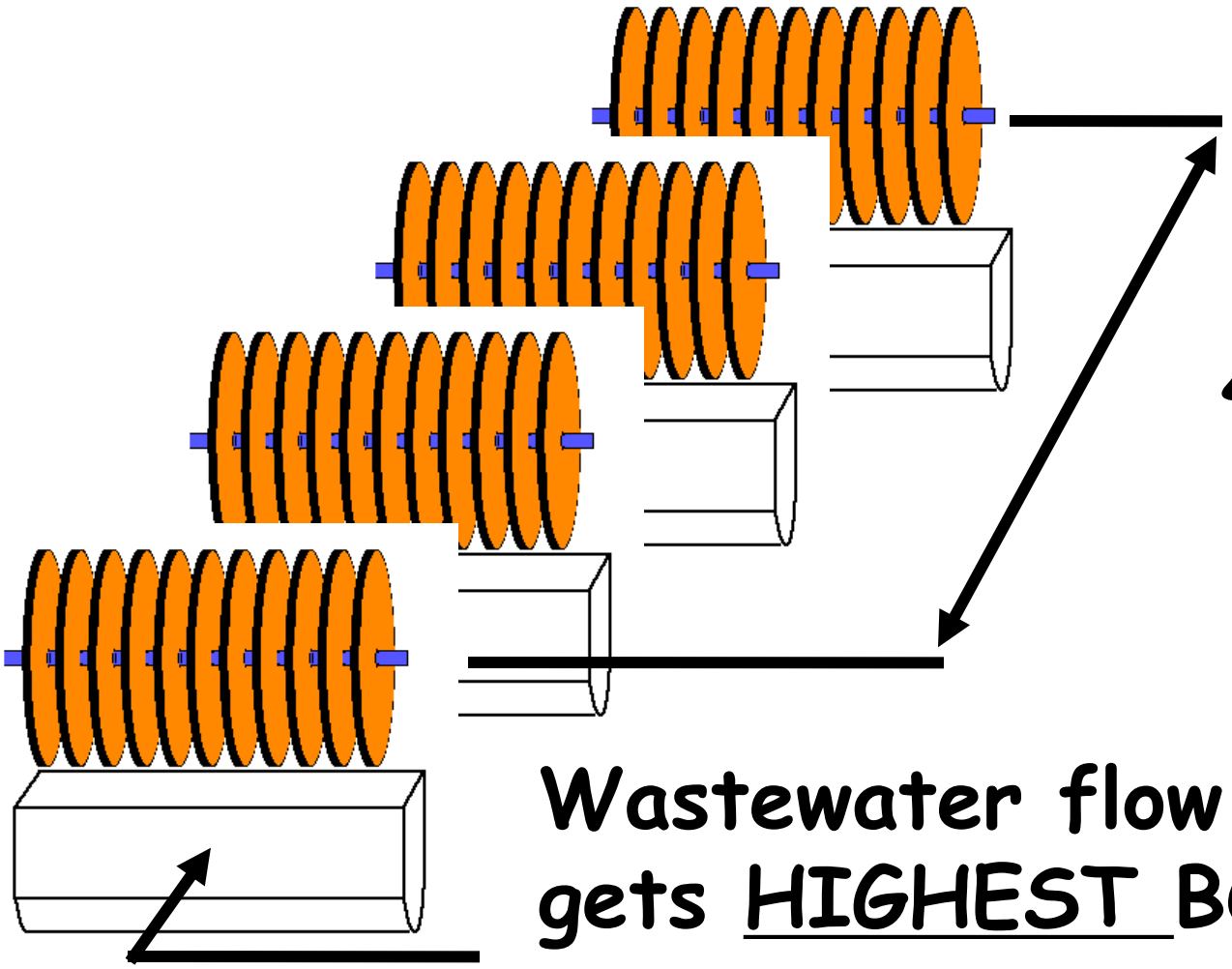
MAJOR PARTS OF AN RBC



CONCRETE OR STEEL TANK SHAPED TO CONFORM TO THE GENERAL SHAPE OF THE DISKS

This eliminates "DEAD SPOTS" where solids could settle and create odors

MAJOR PARTS OF AN RBC



4 stages
(separated by baffles)

Wastewater flow (1st stage gets HIGHEST BOD load)

MAJOR PARTS OF AN RBC

COVERED FOR PROTECTION

RBCs ARE COVERED to:

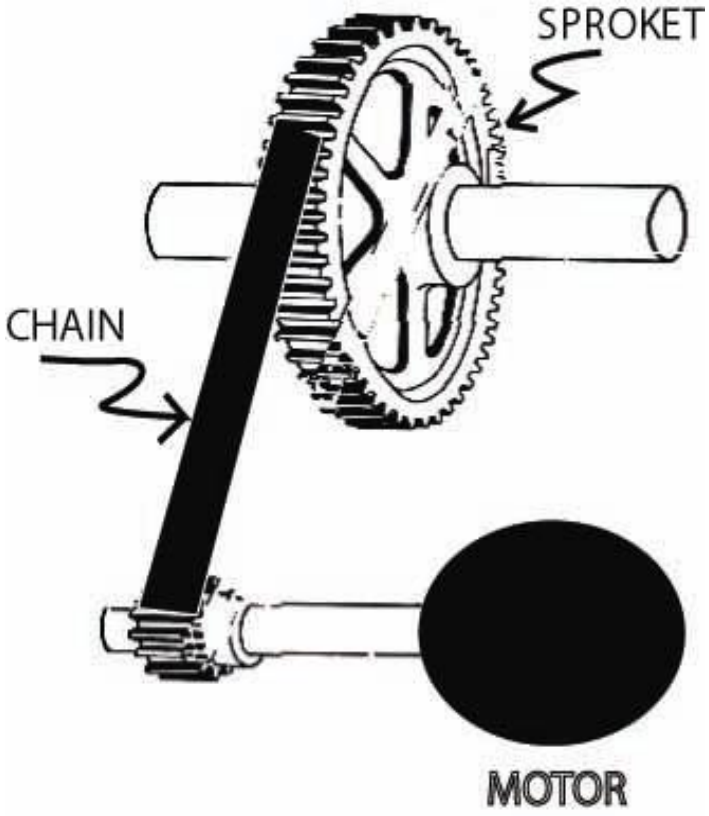
- PROTECT THE SLIME FROM FREEZING
- PREVENT THE RAIN FROM WASHING OFF THE SLIME
- BLOCK SUNLIGHT TO PREVENT ALGAE GROWTH AND DETERIORATION
- PROTECT THE OPERATOR

SOME COVERS ARE COMPLETE BUILDINGS, OTHERS ARE SIMPLY FIBERGLASS COVERS SHAPED LIKE THE DRUMS

RBC DRIVE ASSEMBLIES

3 TYPES:

1. MOTOR & CHAIN DRIVE



RBC DRIVE ASSEMBLIES

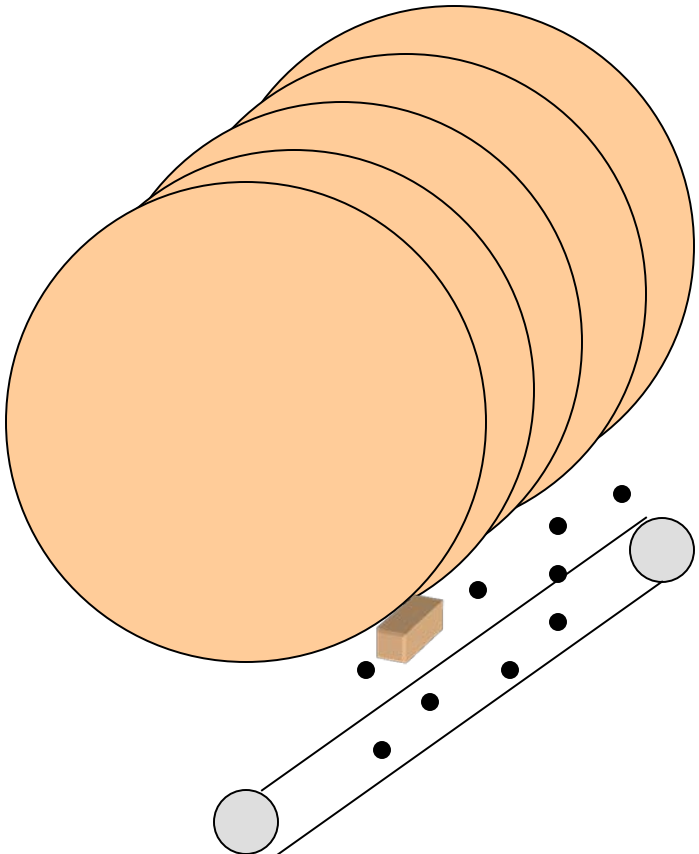
3 TYPES:

1. MOTOR & CHAIN DRIVE

2. MOTOR W/ DIRECT SHAFT DRIVE

3. AIR DRIVE

AIR DRIVE



AIR FROM DIFFUSERS IS DIRECTED TO PLASTIC CUPS ON THE DRUMS CAUSING THEM TO TURN

RBC vs TRICKLING FILTERS

ADVANTAGES OF RBCs:

1. NO PROBLEMS WITH DISTRIBUTOR ARMS, SEALS, NOZZLES

2. NO PONDING

3. NO FILTER FLIES

4. COMPLETELY AEROBIC and BETTER DISTRIBUTION OF THE WASTEWATER OVER THE MEDIA

RBC vs TRICKLING FILTERS

DISADVANTAGES OF RBCs:

1. RBCs ARE MORE SENSITIVE TO INDUSTRIAL WASTES

2. SOLIDS CAN SETTLE IN THE DRUM HOUSING CAUSING SEPTIC CONDITIONS, REDUCED TANK VOLUME, AND SCRAPE THE MEDIA (and possibly stall)

RBCs and NITRIFICATION

IN ADDITION TO REMOVING THE OXYGEN DEMAND (BOD), RBCs ARE USE TO CONVERT AMMONIA to NITRATE.

$$NH_3 + O_2 \xrightarrow{\text{BIOMASS}} NO_2 \longrightarrow NO_3$$

RBC START-UP

PRE-START CHECKS:

- TIGHTNESS (ANCHOR BOLTS, MOUNTING STUDS, JACKING SCREWS, CHAINS, BELTS, MEDIA

- LUBRICATION (MAINSHAFT BEARINGS, ROLLER CHAIN, SPEED REDUCER)

RBC START-UP

PRE-START CHECKS (con't)

- <u>CLEARANCES:</u> BETWEEN MEDIA and TANK WALL; BAFFLES; COVER; BETWEEN CHAIN CASING and MEDIA; SPROCKETS

START-UP PROCEDURE

- ✓ CHECK TEXT FOR DETAILS

1) START FOR 1/4 TURN, TURN OFF-LOCK OUT AND CHECK EVERYTHING

2) SWITCH ON POWER AND ROTATE FOR 15 min

START-UP PROCEDURE

- ✓ CHECK TEXT FOR DETAILS

3) SHUT OFF UNIT AND CHECK BEARING TEMPERATURES WITH A PYROMETER

WHAT'S A PYROMETER?

A SPECIAL THERMOMETER TO MEASURE HIGH TEMPERATURES

SOME PYROMETERS WORK ON OPTICS,
OTHERS ON RADIATION and COLORS,

THE TEMPERATURE OF THE OUTER HOUSING OF THE SHAFT BEARING SHOULD NOT EXCEED

200°F

BIOMASS DEVELOPMENT

1. REGULATE THE RATE AND STRENGTH OF THE WASTEWATER AND RECIRCULATE IF POSSIBLE

2. MAINTAIN TEMPERATURES AROUND 65°F (or higher). SLIME IS LESS ACTIVE IN COLD WEATHER SO TAKES LONGER TO DEVELOP

BIOMASS DEVELOPMENT

3. BEST ROTATION SPEED (rpm) WILL SHEAR OFF BIOMASS GROWTH AND PROVIDE A "HUNGRY AND REPRODUCTIVE" FILM

4. ALLOW 1 to 2 WEEKS FOR FULL DEVELOPMENT

BIOMASS DEVELOPMENT

·EXPECT EXCESSIVE SLOUGHING THE FIRST WEEK

BEST GROWTH IS:

- UNIFORM
- SHAGGY BROWN to GRAY
- FEW or NO BARE SPOTS

RBC OPERATION

INSPECTING EQUIPMENT

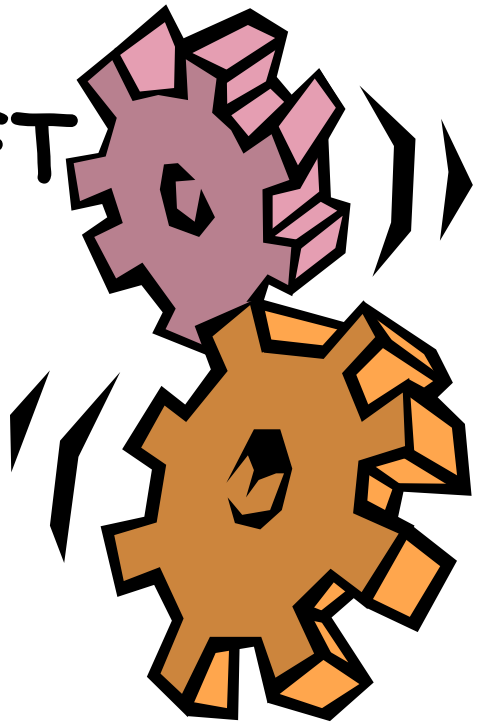
1.SHAFT BEARING TEMP (<200°F)

USE A PYROMETER

RBC OPERATION

INSPECTING EQUIPMENT

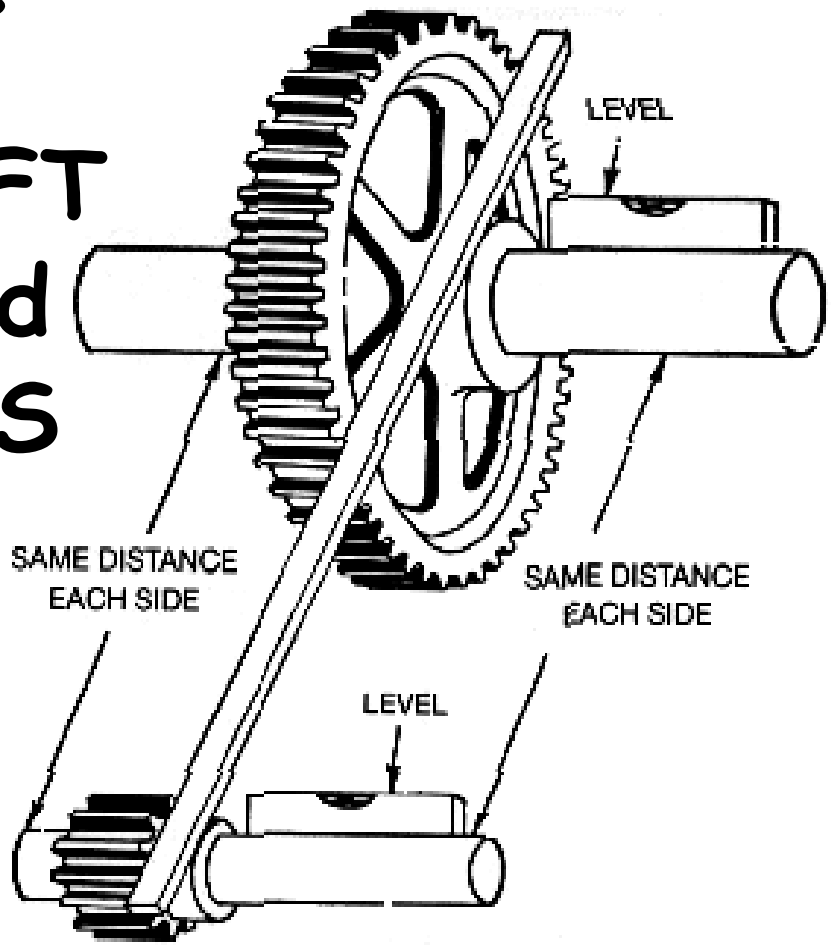
2. CHECK FOR PROPER LUBRICATION OF SHAFT BEARINGS



RBC OPERATION

INSPECTING EQUIPMENT

3. PROPER SHAFT <u>ALIGNMENT</u> and BELT TENSIONS



RBC OPERATION

INSPECTING EQUIPMENT

4. LISTEN FOR UNUSUAL NOISES

RBC OPERATION

INSPECTING EQUIPMENT

5. FEEL MOTORS TO DETERMINE IF THEY ARE RUNNING HOT!

RBC OPERATION

INSPECTING EQUIPMENT

6. LOOK FOR <u>OIL</u> SPILLS, CHECK <u>OIL</u> LEVELS IN SPEED REDUCERS, and INSPECT FOR WORN OUT GASKETS or SEALS

RBC OPERATION

INSPECTING EQUIPMENT

7. CHECK PROTECTIVE GUARDS AND CLEAN UP SPILLS, MESSES OR DEBRIS

RBC OPERATION

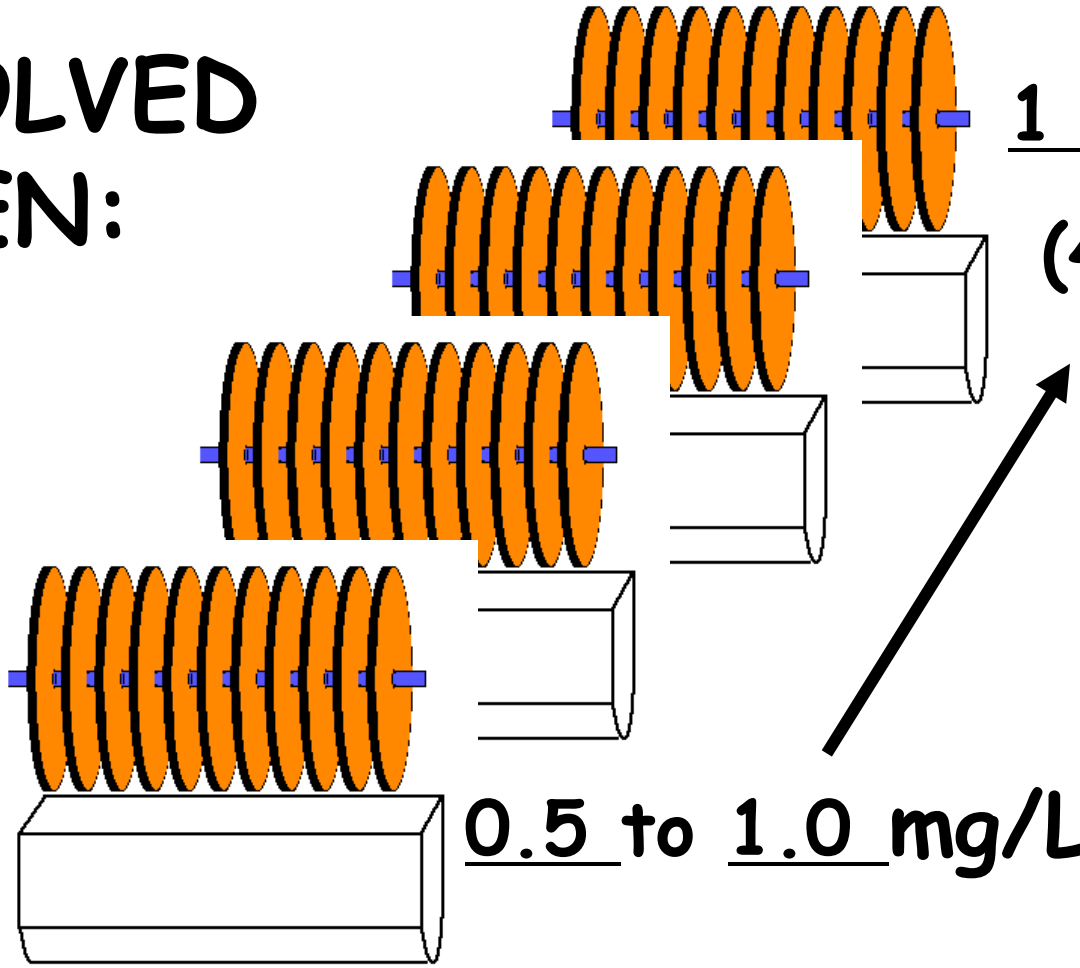
SAMPLING & ANALYSIS

ROUTINELY CHECK (as NPDES PERMIT REQUIRES):

- BOD and TOTAL SUSPENDED SOLIDS (24-hr COMPOSITE)
- DISSOLVED OXYGEN and pH (GRAB SAMPLES)

RBC OPERATION

DISSOLVED OXYGEN:



1 to 3 mg/L

(4th stage)

0.5 to 1.0 mg/L (1st stage)

D.O. VARIES, DEPENDING ON TREATMENT OBJECTIVE: BOD REMOVAL OR NITRIFICATION

EFFLUENT QUALITY

BOD, TSS, AMMONIA (NH_3), AND NITRATE (NO_3) WILL INCREASE WITH:

- INCREASED FLOW
  (DECREASE IN CONTACT TIME WITH BIOMASS)

- INCREASED INFLUENT CONCENTRATIONS

REMOVAL EFFICIENCIES

BOD 80 to 95%

WHAT IF REMOVAL EFFICIENCY DECREASES?

✓CHECK FOR:

- REDUCED WASTEWATER TEMPERATURE
- UNUSUAL VARIATIONS IN FLOW, ORGANIC LOADING (BOD), OR BOTH
- HIGH or LOW pH VALUES (<6.5 or >8.5)

RBC OPERATION

SAMPLING & ANALYSIS

WASTEWATER TEMPERATURE:

Less than 55°F ⟶ REDUCTION IN BIOLOGICAL ACTIVITY WITH CORRESPONDING REDUCTION IN BOD REMOVAL

NOT MUCH AN OPERATOR CAN DO

RBC OPERATION

INFLUENT VARIATIONS:

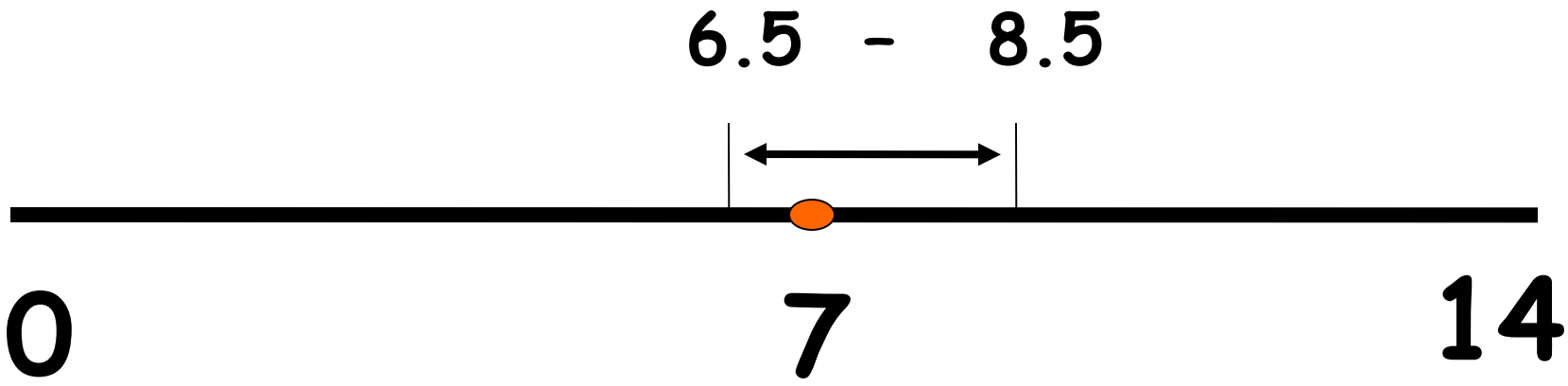
- LESS THAN 3 TIMES THE DAILY AVERAGE FLOW WILL HAVE LITTLE EFFECT

- FOR SEVER ORGANIC OVERLOAD, REMOVE THE BAFFLE BETWEEN FIRST TWO STAGES

RBC OPERATION

pH (optimum: 6.5 to 8.5)

CAN ADJUST BY PRE-AERATION or CHEMICAL ADDITION



TOO LOW? ADD SODIUM BICARBONATE or LIME

TOO HIGH? ADD ACETIC ACID

BE SURE TO WEAR SAFETY EQUIP.

RBC OPERATION

pH DURING NITRIFICATION

(optimum: 8.4)

pH and ALKALINITY CRITICAL FOR NITRFICATION

RECALL: ALKALINITY IS A MEASURE OF THE WATER'S ABILITY TO NEUTRALIZE ACIDS (MEASURED AS $CaCO_3$)

NITRIFICATION

CONVERTING AMMONIA (NH_3) TO NITRATE (NO_3)

- pH as close to 8.4 as possible
- ALKALINITY SHOULD BE AT LEAST 7.1 TIMES THE AMMONIA CONCENTRATION
- SODIUM BICARBONATE IS USED TO INCREASE THE ALKALINITY and THE pH

NITRIFICATION EXAMPLE

THE INFLUENT TO THE RBC HAS AN AMMONIA CONCENTRATION OF 12 mg/L and an ALKALINITY OF 137 mg/L. WILL YOU HAVE TO ADD ADDITIONAL AKLALINITY FOR NITRIFICATION?

WHAT ABOUT DIGESTER SUPERNATANT?

DIGESTER SUPERNATANT

CAN CAUSE PROBLEMS FROM HIGH SUSPENDED SOLIDS AND LOW pH.

- HIGH SOLIDS: RETURN DURING LOW FLOWS (more contact time)
- LOW pH: RETURN DURING DURING HIGH FLOWS (for dilution and neutralization)

WATCH THE MEDIA!

GOOD OPERATION:

BIOMASS IS SHAGGY WITH UNIFORM COVERAGE; BROWN-to-GRAY COLOR; NO ALGAE PRESENT; NON-OFFENSIVE ODOR

WATCH THE MEDIA!

BLACK APPEARANCE (WITH ODORS)

- PROBABLY A BOD OR SOLIDS OVERLOAD
- LIKELY WILL HAVE LOW DISSOLVED OXYGEN IN THE EFFLUENT

WATCH THE MEDIA!

BLACK APPEARANCE (WITH ODORS)

CORRECTIVE ACTIONS

- PLACE ANOTHER RBC IN SERVICE
- PRE-AERATE THE RBC's INFLUENT
- CHECK PRIMARY CLARIFIER AND DIGESTER OPERATION

WATCH THE MEDIA!

WHITE APPEARANCE

MAY BE CAUSED BY:

- HIGH LOADING CONDITIONS
- INDUSTRIAL DISCHARGES WITH SULFUR COMPOUNDS

WATCH THE MEDIA!

WHITE APPEARANCE

CORRECTIVE ACTIONS

- PLACE ANOTHER RBC IN SERVICE
- PRE-AERATE THE INFLUENT
  - REMOVE BAFFLE BETWEEN FIRST TWO STAGES DURING OVERLOAD

WATCH THE MEDIA!

WHITE APPEARANCE

CORRECTIVE ACTIONS (con't)

- PRE-CHLORINATE TO CONTROL SULFUR LOVING BACTERIA

- DRAIN DRUM HOUSING AND CLEAN OUT ANY BUILT-UP SLUDGE BELOW THE DRUM

WATCH THE MEDIA!

SEVER SLOUGHING

MAY BE CAUSED BY TOXIC or INHIBITORY SUBSTANCES

- LOCATE AND ELIMINATE THE SOURCE OF THE TOXICS
- DILUTE, CONTROL INFLOW TO PLANT,or RECYCLE EFFLUENT

WATCH THE MEDIA!

SEVER SLOUGHING (con't)

IF CAUSED BY FLOW/LOADING VARIATIONS:

- THROTTLE PLANT INFLUENT

- RECYCLE SECONDARY CLARIFIER OR RBC EFFLUENT

- TRY TO MAINTAIN A HYDRAULIC LOADING OF 1 to 1.5 gpd/ft^2

TROUBLESHOOTING

SEE TABLE 7.2, PAGE 230 IN YOUR TEXT

ABNORMAL OPERATIONS

1. HIGH or LOW FLOWS

2. HIGH or LOW ORGANIC LOADINGS

REFER TO TABLE 7.2 IN TEXT

ABNORMAL OPERATIONS

3. POWER OUTAGES

- IF LESS THAN 4 hrs: NO SPECIAL ACTION NEEDED
- IF GREATER THAN 4 hrs:
  - a. TURN OFF-LOCK OUT POWER
  - B. TURN SHAFT $\frac{1}{4}$ TURN EVERY 4 hrs
  - C. GENTLY SPRAY THE EXPOSED BIOMASS TO KEEP MOIST

SAFETY

BE CAREFULL WITH "SLOW MOVING EQUIPMENT" and SLIPPERY SURFACES

PRACTICE GOOD PERSONAL HYGIENE (wash hands regularly)

NUTRIENT REQUIREMENTS for BIOMASS

TO PROPERLY GROW AND TREAT WASTEWATER, BIOMASS NEEDS:

- CARBON (SOURCE IS THE BOD)
- NITROGEN (SOURCE IS NH_3)
- PHOSPHORUS (SOURCE IS PO_4)

NUTRIENT REQUIREMENTS for BIOMASS

KNOWN AS THE "CNP" RATIO and is expressed as C:N:P

FOR ATTACHED GROWTH SYSTEMS (i.e. trickling filters and RBCs), the CNP ratio is:

100:5:1

NUTRIENT REQUIREMENTS for BIOMASS

CNP = 100:5:1 means:

It takes 100 pounds of Carbon (BOD), 5 pounds of Nitrogen (Ammonia), and 1 pound of Phosphates

For proper biomass growth

NUTRIENT REQUIREMENTS for BIOMASS

DOMESTIC WASTEWATER (SEWAGE) HAS A PROPER BLEND OF NUTRIENTS FOR GOOD GROWTH

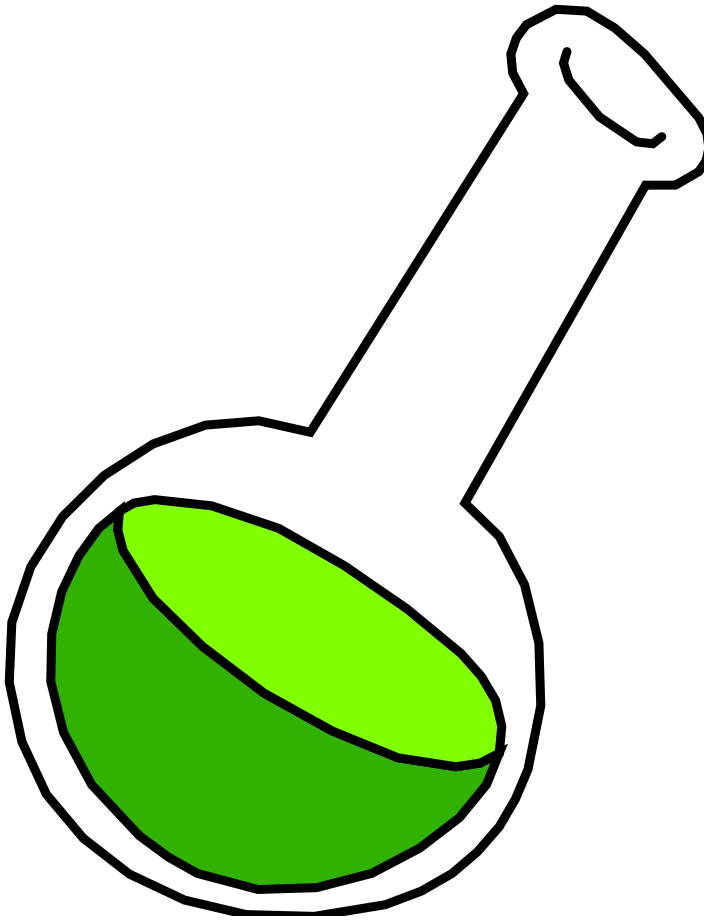
INDUSTRIAL WASTEWATER OFTEN LACKS NUTRIENTS---SO, *C*, *N* or *P* MUST BE ADDED TO GET GOOD TREATMENT

LOADING CALCULATIONS

ORGANIC LOADINGS ARE BASED ON "SOLUBLE BOD"

ORGANIC LOADING = lbs SOLUBLE BOD per day per 1000 ft^2 of MEDIA

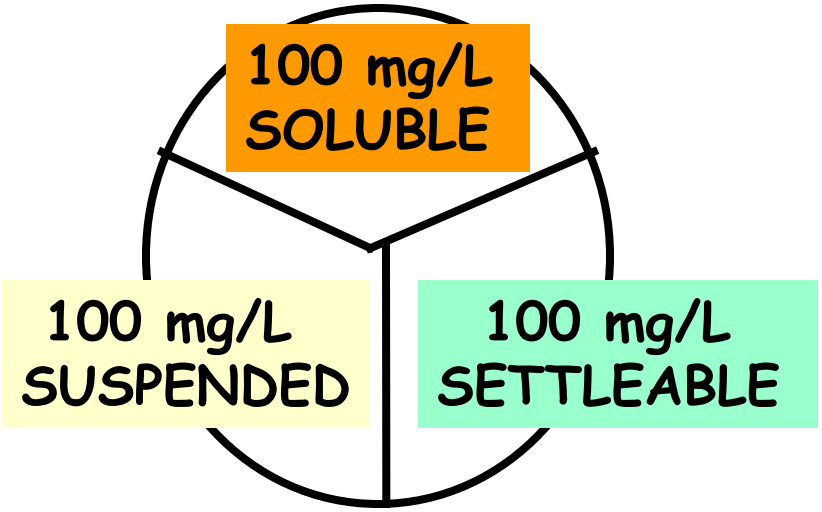
SOLUBLE BOD IS MEASURED ON FILTERED WASTEWATER

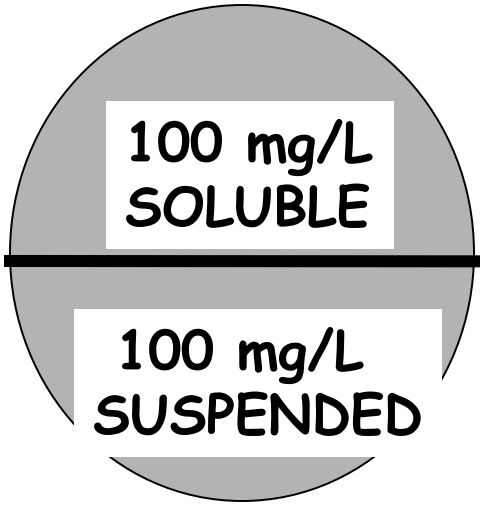


BOD REVIEW:

SAMPLE OF FILTERED WASTEWATER IS STORED IN BOD BOTTLES FOR 5 days at 20°C. DISSOLVED OXYGEN IS MEASURED AT THE BEGINNING AND THE END TO DETERMINE THE OXYGEN DEMAND

"BOD" REVIEW
EXAMPLE: BOD = 300 mg/L





RAW

AFTER PRIMARY SETTLING

ESTIMATING SOLUBLE BOD

SOLUBLE BOD CAN BE ESTIMATED ON THE BASIS OF TOTAL BOD AND SUSPENDED SOLIDS (TSS)

SOLUBLE BOD, mg/L =

TOTAL BOD, mg/L - (K x TSS, mg/L)

Where K = 0.5-0.7 (for sewage)

EXAMPLE:

AN RBC RECEIVES AN INFLUENT BOD of 220 mg/L and 230 mg/L SUSPENDED SOLIDS. WHAT IS THE ESTIMATED SOLUBLE BOD IN THIS WASTEWATER?

SOLUBLE BOD, mg/L =

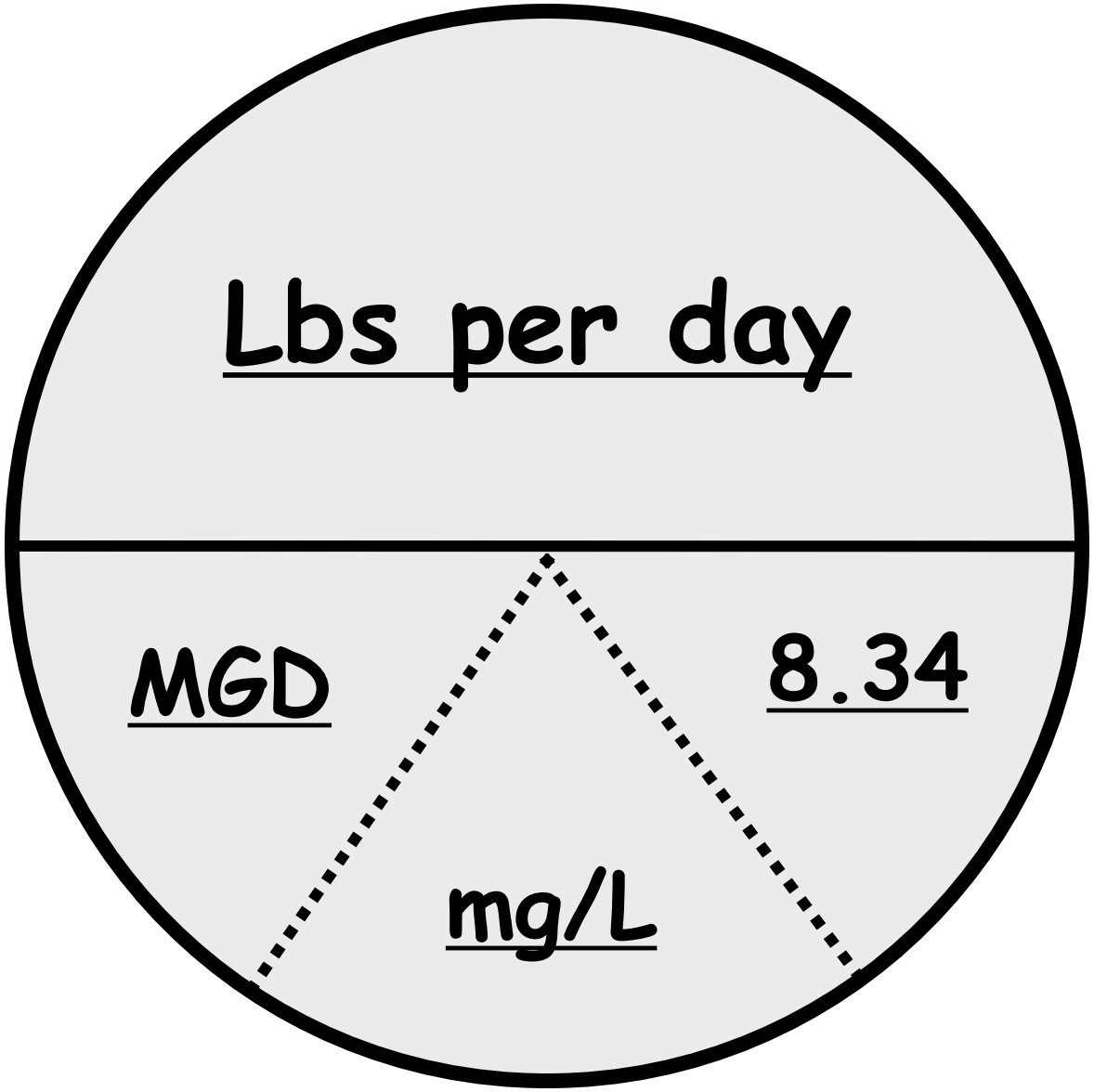
220 mg/L – (0.5 x 230 mg/L) =

220 mg/L – 115 mg/L = 105 mg/L

ORGANIC LOADING EXAMPLE (con't)

WHAT IS THE ORGANIC LOADING FOR THE FOLLOWING RBC?

- FLOW = 2.5 MGD
- SOLUBLE BOD = 115 mg/L
- MEDIA SURFACE AREA = 800,000 ft^2


Lbs per day
MGD
8.34
mg/L

ORGANIC LOADING =

$$\frac{115\ \text{mg/L} \times 2.5\ \text{MGD} \times 8.34\ \text{\#-L/mg-Mgal}}{800{,}000\ \text{ft}^2/1000}$$

= 3 lbs BOD per day/1000 ft^2

HYDRAULIC LOADING

HYDRAULIC LOADING IS:

GALLONS per DAY/FT^2 of MEDIA

WHAT IS THE HYDRAULIC LOADING FOR THE PREVIOUS EXAMPLE?

2,500,000 gpd/800,000 ft^2 = 3.1 gpd/ft^2

TYPICAL LOADING RATES

	RANGE
HYDRAULIC LOADING	
BOD REMOVAL	1.5 - 6 GPD/ft^2
NITROGEN REMOVAL	1.5 – 1.8 GPD/ft^2
ORGANIC LOADING	
SOLUBLE BOD	2.5 – 4 lbs BOD/day/1000 ft^2
TOTAL BOD	6 – 8 " " "