Waste treatment ponds had their beginning in England in the mid-1800's.
WASTE TREATMENT PONDS

RAW WASTE → STABILIZATION POND

PRIMARY TREATMENT → OXIDATION POND
Ponds have been designed and built in this country for about 60 years.

- No expensive equipment
- Easy to construct & operate
- Low energy usage/low sludge
- Wildlife habitat/refuge
ANOTHER IMPORTANT FEATURE OF A WASTE TREATMENT POND IS ITS ABILITY TO EASILY ADJUST TO VARIABLE ORGANIC LOADS
DISADVANTAGES OF PONDS

• REQUIRE LARGE LAND AREA

• MAY EMIT ODORS

• MAY CONTAMINATE GROUNDWATER

• MAY HAVE HIGH SUSPENDED SOLIDS IN THE EFFLUENT
THREE BASIC TYPES OF PONDS

• AEROBIC
• ANAEROBIC
• FACULTATIVE
AEROBIC PONDS

• 3 to 6 FEET DEEP
• DISSOLVED OXYGEN THROUGHOUT
• 30 to 90 DAYS DETENTION TIME
ANAEROBIC PONDS

• DEVOID OF OXYGEN
• 6 to 12+ FEET DEEP
• USUALLY INDUSTRIAL WASTE
• DETENTION TIMES VARY (20-? DAYS)
FACULTATIVE POND

- **Upper part**: Aerobic
- **Bottom**: Anaerobic (like a digester)
- 3 to 6 feet deep
- **Most common type pond**
COMPLETE RETENTION LAGOON

INFLUENT = EVAPORATION + PERCOLATION

EVAPORATION

INFLUENT

NO EFFLUENT

PERCOLATION
INFLUENT

CELL #1

CELL #2

CAN PRODUCE A HIGH QUALITY EFFLUENT
PONDS IN PARALLEL

INFLUENT
HOW AN AEROBIC POND WORKS

(PHOTOSYNTHESIS)

OCCURS WITHIN THE FIRST 2.5 FEET OF POND DEPTH

SUNLIGHT

ALGAE

O₂

NUTRIENTS

CO₂

BACTERIA
AT NIGHT

\[
\text{ALGAE} \rightarrow \text{NUTRIENTS} \rightarrow \text{BACTERIA} \rightarrow \text{CO}_2
\]

\[
\text{O}_2 + \text{CO}_2 + \text{H}_2\text{O} = \text{H}_2\text{CO}_3
\]

(CARBONIC ACID) - pH goes down
NEED TO REMEMBER

IN AN AEROBIC OR FACULTATIVE POND:

OXYGEN AND pH go UP DURING THE DAY and DOWN DURING THE NIGHT.
OXYGEN SATURATION

\[ O_2 \]

Saturated

\[ O_2 \]

Supersaturated
OXYGEN SATURATION

At any given temperature, water can hold only so much oxygen.

<table>
<thead>
<tr>
<th>Temperature, °C</th>
<th>mg/L Oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>13.1</td>
</tr>
<tr>
<td>20</td>
<td>9.1</td>
</tr>
</tbody>
</table>
pH in a POND

ACIDIC

neutral

BASIC

• INFLUENT pH = 6 to 8

• EFFLUENT pH = 9.5 or more

• High pH usually means high dissolved oxygen (pH tied closely to O₂ production)
HIGH pH IN POND USUALLY MEANS HIGH DISSOLVED OXYGEN

LOW pH IN POND CAN BE CAUSED BY SEPTIC WASTE AND INDUSTRIAL WASTE
HOW AN ANAEROBIC POND WORKS

**ACID PRODUCING BACTERIA**

**NUTRIENTS**

**ORGANIC ACIDS**

**METHANE PRODUCING BACTERIA**

**CO₂**

**CH₄**
HOW A FACULTATIVE POND WORKS

AEROBIC BACTERIA

O₂

ALGAE

NUTRIENTS

ANAEROBIC BACTERIA

ACID FORMERS

METHANE FORMERS

ORGANIC ACIDS

CO₂
ALGAE AND BACTERIA NUTRIENTS ARE:

NITROGEN (NH$_3$, NO$_3$, NO$_2$)

and PHOSPHOROUS (PO$_4$)
THE NITROGEN CYCLE

ORGANIC NITROGEN (WASTEWATER)

NITRIFICATION

NO₃

ALGAE

DENITRIFICATION

NH₃

BACTERIA

N₂
HIGH CONCENTRATIONS OF AMMONIA (NH$_3$ >20 mg/L) IN THE EFFLUENT CAN BE HARMFUL TO FISH
TERM TO REMEMBER!!

BIOFLOCCULATION

The “clumping” together of algae and bacteria which settles and removes suspended and dissolved solids.
POND PERFORMANCE

REMOVAL EFFICIENCIES

BOD/SS  90 - 95%

Fecal Coliform  99%
<table>
<thead>
<tr>
<th>TYPE</th>
<th>lbs BOD/acre/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEROBIC</td>
<td>60 - 200</td>
</tr>
<tr>
<td>ANAEROBIC</td>
<td>200 - 1000</td>
</tr>
<tr>
<td>FACULTATIVE</td>
<td>15 - 30</td>
</tr>
<tr>
<td>TERTIARY</td>
<td>5 - 15</td>
</tr>
<tr>
<td>MECH. AERATED</td>
<td>20 - 400</td>
</tr>
</tbody>
</table>
LOCATION AND PROTECTION OF PONDS

• SAME AS ANY WWTP: DOWN-GRADIENT (if possible)

• ORIENTED WITH RESPECT TO THE WIND
Orient the pond to prevent dike erosion but to maximize scum dispersion and re-aeration.
FACTORS AFFECTING PONDS

- PHYSICAL -

WIND:

- Creates mixing
- Affects dissolved oxygen
FACTORS AFFECTING PONDS

- PHYSICAL -

TEMPERATURE

- LOW WATER TEMP HOLDS MORE OXYGEN
- HIGH WATER TEMP INCREASES MICROBIAL ACTIVITY
FACTORS AFFECTING PONDS

- PHYSICAL -

SUNLIGHT

- ESSENTIAL FOR ALGAE GROWTH

SHORT-CIRCUITING
FACTORS AFFECTING PONDS

- CHEMICAL -

- ORGANIC MATERIAL
- pH
- TYPE OF SOLIDS
FACTORS AFFECTING PONDS

- BIOLOGICAL -

• TYPE(S) OF ALGAE
• ACTIVITY OF ORGANISMS
• NUTRIENTS AVAILABLE
• TOXICANTS
POND START-UP

ADD 1 to 2 FEET OF WATER TO THE POND BEFORE ANY WASTEWATER TO PREVENT ODORS AND TO HELP THE POND GET STARTED. ALSO KEEP pH > 7.5 (ADD SODA ASH)
SAMPLING AND ANALYSES

• FOR POND CONDITION: pH and dissolved oxygen — — 5/week (night?)

• TEMPERATURE, pH, DISSOLVED OXYGEN & CHLORINE RESIDUAL—SHOULD BE ANALYZED IMMEDIATELY (GRAB SAMPLE)
DISSOLVED OXYGEN (D.O.)

• Good indicator of activity (in aerobic pond)

• By watching D.O., overloading can be determined

• Low D.O. = high BOD
FOR TREATMENT EFFICIENCY:

- BOD, SUSPENDED SOLIDS, (COMPOSITE SAMPLES)

- COMPOSITE SAMPLES SHOULD BE REPRESENTATIVE
COMPOSITE SAMPLES

2 TYPES OF COMPOSITES; WITH RESPECT TO...

A. TIME & FLOW

B. LOCATION
SCUM CONTROL

TO PREVENT CRUSTING (LOSS OF SUNLIGHT) AND TO DESTROY A HABITAT FOR PATHOGENS AND VECTORS
OPERATION & MAINTENANCE

ODOR CONTROL

- Usually caused by overloading or poor maintenance

- Sometimes a problem in springtime—might have to aerate or add sodium nitrate
OPERATION & MAINTENANCE

IF HYDROGEN SULFIDE \((H_2S)\) ODOR IS PRESENT, RAISING THE pH ABOVE 8.5 (THE pH OF A NORMALLY OPERATED POND) WILL LIKELY TAKE CARE OF THE PROBLEM
WEED & INSECT CONTROL

PROBLEM: ALTERS WIND MOVEMENT AND PROVIDES A VECTOR HABITAT

- KEEP >3 ft of WATER TO PREVENT CATTAIL & TULE GROWTH (LIMITS SUNLIGHT)

- REMOVE EMERGENT GROWTH BY HAND - USE HERBICIDES AS LAST RESORT
MOSQUITOES CAN BE A PROBLEM

EGG RAFTS CAN ATTACH TO SCUM OR EMERGENT VEGETATION
MOSQUITOES SOMETIMES CONTROLLED BY...

GAMBUSIA (MOSQUITO FISH)
CHIRONOMID MIDGE
(chir-ahn-ahn-mid)

2 CHOICES: LIVE WITH THEM or USE A PESTICIDE
OPERATION & MAINTENANCE

DUCKWEED

DUCKWEED CAN BLOCK SUNLIGHT AND HARBOR VECTORS & TOXINS
• DUCKWEED CAN BE CONTROLLED WITH GOOD WIND CIRCULATION

USE PESTICIDES AS A LAST RESORT
OPERATION & MAINTENANCE

DIKE / LEVEE VEGETATION

MOW REGULARLY and CONTROL BURROWING ANIMALS

DO NOT ALLOW ANIMALS TO GRAZE!
LEVEE CONTROL

- If eroding, protect with rip-rap or semi-porous plastic membrane.

Rip-rap also keeps the vegetation growth down.
PONDS SHOULD BE FENCED TO KEEP OUT LIVESTOCK AND TO DISCOURAGE TRESPASSERS

WASTEWATER TREATMENT PLANT

NO TRESPASSING
COMMON PROBLEMS

PROBLEM          CAUSE (?)

ODOR

• BOD OVERLOAD
• POOR AERATION/MIXING
ODOR CONTROL

• REDUCE BOD LOAD BY TAKING POND OFF-LINE AND GRADUALLY RE-LOADING THE UNIT

• RECIRCULATE FROM AN AEROBIC POND (about 17%) TO RESTORE OXYGEN IN "SICK" POND

• USE MECHANICAL AERATOR or ADD SODIUM NITRATE
<table>
<thead>
<tr>
<th>COMMON PROBLEMS</th>
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<tbody>
<tr>
<td><strong>PROBLEM</strong></td>
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<tr>
<td><strong>POOR BOD REMOVAL</strong></td>
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</table>
COMMON PROBLEMS

PROBLEM: HIGH SUSPENDED SOLIDS IN EFFLUENT

CAUSE (?):
• ALGAL BLOOM
• TOO MUCH MIXING/SHORT-CIRCUITING
• SEASONAL OVERTURN
ALGAE BLOOM

CAUSES ODORS and CAN BE TOXIC
PREDOMINATE TYPES OF ALGAE

• GREEN
• BROWN
• RED
• CYANOBACTERIA (BLUE-GREEN)
ALGAL CONTROL MEASURES

- FILTER the EFFLUENT
- CENTRIFUGE the EFFLUENT
- COPPER SULFATE (CuSO₄)
- WATER HYACINTH
- ALGAE “EATERS” - - DAPHNIA
Daphnia aka water fleas will feed on algae.
COMMON PROBLEMS

**PROBLEM:** Poor Fecal Coliform Removal

**CAUSE:**
- Poor disinfection
- Increase in chlorine demand in the effluent
COMMON PROBLEMS

PROBLEM: HIGH pH  CAUSE (?)
- ALGAL BLOOM

PROBLEM: LOW pH
- SLUDGE ACCUMULATION
- EXCESSIVE NITRIFICATION (NH$_3$ $\rightarrow$ NO$_3$)
O&M GOAL FOR PONDS

• DEEP GREEN COLOR (high pH & DO)

• MEET NPDES DISCHARGE LIMITS

• NO EMERGENT VEGETATION IN THE WATER; NO TALL WEEDS ON THE BANK

• EROSION CONTROL ON DIKES
VISUAL INDICATORS

pH | COLOR
---|------
>9 | GREEN
<7 | YELLOW - GREEN

pH is lower in the morning ($CO_2$ produced by bacteria @ night)
pH is higher in the afternoon
O&M GOAL FOR PONDS

- Clean inlet/outlet structures
- Mechanical equipment is well maintained
- Neat & complete records on plant operation and maintenance
MECHANICALLY AERATED PONDS (BEHAVE LIKE AN ACTIVATED SLUDGE PLANT)
AERATORS

DIFFUSED-AIR
AERATORS

SURFACE MOUNTED
MECHANICALLY AERATED PONDS

- PROVIDES ADDITIONAL AIR (NIGHT, WINTER, WHEN OVERLOADED)
- CREATES AN “ACTIVATED SLUDGE-LIKE” PROCESS
AERATOR MAINTENANCE

• MAKE SURE AERATOR IS TURNED OFF AND LOCKED-OUT

CLEANING DIFFUSORS, REMOVING DEPOSITS, KILLING SLIME (see text):

• HYDROGEN CHLORIDE GAS (DANGEROUS)

• HIGH PRESSURE AIR PURGING
How many acres of ponds (with zero discharge) would be needed to serve 650 people in So. New Mexico?

Assume no PERC & 60” per year evap

\[
\frac{650 \text{ cap} \times 100 \text{ gpd/cap}}{7.48 \text{ gal/ft}^3} = 8690 \text{ ft}^3/\text{day}
\]

\[
8690 \text{ ft}^3/\text{day} \times 365 \text{ day/yr} \times \frac{\text{yr}}{60 \text{ in}} \times \frac{12 \text{ in}}{\text{ft}}
\]

\[
= 634,370 \text{ ft}^2
\]

\[
634,370 \text{ ft}^2/43,560 \text{ ft}^2/\text{acre} = 14.6 \text{ acres}
\]

(plus allowances for rain)
DESIGN CRITERIA

DETENTION TIME:
- POND VOLUME, acre-ft
- INFLUENT RATE, acre-ft/day

• HYDRAULIC LOADING:
  INCHES/DAY

• POPULATION LOADING:
  PERSON/acre
ORGANIC LOADING:
LBS BOD/DAY/ACRE

ORGANIC LOADING:
(BOD mg/L) (FLOW, MGD) (8.34 #/gal)
POND AREA, acres
SURFACE AREA = L × W

1 ACRE = 43,560 SQ-FT
REMEMBER....

EACH PERSON DISCHARGES 75-100 GALLONS of WASTEWATER PER DAY

0.2 POUNDS BOD/PERSON
CALCULATING BOD LOADING

CONCENTRATION, ppm X FLOW, MGD X 8.34 lbs/gal = POUNDS/DAY

What is the daily BOD loading, in pounds given the following:
FLOW = 300,000 gal/day;
BOD = 225 mg/L?
BOD LOADING =
225 ppm X 0.3 MGD X 8.34 lbs/gal
= 563 lbs/day

AT AN ALLOWABLE LOADING OF
35 lbs-BOD per day/acre, how large
of a pond is necessary?

\[
\frac{563 \text{ #/day}}{35 \text{ #/day/acre}} = 16 \text{ acres}
\]