

# **ELECTRO-CHEMICAL TREATMENT OF BILGE WATER**

# **ELECTRO-DISINFECTION OF BALLAST WATER**

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# INTRODUCTION

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- Aquatic invasive species are leading threat to marine biodiversity.
- Ballast water is major pathway for aquatic species distribution worldwide.
- National and international law will mandate implementation of ballast water management.

# BALLAST WATER MANAGEMENT

## High seas ballast water exchange (BWE).

- Used frequently
- Shipping industry is concerned about safety of reballasting.

Figure 1. Mid Ocean Exchange

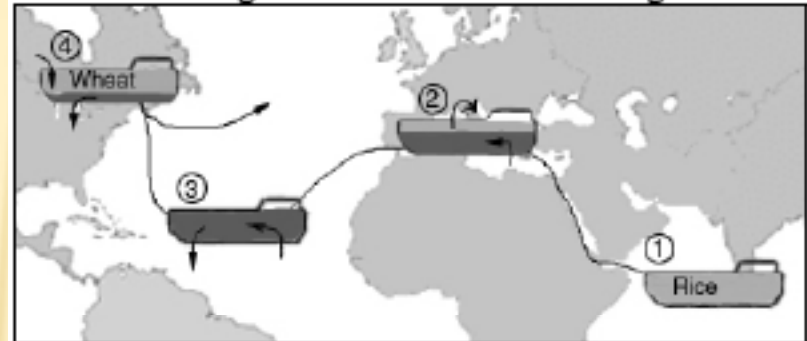


Figure 1 illustrates how ballast water exchange would work. A ship leaves a port in the Indian Ocean, travels through the Suez Canal, discharges cargo in the Mediterranean and takes up ballast water prior to crossing the Atlantic Ocean. Ballast water exchange would occur in the Atlantic prior to the ship entering the Great Lakes to pick up cargo, e.g. wheat for transport to the receiving port.

# BALLAST WATER MANAGEMENT

- Emptying ballast tanks
  - Introduces dynamic loads which may exceed safe hull shear and bending moments
  - Affects draft, trim, stability, and propeller depth.

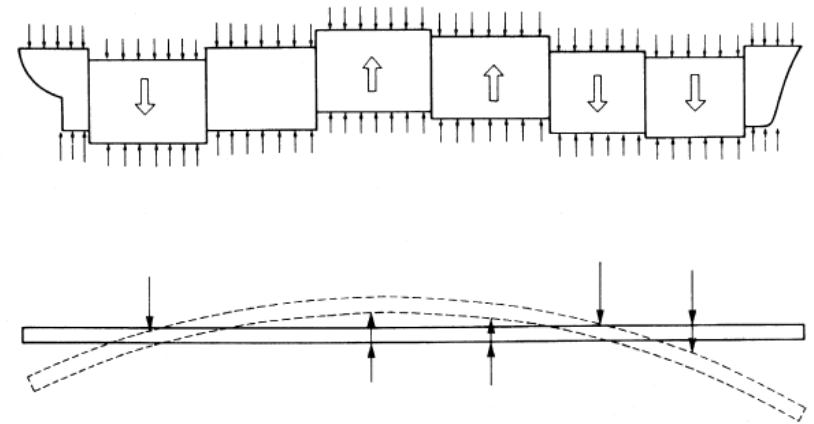


Figure 12. Effect of differential loading in cargo or ballast tanks on shear and bending stresses in ships hulls (Eyres, 1994)

# Ballast Water Exchange



BWE problems

# BALLAST WATER MANAGEMENT

## **Ballast water treatment (BWT) Facts**

- All potential ballast water treatment technologies are currently at very early stage of development.
- Significant further research is required.
- Ballast water treatment involves a combination of:
  - Primary filtration or physical separation (usually, particles > 50 microns)
  - Secondary biocidal treatment.

# BALLAST WATER MANAGEMENT

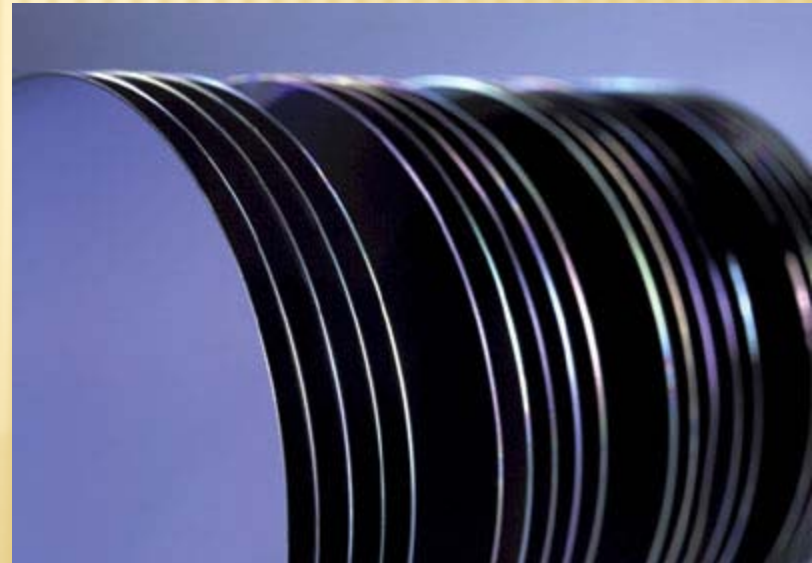
- Current global budget for ballast water treatment R&D (about US\$10 million) is insignificant compared to environmental costs.
- There is a desperate need to develop and implement international standards and procedures for evaluation and approval of new ballast water treatment systems.

# BALLAST WATER QUALITY REGULATIONS

<b>Parameter</b>	<b>IMO</b>	<b>US</b>
Living organisms > 50 microns per 10 m <sup>3</sup>	100	1
Living organisms between 10 and 50 microns per 10 mL	100	1
Colony forming units of <i>Vibrio cholera</i> (O1 and O139) per 100 mL or per gram of zoological sample	1	1
Cfu of <i>Escherichia coli</i> per 100 mL	< 250	< 126
Cfu of intestinal enterococci per 100 mL	< 100	< 33

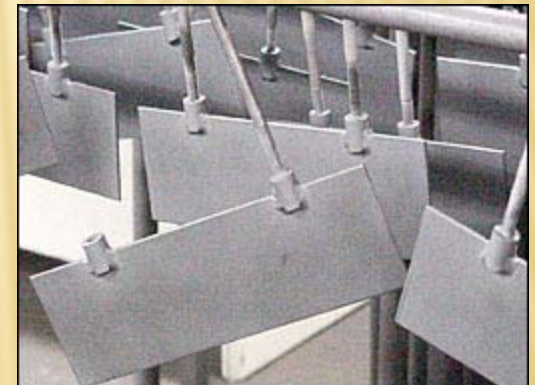
# NEW ALTERNATIVE FOR BALLAST WATER: ELECTRO-DISINFECTION

- Water is forced through reactor equipped with electrodes:
- Electric current kills microorganisms
- Potent disinfecting agents are produced electrochemically:
  - minimal free chlorine production
  - peroxides
  - ozone
  - active oxygen compounds
  - persulfates & percarbonates



# A NEW ALTERNATIVE: ELECTRO-DISINFECTION

- ▶ As effective as chlorination and UV treatment.
- ▶ Capable of producing residual activity.
- ▶ Presence of active oxygen compounds reduces formation of unwanted DBPs.
- ▶ Commonly used in Europe.



# A NEW ALTERNATIVE: ELECTRO-DISINFECTION

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## Advantages:

- ▶ Environmental compatibility
- ▶ Versatility: can be installed in ship
- ▶ Energy efficiency
- ▶ Safety
- ▶ Amenability to automation
- ▶ Cost effectiveness

# BILGE WATER TREATMENT

- ✘ Bilge water: Oil and grease, detergents, aluminum shavings, plastic shreds/shards, dissolved heavy metals and suspended solids.
- ✘ Navy ships produce millions of gallons of bilge water each year, comprising one of the Navy's largest waste streams.
- ✘ Bilge water treatment represents an important cost to the Navy and shipping industry.

# PROJECT OBJECTIVE

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- ✘ **Bilge water:** To find best combination of metals for cathode and anode to optimize flocculation and hydrogen gas generation for flotation of oil and other particles.
- ✘ **Ballast water:** To develop a cost effective, environmentally friendly method for treating ballast water.

# RESEARCH APPROACH

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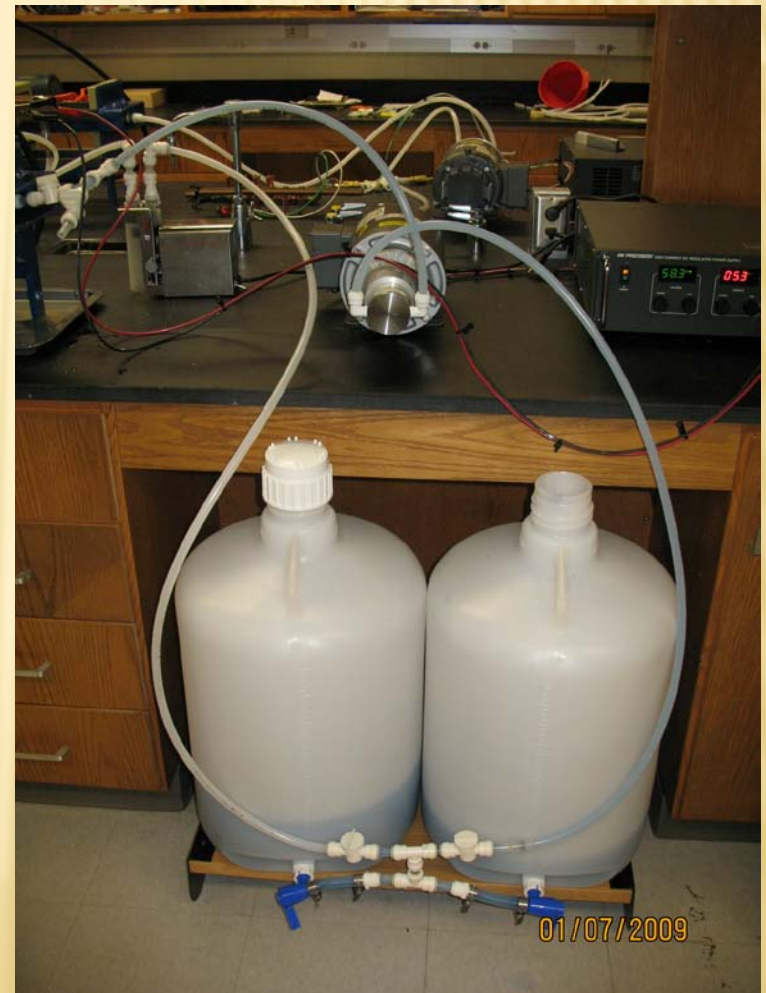
- ✘ Purchased commercially available bench scale, continuous flow lab reactors, 1 L/min.
- ✘ Reactors have metallic electrodes, which promote coagulation of colloidal particles (bilge water treatment), and kill living organisms (ballast water treatment).
- ✘ Find the best combination of electrode materials to optimize reactor performance.

# WORK ACCOMPLISHED

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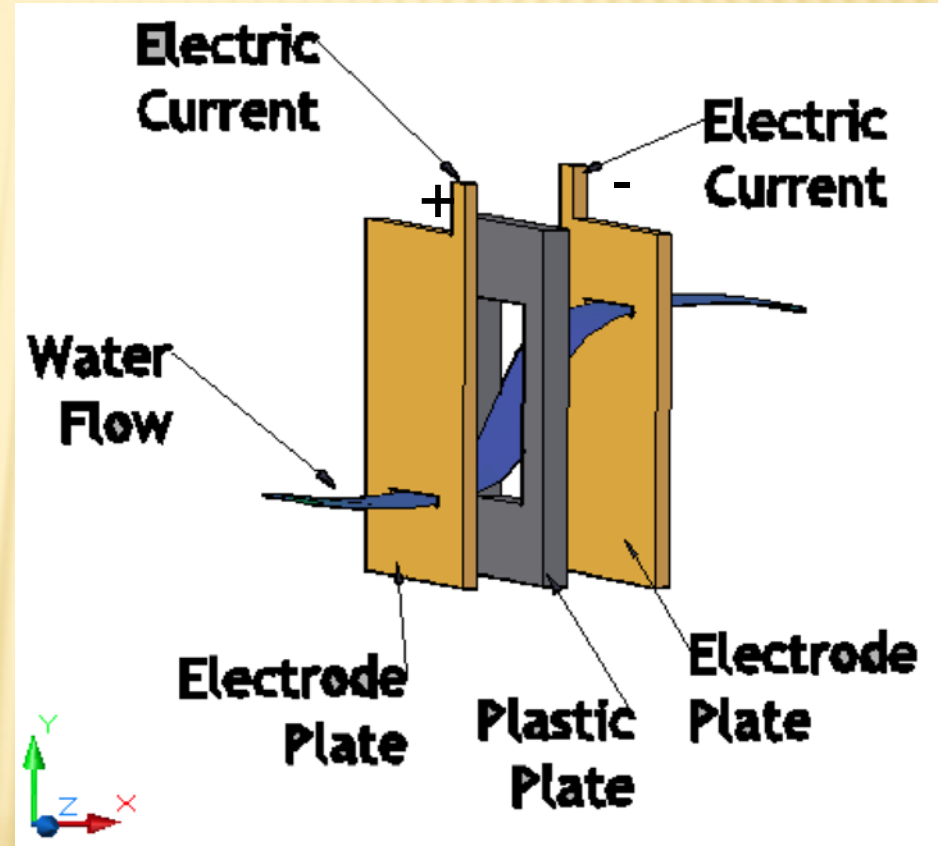
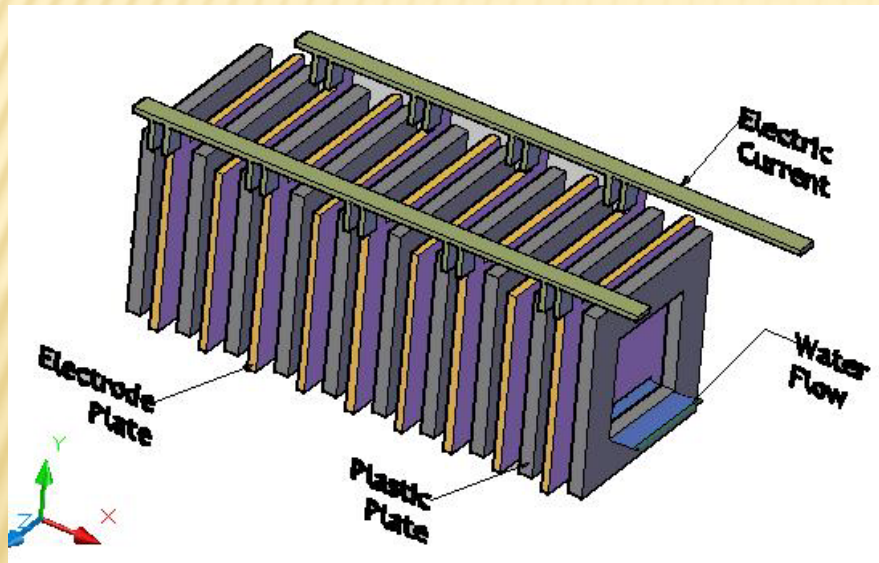
- + Reactors were set up in CERM 109.
- + Prepared synthetic bilge water.
- + Prepared synthetic ballast water by adding target organisms to commercial bottled water.
- + Will also use Lake Pontchartrain water.
- + Run preliminary experiments.

# BILGE WATER TREATMENT



# BILGE WATER TREATMENT

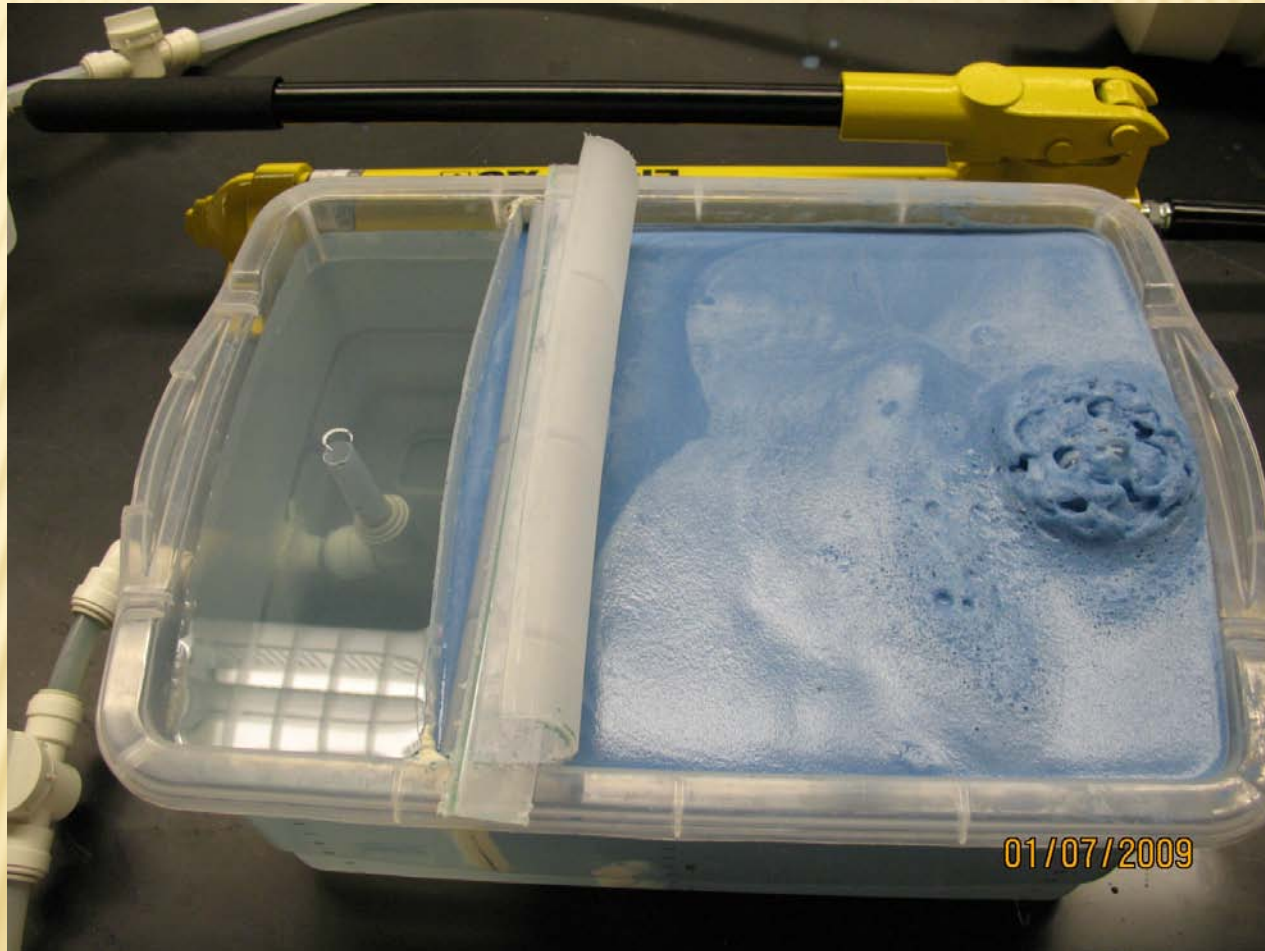
## Reactor details



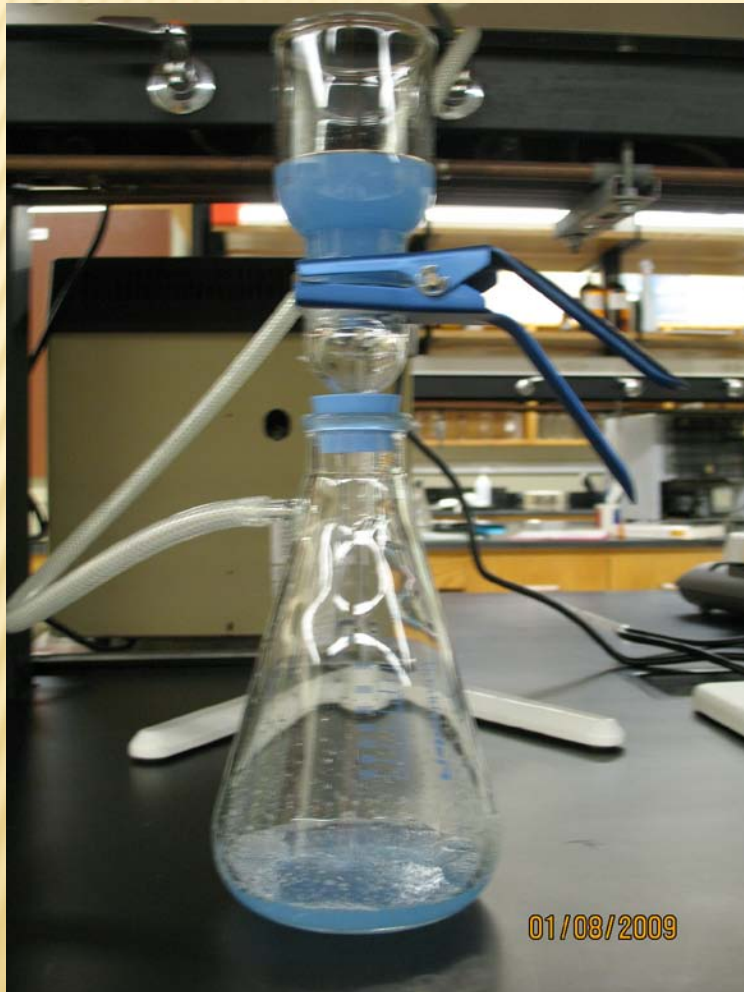
# BILGE WATER TREATMENT



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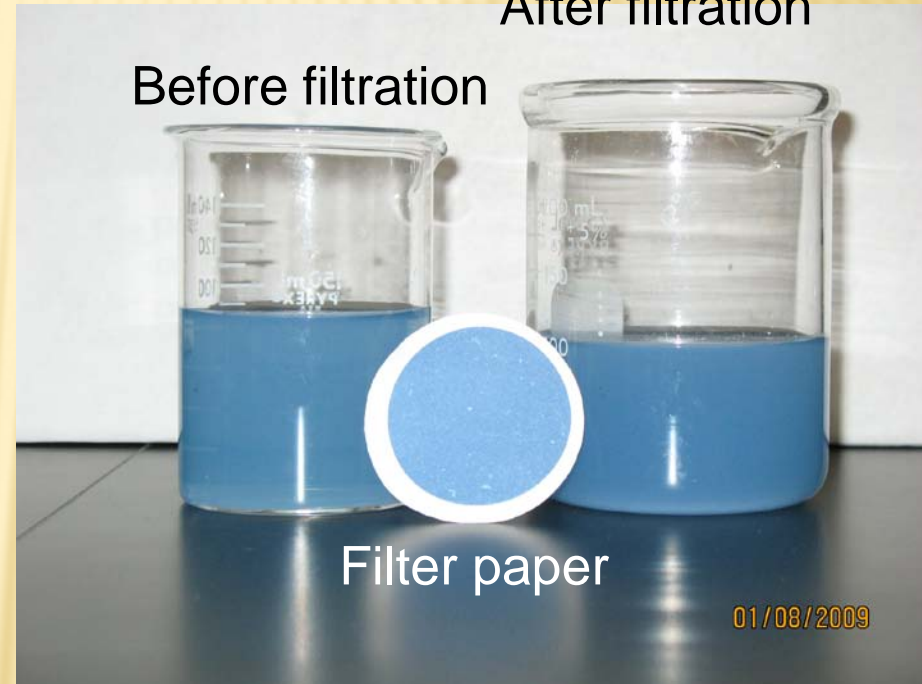


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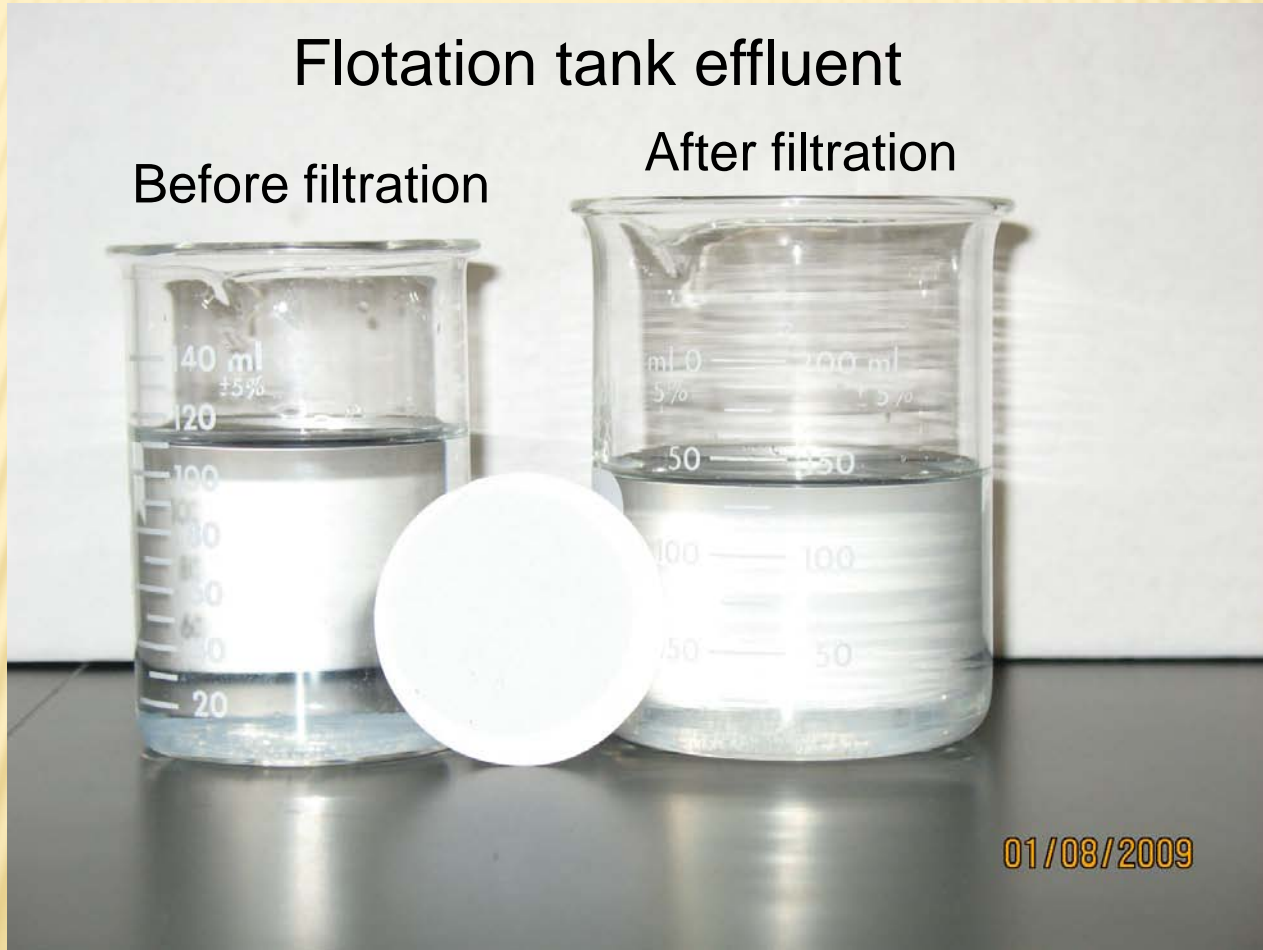


Raw water

After filtration



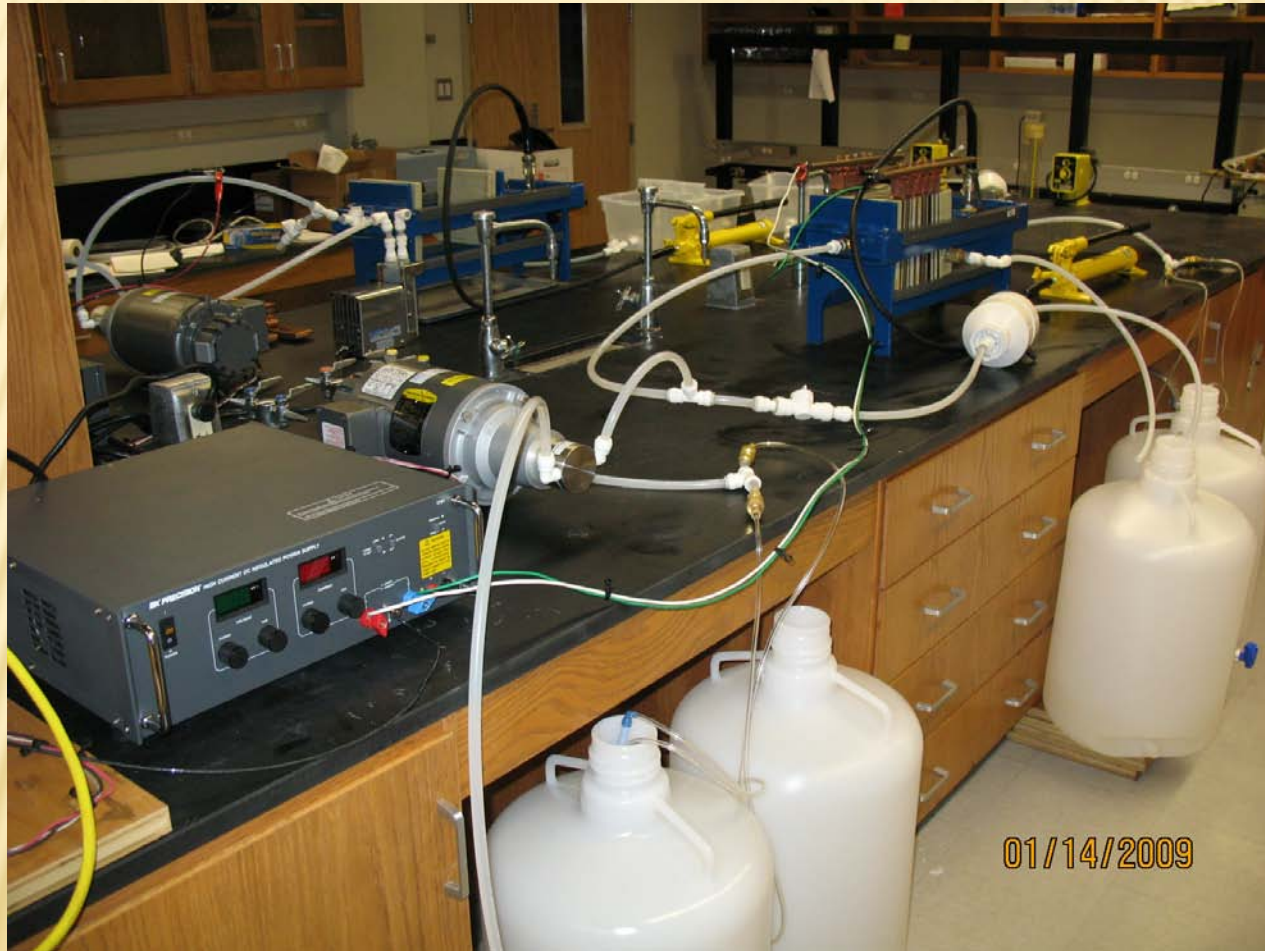
# BILGE WATER TREATMENT



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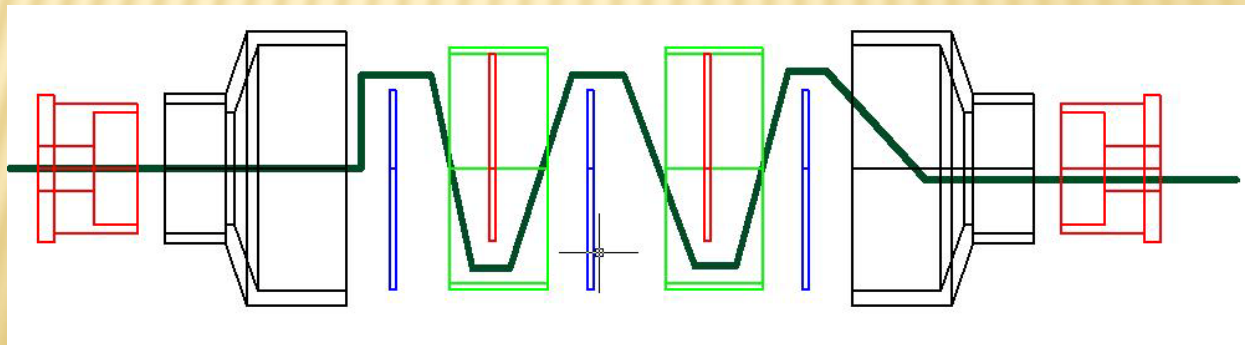
Substance	Influent, mg/L	Effluent , mg/L
Total oil	2500	33
Surfactant	2500	
Paint	200	
CINa	200	
Cu	2.15	0.13
Zn	1.5	0.57
Ni	0.18	0.18
Total metals	3.83	0.88
pH	6.7	6.85
Current intensity, A/m <sup>2</sup>	77.5	
Mass of Al consumed, mg	1480	
Aluminum dosage, mg/L	49.3	

# BALLAST WATER TREATMENT



# BALLAST WATER TREATMENT

## Control "reactor"



# BALLAST WATER TREATMENT

Before treatment

After treatment



Coliform bacteria

# ONGOING ACTIVITIES

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- Conduct additional experiments to determine best combination of:
  - Electrode materials
  - Voltage
  - Current intensity
- Find optimum detention time.
- Perform data analysis and interpretation.

**QUESTIONS?**

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