“The Golden Bear Research Center (GBRC): Insight into Ballast Type Approval and Treatment Efficacy”

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QUESTION:

HOW ARE WE DOING IN BALLAST WATER TREATMENT?

Let’s see how ballast treatment success compares with other applications in pollution* and public health**

* Bloomberg Report 2013;
**World Health Organization
Treatment Efficacy for a Ballast Tank:
What goes in vs. What goes out
If Discharge is reduced to 1% of Uptake:
  = 100x reduction
  = 2 log reduction
  = 99% reduction
Live Zooplankton (>50 μm)

- KLB14_UU: 189,192 organisms/m³
- KLB14_DT: 0.09 organisms/m³

Live Protists, Epi Microscopy (10-50 μm)
Phytoplankton + Heterotrophs

- KLB14_UU: 2,967 protists/mL
- KLB14_DT: 0.33 protists/mL

Live Zooplankton (>50 μm)

- KLB15_UU: 210,000 organisms/m³
- KLB15_DT: 0.28 organisms/m³

Live Protists, Epi Microscopy (10-50 μm)
Phytoplankton + Heterotrophs

- KLB15_UU: 4,213 protists/mL
- KLB15_DT: 0.33 protists/mL
Live Zooplankton (>50um)

- JLB1-UU: 117,979.80 organisms/m³
- JLB1-DT: 38 organisms/m³

Live Protists, Epi Microscopy (10-50um) Phytoplankton+Heterotrophs

- JLB1_UU: 5,526.67 protists/mL
- JLB1_DT: 33 protists/mL

Live Zooplankton (>50um)

- JLB2-UU: 172,020.20 organisms/m³
- JLB2-DT: 10 organisms/m³

Live Protists, Epi Microscopy (10-50um) Phytoplankton+Heterotrophs

- JLB2_UU: 2,462.22 protists/mL
- JLB2_DT: 67 protists/mL
“CHALLENGE” in Ballast Water Treatment Testing: Conceptions and Misconceptions
Biological efficacy does not obey the CHALLENGE Concept in Ballast Water Testing

**Biological Efficacy as a Function of CHALLENGE Concentration**

**Phytoplankton (10-50 um)**

![Graph showing Biological Efficacy](image1)

- 10-50 um Live Phytoplankton (FDA)
- \(N = 85\)

**Biological Efficacy as a Function of CHALLENGE Concentration**

**Zooplankton (>50 um)**

![Graph showing Biological Efficacy](image2)

- >50 um Live Zooplankton
- \(N = 110\)
CHALLENGE: Higher uptake concentrations yield a more ‘Challenging’ test

?? A Misconception ??

Flow Cytometry (FDA): Phytoplankton 10-50 um
Uptake vs. Treatment Discharge

N = 85

10-50 um
Live Phytoplankton (FDA)

Zooplankton Uptake vs. Discharge

N = 110

>50 um
Live Zooplankton
Biological Efficacy as a Function of CHALLENGE Concentration
Phytoplankton (10-50 um)
Biological Efficacy as a Function of CHALLENGE Concentration
Zooplankton (>50 um)

![Graph showing biological efficacy as a function of uptake concentration.](image)
All active (live) phytoplankton (10-50 um)  
N = 174,373 cells

Count Ratio (1-50 um)/(10-50 um) = 8.2x
Let’s see how ballast treatment success compares with other applications in pollution and public health

*Bloomberg Report 2013;*
Environmental Successes:
1. Visible reductions in Los Angeles smog

Then...  Now
Environmental Successes:

1. Visible reductions in Los Angeles smog... How? Regulatory emissions control

Roughly... **10x** reduction in pollution emissions, even with modern 3-way converters
Environmental Successes:
2. Reduction in Acid Rain

Death to acid-intolerant forests

The Clean Air Act 1970

Stack-gas scrubbers:
Roughly...
5x – 20x reductions in SO₂ and NOₓ
Environmental Successes:

3. Reduction of the Antarctic Ozone ‘Hole’

Roughly... **10x** reduction in Fluorocarbons, ... over 30 years!!
How about ‘efficacy’ in disease control?
Recall the Challenge of Land-based Ballast Water Tests:

>50 um Challenge = 100,000/m³

Ballast Water Discharge Std. = 10/m³

A 10,000x reduction (in one day!)
A 0.01% contamination will cause a FAIL
### Successes in Disease Elimination/Eradication: Vaccination programs against ‘organismic invaders’

Progress to date against diseases for which vaccines already exist and deaths from diseases for which vaccines might be developed.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Annual deaths (all ages) if no immunization</th>
<th>Prevented</th>
<th>Occurring</th>
<th>% prevented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smallpox</td>
<td>5.0 million</td>
<td>5.0 million</td>
<td>--</td>
<td>100</td>
</tr>
<tr>
<td>Diphtheria</td>
<td>260,000</td>
<td>223,000</td>
<td>37,000</td>
<td>86</td>
</tr>
<tr>
<td>Whooping cough</td>
<td>990,000</td>
<td>630,000</td>
<td>360,000</td>
<td>64</td>
</tr>
<tr>
<td>Measles</td>
<td>2.7 million</td>
<td>1.6 million</td>
<td>1.1 million</td>
<td>60</td>
</tr>
<tr>
<td>Neonatal tetanus</td>
<td>1.2 million</td>
<td>0.7 million</td>
<td>0.5 million</td>
<td>58</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>1.2 million</td>
<td>0.4 million</td>
<td>0.8 million</td>
<td>33</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>3.2 million</td>
<td>0.2 million</td>
<td>3.0 million</td>
<td>6</td>
</tr>
<tr>
<td>Polio (cases of lifelong paralysis)</td>
<td>640,000</td>
<td>550,000</td>
<td>90,000</td>
<td>86</td>
</tr>
<tr>
<td>Malaria/other parasitic infections</td>
<td>2.2 million</td>
<td>--</td>
<td>2.2 million</td>
<td>0</td>
</tr>
<tr>
<td>HIV/sexually transmitted diseases</td>
<td>1.3 million</td>
<td>--</td>
<td>1.3 million</td>
<td>0</td>
</tr>
<tr>
<td>Diarrhoea/enteric fevers*</td>
<td>3.0 million</td>
<td>--</td>
<td>3.0 million</td>
<td>0</td>
</tr>
<tr>
<td>Acute respiratory infections</td>
<td>3.7 million</td>
<td>--</td>
<td>3.7 million</td>
<td>0</td>
</tr>
</tbody>
</table>

**Reduction:**

- 7.0x
- 2.8x
- 2.5x
- 2.4x
- 1.5x
- 7.1x
Three of the greatest environmental successes in modern history...

1. Reduction in smog derived from automobiles
2. Reduction of acid rain
3. Shrinkage of the ‘ozone hole’

... were accomplished with reductions in the respective putative pollutants that were **approximately 10x**.

**HOW ARE WE DOING IN BALLAST WATER TREATMENT?**

Fantastic...
1. TWO
2. SEVEN
3. THREE
4. FOUR
5. ONE
6. EIGHT
7. FIVE
8. SIX
9. NINE
10. TEN
1. IMO and USCG BWDSs are not evaluated statistically in Type Approval Tests.
2. Calibration ‘standards’ for the ‘live organism’ metabolic condition are not available; true number of ‘live’ protists is never known, it is determined by chemical proxy.
3. A 'fraction-of-a-micron' edge exists near 50 um, where BWDSs elevate to an instant 1 million-fold increase in stringency; 10/mL to 10/m^3.
4. BWDSs for E. coli and Enterococcus are too high, the vast majority of tested water 'passes' with no need for treatment.
5. BWDSs for Vibrio Cholerae provide no efficacy information since none have been detected.
6. The BWDSs for ≥ 50um size class is too low: contamination from 'dead volumes' (0.01% contamination) drive results above the BWDS.
7. USCG BWDSs for the 10-50 um protist group is analyzed by a 'required' method that is plagued by false-positives (FDA/CMFDA).
8. BWDSs for the 10-50 um group vastly underestimate the true number of planktonic protists (by at least 10x) because most protists are <10 um.
9. Challenge level for IMO shipbased HPC bacteria is too high; 10,000 CFU/mL.
10. Required five ‘consecutive’ passes allow statistically poorer systems to pass.
Thank you!