Zinc Additive in Once-Through Cooling Water Identified as Contributing to Toxicity of Effluent Discharged from the Oak Ridge Y-12 Plant

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Introduction

Until 1992, the primary mission of the Y-12 Plant was the production and fabrication of nuclear weapon components. Activities associated with these functions included production of lithium compounds, recovery of enriched uranium from scrap material, and fabrication of uranium and other materials into finished parts (Koncinski 1995). The Y-12 Plant is currently refocusing its technical capabilities and expertise to serve the Department of Energy (DOE). Because the Y-12 Plant continues to discharge treated wastewater to East Fork Poplar Creek, a National Pollutant Discharge Elimination System (NPDES) permit is required for the facility. This study pertains to sampling and analysis required in the NPDES permit at an ambient location (Outfall 201) in East Fork Poplar Creek.

Effluent at Outfall 201 consists of treated process wastewater, treated groundwater, groundwater that infiltrates the storm sewer system, cooling water, condensate water, sump water, cooling tower blowdown and storm water. The current NPDES biomonitoring permit limit for Outfall 201 requires the effluent have a no-observed-effect concentration (NOEC) of 100%. This means that the effluent at Outfall 201 cannot reduce *Ceriodaphnia* survival or reproduction at full strength in laboratory tests.

A toxicity assessment for Outfall 201 was begun in December 1994. This was done prior to NPDES permit renewal because historical toxicity test data at Outfall 201 predicted that the effluent would not pass the anticipated NPDES permit limit of a NOEC of 100%. The biomonitoring permit limit for the outfall has been appealed.

Methods and Materials

- Effluent from Outfall 201 was treated to aid in identifying the general physical and/or chemical characteristics of toxicants present in the effluent

Summary of Treatments

Treatment	Results
pH 6, pH 7, and pH 9 adjustment	Shift in protonation equilibrium of species such as ammonia, sulfide, metals
EDTA addition	Chelation or complexation of certain dissolved, divalent metals
Thiosulfate addition	Reduction of oxidized species; complexation of certain dissolved metals
Filtration: pH low/I/high	Removal of solids; formation of precipitate or desorption of toxicants at adjusted pH
Aeration: pH low/I/high	Removal of volatile compounds, aeration and oxidation of reduced compounds
C18SPE: pH low/I/high	Removal of nonionic dissolved organic compounds or some metals through adsorption

- Toxicity tests were conducted with the crustacean, *Ceriodaphnia dubia*, using procedures similar to those described by the Environmental Protection Agency for toxicity identification evaluations (e.g., EPA 1991).
  - Toxicity tests were 3 brood and lasted for 6 or 7 d
  - Tests were static renewal
  - Generally used 5 replicates per treatment, one animal per replicate
  - 11–22 tests conducted since December 1994 depending on treatment

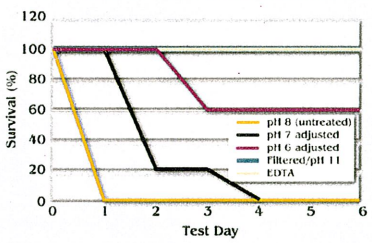
Results and Discussion

Ceriodaphnia reproduction was compared between the pH-8 treatment (considered baseline) and the various treatments.

Clear trends emerged :

- EDTA Treatment Decreased Toxicity
- pH-11 Filtration Decreased Toxicity
- pH-9 Adjustment Increased Toxicity
- pH-6 Adjustment Increased Toxicity
- No clear trend for any other treatments

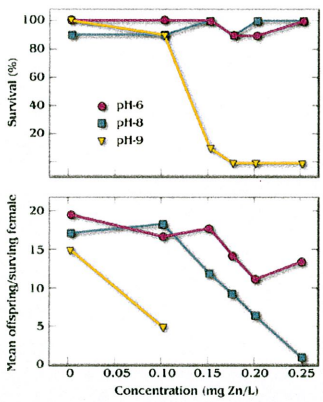
Zinc Acutely Toxic at Outfall 201 during August 1995



Ceriodaphnia Survival
Outfall 201
August 1995 Composite

- Zinc in pH adjusted samples ≈ 0.31 mg/L
- Zinc in Filtered/pH 11 sample < 0.06 mg/L
- Zinc in EDTA Sample = 0.40 mg/L

Zinc Toxicity Greater at pH-9 than at pH-8 or pH-6

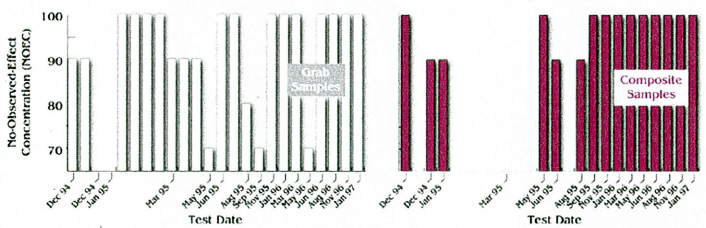


Zinc in potable water ranges from 0.10 0.15 mg/L.

Treatment	Sample Type	Percent of samples with change in toxicity (reproduction of Ceriodaphnia) compared to baseline*		
		No Change	Toxicity Increased (≥20% fewer offspring/female)	Toxicity Decreased (≥20% more offspring/female)
EDTA	G	40	15	45
	C	36	9	55
pH-9	G	0	80	20
	C	20	80	0
pH-6	G	15	55	30
	C	30	62	8
pH-11 Filtration	G	10	45	45
	C	20	30	50

*Baseline = Outfall 201 grab or composite sample adjusted to pH 8.

Summary of Outfall 201 No-Observed-Effect Concentrations



The trends observed clearly pointed toward a metal as contributing to toxicity observed in effluent from Outfall 201. Additional evidence pointed to zinc and in particular, zinc from the additive sodium zinc polyphosphate glass which is added as a corrosion inhibitor to potable water.

Toxicity Tests with Treated Potable Water had Similar Pattern as Outfall 201

Treatment	Survival (%)	Reproduction (Offspring/Surviving Female)
Dechlorinated	100	22
pH-6	100	26
pH-9	0	
pH-8 EDTA	100	29
pH-11 Filtered	80	2
Control (range)	75-100	24-31

Conclusions

- Zinc is clearly one of the metals contributing to toxicity at Outfall 201
- Zinc at Outfall 201 is generally 0.10 mg/L and pH is 7 8, thus zinc in the effluent does not entirely account for toxicity observed.
- Once-through cooling water (potable water) is a major contributor to flow at Outfall 201 and a source of zinc
- Concentration of zinc in potable water will reduce *Ceriodaphnia* survival and reproduction

References

EPA (U.S. Environmental Protection Agency). 1991. Methods for Aquatic Toxicity Identification Evaluations, Phase I Toxicity Characterization Procedures (second edition). EPA/600/6-91/003. Office of Research and Development, Duluth, MN

Koncinski, W. S. (ed.). 1995. Oak Ridge Reservation Annual Site Environmental Report for 1994. ES/ESH-57. Oak Ridge National Laboratory, Oak Ridge, TN