Overview of the Toxicity of the Oil Dispersant Corexit

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[Presentation approved by NHEERL, US EPA but does not necessarily reflect Agency policies]

Outline

- Introduction
- Biodegradation
- Mutagenicity and Toxicity in Rats
- Aquatic Toxicity
- Conclusions

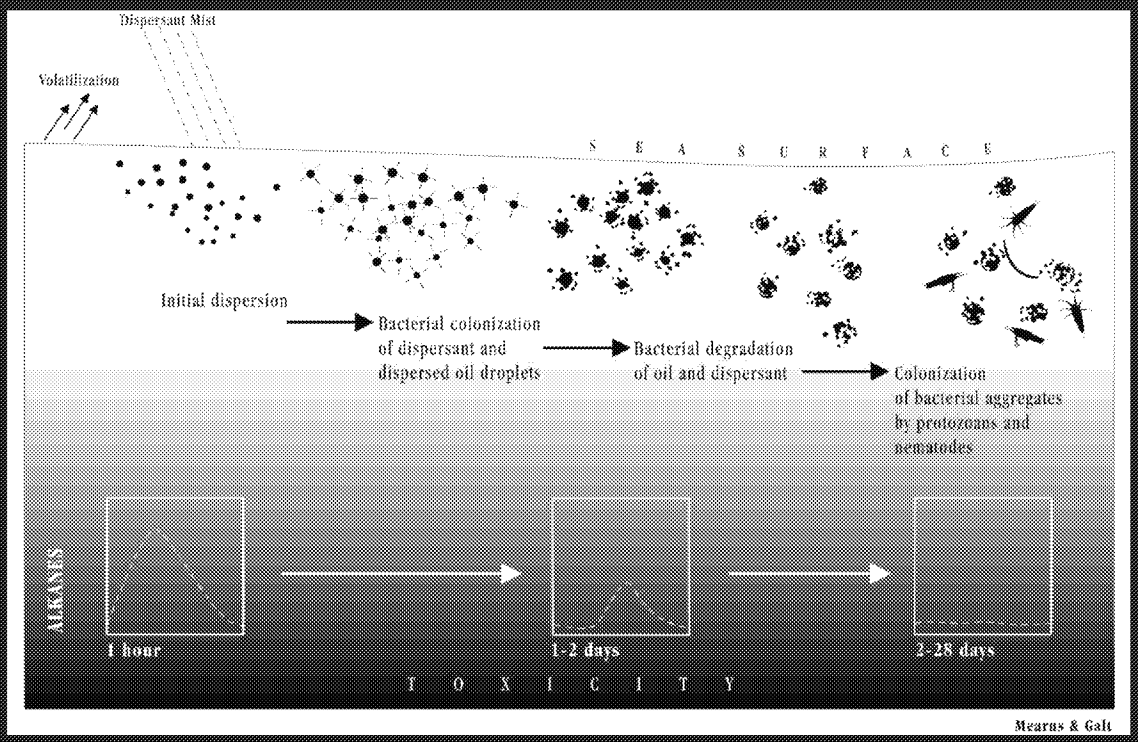
Introduction

- Corexit 9500 was the primary dispersant used at the BP site in the Gulf of Mexico during the summer of 2010; Corext 9527 is closely related, and nearly all of the toxicology data in the open literature is on these 2 dispersants.
- Corexit 9500 and 9527 are oil dispersants composed of 10-30% (w/w) organic sulfonic acid salt and 1-5% (w/w) propylene glycol. They differ in that 9500 contains 10-30% (w/w) petroleum distillates, whereas 9527 has 30-60% (w/w) 2-butoxyethanol.
- Although generally applied at the surface, most of the dispersant used at the BP site was applied below the surface at the site of the well head.

Introduction (cont.)

- The principle underlying the use of dispersants is to break up the oil into small droplets that can then be metabolized by microbes. This can accelerate the biodegradation process by marine microbes and weathering.
- 60% of marine microbes have some capacity to metabolize oil.
- Recent studies have found the presence of microbes with a high capability of metabolizing oil at the cold temperatures of the sea floor in the Gulf of Mexico.

What is the Fate of Dispersed Oil?



What Does Chemically Dispersed Oil Look Like?

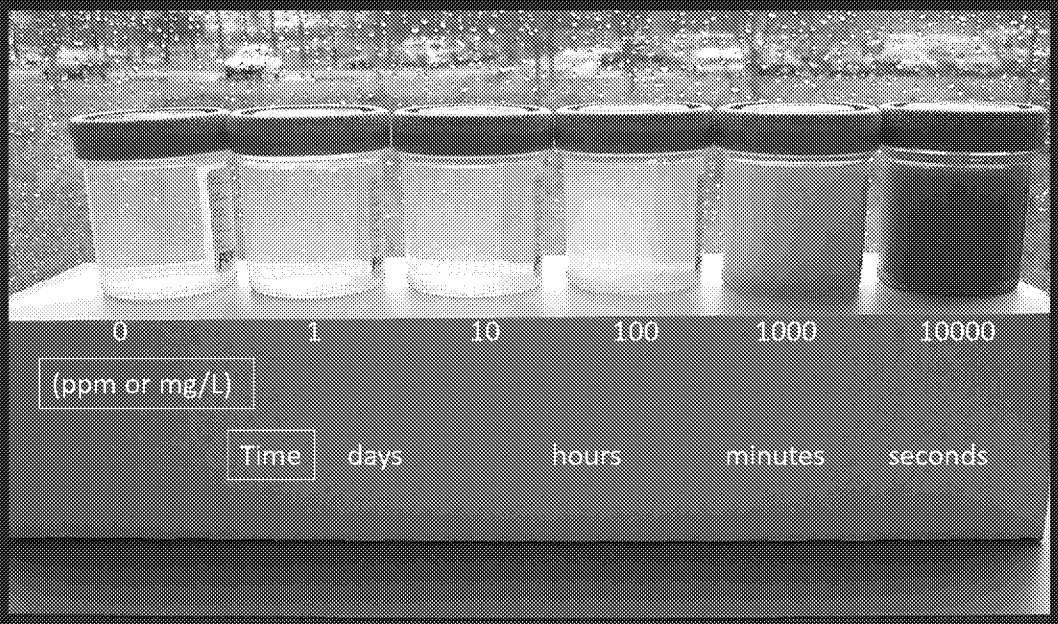
[www.orr.noaa.gov/public/erd/chemistry-data/dispersanttoxicity/]

3 ml Fresh South Louisiana Crude Oil in 30 ml salt water (100,000 ppm)

Shaken and let stand for 10 min

This is what it would look like under the plume immediately after dispersion and if restricted to the upper 3 inches of the water column.

Dispersed particles mix rapidly with adjacent clean water, the rate depending on wave action or other sources of diffusion



USGS road dust standard with particle-size distribution in the same range as dispersed oil

3/13/2003

Biodegradation of Corexit

- There are no studies on the biodegradation of Corexit components under marine conditions.
- There are some studies on the biodegradation of one component, the surfactant sulfonic acids, under non-marine conditions. These show that the sulfonic acids degrade rapidly under aerobic conditions and less so under anaerobic conditions.

Biodegradation of Corexit-Treated Oil

- Two **laboratory** studies have examined the ability of Corexit to alter the biodegradation rate of oil.
- Both studies found that Corexit enhanced the initial rate of degradation of oil + bacteria or oil alone as assessed by the reduction of various PAHs. However, in the end, the oil degraded to the same extent with or without Corexit after 46 days.

Mutagenicity and Toxicity in Rats

- Only one study has been reported on the mutagenicity and rodent toxicity of Corexit (in our lab at EPA by SE George et al. 2001).
- The study showed that Corexit was not mutagenic in the *Salmonella* assay, nor did it produce mutagenic urine in rats gavaged with Corexit.
- However, Corexit was highly toxic to rats if not diluted at least 1:10 prior to gavage.
- Corexit with or without oil (by gavage) altered the intestinal metabolism and gut flora of rats.

Aquatic Toxicity

- There are ~40 papers on the aquatic toxicity of dispersants with and/or without oil in the open literature.
- Dispersant-treated oil is generally more toxic INITIALLY than oil alone to aquatic life on a per-mass or volume-of-oil basis because the dispersant puts more oil (particulate and dissolved) into the water column.
- Most toxicity appears to be due to the dissolved (soluble) hydrocarbons. However, dispersants put some portion of these hydrocarbons into colloidal suspension, and these hydrocarbons are less associated with toxicity than are the dissolved (soluble) hydrocarbons.

Aquatic Toxicity (Cont.)

- Adding dispersant to oil results in greater exposure of organisms to PAHs when the salinity of the water is low, such as in coastal waters.
- Although oil and oil + dispersant are generally more toxic to early-life stages (fish eggs and embryos) than to adults, species differences complicate this generalization.
- Dispersants have little or moderate levels of endocrine-disruption activity as assessed by in vitro assays.

Aquatic Toxicity (Cont.)

- In general, crustaceans are more sensitive than fish to the toxicity of dispersants.
- As seen on the next two slides from the NAS (2005) report, the toxicity of dispersant or dispersant + oil can vary over 2 orders of magnitude among species.

Chemical Name

Corexit 9500 DISPERSANT ONLY

CAS Number

11111111

Fish

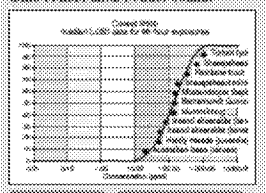
96 H LC50's

Graph 1 | 24 Hours | 48 Hours | 72 Hours | 96 Hours

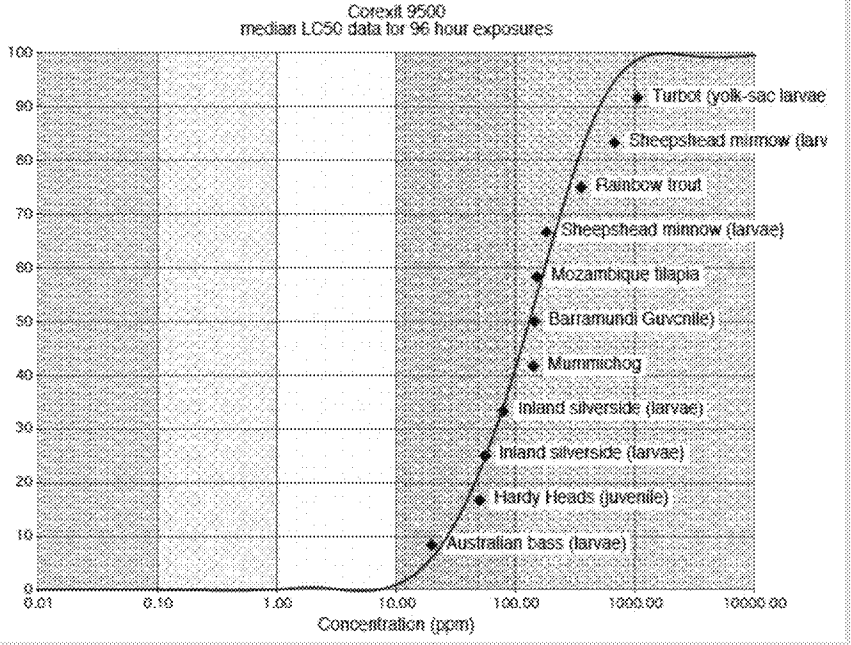
Toxicity Category

- Very Highly Toxic LC50 < 0.1 ppm
- Highly Toxic LC50 0.1 - 1 ppm
- Moderately Toxic LC50 1 - 10 ppm
- Slightly Toxic LC50 10 - 100 ppm
- Not Acutely Toxic LC50 > 100 ppm

Salt Water and Fresh Water



Graph | Graph + Curve



DATA SOURCE: NAS 2005 AND OTHERS

* -- the data from at least one point in this series was the midpoint of a min and max concentration rather than a mean concentration

* -- the data from at least one point in this series was greater than or less than the concentration rather than a mean concentration

Chemical Name

Corexit 9500 DISPERSED OILS

CAS Number

22222222

Fish

96 H LC50's

Graph 1 | 24 Hours | 48 Hours | 72 Hours | 96 Hours

Toxicity Category

- Very Highly Toxic LC50 < 0.1 ppm
- Highly Toxic LC50 0.1 - 1 ppm
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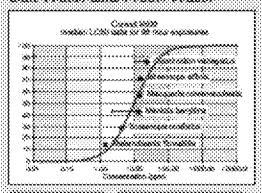
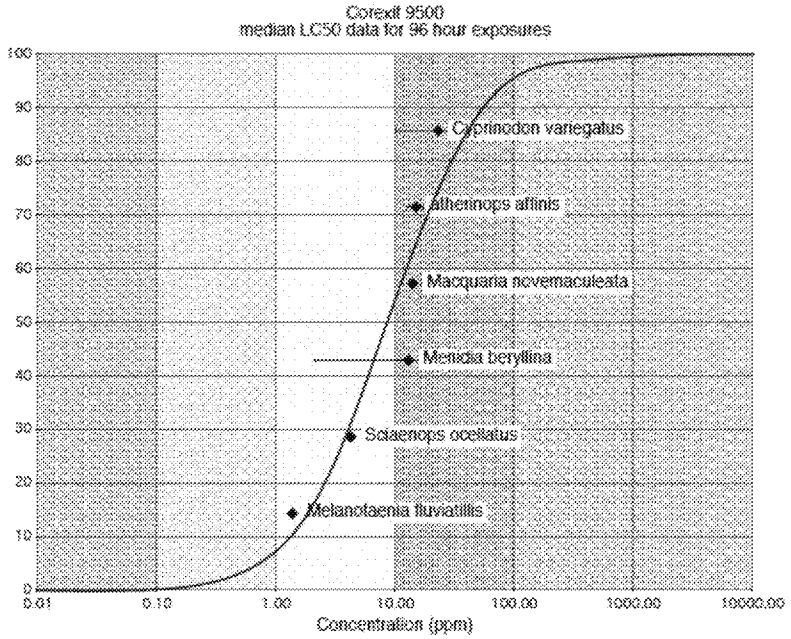
Salt Water and Fresh Water





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Conclusions

- Application of dispersant can increase the initial toxicity of the oil to aquatic life living in the water column—where the oil is dispersed into droplets.
- Microbes can generally metabolize dispersed oil more quickly than un-dispersed oil.
- Early-life stages (eggs or embryos) of aquatic organisms are generally (but not always) more sensitive than juvenile or adult forms of the same species.
- Corexit is not mutagenic and has minimal endocrine-disrupting activity.

References

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