Increased Risk for Chemical Contamination of Coastal Waters During Extreme Storm Events

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Sea level rise and an increase in the severity and frequency of coastal storms are probable outcomes for Chesapeake Bay due to global climate change.
During storm events our coastal region is susceptible to infrastructure loss and the disruption of economically vital transportation pathways.

Contamination of coastal waters by chemicals released by accidental spills during severe storm events is also a potential ecological and economic risk for our area.
Our ports and harbors have been a focus for industry and the military for over 200 years

These industries, by necessity, utilize a variety of chemical and petroleum products in their daily operations
Environmental regulations limit the discharge of toxic chemicals to the waterways via effluents however...

..some of the most severe historical contamination issues in Chesapeake Bay are the result of accidental and deliberate spills
The potential for accidental introduction of contaminants during storm events is very real.

As recently as 2005, Hurricane Katrina devastated the Gulf Coast, resulting in the release of over 8 million gallons of oil to the Mississippi River and the Gulf of Mexico.
For perspective, the volume of oil released by the Exxon Valdez spill in Prince William Sound Alaska was 11 million gallons and is the largest spill on record in the US.

Katrina in the Gulf was a close second at 8 million gallons
Why is the Chesapeake Bay region at risk? What are potential chemical sources?

Highly industrialized ports including: transportation industries, governmental facilities, historically contaminated sites near shore.
Federal facilities on National Priorities List (Superfund sites)

- Defense Supply Center Richmond, Chesterfield County
- Fort Eustis, Newport News
- Former Nansemond Ordnance Depot, Suffolk
- Langley Air Force Base, Hampton
- Marine Corps Combat Development Command, Quantico
- NASA-Langley Research Center, Hampton
- Naval Amphibious Base Little Creek, Virginia Beach
- Naval Surface Warfare Center, Dahlgren
- Norfolk Naval Base, Norfolk
- Norfolk Naval Shipyard, Norfolk
- USN St. Julien’s Creek Annex, Chesapeake
- Yorktown Naval Weapons Station, York County
- Yorktown Naval Weapons Station Cheatham Annex, York County

Many Superfund sites are within the watershed and near shore
How can introduction of an organic chemical cause long-term ecological or economic damage?

- Limited water solubility “hydrophobic”
- “Like Dissolves Like”
- High affinity for lipid material “lipophilic”
- Organic carbon and organisms

We can learn from History
History Lesson: Kepone in the James River, VA

decachlorooctahydro- 1,3,4 – metheno-2H-cyclobuta [cd] pentalen-2-one

Kepone is no longer used in the United States. First introduced in 1958, Kepone was used until 1978 as an insecticide for leaf-eating insects, ants and cockroaches, and as a larvicide for flies (IARC 1979). (Banana root borer, tobacco wireworm) Kepone was used on bananas, non-bearing citrus trees, tobacco, ornamental shrubs, lawns, turf, and flowers (HSDB 2000).

C\textsubscript{10} H\textsubscript{2} Cl\textsubscript{10} O

BIG synthetic molecule, low water solubility $K_{ow} = 10^3$

Where is it going to go?

• Began in Hopewell in 1966 (Allied Chemical)
• Contracted to Life Science Products in 1974
• Peak production of >455,000 Kg in 1974
• Production halted in July 1975 when discovered in the James River
Kepone monitoring

- Began 1975
- 13,041 biota samples collected
- 44 species
- 17 different zones
What’s happened over time?

- James River and its tributaries were closed to recreational and commercial fishing at a cost of millions of dollars to Virginians.
- Recreational fishing ban lifted in 1980.
- Commercial ban modified several times – finally lifted in 1989.
- While now below action levels, Kepone is still detected in fish over 25 years after introduction to the James River.
History Lesson: Creosote Spills in the Elizabeth River, VA

Creosote-A Source for Polycyclic Aromatic Hydrocarbons (PAH)

Unsubstituted PAH Common in Samples from Pyrogenic Sources

- Naphthalene
- Anthracene
- Phenanthrene
- Pyrene
- Chrysene
- Benzo[j]fluoranthene
- Benzo[a]pyrene
- Perylene
- Coronene

Examples of Alkyl Substituted PAH Common in Petroleum

- 1,3-Dimethyl-naphthalene
- 1,3,5-Trimethyl-naphthalene
- 2,6-Dimethyl-phenanthrene
- 2,3,7-Trimethyl-phenanthrene
Are there Biological Effects from High PAH Concentrations?
PAH induced liver lesions and cancer in *Fundulus heteroclitus*

Where PAH are high
Tumors are high
Long-term “Genetic Effects”

Offspring from ER Fish Exposed to AW Sediment

York River *Fundulus*

Atlantic Wood *Fundulus*

There is Genetic Change in the Population due to Long-Term Pollutant Exposure
The Elizabeth River Project is an independent, 501-(c)(3) non-profit organization incorporated in 1993 and governed by a board of directors.

http://www.elizabethriver.org

“The goo must go!”

Clean up process is slow and millions of dollars and years to go.
What has history taught us?

• Contamination of coastal waters during extreme storm events is likely

• Spills of persistent organic chemicals can have long-term ecological and economic effects

• Remediation of contamination can be difficult at best and very costly
Sea level rise and an increase in the severity and frequency of coastal storms are probable outcomes for the Chesapeake Bay due to global climate change.

The best approach for minimizing the risk for contaminant releases is to identify the potential sources for chemicals of concern and evaluate their vulnerability during storm events.

How can we do that?
Specific Recommendations

• A collaborative effort between academia, industry and state, federal and local agencies should develop and administer an integrated plan to minimize the potential for long-term ecological and economic impacts from coastal contamination during storm events.

• Modeling techniques should be used to develop site specific predictions for inundation during storm events.
Specific Recommendations

• Model information can be coupled with databases to identify the facilities at risk in the flood zone, the chemicals in use or in storage at the facilities and a plan developed for removing chemicals or securing the sites prior to a storm event.

• Chemical inventories should be carefully evaluated for their potential to do harm based on environmental fate, persistence and toxicity.
References


Lousiana Sea Grant Website (http://www.laseagrant.org/hurricane/index.htm)


Money Point Revitalization Plan, 2006. ERP. (http://www.elizabethriver.org/Non_pub%20PDFs/MP_layout_061011final.pdf)