PREDICTED CONCENTRATIONS OF BIOCIDES FROM ANTIFOULING PAINTS IN VISAKHAPATNAM HARBOUR

VISAKHAPATNAM PORT

Chemical Fate of Leached Biocides

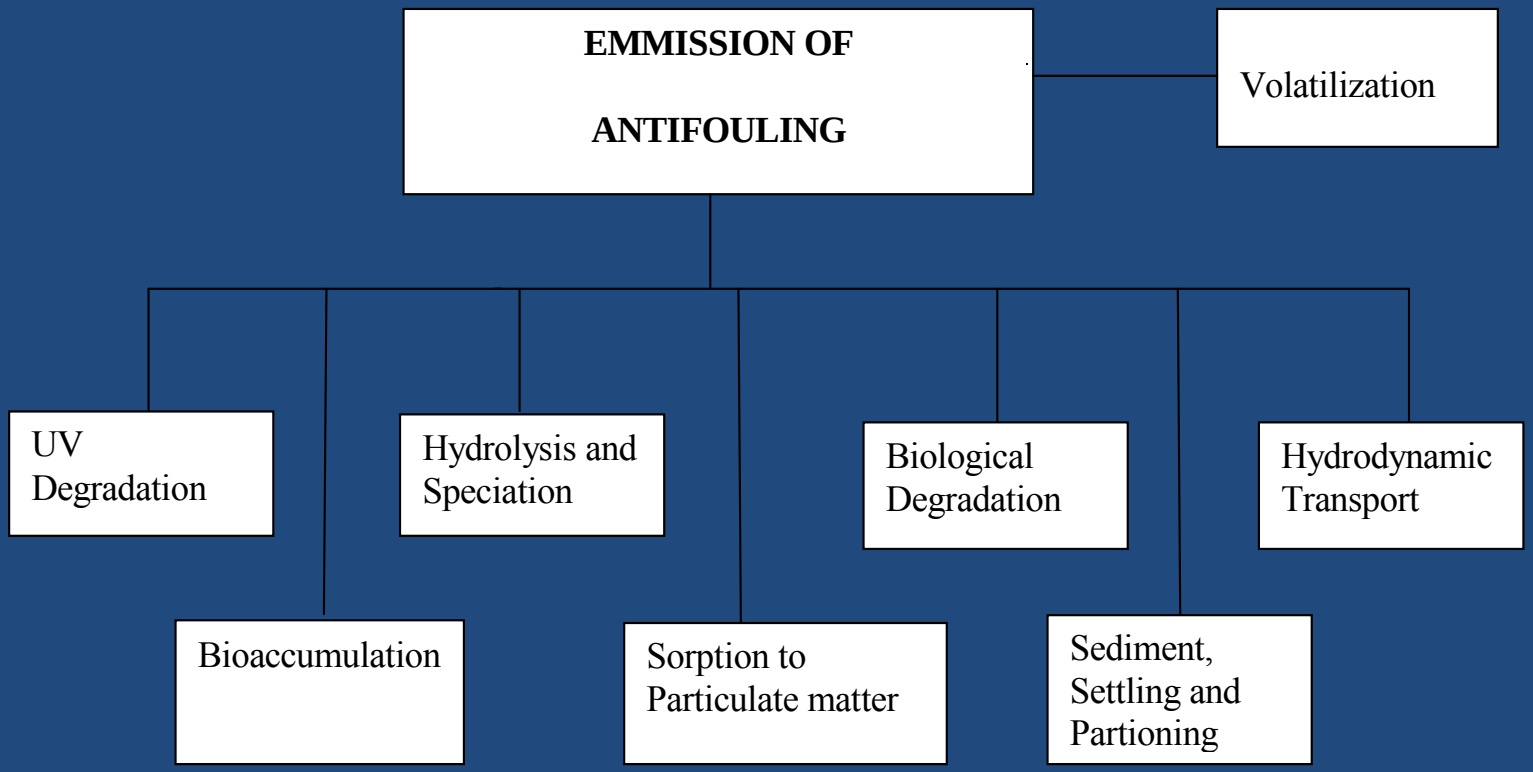


Figure 1. Dominant Physical, Chemical and Biological Interactions involved in the Persistence of Biocides (Miller, 1982; Mackay 1991)

MAM-PEC MODEL

- Predicts Biocide Concentrations in a wide variety of environments
- Inputs rquired
  - Harbour dimensions
  - Hydrology
  - Physical and chemical parameters of water column and sediment
  - Vessel traffic data

MAM-PEC MODEL

- Generates a 10 x 10 grid
- Defines a flow field
- Exchanges between cells
- Hydrodynamic and Chemical fate calculations are made in each cell

Mass balance Equation

Load + inflow - outflow - settling - volatilization - decomposition = 0

$$L + Q_i C_i + Q_o C_t - F_s P f_{df} C_w - r_v f_{df} C_w V_w - r_w C_w V_w = 0$$

LOAD

- Represents emission of biocides
- Biocide leaching from the rear cells only
- Leaching is assumed to be uniform

MEAN EQUILIBRIUM CONCENTRATIONS

$$C_t = (f_{poc} + f_{doc} + f_{doc})C_t$$

Which implies that

$$f_{poc} + f_{doc} + f_{doc} = 1$$

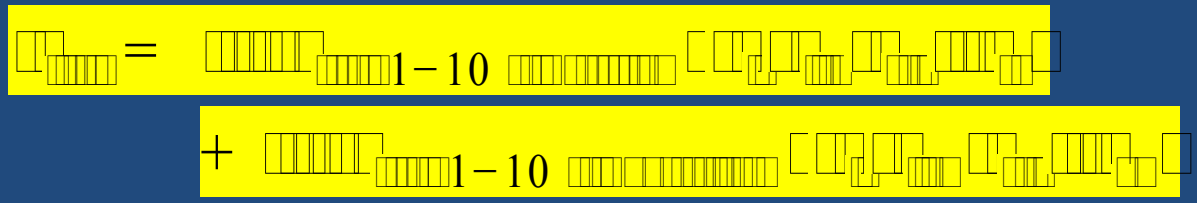
Chemical Fate in Sediment layer

$$C_m(t) = \frac{\frac{F}{\delta\rho}}{\frac{F}{\delta\rho} + k} C_p \left(1 - e^{-\left(\frac{F}{\delta\rho} + k\right)t}\right)$$

Parameters at Visakhapatnam Harbour

Tidal period	12.8 h
Silt concentration	45 mg/l
Particulate organic carbon	1.2 mg/l
Dissolved organic carbon	2.3 mg/l
Salinity	34
Temperatutre	29 C
pH	8.0
Organic carbon in sediment	4.1 %
Net sedimentation velocity	1.1 m/day
Tidal difference	1.7 m
Average depth of harbour	10.5 m

LEACHING FROM VESSELS



Vessel Traffic Data (2006)

Length (m)	No.
50–100	165
100–150	421
150–200	1144
200–250	269
250–300	94

Estimated Concentrations of Biocides in Visakhapatnam Port

No.	Biocide	Persistence in Water Column after 10 years (ng/l)	Persistence in Sediment after 10 years (ng/g)
1	TBT	107	62.2
2.	Copper	4600	70,600
3.	Dichlofluanid	3.58	1.4×10^{-4}
4.	Diuron	225	26.8
5.	Irgarol	221	0.257
6.	Tolylfluanid	6.27	7.8×10^{-5}
7.	Seanine	4.21	7.4×10^{-5}
8.	Zinc pyrithione	9.01	4.23×10^{-6}

ENVIRONMNTAL ISSUES WITH COPPER

- For Copper to be effective, leaching rate of copper should be approximately 60 micrograms/cm/day
- As a result high copper concentrations observed in many harbours and marinas often exceeding safe threshold levels
- Restrictions on use of copper have emerged in some areas especialy in marinas

RESTRICTIONS ON COPPER AF

- EU is proposing to give copper R50/53 classification which states that copper is toxic, persistence and bio-accumulative
- Sweden has banned copper AF along its east coast and imposed restrictions on copper leaching rates along the west coast
- Norway has proposed to implement ecotax of 5 euros/kg of copper used in AF

RESTRICTIONS ON COPPER – contd.

- Dutch authorities have banned the use of copper on pleasure craft
- Finland has banned the use of copper AF's in certain areas
- All biocides are banned in many of the Swiss lakes
- The United States of America has restricted the use of Copper AF's in some Marinas

Uk marine special areas conservation guidelines for water quality management

Threshold limits for copper (µg/l)

	Acute	Chronic
Aquatic Column	5.0	2.9
Sediment	18.7	

CONCLUSIONS

- TBT Concentrations are high and are comparable to those in many western ports
- Diuron and Irgarol levels are above the “no-effect concentration”
- Copper levels are of serious concern
- Zinc Pyrithione, Seanine, Tolylfluanid, dichlofluanid are within “Safe Limits”s