Aquatic Environmental Sciences
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Addendum to the ACZA model. The following discussion describes how the new ACZA metal loss algorithms (Brooks, 2005) have been incorporated into the ACZA Risk Assessment for marine environments.

This model assumes copper is adsorbed to some particle having a settling velocity ($V_{vertical}$) given in input Number 5 in Cell E9 of the spreadsheet (0.05 cm/sec for silt). The incremental width is $V_{model}/V_{vertical}$*dh where dh is an incremental height of piling. All of the metal lost from that incremental height of treated wood surface (dh) is assumed to be deposited in this ring around the piling and to remain there for the life of the piling. In saltwater (30 PSU), Brooks (2005) found that the loss rate from ACZA piling treated to 1.5 pcf was equal to Equation (1) for copper; Equation (2) for arsenic; and Equation (3) for zinc.

Equation 1. Migration of copper $= 10^{(0.837 + 0.504*EXP(-0.287*Time(days))}$ µg Cu/cm^2-day
Equation 2. Migration of arsenic = 0.54 µg As/cm^2-day
Equation 3. Migration of zinc = 5.76 µg Zn/cm^2-day

The total amount of each metal deposited to the sediments from an incremental height of piling (dh) is then equal to M(metal migration rate)*days since immersion*dh*the piling's circumference (πd) where (d) is the piling's average diameter.

For arsenic and zinc this is simply the observed steady state loss rate times the years that the piling is expected to remain immersed (Cell 18) times 365.25 days/year.

Equation 4. Arsenic = dh*π*2*r*365.25*L*0.54 (µg As/dh)
Equation 5. Zinc = dh*π*2*r*365.25*L*5.76 (µg Zn/dh)

Where: L = the piling's anticipated lifespan in years.

For copper, integrating Equation 1 indicates that the accumulation equals 237 µg/cm^2 for the first 30 days and 6.87 µg/cm^2-day for the remainder of the piling's life. Therefore the opper loss per incremental piling height dh over the piling's lifespan is

Equation 6. Copper = dh*π*2*r*(237 + 6.87*365.25*L – 30) (µg Cu/dh)

The model assumes that deposited metals are diluted by sediments within the circular ring of width dh*$V_{model}/V_{Vertical}$ to a depth of 2.0 cm. The density (ρ) of the sediment is entered in User Input 13 (Cell E17) in grams/cm^3. The weight of the diluting sediment is therefore

Sediment Weight (g) = π*(r + D)(cm)*2.0 cm* ρ(g/cm^3) dh(cm) *V_{model}(cm/sec)/$V_{Vertical}$(cm/sec)

Where:

- r = the piling radius (User Input 2 in Cell E6) (cm)
- D = the distance (cm) from the piling at which the prediction is made
- ρ = the sediment density (g/cm^3)
- dh = the incremental piling height (cm)
- V_{model} = the average current speed (Computed in Cell I7 from the maximum current speed entered in User Input 6 in Cell E10. (cm/sec)
- $V_{vertical}$ = Adsorption nucleus settling velocity entered in User Input 5 in Cell E9 (cm/sec)

The concentration of each metal in the circular ring centered at a distance D from the perimeter of the piling at the end of the piling's lifespan, when the concentration would be highest is given in Equations 7, 8 and 9.

Equation 7. Cu conc. = $r*(237 + 6.87*(365.25*L - 30))/(r + D)* \rho*V_{model}/V_{Vertical}$ (μg Cu/g)

$= r*(30.9 + 2,509.3*L)/(r + D)* \rho*V_{model}/V_{Vertical}$ (μg Cu/g)

Equation 8. As conc. = $r*197.24*L/(r + D)*\rho*V_{model}/V_{Vertical}$ (μg As/g)

Equation 9. Zn conc. = $r*2,103.8*L/(r + D)*\rho*V_{model}/V_{Vertical}$ (μg As/g)

The circular distribution is a reasonable approximation when currents are slow. However, when current speeds are greater than a few cm/sec, more of the metal will be distributed along the directions of the ebbing and flooding current vectors. To account for this in a mechanistic way, the model assumes that the distribution be comes an ellipse with increased metal concentrations along the current vectors that is proportion to the Geometry Factor defined in Equation 10. This factor is computed in Cell K8 of the spreadsheet. As seen for every ten cm/sec increase in the Model Velocity, the concentrations of metal along the dominant current vector(s) is increased by an additional factor of one. If the model velocity is 20 cm/sec, then three times as much metal is predicted along the current vector as would be predicted if the geometry was a circle associated with very slow currents.

Equation 10. Geometry Factor =1 + Model Velocity/10

Arsenic accumulation in sediments is predicted to be very low in association with ACZA preservative. Predicted copper accumulation is higher than zinc and the Marine Sediment Quality Criterion (WAC 173-204) for zinc (410 μg Zn/g) is higher than for copper (390 μg Cu/g). Therefore, unless background zinc concentrations in sediments are much higher than copper concentrations, copper is the metal that needs to be managed in association with the use of this preservative. The spreadsheet contains output only for copper.