Lab 10 for 1.106
Atmosphere-Water Exchange
Wednesday, November 19, 2003, 1-5 pm

You will estimate the rate of exchange between a water body (the flume) and the overlying air for two volatile compounds, molecular oxygen and chloroform. You will use an oxygen electrode to measure the changing concentration of oxygen, and gas chromatography (GC) to observe the concentration of chloroform.

Pre-laboratory Activity: This will be collected at the beginning of lab.
In clearly worded prose, estimate the time needed for the slug of chloroform, introduced at $t = 0$, to mix to a uniform concentration along the length of the flume. Assume that the flume channel velocity is 10 cm/s. Including equations and assumptions.
In clearly worded prose describe how you will estimate the mass transfer coefficients for oxygen and chloroform, k_{oxygen} and $k_{chloroform}$, from a time series of concentration.

Description of Experiment:
Before you arrive oxygen levels in the flume water will be depleted by bubbling nitrogen through the water. The flume will then be covered until the start of the experiment to keep the oxygen depleted. At $t = 0$ you will remove the cover and 'dose' the flume with water that is enriched in chloroform.

Oxygen:
At $t = 0$ immediately begin monitoring the oxygen concentration. Continue to record the oxygen concentration until the concentration has reached saturation. You will choose the interval of sampling depending on the rate of observed change.

Solubility of Oxygen in Water at Atmosperic Pressure

ºC	mg/L	ºC	mg/L	ºC	mg/L	ºC	mg/L
15	10.084	20	9.092	25	8.263	30	7.559
16	9.870	21	8.915	26	8.113	31	7.430
17	9.665	22	8.743	27	7.968	32	7.305
18	9.467	23	8.578	28	7.827	33	7.183
19	9.276	24	8.418	29	7.691	34	7.065

Chloroform:
After the initial dose of chloroform has been added to the flume you must wait to begin sampling until after the chloroform has become uniformly distributed in the longitudinal direction. After the chloroform has mixed longitudinally, begin drawing duplicate 100-ml water samples into 100-ml volumetric flasks and quickly stopper the flask to halt air-water exchange. Note the time of each sample on the bottle. Use the following sampling series; $t = 0, 10, 20, 40, 80$ minutes. Bring the samples to the second floor, where you will measure the concentrations of chloroform.

Your Lab Notebook Should Include
1) A detailed sketch of the flume.
2) A description of the sampling procedure.
3) A description of the tracer study used to observe the mixing time scale.
4) A graph of concentration versus time C (t).
5) Details of your analysis to estimate the mass transfer coefficients.
6) Clearly state your estimates for the mass transfer coefficient of oxygen and chloroform with uncertainty. Explain any differences.
7) Estimate the thickness of the waterside laminar sub-layer, δ_w, using both the O_2 and chloroform data. Do these two estimates agree? Should they?
8) How might the transfer coefficients vary if the flow speed, U, increased?
9) How might the transfer coefficients vary if wind were added and increased?

Useful Constants:
Molecular diffusivity of oxygen in water, $D_w(O_2) = 2 \times 10^{-5}$ cm^{2}s^{-1}
Molecular diffusivity of chloroform in water, D_w(chloroform) $= 1.02 \times 10^{-5}$ cm^{2}s^{-1}
Henry's Law constant for toluene, $H_{chloroform} = 0.16$
Henry's Law constant for oxygen, $H_{O2} = 26$

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