USGS science for a changing world

Spatial and Temporal Variability in the K_d-Secchi Conversion Coefficient Observed Among the Tidal Tributary Rivers of the Chesapeake Bay Watershed

Jurate M. Landwehr U.S. Geological Survey, Reston, VA 20192 USA (jmlandwe@usgs.gov)

2005 ERF Chesapeake Research Colloquium A12

PROBLEM SUMMARY AND DISCUSSION

Ambient water quality criteria for water clarity in shallow-water bay grass designated use habitats in different salinity regimes of the Chesapeake Bay (CB) and its tidal tributaries have been defined in terms of the percent light available through the water column (PLW). (Environmental Protection Agency , 2003, p.96.) Percent available light is assessed by measuring photosynthetically active radiation (PAR 400-700 nm) at depth in the water column to establish the diffuse attenuation coefficient (K_d , in m^{-1}) and then applying the Lambuert-Bougert Law to obtain PLW = 100 exp(K_d Z), where Z refers to the relevant depth. Frequently, K_d is not available for a water sample, but a measurement of transparency, that is, Secchi depth, is. The criteria state that the K_d value can be converted to a Secchi depth (in meters) according to the relationship K_d = C / Secchi depth using the conversion factor C = 1.45 . Implicit in the unconditional definition of a single conversion factor C is the assumption that C is effectively constant both temporally, at one site throughout the year, and spatially, over all locations in the tidal CB system.

Difficulties with the assumption of a constant relationship both within and between freshwater lakes have been discussed by Effler (1985). Indeed, Cerco et al. (2004) have suggested that over the Chesapeake Bay region, values for C may range from 0.6 to 2.2. Fig. 1 illustrates how an incorrect assessment of meeting or not meeting the PLW criteria might be made if an incorrect value of C is assumed. Quasi-monthly data for concurrent measurements of K_d and Secchi are available for several CB tributary river systems from the CB Program website. (Fig.2) I used data from the major tributaries, namely James, York, Rappahannock, Potomac, Patuxent, Susquehanna, and Choptank, from 1985 through 2000 and compared the value of K_d * Secchi Depth to the given value = 1.45, both for samples taken in one location over time and between samples taken at different locations over the same season. Time intervals examined included the whole year, the period November through March when non-polyhaline submerged aquatic vegetation senesces, the entire growth period of April through October, and the separate growth periods of April through June, and July through October. Statistical testing (t-test, signed rank or sign test, as appropriate) showed that the hypothesis that the estimated C=1.45 fails in the majority of cases (Tables 1) . Regression analysis of K_d on 1/Secchi Depth was used to obtain a best estimate for C (Table 2). Results were both in excess and less than 1.45, suggesting that the transformations both over and underestimate PLW significantly.

CONCLUSIONS

This work demonstrates that the use of a single conversion coefficient to transform commonly available Secchi to light attenuation in order to assess the percent light through the water column may lead to an assessment of erroneous compliance or non-compliance with the ambient water quality criteria for water clarity for the tidal rivers of the CB.

REFERENCES

Cerco, C., M. Noel, and L.Linker, 2004, Managing for Water Clarity in Chesapeake Bay, Journal of Environmental Engineering, 130(1):631-642.

Effler, S., 1985, Attenuation versus Transparency, Journal of Environmental Engineering, v111(4):448-459.

United States Environmental Protection Agency, 2003, Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries, EPA 903-R-03-002, pp.231 (plus appendices).

Figure 1. PLW at 1 m as a function of C , in comparison to Water Quality Criteria

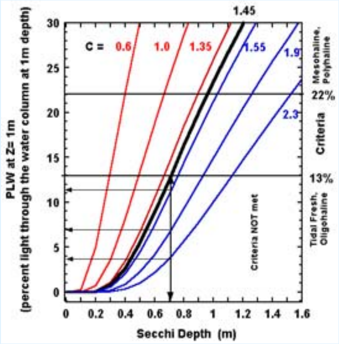

Figure 2. CBP water quality monitoring stations

Source:www.chesapeakebay.net/wqual.htm

Table 1. Hypothesis test of : K_d*SD -1.45 =0

R indicates rejection at p<0.05.

	Station	All Year	NDJFM	AMJ	JASO	AMJJASO
JAMES						
	TF5.2A	R	R	R	R	R
	TF5.3	R	R	R	R	R
	TF5.4	R	R	R	R	R
	TF5.5	R	.	R	R	R
	TF5.5A	R	R	R	R	R
	TF5.6	R	.	R	.	R
	RET5.1A	R	R	.	R	R
	RET5.2	.	.	.	.	.
	LE5.1	.	.	.	.	.
	LE5.2	.	.	.	.	.
	LE5.3	.	R	.	.	.
	LE5.4	R	.	.	R	R
	LE5.5	R	R	R	R	R
YORK						
	TF4.2	R	R	R	R	R
	TF4.4	R	R	R	R	R
	RET4.1	.	.	.	R	.
	RET4.2	R	R	R	.	R
	RET4.3	.	.	R	.	.
	LE4.1	.	.	R	.	.
	LE4.2	R	.	.	.	R
	LE4.3	R	R	.	R	R
	WE4.2	R	.	.	.	R
RAPPAHANNOCK						
	TF3.1E	R	.	R	.	R
	TF3.1B	.	.	.	.	.
	TF3.2	.	.	.	.	.
	TF3.2A	R	.	.	.	.
	TF3.3	.	.	.	.	.
	RET3.1	.	.	.	.	.
	RET3.2	.	.	.	.	.
	LE3.1	.	.	.	.	.
	LE3.2	R	.	.	.	R
	LE3.3	R	R	.	R	R
	LE3.4	R	R	.	R	R
	LE3.6	R	.	.	R	R
POTOMAC						
	TF2.3	R	.	R	.	R
	RET2.2	R	R	R	R	R
	LE2.2	R	R	R	.	.
	LE2.3	.	.	.	.	.
PATUXENT						
	TF1.5	.	.	.	R	R
	TF1.7	R	R	R	.	.
	LE1.1	R	.	R	.	R
SUSQUEHANNA						
	CB1.1	.	.	R	.	.
CHOPTANK						
	ET5.1	.	.	.	.	.
	ET5.2	R	.	R	R	R

Table 2. Coefficient for Regression of K_d vs. 1/Secchi Depth.

Red (blue) indicates that the value 1.45 is above (below) 95% Confidence Interval about the estimate

RIVER	STATION		All Year	NDJFM	AMJ	JASO	AMJJASO
JAMES							
	TF5.2A	TF	1.648	1.646	1.651	1.663	1.656
	TF5.3	TF	1.594	1.601	1.495	1.611	1.565
	TF5.4	TF	1.613	1.626	1.687	1.556	1.602
	TF5.5	TF	1.526	1.458	1.544	1.671	1.616
	TF5.5A	TF	1.706	1.761	1.642	1.759	1.733
	TF5.6	TF	1.356	1.270	1.570	1.569	1.569
	RET5.1A	OH	1.686	1.710	1.635	1.678	1.658
	RET5.2	OH	1.380	1.374	1.392	1.388	1.390
	LE5.1	OH	1.451	1.414	1.521	1.458	1.497
	LE5.2	MH	1.504	1.663	1.336	1.466	1.368
	LE5.3	MH	1.537	1.672	1.373	1.556	1.441
	LE5.4	PH	1.573	1.558	1.524	1.662	1.581
	LE5.5	PH	1.098	1.257	0.919	1.159	1.049
YORK							
	TF4.2	TF	1.222	1.698	0.699	1.895	1.009
	TF4.4	TF	2.224	2.048	2.398	2.380	2.389
	RET4.1	OH	1.628	1.532	1.611	1.889	1.705
	RET4.2	OH	1.768	1.886	1.778	1.581	1.694
	RET4.3	MH	1.612	1.689	1.603	1.503	1.559
	LE4.1	MH	1.599	1.589	1.610	1.591	1.603
	LE4.2	PH	1.704	1.729	1.812	1.508	1.688
	LE4.3	PH	1.634	1.662	1.587	1.641	1.617
	WE4.2	PH	1.332	1.351	1.365	1.302	1.326
RAPPAHANNOCK							
	TF3.1E	TF	1.378	1.315	1.532	1.390	1.423
	TF3.1B	TF	1.250	1.146	1.354	1.363	1.361
	TF3.2	TF	1.229	1.230	1.262	1.209	1.228
	TF3.2A	TF	1.434	1.441	1.365	1.489	1.424
	TF3.3	OH	1.369	1.379	1.406	1.326	1.356
	RET3.1	MH	1.638	1.764	1.572	1.362	1.482
	RET3.2	MH	1.330	1.284	1.434	1.261	1.366
	LE3.1	MH	1.440	1.530	1.375	1.422	1.392
	LE3.2	MH	1.462	1.366	1.457	1.579	1.516
	LE3.3	MH	1.607	1.578	1.498	1.750	1.618
	LE3.4	MH	1.694	1.651	1.662	1.785	1.719
	LE3.6	MH	1.263	1.260	1.251	1.272	1.263
POTOMAC							
	TF2.3	TF	1.136	0.953	1.237	1.337	1.287
	RET2.2	OH	1.115	1.041	1.158	1.171	1.162
	LE2.2	MH	1.249	1.070	1.268	1.286	1.272
	LE2.3	MH	1.378	1.671	1.363	1.324	1.346
PATUXENT							
	TF1.5	TF	1.316	1.062	1.450	1.490	1.468
	TF1.7	OH	1.275	1.240	1.278	1.311	1.291
	LE1.1	MH	1.371	1.292	1.260	1.501	1.385
SUSQUEHANNA							
	CB1.1	TF	1.193	0.796	1.415	1.581	1.460
CHOPTANK							
	ET5.1	OH	1.334	1.169	1.477	1.361	1.415
	ET5.2	MH	1.313	1.317	1.243	1.376	1.313

ACKNOWLEDGEMENTS

This work was supported by the USGS Chesapeake Bay Program and by the USGS National Research Program in Water Resources. The encouragement of Scott Phillips is appreciated.