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Of: **Ultraviolet disinfection of secondary wastewater effluents: Prediction of performance and design,**
F. Loge *et al.,* **68,** 900.

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This is a good paper synthesizing work that the authors have done and presented over the past several years in a number of papers and conferences. It appears that they have refined their procedure for designing UV disinfection systems to the point where it can be almost completely automated.

Precisely because the paper ends with such a detailed procedure, which is likely to be adopted uncritically by many readers, we think it may be important to clear up some minor points in the exposition.

First, the section on "Fit of model to experimental data" ends with "a recommended minimum R^2 value is 0.7" with no reference to the number of data points on which the R^2 value is based. Since the degree of confidence associated with a given R^2 value depends strongly on the number of points, readers whose background in statistics are not strong may need to be reminded of this. The R^2 of 0.79 obtained for the authors' measurements is extremely good for a data set of 150 points, but would be much poorer if for example, there were only 30 points, and $R^2 = 0.65$ might be acceptable if there were as many as 500 points.

A second point concerns typographic errors in Equation 8. The notation $(x_i - \overline{x})^2$ should be replaced by the summation of these quantities for the data points used in the comparison of the model to the observations, and the result may be $(n - 2)^2$ Var(X). Likewise, $(x_i - \overline{x})(y_i - \overline{y})$ should have been $(n - 2)^2$ Cov (X,Y). Making these corrections and factoring out $(n - 2)^2$ as a coefficient for the matrix expression might have been clearer for the readers to whom this section was addressed, since Equation (8) is not needed in the procedure given in Table 6.

On page 903, the minimum detection limit of 0.1 per 100 ml for the 50 tubes per dilution test is 20 times lower than the limit for the 5 tubes per dilution, although only 10 times as many tubes are used. Is this a typographical error or the result of the properties of the Poisson distribution?

It also seems worth emphasizing although it may be beyond the scope of the authors' intentions that the success of the multiplicative model applied in wastewater by these authors, and discussed in more detail by Emerick and Darby (1993) implies the invalidity of the assumption of simple shielding that justifies the Np term in Scheible's model (1987). Hence, one must conclude that sooner or later nearly all the coliform bacteria that are in particles at a given time will emerge into the surrounding water. This exchange of bacteria between particles and water may be a very significant point of wastewater microbiology that has not been discussed.

Finally we have a question for the authors. Since their model seems so successful for unfiltered secondary effluent, we wonder if it would be applicable to tertiary effluent, in particular micro filtered effluent in which some limiting conditions would occur, for example, the SS level may be very low and the transmittance may be quite high. The Memcor microfilteration unit has a most probable pore size distribution of 0.2 micron that could force such limiting conditions. Considering this situation, using Sheibles' model would lead to a negligible N_p term, so that it might give results similar to those of the authors' model.

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Closure: Frank Loge, Jeannie L. Darby

In response to the discussion, we wish to make the following points.

First, with regard to providing clarifying information to potential users of the model about the use of an R^2 value, we believe it is not advisable for people untrained in basic statistics to use a model for design that is statistically based. The R^2 value is not an important statistical parameter in using this modeling approach for design. Certainly the number of data points used to calibrate an empirical model will affect the degree of confidence associated with using that calibrated model for prediction purposes. The important statistical parameter in the use of the calibrated model for design is the RMSE (and associated RMSE'); this parameter includes the effect of number of data points used in calibrating the model as well as the goodness of fit. If the RSME term is too large, the designer will quickly find that there is too much uncertainty associated with their predictions.

Regarding clarification of Equation 8, a typesetting error was made in the expression. Specifically, summation signs should appear in front of each of the nine positions in the inverse matrix in Equation 8. However, the entire expression should not be divided by (n − 2) as suggested in the discussion. The number of degrees of freedom are accounted for in the RMSE.

With regard to the third point, the minimum detection limits arise from properties of the Poisson distribution. These detection limits can be verified by using the Poisson equation directly rather than the standard Most Probable Number tables.

Regarding the fourth point, the fundamental difference between the EPA (Equation 2a) and WERF (Equation 4) disinfection models lies in the assumption of the ability of UV light to penetrate particles at high values of UV dose. In the EPA UV model, the concentration of the coliform bacteria surviving UV radiation at high values of UV dose is a fixed value equal to the additive N_p term. This term is solely a function of the suspended solids concentration (Equation 2c). We interpret the functional form of Equation 2c to imply that UV light does not penetrate particles at high values of UV dose. Thus, targeted organisms embedded within these particles do not receive UV light, resulting in a residual coliform concentration equal to N_p. In the WERF UV disinfection model, the number of coliform bacteria surviving UV irradiation is a function of the suspended solids concentration as well as other water quality parameters and the applied UV dose. Therefore, the concentration of coliform bacteria surviving UV irradiation declines with increasing values of UV dose. The decline of coliform bacteria with increasing values of UV dose implies that UV light can penetrate particles and thus inactivate targeted organisms embedded within particulate material. The complex interaction of the UV light with particulate material is accounted for implicitly in the functional form of the model.

Finally, on the fifth point, this type of modeling approach can be used in any situation that results in an acceptable calibration (acceptable being defined by the degree of confidence desired in the model predictions.) However, the performance of a UV system is highly dependent on wastewater characteristics; in many reclamation situations, there is little variability in effluent quality and thus little need for an empirical model that excels at describing variability. It is most likely not cost-effective in such cases to conduct the extensive pilot-scale testing necessary to obtain calibration data. This point is discussed in more detail elsewhere (Loge *et al.,* 1966).

References

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