ROLE OF ENVIRONMENTAL PARAMETERS IN URBAN POLLUTION PREDICTION MODELS

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Storm water pollution sources are related to various land-use activities. Pollution prediction models are developed.

Although the major concern in recent years regarding pollution from storm water drainage has been associated with combined sewers, the pollution from separate urban storm water drainage systems is a real and apparent problem. Considerable quantitative data regarding pollution from combined and separate sewers are available (1, 2, 3, 4). Also, as a result of several recent studies (5, 6, 7, 8), control methods involving some types of structural system or physical treatment have been proposed to alleviate pollution from urban storm-water runoff. Solution of the basic problem, however, depends upon the identification of the sources of storm-water pollution and elucidation of how these sources relate to various land-use activities. With such knowledge control measures through supervised urban planning, zoning, and land use regulations might be provided. Alterations in space and/or time might thus reduce pollutional loads through civic action.

METHODS

The prediction models developed in this study related land use and environmental inputs (X_i) to pollutional outputs (Y_i) in the form:

$$Y_i = \sum B_i X_i \qquad \text{Eq. 1}$$

where B_i is a parametric coefficient. Previous studies of dispersed pollution were helpful in initially identifying the Y_i's and X_i's. Notable among these studies were those of Palmer (9, 10), Sylvester (11), and Wilkinson (12). In our previous work, mathematical models were developed and tested on six cities in the United States. The dependent variables and independent variables examined in this study are given in Table 1. The data presented are the results of observations made in 15 urban test areas in metropolitan Tulsa.

TABLE 1. *Symbols and units for variables.*

Independent variables (X_i)[a]		
Symbol	Item	Unit
1	Population	Number
2	Average population density	#/Total Acre
3	Number of household units	#
4	Residential density	Households/Acre
5	Number of commercial establishments	#
6	Avg. commercial est./total acres	#/Total Acre
7	Total commercial acres	Acres
8	Commercial est./com. acres	#/Com. Acres
9	Street area	Acres
10	% Streets	%
11	EI (environmental index)	(Dimensionless)
12	HI (housing index)	(Dimensionless)

Dependent variables (Y_i)		
Symbol	Item	Unit
1	Coliform bacilli, total count	1000/100 ml
2	Fecal streptococci	1000/100 ml
3	BOD	mg/l
4	COD	mg/l
5	Organic Kjeldahl	mg/l
6	Soluble orthophosphate	mg/l
7	Total solids	mg/l
8	Fixed solids	mg/l
9	Volatile solids	mg/l

[a] Thirty-eight other variables, ascertained to be insignificant in preliminary studies, included the following:

Housing (%)
- Good; fair; poor
- One family; two family; multi-family; group living

Land use (%)
- Residential
- Commercial
- Industrial
- Institutional
- Transportation
- Agricultural
- Unused

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Evironmental deficiencies (number/acre)

- Refuse
- Burners
- Rubble
- Lumber
- Old autos
- Poor sheds
- Livestock
- Stray dogs
- Privies

RESULTS AND DISCUSSION

As ascertained by the statistical technique of principal component analysis (13), in the initial phase, the data enabled formulation of mathematical models encompassing the 12 important independent variables. A close examination of these revealed that the first four variables, i.e., X_1, X_2, X_3 and X_4, were directly related to population. Therefore, it appeared that the nine dependent variables might be assessed quantitatively to at least the nearest order of magnitude by using population as the only criterion. This was considered a significant step in the approach to the problem because until now even the nearest order of magnitude had not been accurately predictable.

The original mathematical models gave expressions which contained any combination of the twelve independent variables and pertained to the four seasonal variations. As an example, the equation for total number of coliform bacilli is depicted in Table 2, along with the correlation coefficient. For spring the equation for total number of coliform bacilli is:

$$Y_1 = -8321 + 7228(\ln X_1) - 7409(\ln X_3) + 958(\ln X_8) - 2315(\ln X_{11}) \qquad \text{Eq. 2}$$

When population is used as the only criterion, implying that the first four X values are adequate in formulating the predictive model, Eq. 2 assumes the form.

$$Y_1 = -8321 + 7228(\ln X_1) - 7409(\ln X_3) \qquad \text{Eq. 3}$$

This modification results in the correlation coefficient (R^2) changing from 0.86 to 0.66.

An examination of these data leads to the conclusion that disregard of variables other than population produces less effect than those resulting from seasonal variations.

TABLE 2. *Equations for estimating dispersed pollutant concentrations*

Parameter	Unit	Season	Equation	R^2	R^2 Modified
Total number of coliform bacilli (Y_i)	Thousands/ 100 ml	Fall	$Y_i = 1402 + 135(\ln X_2)$	0.66	0.52
		Winter	$Y_i = 125 - 0.00227(X_1) + 15.8(X_4)$	0.15	0.15
		Spring	$Y_i = -8321 + 7228(\ln X_1) - 7409(\ln X_3)$	0.86	0.66
		Summer	$Y_i = -1368 + 632(X_2) + 5.75(X_5)$	0.40	0.31

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