

Sediment Classification for Illinois Inland Lakes
(1996 Update)

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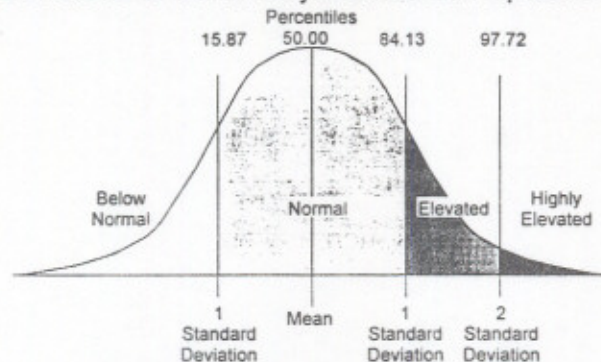
September 1996

Introduction

The Illinois Environmental Protection Agency (Illinois EPA) has been collecting sediment quality data from lakes since 1977. A total of 1,876 sediment samples have been collected from 1977 through 1994 on 307 lakes comprising 781 stations. A large effort was made in 1979 to sample lakes throughout the state and compile the results. The results of 273 sediment samples collected from 63 Illinois lakes were compiled and reported by Kelly and Hite in 1981.

Kelly and Hite proposed a classification of Illinois lake sediments that was based on the statistical properties of the 1979 data. The authors acknowledged the classification levels were not based on biological activity of the chemical components but on the distribution of concentrations in the sampled lakes. The categories were identified as Below Normal, Normal, Elevated, and Highly Elevated. The concentrations that defined these categories were set at one and two standard deviations from the mean concentrations (Figure 1). Highly Elevated concentrations were those samples that were greater than the mean concentration by more than two standard deviations. Elevated concentrations were greater than one standard deviation up to two standard deviations above the mean. Normal concentrations were within one standard deviation from the mean, and Below Normal concentrations were less than the mean by more than one standard deviation.

Figure 1. Standard Deviations of a Normally Distributed Population.



This figure shows a normally distributed population as well as the levels of standard deviation selected by Kelly and Hite (1981) to describe the sediment classification ranges. The percentiles are included to show how much of the population is below the given standard deviation. This information explains why the percentiles were selected for the new sediment classification. (Information from Harnett and Murphy (1980) p. 188.)

Kelly and Hite's classification system has been used for over ten years and collected sediment data have been compared to these levels and reported in Illinois Water Quality Reports and various Phase I Clean Lakes Program Diagnostic-Feasibility Study reports. Although additional data have been collected, the ranges have not been changed to reflect these additional data. The sediment classification system needed to be updated, because additional data have been collected since 1979 and some changes in

laboratory methodology have occurred. Therefore, the purpose of this report is to use more current data to update the sediment classification system.

Methods

Samples have been collected according to the Illinois EPA Field Methods Manual and analyzed according to the Illinois EPA Laboratory Methods Manual. From 1988 through 1994, 854 samples were collected from 418 stations on 265 lakes. These data were selected to represent current conditions and to minimize any variations resulting from modifications of laboratory procedures. All sample data have been entered into U.S. EPA's STORET data management system. The data were analyzed using SAS (Statistical Analysis System) on the National Computing Center mainframe and various desktop computer programs.

The statistical methodology was changed from methods used for normally distributed populations to one that would be less dependent on distribution. Use of mean and standard deviation were found to be highly impacted by concentrations below the

Table 1. General Statistics for 1988 to 1994 Lake Sediment Data.

	n	Mean	Standard Deviation	Minimum	Maximum	% Non Detect
PCB's (µg/kg)	568	15.64	22.31	10	240	91.02
Aldrin (µg/kg)	568	1.026	0.219	1	3.6	97.54
Dieldrin (µg/kg)	568	2.397	4.287	1	58	65.49
DDT (µg/kg)	568	18.49	41.62	10	440	90.14
Chlordane (µg/kg)	568	5.713	3.186	5	44	86.44
Endrin (µg/kg)	568	1.058	1.075	1	25	99.82
Methoxychlor (µg/kg)	568	5.062	0.913	5	25	100.00
alph-BHC (µg/kg)	567	1.047	0.523	1	9.3	98.94
gamma-BHC (µg/kg)	568	1.064	0.863	1	18	99.12
HCB (µg/kg)	568	1.000	0.000	1	1	100.00
Heptachlor (µg/kg)	568	1.012	0.180	1	5	99.30
Heptachlor epoxide (µg/kg)	568	1.039	0.216	1	4	93.13
Phosphorus (mg/kg)	682	772.8	532.4	0.685	6244	0.15
Kjeldahl (mg/kg)	682	3531.	2986.	1.6	31300	0.29
Cadmium (mg/kg)	683	2.604	4.274	0.1	53	56.08
Copper (mg/kg)	683	74.90	209.4	1	4594	0.15
Lead (mg/kg)	683	47.77	73.42	0.69	614	5.56
Mercury (mg/kg)	687	0.136	0.283	0	6.22	44.54
Cyanide (mg/kg)	16	0.162	0.176	0.037	0.79	62.50
Arsenic (mg/kg)	683	13.13	26.66	0.5	370	0.59
Chromium (mg/kg)	683	21.347	13.714	1.7	210	0.00
Iron (mg/kg)	683	27300	11910	2700	113000	0.00
Manganese (mg/kg)	683	1254.	1478.	82	18000	0.00
Zinc (mg/kg)	683	261.8	1888.	10	40870	0.00
Nickel (mg/kg)	598	22.60	10.85	3	182	0.84
Silver (mg/kg)	598	1.916	2.125	0.1	32	97.49
Potassium (mg/kg)	598	1488.	558.	1	3200	13.38
Barium (mg/kg)	598	179.0	92.1	3.1	620	0.00

detection limit. Several of the measured parameters had more than 95% of the analyses below the detection limit (Table 1). It was not certain how these parameters could have adequately been classified using the mean/standard deviation method.

Percentiles were used to represent the limits of the classification levels. This would allow all of the data to be used to determine the classification levels and would remove the question of how many non-detections were too many. Figure 1 shows the percentiles that correspond to the standard deviation levels of a normally distributed population. Table 2 shows the percentiles selected for definition of the percentile ranges to be used in the revised classification scheme. All values below detection limit were converted to zero for analysis, because many of the parameters had multiple detection limits, and all non detections should be given the same consideration in the analysis.

Table 2. Range Determinations for the Sediment Classification System.

Standard Deviations	Percentiles for Normally Distributed Population	Percentiles Selected for Definition of Range
2 standard deviations above mean	97.72	98
1 standard deviation above mean	84.13	84
1 standard deviation below mean	15.87	16

The classification groupings remained the same as those identified by Kelly and Hite (1981). Concentrations greater than the 98th percentile were defined as Highly Elevated. This category would include the top two percent of all samples collected. The Elevated category would include the 14 percent of samples with concentrations from the 84th to the 98th percentiles. Concentrations from the 16th to the 84th percentiles were defined as Normal and would constitute 68 percent of the samples. Samples with concentrations below the 16th percentile were defined as Below Normal and would constitute 16 percent of the measurements.

Results

The results of the revised classification are given in Table 3. There are many more parameters identified than had been included in Kelly and Hite (1981) (Table 4). The use of percentiles allowed levels to be assessed even for parameters with 100% of the measurements below the detection limit. The only parameter that was not assigned classification levels was cyanide, because it had only 16 measurements (Table 3). Sixteen samples were deemed too few for reliable analysis.

Table 3. Classification of Lake Sediments (Revised 1996).

	Sample Number	Detection Limit	Low	Normal	Elevated	Highly Elevated
PCB's (µg/kg)	568	10 µg/Kg	n/a	less than 10	10 to <89	89 or greater
Aldrin (µg/kg)	568	1 µg/Kg	n/a	less than 1	1 to <1.2	1.2 or greater
Dieldrin (µg/kg)	568	1 µg/Kg	n/a	less than 3.4	3.4 to <15	15 or greater
DDT (µg/kg)	568	10 µg/Kg	n/a	less than 10	10 to 180	180 or greater
Chlordane (µg/kg)	568	5 µg/Kg	n/a	less than 5	5 to 12	12 or greater
Endrin (µg/kg)	568	1 µg/Kg	n/a	less than 1	n/a	1 or greater
Methoxychlor (µg/kg)	568	5 µg/Kg	n/a	less than 5	n/a	5 or greater
alph-BHC (µg/kg)	567	1 µg/Kg	n/a	less than 1	n/a	1 or greater
gamma-BHC (µg/kg)	568	1 µg/Kg	n/a	less than 1	n/a	1 or greater
HCB (µg/kg)	568	1 µg/Kg	n/a	less than 1	n/a	1 or greater
Heptachlor (µg/kg)	568	1 µg/Kg	n/a	less than 1	n/a	1 or greater
Heptachlor epoxide (µg/kg)	568	1 µg/Kg	n/a	less than 1	1 to <1.6	1.6 or greater
Phosphorus (mg/kg)	682	0.1 mg/Kg	less than 394	394 to <1115	1115 to <2179	2179 or greater
Total Kjeldahl Nitrogen (mg/kg)	682	1.0 mg/Kg	less than 1300	1300 to <5357	5357 to <11700	11700 or greater
Cadmium (mg/kg)	683	0.1 mg/Kg	n/a	less than 5	5 to <14	14 or greater
Copper (mg/kg)	683	1.0 mg/Kg	less than 16.7	16.7 to <100	100 to <590	590 or greater
Lead (mg/kg)	683	0.1 mg/Kg	less than 14	14 to <59	59 to <339	339 or greater
Mercury (mg/kg)	687	0.1 mg/Kg	n/a	less than 0.15	0.15 to <0.701	0.701 or greater
Cyanide (mg/kg)	16	n/a	n/a	n/a	n/a	n/a
Arsenic (mg/kg)	683	0.5 mg/Kg	less than 4.1	4.1 to <14	14 to <95.5	95.5 or greater
Chromium (mg/kg)	683	10. mg/Kg	less than 13	13 to <27	27 to <49	49 or greater
Iron (mg/kg)	683	10. mg/Kg	less than 16000	16000 to <37000	37000 to <56000	56000 or greater
Manganese (mg/kg)	683	10 mg/Kg	less than 500	500 to <1700	1700 to <5500	5500 or greater
Zinc (mg/kg)	683	10 mg/Kg	less than 59	59 to <145	145 to <1100	1100 or greater
Nickel (mg/kg)	598	1.0 mg/Kg	less than 14.3	14.3 to <31	31 to 43	43 or greater
Silver (mg/kg)	598	0.1 mg/Kg	n/a	less than 0.1	0.1 to <1	1 or greater
Potassium (mg/kg)	598	1.0 mg/Kg	less than 410	410 to <2100	2100 to <2797	2797 or greater
Barium (mg/kg)	598	1.0 mg/Kg	less than 94	94 to <271	271 to <397	397 or greater

All of the ranges for the new classification (Table 3) have changed from those of Kelly and Hite (Table 4). The change of the ranges is mainly a result of the method of statistical analysis and not a result of changes in the characteristics of lake sediments or laboratory analysis.

Just as in Kelly and Hite (1981) these concentrations are based on the population of sampled lakes and are not representative of biologically active concentrations of the various components. These classification ranges are not intended to be standards and should not be used as such. These ranges are, however, intended to be used to compare and classify lake sediments.

Table 4. Kelly and Hite (1981) Sediment Classification.

	Low	Normal	Elevated	Highly Elevated
Volatile Solids (%)	<5	5-13	13-17	>17
Total Kjeldahl Nitrogen (mg/kg)	<1650	1650-5775	5775-7850	>7850
Total Phosphorus (mg/kg)	<225	225-1175	1175-1650	1650 or greater
COD (mg/kg)	<32500	32500-162000	162000-226500	>226500
N:P Ratio	<2.2	2.2-9.7	9.7-13.5	>13.5
Organic Carbon (mg/kg)	<26500	26500-65550	65550-85100	>85199
C:N Ratio	<11	11-17	17-20	>20
Arsenic (mg/kg)		<27	27-41	>41
Cadmium (mg/kg)		<1.8	1.8-2.6	>2.6
Chromium (mg/kg)	<14	14-30	30-38	>38
Copper (mg/kg)		<100	100-150	>150
Iron (mg/kg)	<18000	18000-36000	36000-45000	>45000
Lead (mg/kg)	<15	15-100	100-150	>150
Manganese (mg/kg)		<3000	3000-3900	>3900
Mercury (mg/kg)		<0.25	0.25-0.40	>0.40
Zinc (mg/kg)	<50	50-175	175-250	>250

Bibliography

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