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ENVIRONMENTAL SCIENCES DIVISION
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ABSTRACT

CUSHMAN, R. M., S. G. HILDEBRAND, R. H. STRAND, and R. M. ANDERSON. 1977. The toxicity of 35 trace elements in coal to freshwater biota: a data base with automated retrieval capabilities. ORNL/TM-5793. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 46 pp.

Data are tabulated on the toxicity to freshwater biota of 35 trace elements with the potential for release to the environment from coal conversion effluents. The entire data base is presented on a microfiche appended to this document, in the interest of portability and accessibility. The data were gathered from a variety of research papers, compendia, and reviews. Details of water chemistry and test conditions are presented when available from the documents consulted. The data base may be used by referring directly to the tabulated data as they appear on the microfiche, or, with appropriate computer facilities, by manipulation (sorting, subsetting, or merging) of the data to meet the particular needs of the investigator. The data may be used as they appear in the data base, or the data base may be used to index the cited original papers.

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INTRODUCTION

At least 30 trace elements have been detected in measurable quantities in potential aqueous effluents from coal conversion processes.[1] For elements such as chromium, copper, and zinc, there exists an extensive literature describing the toxic effects on aquatic biota. However, for the majority of elements, the data are less abundant, less available, and scattered throughout a diverse literature of compendia, review papers, and papers describing original research. It is, therefore, difficult for an individual to readily assemble the available toxicity data in order to assess, for example, the potential toxicity of a given concentration of a particular element. Reliance upon one or more of the standard compendia restricts data extraction to that information contained in the compendia. Furthermore, details of the experimental conditions (water chemistry, type of bioassay employed, etc.) may or may not be provided. Maintaining a current knowledge of the burgeoning toxicity literature is also unrealistic for most researchers, if only because of the time consumed.

This effort represents the gathering of trace element toxicity data from a wide variety of sources into a single computerized data base. Data were gathered both from original research papers and from summary and review documents. The 35 elements listed in Table 1 were used in the literature search for available toxicity information, as they had potential for release to the environment from coal conversion process effluents and they could be toxic to freshwater biota. The concentration of the element and details of the bioassay or field conditions were extracted. Such conditions as water chemistry, life stage, and observed toxic effect were extracted in addition to other useful information. In our data extractions from the literature, we consistently sought values for the set of variables in the computerized data base. Table 2 lists and defines the variables used in the data base. Certain variables unique to a research paper were not included in the data base due to space requirements.

Details of the bioassay or field situation used in the paper were extracted when available since water chemistry and test conditions would be necessary for interpretation and application of the data. However, details such as these were frequently not included in summary documents. Table 3 shows the percent frequency of occurrence over all observations for which a value for each of the variables described in Table 2 was

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[1] S. G. Hildebrand, R. M. Cushman, and J. A. Carter. The potential toxicity and bioaccumulation in aquatic systems of trace elements present in aqueous coal conversion effluents. Proc. of 10th Ann. Conf. on Trace Substances in Environmental Health, Columbia, MO, June 8-10, 1976, D. D. Hemphill, ed., in press.

reported. These percentages are listed by element and range from 0 to 100% depending on the element and the variable. Where additional descriptions of the research are desired, we refer the user to the original references.

This report describes the data base we have formulated and computerized and shows a typical use and application of the data base for determining the effects of certain trace elements on biota. Since the data base is in the preliminary stages, we expect that (a) the user will find documents from which we have not extracted data, (b) this data base will be expanded as funding permits, and (c) applications will be more extensive and useful as more data are added. We present the data base in an abbreviated form below to show the user what kinds of data were extracted. The complete data base, together with concise descriptions of the variables, the frequency table (Table 3), and references are supplied on microfiche in the pocket insert (inside back cover). We believe that this form of the entire data base is more portable and accessible than a volumnious printout of the entire data base. With proper attention paid to this report, the reader should be able to use just the microfiche for subsequent access to the data base.

DATA BASE CONTENTS

What follows is a description of what is contained in the data base as presented in its entirety on the microfiche contained in the pocket insert. We will describe the data base as an item contained within the microfiche. The microfiche includes:

Item 1. definitions of the variable names used in the data tables;

Item 2. a table of frequency of occurrence of data for each of the variables in the data base, by element;

Item 3. the entire data base in tabular form, with an observation number assigned to each record;

Item 4. the observations sorted alphabetically by organism, with the element, its chemical form, and a cross-reference to the observation number in the entire data base (Item 3); and

Item 5. the list of references from which data were extracted and which are listed as variables in the entire data base (Item 3) to provide a cross-reference between the data base and the references.

Items 1, 2, 4, and 5 are descriptions, definitions, or rearrangements of the entire data base (Item 3). They are necessary for completing the microfiche as an exportable and usable data base. We have presented a sample of the entire data base in Table 4.

Data are presented both for lethal and sublethal effects. Data in the form LCX signify the lethal concentration for X percent of the organisms tested in the stated time period, if a time is specified, as in a 96-hr LC50. Endpoints reported as ILL (incipient lethal level) indicate threshold effects or concentrations causing mortality with theoretically infinite exposure. Sublethal effects include impairment of reproduction, growth, behavior, etc. For a rigorous discussion of bioassays and toxicity terminology the reader is referred to the series "Measurement of pollutant toxicity to fish," by J. B. Sprague, published in three parts:

(1969) I. Bioassay methods for acute toxicity. Water Research 3:793-821.

(1970) II. Utilizing and applying bioassay results. Water Research 4:3-32.

(1971) III. Sublethal effects and "safe" concentrations. Water Research 5:245-266.

In addition to the element and its concentration (mg/1), test organism (species and life stage), and toxicity end point, we have tabulated water chemistry parameters and other test conditions, including:

(1) type and source of dilution water
(2) whether the test was static or continuous flow
(3) temperature (^{0}C)
(4) hardness (mg/1)
(5) pH
(6) calcium concentration (mg/1)
(7) magnesium concentration (mg/1)
(8) dissolved oxygen (DO) (mg/1)
(9) total dissolved solids (TDS) (mg/1)
(10) alkalinity (mg/1)
(11) miscellaneous comments
(12) form of element or chemical compound used

For some of the variables (concentration, temperature, hardness, pH, dissolved oxygen, total dissolved solids, and alkalinity), a range of values was reported, and minimum and maximum values of the variable(s) are tabulated in the data base. However, where only a single value appears (as either a minimum or a maximum) a range was not reported, and the listed value does not necessarily represent a minimum or a maximum. Where a value for a variable was not present in the report, a period is recorded in the data tables.

For each observation, two reference citations are given, one representing the source(s) from which we directly obtained the data (variables OUR_REF1, OUR_REF2, and OUR_REF3), and the other representing

the source(s) in which the data first were reported (variables REF1ORIG, REF2ORIG, and REF3ORIG). The values for these variables, tabulated in the data base (Item 3), correspond to the numbers preceding each reference in the list of references (Item 5). Thus, the cross-reference between the two items in the data base. Table 5 lists the scientific (and common) names used in the data base, grouped into fish, protozoa, algae, other plants, crustacea, insecta, mollusca, and other animals. Table 6 relates the printout of the chemical form symbols as they appear on the microfiche to the appropriate chemical formulas. Table 7 is the list of references, which also appears in the microfiche output.

DATA BASE PREPARATION

Following the selection of a reference and the itemization of the test conditions used in the bioassay, the data were encoded in a format with a varying amount of space allowed for each variable. Once computerized, each observation consisted of multiple 80-column card images. An initial file was maintained a MODCOMP II/25 computer where editing was performed. This file was then transferred to an IBM 360/91 where management of the data base is currently maintained. The Statistical Analysis System (SAS)[2] was the main computer software used for producing the microfiche output included in the pocket insert.

DATA BASE USE

The data base was prepared to allow for manipulation and display of any of the variables. Some of the manipulations include sorting, e.g., sorting the data base by manganese concentration, subsetting, e.g., separating those observations where a specific water type and/or lifestage are desired, and merging, e.g., adding new observations to the file.

A specific example manipulation of the data base is shown in Table 8. Here we show an entire program listing, less computer-installation-specific job control statements, of statments written in the SAS language, and a portion of the corresponding output, used to subset the data base for a group of organisms (crustaceans). The syntax of this language uses semicolons to end statements. Thus the code which precedes each semicolon constitutes a single instruction. This particular example creates a data set called EFFECTS. The variables are then defined, using mnemonic names, as they occur in columns of the

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[2] A. J. Barr, J. H. Goodnight, J. P. Sall, and J. T. Helwig. 1976. A User's Guide to SAS 76. SAS Institute, Inc., P. O. Box 10522, Raleigh, NC.

input cards. Variables with character, rather than numeric, values are defined by a dollar sign on the input definition statement. The set of "IF" statements is used to include the observations with the desired organisms. A title card is used to label the printed output. This example illustrates how the data base can be subset for a particular organism to determine the effects, compounds, and test conditions which have been observed and included in the data base.

The example presented in Table 8 requires a set of data in the form described by the input statements. If the format changes for additional data, programs will have to be devised to manipulate the new format and merge the old and new data. The data base presented in the pocket insert has a format as described in the SAS input statements. A user who might be interested in manipulating the data base or implementing the data base on his computer should initially contact the third author for the availability of the data base and its available form.

In summary, our data base is an initial step towards expediting the tedious job of extracting, synthesizing, and tabulating, in numeric form, the current data available on toxic effects to aquatic organisms from trace elements in coal conversion process effluents. We feel this kind of effort is important to understanding the state-of-the-art with respect to inorganic toxic substances in aquatic systems. We emphasize the flexibility and ease of use of the computer methodology which we have developed for manipulating and displaying the data base. Researchers will find that the data base will ease the burden of literature search and evaluation. It will provide a starting point for directing researchers to current publications in toxic effects work and also provide a baseline for future research efforts.

Table 1. Elements included in the toxicity data base

Ag (silver)	Mn (manganese)
Al (aluminum)	Mo (molybdenum)
As (arsenic)	Ni (nickel)
Au (gold)	Pb (lead)
B (boron)	Rb (rubidium)
Ba (barium)	Sb (antimony)
Be (beryllium)	Se (selenium)
Br (bromine)	Sn (tin)
Cd (cadmium)	Sr (strontium)
Ce (cerium)	Th (thorium)
Co (cobalt)	Ti (titanium)
Cr (chromium)	Tl (thallium)
Cu (copper)	U (uranium)
Fe (iron)	V (vanadium)
Hg (mercury)	W (tungsten)
La (lanthanum)	Zn (zinc)
Li (lithium)	Zr (zirconium)
Mg (magnesium)	

Table 2. Variables and variable definitions used in the data base.

ALK_MAX =MAXIMUM ALKALINITY OF SOLUTION (MG/L)
ALK_MIN =MINIMUM ALKALINITY OF SOLUTION (MG/L)
CA_ION =CALCIUM ION CONCENTRATION IN WATER (MG/L)
CHEMFORM=CHEMICAL FORM OF ELEMENT
COMMENTS=COMMENTS ABOUT BIOASSAY
CONC_MAX=MAXIMUM CONCENTRATION OF ELEMENT (MG/L)
CONC_MIN=MINIMUM CONCENTRATION OF ELEMENT (MG/L)
DO_MAX =MAXIMUM DISSOLVED OXYGEN CONCENTRATION (MG/L)
DO_MIN =MINIMUM DISSOLVED OXYGEN CONCENTRATION (MG/L)
ELEMENT =ELEMENTAL CONSTITUENT OF COMPOUND IN BIOASSAY
EXP_END =THE END POINT OF BIOASSAY
EXP_TIME=THE DURATION OF THE BIOASSAY
HARD_MAX=MAXIMUM WATER HARDNESS (MG/L)
HARD_MIN=MINIMUM WATER HARDNESS (MG/L)
LIFE_STG=THE LIFE STAGE OF THE ORGANISM
MG_ION =MAGNESIUM ION CONCENTRATION (MG/L)
ORGANISM=SCIENTIFIC OR COMMON NAME OF ORGANISM
OUR_REF1=FIRST REFERENCE NUMBER FROM WHICH TABULATED DATA WERE OBTAINED
OUR_REF2=SECOND REFERENCE NUMBER FROM WHICH TABULATED DATA WERE OBTAINED
OUR_REF3=THIRD REFERENCE NUMBER FROM WHICH TABULATED DATA WERE OBTAINED
PH_MAX =MAXIMUM PH VALUE
PH_MIN =MINIMUM PH VALUE
RECON_FQ=SOLUTION RECONCENTRATION FREQUENCY
REF1ORIG=THE FIRST REFERENCE IN WHICH DATA WERE ORIGINALLY REPORTED
REF2ORIG=THE SECOND REFERENCE IN WHICH DATA WERE ORIGINALLY REPORTED
REF3ORIG=THE THIRD REFERENCE IN WHICH DATA WERE ORIGINALLY REPORTED
TDS_MAX =MAXIMUM TOTAL DISSOLVED SOLIDS (MG/L)
TDS_MIN =MINIMUM TOTAL DISSOLVED SOLIDS (MG/L)
WATER_TY=TYPE AND SOURCE OF DILUTION WATER
WTMP_MAX=MAXIMUM WATER TEMPERATURE (DEGREES C)
WTMP_MIN=MINIMUM WATER TEMPERATURE (DEGREES C)

Table 3. Frequency of occurrence of water chemistry and test conditions variables for each element. Each value represents the percent of the N observations (listed under column heading N) for which data were reported for each of the elements and listed variables.

ELEMENT	N	CHEM	LIPS	EXP	WATT	RECP	WT	WT	HRD	HRD	PH	PH	CAG	MG	DO	DO	TDS	TDS	ALK	ALK
			T	T	T	Q	X	N	X	N	X	N			X	N	X	N	X	N
		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
AG	27	81	11	67	37	30	33	37	0	0	19	19	0	0	0	0	0	0	0	0
AL	34	100	3	79	82	32	21	38	0	15	0	9	0	0	0	0	0	0	0	0
AS	140	93	1	46	53	36	9	21	0	2	2	8	2	0	0	0	0	0	0	0
AU	9	100	0	89	89	67	56	89	0	33	0	0	0	0	0	0	0	0	0	0
B	22	100	0	64	50	55	27	64	0	0	0	5	0	0	0	0	0	0	0	0
BA	43	93	14	67	49	19	16	49	0	12	12	12	0	0	0	0	0	0	0	0
BE	19	100	0	100	100	100	0	0	0	58	58	58	0	0	0	0	0	0	0	0
BR	11	36	0	64	82	100	0	0	0	0	0	18	0	0	0	0	0	0	0	0
CD	82	72	23	78	54	52	20	46	9	21	13	26	0	0	7	11	0	0	0	0
CE	5	100	0	100	0	20	0	40	0	0	0	0	0	0	0	0	0	0	0	0
CO	34	85	6	82	47	41	21	62	9	26	26	38	0	0	9	9	0	0	0	0
CR	208	100	10	80	44	60	16	55	1	7	8	13	0	0	4	4	0	0	0	2
CU	357	79	15	67	38	52	10	51	2	15	6	21	0	0	1	13	0	0	0	1
FE	94	90	17	82	44	15	2	16	3	9	6	12	0	0	3	3	0	0	0	0
HG	95	92	5	66	22	23	8	18	4	12	13	14	0	0	3	3	0	0	0	0
LA	4	100	0	100	100	0	0	75	0	0	0	0	0	0	0	0	0	0	0	0
LI	11	100	0	64	18	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MG	47	100	9	91	66	26	11	23	0	11	11	11	0	0	0	0	0	0	0	0
MN	80	96	24	57	44	34	6	32	0	5	6	6	0	0	0	0	0	0	0	0
MO	5	40	0	40	60	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NI	61	87	3	67	44	34	10	34	5	25	16	28	0	0	5	16	0	0	0	0
PB	108	80	2	78	59	39	13	33	3	22	20	33	0	0	3	8	4	4	0	0
RB	2	100	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE	13	77	0	62	69	38	0	23	0	0	0	0	0	0	0	0	0	0	0	0
SE	13	100	0	85	85	23	23	46	0	23	23	23	0	0	0	0	0	0	0	0
SN	12	92	0	75	75	25	0	42	0	42	0	8	0	0	0	0	0	0	0	0
SR	24	100	0	75	54	38	21	46	0	21	21	21	0	0	0	0	0	0	0	0
TH	4	100	0	75	75	25	0	50	0	0	0	0	0	0	0	0	0	0	0	0
TI	6	83	0	83	100	33	0	33	0	0	0	0	0	0	0	0	0	0	0	0
TL	8	0	0	50	0	0	13	13	0	25	0	0	0	0	0	0	0	0	0	0
U	9	89	0	44	100	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V	7	86	0	86	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	4	100	0	100	100	0	0	75	0	0	0	0	0	0	0	0	0	0	0	0
ZN	352	53	20	81	41	61	19	62	2	20	15	31	4	3	1	14	0	0	0	1
ZR	6	100	0	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (continued). Definitions of variables used in the frequency-of-occurrence table, representing percent frequency of non-blank data.

Column Heading	Variable (see Table 2)
ALKMN_FQ	ALK_MIN
ALKMX_FQ	ALK_MAX
CA____FQ	CA_ION
CHFM__FQ	CHEMFORM
DO_MN_FQ	DO_MIN
DO_MX_FQ	DO_MAX
EXP_T_FQ	EXP_TIME
HRDMN_FQ	HARD_MIN
HRDMX_FQ	HARD_MAX
LIFST_FQ	LIFE_STG
MG____FQ	MG_ION
PH_MN_FQ	PH_MIN
PH_MX_FQ	PH_MAX
RECFQ_FQ	RECON_FQ
TDSMN_FQ	TDS_MIN
TDSMX_FQ	TDS_MAX
WATTY_FQ	WATER_TY
WT_MN_FQ	WTMP_MIN
WT_MX_FQ	WTMP_MAX

Table 4. Sample page from data base.

OBS	ELEM	ELEM	CONC MIN	CONC MIN	CHEM FORM	ORGANISM	LIFE STG	EXP TIME	EXP END
1	1	AG	.	0.0030	AGNO3	GASTEROSTEUS ACULEATUS			ILL
2	4	AG	.	0.0032	AGNO3	DAPHNIA MAGNA			LETHAL
3	2	AG	.	0.0040	AGNO3	GASTEROSTEUS ACULEATUS		7 DAY	SURVIVAL
4	3	AG	.	0.0043	AGNO3	LEBISTES RETICULATUS			LC50
5	5	AG	.	0.0100	AGNO3	GASTEROSTEUS ACULEATUS		4 DAY	SURVIVAL
6	8	AG	.	0.0100		LEBISTES RETICULATUS			LETHAL
7	6	AG	.	0.0200	AGNO3	GASTEROSTEUS ACULEATUS		2 DAY	SURVIVAL
8	9	AG	.	0.0250	AGNO3	ONCORHYNCHUS TSHAWYTSCHA	FRY	48 HR	PARTLY LETEAL
9	7	AG	.	0.0300	AGNO3	DAPHNIA MAGNA		96 HR	ILL
10	10	AG	.	0.0300	AGNO3	MICROREGMA		96 HR	ILL
11	11	AG	.	0.0400	AGNO3	ESCHERICHIA COLI		96 HR	ILL
12	12	AG	.	0.0500	AGNO3	SCENEDESMUS		96 HR	ILL
13	13	AG	.	0.1000	AGNO3	GASTEROSTEUS ACULEATUS		1 DAY	SURVIVAL
14	16	AG	.	0.1000		BUFO VALLICEPS	TADPOLES		LETHAL
15	17	AG	.	0.1000		DAPHNIA MAGNA			LETHAL
16	15	AG	.	0.1500	AGNO3	POLYCELIS NIGRA			ILL
17	14	AG	.	0.2800	AGNO3	SALMON	FRY	48 HR	LETHAL
18	18	AG	.	0.3000	AGNO3	SEWAGE ORGANISMS			50% B.O.D. REDUCTION

OBS	WATER TYP	RENEWAL	WATER TEMP MIN	WATER TEMP MAX	HARD RAW	HARD ADJ	PH	PH	CA	MG	DO	DO	TDS	TDS	ALK	ALK	COND	REF 1	REF 2	REF 3	OUT REF	OUT REF	OUT REF
1	TAP VERY SOFT	RENEWED DAILY	18	14.0			6.8	6.0	.	.	.	.	.	.	.	.		117	118		75		
2	LAKE ERIE		.	25.0			.		.	.	.	.	.	.	.	.		7			159		
3	TAP VERY SOFT	RENEWED DAILY	18	14.0			6.8	6.0	.	.	.	.	.	.	.	.		117	118		75		
4			.				.		.	.	.	.	.	.	.	.		218			159		
5	TAP VERY SOFT	RENEWED DAILY	18	14.0			6.8	6.0	.	.	.	.	.	.	.	.		117	118		75		
6		STATIC	.				.		.	.	.	.	.	.	.	.		217			126		
7	TAP VERY SOFT	RENEWED DAILY	18	14.0			6.8	6.0	.	.	.	.	.	.	.	.		117	118		75		
8			.				.		.	.	.	.	.	.	.	.		153			75		
9	RIVER		25	23.0			.		.	.	.	.	.	.	.	.		35			159		
10	RIVER		27	23.0			.		.	.	.	.	.	.	.	.		36			159		
11	RIVER		27	23.0			.		.	.	.	.	.	.	.	.		35			159		
12	RIVER		27	23.0			.		.	.	.	.	.	.	.	.		35			159		
13	TAP VERY SOFT	RENEWED DAILY	18	14.0			6.8	6.0	.	.	.	.	.	.	.	.		117	118		75		
14		STATIC	.				.		.	.	.	.	.	.	.	.		217			126		
15		STATIC	.				.		.	.	.	.	.	.	.	.		217			126		
16			.				.		.	.	.	.	.	.	.	.		119			159		
17			.				.		.	.	.	.	.	.	.	.		153			159		
18			.				.		.	.	.	.	.	.	.	.		219			126		

Table 5. Scientific and common names of organisms in toxicity table.

Fish

Abramis brama (bream)
Anguilla japonica (Japanese eel)
Anguilla rostrata (American eel)
Brachydanio rerio (zebra fish)
Carassius auratus (goldfish)
Carassius carassius (European goldfish, European carp)
Cyprinus carpio (carp)
Fundulus diaphanus (banded killifish)
Fundulus heteroclitus (mummichog)
Gambusia affinis (mosquitofish)
Gasterosteus aculeatus (threespine stickleback)
Gobio gobio (gudgeon, gobie)
Hesperoleucus (roach)
Ictalurus nebulosus (brown bullhead)
Ictalurus punctatus (channel catfish)
Lebistes reticulatus (guppy)
Lepomis cyanellus (green sunfish)
Lepomis gibbosus (pumpkinseed)
Lepomis macrochirus (bluegill)
Micropterus dolomieui (smallmouth bass)
Micropterus salmoides (largemouth bass)
Morone americanus (white perch)
Morone saxatilis (striped bass, rockfish)
Nemachilus barbatulus (European stoneloach)
Notemigonus crysoleucas (golden shiner)
Notropis cornutus (common shiner)
Notropis hudsonius (spottail shiner)
Oncorhynchus gorbusca (pink salmon)
Oncorhynchus keta (chum salmon)
Oncorhynchus kisutch (coho salmon)
Oncorhynchus nerka (sockeye salmon)
Oncorhynchus tshawytscha (chinook salmon)
Orizias latipes (Japanese medaka)
Perca flavescens (yellow perch)
Perca fluviatilis (Eurasian perch)
Petromyzon marinus (sea lamprey)
Phoxinus phoxinus (minnow, red-sided shiner)
Pimephales promelas (fathead minnow)
Pomoxis (crappie)
Pungitius pungitius (ninespine stickleback)
Rutilus rutilus (roach)
Salmo clarki (cutthroat trout)
Salmo gairdnerii (rainbow or steelhead trout)
Salmo salar (Atlantic salmon)
Salmo trutta (brown trout)
Salvelinus fontinalis (brook trout)
Salvelinus namaycush (lake trout)
Scardinius erythrophthalmus (rudd)
Semotilus atromaculatus (creek chub)
Tilapia mossambica (mozambique mouthbrooder)
Tinca tinca (tench)
Xiphophorus maculatus (southern platyfish)

Table 5. (Continued)

Protozoa

Euglena gracilis
Lepocinclis steinii
Microregma heterostoma
Paramecium
Uroglena

Algae

Anabaena circinalis
Anabaena flos-aqua
Anabaena variabilis
Anacystis
Ankistrodesmus
Asterionella
Calothrix
Cladophora glomerata
Chlamydomonas
Chlorella pyrenoidosa
Chlorella sorokiniana
Chlorella variegata
Chlorella vulgaris
Chlorococcum humicola
Clathrocystes
Closterium
Cylindrospermum licheniforme
Gloeotrichia echinulata
Gomphonema parvulum
Hydrodictyon
Microcystis aeruginosa
Microspora
Mougeotia
Navicula seminulum
Nitzschia linearis
Nitzschia palea
Nostoc
Oedogonium
Oocystis
Oscillatoria
Pandorina
Phormidium ambiguum
Phormidium inundatum
Pithophora
Plectonema
Scenedesmus obliquus
Scenedesmus quadricauda
Selanestrum capricornutum
Spirogyra
Stigeoclonium tenue
Synedra
Synura
Tribonema
Ulothrix
Vaucheria
Zygnema

Table 5. (Continued)

Other Plants

Alisma (water plantain)
Alternaria tenuis (fungus)
Anarcharis canadensis (waterweed)
Bacopa (water hyssop)
Botrytis fabae (fungus)
Ceratophyllum (coontail)
Elodea canadensis (Canadian pondweed)
Escherichia coli (fecal bacterium)
Heteranthera (mud plantain)
Hippurus (mare's tail)
Ludvigia (false loosestrife)
Myriophyllum spicatum (Eurasian watermilfoil)
Najas flexilis (pondweed)
Potamogeton crispus (pondweed)
Potamogeton foliosus (pondweed)
Ranunculus (water crowfoot, spearwort)
Sphaerotilus (bacterium)
Utricularia (bladderwort)

Crustacea

Asellus aquaticus (isopod)
Asellus communis (isopod)
Cyclops vernalis (copepod)
Daphnia longispina (cladoceran)
Daphnia magna (cladoceran)
Daphnia pulex (cladoceran)
Diaptomus oregonensis (copepod)
Gammarus lacustris (amphipod)
Gammarus pseudolimnaeus (amphipod)
Gammarus pulex (amphipod)
Hyalella knickerbockeri (amphipod)
Leptodora kindtii (cladoceran)
Mesocyclops leuckarti (copepod)
Orconectes rusticus (decapod)
Simocephalus serrulatus (cladoceran)

Insecta

Acroneuria lycorias (stonefly)
Argia (damselfly)
Caenis diminuta (mayfly)
Callibaetis (mayfly)
Chloeon simile (mayfly)
Ephemerella subvaria (mayfly)
Hydropsyche betteni (caddisfly)
Ischnura verticalis (damselfly)
Laccophilus maculosus (predaceous diving beetle)
Libellula (dragonfly)
Pteronarcys californica (stonefly)
Stenonema rubrum (mayfly)
Tendipes decorus (midge)

Table 5. (Continued)

Mollusca

Ancylastrum fluviatile
Australorbis glabratus
Biomphalaria alexandrina
Biomphalaris biossyi
Bulinus contortus
Bulinus truncatus
Campeloma decisum
Gyraulus circumstriatus
Helisoma companulata
Lymnaea palustris
Planorbis glabratus
Physa heterostropha
Physa integra

Other Animals

Bufo valliceps (frog)
Limnodrilus hoffmeisteri (oligochaete)
Nais (oligochaete)
Polycelia nigra (planarian)
Rana pipiens (frog)
Xenopus laevis (toad)

Table 6. Chemical form symbols as they appear on the microfiche and the corresponding chemical formulas.

PRINTOUT SYMBOL	CHEMICAL FORMULA	PRINTOUT SYMBOL	CHEMICAL FORMULA
AGNO3	$AgNO_3$	LAAC3	$LaAc_3$ or $La(C_2H_3O_2)_2$
AL(NO3)3	$Al(NO_3)_3$	LICL	LiCl
ALCL3	$AlCl_3$	LIF	LiF
ALK(SO4)2	$AlK(SO_4)_2$	MEHG	MeHg or CH_3Hg
ALNH4(SO4)2	$AlNH_4(SO_4)_2$	MEHGCL	MeHgCl or CH_3HgCl
AL2(SO4)3	$Al_2(SO_4)_3$	MG(NO3)2	$Mg(NO_3)_2$
ASO2-	AsO_2^-	MGCL2	$MgCl_2$
ASO4-3	AsO_4^{-3}	MGNO3	$MgNO_3$
AS2O3	As_2O_3	MGSIF6	$MgSiF_6$
BA(NO3)2	$Ba(NO_3)_2$	MGSO4	$MgSO_4$
BACL2	$BaCl_2$	MN(NO3)2	$Mn(NO_3)_2$
BAF2	BaF_2	MNCL2	$MnCl_2$
BE(NO3)2	$Be(NO_3)_2$	MNCL3	$MnCl_3$
BECL2	$BeCl_2$	MNF2	MnF_2
BESO4	$BeSO_4$	MNSO4	$MnSO_4$
BF3	BF_3	MOO3	MoO_3
B4O7=	$B_4O_7^{-2}$	NAASO2	$NaAsO_2$
CD(NO3)2	$Cd(NO_3)_2$	NABO3	$NaBO_3$
CDCL2	$CdCl_2$	NABR	NaBr
CDSO4	$CdSO_4$	NABRO3	$NaBrO_3$
CECL3	$CeCl_3$	NA2ASO4	Na_2AsO_4
CE2(SO4)3	$Ce_2(SO_4)_3$	NA2B4O7	$Na_2B_4O_7$
CO(NO3)2	$Co(NO_3)_2$	NA2CRO4	Na_2CrO_4
COCL	CoCl	NA2CR2O7	$Na_2Cr_2O_7$
COCL2	$CoCl_2$	NA2HASO4	Na_2HAsO_4
COSO4	$CoSO_4$	NA2SEO3	Na_2SeO_3
CRCL3	$CrCl_3$	NA2WO4	Na_2WO_4
CRO3	CrO_3	NA3ASO4	Na_3AsO_4
CRO4=	CrO_4^{-2}	(NH4)2CRO4	$(NH_4)_2CrO_4$
CR2(SO4)3	$Cr_2(SO_4)_3$	(NH4)2CR2O7	$(NH_4)_2Cr_2O_7$
CR2O7=	$Cr_2O_7^{-2}$	NI(NO3)2	$Ni(NO_3)_2$
CU(NO3)2	$Cu(NO_3)_2$	NICL2	$NiCl_2$
CUCL2	$CuCl_2$	NISO4	$NiSO_4$
CUSO4	$CuSO_4$	PB(NO3)2	$Pb(NO_3)_2$
FECL2	$FeCl_2$	PBAC2	$PbAc_2$ or $Pb(C_2H_3O_2)_2$
FECL3	$FeCl_3$	PBCL2	$PbCl_2$
FEO	FeO	PBSO4	$PbSO_4$
FES	FeS	PBO	PbO
FESO3	$FeSO_3$	PHENYL HGOH	Phenyl HgOH or C_6H_6OHg
FESO4	$FeSO_4$	PHENYL HGAC	Phenyl HgAc or $C_8H_8O_2Hg$
FE2(SO4)3	$Fe_2(SO_4)_3$	PHENYL HGNO3	Phenyl $HgNO_3$ or $C_{12}H_{11}OHgNO_3$
FE2O3	Fe_2O_3	RBCL	RbCl
HAUCL4	$HAuCl_4$	SBCL3	$SbCl_3$
HBO3	HBO_3	SBF3	SbF_3
H3BO4	H_3BO_4	SBKTARTRATE	SbKTartrate or $KSbOC_4H_4O_6$
HG(NO3)2	$Hg(NO_3)_2$	SEO2	SeO_2
HGAC2	$Hg\ c_2$ or $Hg(C_2H_3O_2)_2$	SEO3-2	SeO_3^{-2}
HGCL2	$HgCl_2$	SNCL2	$SnCl_2$
HGNO2	$HgNO_2$	SNCL4	$SnCl_4$
HGSO4	$HgSO_4$	SR(NO3)2	$Sr(NO_3)_2$
KCR(SO4)2	$KCr(SO_4)_2$	SRCL2	$SrCl_2$
KCR2O7	KCr_2O_7	SRF2	SrF_2
KMNO4	$KMnO_4$	TH(NO3)4	$Th(NO_3)_4$
K2CRO4	K_2CrO_4	THCL4	$ThCl_4$
K2Cr2O7	$K_2Cr_2O_7$	TICL2	$TiCl_2$

Table 6. (Continued)

PRINTOUT SYMBOL	CHEMICAL FORMULA
TI2(SO4)3	$Ti_2(SO_4)_3$
UO2(NO3)2	$VO_2(NO_3)_2$
UO2AC2	UO_2Ac_2 or $UO_2(C_2H_3O_2)_2$
UO2SO4	UO_2SO_4
VOSO4	$VOSO_4$
V2O5	V_2O_5
ZN(NO3)2	$Zn(NO_3)_2$
ZNCL2	$ZnCl_2$
ZNSO4	$ZnSO_4$
ZR(SO4)2	$Zr(SO_4)_2$
ZROCL2	$ZrOCl_2$

Table 7. List of references used to document the data presented in the toxicity data base. (Entire list of references also appears on microfiche in pocket insert on inside back cover.)

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Table 8. Program and output listing to subset data base for only those records with an organism name within crustaceans.

A. Program listing

```
DATA EFFECTS;
INFILE CARDS;
INPUT ELEM_CRD 11-13 SEQ 14 ELEMENT $ 26-27 CONC_MIN 28-36 4 CONC_MAX 38-45 4
CHEMFORM $ 47-66 #2 ORGANISM $ 16-45 LIFE_STG $  47-71 #3 EXP_TIME $ 16-25
EXP_END $ 27-56 WATER_TY $ 58-78 #4 RECON_FQ $ 16-35 WTMP_MAX 37-40 WTMP_MIN $
42-45
 HARD_MAX $ 47-56 HARD_MIN $ 58-67 PH_MAX 69-71 PH_MIN $ 73-76 #5 CA_ION 16-23
MG_ION 25-32 DO_MAX 35-39 DO_MIN 41-45 TDS_MAX 47-52 TDS_MIN 54-59 #6 ALK_MAX
16-25 ALK_MIN 27-36 COMMENTS $ 38-67 #7 REF1ORIG $ 16-19 REF2ORIG $ 21-24
REF3ORIG $ 26-29 OUR_REF1 $ 31-34 OUR_REF2 $ 36-39 OUR_REF3 $ 41-44;


COMMENT  THESE IF STATEMENTS ARE USED FOR INCLUDING ONLY THOSE ORGANISMS
         WITH THE NAME INDICATED WITHIN THE SINGLE QUOTES.
IF ORGANISM EQ 'ASELLUS AQUATICUS              ' THEN RETURN;
IF ORGANISM EQ 'ASELLUS COMMUNIS               ' THEN RETURN;
IF ORGANISM EQ 'CLADOCERANS                    ' THEN RETURN;
IF ORGANISM EQ 'CRUSTACEA                      ' THEN RETURN;
IF ORGANISM EQ 'CYCLOPS VERNALIS               ' THEN RETURN;
IF ORGANISM EQ 'DAPHNIA                        ' THEN RETURN;
IF ORGANISM EQ 'DAPHNIA LONGISPINA             ' THEN RETURN;
IF ORGANISM EQ 'DAPHNIA MAGNA                  ' THEN RETURN;
IF ORGANISM EQ 'DAPHNIA PULEX                  ' THEN RETURN;
IF ORGANISM EQ 'DIAPTOMUS OREGONENSIS          ' THEN RETURN;
IF ORGANISM EQ 'GAMMARUS                       ' THEN RETURN;
IF ORGANISM EQ 'GAMMARUS LACUSTRIS             ' THEN RETURN;
IF CRGANISM EQ 'GAMMARUS PSEUDOLIMNAEUS        ' THEN RETURN;
IF ORGANISM EQ 'GAMMARUS PULEX                 ' THEN RETURN;
IF ORGANISM EQ 'HYALELLA KNICKERBOCKERI        ' THEN RETURN;
IF ORGANISM EQ 'LEPTODORA KINDTII              ' THEN RETURN;
IF ORGANISM EQ 'MESOCYCLOPS LEUKARTI           ' THEN RETURN;
IF ORGANISM EQ 'ORCONECTES RUSTICUS            ' THEN RETURN;
IF ORGANISM EQ 'SHRIMP, FRESH WATER            ' THEN RETURN;
IF ORGANISM EQ 'SIMOCEPHALUS SERRULATUS        ' THEN RETURN;
IF ORGANISM EQ  'AMPHIPODS                      ' THEN RETURN;
DELETE;
      CARDS;



TITLE TOXIC EFFECTS FOR CRUSTACEANS;
PROC PRINT DATA=EFFECTS;
```

Table 8 (cont'd). B. Portion of output from previous program.

OBS	ELEM CRD	SEQ	ELEM	CONC MIN	CONC MAX	CHEMFORM	ORGANISM	LIFE STG	EXP TIME	EXP END
1	4	1	AG	0.0032	.	AGNO3	DAPHNIA MAGNA			LETHAL
2	7	1	AG	0.0300	.	AGNO3	DAPHNIA MAGNA		96 HR	ILL
3	17	1	AG	0.1000	.		DAPHNIA MAGNA			LETHAL
4	6	1	AL	0.3200	.	ALCL3	DAPHNIA MAGNA		3 WK	16% REPRODUCTIVE IMPAIRMENT
5	7	1	AL	0.6800	.	ALCL3	DAPHNIA MAGNA		3 WK	50% REPRODUCTIVE IMPAIRMENT
6	8	1	AL	0.6200	.	ALCL3	DAPHNIA MAGNA		3 WK	38% WEIGHT LOSS
7	9	1	AL	1.4000	.	ALCL3	DAPHNIA MAGNA		3 WK	LC50
8	10	1	AL	3.9000	.	ALCL3	DAPHNIA MAGNA		2 DAY	LC50
9	22	1	AL	21.5000	.	AL2(SO4)3	DAPHNIA MAGNA			LETHAL
10	23	1	AL	16.8000	.	AL2(SO4)3	DAPHNIA MAGNA			LETHAL
11	33	1	AL	21.7000	.	ALNH4(SO4)2	DAPHNIA MAGNA			LETHAL
12	34	1	AL	21.6000	.	ALK(SO4)2	DAPHNIA MAGNA			LETHAL
13	3	1	AS	0.5200	.	NA2HASO4	DAPHNIA MAGNA		3 WK	16% REPRODUCTIVE IMPAIRMENT
14	4	1	AS	0.9960	.	NA2HASO4	DAPHNIA MAGNA		3 WK	18% WEIGHT LOSS
15	5	1	AS	0.9960	.	NA2HASO4	DAPHNIA MAGNA		3 WK	15% PROTEIN LOSS
16	15	1	AS	0.8100	.	NAASO2	SIMOCEPHALUS SERRULATUS		48 HR	LC50
17	19	1	AS	7.4000	.	NA2HASO4	DAPHNIA MAGNA		48 HR	LC50
18	20	1	AS	1.4000	.	NA2HASO4	DAPHNIA MAGNA		3 WK	50% REPRODUCTIVE IMPAIRMENT

OBS	WATER TYPE	WATER CONDITION	WT MIN	WT MAX	HARD MIN	HARD MAX	PH	PHA	CAG	MGO	DOA	DOI	TDS	TDS	ALK	ALK	COMMENTS	REF NO	REF PAGE 1	REF PAGE 2	REF PAGE 3
1	LAKE ERIE		.	25.0			.	.	.	.	.	.	.	.	.	.		7		159	
2	RIVER		25.0	23.0			.	.	.	.	.	.	.	.	.	.		35		159	
3		STATIC	.				.	.	.	.	.	.	.	.	.	.		217		126	
4	LAKE(UNFILTERED)		.	18		45	.	.	.	.	.	.	.	.	.	.		28		28	
5	LAKE(UNFILTERED)		.	18		45	.	.	.	.	.	.	.	.	.	.		28		28	
6	LAKE(UNFILTERED)		.	18		45	.	.	.	.	.	.	.	.	.	.		28		28	
7	LAKE(UNFILTERED)		.	18		45	.	.	.	.	.	.	.	.	.	.		28		28	
8	LAKE(UNFILTERED)		.	18		45	.	.	.	.	.	.	.	.	.	.		28		28	
9	LAKE ERIE	STATIC	.				.	.	.	.	.	.	.	.	.	.		5		126	
10	LAKE ERIE		.				.	.	.	.	.	.	.	.	.	.		5		159	
11	LAKE ERIE	STATIC	.				.	.	.	.	.	.	.	.	.	.		5		126	
12	LAKE ERIE	STATIC	.				.	.	.	.	.	.	.	.	.	.		5		126	
13	LAKE(UNFILTERED)		.	18.		45	.	.	.	.	.	.	.	.	.	.		28		28	
14	LAKE(UNFILTERED)		.	18.		45	.	.	.	.	.	.	.	.	.	.		28		28	
15	LAKE(UNFILTERED)		.	18.		45	.	.	.	.	.	.	.	.	.	.		28		28	
16			.				.	.	.	.	.	.	.	.	.	.	LAB	64		24	
17	LAKE(UNFILTERED) HARD		.				.	.	.	.	.	.	.	.	.	.		28		28	
18	LAKE(UNFILTERED) HARD		.				.	.	.	.	.	.	.	.	.	.		28		28	

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