DEVELOPMENT OF MULTIMEDIA ENVIRONMENTAL GOALS (MEG's) FOR POLLUTANTS FROM FUEL CONVERSION PROCESSES

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Abstract

The presentation will highlight the progress to date in developing a systematic approach to describe multimedia environmental goals for chemical substances associated with fuel conversion processes. Discussion will focus on (1) the various types of information pertinent to environmental goals and available for a multiplicity of potential chemical contaminants and (2) models designed to incorporate available data in the prediction of permissible ambient or emission concentrations for each substance. The validity of combining various models in order to assign priorities or to compare distinctly different toxicants based on their respective environmental goals will be addressed. Comments on future work directed toward refinement and expansion of the methodology will also be included.

INTRODUCTION

Multimedia Environmental Goals (MEG's) are levels of contaminants or degradants (in ambient air, water, or land or in emissions or effluents conveyed to ambient media) that are judged to be (1) appropriate for preventing certain negative effects in the surrounding populations or ecosystems, or (2) representative of the control limits achievable through technology.

Establishing Multimedia Environmental Goals is an integral part of the environmental assessment methodology that is currently being developed under the guidance of the Fuels Process Branch of IERL/EPA at RTP. Environmental assessment involves:

1) The determination of contaminant levels associated with emissions and effluents from a point source.
2. Comparison of those determinations with desirable control levels.

The need for MEG's arises in this latter aspect of environmental assessment.

The MEG's project has been conceived to supply sets of control goals for specific chemical contaminants, complex effluents, and non-chemical degradents based on some of the criteria options that might be considered in defining "desirable control levels." These sets of goals, then, provide the values to be compared with actual contamination levels for environmental assessment purposes.

The first year of MEG's development was devoted largely to selecting the options to be used as MEG's criteria and to investigating ways to approach the problem of defining MEG's for a large number of chemical substances. Initially, the objective of this work was to describe MEG's for chemical pollutants associated with coal conversion processes. However, the value of an expanded list of contaminants was recognized, and the potential for extended application of a MEG's methodology called for the development of a broad, systematic, and adaptable approach for addressing a much larger number of chemical and non-chemical pollutants. Hence the scope of the MEG'sproject has been expanded to encompass a broad range of objectives which include the following:

1) Compiling a Master List of all chemical contaminants, complex effluents/mixtures, and non-chemical degradants (such as visual effects, subsidence, heat, and noise) to be addressed by MEG's. (The list is to include but should not be limited exclusively to contaminants from fossil fuels processes.)
2) Arrangement of the chemical substances appearing on the Master List into a practical catalog to provide a useful tool for environmental assessment.
3) Design of a format conducive to the concurrent presentation of sets of Emission Level Goals and Ambient Level Goals. (The format should allow ready comparison of the MEG's within a set as well as facilitating comparison of different substances.)

4) Determination of the kinds of data pertinent to desirable control levels and the availability of that data. A format for presenting background information should be established to accompany MEG's specified for each chemical substance.
5) Development of a methodology to establish meaningful values to serve as MEG's for each chemical substance on the Master List. (The methodology should incorporate as MEG's those Federal standards, criteria, and recommendations pertinent to chemical substances.)
6) Presentation, according to the format prescribed, of a set of Emission Level Goals and Ambient Level Goals for each chemical substance appearing on the Master List. (These MEG's should be accompanied by qualitative supporting data.)

The central purpose of the project remains the derivation of Multimedia Environmental Goals as estimates of desirable levels of control for those chemical contaminants and nonchemical degradents included in a master list.

COMPILATION OF THE MASTER LIST OF CHEMICAL SUBSTANCES AND PHYSICAL AGENTS

A Master List of more than 600 chemical substances and physical agents has been compiled using selection factors prescribed by EPA. Primary emphasis has been placed on contaminants from fossil fuels processes (particularly coal gasification and liquefaction), and the Master List has been compiled largely on the basis of the literature pertinent to these processes. Process streams were characterized both qualitatively and quantitatively wherever possible to provide insight for selecting substances likely to be present but not mentioned specifically in the process literature.

Three levels of priority were assigned to the selection factors to determine what substances (of all possible chemical substances and physical agents that might be described as environmental contaminants) would be entered on the Master List for MEG's. The selection factors are outlined below:

Primary Selection Factors

1) The pollutant is associated with fossil fuels processes.

All those individual substances or classes of substances known or suspected to be present in the emissions or effluents from fossil fuels processes must appear on the Master List.

Secondary Selection Factors

1) Federal standards or criteria exist or have been proposed (ambient, emission, or occupational).
2) A TLV has been established or an LD_{50} has been reported.
3) The substance has been listed as a suspected carcinogen.
4) The substance appears on the EPA Consent Decree list.

Compounds that meet any one of the four secondary selection factors and are representative of a class of compounds associated with fossil fuels processes must appear on the Master List.

Tertiary Selection Factors (Optional)

1) The substance is present as a pollutant in the environment.
2) The substance has been identified as being highly toxic.

Consideration for inclusion in the Master List is also to be given to certain additional pollutants, not necessarily associated with fossil fuels processes, provided they satisfy either of the tertiary selection factors.

ORGANIZATION OF THE MASTER LIST

To organize the more than 600 Master List entries, a system for ordering the substances had to be developed. The approach ultimately determined to meet the need for organization most effectively involves clustering substances into categories based on chemical functional groups for organic compounds and on principle element for inorganics. The categories are then arranged to provide a coordinated framework for the list. This categorization scheme, besides organizing the list of chemical contaminants into manageable chunks, emphasizes logical relationships between groups of substances so that each category is characterized by toxicologically and chemically similar substances.

A total of 85 categories (26 organic and 59 inorganic) are required to logically organize specific chemical contaminants included in the Master List for MEG's.

Generalizations and extrapolations are often valid among the compounds included within a category, allowing data gaps to be filled in some instances. Substances likely to occur together or to behave similarly in an organism may become apparent through the categorization scheme. Also, methods of detection for compounds within a specific category are likely to be similar, and analysis of a category as a whole may in some cases be practical for broad screening applications.

The categorization scheme allows one seeking information on a particular substance to find material of value associated with a related compound or element, should the particular item of interest be missing from the compilations. The utility of isolating related compounds by categorization has become very evident during the course of data collection for the current MEG's work. For example, phenolic compounds are addressed collectively by water quality recommendations;[1] since phenols are grouped as a category in the compilations, it is easy to comprehend the intended subject of the recommendation.

An alphabetical arrangement of Master List entries, although in some ways the simplest approach to organizing the list, has been avoided since it would provide no means of associating related compounds (unless of course their names begin with the same letter).

THE MULTIMEDIA ENVIRONMENTAL GOALS CHART

A MEG's chart has been designed to display concurrently Emission Level Goals and Ambient Level Goals for any specific chemical contaminant in a consistent, easy to use format. The current version of the chart is shown in Figure 1.

The MEG's chart consists of two interrelated tables, one addressing Emission Level Goals and one addressing Ambient Level Goals. Each table is divided into columns devoted to specific criteria for describing desirable control levels (for example, Toxicity Based Ambient Level Goals [Based on Health Effects]). Within each column, space is provided for concentration levels to be specified for air, water, and land in units consistent with those indicated in the index column at the left. Only numbers will appear within the MEG's charts. The name of the substance addressed, its category number, and appropriate toxicity indicator (based on human health effects associated with the substance as an air contaminant) are all presented in bold letters in the upper right hand corner of each chart.

Emission Level Goals

Emission Level Goals presented in the top half of the MEG's chart actually pertain to gaseous emissions to the air, aqueous effluents to water, and solid waste to be disposed to land. These Goals may have as their bases technological factors or ambient factors. Technological factors refer to the limitations placed on control levels by technology, either existing or developing (i.e., equipment capabilities or process parameters). The Standards of Performance for New Stationary Sources[2] provide an example of promulgated Emission Level Goals based on technology.

Since there is obviously a relationship between contaminant concentrations in emissions and the presence of these contaminants in ambient media, it is imperative to consider ambient factors when establishing emission level goals. Ambient factors included in the MEG's chart as criteria for Emission Level Goals include:

1) Minimum Acute Toxicity Effluents (MATE's)—concentrations of pollutants in undiluted emission streams that would not adversely affect those persons or ecological systems exposed for short periods of time.
2) Ambient Level Goals—i.e. estimated permissible concentrations (EPC's) of pollutants in emission streams which, after dispersion, will not cause the level

MULTIMEDIA ENVIRONMENTAL GOALS

EMISSION LEVEL GOALS							
	I. Based on Best Technology		II. Based on Ambient Factors				
Category	A. Existing Standards	B. Developing Technology	A. Minimum Acute Toxicity Effluent		B. Ambient Level Goal*		C. Elimination of Discharge
	NSPS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background*
Air, μg/m³ (ppm Vol)							
Water, μg/l (ppm Wt)							
Land, μg/g (ppm Wt)							

*To be multiplied by dilution factor

	AMBIENT LEVEL GOALS				
	I. Current or Proposed Ambient Standards or Criteria		II. Toxicity Based Estimated Permissible Concentration		III. Zero Threshold Pollutants Estimated Permissible Concentration
	A. Based on Health Effects	B. Based on Ecological Effects	A. Based on Health Effects	B. Based on Ecological Effects	Based on Health Effects
Air, μg/m³ (ppm Vol)					
Water, μg/l (ppm Wt)					
Land, μg/g (ppm Wt)					

Figure 1. Current version of multimedia environmental goals chart.

of contamination in the ambient receiving medium to exceed a safe continuous exposure concentration.

3) Elimination of Discharge (EOD)—concentrations of pollutants in emission streams which, after dilution, will not cause the level of contamination to exceed levels measured as "natural background."

Although technology based Emission Level Goals are highly source specific, goals based on ambient factors can be considered universally applicable to discharge streams for any industry. The Emission Level Goals based on EPC's for example, correspond to the most stringent Ambient Level Goals (dilution factor to be applied) appearing in the MEG's chart, regardless of source of emission. This format for presentation of Emission Level Goals has evolved during the course of the MEG's project and is significantly different from the initial chart introduced some 18 months ago. Elimination of Discharge, as a criteria for Emission Level Goals, was added about a year ago. In another interim version, columns specifying dilution factors in multiples of ten were included under the Emission Level Goals based on ambient factors. Later, Minimum Acute Toxicity Effluents (MATE's) were incorporated and the dilution factor columns deleted. It is likely that the chart will be further altered as the MEG's become more refined, but the format presented here serves well for displaying MEG's at this stage of development.

Ambient Level Goals

The lower half of the MEG's chart is designed to present three classifications of Ambient Level Goals; all of these goals describe estimated permissible concentrations (EPC's) for continuous exposure. The Ambient Level Goals presented in the chart are those based on:

1) Current or proposed Federal ambient standards or criteria.
2) Toxicity (acute and chronic effects considered).
3) Carcinogenicity or teratogenicity (for zero threshold pollutants).

The term zero threshold pollutants is used to distinguish contaminants demonstrated to be potentially carcinogenic or teratogenic. The concept of thresholds is based on the premise that there exists for every chemical substance, some defineable concentration below which that chemical will not produce a toxic response in an exposed subject.[3] The existence of thresholds for carcinogens, teratogens, and mutagens has been widely debated and is still unresolved. In using the term "zero threshold pollutants," we do not wish to imply that we have chosen sides in the debate; rather, we use the nomenclature as a convenience.

BACKGROUND INFORMATION SUMMARIES FOR CHEMICAL SUBSTANCES

An obvious need in the field of environmental assessment has been for a useable instrument bringing together data related to environmental aspects of various chemical substances. The format developed for supplying summarized background information to accompany and substantiate MEG's charts addresses this need, providing a large volume of information in a consolidated, consistent, workable arrangement. This format serves to organize available data in a logical framework, yet at the same time remains flexible enough to allow incorporation of data as it becomes available. Specific items of information are arranged in a consistent pattern, and presented in conjunction with the corresponding MEG's chart. This allows the user to survey the data quickly and to relate multimedia environmental goals to physical and chemical properties, and toxicological characteristics of the chemical substance of interest.

Space is provided on each Background Information Summary to supply the following types of data:

- Identifying Information
- Properties
- Natural Occurrence, Characteristics, Associated Compounds
- Toxic Properties, Health Effects
- Regulatory Actions, Standards, Criteria, Candidate Status for Specific Regulation

Table 1 lists the specific items of information included in the Background Information Sum-

TABLE 1

INFORMATION PRESENTED IN BACKGROUND INFORMATION SUMMARIES

General Heading	Specific Items
IDENTIFYING INFORMATION	Category number, Preferred name, Synonyms, Empirical chemical formula, Structure, Wiswesser Line Notation, Physical description
PROPERTIES	Molecular or atomic weight, Atomic number Periodic group, Boiling point, Melting point, Density, Vapor density, Vapor pressure, Dissociation constant
NATURAL OCCURENCES, CHARACTERISTICS, AND ASSOCIATED COMPOUNDS	Background levels in air, Odor levels, Photochemical activity, Background levels in water, Occurence associations, Dietary intake, Characteristic chemical reactions, Metabolic fate, Background levels in soil
TOXIC PROPERTIES AND HEALTH EFFECTS	Animal toxicity information: LD_{50} - lethal dose (50% kill) LC_{50} - lethal concentration (50% kill) LD_{Lo} - lowest published lethal dose LC_{Lo} - lowest published lethal concentration Human health effects data: acute effects, chronic effects, biological half-life Data pertinent to carcinogenicity or teratogenicity: EPA/NIOSH ordering number, Affected animal species, Recorded human effects, Lowest effective dosages, Adjusted ordering number Aquatic toxicity information: LC_{50} - lethal concentration (50% kill) Bioaccumulation, or biomagnification (potential), Reported tainting levels, Phytotoxicity (plant toxicity) data
REGULATORY ACTIONS, STANDARDS, CRITERIA, RECOGNITION AND CANDIDATE STATUS FOR SPECIFIC REGULATIONS	National Primary and Secondary Ambient Air Quality Standards (40 CFR, Part 50). National Emissions Standards for Hazardous Air Pollutants (40 CFR, Part 61). OSHA Standards for Hazardous Substances (29 CFR, Part 1910). National Interim Primary Drinking Water Regulations (40 CFR, Part 141). Public Health Service Drinking Water Standards (42 CFR, Part 72). EPA Toxic Pollutant Effluent Standards (40 CFR, Part 405-460). Regulations for Protection Against Radiation (10 CFR, Part 20). FDA Declaration EPA National Emissions Standards for Hazardous Air Pollutants, Candidate List. EPA Toxic Pollutant Effluent Standards, Candidate List. EPA Consent Decree List. NCI List of Carcinogens to Man. ACGIH designation as carcinogen, simple asphyxiant, or nuisance particulate. EPA Star Document subject. NIOSH Criteria Document subject. Chemical Industry Institute of Toxicology Priority Chemical Lists.

maries under each of these headings. In addition to these items, calculations of MATE's and EPC's are also presented in the summaries.

MEG' METHODOLOGY

A methodology for evaluating and ranking pollutants for the purpose of environmental assessment, has been developed which can be used to delineate MEG's for a large number of compounds. The system requires certain empirical data which are extrapolated through simple models to yield EPC's or MATE's. The methodology addresses both Ambient Level Goals and Emission Level Goals based on ambient factors.

Existing or proposed Federal standards, criteria, or recommendations are acknowledged as previously established goals and have been utilized wherever applicable. For those substances not addressed by current guidelines, consideration in arriving at MEG's goals has been given to the following: (1) established or estimated human threshold levels; (2) acceptable risk levels for lifetime exposure to suspected carcinogens or teratogens; (3) degrees of contamination considered reasonable for protection of existing ecosystems; (4) cumulative potential in aquatic organisms, livestock, and vegetation; and (5) hazards to human health or to ecology induced by short term exposure to emissions. It is recognized that there are several other criteria pertinent to MEG's that have not been incorporated into the methodology developed thus far (for example, quality of the receiving media before introduction of the substance, characteristics of transport and dispersion of emissions, consideration of location and abundance of sources emitting a given pollutant, numbers of populations affected, synergisms, antagonisms, and other secondary pollutant associations); new research is needed before more refined models of estimation can be developed to allow inclusion of these criteria.

Three distinct aspects of MEG's methodology development have been addressed so far. These are:

1) assembling and collating all existing or proposed Federal guidelines pertinent to each chemical substance on the Master List.
2) defining models to translate empirical data into EPC's) estimated permissible concentrations for continuous exposure to chemical toxicants in air, water, and land).
3) defining models to translate empirical data into values describing MATE's (minimum acute toxicity effluents safe for short term exposure; such effluents may be gases, liquids, or solids).

Federal Guidelines

Investigation of Federal Guidelines has yielded not only values to serve as MEG's, but also insight into the variety of approches applied in standard setting thus far. For example, the National Emissions Standards for Hazardous Air Pollutants established for mercury and beryllium take into consideration estimated safe ambient levels of these pollutants (1 $\mu g/^3$ for Hg, 0.01 $\mu g/m^3$ for Be).[4] Emission guidelines may be expressed in many different units such as the ratio of mass or volume of pollutant to the mass of feedstock or product. Ambient guidelines may also be expressed in units other than concentration units, for example, certain water quality criteria for protection of aquatic life specify application factors to be applied to the 96-hr LC_{50}.

Existing Federal Guidelines fall far short of providing MEG's for all the chemical substances of concern. In fact, our survey of the Federal guidelines showed only about 40 specific contaminants receive attention by more than one set of emissions or ambient guidelines. The MEG's list, as mentioned earlier, includes more than 600 specific chemical substances.

Estimated Permissible Concentrations (EPC's)

To delineate Multimedia Environmental Goals a defined frame of reference for each substance must be established as a common reference point to allow comparison of various characteristics among similar and diverse substances. Translation of various forms of data into EPC's meets this need.

Two types of EPC's are generated through modeling. Empirical data concerning the effects of chemical substances on human health and the ecology are translated into a set of toxicity-based EPC's. Another set of EPC's is supplied by a system relating carcinogenic or teratogenic potential to media concentrations considered to pose an acceptable risk.

The methodology defines a total of 22 different kinds of EPC's, many of them interrelated (EPC's for water, for example, may be derived from EPC's for air). Although multiple EPC's are calculated on the background information summaries, only the most stringent EPC for a given media/criteria combination will appear on the MEG chart for a given substance.

EPC's have been coded by subscripts for easy identification. EPC_{AHI}, for example, is the toxicity based EPC for air based on human health effects (derived from air model #1); EPC_{WEI} applies to water and is based on ecological effects (water model #1 is used); EPC_{ACI} is for air and is based on carcinogenic potential (established by carcinogen model #1).

Several of the models incorporated were developed or suggested by previous researchers; other models were designed or modified specifically for MEG's application. The significance of the methodology lies not in any specific model, but in the array of models which allows MEG's to be defined on the basis of a variety of data items. Empirical data required for the various health based EPC's and interrelationships defined in the methodology are listed in Table 2. EPC's based on ecological effects are defined in Table 3. Most specific types of data required have been compiled previously by others and are largely available in tabulated form within secondary sources of information.

Minimum Acute Toxicity Effluents (MATE's)

The system established to describe MATE values as Emission Level Goals is analogous to that developed for EPC's. The basic difference is that the MATE's refer to concentrations appropriate for short term exposure whereas EPC's consider lifetime continuous exposure. Fourteen different kinds of MATE values are defined currently.

APPLICATION OF METHODOLOGY FOR DESCRIBING MEG's

Presentation in detail of all the models supporting the EPC and MATE derivations is beyond the scope of this paper. However, a few general comments are required to permit some perspective into the methodology. First, all of the modeling schemes require that certain assumptions be made and a worst case approach has been taken to keep the MEG values conservative. In some instances, arbitrary constants are incorporated in an effort to correlate the various sets of EPC's. Efforts have been made to incorporate judgments of others relative to the levels of pollutants safely tolerated by human beings. In this regard, heavy reliance in the methodology has been placed on TLV's established by the American Conference of Governmental Industrial Hygienists (ACGIH).[5]

So far, 216 chemical substances from the MEG's Master List have been addressed utilizing the previously described format and methodology. While the rapid increase in volume of data accessible in recent months has increased the reliability of assessment schemes based on modeling techniques, data gaps remain a problem over a wide range of the entries. These gaps make it impossible to provide, for every substance addressed, goals for each medium on the basis of all the applicable models. However, when provision is made for utilizing data in a variety of forms, it becomes possible to describe MEG's which are reasonable based on at least some of the selected criteria. As a result of this adaptability, the methodology provides a practical, workable system for determining goals in an ever increasing percentage of cases. Of the 216 substances addressed, only 6 emerge with no numerical MEG values, providing a good indication that the methodology is sufficiently broad in its bases to provide the comparison criteria needed for environmental assessment.

Six samples taken from the MEG's compilations follow the text.

TABLE 2

DERIVATION OF HEALTH BASED EPC's

Data	Interrelationship	Specific EPC Derived
TLV or NIOSH Recommendation (occupational exposure)		EPC_{AH1}, EPC_{AC1}
LD_{50}, LD_{Lo}	$TLV \propto LD_{50}$*	EPC_{AH2}
Bioassay data (carcinogen testing)		EPC_{AC2}
Bioassay data (teratogen testing)		EPC_{AT}
	$EPC_{WH} \propto EPC_{AH}$**	EPC_{WH1}
LD_{50}		EPC_{WH2}
	$EPC_{WC} \propto EPC_{AC}$**	EPC_{WC}
	$EPC_{WT} \propto EPC_{AT}$**	EPC_{WT}
	$EPC_{LH} \propto EPC_{WH}$	EPC_{LH}
	$EPC_{LC} \propto EPC_{WC}$	EPC_{LC}
	$EPC_{LT} \propto EPC_{WT}$	EPC_{LT}

* Relationship established by Handy and Schindler.[6]
** Relationship suggested by Stokinger and Woodward.[7]

Subscript Key: A (air); W (water); L (land); H (health effects); C (carcinogenicity); T (teratogenicity); numbers refer to specific models.

TABLE 3

DERIVATION OF ECOLOGY BASED EPC's

Data	Interrelationship	Specific EPC Derived
Air concentration causing an effect in vegetation		EPC_{AE}
LC_{50} or TLm		EPC_{WE1}
Tainting Level		EPC_{WE2}
Cumulative Potential		EPC_{WE3}
Application Factor*		EPC_{WE4}
Hazard Level*		EPC_{WE4}
	$EPC_{LE} \propto EPC_{WE}$	EPC_{LE}

* Value supplied in Water Quality Criteria

Subscript Key: A (air); W (water); L (land); E (ecological effects); numbers refer to specific models.

CONCLUSIONS

The MEG's project represents an important step in EPA's efforts to systematically address a multiplicity of chemical substances for the purpose of establishing priorities in environmental assessment programs. MEG's provide a ranking system furnishing the decision criteria needed in source assessment. The MEG's may also be used for establishing priorities among the pollutants to be ultimately addressed by regulations, and thus, may influence control technology development in the future. In every case care has been taken to arrive at conservative but reasonable figures based upon the array of possible options supplied by the methodology.

It is expected that this initial work addressing Multimedia Environmental Goals will provide a springboard for further research in developing MEG's and that it will stimulate exploration into more sophisticated approaches that make use of empirical data evolving from research efforts currently in progress.

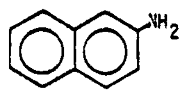
REFERENCES

1. Environmental Protection Agency. Quality Criteria for Water. EPA 440/9/76-023 (1976).
2. Environmental Protection Agency. Standards of Performance for New Stationary Sources, Title 40 Code Federal Regulations Part 60.
3. Herbert E. Stokinger. Concepts of Thresholds in Standards Setting. Arch Environ Health, 25 (Sept. 1972), 153.
4. Environmental Protection Agency. National Hazardous Emissions Standards for Hazardous Air Pollutants. Federal Register, 36, 234, (Dec. 7, 1971), 23239.
5. American Conference of Governmental Industrial Hygienists. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1976. American Conference of Governmental Hygienists, Cincinnati, Ohio (1976).
6. R. Handy and A. Schindler. Estimation of Permissible Concentration of Pollutants for Continuous Exposure. Prepared by Research Triangle Institute under Contract 68-02-1325 for Environmental Protection Agency Research Triangle Park, N.C. EPA-600 12-76-155 (1976).
7. Herbert E. Stokinger and Richard L. Woodward. Toxicologic Methods for Establishing Drinking Water Standards. Journal of American Water Works Association, 515 (1958), 515.

CATEGORY: 10C

WLN: L66J CZ

STRUCTURE:



2-AMINONAPHTHALENE: $C_{10}H_9N$ (2-naphthylamine, β-naphthylamine).

White crystals that darken on exposure to light and air; volatile with steam.

PROPERTIES:

Molecular wt: 143.19; mp: 113; bp: 306; d: 1.0614_4^{98}; vap. press.: 1 mm at 108° C; volatile in steam; slightly soluble in cold water.

NATURAL OCCURRENCE, CHARACTERISTICS, ASSOCIATED COMPOUNDS:

2-Naphthylamine does not occur as such in nature, but is formed by the pyrolisis of nitrogen-containing organic matter. It has been isolated from coal-tar (ref. 44). It has, in general, the characteristics of primary aromatic amines. It is a weak base.

TOXIC PROPERTIES, HEALTH EFFECTS:

Epidemiological studies have shown that occupational exposure to 2-aminonaphthalene is strongly associated with the occurrence of bladder cancer. There is no doubt that the compound is a human bladder carcinogen (ref. 44). 2-Aminonaphthalene is also reported to cause cancer in several animal species.

The EPA/NIOSH ordering number is 7628. The lowest dose to induce a carcinogenic response is reported as 18 mg/kg. The adjusted ordering number is 423.8.

LD_{50} (oral, rat): 727 mg/kg.

Aquatic toxicity: TLm 96: 10-1 ppm (ref. 2).

REGULATORY ACTIONS, STANDARDS, CRITERIA, RECOGNITION, CANDIDATE STATUS FOR SPECIFIC REGULATION:

2-Aminonaphthalene is recognized by ACGIH as a carcinogenic agent in humans. No TLV has been assigned.

β-Naphthylamine was the subject of a NIOSH Hazard Review Document (ref. 43).

OSHA standards dealing with exposure of employees to 2-naphthylamine has been established taking into consideration substantial evidence that 2-naphthylamine is known to cause cancer (ref. 17).

MINIMUM ACUTE TOXICITY CONCENTRATIONS:

Air, Health: $7 \times 10^4/423.8 = 165$ ug/m^3

Water, Health: $15 \times 165 = 2.5 \times 10^3$ μg/ℓ

Land, Health: $0.002 \times 2.5 \times 10^3 = 5$ μg/g

Air, Ecology:

Water, Ecology: $100 \times 1 = 100$ μg/ℓ

Land, Ecology: $0.002 \times 100 = 0.2$ μg/g

ESTIMATED PERMISSIBLE CONCENTRATIONS:

$EPC_{AH2} = 0.107 \times 727 = 78$ μg/m^3

$EPC_{AH3} = 0.081 \times 727 = 59$ μg/m^3

$EPC_{WH1} = 15 \times 59 = 3{,}500$ μg/ℓ

$EPC_{WH2} = 0.4 \times 727 = 291$ μg/ℓ

$EPC_{LH} = 0.002 \times 291 = 0.6$ μg/g

$EPC_{AC2} = 10^3/(6 \times 423.8) = 0.4$ μg/m^3

$EPC_{WC} = 15 \times 0.4 = 6$ μg/ℓ

$EPC_{LC} = 0.002 \times 6 = 0.012$ μg/g

$EPC_{WE1} = 50 \times 1 = 50$ μg/ℓ

$EPC_{LE} = 0.002 \times 50 = 0.1$ μg/g

X
10C
2-AMINONAPHTHALENE

EMISSION LEVEL GOALS							
	I. Based on Best Technology		II. Based on Ambient Factors				
	A. Existing Standards	B. Developing Technology	A. Minimum Acute Toxicity Effluent		B. Ambient Level Goal*		C. Elimination of Discharge
	NSPS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background*
Air, μg/m^3 (ppm Vol)			1.65E2		0.4		
Water, μg/l (ppm Wt)			2.5E3	1.0E2	6	50	
Land, μg/g (ppm Wt)			5.0E0	2.0E-1	0.012	0.1	

*To be multiplied by dilution factor

AMBIENT LEVEL GOALS					
	I. Current or Proposed Ambient Standards or Criteria		II. Toxicity Based Estimated Permissible Concentration		III. Zero Threshold Pollutants Estimated Permissible Concentration
	A. Based on Health Effects	B. Based on Ecological Effects	A. Based on Health Effects	B. Based on Ecological Effects	Based on Health Effects
Air, μg/m^3 (ppm Vol)			59		0.4
Water, μg/l (ppm Wt)			291	50	6
Land, μg/g (ppm Wt)			0.6	0.1	0.012

CATEGORY: 18A

WLN:

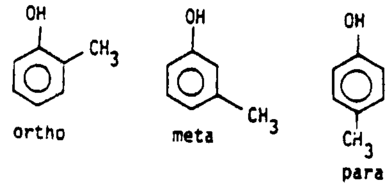
CRESOLS: $C_6H_4OHCH_3$ (cresylic acid, methylphenol, hydroxytoluene).

m-cresol: colorless or yellowish liquid, phenolic odor;

o-cresol: crystals or liquid, phenolic odor;

p-cresol: crystals, phenolic odor.

STRUCTURE:



PROPERTIES:

Molecular wt: 108.37; density$^{4}_{20}$: 1.034-1.047; vap. d: 3.72; soluble in water.

	mp	bp	vap. press.
m-cresol	11	202	0.153 mm at 25°C
o-cresol	30	191	0.245 mm at 25°C
p-cresol	35.5	201.8	0.108 mm at 25°C

NATURAL OCCURRENCE, CHARACTERISTICS, ASSOCIATED COMPOUNDS:

Cresols are methyl-substituted hydroxy benzene compounds, i.e. methyl phenols. Ortho, meta and para compounds occur. The meta isomer predominates in mixtures (ref. 24)

Odor recognition level for cresols ranges from 0.9 to 1.21 mg/m^3 or 0.20 to 0.27 ppm (ref. 3).

The odor threshold in air for p-cresol is reported as 0.001 ppm or 4 μg/m^3 (ref. 29).

Cresols are obtained from coal tar (ref. 24). Due to the low vapor pressure and disagreeable odor, cresols usually do not present an acute inhalation hazard (ref. 63).

Cresols are highly resistant to biological oxidation (ref. 67).

TOXIC PROPERTIES, HEALTH EFFECTS:

Toxic properties of cresols are similar to those of phenol. Cresols may be absorbed through the skin. Respiratory hazard is low because of low volatility. Absorption may cause damage to liver, kidney and nervous system (ref. 9). Order of toxicity beginning with most toxic is reported to be as follows: p-cresol; o-cresol; phenol; m-cresol (ref. 4)

	LD_{50} (oral, rat)
m-cresol	242 mg/kg
o-cresol	121 mg/kg
p-cresol	207 mg/kg

Toxicity to aquatic life: tainting of fish may result from concentrations of 0.07 mg/ℓ of mixed cresol isomers (ref. 28). The toxic concentration of p-cresol is 5 ppm for rainbow trout (ref. 36). The 96-hour LC_{50} for p-cresol is reported as 19 mg/ℓ (ref. 68). For mixed cresol isomers, the 96-hour TLm is reported as 10-1 ppm (ref. 2).

REGULATORY ACTIONS, STANDARDS, CRITERIA, RECOGNITION, CANDIDATE STATUS FOR SPECIFIC REGULATION:

TLV for Cresol (all isomers): 22 mg/m^3 (5 ppm).

EPA 1976 Water Quality Criteria (proposed): 1 μg/ℓ of phenol (including phenolic compounds) for domestic water supply (welfare) and to protect against fish flesh tainting (ref. 33).

NAS/NAE 1972 Water Quality Criteria: 1 μg/ℓ of phenolic compounds in public water supply sources to prevent odor from chlorinated phenols. To prevent tainting and toxic effects in aquatic life: Concentration no greater than 100 μg/ℓ at any time or place; application factor of 0.05 (for phenols) (ref. 28).

U.S. Public Health Service Drinking Water Regulations, 1962--Levels for alternate source selection: 1 μg/ℓ (for phenols) (ref. 65).

MINIMUM ACUTE TOXICITY CONCENTRATIONS:

Air, Health: 2.2 x 10^4 μg/m^3 (5 ppm)

Water, Health: 5 x 1 = 5 μg/ℓ

Land, Health: 0.002 x 5 = 0.01 μg/g

Air, Ecology:

Water, Ecology: 100 x 5 = 500 μg/ℓ

Land, Ecology: 0.002 x 500 = 1 μg/g

ESTIMATED PERMISSIBLE CONCENTRATIONS:

EPC_{AH1} = 10^3 x 22/420 = 52 μg/m^3

EPC_{AH1a} = 5/420 = 0.01ppm

EPC_{WH1} = 15 x 52 = 780 μg/ℓ

EPC_{WH2} = 13.8 x 22 = 304 μg/ℓ

EPC_{WHS} = 1 μg/ℓ (phenolic compounds)

EPC_{LH} = 0.002 x 1 = 0.002 μg/g

EPC_{WE1} = 50 x 1 = 50 μg/ℓ

EPC_{WE2} = 70 μg/ℓ

EPC_{WES} = 100 μg/ℓ (phenolic compounds)

EPC_{LE} = 0.002 x 50 = 0.1 μg/g

MULTIMEDIA ENVIRONMENTAL GOALS

18A
CRESOLS

EMISSION LEVEL GOALS							
	I. Based on Best Technology		II. Based on Ambient Factors				
	A. Existing Standards	B. Developing Technology	A. Minimum Acute Toxicity Effluent		B. Ambient Level Goal*		C. Elimination of Discharge
	NSPS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background*
Air, μg/m³ (ppm Vol)			2.2E4		52 (0.01)		
Water, μg/l (ppm Wt)			5.0E0	5.0E2	1	70	
Land, μg/g (ppm Wt)			1.0E-2	1.0E0	0.002	0.1	

*To be multiplied by dilution factor

AMBIENT LEVEL GOALS					
	I. Current or Proposed Ambient Standards or Criteria		II. Toxicity Based Estimated Permissible Concentration		III. Zero Threshold Pollutants Estimated Permissible Concentration
	A. Based on Health Effects	B. Based on Ecological Effects	A. Based on Health Effects	B. Based on Ecological Effects	Based on Health Effects
Air, μg/m³ (ppm Vol)			52 (0.01)		
Water, μg/l (ppm Wt)	1†	100†	304	50	
Land, μg/g (ppm Wt)			0.002	0.1	

†Phenolic compounds.

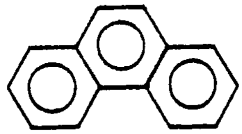
CATEGORY: 21

WLN: LB666J

PHENANTHRENE: $C_{14}H_{10}$.

Monoclinic crystals from alcohol; solutions exhibit faint blue fluorescence.

STRUCTURE:



PROPERTIES:

Molecular wt: 178; mp: 101; bp: 340; d: 0.9800^4; vap. press.: 1 mm at 118.3; vap. d: 6.14; insoluble in water; solubility may be enhanced by surfactant impurities in water (ref. 58); lipid solubility: 2 percent solution in olive oil (ref. 72).

NATURAL OCCURRENCE, CHARACTERISTICS, ASSOCIATED COMPOUNDS:

Phenanthrene is among the lower molecular weight polycyclic hydrocarbons comprising the volatile portion of the benzene-soluble fraction of coal tar (ref. 4). Concentrations of 0.6102 μg/1,500 m^3 and 6 μg/1,000 m^3 in urban air are reported (ref. 1). This is equivalent to 0.0004 to 0.006 μg/m^3. Phenanthrene is associated with particulate polycyclic aromatic hydrocarbons, PPAH, (ref. 71). The following concentrations of PPAH have been estimated or reported: Air (urban environment in winter in seven selected U.S. cities): 21.6 ng/m^3 - 146 ng/m^3 (ref. 71); groundwater and surface-treated water: 0.001 μg/ℓ - 0.025 μg/ℓ (ref. AAS); upper layer of Earth's crust: 100 μg/kg - 1,000 μg/kg (ref. 58).

TOXIC PROPERTIES, HEALTH EFFECTS:

LD_{50} (oral, mouse): 700 mg/kg.

Phenanthrene may be present in soot, coal tar, and pitch, which are known to be carcinogenic to man. Carcinogenic polycyclic aromatic hydrocarbons may induce tumors at the site of application (ref. 59). Phenanthrene is included in the NIOSH Suspected Carcinogens List. The EPA/NIOSH ordering number is 3121. The lowest dose to induce an oncogenic response is reported as 71 mg/kg. The adjusted ordering number is 44.

REGULATORY ACTIONS, STANDARDS, CRITERIA, RECOGNITION, CANDIDATE STATUS FOR SPECIFIC REGULATION:

Phenanthrene appears on EPA Consent Decree List with an assigned priority of 1.

TLV (coal-tar pitch volatiles): 0.2 mg/m^3. [The specification includes naphthalene, anthracene, acridine, phenanthrene, and fluorene, collectively. The purpose of the TLV is to minimize concentrations of higher weight polycyclic hydrocarbons which are carcinogenic (ref. 4)].

MINIMUM ACUTE TOXICITY CONCENTRATIONS:

Air, Health: $7 \times 10^4/44 = 1.59 \times 10^3$ μg/m^3

Water, Health: $15 \times 1.59 \times 10^3 = 2.39 \times 10^4$ μg/ℓ

Land, Health: $0.002 \times 2.39 \times 10^4 = 47.8$ μg/g

Air, Ecology:

Water, Ecology:

Land, Ecology:

ESTIMATED PERMISSIBLE CONCENTRATIONS:

$EPC_{AH2} = 0.107 \times 700 = 75$ μg/m^3

$EPC_{AH3} = 0.081 \times 700 = 57$ μg/m^3

$EPC_{WH1} = 15 \times 57 = 855$ μg/ℓ

$EPC_{WH2} = 0.4 \times 700 = 280$ μg/ℓ

$EPC_{LH} = 0.002 \times 280 = 0.56$ μg/g

$EPC_{AC2} = 10^3/(6 \times 44) = 3.8$ μg/m^3

$EPC_{WC} = 15 \times 3.8 = 57$ μg/ℓ

$EPC_{LC} = 0.002 \times 57 = 0.114$ μg/g

EMISSION LEVEL GOALS							
	I. Based on Best Technology		II. Based on Ambient Factors				
	A. Existing Standards	B. Developing Technology	A. Minimum Acute Toxicity Effluent		B. Ambient Level Goal*		C. Elimination of Discharge
	NSPS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background*
Air, μg/m³ (ppm Vol)			1.59E3		3.8		
Water, μg/l (ppm Wt)			2.39E4		57		
Land, μg/g (ppm Wt)			4.8E1		0.114		

*To be multiplied by dilution factor

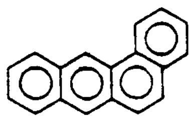
AMBIENT LEVEL GOALS					
	I. Current or Proposed Ambient Standards or Criteria		II. Toxicity Based Estimated Permissible Concentration		III. Zero Threshold Pollutants Estimated Permissible Concentration
	A. Based on Health Effects	B. Based on Ecological Effects	A. Based on Health Effects	B. Based on Ecological Effects	Based on Health Effects
Air, μg/m³ (ppm Vol)			57		3.8
Water, μg/l (ppm Wt)			280		57
Land, μg/g (ppm Wt)			0.56		0.114

CATEGORY: 21

WLN: L D6 B666J

BENZ(a)ANTHRACENE: $C_{18}H_{12}$ (benzo(b)phenanthrene, 1,2-benzanthracene, 2,3-benzophenanthrene, BA). Crystallizes in the form of plates from ethanol. Solutions exhibit greenish-yellow fluorescence.

STRUCTURE:



PROPERTIES:

Molecular wt.: 228.28; mp: 158-9; bp: 400° C; sublimes; insoluble in water; solubility may be enhanced by surfactant impurities in water (ref. 58); lipid solubility: 0.6 mg/0.2 ml neutral, sterile olive oil (ref. 72).

NATURAL OCCURRENCE, CHARACTERISTICS, ASSOCIATED COMPOUNDS:

Benz(a)anthracene occurs in coal tar and is associated with particulate polycyclic aromatic hydrocarbons, PPAH. The lowest urban air concentration reported for benz(a)anthracene is 44.69 $\mu g/m^3$ (ref. 1). This is equivalent to 0.029 $\mu g/m^3$.

Concentrations of BA in soils (nonindustrial areas) ranging from 5-20 ug/kg have been reported (ref. 73).

Other concentrations of BA are reported as follows: (a) drinking water - 23.2 $\mu g/m^3$; (b) cooked meat or fish - 189 μg/kg; (c) vegetables - 230 μg/kg; (d) roasted coffee - 14.2 μg/kg (ref. 73).

TOXIC PROPERTIES, HEALTH EFFECTS:

LD_{Lo} (intravenous, mouse): 10 mg/kg.

Benz(a)anthracene may be present in soot, coal tar, and pitch, which are known to be carcinogenic to man. Carcinogenic polycyclic aromatic hydrocarbons may induce tumors at the site of application (ref. 59). Benz(a)anthracene is included in the NIOSH Suspected Carcinogens List. The EPA/NIOSH ordering number is 3124. The lowest dose to induce a carcinogenic response is reported as 2 mg/kg. The adjusted ordering number is 1562.

REGULATORY ACTIONS, STANDARDS, CRITERIA, RECOGNITION, CANDIDATE STATUS FOR SPECIFIC REGULATION:

TLV = 0.2 mg/m^3 [for particulate polycyclic aromatic hydrocarbons (PPAH). This TLV recognizes the carcinogenic potential of PPAH collectively].

Benz(a)anthracene appears on the EPA Consent Decree List with an assigned priority of 1.

MINIMUM ACUTE TOXICITY CONCENTRATIONS:

Air, Health: $7 \times 10^4/1{,}562 = 44.8\ \mu g/m^3$

Water, Health: $15 \times 44.8 = 672\ \mu g/\ell$

Land, Health: $0.002 \times 672 = 1.34\ \mu g/g$

Air, Ecology:

Water, Ecology:

Land, Ecology:

ESTIMATED PERMISSIBLE CONCENTRATIONS:

$EPC_{AH2} = 0.107 \times 10 = 1.07\ \mu g/m^3$

$EPC_{AH3} = 0.081 \times 10 = 0.81\ \mu g/m^3$

$EPC_{WH1} = 15 \times 0.81 = 12.2\ \mu g/\ell$

$EPC_{WH2} = 0.4 \times 10 = 4.0\ \mu g/\ell$

$EPC_{LH} = 0.002 \times 4 = 0.008\ \mu g/g$

$EPC_{AC2} = 10^3/(6 \times 1{,}562) = 0.11\ \mu g/m^3$

$EPC_{WC} = 15 \times 0.11 = 1.65\ \mu g/\ell$

$EPC_{LC} = 0.002 \times 1.65 = 0.003\ \mu g/g$

EMISSION LEVEL GOALS

	I. Based on Best Technology		II. Based on Ambient Factors				
	A. Existing Standards	B. Developing Technology	A. Minimum Acute Toxicity Effluent		B. Ambient Level Goal*		C. Elimination of Discharge
	NSPS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background*
Air, μg/m³ (ppm Vol)			4.5E1		0.11		0.029†
Water, μg/l (ppm Wt)			6.7E2		1.65		0.023‡
Land, μg/g (ppm Wt)			1.3E0		0.003		0.02

*To be multiplied by dilution factor

AMBIENT LEVEL GOALS

	I. Current or Proposed Ambient Standards or Criteria		II. Toxicity Based Estimated Permissible Concentration		III. Zero Threshold Pollutants Estimated Permissible Concentration
	A. Based on Health Effects	B. Based on Ecological Effects	A. Based on Health Effects	B. Based on Ecological Effects	Based on Health Effects
Air, μg/m³ (ppm Vol)			0.81		0.11
Water, μg/l (ppm Wt)			4.0		1.65
Land, μg/g (ppm Wt)			0.008		0.003

†Reported for urban air. No rural concentration is reported.

‡Drinking water.

CATEGORY: 54

WLN: H2 SE

HYDROGEN SELENIDE: H_2Se (selenium hydride).

Colorless poisonous gas; disagreeable odor of decayed horseradish.

STRUCTURE:

H_2Se

PROPERTIES:

Molecular wt: 80.98; mp: -60.4; bp: -41.5; gas density: 3.664^{760} (air); vap. press: 10 atm at 23.4° C; solubility (in water: 270 mℓ/100 mℓ at 22.5°.

NATURAL OCCURRENCE, CHARACTERISTICS, ASSOCIATED COMPOUNDS:

Hydrogen selenide is formed by the action of dilute acids on metallic selenides. Selenium will combine directly with hydrogen at temperatures below 250° C to form H_2Se. Hydrogen selenide unites directly with most metals to form metal selenides. The odor recognition level for hydrogen selenide is 1.00 mg/m^3 (ref. 3). Hydrogen selenide gas is important as an air contaminant. Because the gas is highly soluble in water, it is also a potential water contaminant.

TOXIC PROPERTIES, HEALTH EFFECTS:

Systemic poisoning as well as pulmonary irritation may result from exposure to hydrogen selenide. Liver damage is reported from exposed experimental animals (ref. 4). It is generally considered to be more toxic than elemental selenium. The lowest toxic dose affecting the central nervous system of a human is 0.2 ppm. See also Selenium and Selenium Compounds.

LC_{50} (inhalation, guinea pig): 1 mg/m^3/8 hr.

REGULATORY ACTIONS, STANDARDS, CRITERIA, RECOGNITION, CANDIDATE STATUS FOR SPECIFIC REGULATION:

TLV = 0.2 mg/m^3 (0.05 ppm).

Standards and criteria applicable to selenium compounds include the following:

Selenium is a candidate for the list for Toxic Pollutant Effluent Standards (ref. 10). It is included in the EPA Consent Decree List, Priority III.

National Interim Primary Drinking Water Standards: 0.01 mg/ℓ, as Se (ref. 102).

U.S. Public Health Service Drinking Water Standards, Levels for Source Rejection: 0.01 mg/ℓ, as Se (ref. 66).

EPA 1976 Water Quality Criteria (proposed): For domestic water supply (health)--10 μg/ℓ; for marine and freshwater aquatic life--application factor: 0.01 (to be applied to 96-hr LC_{50}) (ref. 33).

NAS/NAE Water Quality Criteria, 1972: For public water supply sources--0.01 mg/ℓ for marine aquatic life: hazard level--0.01 mg/ℓ; minimal risk of deleterious effects--0.005 mg/ℓ; application factor--0.01 (to be applied to the 96-hr LC_{50}); for livestock--0.05 mg/ℓ; for irrigation--0.02 mg/ℓ for continuous use on all soils (ref. 28).

MINIMUM ACUTE TOXICITY CONCENTRATIONS:

Air, Health: 200 $\mu g/m^3$ (0.05 ppm)

Water, Health: 5 x 10 = 50 μg/ℓ, as Se

Land, Health: 0.002 x 50 = 0.1 μg/g, as Se

Air, Ecology:

Water, Ecology: 5 x 5 = 25 μg/ℓ, as Se

Land, Ecology: 0.002 x 25 = 0.05 μg/g, as Se

ESTIMATED PERMISSIBLE CONCENTRATIONS:

$EPC_{AH1} = 10^3 \times 0.2/420 = 0.5\ \mu g/m^3$

$EPC_{AH1a} = 0.05/420 = 0.0001$ ppm

$EPC_{WH1} = 15 \times 0.5 = 7.5$ μg/ℓ

$EPC_{WH2} = 13.8 \times 0.2 = 2.8$ μg/ℓ

$EPC_{WHS} = 10$ μg/ℓ

$EPC_{LH} = 0.002 \times 10 = 0.02$ μg/g

$EPC_{WES} = 5$ μg/ℓ

$EPC_{LE} = 0.002 \times 5 = 0.01$ μg/g

EMISSION LEVEL GOALS

	I. Based on Best Technology		II. Based on Ambient Factors				
	A. Existing Standards	B. Developing Technology	A. Minimum Acute Toxicity Effluent		B. Ambient Level Goal*		C. Elimination of Discharge
	NSPS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background*
Air, µg/m³ (ppm Vol)			2.0E2 (0.05)		0.5 (0.0001)		
Water, µg/l (ppm Wt)			5.0E1	2.5E1	10	5	
Land, µg/g (ppm Wt)			1.0E-1	5.0E-2	0.02	0.01	

*To be multiplied by dilution factor

AMBIENT LEVEL GOALS

	I. Current or Proposed Ambient Standards or Criteria		II. Toxicity Based Estimated Permissible Concentration		III. Zero Threshold Pollutants Estimated Permissible Concentration
	A. Based on Health Effects	B. Based on Ecological Effects	A. Based on Health Effects	B. Based on Ecological Effects	Based on Health Effects
Air, µg/m³ (ppm Vol)			0.5 (0.0001)		
Water, µg/l (ppm Wt)	10	5			
Land, µg/g (ppm Wt)			0.02	0.01	

CATEGORY: 78

WLN: CU

COPPER AND COPPER COMPOUNDS (AS COPPER), Cu (cuprum):

An orange, ductile, malleable metal.

STRUCTURE:

Cu Cu^{+} Cu^{+2}

PROPERTIES: Atomic number: 29; group 1b; atomic wt: 63.546; mp: 1,083 ± 0.1; bp: 2336; d: 8.92; insoluble; vap. press: 1 mm at 1628°C.

NATURAL OCCURRENCE, CHARACTERISTICS, ASSOCIATED COMPOUNDS:

Copper forms two series of compounds, cuprous (Cu^{+1}) and cupric (Cu^{+2}). Cupric compounds are the more stable. They ionize in aqueous solution.

Rural background concentration in air is reported as 0.01 to 0.41 μg/m^3 (ref. 1). Another source reports concentrations ranging from 0.06 to 0.078 as a constituent of suspended particulates in non-urban air (ref. 3). Copper salts are in the form of dusts and mists: metallic copper may occur as fume (ref. 4).

Concentration in freshwater as indicated from hydrologic benchmark samples ranges from zero to 40 μg/ℓ; out of 126 samples 87 were zero (ref. 64). Another report indicates that the average freshwater copper concentration in U. S. surface water is 13.8 μg/ℓ with a range of 0.8-280 μg/ℓ (ref. 28). Natural concentration in seawater is reported as 0.001 mg/ℓ (ref. 28) to 0.02 mg/ℓ (ref. 24). Copper imparts a taste to water in concentrations as low as 1 mg/ℓ (ref. 33). Occurrence in earth's crust is 70 ppm (ref. 24). Copper is found in soils at about 20 μg/g (ref. 128).

Copper is an essential element in plants and animals; adult intake of copper is from 2 to 2.5 mg daily (ref. 4).

TOXIC PROPERTIES, HEALTH EFFECTS:

Copper in the form of salts may cause irritation to the gastrointestinal tract if ingested; chronic exposure may result in anemia. Exposure to metallic copper fume may cause respiratory irritation, and eye and skin irritations. Damage to the liver, kidneys, and nervous system may result from exposure to copper (ref. 4,9).

LD_{50} (intraperitoneal, mouse): 3500 μg/ℓ.

LD_{50} (oral, rat): 140 mg/kg for $CuCl_2$; this is equivalent to 66 mg/kg as Cu^{+2}.

Aquatic toxicity: Copper has a synergistic action with zinc, cadmium, and mercury. Concentration of calcium and magnesium influence the toxicity of copper.

The 96 hr LC_{50} for Piephales promelas (fathead minnow) is 0.05 ppm for $CuSO_4$ in soft water, 1.4 ppm in hard water (ref. 28). Copper inhibits photosynthesis of giant kelp, at 0.06 mg/ℓ and it is toxic to oysters at 0.1 mg/ℓ (ref. 28). It has a concentration factor of 30,000 in marine phytoplankton, and 1,000 in marine fish (ref. 28).

Phytotoxicity: Copper concentrations of 0.1 to 1.0 mg/ℓ in nutrient solutions are toxic to a number of plants (ref. 28).

REGULATORY ACTIONS, STANDARDS, CRITERIA, RECOGNITION, CANDIDATE STATUS FOR SPECIFIC REGULATION:

TLV (metallic copper fume): 0.2 mg/m^3.

TLV (dusts and mists): 1 mg/m^3.

Copper is included on EPA Consent Decree Priority III List.

U.S. Public Health Service Drinking Water Regulations, 1962, Levels for Alternate Source Selection: 1.0 mg/ℓ (ref. 66).

EPA 1976 Water Quality Criteria (proposed): For domestic water supplies (welfare): 1.0 mg/ℓ; for freshwater and marine aquatic life: application factor--0.1 (to be applied to 96-hour LC_{50}, nonaerated bioassay)(ref. 33).

NAS/NAE 1972 Water Quality Criteria: For public water supply sources: 1 mg/ℓ; for freshwater aquatic life: application factor--0.1 (to be applied to 96-hour LC_{50}); for marine aquatic life: hazard level--0.05 mg/ℓ; minimal risk of deleterious effects--0.01 mg/ℓ; application factor--0.01 (to be applied to 96-hour LC_{50}); for livestock: 0.5 mg/ℓ; for irrigation: 0.20 mg/ℓ for continuous use on all soils (ref. 28).

Recommendation of U. S. Department of Agriculture and Land Grant Institutions: Copper concentration for most soils--250 kg/hectare (ref. 112).

MINIMUM ACUTE TOXICITY CONCENTRATIONS:

Air, Health: 200 μg/m^3

Water, Health: 5 x 1000 = 5,000 μg/ℓ

Land, Health: 0.002 x 5,000 = 10 μg/g

Air, Ecology:

Water, Health: 5 x 10 = 50 μg/ℓ

Land, Ecology: 0.002 x 50 = 0.1 μg/g

ESTIMATED PERMISSIBLE CONCENTRATIONS:

$EPC_{AH1} = 10^3 \times 0.2/420 = 0.5$ μg/m^3

$EPC_{WH1} = 15 \times 0.5 = 7.5$ μg/ℓ

$EPC_{WH2} = 13.8 \times 0.2 = 3$ μg/ℓ

$EPC_{WHS} = 1,000$ μg/ℓ

$EPC_{LH} = 0.002 \times 1000 = 2$ μg/g

$EPC_{WES} = 10$ μg/ℓ

$EPC_{LE} = 0.002 \times 10 = 0.2$ μg/g

EMISSION LEVEL GOALS							
	I. Based on Best Technology		II. Based on Ambient Factors				
	A. Existing Standards	B. Developing Technology	A. Minimum Acute Toxicity Effluent		B. Ambient Level Goal*		C. Elimination of Discharge
	NSFS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background*
Air, µg/m³ (ppm Vol)			2.0E2		0.5		0.01 to 0.41
Water, µg/l (ppm Wt)			5.0E3	5.0E1	1,000	10	13.8 1 to 20†
Land, µg/g (ppm Wt)			1.0E1	1.0E-1	2	0.2	20

*To be multiplied by dilution factor

AMBIENT LEVEL GOALS					
	I. Current or Proposed Ambient Standards or Criteria		II. Toxicity Based Estimated Permissible Concentration		III. Zero Threshold Pollutants Estimated Permissible Concentration
	A. Based on Health Effects	B. Based on Ecological Effects	A. Based on Health Effects	B. Based on Ecological Effects	Based on Health Effects
Air, µg/m³ (ppm Vol)			0.5		
Water, µg/l (ppm Wt)	1,000	10			
Land, µg/g (ppm Wt)			2	0.2	

†For seawater.