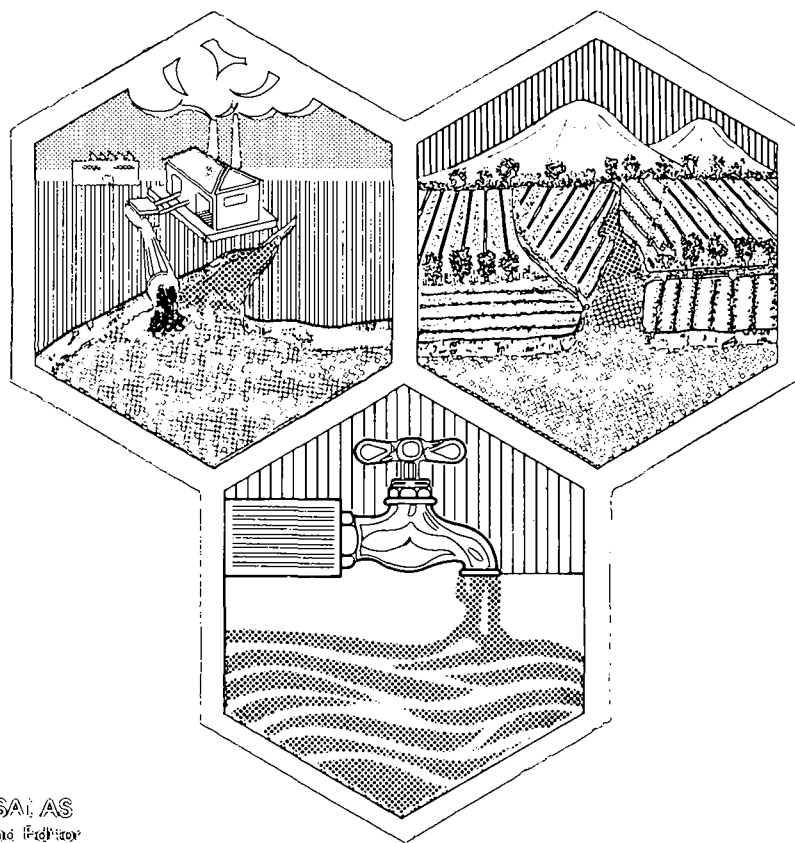




PAN AMERICAN CENTER FOR SANITARY ENGINEERING
AND ENVIRONMENTAL SCIENCES
(CEPIS)

MANUAL FOR THE EVALUATION AND MANAGEMENT OF TOXIC SUBSTANCES IN SURFACE WATERS

EXECUTIVE SUMMARY



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WORLD HEALTH ORGANIZATION
PAN AMERICAN HEALTH ORGANIZATION
Environmental Health Program



203.3-88 MA-3947

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ISN 7947
203.3 88MA

December 1988

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1. BACKGROUND

Without exception, the present world depends on chemical products to increase the production of foodstuffs, protect health and facilitate our daily lives. Also, the number of these substances that must be extracted and concentrated from natural materials or synthetic laboratory processes is increasing every day.

Many of these chemical products are hazardous and the direct or indirect health risks in their use, storage or disposal must be evaluated. Intentional or not, their discharge to the environment can cause serious consequences. When large quantities of these chemicals that did not exist in nature are generated or utilized, significant problems can result, especially when known physical or biological processes cannot be depended upon to degrade them to innocuous forms.

Obviously, the existence of human health risk or damage obliges the Pan American Health Organization (PAHO), through its Program of Environmental Health (HPE), to develop a course of action that benefits the countries of the Region. As a result, the Pan American Center for Sanitary Engineering and Environmental Sciences (CEPIS) has been given the mission to coordinate the Regional Project in Latin America and the Caribbean for the development and dissemination of methodologies and technology for the evaluation and management of toxic substances in surface waters, with special attention on those surface-water bodies which act as water supply sources.

The intention is not only to identify the principal potential problems of toxic substance pollution in the Region, but also those institutions with adequate infrastructure and sufficient human resources to absorb, apply and adapt the technologies in this area and disseminate them through the operation of a cooperative network. This network receives orientation and technical cooperation through the catalytic agent, CEPIS, with the support of: Manhattan College, Vanderbilt University (both of the United States) and the Bureau of Chemical Hazards, Health and Welfare of Canada; all of which are institutions of recognized prestige and experience in these areas. Also, the program relies on the contribution of analytical quality laboratory experts from Japan, through the Japan International Cooperation Agency (JICA) and the contribution of German specialists through the Deutsche Gesellschaft Für Technische Zusammenarbeit (GTZ) of the Federal Republic of Germany.

The goal is to increase the number of Latin American countries which have specific programs for the management of toxic substances as components of their national water quality pollution control programs. In addition, as a final product of this cooperative effort, it is intended that these countries reach self-sufficiency in the adequate evaluation of the fate of toxic substances in surface waters and the risks associated with these; and establish chemical discharge allocations that protect public health and reduce adverse ecological impacts.

The mechanism used to reach an harmonious work program is the Technical Nucleus, composed of experts from countries technically more advanced, and of professionals of Regional institutions with not only an awareness of the problems and national necessities, but also the technical and economic capacity to confront these problems. This Technical Nucleus provides knowledge (manuals and guides) and orientation in the establishment of general guidelines for the workplan of the Executive Nucleus which is principally responsible for the case studies.

This program was officially initiated with the convocation in January 1985, at CEPIS, of the Technical Nucleus, composed of Dr. Robert V. Thomann (toxic substance fate models), of Manhattan College and representatives of Argentina, Brazil, Cuba and Peru, as well as professionals of PAHO-HPE/CEPIS/ECO. The purpose of this meeting was to evaluate and formalize the program and the details of its execution.

Subsequently, three annual meetings of the Technical Nucleus were conducted:

- The Second Meeting in Sao Paulo, Brazil in march 1986, co-sponsored by the "Companhia de Tecnologia de Saneamento Basico de Sao Paulo" (CETESB),
- the Third Meeting at CEPIS, Lima, Peru, in march 1987,
- the Fourth Meeting at CEPIS, Lima, Peru, in march 1988.

In 1986 Dr. Roy Hickman, of Canada Health and Welfare (risk evaluation) and in 1987 Dr. Wesley Eckenfelder, of Vanderbilt University (industrial effluent treatment), were incorporated into the Technical Nucleus. Also, in 1986 representatives of Colombia, Chile and Mexico and in 1988 Ecuador and Venezuela were incorporated. The basic purposes of these meetings were to revise and discuss the progress of the program, the case studies and the drafts of this manual.

2. CASE STUDIES

Apart from the innovative approach of the Technical Nucleus that catalyzes existing knowledge in order to translate it into methodologies and technology, the opportunity is provided to test the viability of the manual through the application to case studies of problems representative of the Region that provide a scenario to ascertain the limitations and complexities and assure its adaptation to the socio-economic context of Latin America and the Caribbean. These case studies will be published independently upon their completion and incorporated into the manual as additional sections. The case studies already in execution or proposed are:

-
- ARGENTINA: The Negro River Basin. Provinces of Neuquén/Río Negro (INCYTH). Pesticide pollution (initiated in 1986).
 - BRAZIL: Paraíba do Sul River. States of Sao Paulo/Río de Janeiro (CETESB/FEEMA). Industrial and agricultural pollution (initiated in 1986).
 - COLOMBIA: Bogotá River and its tributaries in the vicinity of Bogotá (EAAB/CAR). Treatment criteria. Heavy metal and organic pollution (initiated in 1987).
 - CUBA: Sources of surface water supply in the industrial mining zone of Moa (MIN. OF HEALTH). Chromium, nickel and cobalt contamination (initiated in 1987).
 - ECUADOR: Esmeraldas or Guayas or Chona River (IEOS/EMAP-Q). Pesticide contamination (proposed).
 - MEXICO: Lerma-Chapala-Santiago System (SARH/SEDUE). Heavy metals and organic contamination (initiated in 1987).
 - PERU: Rímac River (CONAPMAS/MIN. OF HEALTH). Heavy metals pollution from mining industry (proposed).
 - VENEZUELA: Tuy River (MARNR co-sponsored by UNDP). Industrial and agricultural pollution (proposed).
-

A brief summary of the initial case studies follows.

2.1 The Negro River Basin, Argentina (Natale, et al., 1988)

The selection of this case study by Argentina was based on three primary factors: the multiple uses of the river (i.e., water supply - 400,000 inhabitants - irrigation, hydroelectric power generation), its socio-economic importance and possible pesticide contamination.

The principal economic activity of the basin is the production of fruits and green vegetables with 88% and 77% of the total national production of apples and pears, respectively.

The majority of the pesticides used are organic phosphorus compounds although there is some use of organochlorines. Irrigation with river water is done via canals which in turn serve to transport spent waters from the drainage systems back to the rivers. Direct surface runoff is minimal.

The general tasks and objectives of this case study are as follows:

- To determine the level of presence of pesticides in the aquatic environment.
- To forecast and hindcast the exposure to pesticides through the development of a fate and transport mathematical model.
- To assess the risk to the health of the human community and biota caused by the presence of water borne pesticides through the evaluation of toxic effects.
- To evaluate control engineering practices (agricultural, water treatment, management techniques) that might be effective for preserving the quality of the water of the Negro River for the foreseen uses.
- To develop water quality based-pesticides standards for the Negro River (Argentina) having as criteria basis the output of the previous tiers.

Although preliminary studies showed that the water concentrations of some organochlorine and organophosphorus pesticides were above international criteria for protection of aquatic life, surveys conducted as part of the case study indicate a no-risk situation. Further surveys, inclusive of the use of biomonitors, are planned.

2.2 Paraíba do Sul River, Brazil (Fonseca & Coelho, 1988; Agudo, 1988)

The Paraíba River case study encompasses the head waters of the river in Sao Paulo State up to the diversion of river water at Santa Cecilia to the Guandu River which serves as a water supply for the Greater Rio de Janeiro area (10'000,000 inhabitants).

The principal uses of the waters of Paraíba River are: domestic and industrial water supply, agricultural activities, electrical energy generation and the final disposal of waste waters. Other beneficial uses are: preservation of natural flora and fauna, navigation, secondary contact recreation, among others.

The drainage area of the river at its mouth is 53,400 km². The average flow of the study area is about 180 m³/sec.

Over the past 30 years, the river basin has had a considerable demographic expansion, associated with intensive and diversified industrial development, resulting in that the river water is subject to potential chemical contamination, among others.

Previous studies have indicated fish deformations in the Rio de Janeiro State stretch of the river. As such, it was selected as a case study to be executed in mutual collaboration between FEEMA and CETESB, with the basic

purposes of elaborating a diagnosis of the present chemical substance contamination situation and a control program.

Two focuses have been taken:

- Considering individual chemicals
- Considering total toxicity (river and effluents)

The data indicate low levels of heavy metals in the water column, although there may be accumulation in the sediments. Also, the acute toxicity in the river is low but there is evidence of chronic toxicity.

FEEMA has proposed a control plan which includes toxicity as a control parameter.

3. MANUAL

As the final product of a four-year effort this manual has been prepared with the objective of disseminating the proposed technology. This manual treats the toxic substance surface water problem in its different aspects. It will serve as a basic text for a series of courses concerning the subject, the first of which was conducted in March 1988 at CEPIS.

It is emphasized that the manual is intended to be a technological and management resource. However, in the final analysis, each country must decide on its own control and implementation strategies within its socio-economic context.

A brief description of the most important aspects of the sections of the manual follows:

3.1 Section 1 - Perspective

After a brief introduction, this section is initiated with the definitions of a toxic substance based on different points of view. Of these, a functional approach is adopted within the framework of the preservation and utilization of surface water bodies which is that a chemical substance becomes toxic when it is present in the aquatic environment (water column, sediment or aquatic organisms) in concentrations which interfere with the intended use of the water body because of its negative impact on human health or the aquatic ecosystem, as established by water quality standards. The most notorious substances are heavy metals, pesticides and a large quantity of organic substances of industrial origin.

Three pollutant priority lists are compared:

- Environmental Protection Agency of the United States (126 substances)
- The World Health Organization (88 substances)
- The International Commission for the Protection of the Rhine River (87 substances)

The differences among these are discussed and it is noted that each country should develop its own priority pollutant list inherent to its reality based on the lists of all the countries. Subsequently, the need to adopt a Regional list would be determined.

The reasons for the problems and severe limitations of the Latin American laboratories concerning the confiability of water quality data are discussed. The magnitude of the problem was made evident in the performance evaluation of 44 Regional national laboratories subscribed to the programs GEMS/WATER and PRELAB, in which 61% of the trace metal measurements were outside the acceptable limits of confiability. This study was executed in 1983.

Some problems inherent to the presence of toxic substances in surface water bodies are cited, based on a survey conducted by CEPIS through the PAHO Representations in the Region. This description, which is very preliminary, qualitative and limited to some notorious cases, is presented with the intention of only demonstrating that the problem already exists.

Also, a synopsis of control strategies for the discharge of wastes is presented. This subject is treated with more detail in Section 7.

3.2 Section 2 - Risk Assessment and Risk Management

The concept of risk and the distinction between the evaluation and management of risk are defined. The information concerning the toxic properties of a chemical is obtained through the following types of investigation:

1. Animal investigations
2. Controlled epidemiological investigations
3. Clinical studies or case reports of exposed humans

Available methodologies for the measurement of toxicity are presented.

The fundamental parameter of acceptable daily intake (ADI) is presented as well as the safety factors that are applied to this. A "multistage" model is presented, which is utilized by the Environmental Protection Agency of the United States (EPA) to describe the life time risk (i.e., the probability) of cancer for a given dose. This is simplified and an application is demonstrated. The concept of "acceptable risk" and the evaluation of exposure is discussed.

This section continues with the presentation of proposed EPA water quality criteria for carcinogens at a 10^{-6} risk level, that is, one additional case of cancer in a population of one million in one life span. The water concentrations listed are for the routes of water and food and food only of aquatic origin.

A table is presented of concentration values suggested as guidelines by the World Health Organization for water supply, as well as a table of foodstuff standards of aquatic origin used in the United States of America. These latter standards have been used as a base to certify when fish and shellfish may be purchased in the market place. In addition, water quality criteria applied in Canada are also presented.

The effects on the aquatic ecosystem are discussed, in which bioassay investigations and the concept of the toxic unit are addressed. Also, acute and chronic levels recommended by the EPA of 0.3 toxic units (maximum concentration criteria) and 1.0 toxic units (continuous concentration criteria), respectively, are presented.

A presentation of risk in the comparative context then follows, such as:

1. Comparison with natural "background" levels,
2. comparison with the risks of alternatives,
3. comparison with unrelated well known hazards,
4. comparison with benefits.

This section terminates with a discussion of the management of risk including a rapid evaluation. Also, the recent tendency and necessity for an integral risk management is emphasized, in which the contaminants in diverse media are evaluated in an integrated form.

3.3 Section 3 - Preliminary Rapid Evaluation

The basic components of a rapid preliminary evaluation with minimum technical details are presented, which consists of the following:

1. Chemical inputs
2. Nature of the water body/fate of chemical
3. Water quality criteria/guidelines/standards

The section discusses that toxics can be considered from the point of view of an individual chemical (i.e., specific chemicals such as lead, chlordanone or lindane) or from the point of view of total effluent toxicity. For the latter, the effluent toxic unit is utilized as the relevant substitute variable for control purposes. Relative advantages are presented for both approaches.

The evaluation of space and time scales is discussed. The spatial scales encompass from the local minimum that involves the local mixing zone to the maximum on a basin wide scale. The temporal scales for toxic problems extend over a very wide range. The short term scales of hour to hour and day to day observations are of importance for acute effects of the ecosystem and public health through high concentrations over short periods of time. The longer time scales of year to year, out to a decade and more, incorporate the potential chronic effects on the public health over standard life spans. The resulting complexities of extending both scales are presented.

Toxic discharges are separated into two major groups: a) point sources and b) non-point sources. Some compilations are provided of point source input concentrations and loads for several industrial categories and various municipal inputs. Non-point source from non-urban areas are discussed, such as: construction, agriculture, silviculture, sludge management (treatment plants), hydrological modifications and mining; as well as the available mathematical models that allow the estimation of these non-point sources. An applied example is presented. Non-point source urban inputs and atmospheric inputs are also discussed.

For most practical cases, the maximum concentration of a toxic discharge from a single point source will be at the outfall. As such, a first approximation would consist of the application of a simple dilution model and compare the results to the water quality guideline. Key aspects of such an application are discussed, such as the selection of the appropriate water quality guideline, the incorporation of chronic and acute considerations through the inclusion of aspects of exposure duration and the permitted exceedance frequency, and the selection of the flow for the dilution calculation. U.S. EPA suggestions are presented for criteria maximum concentration (CMC) for acute levels (one hour) and criteria continuous concentration (CCC) for chronic levels (four days) that should not be exceeded more than once in three years. The flow frequency and duration to be applied are also presented.

This section continues with a simplified evaluation to estimate the downstream fate of the chemical which is necessary under two situations: 1) there is a critical water use downstream, as for example, a water supply withdrawal, or 2) there are several inputs of the same chemical or toxicity along the length of the river and the total concentration or total toxicity must be estimated. This evaluation depends on the following: 1) the properties of the river, such as the depth, velocity and dilution downstream due to groundwater infiltration or tributary inflow, and 2) the physical, biological and chemical properties of the substance, such as volatilization, biodegradation or partitioning on to the solids, among others. For first approximations, it is estimated that the heavy metals, toxicity and organic chemicals with water solubility of less than 1 $\mu\text{g}/\text{l}$ can be considered as

conservative. For those non-conservative substances, preliminary guidelines are presented in order to approximate the loss rate. Also, guidelines to estimate the fraction of the chemical in the dissolved form are presented.

3.4 Section 4 - Toxic Substance Fate Models

In order to evaluate the effect of potentially toxic substances on a water supply or on the aquatic ecosystem, it is necessary to estimate or predict the concentration of the chemical at various locations in the water body and at various times. One of the means for calculating these concentrations is through the use of models of the fate of the chemical in the surface water body.

It is noted that chemical fate models are similar to other more classical water quality models that have been traditionally used for conventional pollutants such as: chlorides, biochemical oxygen demand and effects on dissolved oxygen. The principles of the traditional water quality models are reviewed, but the emphasis is on the additional mechanisms that need be recognized in toxic substance modeling. These additional mechanisms include:

1. Sorption and desorption of the chemical to and from particulate matter (inorganic and organic solids),
2. settling, resuspension, deposition and incorporation into the bottom sediments of the water body,
3. diffusion of the toxicant into or from the pore waters of the sediment,
4. atmospheric exchange between chemical in atmosphere and chemical in water,
5. loss of chemical due to:
 - a. microbial degradation
 - b. photosynthesis
 - c. hydrolysis
6. bioconcentration by aquatic organisms,
7. transfer of chemical up the food chain to upper trophic level aquatic foodstuffs (e.g., fish).

A detailed description is presented of the "partition coefficient" and its important role in defining in which medium (liquid or solid) the chemicals are concentrated. In addition, its measurement is discussed and values taken from the scientific literature are presented.

The octanol water partition coefficient is introduced for organic chemicals and that the sorption of these substances is a function of the weight fraction of organic carbon of the solids.

The chemical fate models are steady-state and the case of a completely mixed lake is first presented followed by river and estuary cases. After the detailed development of these models is presented, simplifications of the complex interaction among these are discussed through the calculation of the total chemical loss rate.

The section continues with the development of food chain models. The section is finalized with an example problem.

3.5 Section 5 - Guidance for Sampling, Monitoring and Data Analysis

The purpose of this section is to provide some overall guidance and direction for the sampling and monitoring of toxic substances in surface waters. There are essential considerations that govern the extension and magnitude of the sampling and monitoring effort that include: a) the nature of the problem context, b) the available financial resources, and c) the technical capacity of the available human resources.

The principal components of a sampling program are discussed as well as the forms of the chemicals and spatial and temporal considerations. The central point is the development of sampling and monitoring as support for toxic substance management programs. As such, the text does not present the details of the laboratory analysis for toxics, nor the recommended laboratory procedures.

The necessary information concerning the basic properties of the chemicals is defined and some sources of information are cited. A detailed description is given of various time and space scales and it is concluded, as a general guideline, that field surveys should be conducted on an intensive spatial scale and on an approximate bi-weekly or weekly basis, several times throughout the year. The seasonal survey periods should be conducted during periods of low flow and during periods of potential sediment scour, if the chemical partitions to the suspended solids.

It is noted that such a sampling program, where several intensive surveys are conducted throughout the year is preferred to a more spread out sampling program throughout the year with fewer stations. In order to fill in the temporal gap between the individual intensive surveys, several monitoring or index stations may be occupied on an approximately weekly basis throughout the year.

It is also noted that field placement of biomonitors such as fish or shellfish, will provide an integrated sample over a longer period of time (e.g., weeks) with substantially less effort than compositing of individual grab samples over the same period of time.

The section continues with the description of surveys of point and non-point inputs. The relation between concentration and flow that depends on three factors is discussed: 1) the type of input (point vs non-point input), 2) the extent to which the chemical adsorbs to solids, and 3) the presence in the water body of control structures, such as dams.

Methodologies to measure flow, velocity and dispersion utilizing tracers are presented. The parameters that should be measured in the water column and sediment are also discussed.

Certain situations are cited, in which the elaboration of a complete inventory of the chemicals present and their individual concentrations may be difficult or impossible to realize, or when there is a toxicological interaction among these substances. In these cases, the determination of total toxicity of the inputs to the water body can be useful, as well as the toxicity in the water body. Experimental procedures that measure chronic and acute toxicity are described, as well as the toxic unit. A procedure developed by the U.S. EPA is cited that permits the selection of the type of toxicity studies most recommended, which is based on a comparison between the receiving water body flow and the input flow.

A brief description of the chemical sampling in aquatic organisms is presented. Laboratory experiments are also discussed that measure: a) partitioning to solids, b) degradation, c) toxicity, d) bio-concentration factor to resident fish, e) Henry's constant, and f) octanol-water partition coefficient. Specific references for these and other parameters, such as hydrolysis and photolysis, are cited.

The section terminates with suggestions concerning the statistical analysis and presentation of data including "less than detectable limit" data.

3.6 Section 6 - Control of Toxic Substances

Traditionally, wastewater treatment processes have been designed for removal of conventional pollutants. However, the presence of new pollutants, such as heavy metals, toxic organics and pesticides, necessitate the development of new alternative technologies to solve these problems.

The control of toxic substances is divided in accordance with the discharge characteristics as point and non-point sources.

A procedure is developed for the evaluation of technologies applicable to point source toxicity reduction which considers wastewaters containing mixtures of organics and inorganics. With this procedure it is determined which of the following pertains to the wastes: a) not biodegradable and toxic, b) biodegradable with threshold toxicity, or c) without apparent toxicity. All the toxicity evaluations are executed with the LC50 test (lethal concentration that kills 50% of the organisms).

For the first type, and in accordance with the its characteristics, the following treatment technologies are proposed:

- Organic chemical: chemical or wet air oxidation, carbon adsorption
- Volatile organics-ammonia: stripping
- Heavy metals: oxidation-reduction, precipitation, filtration

Although still under development, the use of macro-reticular resins for the treatment of specific organic compounds is proposed.

The technology for the removal of heavy metals is presented in an extensive manner. Metal concentrations that can be obtained in the effluent are presented in accordance with each type of treatment. It is demonstrated that the reduction of metal concentrations in the effluent significantly better the LC50 and information in this regard is presented.

The majority of toxic organic compounds are removed through biological treatment. This removal, however, can occur through one or more dominating mechanisms: sorption, stripping or biodegradation. These processes are presented in detail in tables and graphs with their efficiencies with respect to different organic compounds.

The adsorption of organic compounds by granular activated carbon columns or powdered activated carbon, integrated into the activated sludge process, constitute an effective method of treatment. The use of this technology requires the consideration of numerous factors which include: the physical-chemical properties of the compound and absorber, the characteristics of the carbon to be employed and the design of the different treatment systems considering the absorbent, the adsorbed and the desired efficiency.

Numerous tables and graphs of data of efficiencies, physical-chemical characteristics, reaction rates and toxicity reduction are presented. In addition, schematics of particulate or granular carbon activated plants, are also presented.

In the case of some organic compounds resistant to treatment it is necessary to employ chemical oxidation. The most common oxidants include: ozone, potassium permanganate and hydrogen peroxide.

Three levels of oxidation depending on the extent of rupture of the hydrocarbon chains are established:

- primary degradation, better the biodegradability
- acceptable degradation, there is reduction of toxicity
- ultimate degradation, total rupture of the carbon chains

Graphs and figures are presented to illustrate this subject.

With references to the control of non-point sources of agricultural and urban origin, an evaluation of the factors which intervene is presented along with a summary of the control measures to be applied.

3.7 Section 7 - Development of National/Regional/Local Programs

The purpose of this section is to present the principal aspects that should be considered for the development of pollution control programs for toxic substances in surface waters in Latin America. Considering the different levels of technological and institutional development of the countries of the Region and also the different political-administrative structures that exist, it is not intended to suggest concepts that can be indiscriminately applied in the different countries. In reality the emphasis of this section is an evaluation of the different forms which have been used to confront the problem in the different countries. Suggestions are also presented of different criteria which could be utilized for the development of national, regional and local programs in the countries.

A review of the existing organizational and legal structures in the following countries is presented: Argentina, Brazil, Colombia, Costa Rica, México, Perú and Puerto Rico. Using as a basis the analysis of the existing institutional situation and adopting as an objective, the implementation of evaluation and control programs, structural schemes operational on a national or Regional level are proposed. An analysis of the infrastructure proposed is conducted, with advantages and disadvantages, in order to facilitate decision making in accordance with the situation in each country.

In the succeeding elements the planning and application of a toxic substances control program is presented, as well as the procedures for the establishment of standards.

The section continues with alternative control strategies for wastewater discharges. It is noted that the uncontrolled discharge of industrial wastes to natural water bodies, combined with the runoff from agricultural

areas where pesticides are utilized, may increase chemical concentrations in these water bodies to levels that perhaps are harmful to the aquatic environment and human health and the potential consequences have not received sufficient priority. Industrialization at any cost is not a valid alternative and it would not be possible to sustain a long-term growth, development and a betterment in the standard of living if the water bodies are contaminated to the degree that they cannot be used.

Inherent and previous to the imposition of specific control strategies is the inclusion of industrial wastes minimization programs and best management practices for agriculture. However, the detailed specification of these is beyond the scope of this manual.

The section continues with the detailed description, including advantages and disadvantages of the following control strategies: 1) waste load allocations based on the assimilative capacity concept, 2) control strategies based on minimum effluent technology, and 3) effluent tax.

This section concludes with a description of monitoring and compliance and community participation.

4. CONCLUSIONS AND RECOMMENDATIONS

- 4.1 Toxic substance contamination has been identified in certain key areas of the Region. However, as evidenced by the poor response to a questionnaire distributed by CEPIS to key pollution control agencies, the in-depth overall identification of the location, extent and magnitude of toxic contamination problems in the Region cannot be accomplished due to the lack of data, the poor confiability of the limited data available, the defficiencies in analytical laboratory capabilities to measure toxic substances (i.e., pesticides) in the various media (water, sediments and fish) and the lack of routine monitoring programs for toxic substance contamination on a national basis.
- 4.2 There remains a need to exert a concerted effort in analytical quality control (AQC) for laboratories both on the Regional and national basis.
- 4.3 Technology development, transfer and dissemination was accomplished through the Regional Program and is continuing through the horizontal cooperation among the countries, as evidenced by the interchange of experiences via the case studies.
- 4.4 The case studies are providing ia practical setting to test the application of the technology to Latin America.

- 4.5 There is sufficient expertise for utilizing the Manual in existing pollution control agencies of the countries. Such capabilities are now being utilized to transfer technology to others in the Region.
- 4.6 The Manual is intended to be a technological and management resource. However, each industrial country must decide on its own control and implementation strategies.

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List of acronyms and abbreviations

CAR	Corporación Autónoma Regional de las Cuencas de los Ríos Bogotá, Ubaté y Suárez (Colombia)
CETESB	Companhia de Tecnologia de Saneamento Básico (Brasil)
CONAPMAS	Comité Nacional de Protección del Medio Ambiente para la Salud (Peru)
EAAB	Empresa de Acueducto y Alcantarillado de Bogotá (Colombia)
EMAP-Q	Empresa de Agua Potable de Quito (Ecuador)
EPA	Environmental Protection Agency (United States of America)
FEEMA	Fundação Estadual de Engenharia do Meio Ambiente (Brasil)
GEMS	Global Environmental Monitoring System (Sistema Mundial de Monitoreo Ambiental)
IEOS	Instituto Ecuatoriano de Obras Sanitarias (Ecuador)
INCYTH	Instituto Nacional de Ciencia y Técnica Hídricas (Argentina)
MARNR	Ministerio del Ambiente y de los Recursos Naturales Renovables (Venezuela)
PNUD	Programa de Naciones Unidas para el Desarrollo
PRELAB	Programa Regional de Laboratorios
SARH	Secretaría de Agricultura y Recursos Hidráulicos (Mexico)
SEDUE	Secretaría de Desarrollo Urbano y Ecología (Mexico)

ACKNOWLEDGEMENTS

We wish to acknowledge the following persons for the contribution made in the preparation and publication of this Manual, and for their continual active collaboration in the Project on the Evaluation and Management of Toxic Substances in Surface Waters.

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