United States
Environmental Protection
Agency

Environmental Research
Laboratory
Athens GA 30613

Research and Development

EPA-600/S3-82-047 August 1982

EPA

Project Summary

Feasibility of Developing a Comprehensive Methodology for Source Identification and Environmental Loading (Materials Balance)

A. E. Wechsler, A. Q. Eschenroeder, D. Gilbert, K. Loos, P. Poston, and J. M. Stevens

A materials balance is defined as an array of the flows of materials or chemicals from the cultural environment to the first point of entry into the natural environment and includes information regarding location, time rate, quantity and chemistry of the flows. The materials balance encompasses two major components — identification of sources of materials and estimates of environmental loadings. The scope and focus of a materials balance is determined by various characteristics, such as geographic scale, time frame, environmental media or chemical class.

The materials balance framework depicts the interrelationships of controlled and accidental flows of the material in various industrial, commercial and consumer activities. The activities considered are: extraction, refining, manufacturing, processing, transportation, storage, use and disposal; natural sources are also included. A general and specific approach to each activity is described. A checklist is presented to assure completeness in performing the materials balance. The checklist is a matrix comprised of sources (activities) and environmental inputs (flows).

Feasibility criteria are presented to evaluate the various approaches. The feasibility criteria are: degree of uncertainty in source or quantities, human resource requirements, time constraints, identification of controllable sources, applicability to exposure predictions, comprehensiveness of the method, ability to use similar chemicals as guides, interfacing with fate models, accuracy of results, compatibility with existing data, applicability of method to different geographic scales, resolution of results in time and space, requirements for monitoring data, use of confidential information, data processing demands and complexity of input data and method.

This Project Summary was developed by EPA's Environmental Research Laboratory, Athens, GA, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Materials balances have several important uses: to predict exposure in the absence of monitoring data, to enable confirmation and/or extension of

limited monitoring data, and to permit identification of critical controllable pollutant sources as part of risk abatement. Because of the limited coverage, high cost, and extensive time requirements for monitoring studies, materials balances may be the most cost effective method of providing data for estimating exposure. Materials balances, in some cases, may be the only technique available to examine the contribution of a specific source to the ultimate risk of a pollutant. Therefore, a comprehensive and systematic methodology for materials balances — source identification and loading estimation — is a valuable part of a toxic pollutant regulatory program.

The two major elements of materials balances are source identification and loading estimation. It is important to consider and identify all major sources — natural and anthropogenic, deliberate and inadvertent — that can lead to potential exposure of humans and other biota including a characterization of the chemical or physical form in which the materials are released. All processes which result in environmental loading — manufacture, processing, transportation, storage, disposal and others — need to be considered. Furthermore, it is necessary to quantify the magnitude, location, and time dependence of the environmental loading since these factors form the basis for fate calculations, subsequent concentration determinations and exposure estimates. In the context of this study, however, the endpoint of the materials balance is the identification of sources and quantification of loadings to the "initial environmental compartments," e.g., the air, water, soil in which the release first occurs. Methods for establishing environmental fate and estimating exposure are not included in the materials balance methodology although the methodology must yield results that are compatible with the requirements of the environmental fate, exposure, and risk assessment methodologies.

Several materials balance studies or approaches have been developed in the past for specific applications. The methods used have not been reviewed, analyzed, summarized, or generalized to the point where a comprehensive approach — suitable for many types of anticipated applications — is available. Furthermore, the feasibility and expected results of and resources required for materials balances have not been established.

The objectives of this study were to examine the overall feasibility of a systematic approach to source identification and environmental loading estimation — materials balance — and to outline the most feasible materials balance method(s) and steps needed for implementation, so that they can be further developed and used in regulatory development by EPA.

The study was structured into the following work elements:

- First, a simplified framework for the conduct of materials balances was developed that included a broad range of industrial and consumer activities from raw material extraction through product disposal sources of environmental loadings — and that could account for routine, planned, fugitive, or accidental environmental releases.
- Second, new materials balance methodologies were developed for each of these industrial/consumer activities, incorporating existing approaches where possible. The methodologies were described in sufficient detail to show how the materials balance should be conducted, giving sample calculations and references to data and information that could be used in a materials balance; however, preparation of a step by step or "cookbook" method was not considered appropriate. In describing the use and applicability of the materials balance methods, the feasibility criteria identified earlier were considered.
- Third, an expansion of the checklist or matrix approach to organizing and presenting the results of a materials balance was examined.

Conclusions and Recommendations

Materials balances provide useful data for exposure and risk assessments, environmental fate modeling, evaluations required as part of the Toxic Substances Control Act and research on the distribution and disposition of pollutants in the environment. A number of materials balances have been performed and reported in the literature; most of these materials balances are limited or restricted. Some consider only certain geographic regions whereas others deal with only a limited number of industrial or consumer activities that may produce pollutants. Also a specific methodology for performing materials balances has not been developed.

A materials balance methodology should be complete in its coverage and adaptable to each particular case of interest. A variety of factors determine the usefulness and compatibility of a methodology with a particular materials balance program. These factors have been summarized in feasibility criteria developed as part of this task. A methodology is outlined for performing materials balances. In addition, a checklist has been developed to assure that all potential sources and sinks have been evaluated in performing the balance.

A complete materials balance must cover all activities in which a material participates from the point at which it enters the cultural environment until it returns to the natural environment. The activities may include extraction, refining, manufacturing, processing, transportation, storage, use and disposal. For completeness one should also consider natural sources of the material. Each of these activities must be examined in terms of inputs and outputs to the natural environment and to other activities. Although the general concept is the same for each activity, a different approach may be required for each specific activity.

The actual method selected for a materials balance will depend on a number of factors. The time and resources available for the project determine whether a thoroughly documented evaluation or only estimates will be accomplished. The scope of the study, in terms of time period covered, geographic area considered and activities evaluated, influences selection of the methodology. The specific material considered and availability of pertinent data determine whether sufficient factual information exist, whether estimates must be made, or whether analogies to similar chemicals will suffice. The desired output and use of the materials balance is very important in selecting a methodology. A study for use in risk assessment would require a different orientation and outputs from one to provide input to fate modeling. Each user must select those parts of the methodology that best fit the needs of the particular project.

The methodology and feasibility criteria presented in the report have not been applied in their entirety to a materials balance. The methodology is, in some cases, based on previous work

but much of it represents the approach that the authors would suggest in performing a materials balance. Thus, a major recommendation from the conclusion of this work is that the methodology and criteria be tested in performing one or more comprehensive materials balances. This work would evaluate the usefulness and applicability of the methods, the feasibility criteria and the checklist as well as providing valuable input for modification and revision of the methodology to make it as useful as possible. A more detailed step-by-step procedure could be developed as part of the documentation of this work.

A. E. Wechsler, A. Q. Eschenroeder, D. Gilbert, K. Loos, P. Poston, and J. M. Stevens are with Arthur D. Little, Inc., Cambridge, MA 02140.
***J. W. Falco** is the EPA Project Officer (see below).*
The complete report, entitled "Feasibility of Developing a Comprehensive Methodology for Source Identification and Environmental Loading (Materials Balance)," (Order No. PB 82-239 286; Cost: $12.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Environmental Research Laboratory
U.S. Environmental Protection Agency
Athens, GA 30613

★ U.S. GOVERNMENT PRINTING OFFICE: 1982 - 559-017/0791

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

Postage and
Fees Paid
Environmental
Protection
Agency
EPA 335