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Development of a geography-referenced regional exposure assessment tool for European rivers—GREAT-ER

T. Feijtel [a,*], G. Boeije [b], M. Matthies [c], A. Young [d], G. Morris [e], C. Gandolfi [f], B. Hansen [g], K. Fox [h], E. Matthijs [a], V. Koch [i], R. Schroder [j], G. Cassani [k], D. Schowanek [a], J. Rosenblom [l], M. Holt [m]

[a] *Procter and Gamble European Technical Centre, Temselaan 100 B-1853 Strombeek-Bever, Belgium*
[b] *University Gent, Department of Applied Mathematics, Biometrics and Process Control, Coupure L-653, 9000 Gent, Belgium*
[c] *University Osnabruck, Institute of Environmental Systems Research, ArtillerieStrasse 34, D-49069 Osnabruck, Germany*
[d] *Institute of Hydrology, Crowmarsh Gifford, GB-Wallingford, Oxfordshire OX10 8BB, UK*
[e] *Environment Agency, Olympia House, Gelderd Lane, Gelderd Road, Leeds LS12 6DD, UK*
[f] *University of Milan, Institute of Agricultural Hydraulics, via Celoria 2, I-20133, Milano, Italy*
[g] *European Chemicals Bureau, TP 641, JRC ISPRA, I-21020, Varese, Italy*
[h] *Unilever Research Port Sunlight Laboratory, Quarry Road East, Bebington, Wirral L63 3JW, UK*
[i] *Hoechst, Dept. Product Safety, Building D787, D-65926, Frankfurt am Main, Germany*
[j] *Henkel, TTB / Okologie, D-40191 Dusseldorf, Germany*
[k] *Condea Augusta Research Center, Via Reali 4, I-20037 Padermo Dugnano, Italy*
[l] *Akzo Nobel Surface Chemistry, PO Box 115 36, S-10061, Stockholm, Sweden*
[m] *ECETOC, Avenue van Nieuwenhuyse 4, Box 6, B-1160, Brussels, Belgium*

Abstract

The objective of the GREAT-ER project is to develop and validate a powerful and accurate aquatic chemical exposure prediction tool for use within the EU environmental risk assessment schemes. Current techniques to estimate regional PECs use a generic multimedia 'unit world' approach and do not account for spatial and temporal variability in landscape characteristics, river flows and/or chemical emissions. Hence, the results are merely applicable on a generic screening level since these models do not offer a realistic prediction of actual steady-state background

* Corresponding author.

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concentrations. In addition, the default EU generic regional environment (EU Technical Guidance Documents, 1996) only allows treatment for 70% of the waste water mass loading, leaving 30% of mass loading to this generic region untreated. A new database, model and software system will be developed to calculate the distribution of predicted environmental concentrations (PEC), both in space and time, of down the drain chemicals in European surface waters on a river and catchment area level. Data on dissolved oxygen, biological oxygen demand and ammonia will also be used to assess water quality and to provide data for calibration and validation. The system will use Geographical Information Systems (GIS) for data storage and visualization, combined with simple mathematical models for prediction of chemical fate. Hydrological databases and models will be used to determine flow and dilution data. This refined exposure assessment tool should greatly enhance the accuracy of current local and regional exposure estimation methods. The new exposure assessment methodology will integrate specific environmental information and be worked out in a geographically-referenced framework, ultimately on a pan-European scale. This research project is carried out on behalf of ECETOC, and sponsored by the Environmental Risk Assessment Steering Committee (ERASM) of the Association Internationale de la Savonnerie, de la Détergence et des Produits d'Entretien (A.I.S.E.) and the Comité Européen de Agents de Surface et Intermédiares Organiques (CESIO) in cooperation with the UK Environment Agency.

Keywords: European legislation; Risk assessment; Environmental exposure assessment; Fate models; Geography-referenced regional exposure assessment tool for European rivers

1. Introduction

The assessment of whether a substance presents a risk to organisms in the environment is based on a comparison of the predicted environmental concentration (PEC) with the predicted no effect concentration (PNEC) to organisms in ecosystems. This assessment can be performed for different compartments (e.g. air, water and soil) and on different spatial scales (local, regional). This is further captured in a number of EU Commission documents (Technical Guidance Documents supporting the Commission Directive on Risk Assessment of New Chemicals (93/67/EEC) and Commission Regulation on Risk Assessment of Existing Substances (1488/94/EEC) in support of Existing Substances Regulation (793/93/EEC)) and computerized calculation model EUSES (European Uniform System for Evaluating Existing Substances) [1–3].

In the environmental exposure assessment, it is essential to define the primary target compartment of the exposure assessment, i.e. what is being exposed and how long (point-source vs. diffuse and intermittent vs. continuous)? The exposure estimate may describe the exposure of the aquatic compartment close to the source of emission (e.g. wastewater effluent) and assess maximum exposure (i.e. 'local' realistic worst-case estimates).

Alternatively, the exposure assessment may be developed taking into consideration the fate, transport and distribution of the chemical into different media (air, water, soil and biota) away from the source of emission (i.e. 'regional' background estimates). In order to decrease the complexity inherent to 'real' spatial/temporal environments, the use of 'generic' or 'evaluative' steady state environments with standard properties have

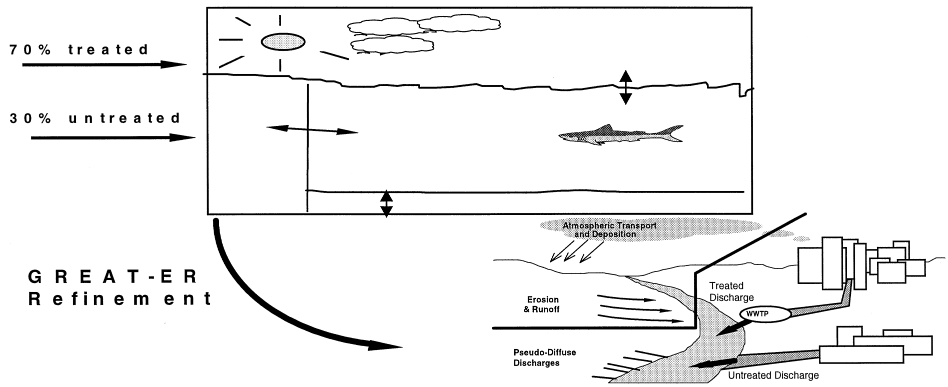

Fig. 1. Refinement of generic regional exposure models by using actual discharge pathway, treatment and river flow data into account.

been suggested and developed for chemical assessments. Mathematical distribution and fate models of the 'Mackay level III' type are used for this purpose in the screening phases of the assessment (e.g., USES—RIVM, VROM and WVC 1994 [4]; HAZCHEM—ECETOC 1994 [5]; EUSES, DG-ECB 1997 [3].

Realism can only be further introduced by taking into account environmental specifications of the receiving environment, and by verifying each underlying assumption used in these exposure models as illustrated in Fig. 1.

These PECs should be preferentially used in realistic environmental risk assessments in support of EU risk assessment legislation.

2. Theory—scientific project description

The project will be approached in a modular way as described in detail in Feijtel et al. [6].

2.1. GIS data manipulation

In the data manipulation module, input data sourced from several data bases and from the hydrology module will be transformed into appropriate GIS formats. Geographical segmentation will also be performed in this module.

2.2. Hydrology

The hydrology module will combine several hydrological databases with a hydrological model. It will provide the GREAT-ER system with the required flow distributions and river characteristics.

2.3. Waste pathway and river modelling

This module is used for the prediction of chemical emission, of chemical transformation during conveyance and treatment, and of chemical fate in rivers.

2.4. End-user desktop GIS

In this module, access to and visualization of the data banks and model results are achieved, as well as the linking of the models with the data banks.

2.5. Monitoring

A detailed monitoring program will be performed in order to provide the specific environmental measurements required for model calibration and verification.

The (standardized) GIS data banks, the waste pathway models and the river models are to be integrated into one coherent simulation system (Fig. 2). Such integration process will result in an operational end-user system, which will run on a PC platform. The hydrological models and the ARC/INFO spatial data processing steps will not be integrated into the end-user software system. Data transfer between the GIS data banks and the models will be allowed only via a pre-defined format, which depends neither on the implemented model formulations, nor on the used GIS software. All data transfers will be arranged by a GIS/Model Interchange Server. This server program will have the GIS and the models as clients. It will use model object descriptions (MOD) to determine which parameters and variables have to be written or read, and in which sequence.

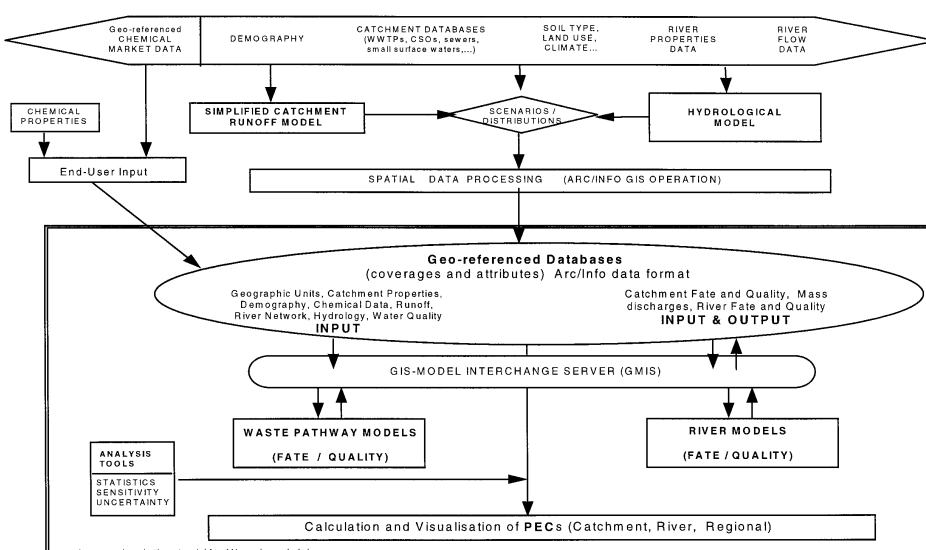

Fig. 2. Integration of the GREAT-ER methodology.

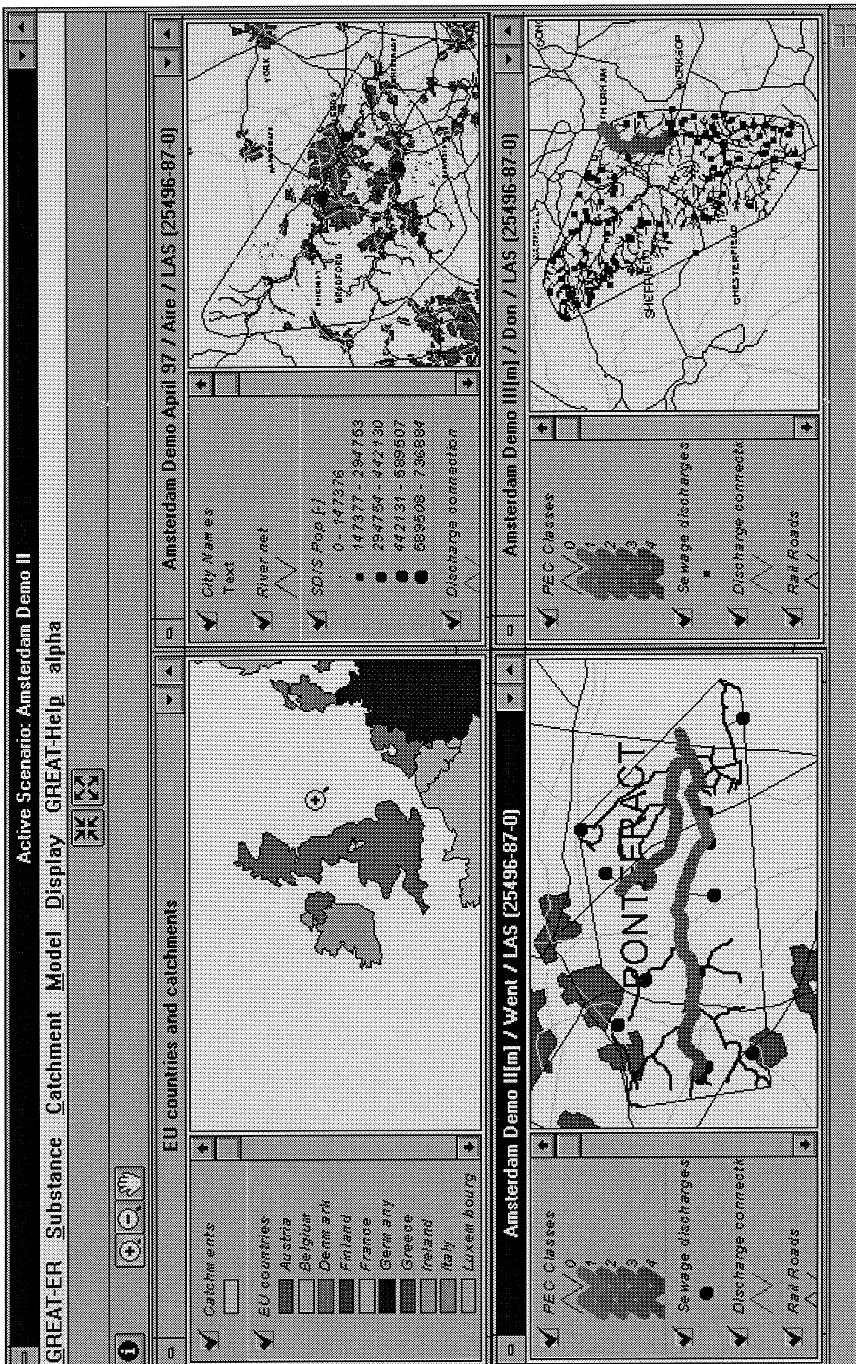

Fig. 3. Prototype output screen of GREAT-ER.

A menu-oriented user interface will be developed as an 'easy-to-use' front-end between the user and the software system. It will allow the selection of catchments as well as the input of model and scenario parameters. Depending on these inputs, the access to GIS data is carried out under control of the user interface and the GIS/Model Interchange Server. The user interface will also handle filtering and visualization of model results by GIS. Avenue® (ESRI) will be used for the development of this interface in an ArcView® (ESRI) environment.

3. Conclusions

The output of GREAT-ER will be a distribution of a chemical's predicted aquatic environmental concentration (PEC), throughout the geographical region of interest (Fig. 3). An additional output will be standard water quality parameters (from databases or predicted). The chemical-specific input data for the model are the physico-chemical and biochemical parameters, together with geographical consumption patterns or market data. Required environmental information will be taken from available geography-linked databases. For the storage and the access of the majority of these data in a user-friendly format, a Geographic Information System (GIS) approach will be used. GIS will also be used as a viewer for the model's output.

The final deliverable of this project will be a blueprint software prototype of the exposure assessment tool. This prototype will be applicable to the entire EU, and will be calibrated and validated for the pilot study areas. The software, which will run on personal computer systems, will be freely available by the end of this project.

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