Environmental Effects of Dredging
Technical Notes

Computerization of the Decision-Making Framework: Surface Runoff Toxicity Bioassay Test Results (LAT-R Program)

Purpose

The Decision-Making Framework (DMF) for the management of dredged material has been developed and used at numerous Corps projects (Lee and others 1991). Among the many components of the DMF is surface runoff water quality, which is one of the pathways investigated when confined disposal is considered.

Evaluation of surface runoff quality, like the evaluation of effluent quality, is based on the chemical composition of the discharge as well as the biological effects (toxicity). To perform these evaluations, surface runoff tests (Skogerboe, Price, and Brandon 1988) are performed on wet, anaerobic sediment and oxidized, aerobic sediment to generate representative samples of the runoff immediately after disposal and later when the dredged material has dried out.

The chemical composition of the runoff test samples is compared with existing water quality standards. When constituents not having water quality standards are present or a biological evaluation is desired, the toxicity of the surface runoff test samples is evaluated using the water column bioassay test for acute toxicity (U.S. Environmental Protection Agency/U.S. Army Corps of Engineers (USEPA/USACE) 1994).

Analysis of these test results has now been computerized as part of the Automated Dredging and Disposal Alternatives Modeling System (ADDAMS) (Schroeder and Palermo 1995). The surface runoff test for chemical composition is evaluated using the RUNQUAL module (Schroeder, Gibson, and Dardeau 1995), and the bioassay test is analyzed by the LAT-R module (*L*aboratory *A*nalysis of *T*oxicity from a CDF *R*unoff), which is described herein.

PRINTED ON RECYCLED PAPER

The LAT-R program compares survival data for various aquatic organisms at several runoff dilutions and computes the LC_{50} for the runoff under both wet and dried conditions. Using the LC_{50} and a mixing zone model, the toxicity of the discharge can be evaluated for compliance with water quality regulations. The purpose of this technical note is to introduce the LAT-R module.

Background

The DMF includes consideration of sediment chemistry, the physico-chemical nature of disposal site environments, and biological effects of sediment contaminants. The DMF also provides the basis for selecting the environmentally preferable disposal alternative and identifying appropriate control measures to minimize problems associated with the presence and potential migration of contaminants. The DMF is consistent with the approach described in the technical framework guidance document (USEPA/USACE 1992).

Techniques for predicting surface runoff water quality are presented by Skogerboe, Price, and Brandon (1988). Guidance for conducting water column bioassays is presented in Part 11 and Appendix E of the Inland Testing Manual (USEPA/USACE 1994). The LAT-R computer module was developed to facilitate the use of these methods.

Additional Information

This technical note was written by Mr. Dennis L. Brandon, Dr. Paul R. Schroeder, and Dr. Charles R. (Dick) Lee. The LAT-R User's Guide was written by Dr. Schroeder and Mr. Anthony C. Gibson.

For additional information, contact Mr. Brandon, (601) 634-2807; Dr. Lee, (601) 634-3585; Dr. Schroeder, (601) 634-3709; Mr. Gibson, (601) 634-3710; or the manager of the Environmental Effects of Dredging Programs, Dr. Robert M. Engler, (601) 634-3624.

Note: The contents of this technical note are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

Requirements

LAT-R requires 2 megabytes of hard disk space, with 560 kilobytes of free conventional RAM. LAT-R must be executed under DOS (Disk Operating System). The program diskettes include the User's Guide, installation files, and LAT-R executable files.

The User's Guide describes installation routines for disk drives A and B, execution procedures, and complete examples which display all input and output screens. The User's Guide contained in the README.R file is in Word Perfect 5.1 format.

The installation/execution sequence is as follows:

» Insert each diskette into drive A or B.
» Enter A:INSTALL or B:INSTALL as appropriate.
» After installation is complete, enter LAT-R at the DOS prompt to execute the program.

LAT-R was coded with LPI RM/FORTRAN and Fortran Powerstation. LAT-R also uses subroutines from the IMSL 32-bit Mathematical and Statistical Libraries. A LAT-R request form is provided at the end of this technical note.

The user is required to enter the following information to execute the program: text description of test, species name and test acceptability criterion, length of test exposure and number of treatments, number of organisms exposed to each treatment, number of replicates, and number of survivors for each treatment and replicate. This information can be saved in a file and edited by the user. All input screens have default values. LAT-R handles a maximum of 9 runoff treatments (dilutions) and 10 replicates under wet or dried sediment conditions. Wet and dry sediments are handled separately. Each treatment must have a minimum of 3 replicates.

Dilution water is defined as that water used to create various concentrations of the runoff. Dilution water survival must equal or exceed the test acceptability criterion. LAT-R provides a list of many common species and the test acceptability criterion for each. Users may expand and update this list to reflect regional priorities.

LAT-R Analysis Capabilities

LAT-R statistically analyzes the survival data from a suite of water column bioassay tests for acute toxicity in accordance with the guidance in the Inland Testing Manual (USEPA/USACE 1994). The results of the analysis are the LC_{50} for each species of organism employed in the testing and a listing of any deficiencies in the bioassay data.

LAT-R compares organism survival percentages in the dilution water to a test acceptability criterion. If organism survival in dilution water is less than the criterion, the test should be repeated. If the organism survival in 100-percent strength runoff is within 10 percent of the survival in dilution water, the 100-percent strength runoff treatment survival is considered not different from the dilution water treatment survival, and additional data analyses are not performed. The toxicity of the runoff is predicted to cause no further degradation of the environment.

For all other cases, an arc sine transformation is performed on the survival data. The Shapiro-Wilk W-test is used to evaluate the normality assumption of the statistical model. Results from the Shapiro-Wilk W-test will generally vary between 0.3 and 1.0. The lower values indicate greater departure from normality. Since normality is desired, one looks for a high value with an associated probability greater than the prespecified alpha level (USEPA/USACE 1994).

T-test results, including the F´ test for equality of variances, are written to an ASCII file named DETAIL.STA. These results are printed by selecting the PRINT RESULTS option (number 3). USEPA/USACE (1994, Appendix D) provides a detailed discussion of these tests.

When the survival in the 100-percent strength runoff is significantly lower than the survival in dilution water, three techniques are available to compute the LC_{50}—PROBIT, Trimmed Spearman-Karber (TSK), and linear interpolation.

The LC_{50} is the runoff concentration predicted to be toxic to 50 percent of the test organisms. If survival in the lowest runoff concentration is less than or equal to 50 percent, the test should be repeated using lower concentrations. If survival at all runoff concentrations is greater than or equal to 50 percent, the LC_{50} is assumed to be greater than or equal to 100 percent runoff.

LAT-R executes the PROBIT program (Version 1.5), distributed by the USEPA (Ecological Monitoring Research Division 1992a). In PROBIT, the minimum and maximum number of exposure concentrations is 3 and 20, respectively. These are in addition to the 100-percent dilution water treatment. There must be exposure concentrations yielding survivals that are greater than 0 percent and less than 100 percent.

The chi-square statistic provides an indication of how well the data fit the model. A low chi-square indicates a good fit. The fit is considered adequate if the chi-square for heterogeneity (calculated) is less than the tabular value for the 0.05 level of significance.

LAT-R also executes the TSK program (Version 1.5), distributed by the USEPA (Ecological Monitoring Research Division 1992b). TSK requires a maximum of 8 exposure concentrations including the 100-percent dilution water treatment. TSK assumes the survival results will be monotonically nondecreasing (that is, survival for each higher runoff concentration is less than or equal to survival at lower concentrations). The linear interpolation method is used when there are 0 or 100 percent partial mortalities and the data do not fit the PROBIT model. LAT-R provides output from PROBIT and TSK or linear interpolation, but not all three simultaneously. Output from the LC_{50} techniques is included in the file DETAIL.STA.

Application

The results of LAT-R are used to determine compliance with water quality regulations. As generally applied, 1 percent of the lowest LC_{50} computed by the LAT-R program would be applied as the toxicity standard. Then, the dilution provided in a mixing zone at the discharge point would be calculated and compared with the toxicity standard to determine whether the runoff discharge is acceptable. Otherwise, the size of the mixing zone that provides the required dilution is computed to determine whether the mixing zone is acceptable.

The CDFATE module (presently in draft release) of ADDAMS or the procedures in *Environmental Effects of Dredging Technical Note* EEDP-04-5 (MacIntyre 1987) are used to estimate dilution and mixing zones. Appendix C of the Draft Inland Testing Manual provides additional guidance on mixing zones (USEPA/USACE 1994).

Availability

LAT-R is distributed as a stand-alone program that can also be accessed from the ADDAMS shell (main menu). Several acquisition methods are available: diskette, World Wide Web (WWW), and FTP.

To acquire LAT-R on diskette, complete and mail the request form (provided at the end of this technical note). To acquire the program from the WWW, go to *http://www.wes.army. mil/el/elmodels/*. Then, select ADDAMS, Download, and LAT-R, and follow the instructions. To download by FTP, call Dr. Paul R. Schroeder, (601) 634-3709, for the FTP host ID, user name, password, file name, and instructions.

References

Ecological Monitoring Research Division. (1992a). "User's guide—PROBIT program," Version 1.5, Environment Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH.

_____. (1992b). "User's guide—Trimmed Spearman-Karber (TSK)," Version 1.5, Environment Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH.

Lee, C. R., Tatem, H. E., Brandon, D. L., Kay, S. H., Peddicord, R. K., Palermo, M. R., and Francingues, N. R., Jr. (1991). "General decisionmaking framework for management of dredged material; Example application to Commencement Bay, Washington," Miscellaneous Paper D-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

MacIntyre, D. F. (1987). "Interim procedures for estimating mixing zones for effluent from dredged material disposal sites (single-point discharge),"

Environmental Effects of Dredging Technical Notes EEDP-04-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schroeder, P. R., Gibson, A. C., and Dardeau, E. A., Jr. (1995). "Documentation of the RUNQUAL module for ADDAMS: Comparison of predicted runoff water quality with standards," *Environmental Effects of Dredging Technical Notes* EEDP-06-19, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schroeder, P. R., and Palermo, M. R. (1995). "The automated dredging and disposal alternatives modeling system (ADDAMS)," *Environmental Effects of Dredging Technical Notes* EEDP-06-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Skogerboe, J. G., Price, R. A., and Brandon, D. L. (1988). "New Bedford Harbor Superfund Project, Acushnet River Estuary engineering feasibility study of dredging and dredged material disposal alternatives; Report 4, Surface runoff quality evaluation for confined disposal," Technical Report EL-88-15, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

U.S. Environmental Protection Agency/U.S. Army Corps of Engineers. (1992). "Evaluating environmental effects of dredged material management alternatives—A technical framework," EPA-842-B-92-008, U.S. Environmental Protection Agency, Washington, DC.

_____. (1994). "Evaluation of dredged material proposed for discharge in waters of the U.S.—Testing manual," EPA-823-B-94-002, U.S. Environmental Protection Agency, Washington, DC.

Request Form, LAT-R Module

Name and Title _____

Mailing Address _____

_____

Office Symbol _____

Telephone Number _____

Signature_____ Date _____

Mail request form and two DOS-formatted diskettes to:

U.S. Army Engineer Waterways Experiment Station
ATTN: CEWES-ID-E (G. Naylor)
3909 Halls Ferry Road
Vicksburg, MS 39180-6199