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LONG-TERM EFFECTS OF DREDGING
OPERATIONS PROGRAM

TECHNICAL REPORT D-86-4

DEVELOPMENT OF A MODIFIED ELUTRIATE
TEST FOR ESTIMATING THE QUALITY OF
EFFLUENT FROM CONFINED DREDGED
MATERIAL DISPOSAL AREAS

by

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II A: RECOMMENDED PROCEDURE FOR CONDUCTING MODIFIED ELUTRIATE TESTS

This appendix describes a modified elutriate test procedure which is used to predict both the dissolved and particle-associated concentrations of contaminants in confined disposal area effluents (water discharged during active disposal operations). The laboratory test simulates contaminant behavior under confined disposal conditions, reflecting the sedimentation of dredged material, retention time of the containment, and the chemical environment in ponded water during active disposal. A schematic of the test is shown in Figure A1.

Long-term geochemical changes may occur following disposal, site stabilization, and subsequent drying of the dredged material. The quality of the surface runoff from disposal sites after these long-term changes occur may be quite different from the quality of the effluent discharged during active disposal. The modified elutriate test described in this appendix does not account for long-term geochemical changes and therefore should not be used to predict the quality of surface runoff.

Sampling Requirements

Samples of channel sediment and dredging site water are required for conducting modified elutriate tests and column settling tests, and for characterizing the sediment to be dredged. The level of effort, including the number of sampling stations, the quantity of material, and any schemes used for collecting samples is highly project-specific. If at all possible, the sampling operations required for (a) sediment characterization (both physical and chemical), (b) design and evaluation of the disposal site, and (c) the modified elutriate testing should be conducted simultaneously to avoid duplication of effort.

Normally, sediments from maintenance dredging are those for which the quality of the effluent from the disposal site will be of concern. Grab samples of such sediments are satisfactory for obtaining the quantities needed for all testing requirements. General guidance on sampling for chemical

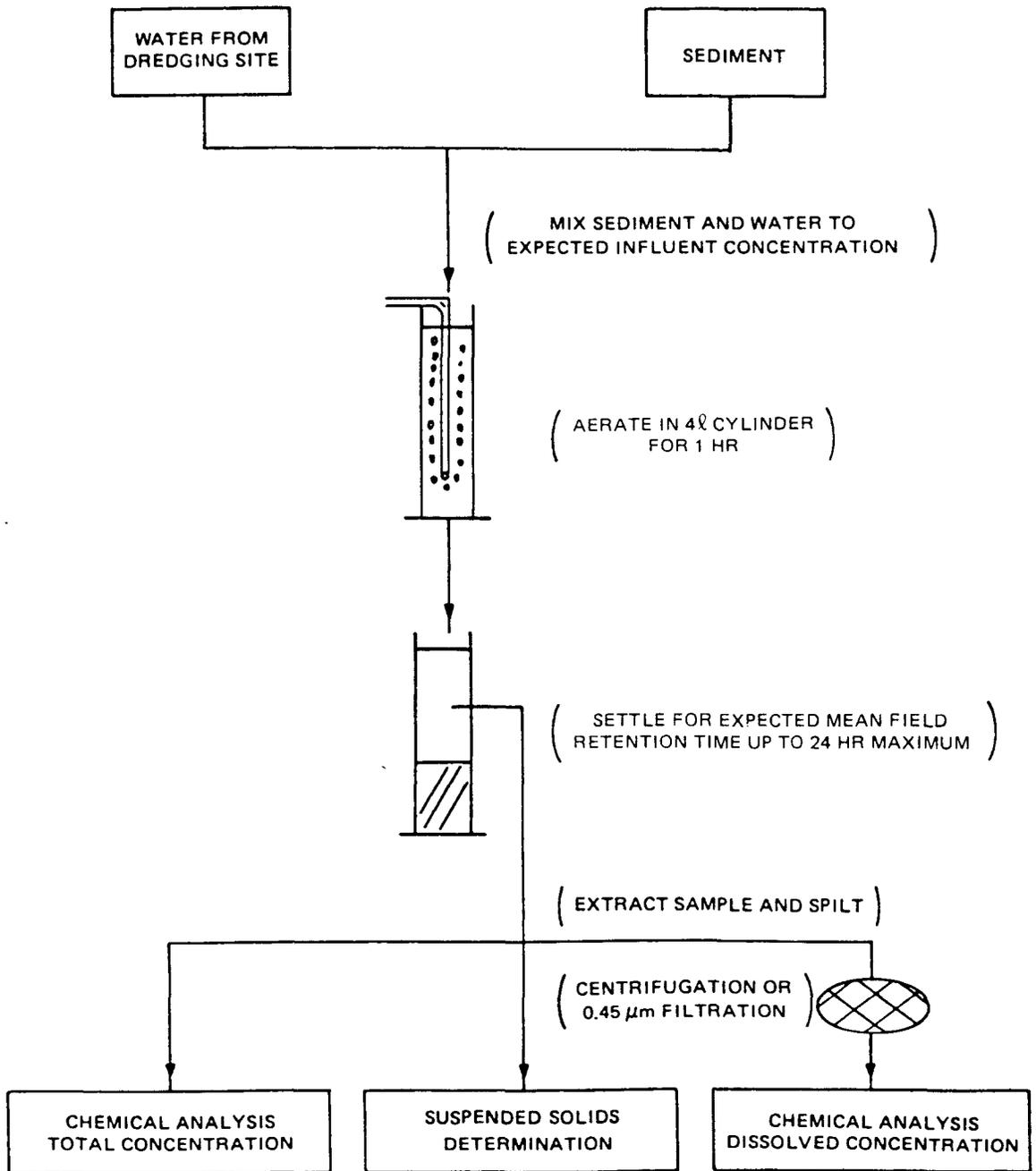


Figure A1. Schematic of modified elutriate test procedure

characterization purposes was given by Plumb (1981).* Sampling guidance for purposes of disposal site design and evaluation was given by Palermo, Montgomery, and Poindexter (1978).

* A list of references can be found at the end of the main text.

Sample collection and preservation

5. Procedures for sample collection and preservation given below are largely patterned after similar guidance for evaluation of proposed discharges into ocean waters (Environmental Protection Agency/Corps of Engineers (EPA/CE) 1977, Plumb 1981). Samples that are improperly collected, preserved, or prepared will totally invalidate any testing conducted and will lead to erroneous conclusions regarding the potential impact of the proposed discharge. Meticulous attention must therefore be given to all phases of water and sediment sampling, storage, and preparation. The procedures described herein specify the apparatus and procedures to use for sampling water and sediments and for preparing the water and sediments for chemical analysis. The procedures are designed to minimize sample contamination and alteration of the physical or chemical properties of the samples due to freezing, air oxidation, or drying.

6. Number of samples. The number of sediment and water samples to be taken for processing from the dredging or excavation site must be carefully considered because of the extremely heterogeneous nature of samples of this type. The largest source of variation between sediment samples taken at a dredging site has been shown to be the vertical and horizontal distribution of the samples (Brannon et al. 1976). With this in mind, sediment should be collected from a minimum of three sampling stations within the dredging area. The sampling stations should be located throughout the area to be dredged and should be selected to characterize obviously contaminated as well as noncontaminated areas. The amount of sediment and water collected should be limited to the amount that can be used in the testing program within 2 weeks after sampling.

7. Apparatus. The following items are required for water and dredged material sampling and storage:

- a. Noncontaminating sediment grab or core sampler (Smith-McIntyre or Van Veen grab, K. B. Corer, etc.).
- b. Noncontaminating water sampler (Van Dorn water sampler, etc.).
- c. Acid-rinsed linear polyethylene bottles for water samples to be analyzed for metals and nutrients.
- d. Solvent-rinsed glass bottles with Teflon-lined screw-type lids for water samples to be analyzed for pesticide materials.
- e. Plastic jars or bags for collection of sediment samples.

f. Ice chests for preservation and shipping of dredged material and water samples.

8. Water sampling. A collection of water samples should be made with appropriate noncontaminating water-sampling devices. Special care must be taken to avoid the introduction of contaminants from the sampling devices and containers. To avoid trace metal contamination, sampling devices should be constructed of plastic materials. Prior to use, the sampling devices and containers should be thoroughly cleaned with a detergent solution, rinsed with tap water, soaked in 10-percent hydrochloric acid (HCl) for 4 hr, and then thoroughly rinsed with metal-free water. Water samples taken for trace organic analyses should be taken with glass or stainless steel devices. If plastic devices must be used, they must be cleaned, aged, and characterized as to the material that may leach from them into the samples. The sampling devices should be thoroughly cleaned, following the procedures outlined by EPA (1974a), and then rinsed just before using with the same solvent to be used in the analysis, probably hexane.

9. A representative dredging site water sample is obtained by collecting the sample volume from approximately 1 m above the sediment surface. The portion of the samples to be used for pesticide material analyses must be stored in glass or aluminum containers.

10. The samples should be stored immediately at 2 to 4° C, never frozen. The storage period should be as short as possible to minimize changes in the characteristics of the water. It is recommended that samples be processed within 2 weeks of collection.

11. Sediment sampling. Sediment samples should be taken with a corer or a grab sampler in a manner designed to ensure that their characteristics are representative of the proposed dredging site. Sampling stations should include known or suspected areas of high contamination as well as more representative areas. The larger the proposed dredging site, the more samples will be required for adequate coverage and characterization. The samples should be placed in airtight linear polyethylene containers. If organic materials are of primary concern, airtight glass storage containers should be used. Care should be taken to ensure that the containers are completely filled by the samples and that air bubbles are not trapped in the containers. The samples should be stored immediately at 2 to 4° C. The samples must never be frozen or dried. The storage period should be as short as possible to minimize

changes in the characteristics of the dredged material. It is recommended that the samples be processed within 2 weeks of collection.

Modified Elutriate Test Procedure

12. The modified elutriate tests should be conducted and appropriate chemical analyses should be performed as soon as possible after sample collection. The volume of elutriate sample needed for chemical analyses will vary depending upon the number and types of analyses to be conducted. Both dissolved and total concentrations of contaminants must be determined. The volume required for each analysis, the number of parameters measured, and the desired analytical replication will influence the total elutriate sample volume required. A 4-l cylinder is normally used for the test, and the supernatant volume available for sample extraction will vary from approximately 500 to 1,000 ml, depending on the sediment properties, settling times, and initial concentration of the slurry. It may be necessary to composite several extracted sample volumes or use large diameter cylinders to obtain the total required volume.

Apparatus

13. The following items are required:
 - a. Laboratory mixer, with stainless steel or Teflon shaft and blades.
 - b. Graduated cylinders (Four-litre cylinders are normally used. Larger cylinders may be used if large sample volumes are required. Nalgene cylinders are acceptable for testing involving analysis of metals and nutrients. Glass cylinders are required for testing involving analysis of organics.)
 - c. Assorted glassware for sample extraction and handling.
 - d. Compressed air source with deionized water trap and 3/16-in. inside diameter tubing for bubble aeration of slurry.
 - e. Vacuum or pressure filtration equipment, including vacuum pump or compressed air source and an appropriate filter holder capable of accommodating 47-, 105-, or 155-mm-diam filters.
 - f. Presoaked filters with a 0.45- μ m pore-size diameter.
 - g. Plastic sample bottles, 250-ml capacity for storage of water and liquid phase samples for metal and nutrient analyses.
 - h. Wide-mouth, 1-gal capacity glass jars with Teflon-lined screw-type lids for sample mixing. These jars should also be used for sample containers when samples are to be analyzed for pesticide materials.

14. Prior to use, all glassware, filtration equipment, and filters should be thoroughly cleaned. Wash all glassware with detergent, rinse five times with tap water, place in a clean 10-percent (or stronger) HCl acid bath for a minimum of 4 hr, rinse five times with tap water, and then rinse five times with distilled or deionized water. Soak filters for a minimum of 2 hr in a 5-M HCl bath and then rinse 10 times with distilled water. It is also a good practice to discard the first 50 ml of water or liquid phase filtered. Wash all glassware to be used in preparation and analysis of pesticide residues using the eight-step procedure given by EPA (1974a).

Test procedure

15. The step-by-step procedure for conducting the modified elutriate test is outlined below. An example calculation procedure is also given in the following pages.

16. Step 1 - Slurry preparation. The sediment and dredging site water should be mixed to approximately equal the expected average field influent concentration. If estimates of the average field influent concentration cannot be made based on past data, a slurry concentration of 150 g/l (dry-weight basis) should be used. Predetermine the concentration of the well-mixed sediment in grams per litre (dry-weight basis) by oven drying a small subsample of known volume. Each 4-l cylinder to be filled will require a mixed slurry volume of 3-3/4 l. The volumes of sediment and dredging site water to be mixed for a 3-3/4-l slurry volume may be calculated using the following expressions:

$$V_{\text{sediment}} = 3.75 \frac{C_{\text{slurry}}}{C_{\text{sediment}}} \quad (\text{A1})$$

and

$$V_{\text{water}} = 3.75 - V_{\text{sediment}} \quad (\text{A2})$$

where

V_{sediment} = volume of sediment, l

3.75 = volume of slurry for 4-l cylinder, l

C_{slurry} = desired concentration of slurry, g/l
(dry-weight basis)

C_{sediment} = predetermined concentration of sediment, g/l
(dry-weight basis)

V_{water} = volume of dredging site water, l

17. Step 2 - Mixing. Mix the 3-3/4 l of slurry by placing appropriate volumes of sediment and dredging site water in a 1-gal glass jar and mixing for 5 min with the laboratory mixer. The slurry should be mixed to a uniform consistency with no unmixed agglomerations of sediment.

18. Step 3 - Aeration. The prepared slurry must be aerated to ensure that oxidizing conditions will be present in the supernatant water during the subsequent settling phase. Bubble aeration is therefore used as a method of sample agitation. Pour the mixed slurry into a 4-l graduated cylinder. Attach glass tubing to the aeration source and insert the tubing to the bottom of the cylinder. The tubing can be held in place by insertion through a pre-drilled No. 4 stopper placed in the top of the cylinder. Compressed air should be passed through a deionized water trap, through the tubing, and bubbled through the slurry. The flow rate should be adjusted to agitate the mixture vigorously for 1 hr.

19. Step 4 - Settling. Remove the tubing and allow the aerated slurry to undergo quiescent settling for a time period equal to the anticipated field mean retention time, up to a maximum of 24 hr. If the field mean retention time is not known, allow settling for 24 hr. Guidance for estimating the field mean retention is given in the following paragraphs.

20. Step 5 - Sample extraction. After the period of quiescent settling, an interface will usually be evident between the supernatant water with a low concentration of suspended solids and the more concentrated settled material. Samples of the supernatant water should be extracted from the cylinder at a point midway between the water surface and interface using a syringe and tubing. Care should be taken not to resuspend the settled material.

21. Step 6 - Sample preservation and analyses. The sample should be analyzed as soon as possible after extraction. Total suspended solids in milligrams per litre, and dissolved and total concentrations of desired analytes in milligrams per litre should be determined. The analyte fraction of the total suspended solids in milligrams per kilogram of suspended solids (SS) can then be calculated for appropriate analytes. Filtration using 0.45- μm filters

should be used to obtain subsamples for analysis of dissolved concentrations. Samples to be analyzed for dissolved pesticide or polychlorinated biphenyl (PCB) materials must be free of particles but should not be filtered, due to the tendency for these materials to adsorb on the filter. However, particles can be removed before analysis by high-speed centrifugation at 10,000 times gravity using Teflon, glass, or aluminum centrifuge tubes (Fulk et al. 1975). The total suspended solids concentration can also be determined by filtration (0.45 μm). The analyte fraction of the total suspended solids may be calculated in terms of milligrams per kilogram of SS as follows:

$$F_{SS} = (1 \times 10^6) \frac{C_{\text{total}} - C_{\text{diss}}}{SS} \quad (\text{A3})$$

where

- F_{SS} = analyte fraction of the total suspended solids,
mg analyte/kg of suspended solids
- (1×10^6) = conversion factor, milligram/milligram to milligram/
kilogram
- C_{total} = total concentration, mg analyte/ ℓ of
sample
- C_{diss} = dissolved concentration, mg analyte/ ℓ of
sample
- SS = suspended solids concentration, mg solids/ ℓ of
sample

22. Subsamples for analyses of total concentrations should undergo appropriate digestion prior to analysis. All digestion and chemical analyses should be performed using accepted procedures (American Public Health Association (APHA) 1981; EPA 1974a, 1974b).

23. Samples to be analyzed for pesticide or PCB materials should immediately undergo solvent extraction. The extract may then be held in clean uncontaminating containers for periods up to 3 or 4 weeks at -15 to -20°C before the analyses are performed.

24. Samples for metals analysis should be preserved immediately by lowering the pH to <2 with 3 to 5 ml of concentrated HNO_3 per litre (EPA 1979). High purity acid, either purchased commercially or prepared by a subboiling unit, must be used.

25. Nutrient analyses should be conducted as soon as possible. Acidification with H_2SO_4 to pH <2 and storage at 4° C may allow the sample to be held for a maximum of 24 hr for ammonia nitrogen, Kjeldahl nitrogen, and nitrate nitrogen analyses (EPA 1979). Storage at 4° C will allow holding of samples to be analyzed for dissolved orthophosphate and total dissolved phosphorus for up to 24 hr. Subsamples to be analyzed for cyanide should be preserved with 2 ml of 10 N sodium hydroxide per litre of sample (pH >12) (EPA 1979).

Prediction of Effluent Quality

26. Concentrations of contaminants discharged in the effluent will be the sum of the dissolved fraction and that fraction associated with suspended particulates which are discharged. Prediction of effluent quality in terms of total contaminant concentrations must therefore be based on both the modified elutriate test results and estimates of the total suspended solids concentration in the effluent. Procedures for confined disposal site design and operation (Palermo, Montgomery, and Poindexter 1978; Montgomery, Thackston, and Parker 1983; Palermo 1985) must therefore be applied to evaluate sedimentation performance for the containment area. These procedures provide estimates of effluent suspended solids concentrations based on results of settling column tests. The standard column settling test for site design is now being modified to allow a refined prediction of effluent suspended solids concentrations. These modifications will be documented in a forthcoming report.

27. The modified elutriate test procedure defines dissolved contaminant concentrations in milligrams per litre and particulate-associated concentrations in milligrams per kilogram under quiescent settling conditions and accounts for geochemical changes occurring in the disposal area during active disposal operations. Using these test results, the total contaminant concentration in milligrams per litre in the effluent may be determined for the estimated sedimentation performance as follows:

$$C_{\text{total}} = C_{\text{diss}} + \frac{C_{\text{part}} \times \text{TSS}_{\text{eff}}}{1 \times 10^6} \quad (\text{A4})$$

where

C_{total} = estimated total concentration in effluent,
mg analyte/ ℓ of water

C_{diss} = dissolved concentration, as determined by modified
elutriate tests, mg analyte/ ℓ of sample

C_{part} = particulate concentration, as calculated from modified
elutriate results, mg analyte/kg of suspended solids

TSS_{eff} = suspended solids concentration of effluent, as estimated
from evaluation of sedimentation performance in 8-in.
column, mg suspended solids/ ℓ of water

The acceptability of the proposed confined disposal operation can then be evaluated by comparing the predicted total contaminant concentrations with applicable water quality standards, considering an appropriate mixing zone.