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Project Summary

Nonpoint Sediment Production in the Colusa Basin Drainage Area, California

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An investigation was conducted to identify the nonpoint sources of suspended matter in the California Colusa Basin Drainage Area, to interpret the factors contributing to or affecting suspended solids loading, and to develop recommendations for best management practices. The 1977-1979 project period (Phase I) focused on an overview appraisal of sediment production and transport. The 1979-81 project period (Phase II) involved intensive quantitative investigations into the causes of the turbidity problem and the development of recommendations for sediment control.

The study area included the 70-mile-long Colusa Basin Drain (CBD), the 164,000 ac Glenn-Colusa Irrigation District (GCID), and selected tributaries. This report contains data on water flow and suspended and bedload materials and their biological, chemical, physical, and mineralogical properties, rainfall simulation studies to extend the usefulness of the Wischmeier Universal Soil Loss Equation (USLE), a pesticide survey for selected chemicals, and the development and validation of a computer simulation model for sediment transport. This investigation resulted in conclusions and the development of guidelines for best management practices and recommendations for sediment control. These findings, reported in Water Science and Engineering Paper No. 4023, were reviewed by project collaborators and interested parties for feasibility and implementation.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, 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

Soil erosion and sediment production can affect the productivity of lands devoted to food and fiber production and the quality of the receiving waters. Within the context of these perspectives, this project emphasizes drainage watersheds. The objectives of this project are:

(1) to appraise soil erosion and sediment production in the study area;

(2) to conduct field investigations on production and transport of suspended matter;

(3) to ascertain factors contributing to or influencing erosion and sediment production and the transport, deposition, and resuspension of sediment;

(4) to develop a sediment transport model;

(5) to develop recommendations for best management practices for nonpoint source control on the production of suspended matter in the study area; and

(6) to consult and inform interested parties and agencies on research

findings and to review the feasibility and implementation of proposed management.

This project was coordinated with the Soil Conservation Service (SCS) pilot study in the Buckeye Creek-Dunnigan Creek drainage area in northeastern Yolo County, California. This project contributed to the current Section 208 of PL 92-500 planning efforts for developing water quality management for non-designated areas as well as meeting the mandates of the State of California Porter-Cologne Water Quality Act.

Conclusions

The conclusions generated from this project are presented under five headings: (1) sediment sources and yield, (2) sediment component and sizes, (3) factors (physical, chemical, mineralogical, and biological) controlling sediment transport, (4) sediment as a pesticide carrier, and (5) sediment transport modeling.

Sediment Sources and Yield

The four potential sources of sediment-yielding processes are sheet and rill, channel, gully, and roadway erosion. In the study area, sheet and rill erosion from upland and dry-farmed areas are the main sources of erosion; they are caused by raindrop impact and the water flowing on the soil surface. The Wischmeier and Smith Universal Soil Loss equation (USLE) which underestimates the soil loss by about 20%, was used to estimate potential soil losses. In the western portion of the basin, slope steepness was a critical parameter for estimating potential soil losses. Rainfall-simulation studies indicated that as slopes increased beyond 40 percent, the effect of slope on erosion decreased. The concentration of suspended sediment in CBD indicated that sediment was deposited at intermediate locations, wherever the entraining runoff waters were inadequate for sustaining transport. The deposited sediment was transported to CBD by stream-bed erosion during winter runoff.

Channel erosion is caused by sediment-removal by shearing forces of water. This sediment production comes from channel banks and beds, and from channel overflow areas having no protective cover.

Gully erosion, viewed as a point source of erosion, results from water accumulating in narrow channels.

Erosion from roadways, especially unpaved roads and shoulders of paved roads, is also viewed as a point source which causes sheet, rill, or gully erosion.

Sediment Component and Sizes

Analyses of water samples from CBD and its tributaries indicate that the suspended sediment composition, on the average, was 60 percent minerals, 30 percent organics, and 10 percent algae. Suspended organic matter averaged 60 percent biodegradable organic matter and 40 percent refractory organic matter. Suspended mineral sediments were mainly silt and clay, with a small fraction of sand. The particle-size analysis of the bedload sediment in CBD was about 60 percent sand-size material, 10 to 30 percent organic matter, and lesser amounts of silt, clay, and gravel.

Factors Controlling Sediment Transport

The physical factors controlling sediment production, transport, and deposition are: flow pattern, flow rate, bed configuration and roughness, current velocities, fluid shear stress, critical shear stress of the bed material, and water depth.

The chemical factors affecting dispersion, flocculation, and sedimentation of cohesive suspended particles in the drain are the concentration of soluble ions: total dissoved solids (TDS) or electrical conductivity (EC), sodium adsorption ratio (SAR), and pH of the water

The aquatic organisms contributed up to 20 percent of the total suspended sediments.

Clay-size (<2 μm) particles constituted over 50 percent of the suspended mineral load in CBD. Chlorite and kaolin were the dominant phyllosilicate species in coarse clay (2 - 0.2 μm) fractions. Smectite was dominant in fine clay ($<0.2 \mu m$) fractions in suspended mineral matter. Adsorption specificity exhibited by clays favored Ca over Mg, and favored Ca and Mg over Na.

Sediment as a Pesticide Carrier

Emission of chemicals into the water courses appeared to be site- and time-specific. The degree of saturation of the sediment with chemical was a function of the concentration of chemical and sediment in the aqueous phase. Spatial and time surveys indicate complex interaction of variations in timing of application, sources of chemical and water outflow, variations in drain flow and probable biological and sedimentation processes that occur in the system.

Sediment Transport Modeling

A one-dimensional computer model was developed and applied to a 20-mile-long lower reach of CBD. Sensitivity analysis indicated that the model was sensitive to flow rate, current velocities, settling velocities of particles, and the bed shear stress.

Best Management Practices (BMPs)

Practices designed to reduce erosion and sediment delivery should not be an impediment to continued agricultural productivity, and they must be economical. BMPs may stop or reduce on-site soil erosion or prevent sediment from reaching a body of water.

Livestock management can be the most effective and least costly method of erosion control. Practices to control soil erosion and range productivity are grouped into three broad management types: vegetation management, facilitating practices, and accelerating practices. A management program which includes plant-growth acceleration and appropriate animal management can yield multiple positive benefits. Conservation management practices which increase animal yield are more effective than sediment-retention structures. The most productive BMP is one designed specifically for a particular area.

Soil loss on sloping cultivated areas can be reduced by implementing contour cropping, zero or minimum tillage agriculture, conservation cropping systems involving rotations of grasses and legumes, or by allowing plants to grow during critical erosion periods Contour plowing of sloping land where tillage is required helps prevent runoff during storms, resulting in an increased infiltration and reduced sediment. Increased infiltration rates can be maintained by reducing compaction caused by excessive vehicular traffic and equipment operation; by applying chemicals, or incorporating organic matter into the soil. The BMP for controlling sediment production from irrigated land consists of minimizing surface runoff.

Unpaved roads are a major source of sediment in the CBD. Road-management practices can reduce sediment; e.g., closure of such roads in wet weather, permanent closure of some nonessential roads, and installation of water bars, culverts, and water spreaders. Channel erosion can be controlled with vegetative stream bufferstrips alone, or in combination with grade stabilization and inlet structures.

Recommendations

The first step for implementing BMPs is education of landowners, farmers, and ranchers to the long- and short-term benefits possible with effective land management. Once the land-use benefits are understood, actual implementation of practices should be facilitated.

Improved range management should include vegetation management by proper grazing pressure and planned grazing levels, development of water trails for livestock, and implementation of practices to accelerate plant growth. Conservation management practices should be specific to the soil-slope-vegetation-land-use problem.

Where erosion problems exist, unpaved roads should be closed during wet weather, permanently closed, or rocked with water control structures.

Contour cropping, cultivation, and "no-till" or "minimum-till" practices should be implemented to reduce runoff in cultivated areas. Equipment operation and other vehicular traffic should be regulated or reduced to lessen compaction and to improve infiltration. Chemicals or organic matter should be used to improve water entry into the soil. Catchment basins should be designed to collect sediment discharge from cultivated fields.

Conservation cropping systems, contour plowing on sloping lands, and practices to reduce discharge of water and sediment, e.g., reuse of tailwater discharge from irrigated areas should be practiced where appropriate to reduce erosion and sediment yield. Careful planning and implementation of conservation practices to reduce erosion should precede development of range land or dry-farmed land into cultivated and irrigated land.

Control measures for channel erosion should be implemented by reshaping the channel, planting suitable ground covers, erecting rock structures or riprap at places where creeks bend, installing large boulders with wire fences and revetments to reduce land erosion, and/or installation of sedimentation basins.

To lessen the outflow of chemicals from agricultural fields, the outflow of water should be minimized during, and immediately after chemical application. Optimum amounts of chemicals should be applied to minimize contamination of nontarget areas.

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The complete report, entitled "Nonpoint Sediment Production in the Colusa Basin Drainage Area, California," (Order No. PB 83-193 920; Cost: $14.50, subject to change) will be available only from:

National Technical Information Service
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