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A FLUME FOR STUDYING THE RELATIVE ERODIBILITY OF SOILS AND SEDIMENTS

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Abstract

A flume has been built for studying the erodibility of soils and sediments by gullying. It consists of two boxes containing undisturbed soil samples. One box is set above the other and water from a stilling tank passes over the soil of the upper box and falls onto the soil of the lower box causing lip and channel scour and plunge-pool erosion. The sediment is collected and measured, and a measure of erodibility related to discharge, length of test and sediment yield is thus available.

INTRODUCTION

The relative erodibility of soils and sediments is difficult to measure indirectly because resistance and hardness are difficult to specify in geomorphic terms (Chorley, 1966, p. 281 - 283), and strength in an engineering sense cannot bear a direct relationship to resistance to degradation (Rich, 1911) : yet it is often important to know the relative resistance to erosion of soils under different kinds of vegetation or land use. Accordingly a flume has been devised which will simulate gully erosion of soils and unconsolidated sediments. It has been used successfully to study erodibility of soils with a range of textures from clay to fine gravel, and of unconsolidated fine volcanic ashes to coarse pumice and rhyolitic gravels. Samples have been taken from areas under pasture, rough grass, and forest.

THE FLUME

The flume consists of four main components, shown in figure 1 as A, B, C, D, a reservoir and a collecting basket for sediments. Details of the construction are shown in figure 2. Each of the components A, B, C, D is fabricated from 2mm thick galvanised sheet steel. Box A has a removable bottom and removable sliding lid, and half of one end is open. Box D is smaller and one end is completely open; it too has a sliding lid. The box B is designed to fit on the upper rim of A when the sliding lid of A is removed. It has two plates which fit inside A between the side of the box and the soil sample. The bottom of B is angled at 5° (see figure 1). The stilling box C has four inlets for water at the back and a baffle plate to reduce turbulence. The water flows down the inclined chute. The reservoir used in the experiments so far is a 4,500 litre tank with four 25.4mm diameter gate valves at the bottom. Pipes from the valves lead into the stilling tank. The reservoir may be fitted with ballcocks at the inlet so that it can be kept full during the experiments. The sediment trap is a stainless steel wire-mesh basket with a mesh of 100 μ which contains a linen or muslin bag in which sediment is trapped. The flume may be assembled in a laboratory or in the open. The assembled units are shown in figure 1, supported by a slotted angle-iron frame.

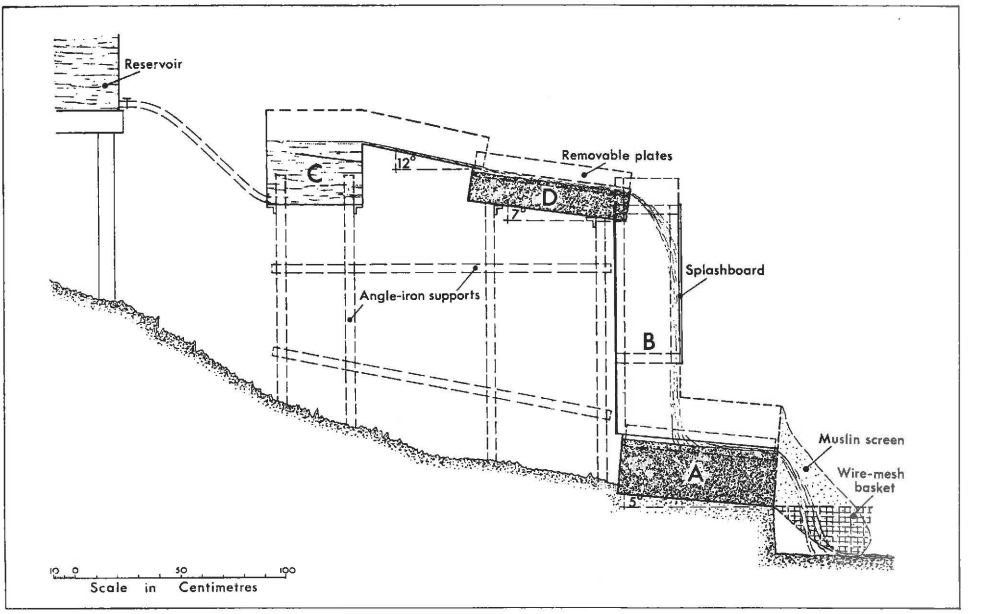

Figure 1. The components of the flume assembled for an experiment.

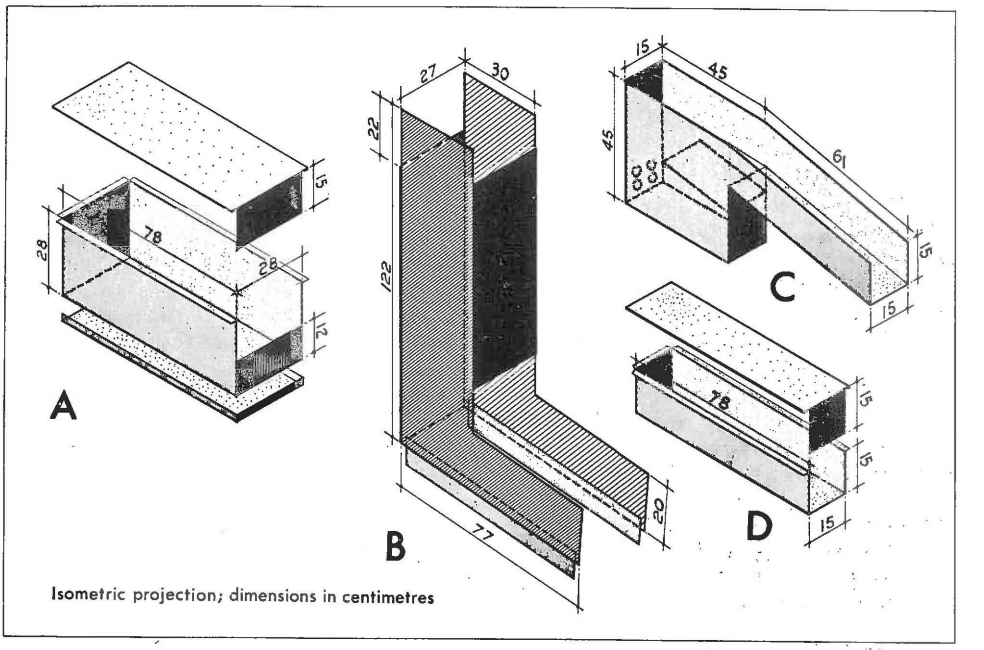

Figure 2. Dimensions of the main components of the flume.

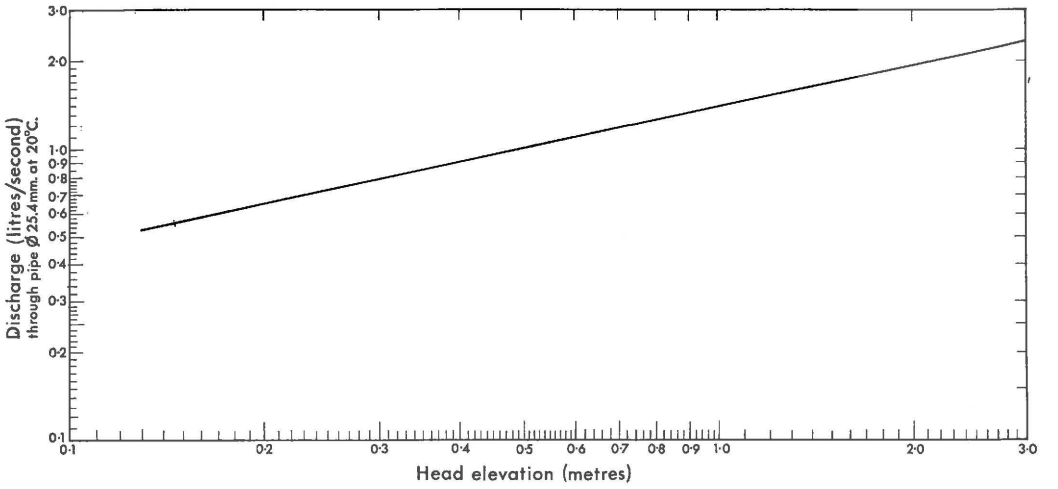

Figure 3. Discharge from a 4,500 litre tank, through a 25.4mm diameter pipe of one metre length at a temperature of 20°C, for various heads.

SAMPLE COLLECTION

To collect soil or sediment samples box A is placed on the ground with the bottom removed. A trench is then dug round the box and the box eased downwards as soil is cut away from its edge with a flexible long-bladed knife. It is important not to deform the box or shake the sample by hitting it. When the sample surface is just below the rim of the box the soil beneath the box is dug away and the lid and bottom slid on. The weight of a full box may be about 100 kg. To fill box D the lid is removed, the box is placed on the soil, a trench dug around it and the box then pushed horizontally into the resulting 'slice' of soil as the spare soil is cut away with a knife. The sliding lid is then replaced.

TESTS

For running a test the boxes of soil are placed in the frame and the sliding lids removed. The box B acts as a wind shield and as a deflector to keep the water falling onto the same part of the sample in A — as would happen in a waterfall in nature — , and to make it fall as a sheet rather than a column of water. Removable plates are then fitted to the rim of box D to prevent loss by splashing. Box D has a slope of 7° and box A one of 5° as these are slopes commonly occurring respectively above and below the heads of gullies in the areas of pumice gully erosion which are being investigated. The angle of 12° on the chute provides sufficient velocity for scour to occur on the surface of the sample in D. The reservoir has four outlets which thus provide four set discharges, and measurements of discharge are therefore not necessary once the discharge from the tank has been calculated. The discharge occurring at one outlet for different heads is shown in figure 3. Although it is not always possible, it is desirable to keep a constant head because a 4,500 litre tank with four valves open and a head of 2m. will only discharge for 18 minutes, which is not long enough to significantly erode a soil sample bonded by grass roots.

The test gives measures of channel erosion and lip erosion on A and D and plunge-pool erosion on A. The total weight of sediment removed is measured.

When samples are collected it is necessary to take core samples alongside the box samples because the box samples are destroyed in the test, and analyses of their physical properties cannot then be made. The following tests are made on samples : particle size, organic matter content, root volume, bulk density, shearing resistance, penetration resistance, macro- and micro-porosity, dry weight of vegetation on the soil, and soil moisture content.

Preliminary tests show that the flume can be used on a wide range of soils, with textures varying from clays to fine gravels, and from pastures and forests. Fluvial, and colluvial deposits can also be studied. The information gained can be extended in the field by determining the value of soil characteristics which are shown, by correlation analysis, to have a high significance for erosion.

ACKNOWLEDGMENT

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