DESIGN AND DEVELOPMENT OF RUNOFF AND SOIL LOSS MEASURING DEVICE

S. SANTHANA BOSU[1]. O. PADMAKUMARI[2] AND M. KOTEESWARAN[3]

[1,2,3] *Professors and Professor and Head, Dept. of Soil and Water Conservation, College of Agricultural. Engg., Tamil Nadu Agricultural University, Coimbatore-641 003*

ABSTRACT

For a systematic approach to quantify soil loss and runoff from agricultural fields, a standard device has to be evolved. The erosion plot equipment must be adequate to collect runoff and soil loss from the plot and to store all or a part for measurement and analysis. Thus a multislot devisor is designed and presented in this paper. It helps in the scientific assesment of the runoff and soil loss useful for dryfarming and soil conservation.

1. INTRODUCTION

Erosion is the greatest destroyer of land resources. In addition to losses in soil, many other problems are created by soil erosion like siltation of reservoirs, canals and rivers, deposition of unfertile material on cultivated lands, harmful effects on water supply, fishing, power generation and most important the destruction of fertile agricultural land. To design appropriate soil management systems and methods for erosion control, it is essential to have a clear understanding of the causes of erosion and quantitative information on the factors involved. Although rainfall erosion research began with the work of Wollny in Germany in the later half of the 19th Century, the systematic study of the soil loss prediction from agricultural fields was conducted in the United States beginning around the 1930s. Data for derivation and field use of equations were obtained from the field runoff plots. The first systematic and scientific approach to dry farming and soil conservation was made in India in 1923 at Manjiri, Bombay. A planned programme was initiated in 1933 with the sanction of ICAR schemes for dry farming research in Bombay.

2. MATERIALS AND METHODS

The measurement of runoff from the runoff plots can be accomplished either by collection of the entire runoff or an aliquot of the total runoff volume. In case of a very small runoff plot under medium to low rainfall areas, it may be possible to collect the entire runoff in a tank and measure it volumetrically. This method is very accurate but cannot be adopted in large plots where the runoff amount is generally quite large. This large quantity of runoff may require huge collection tanks which may be uneconomical and unmanageable. The size of the collecting tank and the cost can be substantially reduced by collecting aliquot and measuring it. The accurate sampling and measurement of aliquot is absolutely necessary for reliable results. This is accomplished by the use of devices like multislot devisors. The devisor consists of a number of slots of equal dimensions, out of which only one slot is measured. The equipment is based on the use of the multislot devisor and is one of the best sampling units we have today for quantitative measurements of runoff and soil loss.

3. RUNOFF ESTIMATES

The erosion plot equipment must be adequate to collect runoff and soil loss from the plot and to store all or a part for measurement and analysis. By knowing the area contributing to the runoff, the maximum runoff rate and amount were estimated by the use of long term weather records of the Meteorological Observatory, Tamil Nadu Agricultural University, Coimbatore. Since short duration intensities are the highest, an estimate was made for time of concentration which is the time required for all parts of the plot area to contribute to the maximum runoff rate measured at the bottom of the plot. Since five minutes is the smallest time interval generally used in calculating maximum rainfall intensities, the five minutes duration intensity was used to estimate the size of rate measuring equipment needed for bare and clean tilled plots. 100 per cent of a 24 hour duration rainfall amount was used for storage capacity and 100 per cent of the five minutes duration rainfall intensity was used for estimating maximum runoff.

The equipment listed as follows were designed and fabricated for the measurement of runoff and soil loss.

1. Boundaries around the plot to define the measured area.
2. Collecting equipment to catch and concentrate runoff from the plot.

3. Conveyance equipment to carry runoff to a sampling unit.
4. Sampling unit to aliquot the runoff and soil loss into manageable quantities.
5. Storage tanks to hold aliquot portions of runoff and soil loss for analysis.

4. ALIQUOT SAMPLING

Runoff of large storms invariably is too voluminous to sample directly for soil loss. Therefore a method of aliquoting is used, although use of the multislot devisor requires a large amount of labour. It is a near precision device that is quite reliable and time proven. The reason for the accuracy of the multislot devisor is the use of a sludge tank, thus requiring the devisor only of water and suspended sediment. In the case of multislot devisor, the design principles are (1) slot similarity of size, shape and position; (ii) approach channel cross-section dimensions, and (iii) approach flow smoothness, i.e. no sharp protruding edges to disturb the flow (Mutchler, 1963).

4.1 Design of multislot device and aliquot tank

(i) To calculate the rate of flow through multislot using five minutes duration intensity,

Assuming the max I_5 intensity = 150 mm/hr i.e. 5.91 inches/hr

$$\text{Runoff from unit plot } (72.6' \text{x} 6') = \frac{5.91}{12} \times 435.6 = \frac{2574.396}{12} \text{ cft}$$

$$\text{Therefore, rate of flow from unit plot } = \frac{2574.396}{60 \times 60 \times 12} = 0.0595 \text{ cft/sec.}$$

From the tabulation for "Capacities of standard multislot devisor" (Book ARS 41-79 of USDA), for minimum capacity of 0.09 cft/sec. the number of slots are three of size 4"x1/2".

ii) To calculate aliquot tank capacity

Using 24 hours duration amount of rainfall from the data available at the Meteorological Observatory, Tamil Nadu Agricultural University, Coimbatore, the single day maximum rainfall that occurred on November 21, 1979 was 107.9 mm. The scheme studies were conducted at Coimbatore, Pollachi and Veerappanur. Assuming Pollachi and Veerappanur received higher amount of single day rainfall than Coimbatore, the single day maximum rainfall was assumed as 125 mm.

$$\text{Runoff from unit plot} = \frac{125 \times 435.6}{25.4 \times 12}$$

$$= 178.64 \text{ cft}$$

Therefore, capacity of flow from one slot = 59.55 cft
(having three slot multislot devisor unit) = 60 cft app.

Assuming the first aliquot tank has a capacity of 27 cft, the size of the tank is 3'x3'x3'.

For the balance of 33 cft of runoff another aliquot tank was designed and installed with another three slot multislot devisor unit, so that the capacity was reduced to 11 cft. Hence, the size of the second aliquot tank was 3'x2'x2'. The figure of the runoff and soil loss measuring device as designed and fabricated is given in Fig.1.

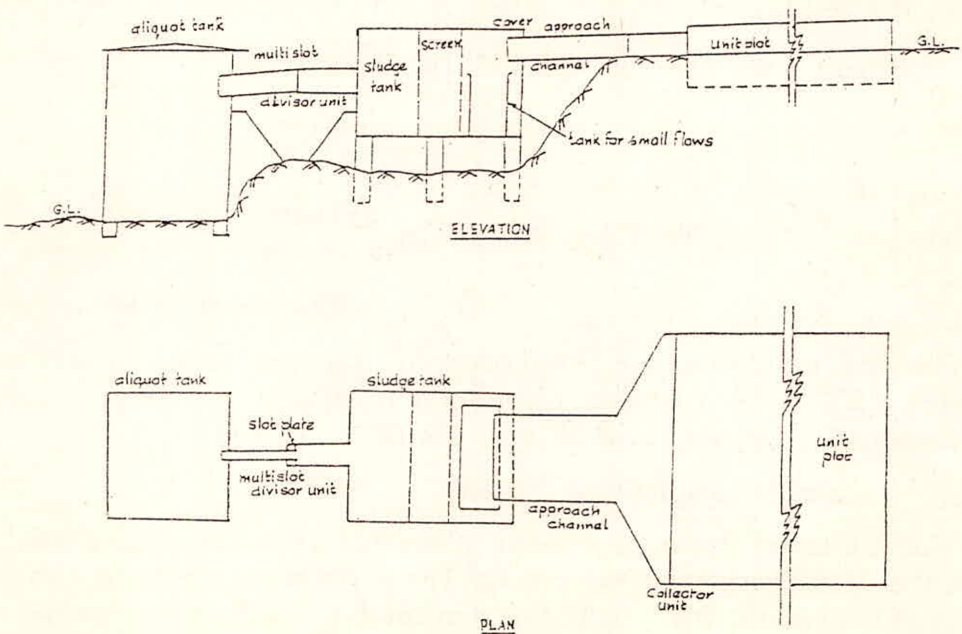

Fig.1 Runoff and Soil Loss Measuring Device

4.2 Procedure for Collection of Samples and Estimation of Soil Loss

In the experimental plots runoff and soil loss from the plots first fall into the tank for small flows. During heavy rains after filling up of tank for small flows, the excess overflows into the sludge tank. For very heavy rains, after filling up of the above two tanks the excess runoff passes through the multislot devisor unit. From the multislot devisor unit, one third of the flow is collected in the aliquot tank. To arrive at the runoff volume, the depths of collection in the individual tanks were collected in the individual tanks and were measured. For taking representative samples, the runoff collected in each tank viz.small flow tank, sludge tank and aliquot tank were thoroughly agitated and samples were taken in standard bottles. These samples were then evaporated in the laboratory and the amount of soil was measured gravimetrically to give soil loss in gm/ litre. This quantity was further multiplied by the total runoff volume and divided by 10^6 to give the total soil loss in tonnes per plot. Multiplying this by the size of the plot, soil loss in tonnes per hectare for that storm was worked out. The soil loss from all the storms during the year can be added to get the annual soil loss in tonnes/hectare/year.

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References

Mutchler,C.K. (1963). Runoff Plot Design and Installation for Soil Erosion Studies, USDA Hand Book. ARS 41–79.