Soil Erosion in India*

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CONTRASTS WITH AMERICAN DATA

EROSION losses are less where the rainfall is well distributed, and it is now commonly recognized that erosion has most serious consequences in arid tracts. A heavy monsoon has more effect upon sloping fields than it has on neighbouring grasslands, whereas in arid climates the smaller area of fields is more carefully terraced, but the neighbouring grazing grounds are more vulnerable to infrequent but heavy downpours. This may serve to explain an anomaly that occurs in run-off intensity data. American figures worked out by Ramser and frequently quoted show the following averages in cubic feet per second per square mile, and in contrast I also quote tentative data of the same sort for Indian conditions.

RUN-OFF IN CUBIC FEET PER SECOND PER SQUARE MILE*.

AMERICA.		PUNJAB.	
	Cusecs		Cusecs
Hilly timber, 10-30% slope	300	Terraced rice fields	50
„ pasture	620	Foothills afforested and	
„ cultivated ..	1040	with soil-catching small	
		dams	120
		Foothills scrub forest closed	
		to grazing	700
		„ open to grazing ..	1100
		„ disforested and	
		heavily grazed ..	1600

* Cf. *Current Science*, August 1937, author's review of Q. C. Ayres' *Soil Erosion*.

The American farmer using a motor-tractor keeps his fields large, and so the run-off from broad slopes of bare plough land is greater than from his paddocks of comparatively well clothed pastures. This also applies to Canadian and Australian average conditions and to parts of South Africa. On the other hand, the Indian peasant farmers have their fields in tiny and often well-terraced units which catch and hold the rainfall, whereas their grazing grounds are so misused and so badly protected with a mutilated plant cover that the run-off from them is far heavier. In the African dependencies, according to Sir Frank Stockdale's statement at a meeting of colonial officers held in Oxford in June 1937, "agricultural activity was as frequently to blame for erosion as overstocking with live-stock", so probably their run-off figures would be equally heavy for cropped land as for grazed land. Reliable data for run-off and erosion, and also for rainfall intensities and storm behaviour, are lamentably scarce even for our most important catchments, and a great field of work awaits the next generation of colonial research workers.

* Substance of a paper read before the Royal Society of Arts on May 3.

RAINFALL AND RIVER BEHAVIOUR

Mr. E. G. Bilham's paper on "Weather and Water Supply" read at the Public Works Congress, 1937, directs attention to the fact that even in Great Britain very few attempts have so far been made to correlate the loss of rainfall by evaporation, surface run-off, and seepage with the behaviour of streams. More work is required upon the actual fate of all the rain that falls upon a given type of plant cover and the contribution which this cover makes to the nearest stream in terms of surface and ground-water flow, before we can discuss intelligently the reactions of the larger rivers.

A study of the Ravi River flow records for the last twenty-five years carried out by the staff of the Punjab Irrigation Research Institute shows no significant indication of any gradual increase in number or intensity of floods nor any direct correlation of heavy floods with heavy rain. This is presumably owing to the fact that the heaviest floods arise from heavy snow-melt in the high inner hills, combining with a series of downpours falling on eroded ground in the foothills. The figures of winter flow do, however, indicate a continued deterioration in supplies available for winter irrigation. It is scarcely to be expected that a simple phenomenon such as the run-off of rain can be correlated exactly with the highly complex phenomena which go to make up the stream-flow of a large river. The Ravi River's catchment of nearly 15,000 square miles varies from 2,000 ft. to 20,000 ft. in altitude and contains several recognizable meteorological zones, so instead of looking for any correlation between rainfall and run-off for the whole, it would be better to study small individual sections and find out how each tributary reacts to the rain and snow which fall within its catchment. Unfortunately, the rainfall data in this case are for only one rain gauge for the 15,000 square miles!

NEW INDIAN STATISTICS OF EROSION LOSSES

Reliable run-off figures for forest and grassland are now available for the first time for Indian conditions. A technique of volumetric analysis of water and silt was worked out by the Punjab Irrigation Research staff at Madhopur in 1936 for a type of small isolated plot of undisturbed soil $3\frac{1}{2}$ sq. ft. in area, and this method has since been followed in forest plots at Nurpur in Kangra district. A battery of six plots gave three pairs, namely, (i) grass, (ii) grass and shrubs, and (iii)

bare soil, on a slope of 1 in 4 on an eroded hillside of poor Siwalik sandstone. The grass cover over all is distinctly poor, as it is recovering slowly from previous heavy grazing. The bare plots contain a little grass which has been kept clipped back with scissors. They thus simulate local grazing conditions to some extent, though we have not reproduced the destructive trampling action of cattle scrambling on a greasy hill-side; and the run-off from grazed areas must therefore be considerably heavier than the figures now reported.

Measurements reported from the Bombay Dry Farming Research Station at Sholapur (chief investigator, Mr. N. V. Kanitkar) show a loss of 115 tons of soil per acre per annum from a field of *jowar*, a *Sorghum* which is the most important combined grain and fodder crop in the Bombay Deccan. This loss was caused in a properly cultivated plot as a result of two very intense storms of 3.5 in. and 4.3 in. The total rainfall of 28 inches is usually fairly well distributed and no such intense storms occurred during the previous year when

measurements were started. The silt lost in these intense storms was particularly rich in valuable plant foods such as lime and potash, which were stolen by erosion, leaving the remaining soil much poorer. Of the various other kinds of plant cover tested, the amount of water lost in the run-off was not strikingly different where weed or crop cover was dense. The amount of soil lost where the weeds had been reserved in fallow was just one two-hundredths of the *jowar* plot, while the clean fallow of bare but uncultivated ground yielded 25 tons of soil per acre or 22 per cent of the *jowar* plot's loss. These astonishingly heavy losses of silt were

COMPARATIVE RUN-OFF FOR AMERICAN AND PUNJAB CONDITIONS.

American data from C. E. Ramser's curves (broken lines). Indian data from Pabbi Hills torrent measurements by Irrigation Branch (full lines).

The results of the first monsoon's catch is as follows :

PERCENTAGE OF RAIN WHICH RAN OFF :	Grass 80% cover	Grass and shrubs 90% cover	Bare soil, grass clipped every 3 days
Out of total of 46 in. on 32 wet days during July-October 1937 ..	7	5	25
Out of total of 5½ in. in 4 hours, the heaviest single storm ..	2.2	1.7	6
WEIGHT OF SOIL LOST PER ACRE :			
Carried away on 32 wet days ..	3,500 lb.	3,900 lb.	18,500 lb.
Carried away by a single storm (5½ in. rain) ..	260 lb.	307 lb.	3,511 lb.

These figures give one food for thought when it is realized that in a single storm the uncovered plots lost soil at the rate of 1½ tons per acre. This may be taken as a typical figure for all bare fallow fields in the foot-hills of northern India except properly levelled rice land, and they are definitely conservative for the average village grazing lands which suffer from trampling of cattle. The ordinary grazing lands also suffer from the accumulative action of shallow gullies cutting the surface on long slopes, a phase of erosion which is, of course, not reproduced in our small square plots.

from very gently sloping ground, the average slope being 1¼ per cent or 1 in 80, and the data are entirely reliable, having been collected from thoroughly isolated plots. I am indebted to Mr. Kanitkar and Dr. W. Burns for permission to use these figures.

The point which this experiment has brought out is that, under Indian conditions, good cultivation on even a slight slope is no better than bad cultivation for saving soil, unless it is protected by some form of contour ridging. The only sure way of reducing soil losses during exceptionally heavy storms is by contour ridging which is sufficiently deep to render each field a more or less self-contained catchment unit, so that cumulative run-off from a series of fields is prevented. The necessity for such protection is brought out by subsequent figures for these same plots in 1937, so far unpublished but furnished in a letter from Mr. N. V. Kanitkar, who reports that this same *jowar* plot has lost a total in the year of 133 tons per acre. This included one storm in which 2.13 in. of rain in half an hour removed the huge amount of 52 tons of silt per acre.