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Erodibility of hill peat

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The energy necessary to entrain soil in water depends on the soil strength. Once entrained, the settling velocity of the eroded soil in water is of fundamental importance to the processes of sediment transport and deposition. In this paper, stream power theory and transport concepts coupled with the equation of continuity were used to derive a transport-limited peat concentration. The ratio of the log of the actual sediment concentration in surface run-off to the log of the transport-limited sediment concentration was the index of erosion used. The value of this index is a measure of the sensitivity of peat to erosion by sheet flow. Four peats were subjected to a range of overland flow rates under two slopes in a laboratory flume. The peats represented peat farmed in a sustainable manner (Leenane), overgrazed peat (Maam), peat undergoing erosion (Newport) and peat which had undergone weathering following exposure by a landslip (Croagh Patrick). Both *in situ* and surface damaged slabs were studied. The results indicate that shearing and remoulding of a wet peat surface (e.g., by animal treading) and weathering of exposed drained peat surfaces predispose peat to erosion. Defoliation by overgrazing is considered to be of secondary importance.

Keywords: peat erodibility; sedimentology; sustainable farming

Introduction

Soil erosion by water results in: (i) the depletion of soil *in situ* and (ii) the transport of the resulting sediment to downslope and downstream areas. When sufficient energy is no longer available to transport soil particles in suspension or by saltation, net deposition occurs. Depletion of soil *in situ* is caused by the following erosion processes: detachment and re-detachment by raindrops, entrainment and re-entrainment by overland flow, accompanied by transport in sheet and rill flow (Rose, 1993). Detachment refers to the removal of soil from the original soil matrix by raindrop-induced shear

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stresses in the absence of any flow (Torri and Borselli, 2000). Some of this soil sediment settles back close-by and some may be splashed into the air to be captured in a shallow water layer as it falls back down. Re-detachment refers to rainfall detachment of already detached and deposited soil sediment. *In situ* soil always has some cohesion while the deposited sediment is loose and much more easily eroded as it does not have time to build up cohesive links with neighbouring particles (Rose, 1993). A similar reasoning applies to the entrainment of original soil, and its re-entrainment by overland flow following deposition.

Flow-driven erosion is commonly differentiated into sheet erosion and rill erosion. Sheet erosion can be caused by rainfall detachment/re-detachment and/or run-off entrainment/re-entrainment on a land surface. Detachment/re-detachment are dominant where the thickness of the water layer on the soil is less than 3 rain drop diameters (Rose, 1993). As the water layer thickens, the streampower increases in accordance with SDV, where S is the land slope and the product DV is the flux of water per unit width of plane surface, D being the thickness of the overland flow layer and V the water velocity. With an increase in the thickness of the water layer, erosivity of run-off increases and rainfall effects become unimportant. The erosive effects of rainfall and run-off depend on the soil cohesion. In erodible soils, a combination of heavy rainfall and run-off produces a greater soil loss than run-off alone due to the increase in turbulence of the run-off produced by the rainfall (Proffitt and Rose, 1991), except on steep (e.g., >5%) slopes. Where soil strength is dominant, due to soil type or reinforcement by a dense mesh of strong roots, the effects of a surface cover or canopy of low growing vegetation in reducing soil loss is secondary (Rose, 1993); in erodible soils a vegetation cover or canopy near the soil surface can limit rainfall effects. Likewise, a surface cover such as a mulch, by intercepting rainfall and slowing down run-off rate, is effective against both rainfall and flow-driven erosion.

Rills are small streams eroded out by water flow, fed by run-off from sheet flow. Erosion from rills is due to entrainment and re-entrainment by running water aided by mass movements of soil into the rill due to sidewall sloughing and slips, undercutting of sidewalls and head cutting of rills. Generally, the erosive power of flowing water in rills is greater than in sheet flow. This is due to the greater streampower in the rill (Marshall, Holmes and Rose, 1996).

The sedimentology of peat silt from milled peat fields has been investigated arising from concerns about its impact on salmonid spawning grounds in Ireland (Migniot *et al*., 1969). In windy weather, wind-blown milled peat from storage piles and harvesting grounds is trapped in drainage trenches and later re-entrained and transported by water in wet weather to streams, rivers and sedimentation basins where it settles out. The mean velocity for re-entrainment of peat sediment in the bottom of a river is about 0.15 m/s for 0.4 m depth of water; depending on depth of flow, this value should be adjusted upwards or downwards; e.g., for a 1 m depth of water the value would be 10% greater (Migniot *et al*., 1969). The critical shear stress (τ_0) for re-entrainment was estimated at 0.05 N/m^2 using measured velocities at different depths in a flume and applying the logarithmic velocity law; τ_0 for 0.1 mm diameter sand grains is 0.1 N/m^2 (Migniot *et al.*, 1969).

Mulqueen, Rodgers and Marren (2000) quantified hill peat erosion from a south-facing slope of a predominantly peat covered hillside catchment at Leenane, Co. Mayo, Ireland. They reported a mean annual sediment loss of 278 kg/ha (equivalent to 0.4 mm/y loss), which approximately balanced the build-up of peat from the accumulation of plant remains. They also reported on the erodibility of hill peat from four diverse sites in a laboratory flume under various degrees of remoulding, simulating treading damage (poaching) by hill sheep. They found that remoulding and weakening of the peat predispose it to detachment, entrainment and transport in flowing water.

Using theory developed by Rose (1993) and Yang (1996), theoretical developments in erosion are reviewed and a transport-limited peat sediment concentration is derived. The ratio of the log of the actual peat sediment concentration released from a flume or a small catchment to the log of the transport-limited peat sediment concentration gives an erodibility index (β). The numerical value of this index is a measure of the sensitivity of the peat to erosion by surface run-off, and may be a useful tool in environmental management.

Erosion theory

Water flowing overland or in a channel exerts a shear stress on the soil surface. This is expressed for a channel by

$$\tau = \rho_e \, g R_h S \qquad (1)$$

where τ is the shear stress (N/m^2), ρ_e is the density (kg/m^3) of sediment-laden water, g is the acceleration due to gravity (m/s^2), R_h is the hydraulic radius (i.e., the cross sectional area of a channel divided by its wetted perimeter (m)) and S is the slope of the channel (mm^{-1})

For sheet flow, R_h is replaced by D, the depth of the flowing water. The sediment-laden fluid density is (Marshall *et al.*, 1996)

$$\rho_e = \rho + \frac{\rho_s - \rho}{\rho_s} c \qquad (2)$$
$$= \rho + 0.62c \text{ (mineral soil);}$$
$$= \rho + 0.29c \text{ (peat soil)}$$

where ρ is the density of clean water, ρ_s is the density of solids in the soil (2650 kg/m^3 for mineral soil; 1400 kg/m^3 for peat soil) and c is the concentration (kg/m^3) of sediment in sheet flow. The density of peat is within the range quoted by Bell (1981).

Bagnold (1977) defined the stream-power (Ω) that may cause erosion as

$$\Omega = \tau V \qquad (3)$$

where V is the mean velocity (m/s) of flow and Ω is measured in W/m^2.

Streampower combines the effects of slope, water flux and the flow concentrating effects of rills. For sheet flow from equations (2) and (3) and with ρ substituted for ρ_e, the stream power is given by

$$\Omega = \rho g D S V \qquad (4)$$

where SV is the unit streampower, i.e., the rate of decline of potential energy of a unit weight of water (Yang, 1996).

A model of the entrainment and re-entrainment processes by overland flow is presented in Marshall *et al*. (1996). A threshold stream power (Ω_0) is required before any sediment is moved by water flowing over it. F is the fraction of the excess streampower ($\Omega - \Omega_0$) available to drive re-entrainment of deposited sediment or entrainment of *in situ* soil leaving the fraction (1–F) to dissipate in heat and noise; F has values of 0.2 for laminar flow and 0.1 for turbulent flow (Rose, 1993).

Flow is laminar when the Reynolds number, Re, is less than about 500 and is turbulent when Re is larger than about 2000 (van Dort and Bos, 1974). H is the fraction of original soil shielded from entrainment by deposited sediment and (1 – H) the fraction exposed.

At equilibrium, the rate of deposition equals the rate of re-entrainment of the deposited layer, yielding the following relationship (Marshall *et al*., 1996):

$$\frac{v_i c_i}{I} = \frac{HF}{g} \frac{\sigma}{(\sigma - \rho)} \left(\frac{\Omega - \Omega_O}{D} \right) \frac{m_{di}}{M_d} \qquad (5)$$

where v_i is the settling velocity (m/s) of the i^{th} class, c_i is the concentration (kg/m^3) of the i^{th} class sediment in the run-off water, σ is the submerged density of the soil (1,050 kg/m^3 for a peat soil), I is the number of class sizes into which the original *in situ* soil may be distributed for water erosion, m_{di} is the mass of sediment class i per unit area (kg/m^2) of deposited layer and M_d is the total mass of sediment per unit area of deposited layer (kg/m^2). Summing equation (5) over all i size classes, and since $\Sigma(m_{di}/M_d) = 1$, yields

$$c = \frac{HF}{\frac{\Sigma v_i}{I}} \frac{\sigma}{(\sigma - \rho)} \left(\frac{\Omega - \Omega_O}{gD} \right) \qquad (6)$$

Since H has an upper limit of 1, then c has an upper limit or maximum concentration (c_t) for given flow conditions. For sheet flow, substituting equation (4) into equation 6 and neglecting Ω_o in comparison with Ω, yields the transport-limited sediment concentration, c_t

$$c_t = \frac{F\rho}{\frac{\Sigma v_i}{I}} \frac{\sigma}{(\sigma - \rho)} SV \qquad (7)$$

For non-cohesive sediments, Yang (1996) found sediment concentration closely proportional to SV. Equation (7) may also be used to evaluate F. In rill erosion, c_t is defined (Marshall *et al*., 1996), by

$$c_t = \frac{F\rho}{\sum \frac{v_i}{I}} \frac{\sigma}{(\sigma - \rho)} \left(\frac{\Omega - \Omega_o}{gD} \right) \frac{W_b}{W_b + 2D} \qquad (8)$$

where W_b is the width of the rill, D is the depth of flow, and W_b+2D its wetted perimeter.

In cohesive soil, the specific energy, J, required for entrainment increases with soil strength and, as a result, the sediment concentration is less than the transport-limited concentration (Marshall *et al*., 1996). If c is plotted against streampower for particular values of J, a family of positive response curves starting from the origin and tending toward asymptotes (c_t) with increasing streampower is obtained (Rose, 1993). A similar suite of curves can be obtained (Marshall *et al*., 1996) from

$$c = c_t^{\beta} \quad (\beta < 1) \qquad (9)$$

where β is an empirical or approximate erodibility parameter (closely related to J) and can be determined from

$$\beta = \frac{\ln c}{\ln c_t} \qquad (10)$$

where c is the flux weighted concentration, determined from run-off plots or flumes. β will only exceed unity if other erosion mechanisms, such as rainfall impact or bed-load transport, add sediment to that from flow-driven erosion.

Materials and Methods

Peat erosion

A laboratory flume comprising a 150 mm × 150 mm galvanised steel channel 3 m long was built to accommodate relatively undisturbed 150 mm wide slabs of peat. Peat slabs at least 150 mm wide and 600 mm long were carefully excavated in the field. They were transported to the laboratory, trimmed and placed in the flume; each slab was butted against its adjacent slab or the head weir to form a continuous peat surface, 2.4 m long, and the slab was prevented from sliding out by a retainer plate. Overland flow was applied to this flume and the effects, on sediment concentration, of flow rate, slope of surface and surface disturbance of the peat examined. The slope of the flume was set at either 5° or 10°. Water was supplied from a constant head tank from which the flow rate was controlled by two 12.5 mm lever valves. Water from the tank flowed into a small chamber at the head of the flume and then over a weir onto the surface of the peat. At the tail end, the water flowed over the end of the peat surface and retainer plate into a tank which was placed on a balance. The balance was read and 250 ml samples of the run-off were taken every 1 or 2 min for the first 10 min and thereafter every 10 min until equilibrium sediment concentrations were obtained.

Slabs of peat were taken for erosion investigation from four sites: Leenane (where the field studies were conducted), Maam, Newport and Croagh Patrick. At Leenane, the field measurements (Mulqueen *et al.*, 2000) were carried out at the scale of the sub-catchment (0.5 to 20 ha) to include the effects of soil cover and rock outcrop, slope and breaks in slope, rilling and channelised flow and land management, which would not be evident at a plot scale of up to 1,000 m^2. The sub-catchment was 7.68 ha and located on the Teagasc Hill Farm at Glendavock townland, Leenane, Co. Mayo. This site was also the source of peat sediment for sizing and measurements of settling velocity. The peat depth varied from a thin veneer over most of the catchment to a maximum of 2.7 m in a concave valley. A canopy of grassy plants gave a 70% ground cover and there was also a more or less continuous layer of gelatinous algae on the surface. The entire farm, including the sub-catchment, was grazed by Scottish Blackface sheep stocked at a rate of 0.9 ewes/ha under a sustainable management system (Hanrahan and O'Malley, 1999).

Maam peat was also sampled as it was overgrazed and devoid of a vegetation cover in winter; Newport peat was taken from a sub-catchment of Lough Feeagh near Furnace, some of which was undergoing significant erosion. Croagh Patrick peat was used as it had developed on a surface left bare and subject to weathering after a landslip. This peat had no plant growth and had developed a blocky structure due to weathering under ambient conditions. It was not possible to retrieve slabs or blocks of Croagh Patrick peat due to its blocky and brittle nature; instead a 25 mm layer of the blocky peat was placed on an existing peat slab and compacted lightly to a level surface, resembling on-site conditions. With the exception of Croagh Patrick peat, all peats selected were very slow draining with hydraulic conductivities <10 mm/d when tested in the saturated state.

The rainfall at Leenane is among the highest in Ireland; annual average rainfall as measured on the lower slopes at about 30 m OD amounting to 2,500 mm is distributed throughout the year with lowest monthly values of 100 to 200 mm in April through September and the highest (up to 465 mm/month) in October through January. For example, the rainfall in October 1995 was 435.8 mm with a maximum daily value of 53.4 mm and there were 7 days with daily rainfalls in excess of 25.4 mm. Rainfalls at Maam, Newport and Croagh Patrick are of a similar order.

The surfaces of the peats in the flumes were disturbed by pushing steel rods into them to simulate punching failure of the

Table 1. Disturbances used in flume tests

Disturbance	Hole diameter (mm)	Spacing along flume (mm)	Spacing across flume (mm)	Rod type
1	3	100	30	smooth
2	3	30	25	smooth
3	6	30	50	threaded
4	20	40	50	threaded

peat by sheep hooves. Four degrees of disturbance, including zero disturbance, were employed (Table 1). The applied disturbance caused compaction and remoulding of the peat, reducing its cohesion at the surface and rendering the peat more liable to erosion by flowing water.

Flow rates were set at 0.05, 0.1, 0.2 and 0.3 L/s over the undisturbed peats at slopes of 5° and 10°, and at 0.2 L/s only over the disturbed peats at a slope of 10°. The variables measured in each test were the slope of the flume, the rate of flow (m^3/s) and the sediment concentration (mg/L). The depth of flow, D, was derived using the Manning equation (Chow, 1959)

$$Q = \frac{1}{n} S^{0.5} D^{1.66} w \tag{11}$$

where Q is the measured rate of discharge (m^3/s), n is the Manning roughness number, S is the tangent of the slope angle (5° or 10°) of the flume, D is the depth (m) of flow and w is the width of flume (0.15 m). The Manning roughness number was assigned to the soils after visual inspection of the soils using values from Chow (1959).

Having derived D, the velocity of flow was computed from V=Q/A where A is the cross section of the flow area (wD). F, the fraction of excess streampower available to drive entrainment or re-entrainment, was assigned a value of 0.2, as all calculated Reynolds numbers were less than 2,000.

Sediment settling velocity

Samples of peat sediment were taken from a collection chamber at Leenane. Particle size distribution was measured by sieving under water using a nest of sieves with decreasing mesh size in accordance with the British Standards (BS 1377, 1990). The peat retained on each sieve was washed off into a beaker, filtered and dried. Particle size distribution was expressed as a grading curve.

Particle settling velocities were determined using the modified bottom withdrawal tube (BWT) method (Lovell and Rose, 1988) and incorporating constructional and operational details from Vanoni (1975). Settling velocity is the terminal velocity attained by a particle settling under gravity in a fluid (Torri and Borselli, 2000). It depends on the size, density, shape and surface texture of the particle, on the viscosity, density and degree of turbulence of the fluid, and on the distribution and concentration of other particles in the fluid (Lovell and Rose, 1988). A BWT tube was made from polyethylene tubing and the bottom was drawn down to an 8 mm nozzle by welding a funnel to it. A 75 mm length of 15 mm bore rubber tube was fitted to the nozzle and closed off using a 'snap lock' pinch clamp to enable quick withdrawals. The BWT was calibrated by marking off 0.9 m on the straight portion and measuring the volume contained between the calibration marks. One ninth of this volume was then added to the drawn-down end of the tube making the bottom of the water meniscus the 0.1 m mark. The BWT was then marked off every 0.1 m to the 1 m mark. An estimated amount of wet peat sediment and water to give the desired concentration (225, 907 or 1,946 mg/L) approximately and volume (to bring the meniscus to the 1.0 m mark in the BWT) were placed in a 5 L flat-bottomed round flask. The flask was then agitated to produce a uniform dispersed suspension that was poured quickly and carefully into the sloping BWT, which was corked when full. In order to dislodge peat particles that would have settled in the tube nozzle during pouring, the corked BWT was tilted to about 30° with the nozzle upwards (Lovell and Rose, 1988). Particles from the nozzle then slid along the length of the tube and with additional tapping and rotating of the tube about the horizontal, a uniform suspension was obtained. The BWT was uncorked and then quickly mounted vertically at time t_0. The 'snap lock' was opened ten times, e.g., at 0.5, 1, 2, 4, 8, 16, 32, 64, 128 and greater than 128 min; approximately 0.1 of the initial volume was discharged each time. Since it was not found possible to withdraw an exact 0.1 m at each opening, withdrawals were collected in numbered conical flasks which were measured for volume and filtered. The filtered sediment was dried at 50 °C for 24 h. The volumes of suspensions and masses of peat silt were accumulated to give the total volume and mass respectively, from which the concentration of the suspension was derived. The settling velocity was then calculated using the improved approximate method of Anon. (1943), detailed in Lovell and Rose (1988).

Results

Particle size and settling velocity

About 50% of the eroded peat particles were finer than 0.2 mm while about 10% were finer than 0.035 mm (Figure 1). The mean settling velocity (V_{50}) of the Leenane peat sediment for sediment concentrations of 225 and 907 mg/L were similar and varied from 2.2 to 2.5 mm/s

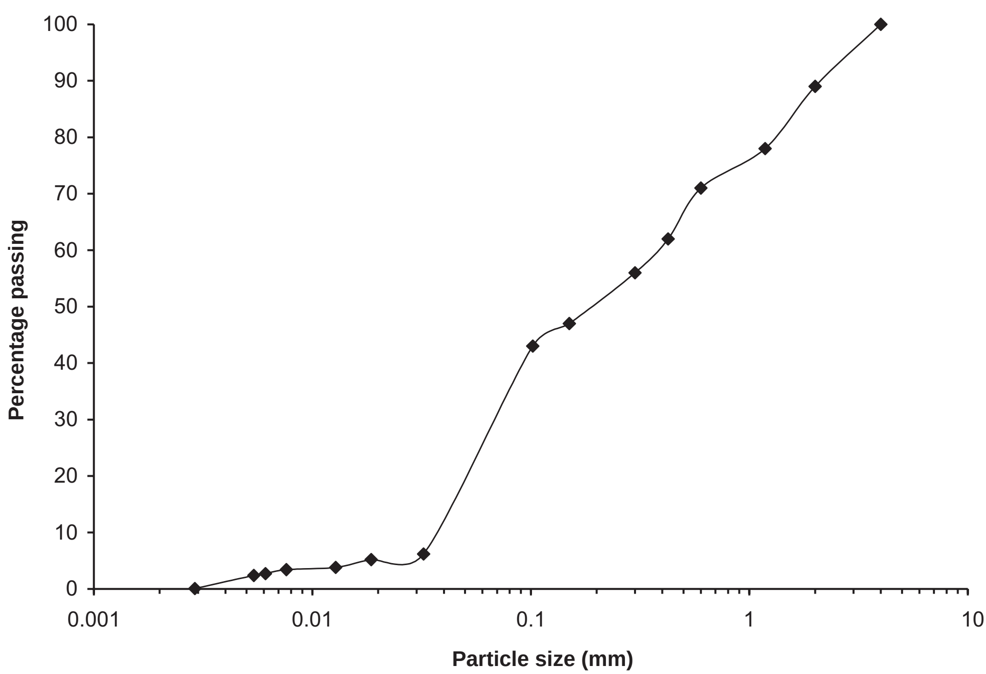

Figure 1. Grading curve for eroded hill peat (Leenane site).

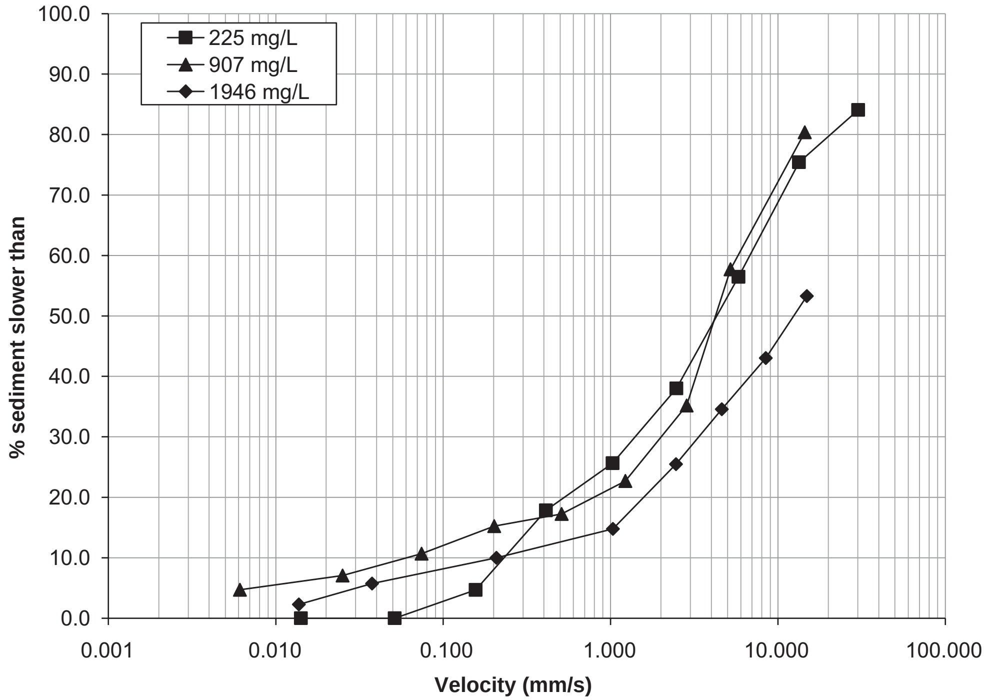

Figure 2. Settling velocity curves of Leenane peat suspensions for three different concentrations.

(Figure 2). The V_{50} for the 1,946 mg/L sediment concentration increased to 5.5 mm/s, indicating aggregation of the sediment concentration.

Erodibility

Results in Table 2 show that unit stream-power (SV) was lowest for the Leenane peat reflecting the greater (70%) ground cover by grassy vegetation and resulting surface roughness causing an increase in the depth of water flowing downslope. The mean (C_{mean}) and maximum (C_{max}) concentrations of sediment from the Leenane and Maam peat surfaces were low compared to the Newport and Croagh Patrick peats, showing that the latter two peats are erodible. While β_{mean} values for Leenane and Maam were ≤0.17, β_{mean} values for Newport were in excess of 0.30 for three of the flow tests. β_{max} followed similar trends with three high values from Newport varying from 0.53 to 0.70. The results show that both the grassy Leenane peat and the defoliated but gelatinous algae-covered Maam peat are entrainment-limited due to their high shear strengths (26 and 13 kPa, respectively). The Newport and the strongly weathered Croagh Patrick peats are erodible. Values for β are not quoted for the Croagh Patrick peat in Table 2 as the settling velocity curves were calculated from the Leenane peat, which was considerably different in texture to the Croagh Patrick peat.

Effect of disturbance on erodibility

Table 3 shows results for the erodibility of peats from Leenane, Maam, Newport and Croagh Patrick sites after they were disturbed. Both Leenane and Maam peats showed reduced resistance to erosion in

Table 2. A comparison of erodibility for four *in situ* peats from four sites

Site	Slope (°)	Flow rate (L/s)	Manning roughness number (n)	Depth of flow (mm)	SV[a] (m/s)	Sediment concentration[b]			Erodibility index	
						C_{max} (mg/L)	C_{mean} (mg/L)	C_t (g/L)	β_{max}	β_{mean}
Leenane	5	0.05	0.042	2.5	0.011	4.3	2.3	11	0.16	0.09
	5	0.1	0.042	3.8	0.015	11.5	4.2	15	0.25	0.15
	10	0.05	0.042	2.0	0.028	12.7	3.4	28	0.25	0.12
	10	0.1	0.042	3.1	0.038	13.0	5.0	37	0.24	0.15
	10	0.2	0.042	4.7	0.050	5.8	3.4	48	0.16	0.11
	10	0.3	0.042	6.0	0.058	8.4	4.3	57	0.19	0.13
Maam	5	0.05	0.019	1.6	0.018	13.4	5.5	18	0.26	0.17
	5	0.1	0.019	2.4	0.024	6.0	2.0	23	0.18	0.07
	10	0.2	0.019	2.9	0.080	18.5	4.4	77	0.26	0.13
	10	0.05	0.019	1.3	0.046	12.6	3.6	45	0.23	0.12
	10	0.1	0.019	1.9	0.060	48	4.9	59	0.35	0.14
	10	0.3	0.019	3.8	0.094	6.0	3.8	91	0.16	0.12
Newport	5	0.05	0.019	1.6	0.018	117.5	44.5	18	0.48	0.38
	5	0.1	0.019	2.4	0.024	462	21.9	24	0.60	0.30
	10	0.1	0.019	1.9	0.060	366	12.8	59	0.53	0.23
	10	0.3	0.019	3.7	0.094	3170	73.6	91	0.70	0.37
Croagh Patrick	5	0.05	0.010	1.1	0.027	295	135.6	-	-	-
	5	0.1	0.010	1.6	0.036	1243	458	-	-	-
	10	0.1	0.010	1.3	0.089	356	36.9	-	-	-
	10	0.3	0.010	2.6	0.138	3910	264.3	-	-	-

[a]Unit stream power.

[b]C_{max} (C_{mean}) = maximum (weighted mean) concentration in run-off; C_t = transport-limited sediment concentration.

Table 3. Estimates of the erodibility parameter (β) for disturbed peats[a]

Site	SV[b] (m/s)	Sediment concentration[c]			Erodibility	
		C_{max} (mg/L)	C_{mean} (mg/L)	C_t (g/L)	β_{max}	β_{mean}
Leenane	0.050	146	14	48	0.46	0.24
Maam	0.080	1326	106	78	0.63	0.41
Newport	0.080	5440	585	78	0.76	0.57
Croagh Patrick	0.117	10 042	950	-	-	-

[a]Disturbance (see Table 1), Slope 10°, flow rate 0.2 L/s.
[b,c]See footnotes to Table 2.

the disturbed state. The mean sediment solids concentration of the run-off waters from the Newport and Croagh Patrick peats were still substantially greater than those from the Leenane and Maam peats. Complete remoulding, as might happen at sheep feeding facilities, would be expected to yield sediment concentrations closer to the transport-limited value as indicated by the behaviour of the disturbed Newport peat.

Distribution of sediment in an erosion event

Figure 3 shows sediment run-off measurements in the flume. Each run-off test took place 24 h after the previous event so that the peat was in a similar saturated state at the start of each event. It was noticeable that the sediment concentrations were highest by orders of magnitude in the first minute of each event. The much higher initial sediment concentrations for

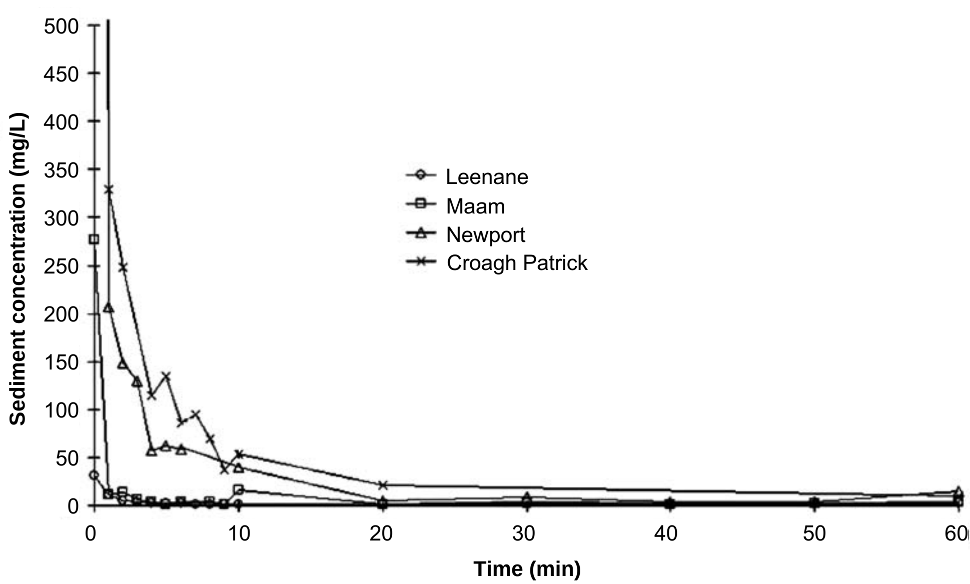

Figure 3. Sediment concentrations from flume tests on each of four peats after disturbance 4 (maximum sediment concentrations 5440 and 10 042 mg/L for Newport and Croagh Patrick, respectively). See Table 1 for description of disturbance used.

Newport and Croagh Patrick peats are evident. Further work is required to understand the mechanics of this erodibility.

Discussion

Settling velocities for eroded hill peat and water-transported milled peat were similar, with eroded hill peat having mean settling velocities slower than 2.2 to 2.5 mm/s for sediment concentrations less than 1,000 mg/L. These are to be compared with the values of 0.55 to 1.55m/s for wind-blown milled peat sediment (Migniot *et al*., 1969), reflecting the larger size of the water eroded peat sediment. In comparison, as would be expected from a consideration of their specific gravities, mineral soils have much higher settling velocities: the V_{50} for a dispersed soil (e.g., a sodic soil) is about 15 mm/s, for a well aggregated vertisol soil is about 40 mm/s and for a sea sand is about 65 mm/s (Lovell and Rose, 1988). As a result of its low density, the critical shear stress for entrainment of peat is less than that for mineral soils (Migniot *et al*., 1969).

Streampower values employed in the flumes were high and were well in excess of the values required to impart the critical shear stresses to induce erosion, confirming the high resistance of virgin fibrous peats to erosion.

The calculation of β assumes an approximate steady-state has been achieved in the erosion event. The β_{mean} values, reported in Tables 2 and 3, are in line with the theoretical origin of β. Calculating β using the maximum value of sediment concentration achieved early in the erosion experiment, whilst not strictly valid in terms of basic theory, does have practical utility. The use of β_{max} does quantify the rapid early loss of sediment in the erosion event (Figure 3). As the sediment lost early in a runoff event is high in sorbed nutrients (Rose and Dalal, 1988), β_{max} is a useful parameter to emphasise soil erodibility.

Conclusions

The studies indicated that the physical state of the peat is the primary factor predisposing to erosion. Shearing and remoulding of the peat by animal treading (poaching) – as simulated in the flumes by driving threaded rods through the surface of the peat – and weathering-induced cracking of exposed peat surfaces along sheep tracks and land slips predispose the peat to erosion. Defoliation is thought to be of secondary importance in promoting erosion due to the resistance offered by the strongly fibrous nature of the top layer of many peats, as indicated by the low value of the erodibility parameter, β, for defoliated Maam peat.

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