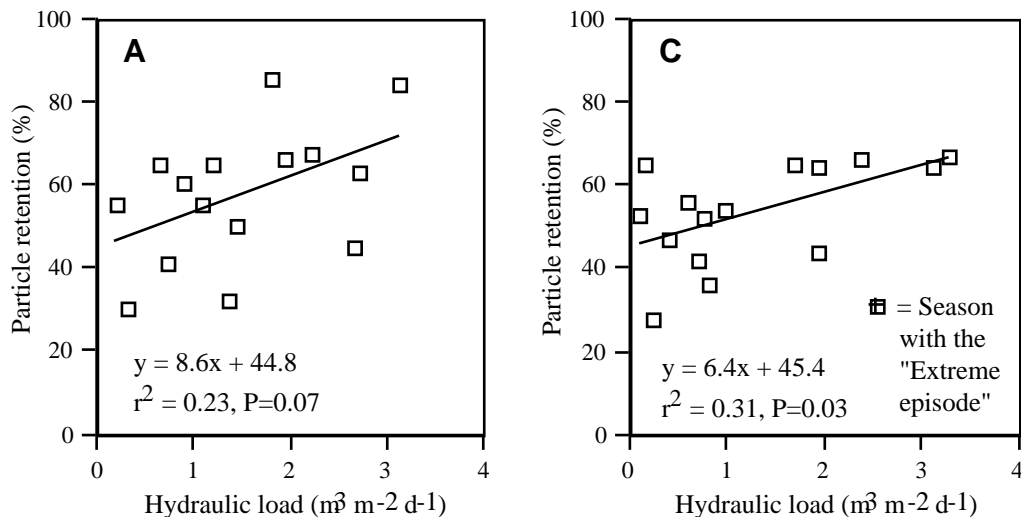


The Influence of Hydraulic Load and Aggregation on Sedimentation of Soil Particles in Wetlands

Abstract - Loss of soil particles from arable land to streams and lakes negatively affects water quality. When initiatives to mitigate soil erosion are insufficient or fail, constructed wetlands (CWs) could be a *last buffer* to mitigate pollution. The objectives in this study were to determine the influence of aggregation on clay sedimentation in CWs, and evaluate the prediction performance of two commonly used retention models, based on hydraulic load and particle sedimentation velocity. Retention was measured three ways, with (i) water flow proportional sampling systems in the inlet and in the outlet, (ii) sedimentation traps and (iii) sedimentation plates. Surface area of the wetlands was 0.03 to 0.07 % of the watershed, which consisted of silty clay loam (18-33 % clay). Some runoff episodes, usually at high runoff rates, accounted for a relatively high proportion of total sedimentation. Thus 80 % of the particles were retained from less than 44 % of the total runoff. Constructed wetland performance increased with increased hydraulic load or decreased detention time. The clay content in the CW sediment reflected the clay content in the arable soil. Actual CW sediment exceeded model estimates 2.5 to 8.2 times, depending on wetland size and runoff. The probable reason for the prediction error is clay particles entering the wetlands as aggregates. Constructed wetlands should be located in small streams to avoid break up of aggregates, and a reduction in retention efficiency.

Reference: Braskerud, B. C., H. Lundekvam and T. Krogstad, 2000. *The Impact of Hydraulic Load and Aggregation on Sedimentation of Soil Particles in Constructed Wetlands*. Journal of Environmental Quality 29 (6): 2013-2020.



Seasonal sedimentation of soil particles as a function of hydraulic load in Constructed Wetlands A and C. Increased runoff did not result in decreased particle retention, as expected.

The retention of soil particles is a key factor, since phosphorus and many other pollutants are mainly particle bound. It is a general agreement that particle sedimentation velocity, runoff and pond or wetland surface area influence the retention performance. This can be expressed in a commonly used model. For fully developed turbulence, the relative retention, E (%), is (e.g., Chen, 1975):

$$E = 100 [1 - \exp(-w AQ^{-1})] \quad [1]$$

where w is the particle settling velocity (m s^{-1}), A is the constructed wetland (CW) surface area (m^2), and Q is the runoff from the pond ($\text{m}^3 \text{s}^{-1}$), and \exp is the value of e (2.718..).

Sedimentation velocity is estimated by Stoke's Law for water temperature 7°C , and specific gravity of particles 2.65 g cm^{-3} . As an example, Fig. 2 shows that the predicted average retention of $2 \mu\text{m}$ particles, which is the largest clay particle, should have been 17 % for the average AQ^{-1} -value $76000 \text{ m}^2 \text{ m}^{-3} \text{ s}$. The hydraulic load decreases to the right hand side in the figure. Observed retention of clay particles in composite sample events are points in Fig. 2.

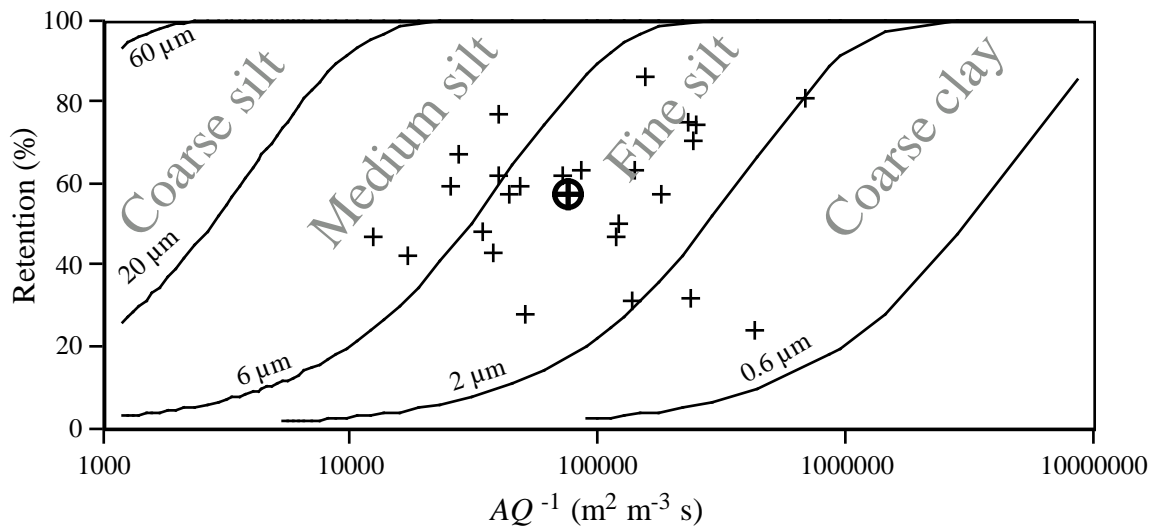


Fig. 2. Predicted retention of five grain sizes (lines) and observed retention of clay (+) in CW-A as a function of inverse hydraulic load. Large symbol gives average observed AQ^{-1} and average observed clay retention.

The average observed clay retention was 57 %, which is more than three times higher than predicted by [1]. Since average A , Q and E is known in every composite sample, [1] can estimate w . The data in Fig. 2 show that the clay particles behaved as fine silt and medium silt

with respect to sedimentation velocity. Several investigations show that particles in streams and rivers are transported as flocs or aggregates (e.g., Droppo and Ongley, 1994; Eisma, 1993). Floc and aggregate are often used synonymously, because they may be difficult to distinguish (Droppo and Stone, 1994). However, their origin is different: aggregates are formed as a result of processes in the soil, while flocs are formed in the watercourse.

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