How to Assess Degradation of Freshwater Communities due to Hydromorphological Changes

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How to assess degradation of freshwater communities due to hydromorphological changes

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Background

Man-made modifications to in-stream channel morphology are one of the main reasons that rivers do not achieve good ecological quality. Channelisation, dredging and weed cutting have seriously degraded habitat diversity thereby excluding some species and reduce numbers of others. In a Water Framework Directive context these are known as hydromorphological pressures and to mitigate these pressure are identified as being of key importance in fulfilling the Directive.

The current physical structure of streams and diversity of biological communities are closely linked past and present human activities in the entire catchment. Human activities influence stream ecosystems on multiple scales, ranging from direct manipulation of the in-stream environment on the stream reach to altering the landscape and land use in the catchment thereby influencing the hydrological pathways and morphological structure (Vannote et al., 1980; Frissell et al., 1986; Fitzpatrick et al., 2001; Allan, 2004). Past and present disturbances act simultaneously with different intensity on the stream ecosystem elements and it can thus be difficult to distinguish the exact disturbance from the individual stressors on the biotic communities (Lane & Richards, 1997; Harding et al., 1998; Allan, 2004).

Thesis 1: Physical-biological coupling are important in determining freshwater communities

The scientific literature reports many linkages between individual parameters (substratum, current velocity etc.) describing the in-stream physical environment and different attributes of the macroinvertebrate community. On a fine scale using high resolution measurements without other confounding factors, the importance of physical-biological coupling in streams have been shown albeit many aspects are still not fully understood (Hart & Finelli 1999). One reason is that numerous physical factors interact across different temporal and spatial scales, resulting in very different biotopes (riffles, pools etc.) as well as inducing variation within these biotopes. One example of the latter is shown in figure 1 as the response of two macroinvertebrate metrics (total abundance and EPT taxa abundance) to mean particle size varied considerably between to adjacent riffle biotypes in the same stream. The majority of studies have shown that diversity and abundance of macroinvertebrates increase with particle size as this increase habitat complexity and volume of interstitial spaces. In one riffle (B and D) there was the expected positive relationship between particle size and macroinvertebrate metrics whereas there was no relationship in the other riffle (A and C), the reason being that it was consolidated by fine sediments reducing habitat availability. This study illustrates that even within the same biotype that would appear completely similar when visually assessed there can be considerable differences in the physical-biological coupling.

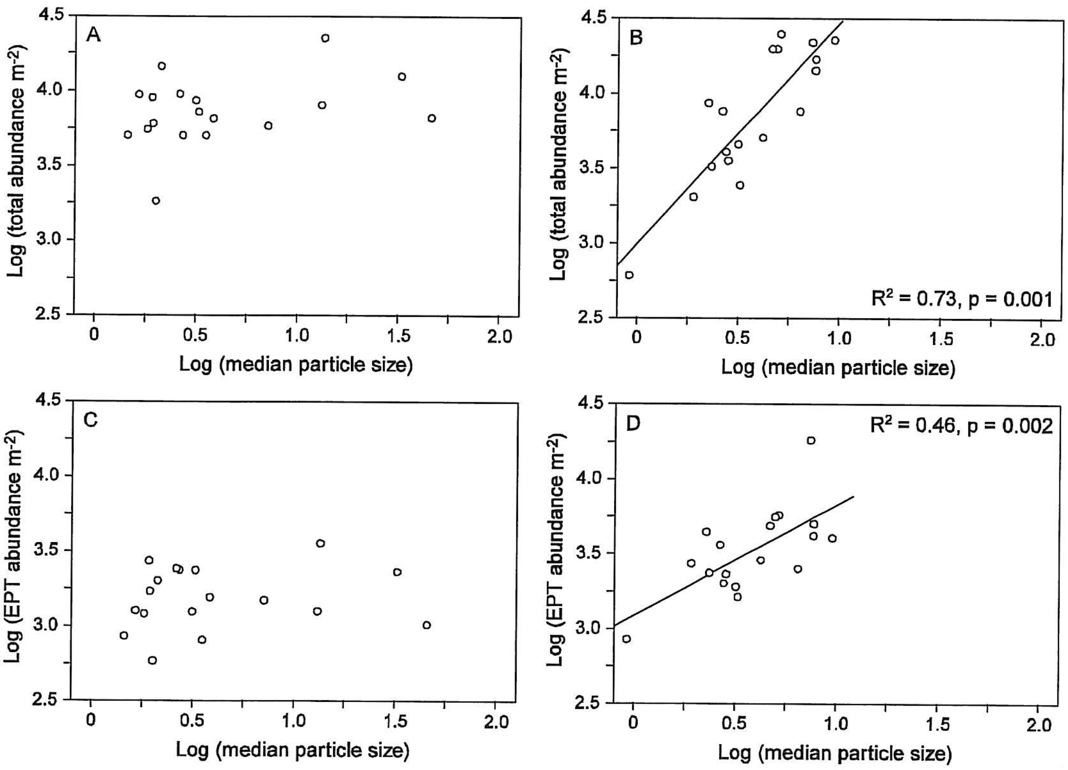

Fig. 1: Relationship between median particle size and total macroinvertebrate abundance/EPT abundance in two riffles spaced 100 m apart in the same 3. order stream. A,C is the upstream riffle whereas B,D is the downstream riffle. From Pedersen & Friberg (2007).

Thesis 2: Multiple stressors interact and this will influence impacts of hydromorphological degradation

One key issue when assessing the influence of hydromorphology is that interpretation of results is often confounded by multiple stressors influencing freshwater communities. Typically, streams that have undergone a high degree of habitat degradation or alterations of flow regimes will be situated in areas with multiple anthropogenic pressures. A recent analysis of 1127 stream sites in three European countries showed that the strongest relationship to a biological metric (ASPT) was found when including both land use, chemistry and habitat modification in a multiple regression (Table 1). In addition, stressors can interact in a synergistically manner and increased concentrations of easy degradable organic matter will have a more detrimental impact in a habitat degraded stream because number of reactive surfaces and re-aeration capacity are reduced (Andersen, 1994).

Table 1: Relationship between the macroinvertebrate based metric ASPT and explanatory environmental variables (PTOT=total phosphorous concentration; ARABLE=percentage agriculture in the catchment; MD=morphological degradation). Data from the EU REBECCA project (SSPI-CT-2003-502158).

Metric	Countries	Relationship	R^2
ASPT	Sweden Slovakia Denmark	y = 5.26-3.33PTOT-0.014ARABLE+2.32MD	0.61

Thesis 3: Hydromorphology can be assessed

The linkage of reach scale physical parameters and biotic samples on sites only disturbed by physical alterations are scarce. There has been moderate success in linking biota with the currently used habitat surveys which is exemplified by the generally weak relationships found when investigation the relationship between morphological degradation and number of EPT families in 1541 stream sites from four countries (Figure 2). This is partly due to the mixed nature of pressures acting of a river reach and the habitat surveys using parameters of at least two spatial scales. It furthermore reflects that methods for sampling macroinvertebrates often are on a different scale to that of the hydromorphological assessment and that the sampling strategy was developed to target mainly organic pollution. At present, a few assessment systems that target impacts of low flow (Extence et al. 1999) and degraded hydromorphology (Barbour et al. 1996, Lorenz et al. 2004) do exist but they are not generally applicable and could be further developed. Therefore, the development of more indicator systems sensitive to hydromorphological degradation, using appropriate sampling techniques, will be a key issue in future.

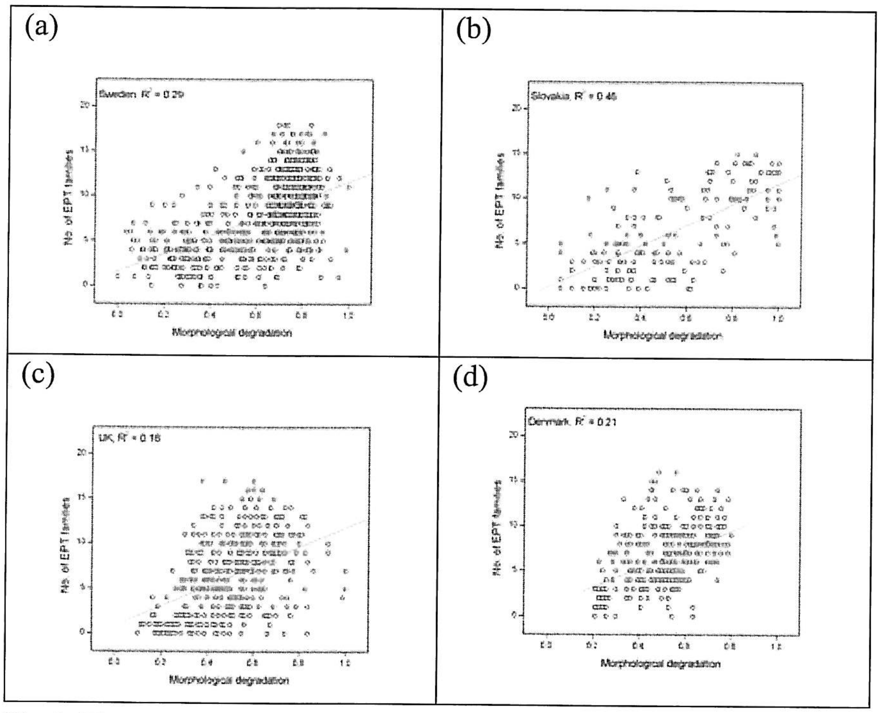

Fig. 2: The number of EPT families along a gradient in hydromorphological quality in 4 countries, (a) Sweden, (b) Slovakia, (c) UK, (d) Denmark. Data from the EU REBECCA project (SSPI-CT-2003-502158).

Recommendations & perspectives

Hydromorphological degradation is one the most important pressures on European and imposes a serious risk to freshwater communities either when acting alone or in combination with other pressures. Impairment of hydromorphology in river ecosystems will significant reduce its resistance towards other pressures on the ecosystem. Hydromorphology are currently assessed using a range of techniques that are suboptimal as they lack appropriate sensitivity as well as the ability to quantify the importance of individual pressures. There is an urgent need to develop refined and updated assessment systems targeting hydromorphology.

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Terrestrial-aquatic linkages and how recovery of riparian zones can improve ecological quality, assessment of pressures on stream ecosystems with specific emphasis on hydromorphology, interactions between organism groups and ecosystems function as indicator of impairment, global changes impacts on aquatic ecosystems and biodiversity