Characterising impacts on receiving waters of contaminated sediments derived from highway runoff: Field survey

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Introduction

Fig. 1: M40 motorway, which discharges runoff into Horse Brook, one of the sites used for this study.

- Highway runoff contains a complex mixture of contaminants from vehicles and highway-maintenance; many of which are associated with fine particulate material.
- Previous studies have demonstrated that highway runoff can have a major impact on the ecology of receiving waters and that the major contaminants of concern are metals and PAHs[1].
- However, the extent of the problem is unknown and it is unclear how receiving water hydrology and biology mitigate impact.
- Here we report on the first phase of a detailed study to understand the fate, behaviour and effects of highway-derived sediment on the ecology of receiving waters, with a view to devising assessment and prediction procedures.

Aim

To compare the impact of highway-derived contaminated sediments on the ecology of sediment-accumulating and sediment-dispersing receiving waters.

Methods

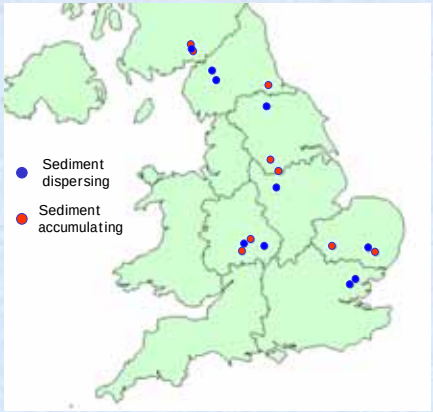


Fig. 2: Geographical distribution of the 19 study sites.

- Traffic density information, highway drainage plans and historical survey data were used to identify UK rivers at risk from highway runoff.
- Site selection criteria were:
  - traffic flows >30,000 vehicles per day;
  - lack of pollution reduction devices;
  - discharge into small river/stream;
  - diverse community upstream of discharge.
- Nineteen study sites were selected, of which 9 were sediment dispersing and 10 sediment accumulating (Fig. 2).
- Macroinvertebrate surveys were performed at locations upstream and downstream of highway discharges.
- Sediment samples were collected from sediment accumulating sites and analysed for metals (Cu, Cd, Zn, Al) and PAHs (fluoranthene, pyrene).

Results

- Highway runoff did not have the same impact on macroinvertebrate communities at sediment accumulating and sediment dispersing sites (Mann Whitney test, $p < 0.05$).
- Species richness was reduced downstream of highway runoff discharges at sediment accumulating sites, but not at sediment dispersing sites (Fig. 3).
- There was a shift in community composition downstream of discharges at sediment accumulating sites towards fewer amphipods and gastropods and more bivalves, dipteran larvae and leeches (Fig. 4).
- Sediments collected from sites receiving highway runoff had elevated concentrations of metals and PAHs (Fig. 5).
- Fluoranthene and pyrene were only detected in downstream sediments, which also contained significantly higher concentrations of copper cadmium and zinc (One-tailed t-test, $p < 0.05$).

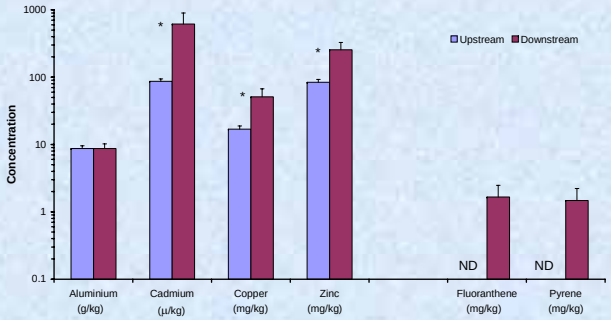


Fig. 5: Concentrations of contaminants in sediment collected upstream and downstream of highway runoff discharges. Bars represent 1 SE and asterisk indicate significant pair-wise comparisons. ND indicates that chemical was below detection limits.

Conclusions

- Highway runoff has a greater impact at sediment-accumulating than at sediment-dispersing sites, implying that sediment-bound contaminants are of greater concern than soluble contaminants.
- Highway-derived sediment is contaminated with metals and PAHs.
- Macroinvertebrate communities at sediment-accumulating sites receiving highway runoff have a reduced diversity and demonstrate a shift in composition from a dipteran-amphipod dominated assemblage to a dipteran-isopod dominated assemblage. There is also a shift from gastropod to bivalve molluscs.
- Studies are currently on-going to elucidate the mechanisms driving the patterns observed.

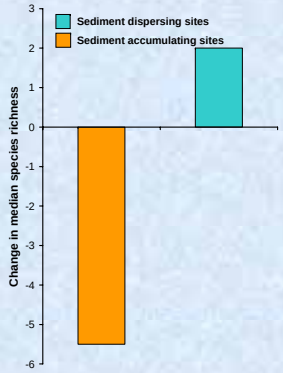
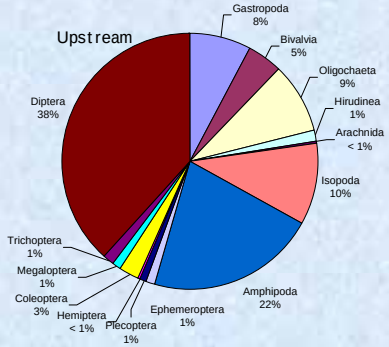


Fig. 3: Change in macroinvertebrate species richness downstream of highway runoff discharges



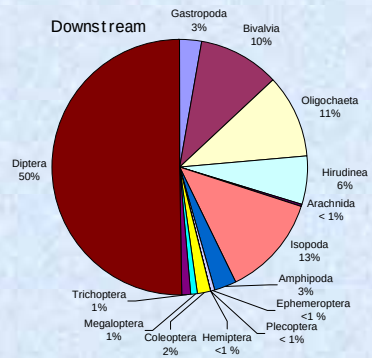


Fig. 4: Macroinvertebrate community composition at sediment accumulating sites.

[1] Maltby et al (1995a) ET&C, 14, 1079; Maltby et al (1995b) ET&C, 14, 1093; Boxall & Maltby (1997) Archives Environ. Contam. Toxicol., 33, 9.