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Trace Metal Export in Urban Runoff and Its Biological Significance

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Urban runoff has been suggested as a major non-point source of trace metals to aquatic environments (Australian Water Resources Council 1981). To assess the impacts of trace metals in urban runoff to aquatic ecosystems, information is required about concentrations of trace metals entering the system from urban runoff, the subsequent accumulation of metals in aquatic organisms and the potential toxicity of metals to organisms.

The purpose of this study was to measure the levels of selected trace metals present in sediments of a stream draining an urban catchment and to determine the relationship of the trace metal concentrations in the sediment fractions to the trace metal concentrations available for uptake by the resident detritovores. Trace metal concentrations in detritus feeders are of interest as detritovores occupy a key position in stream food chains where the major source of fixed carbon is in the form of organic detritus (Hill and Webster 1983).

MATERIALS AND METHODS

Sediments and detritovores were collected in august 1984 from two creeks (Figure 1). Sullivan's Creek (37° 17′ S, 149° 09′ E) has a catchment area of 52.2 sq km, the upper 50% of the catchment is used for grazing and the remaining 50% is mainly urban as the creek runs through North Canberra into Lake Burley Griffin. Woolshed Creek has a catchment of 25.7 sq km and is used solely for grazing. Soils and geology of both catchments are similar (Sleeman and Walker 1979). Six replicate sediment samples were taken at each sampling site using a plastic core sampler (3.5 x 10 cm). This limited samples to a depth to which tubificids burrow (McCall and Fisher 1979). Sediment was placed in acid rinsed containers and on return to the laboratory each sample was split, one half for sediment and interstitial water analysis and the other for biota analysis.

Sediment to be chemically fractionated was centrifuged at 5000rpm (4080 g) for 10 min to separate the interstitial water. An aliquot (5mL) was transferred to a 10mL volumetric flask, 0.05mL

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of concentrated nitric acid added, made up to volume with distilled water and stored at 4°C.

Sediment was dried to constant weight at 55°C. and size fractionated by sieving. The sieved fraction (<60um) was further fractionated using the scheme outlined in Table 1. Extracts were filtered through Whatman 541 filter paper and stored at 4°C. until analysed. All solutions were stored for a maximum of three weeks before analysis took place. Concentrations of zinc, copper and lead were measured in solutions by flame absorption spectroscopy on a Varian Techtron 1200 AA6 using standard conditions (Varian Techtron 1974). Metal concentrations were calculated from calibration curves produced from stock solutions.

Sediment for biota analysis was washed through a 0.4mm nylon sieve to separate the macrobiota. Excess moisture was removed by draining and the tubificids were frozen and stored until analysed (one week). Tubificids were taken to represent the detritovores as they were the most abundant macrodetritovores. Subsamples (0.05g) were digested using the pepsin solution as previously described (Table 1). Digestion with acidic proteinase (pepsin) approximates the conditions in the digestive tracts of oligochaete predators (Kapoor et al 1962) and thus gives an estimate of trace metal concentrations available to other organisms.

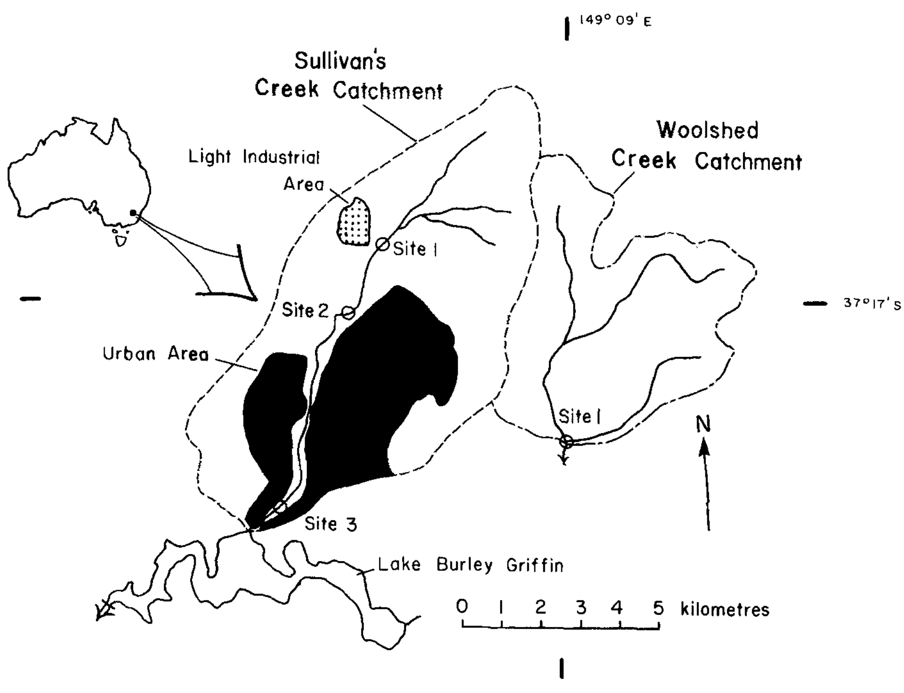

Figure 1 Study Area and Sampling Sites

RESULTS AND DISCUSSION

Total trace metal concentrations measured in sediments and animals are given in Table 2.

The trace metal concentrations in all interstitial waters were below limits of detection (0.1ug/g Zn, 0.5ug/g Pb and 0.2ug/g Cu). Concentrations of trace metals in sediments increased downstream in the urban catchment while the sediment from the Woolshed catchment and Sullivans Creek Site 1 had similar low levels of trace metals reflecting the rural nature of both catchments above these sampling sites. Trace metal concentrations at Sites three and four, which had more urban runoff, are higher than those found in the sediments of some waterbodies with recognized point source pollution (Hall and Fletcher 1974; Hakanson 1984). These levels indicate that urban catchments may be significant non-point sources of trace metals to aquatic ecosystems.

Table 1 Fractionation Scheme (a)

Nominal Fraction Extracted	Procedure
Exchangeable (trace metal weakly adsorbed to sediment)	1M $MgCl_2$ (10mL), continously agitated,24 hours.
Pepsin Digested (gut soluble trace metals)	1g/L pepsin (10mL), adjusted to pH 1.2 (HCl), continuously agitated, 24 hours.
Total trace metals	12MHCl(7.5mL)and 14MHNO_3 (2.5mL), evaporated, 5M HCl (5mL), made up to 10mL with distilled water.

(a) 1g subsamples used

Trace metal concentrations in the tubificids do not show a trend as was evident for the sediments. No significant linear or log-linear relationship ($p < 0.05$) was found between the sediment metal concentrations and the pepsin digestable metal concentrations in tubificids. Trace metals in tubificids were also not significantly correlated to the trace metals liberated by the magnesium chloride leach or the pepsin digest. Trace metal levels in tubificids may therefore be more closely related to a yet unidentified fraction. The literature disagrees as to whether a relationship between trace metal concentrations of sediments and sediment macrobiota exists. Mathis and Cummings (1973), Wentzel et al (1977), Talbot and Chedwiggen (1982), and Tessier et al (1984) found relationships between sediment levels and biota levels, whereas Dean (1974), Hakanson (1984) and Thomson et al (1984) did not.

The significance of the levels of trace metals in Sullivans creek is difficult to assess. In streams such as Sullivans Creek where much of the carbon sustaining the system may be of allochthonous origin the decomposer food chain is critical to the maintenance of the ecosystem. Macrodetritovores occupy a key position, feeding on the microdecomposers and being preyed upon by other organisms in the system. Consequently, if the sediment metal concentrations found in this study are high enough to have adverse effects on the tubificids, the effect on the ecosystem may be severe. Some indications of the ecological effects of metal levels in this stream may be gained by comparison with other studies. Norris (1983) found that zinc levels similar to those at Sullivan's Creek Site four, combined with very low copper and lead levels produced mild stressing of the benthic invertebrates. Leland and McNurney (1974) found that in a stream in which lead levels in the tubificids reached 50ug/g, the number of species present was significantly reduced.

Table 2 Trace Metals in Sediment Fractions and Tubificids from Sullivan's and Woolshed Creeks.

Metal and Site	Total (ug/g)	Interstitial	Exchangeable (% of Total)	Pepsin	Tubificids (ug/g)
Zn					
Woolshed	87 ± 24	N.D.	3.1	8.9	60 ± 22
Sullivan's					
2	113 ± 47	N.D.	8.6	12.2	32 ± 23
3	292 ± 37	N.D.	1.5	29.0	194 ± 229
4	878 ±1 79	N.D.	14.8	72.4	66 ± 23
Pb					
Woolshed	53 ± 3	N.D.	50.5	22.9	N.D.
Sullivan's					
2	51 ± 11	N.D.	58.0	22.3	N.D.
3	203 ± 23	N.D.	14.4	13.1	64 ± 53
4	596 ± 114	N.D.	7.1	63.4	80 ± 36
Cu					
Woolshed	22 ± 2	N.D.	N.D.	10.5	N.D.
Sullivan's					
2	31 ± 9	N.D.	N.D.	19.0	N.D.
3	37 ± 9	N.D.	N.D.	5.8	N.D.
4	98 ± 16	N.D.	N.D.	60.5	8 ± 2

N.D. not detectable.

This study has highlighted the importance of urban inputs as non-point sources of trace metals to aquatic ecosystems. No relationship between trace metal concentrations in sediment fractions and accumulation by the resident detritovores has been established.

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