Copper and Zinc concentrations from an Artificial Turf Field

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solutions for your environment

Overview

- Introduction
  - what are artificial turf fields?
- Study background
- Methodology
- Results
- Discussion
- Conclusion

- Questions

Introduction

- Third generation artificial turf field (ATF)
- Crumb rubber used
  - Primarily sourced from recycled car tyres
  - 4-5 kg per tyre
  - Up to 2.5% ZnO by weight
  - Cu varies by make and model
- Other materials:
  - Polyethylene, polyurethane, polypropylene

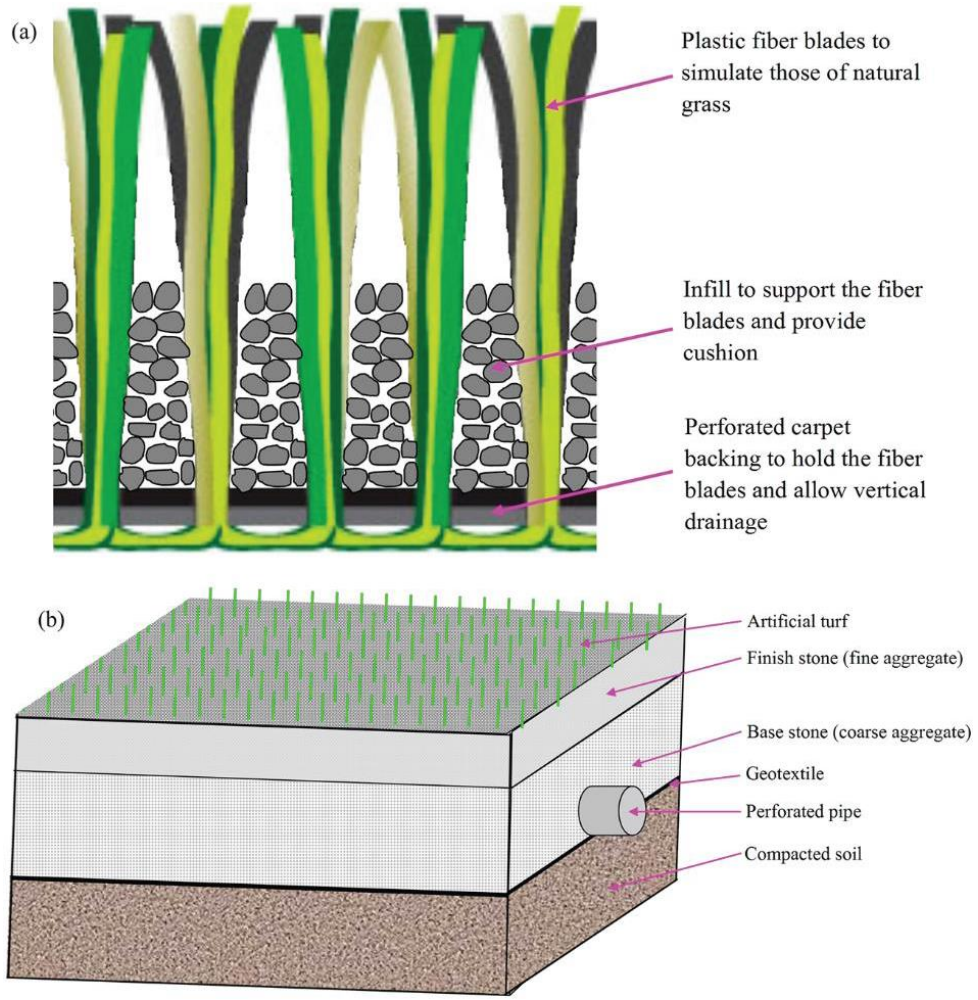


Figure 1. The illustration of a typical third generation artificial turf field: (a) crumb rubber infill and major constituent parts, and (b) the base course and drainage system. (From Cheng et al, 2014, p.2116)

Introduction

- Studies to date:
  - Laboratory analysis of crumb rubber
  - Field monitoring haphazard
  - Little information about lifecycle effects
- Do we know what the cumulative effects are of an ATF are?
  - Inter and intra event

Study Background

- Auckland Council Sports Field Development Programme
  - Identified growing demand for facilities
  - Will increase annual playable hours
  - 32 ATFs to be built
- Michaels Avenue, Ellerslie
  - Opportunity to monitor a new ATF

Methodology

- Site installed during final ATF construction
  - Operational on the first day
- Automated flow-proportional sampling
  - ‘Leachate’ suite of heavy metals (total)
  - Run for 28 months
  - Field team notified by text alarm, samples collected and delivered to IANZ laboratory

Methodology

Figure 2. Contributing catchments for the Michaels Ave ATF (aerial photo from Auckland Council)

Methodology

Plate 1 (left): View inside the manhole where monitoring equipment was located. Exit pipe orifice is top left, one sub-surface drain can be seen entering at top right.
Plate 2 (right): Datalogger, raingauge and sampler equipment one week after installation

Results

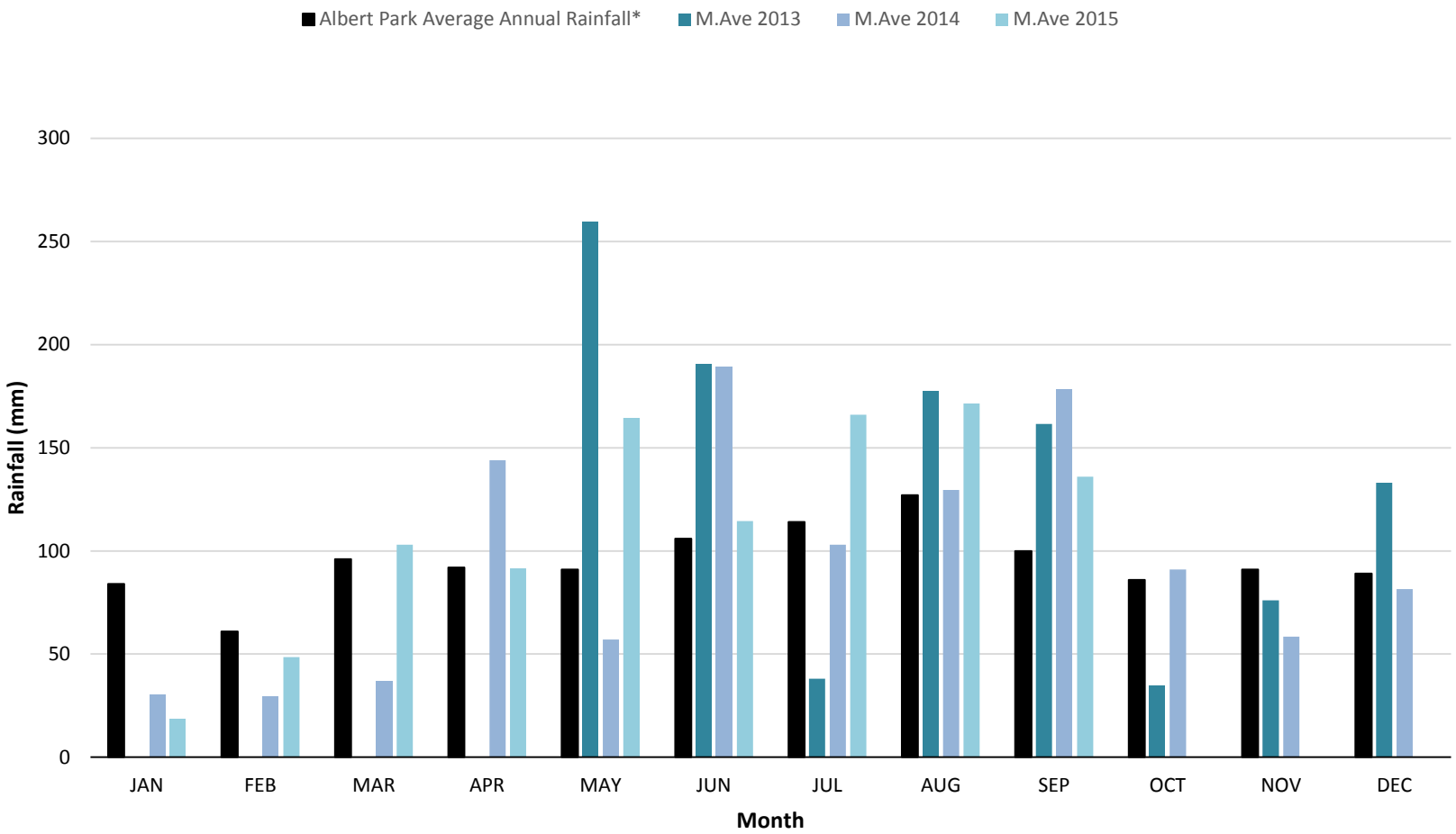


Figure 3. Rainfall by month

**data from NIWA CliFlo*

Results

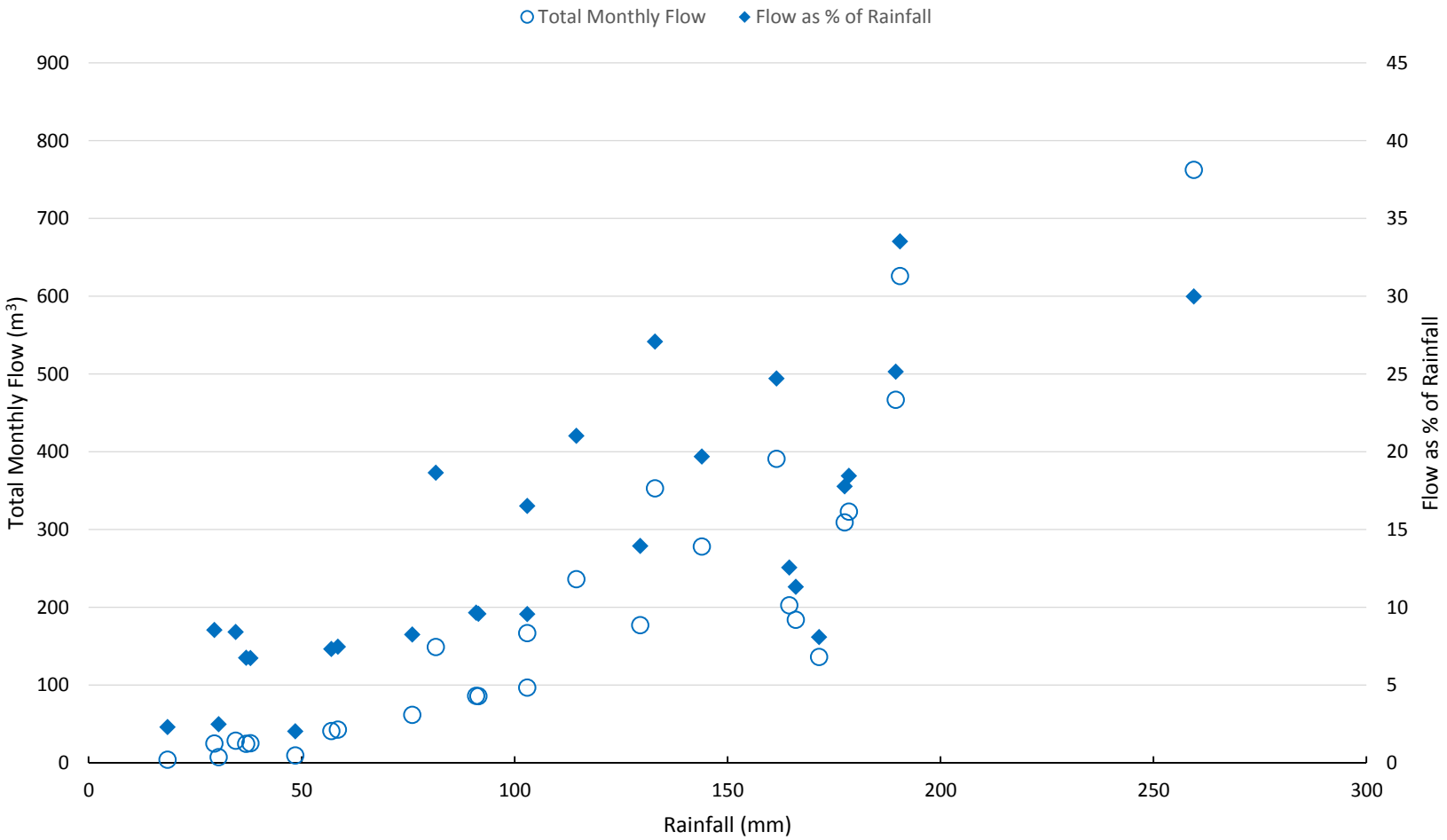


Figure 4. Total monthly flow and flow as percentage of rainfall

Results

- Thirty-four ‘Sampling Events’

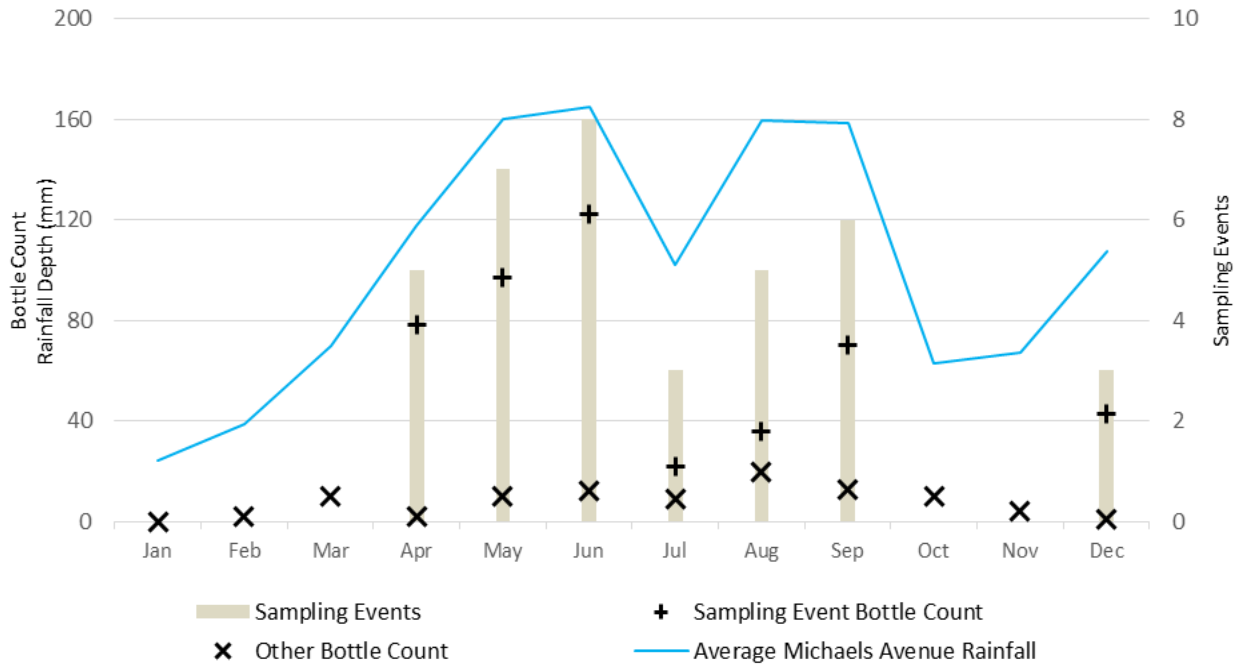


Figure 5. Sampling Event occurrence, number of samples collected and rainfall depth observed at Michaels Avenue by calendar month

Results

- 87% of Cu & 26% of Zn samples exceeded ANZECC 80% species survival

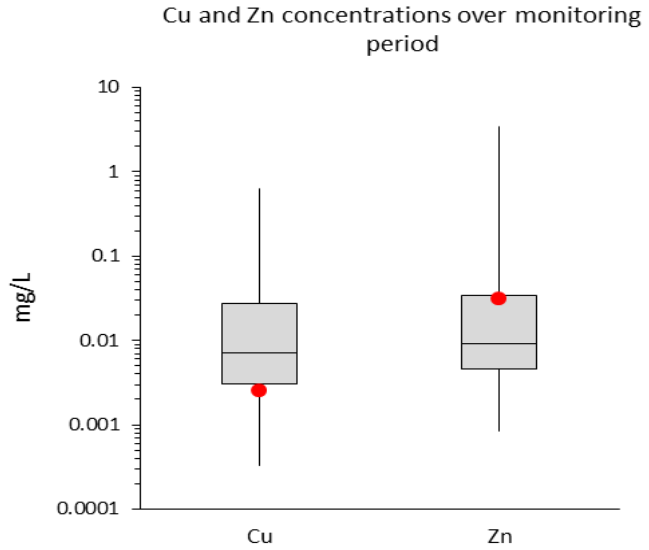


Figure 6. Cu and Zn concentrations over the monitoring period (box plots) with respective ANZECC 80% species survival marked (red dot). Box plots indicate maximum, minimum, median and upper and lower quartile values.

Results

- Concentrations changed over time

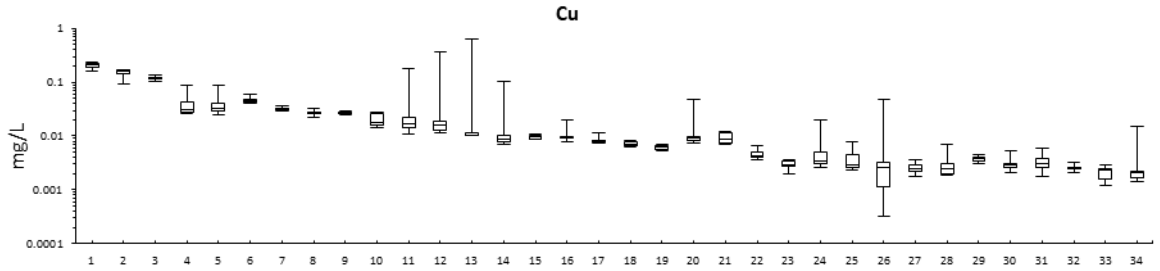


Figure 7. Cu concentrations by Sampling Event. Box plots indicate maximum, minimum, median and upper and lower quartile values

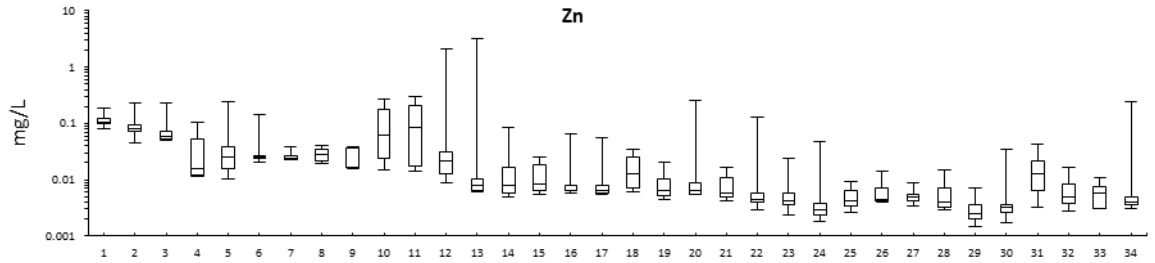


Figure 8. Zn concentrations by Sampling Event. Box plots indicate maximum, minimum, median and upper and lower quartile values

Results

- Crumb rubber mobilised from the field

Plates 3-6. Above, a catchpit grate on the concrete path (left, Plate 3) and the Enviropod filter bag (right, Plate 4). Below, crumb rubber deposited within the Enviropod filter bag overflow (left, Plate 5) and in the bottom of the bag (right, Plate 6)

Discussion

- Zn normally identified as the metal of concern in other field studies
- Relative toxicity of Cu greater (ANZECC 2000)
- Maximum observed concentrations exceeded other field studies
  - Comparable to laboratory studies
  - First 3 months

Discussion

Table 1. Concentrations of metals in Artificial Turf studies (µg/L)

Study	Cu	Zn	No. of samples	Age of field/ crumb rubber
This study			561	0-2 years
- Minimum	0.33	0.84		
- Lower Quartile	3.06	4.63		
- Median	7.22	9.29		
- Upper Quartile	27.2	34.7		
- Maximum	635	3,492		
Other artificial sports field studies				
Bristol & McDermott (2008)	Not tested	<2.0 - 36	8	1-2 years
Lim & Walker (2009)	5.4	59.5	1	2 years
Connecticut DEP (2010)	1.5 – 5.0	10 – 260	8	2-4 years
Cheng & Reinhard (2010)	1.0 – 34	130 – 470	4	1 year
Moretto (2007)*	0.1 – 10	1 – 500	7	0-11 months
Laboratory studies of crumb rubber				
Bocca et al (2009) (pH 5.0 artificial leachate)	0.2 – 216	2.0 – 62,120	32	Unknown
Rhodes et al (2012) (pH 5.0 artificial leachate)	Not tested	100-2,700	Unknown	Fresh crumb rubber
Li et al (2010)	0.31 – 9.5	220 – 13,000	9	0-2 years

Discussion

- If extrapolated to annual loads:
  - First 3 months similar to heavily trafficked road

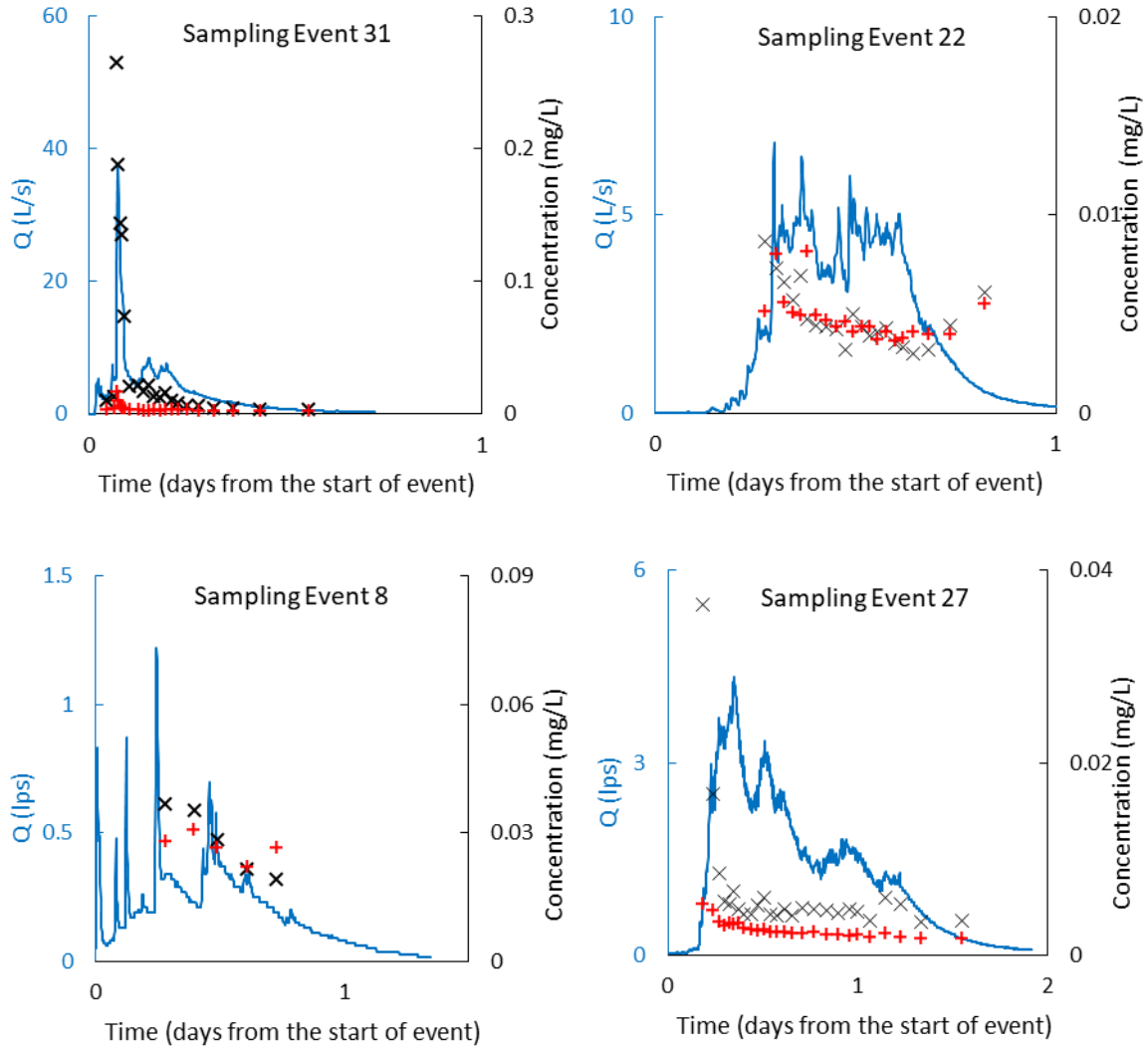
Table 2. Annual loads, units g $m^{-2}a^{-1}$. All data not from this study sourced from the Auckland Council Contaminant Load Model (Auckland Council 2010a), figures reduced to four decimal places. Selection of CLM classifications used for brevity. Vpd = vehicles per day.

Component	Zn	Cu
This study		
First three months (annualised)	0.1238	0.0449
First 6 months (annualised)	0.0659	0.0243
First year	0.0342	0.0126
Second year	0.0013	0.0007
CLM		
Galvanised steel roof well painted	0.2000	0.0003
Zinc/aluminium unpainted	0.2000	0.0009
Zinc/aluminium coated	0.0200	0.0016
Copper roof	0.0000	2.1200
Concrete roof	0.0200	0.0033
Other roof	0.0200	0.0020
<1000 vpd	0.0044	0.0015
1000-5,000 vpd	0.0266	0.0089
5,000-20,000 vpd	0.1108	0.0369
20,000-50,000 vpd	0.2574	0.0858

Discussion

- Two different pathways of site discharge
  - Infiltration (through the ATF pitch)
  - Runoff (from concrete path, bank and infiltration excess)
- Discernible in hydrograph
- Pollutant concentrations varied with flow pathway
  - Zn source limited
  - Cu flow limited

Discussion



Figures 9 – 12, clockwise from top left: Large Sampling Events with a runoff spike (Figure 9) and without a runoff spike (Figure 10), a medium Sampling Event showing Zn exhaustion (Figure 11) and a small Sampling Event showing Zn exhaustion (Figure 12), both with no runoff spike sampled.

For all Figures flow rates are marked by blue lines, Zn concentrations with black crosses and Cu concentrations with red plus symbols.

Discussion

- Zn likely to demonstrate mass first flush (MFF), Cu less likely

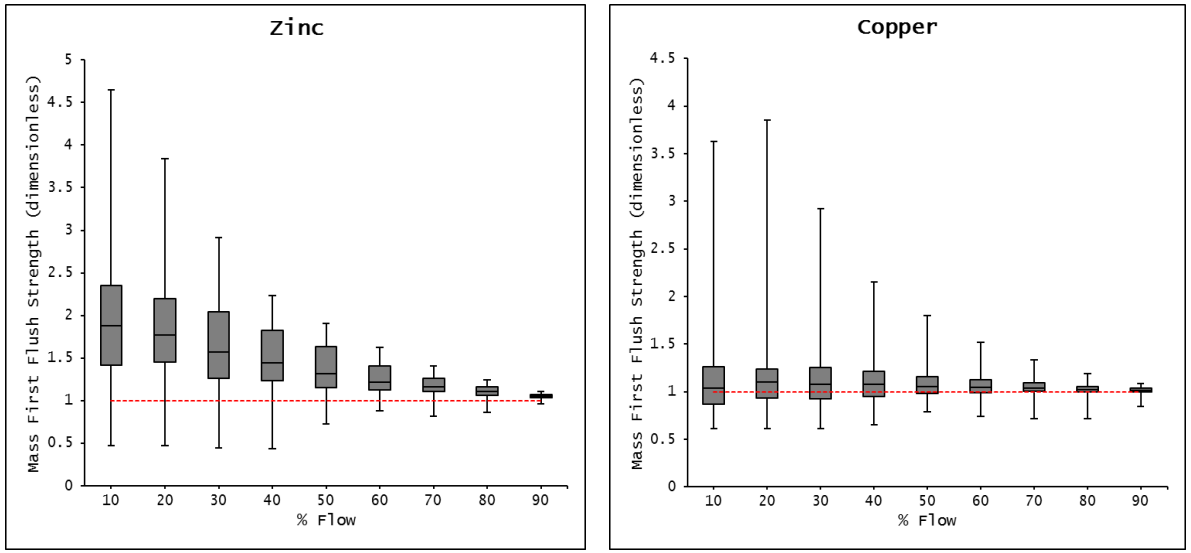


Figure 13 & 14. Left, Zn MFF values (Figure 13). Right, Cu MFF values (Figure 14)

Discussion

- Rainfall intensity related to highway MFF (Sansalone and Cristina 2004)
- Strong first flush related to mass-limitation and weak first flush linked to flow-limitation (Sansalone and Cristina 2004)
- Short-duration events don’t exhaust sources
- Long-duration events exhaust short-term pollutant sources, but are influenced by long-term sources (Kang et al 2008)

Discussion

- MFF at Michaels Ave ATF linked to maximum 1-hour precipitation, short duration events and high peak flow rates
- Weak to moderate correlations (small sample *n*)

Discussion

- MFF can be applied at seasonal scales (Lee et al 2004, Tiefenthaler et al 2008)
- Can MFF be applied at a longer scale at Michaels Ave?
  - Treatment implications

Discussion

- Michaels Ave ATF demonstrates ‘Land-Use First Flush’

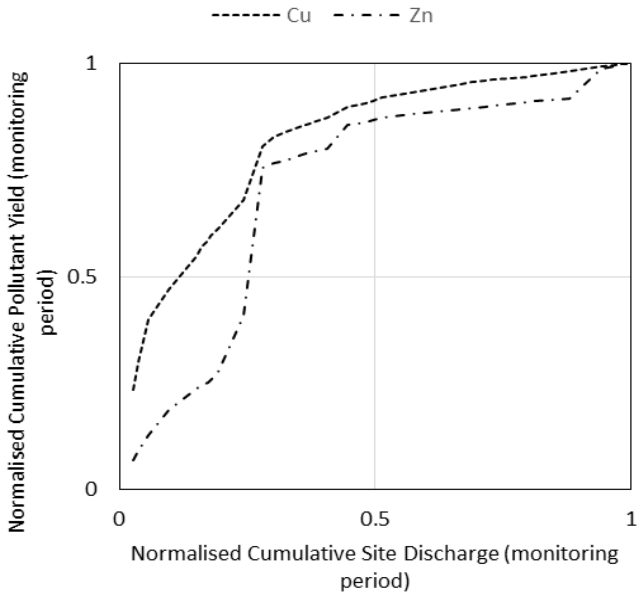


Figure 15: Land-Use First Flush for Cu and Zn

Conclusion

- Observed concentrations of Cu and Zn decrease rapidly with time
  - ‘Land-Use First Flush’
  - Similar to other field studies
- Two different flow paths
  - Infiltration
  - Runoff
- MFF demonstrated more by Zn than Cu
  - Source vs flow limited transport

Acknowledgements

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Questions?