


Key Findings and Recommendations from the National Biosolids Research Program

Cadmium

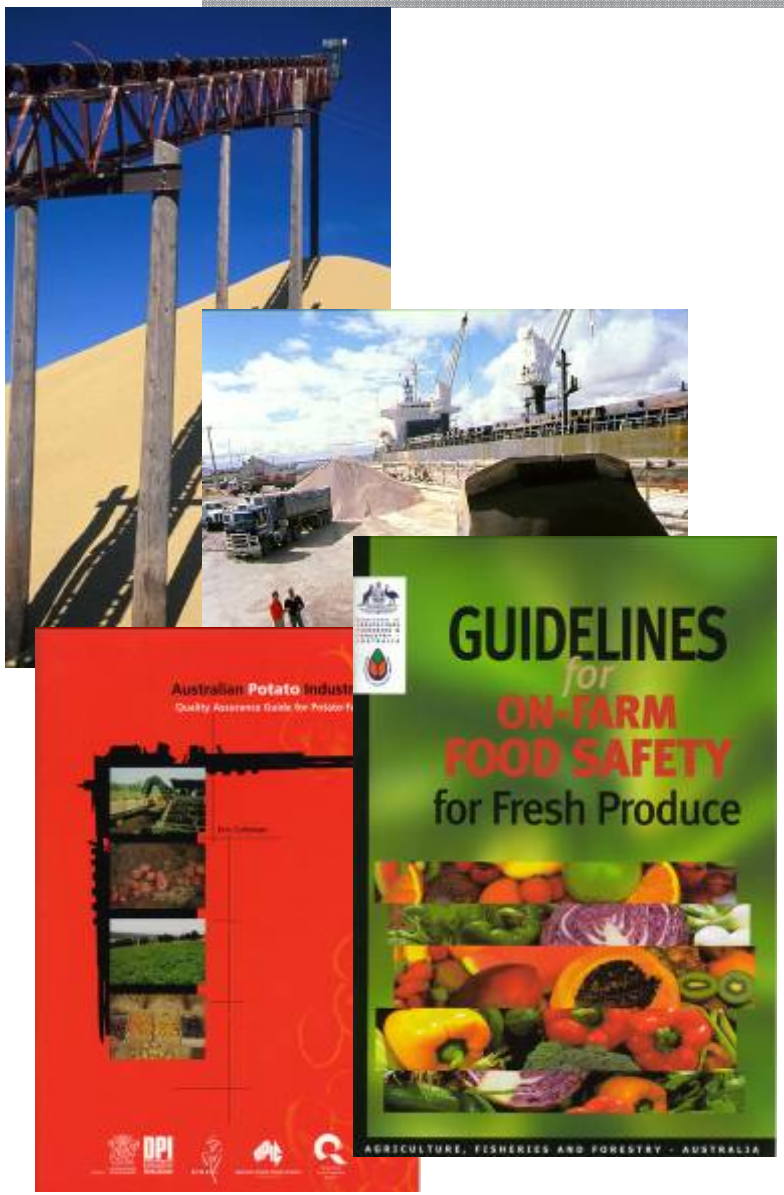
Mike McLaughlin on behalf of the NBRP team

7 December, 2007

Introduction – why is Cd a problem?

- Cadmium is a chronic toxicant for human health – accumulates in kidney and liver and affects organ function
- Levels of Cd in foods are monitored and regulated by state/national/international organisations
- Australia has experienced periodic problems with produce from some crops exceeding maximum levels (MLs) specified in the Food Standards Code

Introduction – why is Cd a problem?



Agricultural commodity exports are vital to Australia's economy and Cd is a marketing issue in international trade

Cadmium is an issue for national retailers and suppliers in relation to food quality – food QA schemes are increasing

Introduction – why is Cd a problem?

COMMISSION REGULATION (EC) No 466/2001

of 8 March 2001

setting maximum levels for certain contaminants in foodstuffs

FAO/WHO Codex and EU guidelines provide a limit for Cd in food staples. Australian also has food Cd standards

codex alimentarius commission

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

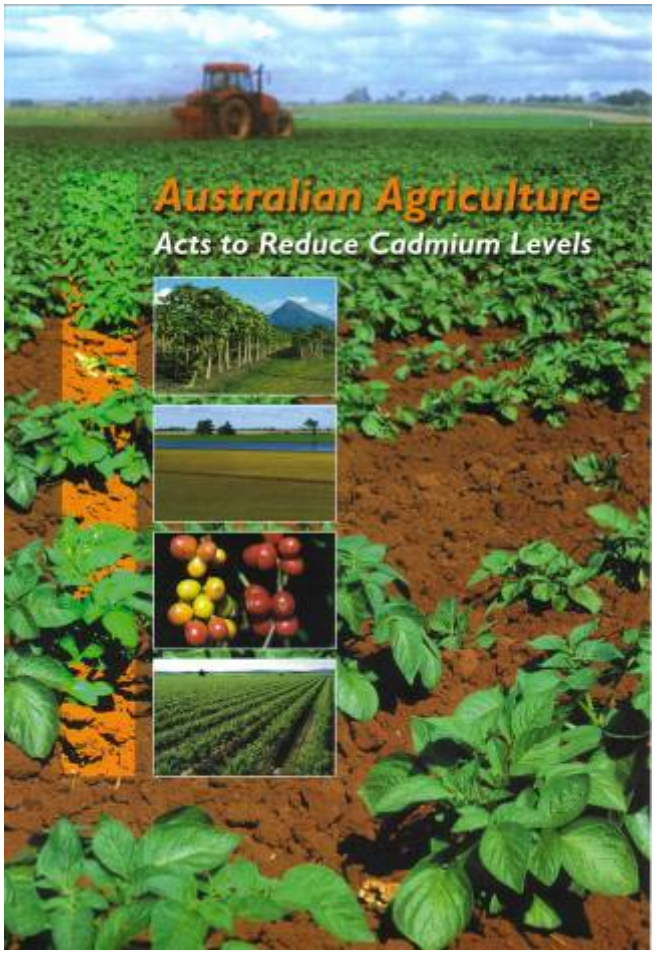
WORLD HEALTH ORGANIZATION

JOINT OFFICE: Viale delle Terme di Caracalla 00100 ROME Tel: 39 06 57051 www.codexalimentarius.net Email: codex@fao.org Facsimile: 39 06 5705 4593

Current FSANZ Food Safety Standards

Cadmium	
Chocolate and cocoa products	0.5
Kidney of cattle, sheep and pig	2.5
Leafy vegetables (as specified in Schedule 4 to Standard 1.4.2)	0.1
Liver of cattle, sheep and pig	1.25
Meat of cattle, sheep and pig (excluding offal)	0.05
Molluscs (excluding dredge/bluff oysters and queen scallops)	2
Peanuts	0.1
Rice	0.1
Root and tuber vegetables (as specified in Schedule 4 to Standard 1.4.2)	0.1
Wheat	0.1

Introduction – why is Cd a problem?



Australia keeps a watching brief on Cd issues and aims to reduce Cd accumulations in Australian agriculture through the National Cadmium Minimisation Strategy

Current guidelines – soils where biosolids are used

	mg/kg
NSW	1.0 (5.0 non agric)
SA	3.0 (1.0 proposed)
Tasmania	0.7
Victoria	1.0 (unrestricted)
	3.0 (pH≥6, non food crops)
WA	1.0
Qld (interim)	1.0
National Cd	1.0
National EIL	3.0
National HBIL	20.0

National Cadmium Management and the Australian water industry

- At a meeting convened by NCMC between regulators and the water industry in Melbourne in 2002 and the following actions agreed
- Maximum annual loading rate of 30 g/ha/yr averaged over 5 years (150 g/ha/5yr) – for a typical biosolid this equates to an annual loading limit of ~50 dry t/ha every 5 years
- Trade waste policies to be reviewed and Cd “traceback” commenced
- Maximum soil Cd concentration of 1 mg/kg pending further research

Rationale for original biosolid/soil Cd guidelines

- Limit values in NSW Guidelines derived from field trials with wheat using highly contaminated sludges on a very acidic soil (Glenfield) – considered worst case scenario

- Limit value of 1 mg/kg was derived to protect wheat from exceeding the then National Food Authority limit of 0.1 mg Cd/kg

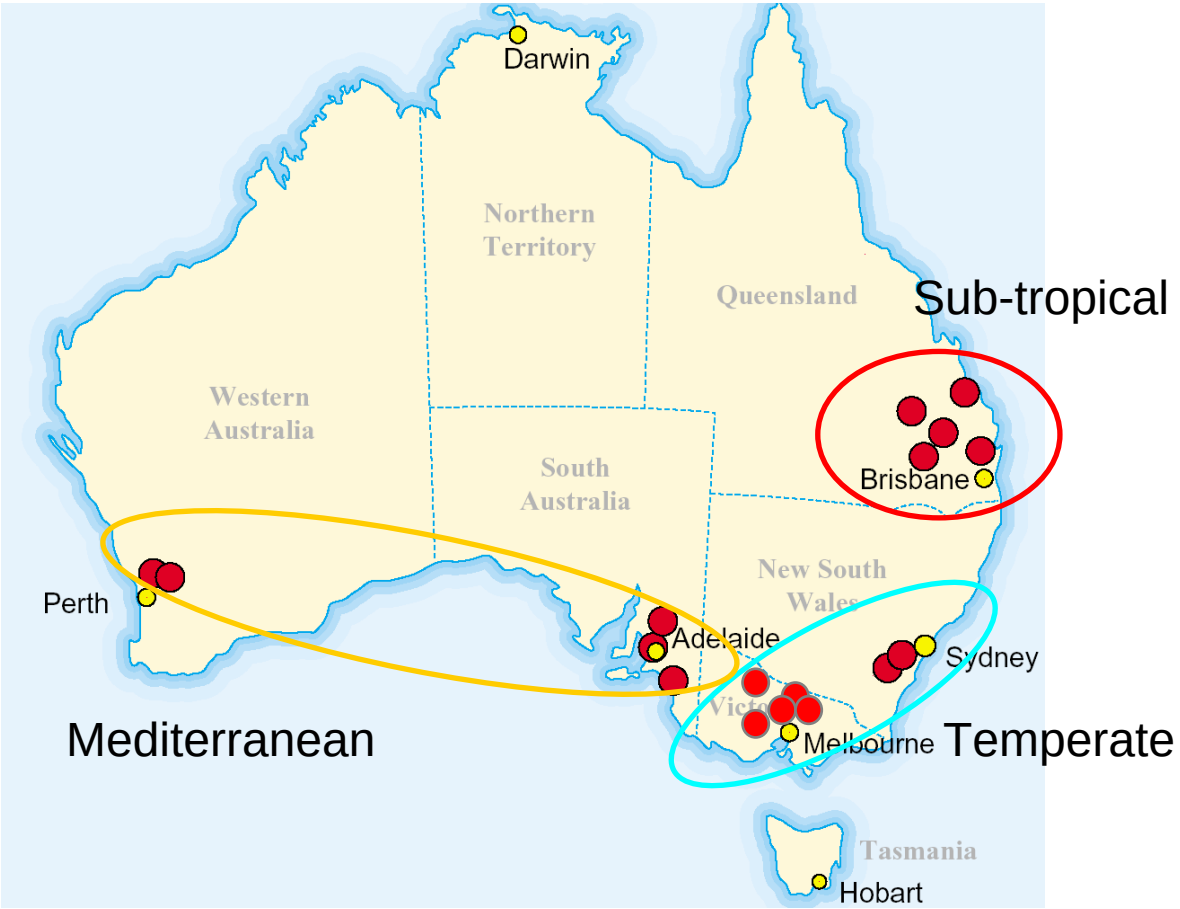
Background

- Soil and waste characteristics influence Cd bioavailability – how to recognise this in soil guidelines?
- Uptake of Cd has traditionally been stated to be lower from Cd in wastes than from pure Cd salts
- Thought that urban sewage sludge **(**biosolids) bind Cd to oxides/minerals in waste and hence minimise Cd risks

Field site methodology

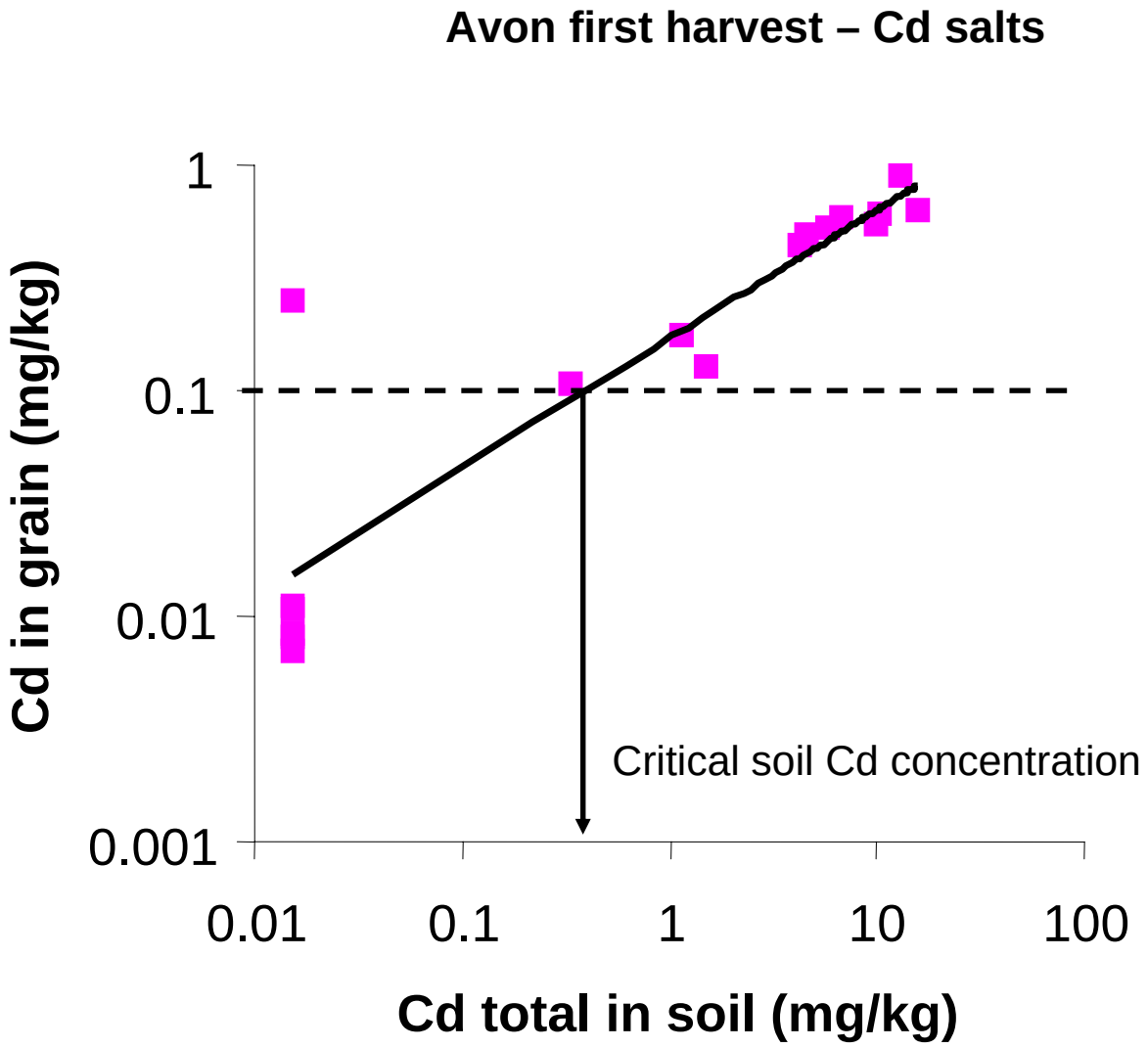
Crops

Wheat*
Barley
Triticale
Maize
Millet
Sorghum
Peanut*
Canola
Pasture
Cotton
Sugar

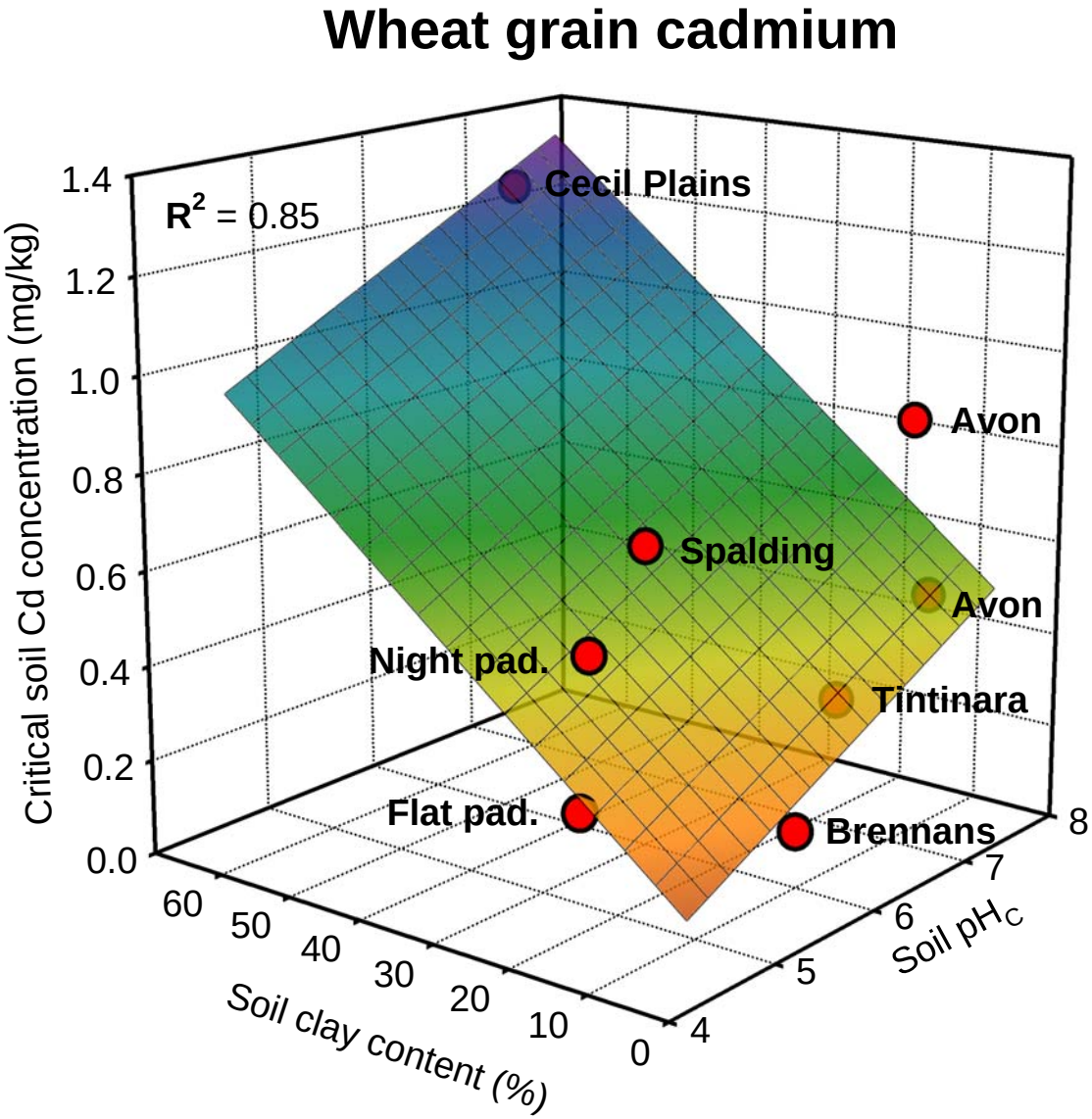


Field site methodology

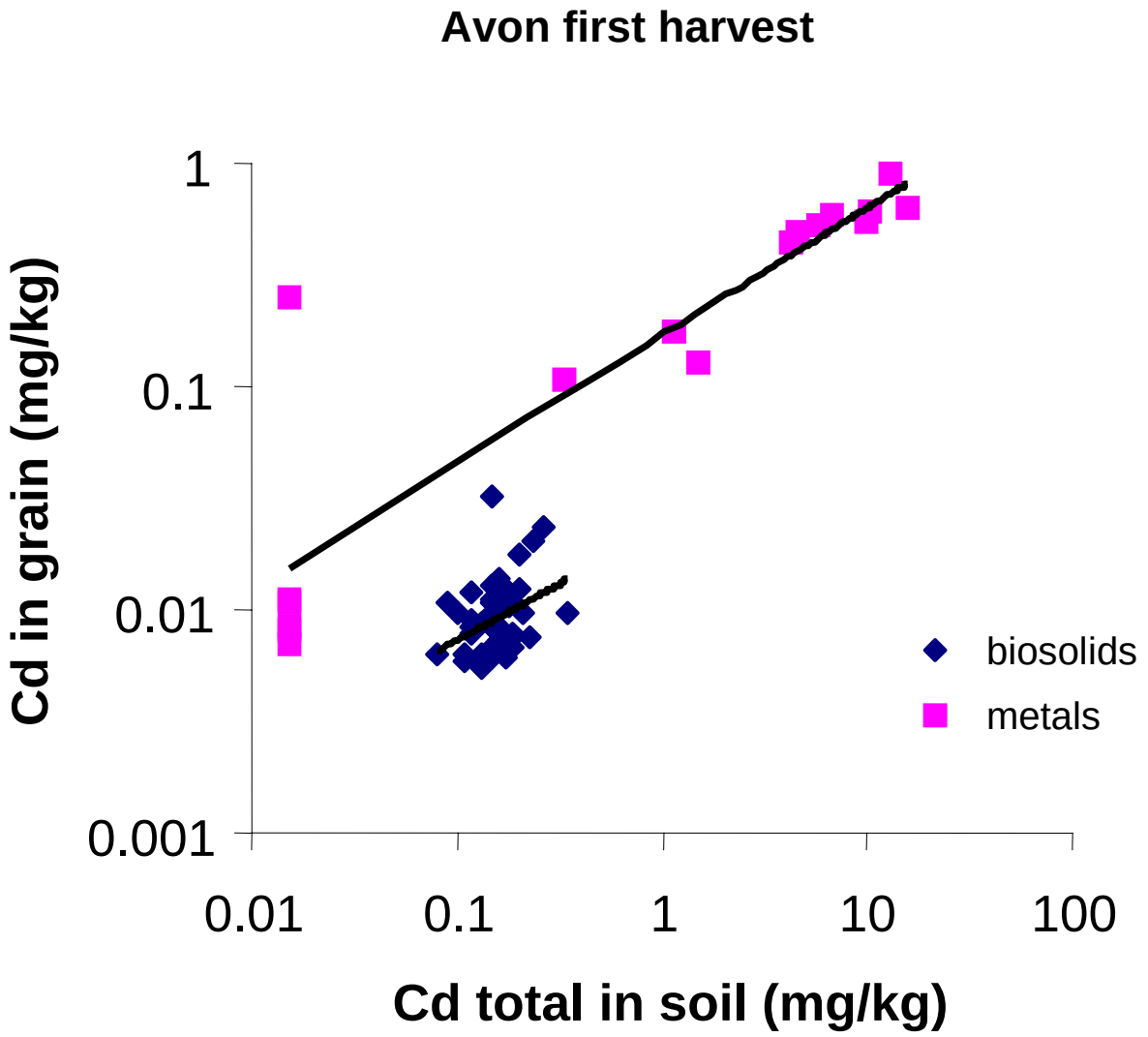
Cadmium concentration in soil and grain - Avon



Relationship between critical Cd concentration and soil properties – wheat



Cadmium concentration in soil and grain - Avon

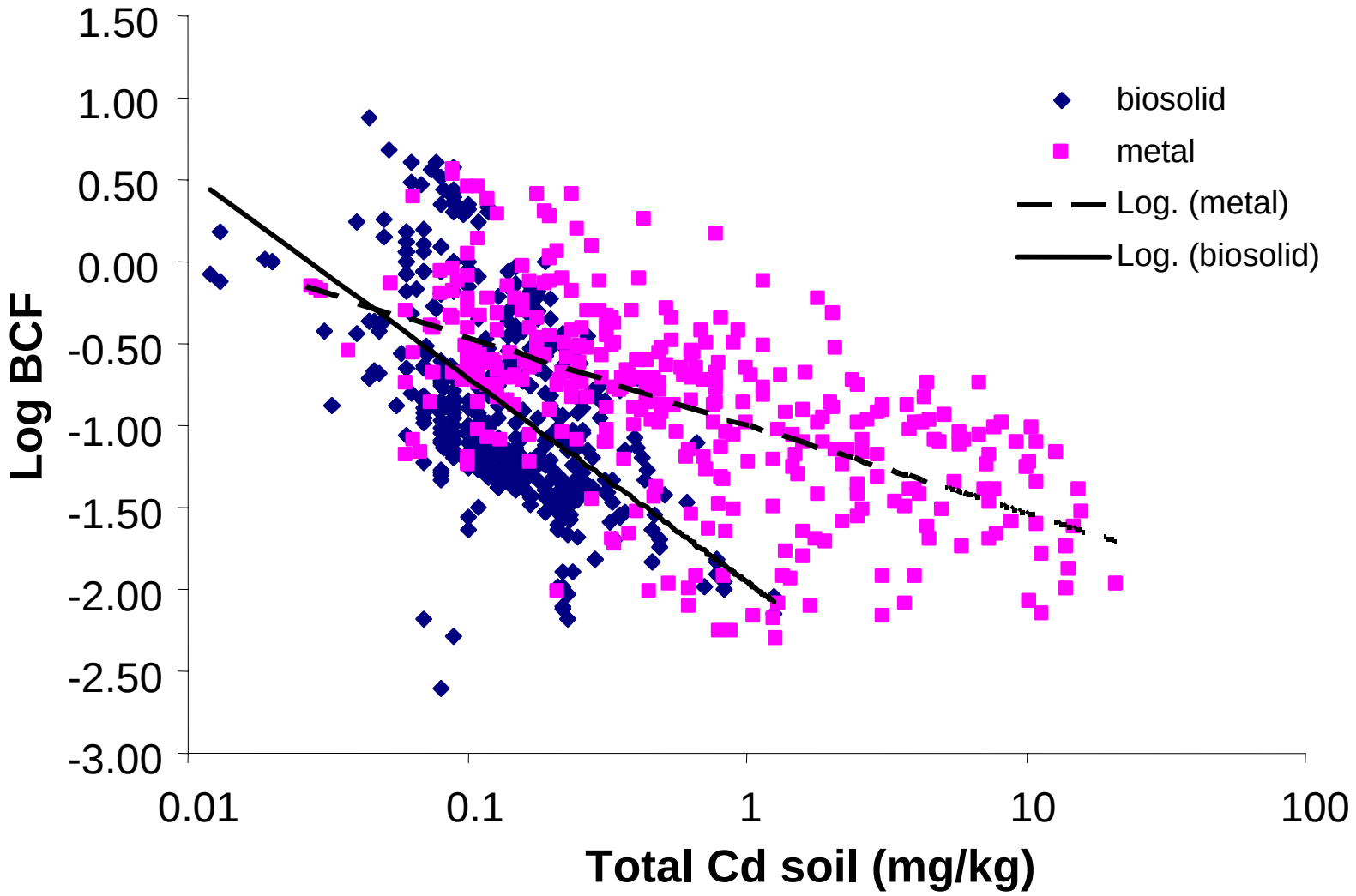


Compiling soil to plant transfer Cd data

- Need to determine biosolid Cd availability
- Possible to use soil-to-plant transfer factors (BCF) for each plot at each site for each year

$$BCF = \frac{\text{Grain Cd concentration}}{\text{Soil Cd concentration}}$$

Biosolid and metal BCFs



Interim soil specific Cd guidelines – combining soil and biosolid bioavailability

Clay %	5	25	50
pH	Cd B-SQG value (mg/kg)		
4.5	0.25	0.75	1.25
5.5	0.50	1.00	1.50
6.5	0.75	1.25	1.75
7.5	1.00	1.50	2.00
8.5	1.25	1.75	2.25

Interim soil specific Cd guidelines – Cd loading limits

Available online at www.sciencedirect.com
ScienceDirect
Chemosphere 66 (2007) 1415–1423
CHEMOSPHERE
www.elsevier.com/locate/chemosphere

Cadmium availability to wheat grain in soils treated with sewage sludge or metal salts

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Interim soil specific Cd guidelines – Cd loading limits

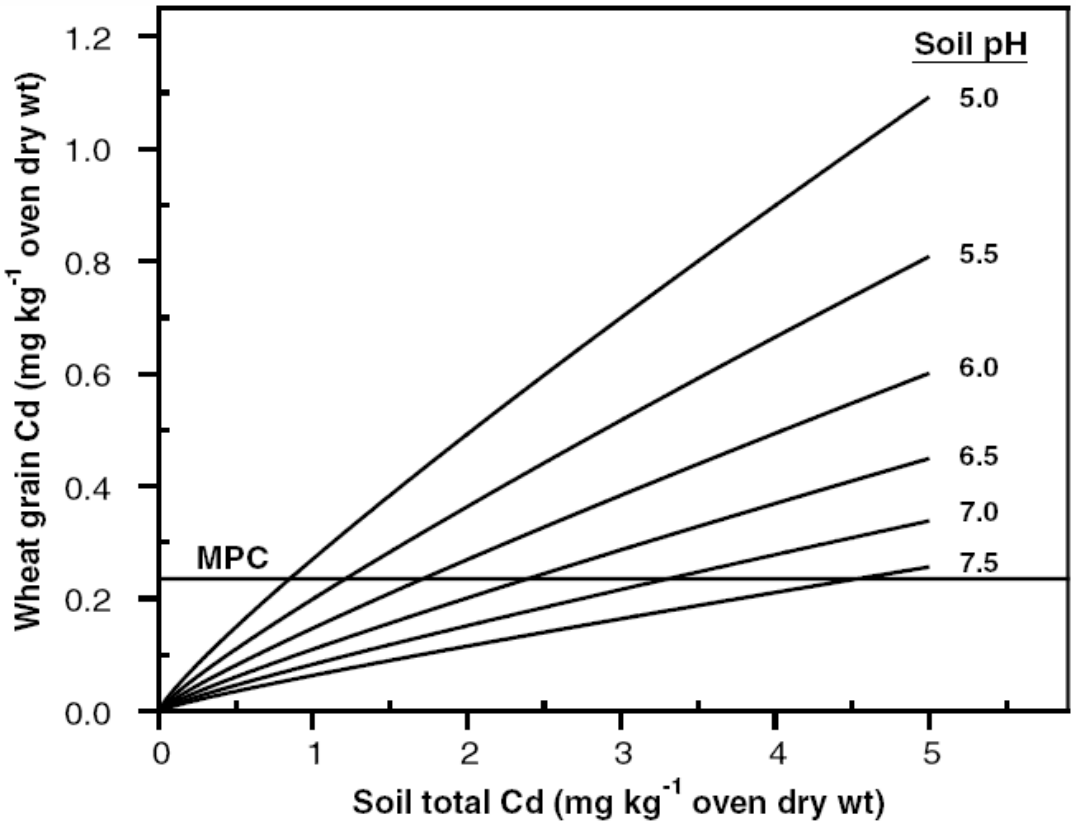

Fig. 4. Predicted grain Cd concentrations in wheat from the regression model in Eq. (1) as influenced by soil total Cd and pH, with organic carbon set at 22.2 g kg^{-1} soil. Curves represent the upper 95% confidence intervals of the grain Cd concentrations.

Assume OC = 1.5%
pH=5.5

Soil Cd limit = 0.35 mg/kg

From Chaudri et al. 2007

Biosolid Guidelines (EU proposed)

Annex II: Limit values for concentrations of heavy metals in soil

Elements	Limit values (mg/kg dm)			
	Directive 86/278/EEC 6<pH<7	5<pH<6	6<pH<7	pH>7
Cd	1 – 3	0.5	1	1.5
Cu	50 – 140	20	50	100
Hg	1 – 1.5	0.1	0.5	1
Ni	30 – 75	15	50	70
Pb	50 – 300	70	70	100
Zn	150 – 300	60	150	200

Conclusions

- Biosolid Cd is generally less available to crops than Cd salts (2 to 10-fold on average) despite being more *soluble*
- Some crop/soil combinations are highly risky e.g. peanuts, leafy vegetables and should not be grown on land receiving biosolids

Conclusions

- The current soil Cd guideline value of 1 mg/kg may not be adequately protective in all soils, even if soil pH is >5.5, and is maintained >5.5 over time. Sandy soils with low pH are most at risk.

- Setting a single protective total soil Cd trigger value across Australia is possible, but would have to be conservative (~0.5 mg Cd/kg) to account for acidic sandy soils, **and** a pH limitation is needed. This has implications for the unrestricted use category of biosolids.

- Biosolid Cd loading limits to soil should be maintained at 150 g Cd/ha/5 yr

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Thank You