Key Findings and Recommendations from the National Biosolids Research Program

Nutrient Issues

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Essential Plant Nutrients

Organic nutrients

Carbon

Hydrogen

Oxygen

Macronutrients

Nitrogen

Phosphorus

Potassium

Sulphur

Magnesium

Calcium

Micronutrients

Zinc
Manganese
Copper
Molybdenum
Boron
Iron
Chloride

Can be found in plants but are not essential

- Sodium
- Cobalt
- Vanadium
- Nickel
- Selenium

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Grow to your full potential.

Nutrient removal in crops

Nutrient (kg/tonne)

Crop		N	P	K	S	Mg	Ca	Cu	Zn	Mn
Wheat	Grain	21	3	4	2	1	0.4	0.003	0.02	0.03
Canola	Seed	37	8	9	8	3	3	0.005	0.04	0.03
Lupins	Grain	45	3	8	2	1	2	0.005	0.03	0.02
Oaten	Hay	16	2	12	2	1	1	0.003	0.02	0.03

Macro nutrients **Micro nutrients**

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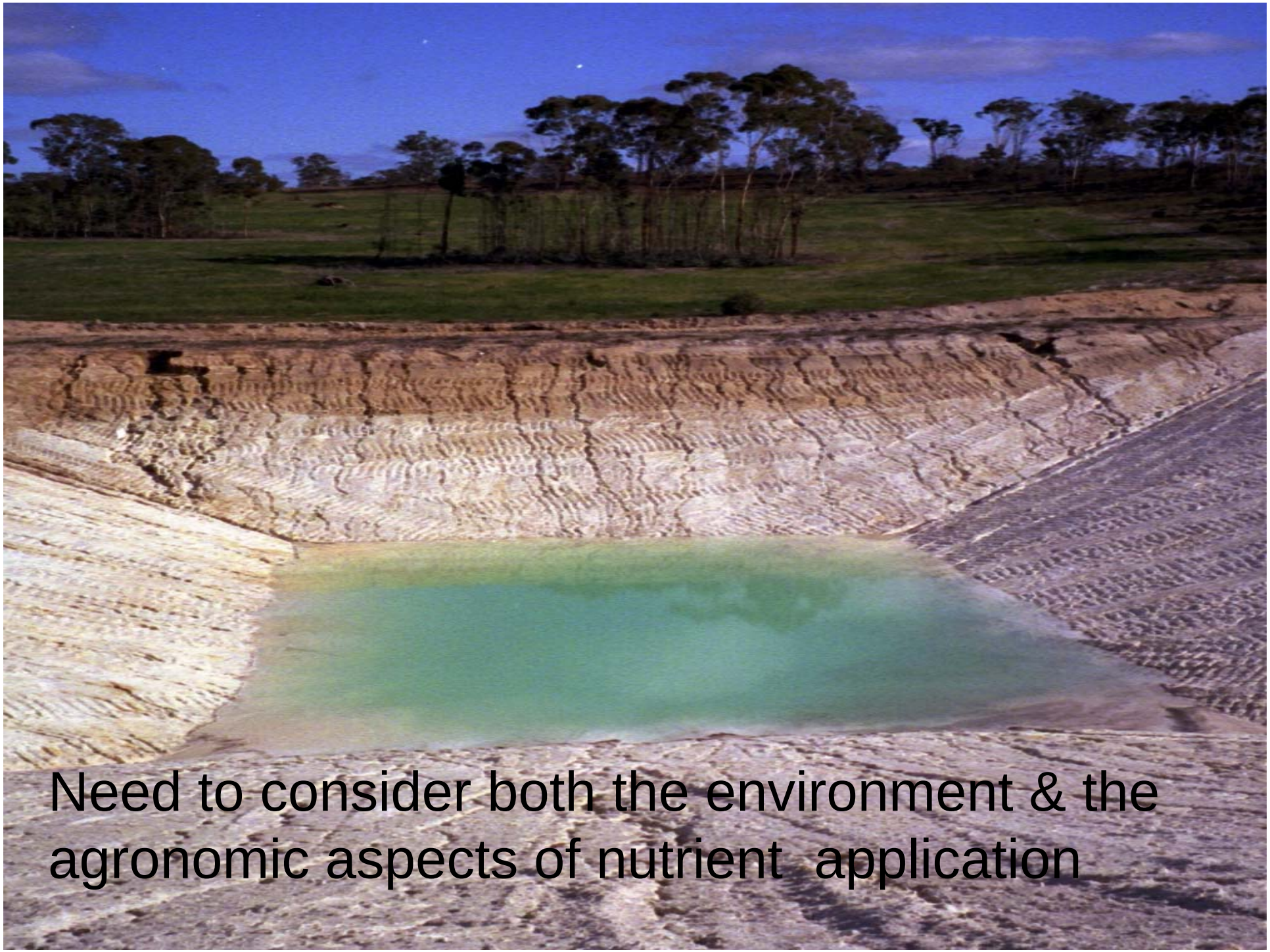
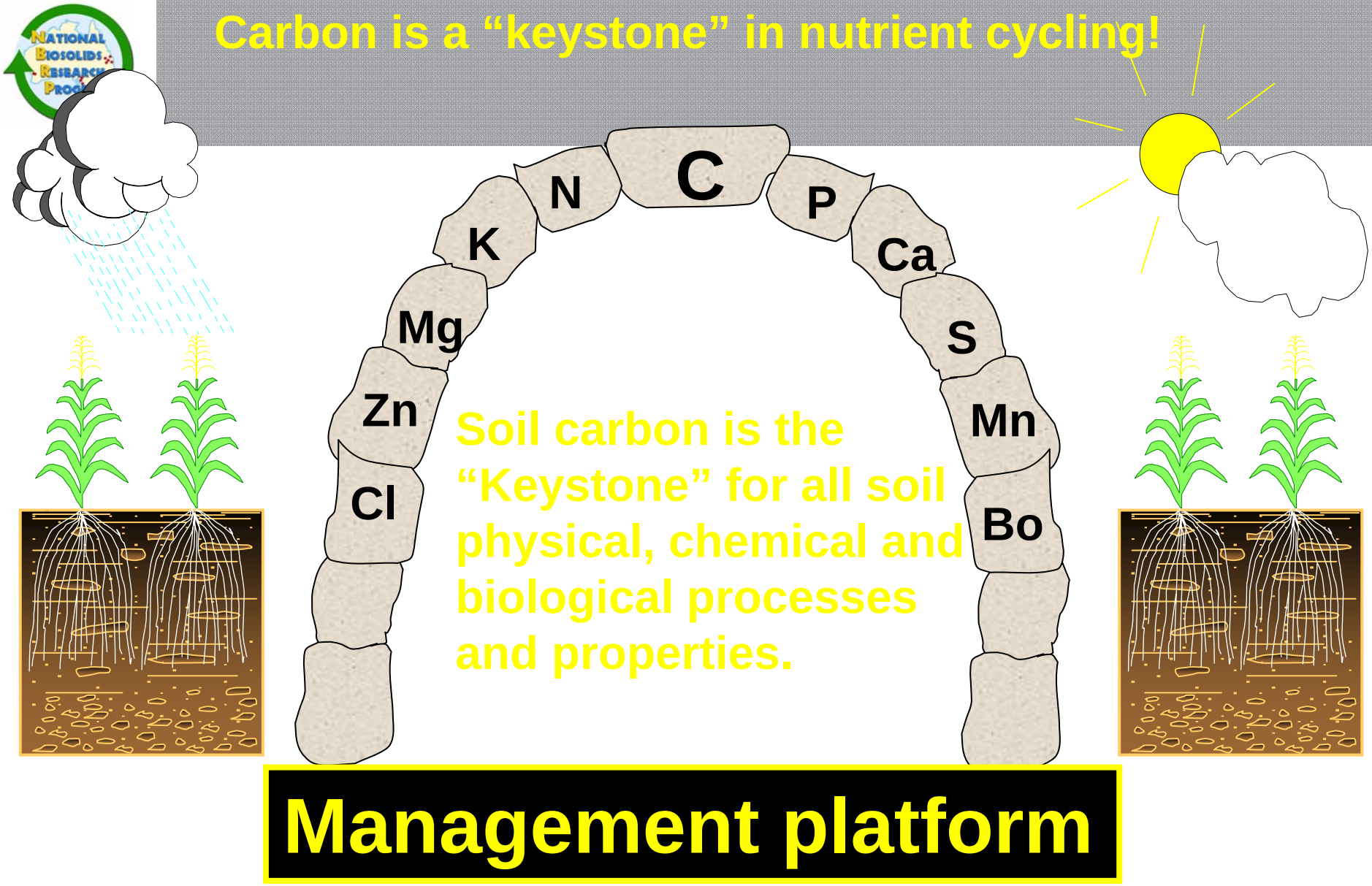
Are biosolids loading rates appropriate for WA agricultural soils?


Need to consider both the environment & the agronomic aspects of nutrient application

Carbon is a “keystone” in nutrient cycling!



Management platform

fertility, variety, irrigation, species, cover crop, manure, rotations, tillage, soil type, erosion, timing,

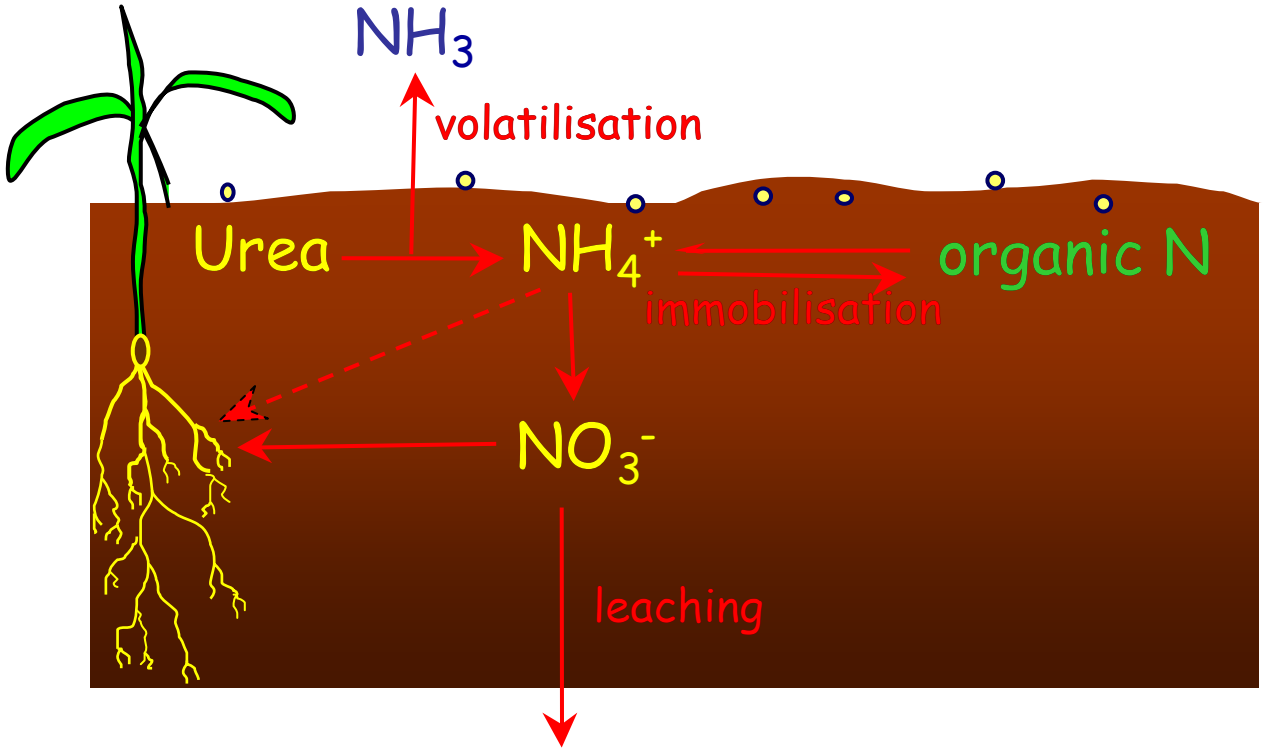
Nitrogen

Most (>98%) soil N is in the organic form.

Primarily taken up as nitrate but also some ammonium.

Fertiliser requirements heavily dependent upon yield potential and soil supply (rotation, organic matter).

For agricultural applications in WA, the NLBAR is defined by DEP *et al.* (2002) as; NLBAR (t/ha DS) = crop requirement (kg/ha)/ PAN_1 (kg/t)



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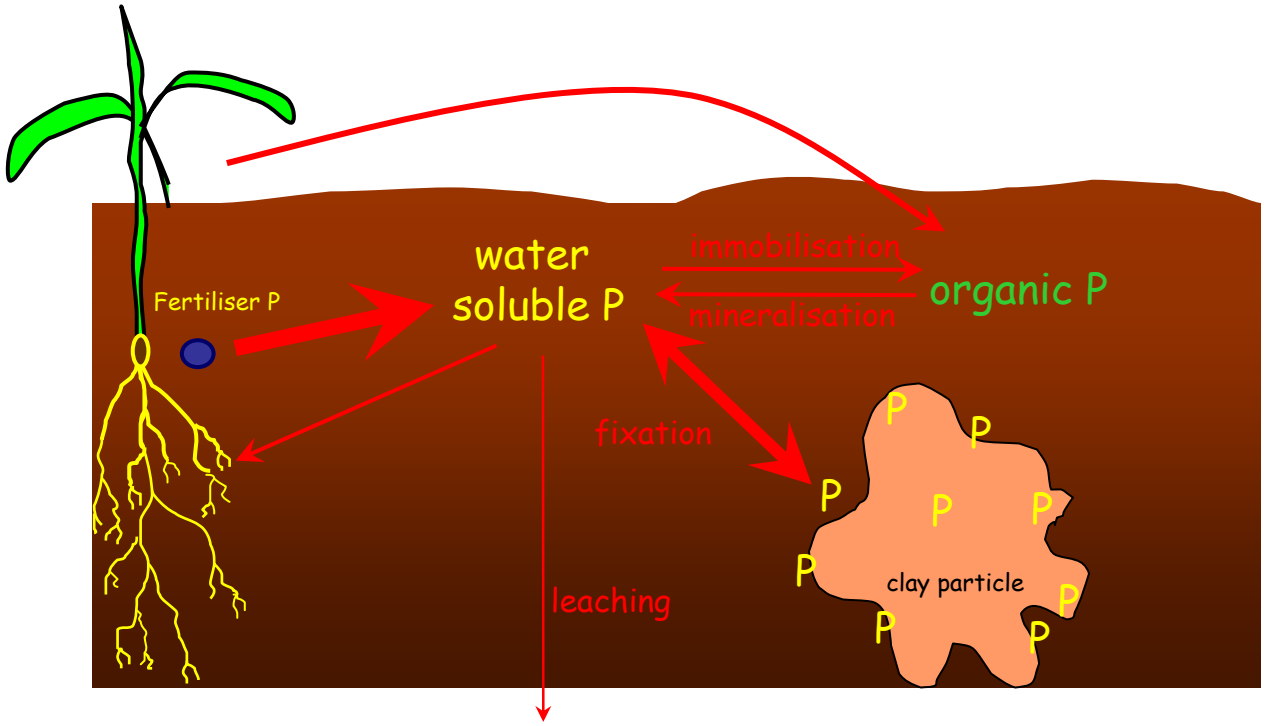
Phosphorus in Soils

Plants only take up P in the inorganic water soluble form.

Most soil P is “fixed” to soil particles.

Majority of fertiliser P is fixed by the soil, usually within 5-10mm of the granule.

Leaching is only a problem on gutless sands.



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Why study phosphorus?

Direct land application in agriculture & forestry accounts for 80% of production in WA

Application rates generally based on plant nutrients, specifically nitrogen (N)

N based application rates lead to an excess of phosphorus (P) if 100% of the P is available

- 2.8% total P & 5% total N.

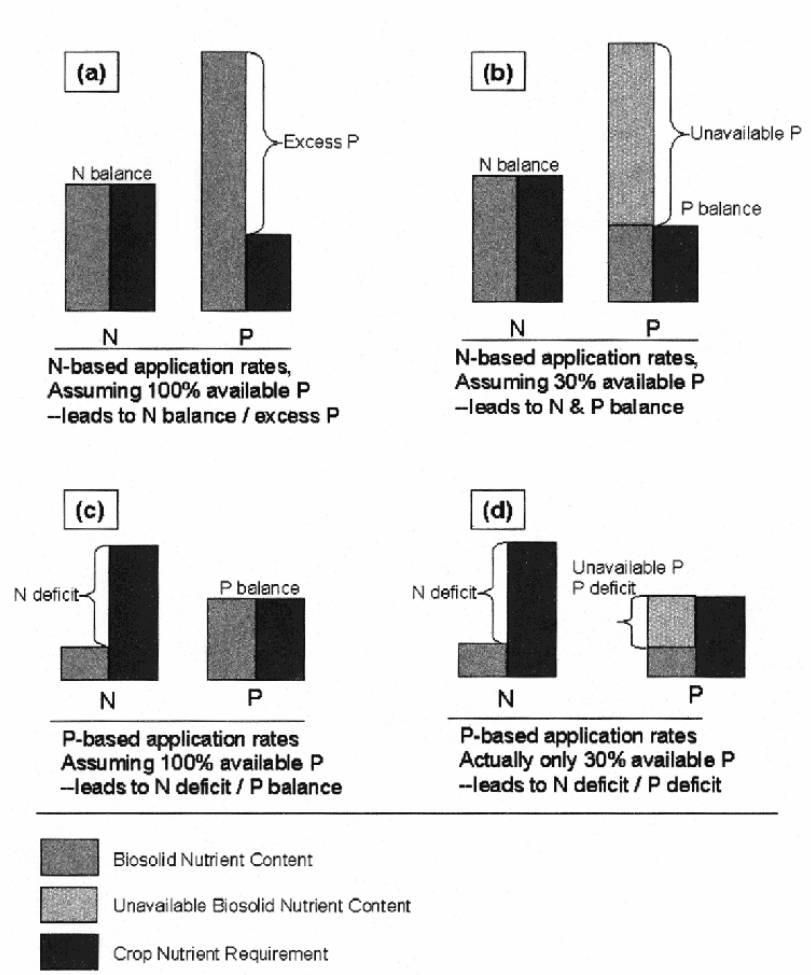


Figure 1. Results of different application rate bases and assumed biosolids P availabilities. Adapted from Sharpley and Beegle, 1999.

P release affected by

e.g. the placement of biosolids (i.e. spatial heterogeneity) was primarily responsible for the decreased ability of plant roots to locate and absorb P.

Biosolids	Soils	Local
Wastewater types	P concentration in solid, soluble phases	Hydrology
Presence of water treatment residuals	P speciation and bioavailability	Topography
P removal processes (BNR, chemical)	P binding capacity (eg. Presence of Al, Fe)	Crop management practices
Chemical additives used (Lime, Fe)	Erosion potential	Other nutrient applications
Stabilisation processes used	Porosity and subsurface drainage	Ditch and stream flow characteristics
		Proximity to surface waters
Dentel et al. 2001 See also McLaughlin 1984 (chemical, physical & environmental factors)		Sensitivity of surface waters to elevated P levels

P responsive soils in WA

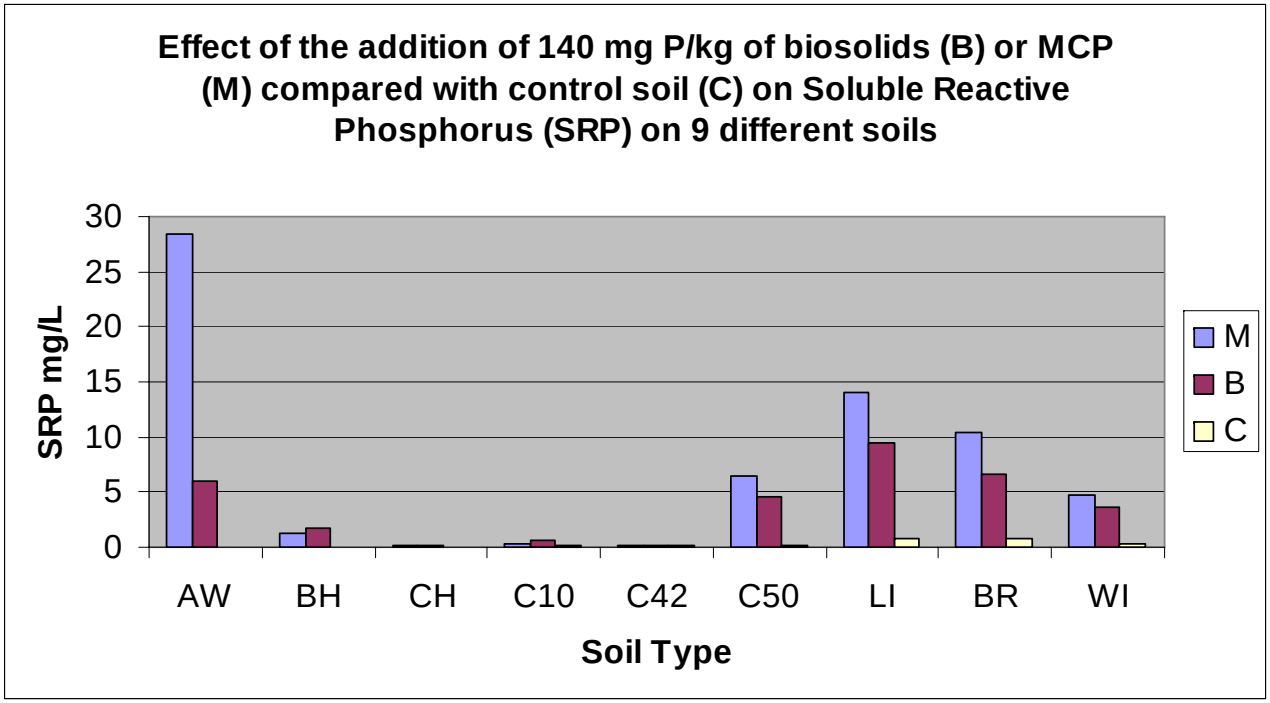
Effectiveness of biosolid P

The effectiveness of biosolid P was less than top-dressed inorganic P when applied to a field site representative of that typically used for agricultural application in Western Australia.

Solubility of biosolid P

Biosolid P was of lower solubility than inorganic sources of P and applied to soil would be less likely to contribute to the leaching of P.

DNA fingerprinting to monitor faecal contamination of waterways



How soluble is biosolid P?

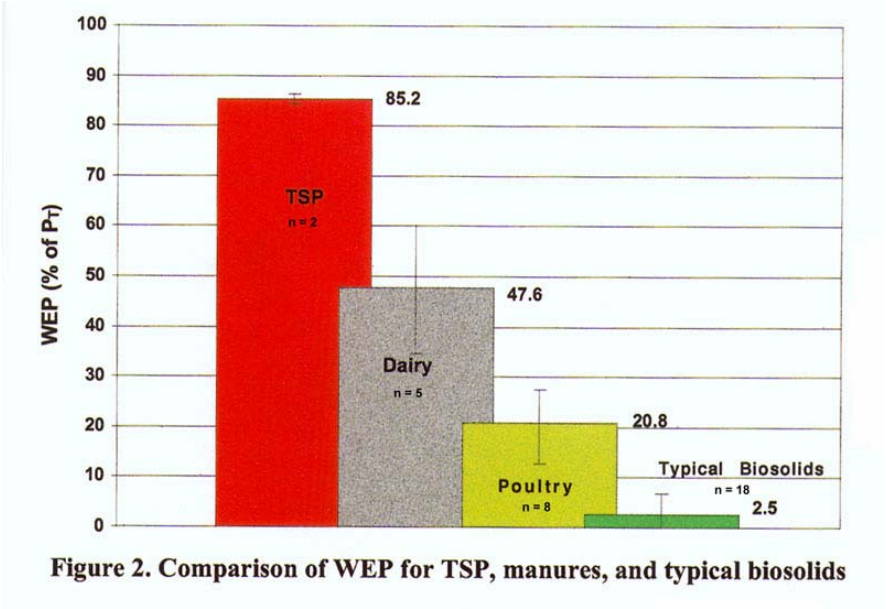


Figure 2. Comparison of WEP for TSP, manures, and typical biosolids

Lower concentration of total P & less soluble P than inorganic fertilisers

Other elements in biosolids affect P chemistry

Brandt et al. 2002

MINIMUM RATES OF BIOSOLIDS AND PLBAR REQUIRED TO OBTAIN OPTIMUM WHEAT YIELD (YO) COMPARED WITH DRILLED INORGANIC P (PI)

BASED ON SOILS DIFFERING IN PRI (MG/L) AND AVAILABLE SOIL P (PPM) WHERE BIOSOLIDS P IS 2.96% AND RELATIVE EFFECTIVENESS COMPARED TO INORGANIC P (PI) IS 20%.

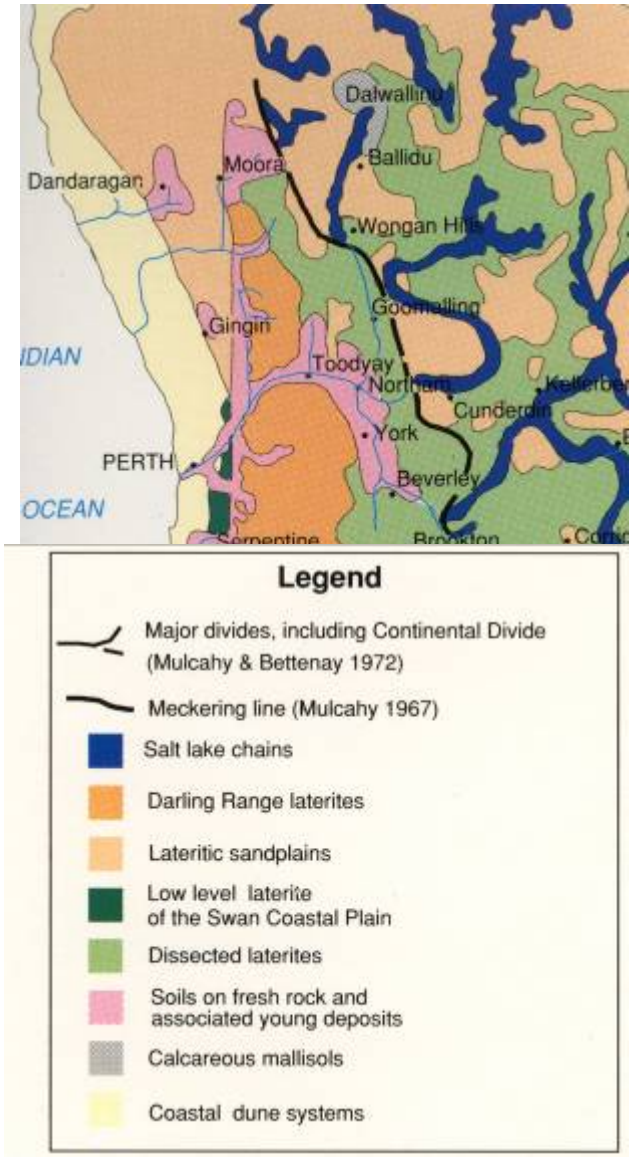
	PRI <2			PRI 2 to 15			PRI > 15		
Colwell P (mg P/kg)	Yo Pi (kg/ha)	PLBAR (kg/ha)	BS rate (dry t/ha)	Yo Pi (kg/ha)	PLBAR (kg/ha)	BS rate (dry t/ha)	Yo Pi (kg/ha)	PLBAR (kg/ha)	BS rate (dry t/ha)
<2	35	175	5.9	44	220	7.4	48	240	8.1
4	30	150	5.1	37	185	6.3	44	220	7.4
6	27	135	4.6	34	170	5.7	41	205	6.9
8	24	120	4.1	31	155	5.2	39	195	6.6
10	22	110	3.7	27	135	4.6	37	185	6.3
12	19	95	3.2	24	120	4.1	31	155	5.2
15	15	75	2.5	19	95	3.2	26	130	4.4
18	11	55	1.9	15	75	2.5	20	100	3.4
21	7	35	1.2	8	40	1.4	15	75	2.5
25	2	10	0.3	2	10	0.3	9	45	1.5
30	0	0	0.0	0	0	0.0	4	20	0.7

Agronomic P & loading rates

Require loading rates from 0 to 8.1 dry t/ha to satisfy the minimum agronomic P requirements of wheat in WA in the first season depending on soil PRI and bicarbonate available P values.

e.g. loading rates of biosolids based on the NLBAR were inadequate for optimum P uptake by wheat at 5 dry t/ha (i.e. 145 kg P/ha), on high P sorbing soils with a low fertiliser history (i.e. PRI >15, Colwell bicarbonate extractable P <15 mg P/kg). However, biosolids applied on soils of PRI <2 mL/g at identical loading rates would result in excess P.

Excess P generally not an agronomic problem.



Main recommendations

Refine NLBAR calculation by further investigation of the mineralisation and volatilisation rates

Best practice land application program of biosolids in WA should be based on soil factors that result in a high demand for P and low risk of P leaching at 1 x NLBAR.

No restrictions on biosolid P loading where PRI >2 mL/g and reactive iron >200 mg/kg.

Soils categorised according to bicarbonate extractable P (Colwell) (mg P/kg), PRI and agronomic demand for P.

Currently use ~ 2,000 ha/pa of agricultural land in WA.

Proposed classification system

PRI (mL/g)	Bicarbonate extractable P (Colwell) (mg P/kg)	Agronomic demand for P	Risk of P leaching	Category*
>70	<15	High	Negligible	1
	>15	Moderate	Negligible	1
15-70	<15	High	Low	1
	15-25	Moderate	Low	2
	>25	Low	Low	3
2-15	<10	High	Low	1
	10-20	Moderate	Low	2
	>20	Low	Low	3
<2	<15	Moderate	Moderate	4
	>15	Low	High where <200 mg Fe/kg	5

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NSW DEPARTMENT OF
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