AUSTRALIAN PORK LIMITED

Getting the Best Value from Manure Nutrients

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INTRODUCTION

Most piggery operators reuse effluent and manure on their own farms. These manure products are excellent sources of both macro-nutrients: nitrogen (N), phosphorus (P) and potassium (K), and a range of micro-nutrients including zinc (Zn), sulfur (S), copper (Cu), magnesium (Mg), manganese (Mn), iron (Fe), calcium (Ca) and chloride (Cl). They also return organic matter and other nutrients to the soil, building soil fertility, structure and moisture-holding capacity. Used at suitable rates, manure products can contribute considerable value to farming systems. This booklet describes how to get the best value from manure nutrients.

Factors Affecting the Value of Manure Products

The value of manure products depends on:

» their composition, including nutrient availability

» crop nutrient needs

» soil fertility

» cost and ease of spreading

» whether they could contain weed seeds

» fertiliser prices (that are used to value nutrients)

» local demand for manure products.

Composition of Manure Products

Tables 1, 2 and 3, taken from the Australian Pork Ltd (APL) "2012/1028, Piggery Manure and Effluent Management and Reuse Guidelines 2015", show analysis results for effluent, pond sludge and spent bedding, respectively. Department of Agriculture, Fisheries and Forestry (2010) provides a single analysis result for pig mortalities compost. On a wet weight, this contains 1.28% N, 0.27% P and 0.28% K. While manure products are nutrient-rich, and also contain carbon which improves soil structure, they vary widely in composition.

The composition of effluent and manure varies widely. Test effluent and manure before the main reuse period so these can be spread at suitable rates.

Photograph 1 Spent bedding composition varies with bedding material and management

Plants can only take up nutrients if they are in inorganic forms. Most of the K in manure products will be in these forms. However, some of the N and P will be in organic forms and will need to be mineralised before these nutrients can be used. This process can take several years. Hence, the value of spent bedding or compost could be spread over 2-3 years as nutrients become available to plants.

Crop Nutrient Needs

Getting the most value from manure nutrients relies on spreading these at rates that meet crop nutrient requirements. The mass of nutrients removed when the crop is harvested provides a guide to its requirements. Table 4, which is taken from the National Environmental Guidelines for Piggeries 2010 2nd Edition revised (Tucker et al. 2010), presents typical nutrient removal rates for a range of crops and crop yields.

TABLE 1 Effluent analysis results

Element	Units	Raw effluent[a]	Final pond effluent[a]	Pond effluent[b]	Range for pond effluent[b]
Total solids	mg/L	49,500	3623	7900	1100-44300
Volatile solids	mg/L	-	1809	1640	480-5290
pH		6.7	8.0	8.0	7.0-8.7
Total-N or (Total Kjeldahl N)	mg/L	2175	(384)	584	158-955
Ammonium N	mg/L	1800	249	144	25-243
Total P	mg/L	850	44	69.7	19.3-175.1
Ortho-P	mg/L	-	28.5	16.3	2.4 – 77.9
K	mg/L	618	-	491	128-784
Sulphur	mg/L	-	22	-	-
Sulphate	mg/L	69	26	47.6	13.3-87.2
Copper	mg/L	2.43	-	0.09	0.00-0.28
Iron	mg/L		-	0.56	0.09-1.61
Manganese	mg/L		-	0.02	0.00-0.05
Zinc	mg/L		-	0.47	0.16-1.27
Calcium	mg/L		-	20.6	7.3 – 41.2
Magnesium	mg/L		-	25.0	6.6 – 72.3
Sodium	mg/L		603	399	41 – 1132
Chloride	mg/L		810	19.1	3.6 – 34.4
EC	dS/m	10.1	-	6.4	2.5 – 11.7

a Kruger et al (1995) - samples from piggeries in New South Wales, Queensland and Western Australia.
b Unpublished data from Department of Employment, Economic Development & Innovation, Qld data – samples from 10 piggeries in southern Queensland.

Photograph 2 Effluent composition varies widely and it should be tested before the main irrigation season

TABLE 2 Pond sludge analysis results

Element	Effluent at Work[a]	Wang et al. (2006)[b]	DEEDI data[c]	
			Average	Range
Total solids	-		13.1% wb	6.9-17.1% wb
Volatile solids	-		6.9% wb	5.3-9.5% wb
pH	7.3		-	-
C	-	12-13%	28.1%	22.5-37.1%
Total N or (Total Kjeldahl N)	(2617) mg/L	1.7-2.4%	3.41%	2.84-4.02%
Ammonium N	1156 mg/L	1100 mg/kg	2582 mg/kg	1472-4422 mg/kg
Nitrate-N	-	750-1100 mg/kg	-	-
Total P	1696 mg/L	2.8-3.8%	4.69%	2.83-5.9%
Ortho-P	1082 mg/L		-	-
K	-	6100-8400 mg/kg	0.75%	0.27-1.33%
Sulphur	-	0.58-0.61%	1.99%	1.53-3.08%
Copper	25 mg/L		1.02%	3.43-1.82%
Iron	-		1.17%	0.52 – 2.21%
Manganese	-		1050 mg/kg	786-1389 mg/kg
Zinc	-		3188 mg/kg	2184-3698 mg/kg
Calcium	2210 mg/L		7.08%	4.28-10.4%
Magnesium	-		1.93%	1.0-3.19%
Sodium	108 mg/L		0.52%	0.15-1.40 %
Selenium	-		0.59 mg/kg	0.07-2.41 mg/kg
Chloride	232 mg/L		-	-
EC	8.5 dS/m		-	

DEEDI = Department of Employment, Economic Development & Innovation, Qld
a Kruger et al. 1995 - samples from piggeries in New South Wales, Queensland and Western Australia, b two samples of sludge,
c unpublished data – samples from 10 piggeries in southern Queensland.

It is also important to recognise that effluent and manure are not balanced fertilisers. Applied at a set rate, manure products will deliver some nutrients at the ideal rate but not enough (or too much) of others. Manure products may need to be used in conjunction with inorganic fertiliser to ensure the supply of all nutrients needed by the crop being grown. Additional spreading costs may be incurred.

TABLE 3 Spent bedding analysis results – average and (range)

	Unit	Straw[a]	Straw[b]	Rice Hulls[a]	Sawdust[c]
Moisture	% wb	41.6 (18 - 64)	48 (7-74)	36 (21 - 53)	40.8 (21 - 50)
pH		6.8 (5.7 - 8.5)	-	7.1 (7 - 7.3)	6.3 (6.2 - 6.3)
Total N or TKN	% db	0.8 (0.2 - 1.3)	2.9 (1.7-4.5)	0.7 (0.1 - 1.6)	0.9 (0.6 - 1.3)
Ammonium N	% db	0.5 (0 - 1.2)	-	0.3 (0.1 - 0.5)	0.6 (0.4 - 1)
Total P	% db	1.1 (0.2 - 2.5)	1.2 (0.5-2.6)	0.9 (0.6 - 1.3)	1 (0.4 - 1.3)
Ortho-P	% db	0.4 (0.2 - 0.6)	-	0.4 (0.3 - 0.6)	0.4 (0.2 - 0.5)
K	% db	1.8 (0.6 - 2.8)	2.0 (0.9-3.8)	1.8 (1.2 - 2.1)	1.8 (1.6 - 1.9)
Sulphur	% db	0.4 (0.1 - 0.7)	0.6 (0.4-1.0)	0.4 (0.3 - 0.5)	0.5 (0.4 - 0.5)
Copper	% db	0 (0 - 0.1)	0.01 (0-0.05)	0 (0 - 0)	0 (0 - 0)
Iron	% db	1.3 (0.1 - 3.2)	0.4 (0.09-1)	1 (0.7 - 1.6)	1.1 (0.5 - 1.6)
Manganese	% db	0.1 (0 - 0.8)	0.04 (0.02-0.06)	0.2 (0 - 0.8)	0.3 (0 - 0.8)
Zinc	% db	0.2 (0 - 0.4)	0.1 (0.03-0.4)	0.1 (0 - 0.3)	0.1 (0.1 - 0.2)
Calcium	% db	1.9 (0.4 - 3.1)	2.5 (0.9-5.4)	1.4 (1 - 2.1)	2.4 (2.1 - 2.7)
Magnesium	% db	0.7 (0 - 1.8)	0.04 (0.02-0.06)	0.4 (0 - 0.6)	0.4 (0 - 0.7)
Sodium	% db	0.4 (0.1 - 0.7)	0.7 (0.2-1.8)	0.3 (0.1 - 0.4)	0.4 (0.4 - 0.5)
Chloride	% db	0.8 (0.3 - 1.3)	-	0.6 (0.4 - 0.8)	0.7 (0.4 - 1.1)
EC	dS/m	11.7 (6.6 - 15.6)	-	9.6 (9.2 - 10)	13 (12.6 - 13.4)

NOTES: Nutrient contents based on a combination of fresh, stockpiled and composted spent bedding
a Black (2000) and Nicholas et al. (2006)
b Craddock (2011)
c Nicholas et al. (2006)

TABLE 4 Approximate nutrient removal rates for various crops and crop yields

Crop	Dry Matter (DM) Content (kg/t)			DM yield range[a]	Nutrient Removal Range (kg/ha)		
	Nitrogen	Phosphorus	Potassium	(t/ha)	Nitrogen	Phosphorus	Potassium
Grazed pasture[b]					7-19	1-2	0.1-0.6
Dry land pasture (cut)	20	3	15	1-4	20-80	3-12	15-60
Irrigated pasture (cut)	20	3	15	8-20	160-400	24-60	120-300
Lucerne hay (cut)	31	3	25	5-15	155-465	15-45	125-375
Maize silage	22	3	20	10-25	220-550	30-75	200-500
Forage sorghum (cut)	22	3	24	10-20	220-440	30-60	240-480
Winter cereal hay	20	3	16	10-20	200-400	30-60	160-320
Barley grain	19	3	4	2-5	38-95	6-15	8-20
Wheat grain	19	4	5	2-5	38-95	8-20	10-25
Triticale	19	4	6	1.5-3	29-57	6-12	9-18
Rice	14	3	4	12-24	56-112	12-24	16-32
Oats grain	15	3	4	1-5	15-75	3-15	4-20
Sorghum grain	20	3	3	2-8	40-160	6-24	6-24
Maize grain	20	3	4	2-8	40-160	6-24	8-32
Chickpeas	40	4	4	0.5-2	20-80	2-8	2-8
Cowpeas	30	4	20	0.5-2	15-60	2-8	10-40
Faba beans	40	4	12	1-3	40-120	4-12	12-36
Lupins	45	3	8	0.5-2	22.5-90	1.5-6	4-16
Navy beans	40	6	12	0.5-2	20-80	3-12	6-24
Pigeon peas	26	3	9	0.5-2	13-52	1.5-6	4.5-18
Cotton	20	4	8	2-5	40-100	8-20	16-40

a Yields may vary from these ranges (refer to historical data for the region for more accurate estimates).
b The grazed pasture example assumes a liveweight gain of 75 – 200 kg/ha/yr, with no ammonia volatilisation losses from the grazed animal's manure.
Sources: National Research Council (1984) and Reuter and Robinson (1997)

Soil Fertility

The nutrients for the crop can come from soil reserves or can be added as manure nutrients and/or inorganic fertiliser. If the soil has a good nutrient status, less nutrients will need to be added. Regular soil testing should be used to monitor fertility.

Cost and Ease of Spreading

Effluent can contain solids that make it unsuitable for use with irrigation equipment with small apertures. Lumpy or wet manure solids may be difficult to spread evenly. Consistent products are preferred. Manure products have greatest value if they can be spread at a time that suits the user (e.g. pre-planting) using existing spreading equipment.

Weed Seeds

Spent bedding may contain viable weed seeds. Composting can destroy these, but all material must be sufficiently heated to ensure these are no longer able to germinate.

Fertiliser Prices

Fertiliser prices can be used to place an economic value on manure nutrients. This is done by dividing the fertiliser cost ($/t) by the nutrient content (kg/t) to find the nutrient value ($/t). As fertiliser prices fluctuate, it is important to use current pricing.

Local Demand for Manure Products

In some cases, there may be local demand for manure products, either for land spreading or for composting. This can increase their value.

> "We sell half of our compost to gardeners at $60/m^3 and half to vegie farmers ($30/m^3)."
>
> Producer TAS

Reuse Area Selection

Manure products are best used to grow high-yielding crops or pastures that can use the N, P and K they contain. To ensure nutrient uptake, the land needs to be able to produce dryland crops reliably or should be irrigated.

Ideally reuse areas should have good agricultural soils with no serious limitations for crop growth. The carbon and nutrients in manure products can be used to remediate soil concerns, but larger areas will be needed if crop yields will be lower.

To protect water resources, provide well-vegetated buffers between reuse areas and watercourses, and poorly protected aquifers. Also provide suitable separation distances between reuse areas and neighbours and public use areas. This allows odour, droplets and dust to disperse, reducing the likelihood of nuisance and complaints.

Photograph 3 Manure nutrients are best used to grow high yielding crops

Determining Sustainable Reuse Rates

Various factors influence sustainable reuse rates for manure nutrients. A reuse system can be considered sustainable if the N and P added in manure products can be matched by removal of these nutrients in crops or pastures harvested from the area, plus acceptable storage and losses (N volatilisation). Although the K balance is also determined, K is generally considered less important than N and P as it causes few environmental concerns unless applied at very high rates.

The nutrient status of the soil and the availability of nutrients for plants should also be considered when deciding on reuse rates. This section provides a process for determining sustainable reuse rates.

Step 1 Find N, P & K Removal by Crop or Pasture

Finding the N, P and K removal by the crops or pastures that will be grown is the first step in determining sustainable reuse rates. From Table 4, select the crop or pasture. Use the expected dry matter (DM) yield and the DM nutrient content of the crop in the calculation template below to calculate the expected N, P and K removal rates (kg/ha).

Use historical average farm yields, or district farm yields, when estimating nutrient removal rates.

Crop type: ________________ Yield (DM t/ha) ________

Parameter	N	P	K
Nutrient content (kg/t)			
Nutrient removal rate (kg/ha)			

For example:

Crop type: Barley Yield 3 DM t/ha

Parameter	N	P	K
Nutrient content (kg/t)	19	3	4
Nutrient removal rate (kg/ha)	19 kg/t x 3 t/ha = 57 kg/ha	3 x 3 t/ha = 9 kg/ha	4 kg/t x 3 t/ha = 12 kg/ha

Step 2 Determine Target Nutrient Application Rates

Determine target nutrient application rates using the nutrient mass balance equation below:

Amount of nutrient applied (kg/ha) = nutrient removed by plant harvest (kg/ha) + acceptable nutrient losses to the environment (kg/ha) + nutrient safely stored in the soil (kg/ha)

This needs to be applied for N, P and K. The inputs are:

» Nutrient removed by plant harvest (previous step). For the example this is:

  N 57 kg/ha
  P 9 kg/ha
  K 12 kg/ha

» Acceptable nutrient losses to the environment. This generally only applies for N where ammonia (NH_3) volatilisation losses occur with reuse. Losses vary depending on the reuse method and the type of manure product. As a percentage of N removed by the crop, these are typically:

  – effluent spray /drip irrigated 20% of N
  – effluent surface flow irrigated 10% of N
  – fresh bedding spread 20% of N
  – compost spread 10% of N

Photograph 4 N losses are greater from spray irrigators than dropper or surface systems

» Nutrient safely stored in the soil. This generally applies only to P and only to reuse areas used for spreading manure solids every few years. P sorption capacity varies with soil type and land use history and should be determined by soil testing. If testing is not done, assume that reuse areas have no P storage capacity. However, if solids are spread on an area every few years, P can be applied to meet crop requirements for the years between spreading.

Use the nutrient removed by plant harvest (Step 1), an allowance for N volatilisation losses and soil P storage (if appropriate) to complete the calculation template below for N, P and K. Two worked example for barley yielding 3 t/ha are also provided overleaf.

N rate (kg/ha)	=	N removed by plant harvest (kg/ha) + ammonia-N losses (% N loss x N removed by plant harvest (kg/ha))
N rate (kg/ha)	=	_____ kg/ha + (_____ % x _____ kg/ha)
P rate (kg/ha)	=	P removed by plant harvest (kg/ha) + nutrient safely stored in the soil (kg/ha)
P rate (kg/ha)	=	_____ kg/ha + _____ kg/ha
K rate (kg/ha)	=	K removed by plant harvest (kg/ha)
K rate(kg/ha)	=	_____ kg/ha

Sometimes, adjustment of the nutrient application rate may be warranted depending on soil fertility. If the soil is deficient in a nutrient, a higher application rate may be needed to ensure adequate plant nutrition. Where there is a nutrient surplus, a lower application rate or even cessation of reuse may be recommended until desirable nutrient levels return.

Where soils have significant nutrient deficits, seek agronomic advice on how much extra nutrient to apply.

Also be aware of N and P availability issues. Applying a mass of nutrients that matches the expected nutrient removal in crop harvest may not always ensure that plant needs are satisfied. Some of the nutrients in manure products will be in an inorganic form and readily available for uptake by plants; others will be in an organic form. The amount in each form can vary considerably. The organic nutrients need to mineralise into the inorganic form before they become available to the plants.

Mineralisation occurs progressively over a lengthy period, often years. For example, only one-third of the N in compost might be available in Year 1, while P availability varies widely between soil types. This is rarely an issue for areas that are spread with manure or effluent annually, since ongoing mineralisation of nutrients applied over a number of years ensures nutrient availability. However, it can present a nutrient availability challenge in the first year a reuse area is used, or in paddocks that are used intermittently.

Nutrient availability concerns can be overcome by using a higher application rate in the first year of reuse. In some soils, reductions in crop vigour in paddocks spread with spent bedding are related to P availability. A "starter" application of inorganic P fertiliser in the seed row, in addition to the application of manure prior to planting can overcome these issues. Applying manure 4-6 months before crop establishment is another way to provide time for nutrient mineralisation and also overcomes the N drawdown that can occur during this process. For manure solids reuse areas, applying several years' nutrients in one year can overcome nutrient availability concerns and ensure practical spreading rates.

Consider nutrient availability issues and seek agronomic advice on start-up fertiliser or reuse rates for new paddocks or those used infrequently.

Worked Example **Barley grown on effluent reuse area**

Because the land is used for effluent irrigation, only one year's P can be applied. A spray irrigation system is used so expected N losses are 20% of the crop removal rate. Crop nutrient removal rates come from the previous step. (Step 1)

N rate (kg/ha) = N removed by plant harvest (kg/ha) + acceptable nutrient losses to the environment (% N loss X N removed by plant harvest (kg/ha))

N rate (kg/ha)	=	57 kg/ha + (20 % x 57 kg/ha)
	=	68.4 kg N/ha
P rate (kg/ha)	=	9 kg/ha + 0 kg/ha
	=	9 kg P/ha
K rate (kg/ha)	=	12 kg K/ha

If the soil has a nutrient surplus or deficiency, account for this in the reuse rates as well. For instance, if the soil has a P deficiency and addition of 20 kg P/ha is recommended, the P application rate can increase to 29 kg P/ha.

Worked Example **Barley grown on a reuse area spread with spent bedding every four years.**

Because spent bedding is spread every four years, four years nutrients can be applied at each spreading. N losses are 10% of the crop removal rate. Crop nutrient removal rates come from the previous step. (Step 1)

N rate (kg/ha)	=	4 yrs x (57 kg/ha + (10% N loss X 57 kg/ha))
	=	4 x (57 kg/ha + 5.7 kg/ha)
	=	251 kg N/ha
P rate (kg/ha)	=	4 x (9 kg/ha + 0 kg/ha)
	=	36 kg P/ha
K rate (kg/ha)	=	4 x 12 kg/ha
	=	48 kg K/ha

Step 3 Determine manure product application rate

Because manure products can vary considerably in composition, it is important to use recent analysis results to determine spreading or irrigation rates.

The effluent or manure application rate is determined by dividing the target nutrient application rate by the nutrient concentration in the manure product. Examples for effluent and manure are provided below.

If an effluent analysis result is given as mg/L, it is equal to kg/ML
e.g. 100 mg/L = 100 kg/ML.

If a manure analysis result is given as mg/kg, divide the value by 1000 to find kg/t
e.g. 10,000 mg/kg = 10 kg/t.

If an analysis result is given as %, multiply by 10 to find kg/t
e.g. 1% = 10 kg/t.

"We don't sell our manure. We use $200K worth of nutrients on-farm annually, we just need to add N."

Producer NSW

Worked Example **Effluent**

For this example, it is assumed the effluent contains 600 mg N/L, 50 mg P/L and 300 mg K/L.

N rate (KL/ha)	=	68.4 kg/ha / (600 mg/L / 1000)
	=	114 KL/ha
P rate (KL/ha)	=	9 kg/ha / (50 mg/L / 1000)
	=	180 KL/ha
K rate (KL/ha)	=	12 kg/ha / (300 mg/L / 1000)
	=	40 KL/ha

An effluent irrigation rate of 40 KL/ha or 4 mm is very light and likely to be practically difficult to achieve without dilution with irrigation water. Since K rarely causes environmental impacts application of effluent to meet the N requirements is recommended. N can be considered the limiting nutrient, or the nutrient that determines the application rate. The target N application rate of 114 KL/ha or 11.4 mm would apply 68.4 kg N/ha, 5.7 kg P/ha and 34.2 kg K/ha. Unless the soil has a P surplus to start with, start-up P fertiliser should be added to meet plant needs.

Photograph 5 Dropper irrigators can apply effluent at low rates

1 KL/ha is equivalent to an irrigation depth of 0.1 mm.
1 ML/ha is equivalent to an irrigation depth of 100 mm.

Worked Example **Spent Bedding**

It is assumed the spent bedding contains 0.8% N, 1.1% P and 1.6% K on a DM basis; or 8000 mg N/kg, 11,000 mg P/kg and 16,000 mg K/kg.

N rate (t/ha)	=	251 kg/ha / (8000 mg/kg / 1000)
	=	31 dry t/ha
P rate (t/ha)	=	36 kg/ha / (11,000 mg/kg / 1000)
	=	3 dry t/ha
K rate (t/ha)	=	48 kg/ha / (16,000 mg/kg / 1000)
	=	3 dry t/ha

P and K are the limiting nutrients with a spreading rate of 3 dry t/ha. If the moisture content of the spent bedding is 40%, the application rate will need to be 5 t/ha (i.e. 3 t / (1-0.4)). Additional N will need to be applied to meet the crops needs.

Overcome impractically low spreading rates by diluting effluent with irrigation water, choosing a higher yielding crop (e.g. silage or hay), or applying several years of manure solids nutrients at once (provided the soil can safely store these).

Photograph 6 A manure spreader can distribute aged or composted spent bedding

"Effluent is an excellent resource."

Producer QLD

Valuing Manure Nutrients

An economic value can be placed on manure nutrients using the cost of inorganic fertiliser. This can help in marketing manure products or in making fertiliser decisions.

Step 1 Determine the nutrient content of the manure product

Analyse the manure product to accurately determine its nutrient content. Ideally this should occur shortly before reuse happens. The moisture content of the manure product should be considered when calculating the nutrients applied.

For example, if spent bedding contains 20 kg N/t, 14 kg P/t and 29 kg K/t on a dry basis, and has a moisture content (MC) of 40%, the concentration of each nutrient as-spread can be determined using the formula:

Nutrient concentration (kg/wet t) = DM concentration (kg/t) X (1 - (MC%/100))

N = 20 kg/dry t X (1 - (40/100))
= 12 kg/t or 1.2%

P = 14 kg/dry t X (1 - (40/100))
= 8.4 kg/t or 0.84%

K = 29 kg/dry t X (1 - (40/100))
= 17 kg/t or 1.7%

Step 2 Value the Nutrients in Inorganic Fertilisers

Use the price and N, P and K concentrations of inorganic fertilisers to assign an economic value to manure nutrients. Table 5 shows the composition of a range of fertilisers.

» Urea is 46% N and costs $550/t, so N can be valued at $1.20/kg (i.e. ($550/t / 0.46)/1000)

» Triple superphosphate is 20% P and costs $800/t. The P in triple superphosphate is worth about $4/kg (i.e. ($800/t / 0.2)/1000)

» The K in muriate of potash is worth about $1.60/kg (i.e. ($800/t / 0.5)/1000)

TABLE 5 Nutrient value of common fertilisers

Nutrient	Fertiliser	Price	Nutrient content %	Nutrient value ($/kg)
N	Urea	$550	46%N	N = $1.20/kg
P	Triple Superphosphate	$800	20% P	P = $4.00/kg
K	Muriate of Potash	$800	50% K	K = $1.60/kg

Step 3 Apply Fertiliser Nutrient Values to Manure Nutrients

The nutrient values ($/kg) for N, P and K calculated in Step 2 can be multiplied by the N, P and K in manure products (from Step 1) to obtain a macro-nutrient value for the product. Table 6 provides an example for spent bedding.

TABLE 6 Example: Value of nutrients in spent bedding based on inorganic fertiliser nutrient prices

Parameters	Nutrient concentration[a] (kg/wet t)	Value[b] ($/kg nutrient)	Value of nutrients in spent bedding ($/t)
N	12	$1.20	$14.40
P	8.4	$4.00	$33.60
K	17	$1.60	$27.20

a from Step 1
b from Step 2

Greater accuracy can be obtained by using site-specific data for the composition of spent bedding or compost and up to date fertiliser prices.

It is important to realise that:

» the nutrients in manure products are only of value if they are needed in the cropping system. For instance, if the crop needs N, P and K, the manure is worth the sum of the N, P and K contributions. However, if soil contains ample K to grow a crop, the K in manure adds no value and the value is the sum of the N and P only. Manure products generally contain high levels of P and K, and relatively low N levels

» nutrients like sulfur, zinc, calcium, magnesium, boron, copper and other trace elements that may be beneficial to the cropping system depending on the soil nutrient status. The value of other nutrients can be accounted for by applying the process used to assign a value to N, P and K. Manure products also add carbon to the soil. While the benefits of this in improving soil structure, water-holding capacity and biological activity, and reducing erosivity are well known, it is difficult to assign a dollar value to these

» N losses after spreading must be considered and the value of the N contribution adjusted accordingly. Spreading manure close to planting time, or irrigating growing crops with effluent, maximises the value obtained from manure products

» the nutrients contained in manure products may not all be readily available. The value of manure N and P could be spread over 2-3 years as nutrients become available to plants

» because manure products do not supply nutrients in the ideal ratios for plant needs, they are often best used in conjunction with an inorganic fertiliser program.

One option is to apply the manure at a rate that meets P requirements and then supplement the N with a conventional fertiliser to meet additional crop needs.

An alternative is to apply the manure at a rate that meets crop N requirements although this is only acceptable if testing demonstrates that the soil is able to store the surplus P. If this option is chosen, N availability in the first year needs to be carefully considered to avoid N deficiency. P storage in the soil can only be a temporary measure. The stored P should be removed by growing and harvesting crops before additional manure is applied to the land.

Step 4 Calculate the Value of the Nutrient Applied

The value of nutrients applied as spent bedding with an application rate of 5 t/ha are shown in Table 7. The value is determined by multiplying the value of each nutrient ($/t) by the spreading rate (5 t/ha).

TABLE 7 Example: Value of nutrients applied as spent bedding

Nutrient	Nutrients applied[a] (kg/t)	Value of nutrients applied[b] ($/t)	Nutrients applied @ 5 t/ha (kg/ha)	Value of nutrients applied @ 5 t/ha ($/ha)
N	12	$14.40	60	$72.00
P	8.4	$33.60	42	$168.00
K	17	$27.20	85	$136.00

a from Step 1
b from Step 3

Nutrients in manure products only have value for a particular cropping system if they are needed by that system.

If N, P and K are needed by the cropping system, the value of the nutrients applied as spent bedding is $75.20/t (i.e. $14.40 + $33.60 + $27.20). If N and P are needed by the cropping system, but not K, the value of the nutrients applied as spent bedding would be $48/t (i.e. $14.40 + $33.60).

Step 5 Determine the Net Benefit of Spreading the Manure

Table 8 provides the net benefit of using spent bedding, considering the costs of carting and spreading, compared to the calculated value of the nutrients contained in the bedding. In this example it is assumed that the cropping system needs N, P and K. Table 9 provides the net benefit of using spent bedding for a system that only needs N and P.

TABLE 8 Net benefit of N, P and K applied as spent bedding considering all costs

Item	Cost per t ($/t)	Total cost at 5 t/ha ($/ha)
Cost of bedding	$8.00	$40.00
Carting & spreading	$36.00	$180.00
Total cost	$44.00	$220.00
Value of nutrients applied[a]	$75.20	$376.00
Net benefit of using spent bedding	$31.20	$156.00

a From Step 4

In this example, there is an economic advantage of about $156/ha in applying 5t/ha of spent bedding compared to applying equivalent rates of nutrients using triple superphosphate, muriate of potash and urea.

TABLE 9 Net benefit of N and P applied as spent bedding considering all costs

Item	Cost per t($/t)	Total cost at 5 t/ha($/ha)
Cost of bedding	$8.00	$40.00
Carting & spreading	$36.00	$180.00
Total cost	$44.00	$220.00
Value of nutrients applied[a]	$48.00	$240.00
Net benefit of using spent bedding	$4.00	$20.00

a From Step 4

As tables 8 and 9 show, the net benefit of reusing spent bedding is highly dependent on which nutrients are needed by the cropping system.

The Importance of Sustainable Reuse

It is important to spread manure at sustainable rates and to adopt good reuse practices. Good reuse practices include:

» applying manure and effluent just before sowing, or when plants are actively growing, to maximise nutrient uptake and to minimise nutrient losses by leaching. Effluent can be irrigated during the growing season to regularly feed the crop

» applying the manure, compost or effluent at sustainable rates. Consider the nutrient and salt content of the manure and effluent, the land use and expected plant harvest and climatic conditions

» applying effluent at a rate that does not result in runoff. For surface flow irrigation, use suitable rates and suitable runoff collections methods

» spreading effluent, manure and compost evenly

» incorporating spread manure or compost into the soil to a shallow depth (if practical with available machinery)

» avoiding manure and effluent spreading if the soil is very wet or if heavy rain is expected. This may promote loss of valuable nutrients in drainage or runoff. This may pose a pollution risk to groundwater and / or surface waters

» monitoring soil nutrient levels on a regular basis. This helps in understanding the ongoing suitability of reuse areas and the likelihood of nutrient losses to the environment

» protecting amenity by using good practices and carefully timing reuse

» choosing to irrigate effluent or spread manure when the prevailing wind direction is away from sensitive location reduces the likelihood of odour impact

» avoiding spreading early in the morning or late in the afternoon when inversion layers are forming or under heavy cloud. Dispersion is lower under these conditions so odour and dust levels may be higher for close neighbours

» avoiding reuse on weekends or holiday periods when neighbours are likely to be home.

Marketing Manure

While increasing prices for inorganic fertilisers have heightened interest in the use of pig manure as a crop nutrient source, retrieving the nutrient-value through sales has proved difficult.

Many broadacre farmers are seeking a more concentrated, consistent fertiliser-type product that is quickly and cheaply spread and doesn't result in soil compaction from additional traffic movements. If they know that a piggery operator needs to send some manure off-site, some may use this knowledge to reduce what they pay. Others simply don't recognise the nutrient value of manure. Transport and spreading logistics can be a barrier for some.

Techniques for cost-effectively extracting manure nutrients to produce fertiliser-type products are under development. Composting may improve the marketability of spent bedding and sludge since it produces a less bulky, reasonably dry, low odour, consistent, more easily handled product. However, the demand, costs and sale price need to be carefully evaluated.

Piggery operators have a duty of care to ensure sustainable reuse of manure and effluent from their operations, even when these are sold or given to other parties. Recent analysis results for manure products should be provided to buyers. It may also be beneficial to calculate the value of the macro-nutrients in the manure. Since manure products generally contain high levels of P and K, and relatively low N levels they will have most value for farmers who need the P and K.

Facilitating the transport and / or spreading of manure products to purchasers may help with their marketing.

Further details on effluent and manure reuse, including an example duty of care statement, are provided in the APL Piggery Manure & Effluent Management & Reuse Guidelines 2015 and APL Piggery Manure and Effluent Reuse Glovebox Guide 2015.

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"Effluent provides the only nutrients for our cropping system."

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