Making the Most of Animal By-Products

Fact Sheet Series Workbook

(May 2007)

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- Effluent can contain high levels of salt that needs to be managed
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- Manure reuse is regulated in the feedlot, piggery and poultry industry and practices must comply to the licensing agreement
- Animal by-product reuse must comply with environmental laws related to air and water pollution
- Special laws restrict access for ruminant animals to chicken litter because of disease risks – animals are prohibited from accessing this material

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- Animal by-products may contain many different metals
- Metals are not generally a problem when by-products are applied at recommended rates
- Caution should be used when applying by-products to vegetable crops – it is recommended that an analysis of the product used is taken to ensure it meets guideline levels for metal contamination

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- Animal by-products may contain pathogens that pose a risk to animal and human health but the risk is relatively low
- If growing vegetables it is a requirement from some supermarkets that only composted by-products are used
- Good hygiene and management practices are recommended
- Composting of solid by-products will substantially reduce the risk from pathogens

Australian Government
Department of Agriculture, Fisheries and Forestry
National Landcare Programme

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INTRODUCTION

In conjunction with representatives from Qld Chicken Growers Association, Meat and Livestock Australia, Australian Lot Feeders Association, Pork Queensland Inc and Dairy Australia, Queensland Dairy Organisation (QDO) was successful in the development of a project to address the utilisation of animal waste products as fertiliser in the Wide Bay-Burnett and South East Queensland regions. Funding for this project was supplied by Landcare and Burnett Mary Regional Group. QDO contracted FSA Consulting to deliver this project.

Stage 1 of the project was the development of a workbook. This was to include aspects specifically relating to the use of dairy, feedlot and piggery manure as well as the use of chicken litter. Key issues to be covered in the workbook include:

- A summary of the legal issues associated with using animal waste as fertiliser (i.e. general environmental duty etc)
- Typical composition of dairy, pig, feedlot and chicken waste products
- Recommended practices for use, including timing, rates of application, application processes etc
- Typical costs of using these type of fertilisers and comparison with conventional fertilisers
- Risks associated with using manure as fertiliser and management options to address the risks.

This workbook has been compiled by developing a series of fact sheets on the composition, application and management of animal by-products (effluent and manure from dairies, feedlots, meat chicken farms and piggeries) for end users.

The workbook contains 16 fact sheets that provide an overview of best practices for animal by-product reuse and covers the three broad categories of:

- Application
- Composition, and
- Management

APPLICATION – Benefits to Soil Health

Applying animal by-products to soil can improve soil health in a variety of ways by improving soil structure and biology.

Measuring soil health can be difficult, and estimates are usually based on soil organic matter levels or microbial carbon levels (the amount of carbon in live microbial bodies). Generally speaking, more organic matter in a soil means better the soil health.

Animal by-products improve soil health directly (through the addition of carbon and nutrients that feed soil micro-organisms) and indirectly through improved plant growth which can lead to higher amounts of organic matter being added to the soil. Both these pathways affect the different aspects of soil health.

Influence on soil biology

Soil biology is important for soil health. It is now more widely recognised that plants need more than nutrients for maximum growth. Soil biology, or soil life, refers to microbes (such as bacteria and fungi) and soil fauna (protozoa and invertebrates such as mites and earth worms). This is the living portion of soil organic matter and is responsible for improving soil structure and cycling nutrients. There are not many good tests available for soil biological activity, however the amount of microbial carbon in a soil will give some indication of this. Improving soil biological activity is mainly done by adding suitable 'food' to the system, particularly in the form of available carbon and nitrogen.

Adding a animal by-product to soil adds a food source for the soil life. The added nutrients in the by-product will promote higher plant growth which may increase organic matter inputs to the soil. This will further improve soil health.

Inorganic fertilisers can also improve soil health if it results in higher organic matter inputs to the soil system.

Improved soil structure

Adding animal by-products to the soil in adequate amounts (> 5 t / ha) can improve soil structure by decreasing bulk density, increasing permeability, increasing the cation exchange capacity (CEC) and increasing aggregate stability. Adding animal by-products can also lead to lower soil sheer strength which improves plant growth and friability.

These changes lead to higher infiltration and moisture retention in soil, better nutrient retention and better plant growth. These benefits can occur quite rapidly after one or two applications but they may not persist if usage declines.

Improved nutrient cycling

Applying animal by-products to the soil can improve the ability of the soil to cycle nutrients. This is because the changes in nutrient form within soil are brought about by microbial activity and enzymes produced by microbes. Animal by-products supply nutrients to the soil which increase the supply available for microbial activity. This cycle of nutrients in organic matter supplies a large amount of nutrient for plant growth and production. The microbial population will also cycle nutrients from inorganic sources and soil minerals. Organic matter also improves the soil CEC which improves the ability of the soil to hold nutrients and prevent leaching losses, keeping more nutrients in the system.

The benefits of using animal by-products are weighed up by only a few negatives. Soil structure can be damaged during application by compaction, and other contaminants (salts and heavy metals) can be added with the by-product which may inhibit soil health. However these risks can be minimised by good management practices (see other fact sheets in this series for management information).

SOLID BY-PRODUCTS – How much should I use?

Using solid by-products (manure, spent bedding or litter) as a crop fertiliser can be a sustainable management option that saves you money and provides benefits to soil health by increasing organic matter. However, it will take some calculations to work out the best rate to apply for good crop growth. The best way to go about managing the application rate is to work out:

- Plant nutrient requirements
- Soil nutrient status
- Composition of the recycled organic product you are applying
- Estimated nutrient availability and mineralisation rate of the organic product

Nutrient Demand

The first step is to calculate the nutrient demand for the crop being established. Estimating the nutrient demand for a crop requires an estimate of the yield per hectare and the nutrient content of the crop removed. For crops where the whole plant is harvested, the nutrient removal will be similar to the nutrient requirement for the plant.

Table 1 provides estimated net removal of nutrients for some typical crops grown in South East Queensland.

Table 1. Yield and nutrient removal of some crops

On dry matter basis	Sorghum (grain)	Corn Silage (Irrigated)	Lucerne hay (irrigated)
Yield (t/ha)	5	15	10
Protein content	10%	10%	18%
N (kg/t)	16	16	29
N Removal (kg/ha)	80	240	290
P (kg/t)	3.2	2.5	3
P Removal P (kg/ha)	15	40	30
K (kg/t)	5	11	16
K Removal (kg/ha)	20	170	160

Soil Nutrient Status

Once the amount of nutrients required by the crop have been estimated, it is valuable to get a soil analysis to indicate the fertility of the paddock to make a decision on fertiliser rates. By matching the fertiliser additions (inorganic fertiliser and animal by-products) to the crop demand, you can maintain a sustainable level of production. If the soil analysis shows that paddocks have low nutrient levels, higher levels of animal by-product may be applied to improve fertility.

Composition of the by-product

Once the crop demands and soil condition is known, the next step is to work out the nutrients contained in the animal by-product being used. Table 2 shows some typical nutrient values for animal by-products after different treatment (fresh, stockpiled, composted). Further information on composition can be found in the 'Typical composition' fact sheets).

Table 2. Nutrient composition of feedlot and meat chicken spent litter

	Feedlot Manure			Spent Chicken litter
	fresh	stockpiled	composted	fresh
Moisture	**34%**	**26%**	**30%**	**25%**
N content (kg/t)	16	16	16	19.5
P content (kg/t)	5	7	7	13.5
K content (kg/t)	17	18	17	7.5

The best way to find out the nutrient content of the product is to get a nutrient analysis done or request an analysis from the supplier. This will give the nutrient content as a fraction of the total dry matter. As manure is usually applied with some moisture, the nutrient content for manure 'as spread' will be lower than the dry

analysis. Table 2 shows the amount of nutrient on a 'wet' or 'as spread' basis. After the nutrient analysis has been done, the next step is to work out the amount of nutrient in the material per tonne as applied (see example 1). It is also important to note that not all the nutrients will be available for plant growth in the first year. If animal by-products are used for several years, nutrients will build up in the soil. If this is the case, working out the amount of available nutrient is best done by soil testing prior to planting. From the soil test, recommendations about additional fertiliser applications can be made.

Example 1:
Stockpiled feedlot manure analysis;
N = 2.2%, P = 0.8%, K = 2.3%
Dry matter = 70% (Moisture = 30%).

Calculate N content on wet basis;

N content Dry matter %

= 2.2 x 0.7

= **1.5 % N** as applied @ **30% moisture**
Using the same calculation gives
0.6 % P and **1.6 % K**.

Calculate **kg** of **N, P, K** applied **per tonne (wet)**

N = 0.015 x 1000 = **15 kg**
P = 0.006 x 1000 = **6 kg**
K = 0.016 x 1000 = **16 kg**

Nutrient Availability

The availability of nitrogen will vary with the rate of application, the weather conditions and the type of product. Most of the nitrogen in animal by-products is in an organic form and has to be mineralised. If the product has been composted, the product will be slower in releasing nitrogen than a non-composted product.

Trials conducted by Queensland DPI & F (deep litter and animal manure) indicate more nitrogenous fertiliser is required when using composted product in the short term.

A reasonable estimate for stockpiled feedlot manure is 50% of the N and 60% of the P and K available in the first season. This amount is likely to be less for a composted product.

Animal by-products rarely have a balanced nutrient content. For this reason it is generally recommended to apply at a rate that will supply the P demand of the crop and supplement with an N and K fertiliser as required.

This will make better use of the resource and avoid having high amounts of nutrients that can be lost from over application.

Application Rates

When selecting the application rate be mindful of ease of spreading. A minimum quantity of 3 tonnes per ha is usually needed to obtain a good distribution with a spreader.

It is recommended that soil tests are used in subsequent seasons to assist in meeting nutrient requirements. It should be remembered that significant amounts of nutrients from animal by-products may mineralise during the season.

Example 2: *Manure and fertiliser application for a 15t (dry matter) / ha corn silage crop*

Nutrient requirement for 15t/ha corn silage from table 1): N = 240 kg
P = 40 kg
K = 300 kg
Aim manure application to meet P demand of crop. Estimated 40% of P* available for the first year.

Manure application (from example 1):

Feedlot manure (wet – as spread) supplies 6 kg of P. At 40% availability in the first year this will supply 2.4 kg P per wet tonne (6 kg x 0.4).
To calculate application rate, divide nutrient requirement by nutrient supply:

40 kg P required per ha / 2.4kg available P/t = 17 t required / ha.

Therefore, approximately 17 tonnes of feedlot manure will supply the required P for corn silage in the first year. Likewise, this application will supply about 250kg of N and 260kg of K. Of these nutrients, about 40 % of the N** may be available, and almost all of the K.

At 40% availability, about 100 kg of N will be supplied from the manure, which is 140 kg less than the amount removed. This additional nutrient will need to be supplied by fertiliser – for instance 300 kg urea/ha.

Additional nutrients will become available in the second year after application – meaning the above application would be best supplied every second year with additional fertiliser additions based on soil test results.

* Availability of P can vary form 20 – 50%
** Availability of N in the first year can vary greatly by is generally (30-50%)

APPLICATION – How much is manure worth?

Animal by-products (manure) can be a valuable resource as an agricultural fertiliser and soil conditioner. However, calculating the real value of manure can be a difficult task. This is because there are many different factors to consider, including nutrient content and availability, the value of trace elements and the value of organic matter. Also, transport and spreading costs are higher than for inorganic fertilisers and this should be taken into account.

There are different animal by-products available in different regions of Queensland, including feedlot manure, piggery spent bedding, piggery sludge and spent litter from meat chicken production. Each has different characteristics and nutrient composition (see 'Typical Composition' fact sheets in this series).

Factors that influence price

In dollar terms, animal by-products in south east Queensland are generally sold for between about $4 to $40/t. At times animal by-products are given away because of necessity; however most by-products are sold for at least a modest price. The main drivers of price are;

- Product type and quality
- Handling (the lowest prices known of involve collection of manure using your own labour and equipment)
- Timing / supply – at times manure needs to be moved 'on demand' from an animal production facility and this usually reduces the price
- Proximity to major users
- Processing – screened manure or compost usually sell for higher prices.

This fact sheet uses spent litter from meat chicken production as a case study to look at how to value an animal by-product, but the principles for valuing other organic products are the same. The total value of the product 'as spread' will influence the sale value per tonne or m^3 and also the distance a product can be carted before it is not economically viable.

Valuing animal by-products

The first step to estimating the value of an animal by-product is to calculate the nutrient content. Table 1 provides a sample nutrient analysis for spent litter from meat chickens. The analysis values provided are indicative only and may vary from one batch to another.

Table 1. Measured average and ranges of the composition of spent litter

Amounts given on a DM basis	Average (% dry basis)	Range (% dry basis)
pH	8.1	6.0 – 8.8
Dry matter	75	40 – 90
Nitrogen (N)	2.6	1.4 – 8.4
Phosphorus (P)	1.8	1.2 – 2.8
Potassium (K)	1.0	0.9 – 2.0
Calcium (Ca)	2.5	1.7 – 3.7
Magnesium (Mg)	0.5	0.4 – 0.8
Sulphur (S)	0.6	0.5 – 0.8
Carbon (C)	36	28 – 40
Weight (kg/m^3)	550	500 – 650

Griffiths 2004

This analysis is not comprehensive, and further information can be sourced from the 'Composition of Meat Chicken Spent Litter' fact sheet. Most animal by-products do not supply nutrients in the right ratios for crop or pasture needs. It is recommended that they are used as part of a fertiliser program including other fertilisers to account for plant needs. One management option is to apply an animal by-product at a rate equal to phosphorus requirements and supplement the level of nitrogen to meet crop or pasture needs. It is possible to roughly estimate of the value of spent litter by comparing the amount of N, P and K supplied with the cost of commercial inorganic fertilisers (see Table 2).




However, it should be understood that the value of these nutrients will need to be spread over 2-3 seasons as they become available to plants.

Table 2. Value of nutrients in meat chicken spent litter compared to commercial fertiliser

	Manure analysis (% dry basis)	Manure analysis (% wet basis)	Inorganic fertiliser product & $/t	Manure value (wet) ($/t)
Moisture content	0%	25%		
N	2.6	2	Urea (46%N) @ $485/t	20
P	1.8	1.4	Triple super (20.7% P) @ $510/t	33
K	1.0	0.8	Potash (50% K) @ $590/t	9
Total value of manure per tonne				***$62***

The dollar value in Table 2 is calculated assuming the manure is 25% moisture, meaning the actual amount of nutrients is 25% lower than the dry analysis value. Because of the variable moisture content, animal by-products are sometimes sold on a volume basis (m^3) rather than in tonnes. This needs to be converted into tonnes to work out the amount of nutrients that are being supplied.

Example: The value of spent litter at 10t / ha
Cost of using spent litter:
$18 t cost for the spent litter
$15 t cost for delivery and spreading
= $33 t total cost, or **$330 / ha at 10t / ha.**

Using a moisture content of 25%, 10 t / ha of spent litter will supply approximately **195 kg of N, 135 kg of P** and **75 kg of K**. (for further information on doing these calculations, see the fact sheet 'Animal by-products – how much should I apply').

Comparing this to commercial inorganic fertiliser…

Fertiliser cost:
If the equivalent amount of nutrients were applied as Urea, Triple super phosphate and Potash this would amount to;

425kg Urea (@ $485/t)	= $205
650 kg Triple super (@ $510/t)	= $330
150 kg Potash (@ $590/t)	= $90
Total Cost	= **$625/ha**

In addition to the value of N, P and K, there are significant amounts of calcium, sulphur and trace elements that may be highly valuable when required on the application area.

Comparing the value of spent litter with lime (at $40/t) as a source of calcium, the litter may be valued at around $2/t.

In practice, at 2.5% calcium, 10t of spent litter supplies about the same amount of calcium as half a tonne of agricultural lime. The trace elements in animal by-products include magnesium, boron, copper and zinc. These trace elements can be expensive to apply as inorganic fertilisers if required, making animal by-product a cost effective alternative.

Animal manures are valuable as a soil conditioner because of the beneficial effects on water holding capacity and soil structure. These values have been reported by research and farmer observations but are difficult to measure in dollar terms.

Nutrient Availability

Nutrient availability is an important consideration when valuing animal by-products. The availability of nutrients will vary depending on a large number of factors, and may range from 30 – 80% of the nutrients applied during the first year. This will not affect the total value of the product provided the nutrients are still available to crops or pastures in the following years.

To calculate the dollar value of an animal by-product for the first year, the nutrient content can be multiplied by an estimate of the available nutrients. Using spent litter for example;

1 t spent litter (as applied) = 20kg N, 14kg P and 8kg K (from Table 2). If **60%** of these nutrients are available in the first year the $ value = **$37**.

The low availability of some nutrients supplied in an organic form may also be of benefit to some systems as these nutrients can act as a slow release fertiliser. This can result in higher nutrient usage by plants in the following seasons and lower risk of nutrient losses to the environment. It also means that higher application rates can be used in a two year cycle to reduce spreading costs and management.

The value of an animal by-product in terms of nutrients and organic matter benefits needs to be weighed against the higher costs of transport and application. For further information on options for application including costs, see the fact sheet 'Spreading solid by-products'.

References and further reading:
Griffiths, N 2004, *Best practice guidelines for using poultry litter on pastures*, New South Wales Department of Primary Industries.

APPLICATION – Spreading Animal By-Products

Solid by-products (animal manures) are valuable as fertilisers and soil conditioners when spread at suitable rates.

A large amount of the cost of applying animal by-products to land is the cost of spreading. Not only is cost an issue, there can be concerns about even distribution of the by-product and compaction concerns from driving over paddocks loaded with tonnes of manure. These problems are all manageable and need to be considered before deciding to use animal by-products on your farm. The issues of concern will be different for grazing properties compared to cropping enterprises.

Cost

The cost of spreading animal by-products can be as great as the cost of the product itself. This makes spreading costs critical to the cost-benefit analysis of using animal by-products. The main options for spreading are; owning a spreader, employing contractors to spread manure or using a co-operative approach to buy a spreader for use by members. Spreaders vary greatly in size, from 1 tonne capacity to over 20 tonnes capacity. The size will affect both the price of the unit and other issues such as compaction.

Spreaders may be three point linkage mounted, trailing or truck mounted depending on size and intended use. If manure needs to be carted as well as spread, a truck mounted model may be preferred; however these units are generally mounted to the truck chassis and are not easily removed. Some contractors use specialised 4wd trucks for manure spreading but these units are quite expensive.

Three point linkage spreaders are relatively small capacity, lower priced units for spreading small amounts of manure and small areas of land. Trailing units are probably the best option for the farmer or co-operative farmer group.

Trailing units vary in size from less than 5 tonne to over 20 tonne capacity. A good quality 10t manure spreader is likely to cost $35,000 or more. These can generally be used for spreading lime and fertilisers which may offset the cost to some degree.

As spreaders are used infrequently, they are a good item to be purchased by a farmer or landcare group for joint usage. This could allow several farmers to benefit from using manure while reducing the capital costs.

Photo 1. *9 tonne Unibar spreader in use*

Hiring contractors is another option to keep costs down when spreading is being done on a one off basis or on a small scale. Contractors may operate on an hourly rate or tonnes spread basis and costs vary. Larger jobs are likely to be done for a lower rate as expenses are reduced. Rates quoted by contractors contacted at the start of 2007 ranged from $7/t + fuel for on farm spreading (stockpile to paddock) to $13/t, which included transport of manure from a nearby off farm site.

Spreading rates

Working out the best rate of manure to apply per hectare is best done by estimating crop demands for nutrients (see the fact sheet 'How much manure should I apply'). However, knowing the best rate to apply and getting that amount onto the paddock requires correct calibration of the spreader.




One way to check the calibration of your spreader is given in example 1 below.

Example 1. Measuring your spreading rate
1. Lay a drop sheet (tarp or plastic at least 2m x 2m) in the path of the spreader
2. Run the spreader past the drop sheet
3. Measure a $1m^2$ area on the drop sheet and collect all the manure inside the square
3. Weigh the manure (in kg), then multiply this weight by 10,000 to get the number into kg/ha.
4. Divide this number by 1000 to get tonnes per ha.

Distribution

Poor distribution from spreaders can be a source of application inefficiency and irregular crop growth. Distribution can be affected by the consistency of the product, the type of spreader and the operator. Generally manure will spread better if it contains at least 30% moisture. This will also reduce dust during spreading. Spreading will also be affected by the particle size of the manure. Generally speaking, fresh manure is likely to have an irregular, lumpy consistency while older manure contains fewer lumps. Screening manure will reduce the number of large particles (and rocks etc) and improve the spreading ability of the product. Screening is also useful for removing other contaminants such as bones which may be an animal health risk. Composted product also has a more uniform particle size which aids spreading.

Distribution can also be affected by the spreader being used. For most spreaders, a minimum rate of about 3-5 t/ha is required to get an even spread, and this may be higher for some spreaders.

Operator efficiency will influence where manure is spread on the paddock and at what rate. This is especially relevant for spreaders where operation speed influences the rate applied. Ensuring that row spaces are even is important for covering the whole paddock evenly. This can be estimated by the operator or done with GPS if available.

Compaction

Compaction is caused by the movement of large implements across paddocks, and is a greater concern on crop land than on grazing land. Compaction is greatest when soils are close to field capacity. Ideally, spreading would be carried out when the soil is quite dry. Compaction can be reduced on crop land if the spreader can be set up to run on controlled traffic lines. Also, spreading manure on a 3 to 5 year rotation and supplementing with inorganic fertiliser as required is one option for reducing compaction and saving costs.

Timing

The timing of manure application is influenced by a number of factors including:

- Crop or pasture needs
- Field conditions (soil moisture)
- Timing of other management events (ploughing to incorporate manure)
- Wind conditions

Applying fresh manure 4-6 months prior to the crop establishment will allow time for nutrients to mineralise from manure. This can also reduce the risk of nitrogen draw-down which may occur after fresh or stockpiled manure is applied. However, there is a risk that some of the nitrogen in stockpiled manure will be lost if it is applied a long time prior to crop planting.

Ideally manure should be incorporated within 36 hours of application as this will reduce nitrogen loss and aid soil microbial processes.

In grazing systems, manure application should be timed to supply nutrients when feed demand is highest. For example, to boost spring feed growth manure can be applied in early winter.

If possible, manure spreading should occur when field conditions are best for reducing compaction. Spreading should be carried out in low wind conditions to ensure distribution efficiency and reduce any negative impacts on neighbours.

Social and environmental considerations

Spreading can result in dust and odour being spread for considerable distances. If spreading is to take place close to neighbours or other receptors, it is recommended that this is done when conditions are most favourable, when wind is low and ideally on weekdays. If odour is a concern, informing neighbours that spreading is occurring may be a good idea. Generally odour will only be a problem for a one or two days after spreading depending on the weather conditions and the spreading rate.

Spreading also needs to take into account the risk of environmental harm. While there is no specific legislation controlling the spreading of manure, all people have an environmental duty of care under the Environmental Protection Act (1994). Manure should be contained on the intended area, and should not be carried out within 30 m of waterways or on steep slopes where erosion losses may occur. While a small amount of rain following application can be useful, it is not advisable to spread when heavy rain is predicted.

Making the Most of Animal By-Products

FACTSHEET SERIES - Fact Sheet Number 5
Updated: 19/3/2007

APPLICATION – Spreaders for Animal By-Products

Animal by-products are a major resource in south east Queensland and the Burnett Mary catchments. If animal by-products (particularly manure) are regularly used on property, the purchase of a spreader is an important decision to be considered. This fact sheet reviews some of the spreaders available in Australia along with design features and 2007 prices.

Sizes

Spreaders vary greatly in size, from 1 tonne capacity to over 20 tonnes capacity. The smaller capacity spreaders (1-2 tonnes) are generally designed for three point linkage mounting. They are generally not suitable for spreading large amounts of manure because of the amount of time spent loading and travelling from the spreading area to the stockpile.

Larger capacity spreaders are usually trailing or truck/tractor mounted. Trailing units are probably the best option for the farmer or co-operative farmer group. Trailing units vary in size from less than 5 tonne to over 20 tonne capacity. These can generally be used for spreading other products such as lime and fertilisers, which may offset the cost.

Features

Some features to be considered when purchasing a spreader include:

Adjustable spreading pattern and spreading width (to ensure an even spreading pattern and application rate are achieved)

Horizontally vs vertically mounted beaters – vertically mounted beaters generally spread over a larger area with each pass, throwing manure beyond the width of the spreader. Horizontal beaters usually only spread about the width of the spreader.

Conveyor belt vs moving floor chains – movement of the manure to the back of the spreader can be achieved using a conveyor belt or chain and slats. These can be either hydraulic or PTO driven. Conveyor belts may need to be replaced more often as the belt wears easier than the chains.

Rotation speed – the rotation speed of the beaters will affect the width of spread and application rate.

Spreader Power Requirements – check the power requirements of the spreader in relation to your tractor or truck. For example a three point linkage spreader may need a tractor with 50-60 horsepower to operate effectively.

Photo 2. *Horizontal flat spinners are also effective in spreading over a wide area. Landaco Maxispread.*
www.landaco.com.au

Price

The size of a spreader generally determines the price. As a guide, prices for a range of different makes of spreaders available in Australia and are provided to give an indication of the 2007 prices for a range of spreaders (All prices are ex GST).

Three point linkage – 1.7 m^3 (est. 1 t manure) capacity – $13,400




Trailing spreader – 4.1 m^3 (est. 2.5 t manure) capacity – $23-35,500
Trailing spreader – 8-9.5 m^3 (4.5-5 t manure) capacity – $26-60,300

Trailing spreader – 14 m^3 and above (est. 7+ t manure) capacity – $52-89,250

Truck mounted – 8-10 t capacity – $50-60,000

Price will also depend upon extra options such as inspection ladders, tarpaulin rails, GPS guidance systems, monitors and controllers (that can record and display application rates, spinner RPM etc).

Photo 4. *Landaco tractor mounted spreader*

Questions to ask before you buy:

- How much manure will I need to spread?
- Over what area do I need to spread?
- How large a spreader do I need?
- Do I need a three point linkage, trailing or tractor/truck mounted model?
- Are there any spreaders available second hand?
- Can I buy a spreader as part of a co-operative of farmers to share cost?
- What spreader features do I need?

The following list of suppliers is provided as a service to farmers, it is not intended to be comprehensive, nor does FSA Consulting or the supporting organisations endorse or recommend any make or dealer over any other. Omission of any make of spreader or dealer does not imply any opinion on behalf of FSA Consulting or the supporting organisations and buyers are encouraged to carry out their own market research.

Suppliers and Dealers

Nufab Industries
Lot 27 & 28 Moore Road
P O Box 171
Dongara WA 6525
Ph 1800 671 606

Landaco Equipment
7 Wentworth Street
Wagga Wagga NSW 2650
Ph 1800 358 600

Landaco Dealer - Rod Frahm Machinery
King Street
Clifton QLD 4361
Ph: 07- 4697 3411

Strautmann, Gason and Grizzly Dealer
Sunstate Ag
388 Taylor St
Toowoomba QLD 4350
Ph 07-4633 1150

Axon Machinery Pty Ltd
9 Beauty Dr
Whale Beach NSW 2107
Ph 02- 9974 2704

Unibar Engineering Pty Ltd
49-53 Hanbury St
Bundaberg QLD 4670
Ph 07-4152 9555

References and further reading:

Kondinin Group 2006, Fertiliser spreaders research report, *Farming Ahead*, no. **175**, 18-21.

APPLICATION – Sustainable Effluent Reuse

Effluent is the by-product of dairy and pork production where water is used for manure management. Effluent is also produced by runoff at beef feedlots and dairies. Provided effluent is managed carefully, this by-product can be a valuable nutrient resource for irrigating onto agricultural land.

Land application of effluent can allow for nutrient and water usage by crops and nutrient storage in the soil profile without environmental degradation. However, poor management of effluent can result in contamination of land and water along with land degradation.

To develop a sustainable land reuse system, the following factors need to be considered:

- Volume and strength of the effluent
- Availability of good quality land for crop production
- Availability of additional clean water supplies for diluting effluent
- Irrigation infrastructure
- Management expertise to run the system

The key components for sustainable management are:

- Balancing the addition of nutrients with the off-take of nutrients in agricultural produce, the safe soil storage capacity and acceptable nutrient losses
- Manage other contaminants in the water (salts) to prevent soil degradation

Farms that produce effluent are responsible for the sustainable reuse of this product. While dairy farmers are not under specific regulations, piggeries and beef feedlots are required to identify suitable land for effluent reuse and to undertake regular monitoring to prevent the loss of their operating licence under the authority of the EPA. It is recommended that dairy farmers follow the Queensland dairy guidelines[7] for appropriate management options.

Aiming to improve effluent management will ensure the longevity of your operation and maximise the value of the by-product. This can be helped by using the best possible land resources and irrigation infrastructure and producers are encouraged to aim for best management practices.

Nutrients

The nutrient analysis of effluent shows that significant amounts of valuable plant nutrients are present in irrigated effluent. A typical analysis for piggery, dairy and beef feedlot effluent is shown in Table 1 below.

Table 1. Typical nutrient composition of piggery, dairy and beef feedlot effluent

	Pigs	Dairy	Feedlot
	Conc.[1,2] (mg/L)	Conc.[5] (mg/L)	Conc.[6] (mg/L)
pH		-	8.0
EC (dS/m)	2-14	-	6.8
Total N	854 (158-1025)	158	188
Ammonium N	398 (105-726)	-	139
P	109 (11-123)	35	65
K	97-1845	263	1399
Na	623 (103-2870)	-	473
Ca	8.6-40	-	65
Mg	4-108	-	158
Cu	0-8	-	0.09

Source: [1]Kruger et al. 1995 [2]Casey et al. 1995. [5]Skerman et al. 2006. [6] DPI&F unpublished data from 11 feedlots on the darling downs.

It is suggested that an analysis be taken of the effluent on site before management decisions are made. This will provide information to estimate nutrient applications. The actual amount of nutrients (in kg) contained in effluent on a mega litre (ML) basis is the same as the number in mg/L (i.e. 109 mg/L = 109 kg / ML).




Since 100mm of irrigation applied per ha = 1 ML/ha this makes calculating the application of nutrients relatively simple. Once the water volume and the total nutrients are known, the application rate per hectare can be determined. Ideally, effluent water would be mixed with clean irrigation water (shandied) to lower the nutrient concentration and prevent leaf burn with application. If clean water is not available, application of effluent will need to be carefully managed to avoid plant damage. If there is a limited amount of land suitable for irrigation with effluent, nutrient removal becomes an important consideration in order to keep nutrient levels within an acceptable range. High rates of nutrient removal will ensure that the effluent reuse area doesn't become a threat to the environment.

Crops with maximum nutrient removal are typically high yielding fodder plants, for example maize or sorghum forage. Pasture or lucerne for hay production can also remove a significant amount of nutrients (see Table 1). When maximising nutrient off-take the key is to maximise plant yield and harvest the whole plant as hay or silage.

Grazing will not remove high quantities of nutrients (see Table 2), as a large percentage of the fodder that livestock consume will be returned to the paddock in the manure and urine. For this reason pasture for grazing is not generally a sustainable option for effluent reuse areas.

Table 2. Nutrient removal rates for different crops

Crop	Yield (t/ha)	N removal (kg/ha/yr)	P removal (kg/ha/yr)
Lucerne hay	5-15	150 – 450	15 – 45
Dry land winter cereal (grain only)	2-4	40 – 80	6 – 20
Dry land winter cereal (grain+straw)	2-4 grain (+straw)	59 – 239	9 – 20
Grain sorghum	2-8	40 – 160	6 – 24
Forage sorghum	10-20	200 – 400	30 – 60
Maize silage	10-25	200 – 500	35 – 75
Dryland pasture (cut)	1-4	20 – 80	3 – 12
Irrigated pasture (cut)	8-20	160 – 400	24 – 60
Grazing	-	7.1 - 9.5	0.9 - 1.1

[4] Adapted from Reuter and Robinson 1997.

If effluent is being applied without additional irrigation water and rainfall is low, crop yield and nutrient uptake will also be low. This means that effluent will need to be applied to larger areas to avoid over applying nutrients. Effluent does not always have a balanced nutrient content. This is particularly true if large amounts of N are lost during application as ammonia gas through volatilisation.

One option is to apply effluent at a rate that will meet the P demands of the crop and supplement with fertiliser N if required. Another way of reducing the amount of nutrient applied per hectare is to rotate effluent applications to different paddocks in different years. This will reduce the overall amount of nutrients applied over time, but increases the area required for irrigation infrastructure and crop management. If high strength effluent is applied, crop production must be high in all years to maximise nutrient uptake.

Managing contaminants

Effluent can contain undesirable elements and pathogens. Of particular concern is the amount of sodium (Na) and chloride (Cl) found in some effluent samples. Chloride can be toxic to plants at medium to high levels, and high levels of sodium (sodicity) can cause soil degradation. If the effluent available has a high level of Na and Cl, this can be managed by:

- Diluting the effluent with clean water (this will result in less salt being applied per ha)
- Rotating the land used for effluent irrigation from one season to the next
- Applying gypsum if the soil becomes sodic
- Flushing salt accumulation with clean water after effluent application
- Growing salt tolerant plants if levels rise

Further information about managing salt levels can be found in the fact sheets – Management – salt in animal by-products, Management – health risks with animal by-product reuse and Management – Metals in animal by-products.

References and further reading:

[1] Kruger, I, Taylor, G & Ferrier, M 1995, Effluent at work, NSW Agriculture, RMB 944, Tamworth NSW.

[2] Casey, KD, Gardener, EA & McGahan, EJ 1995, 'Characterisation of piggery anaerobic lagoons in southern Queensland', *Proceedings of manipulating pig production v,* Australasian Pig Science Association Conference, Canberra.

[3] Queensland Department of Primary Industries 2000, *Environmental code of practice for Queensland piggeries*, DPI Publications, Brisbane, Qld.

[4] Reuter, DJ & Robinson, JB (eds) 1997, 'Plant analysis – an interpretation manual', CSIRO publishing, Canberra.

[5] Skerman, A, Kunde, T & Biggs, C 2006, Nutrient composition of dairy effluent ponds, Final report to subtropical dairy South-East Qld Subregional team, DPI&F, Queensland.

[6] QDO and QDPI&F 2004, 'Queensland Dairy Farming Environmental Code of Practice' Queensland Department of Primary Industries and Fisheries.

Skerman, A 2000, Reference manual for the establishment and operation of beef cattle feedlots in Queensland, Information Series QI99070, Queensland Cattle Feedlot Advisory Committee (FLAC), Department of Primary Industries, Queensland.

TYPICAL COMPOSITION – Dairy Effluent & Solids

Dairy production creates a supply of effluent and solid manure which can be a valuable source of nutrients for reuse on farm, provided the system is set up to reuse this product efficiently.

As the average herd size and intensity of production for dairies in Queensland increases, higher amounts of these by-products will become available for reuse. While in the past effluent may have been considered a waste to be disposed of, it is worth looking at the composition of the product to see how it can be best used.

Effluent

The composition of the effluent may vary significantly between dairies because of differences in herd size, management and the amount of cleaning water used.

It is hard to give a 'typical' composition of effluent and the best way to work out the value of the resource is to measure the volume produced each day and get an analysis of nutrient levels. There are also two types of effluent that may be produced, raw effluent (from daily cleaning practices) and pond effluent (where dairies have constructed an effluent pond system). Table 1 shows an indicative raw effluent analysis.

Table 1. Indicative raw effluent analysis

Nutrient	Dairy effluent concentration (in mg/L)	Nutrients in 1 kL of effluent (0.1 ML)
Nitrogen (N)	360	36 kg
Phosphorus (P)	75	7.5 kg
Potassium (K)	465	46.5 kg

Skerman et al. 2006.

This represents a nutrient source that is produced daily at most dairies available for reuse. For dairy effluent ponds (measured in south east Queensland by the DPI&F) an average analysis is shown in Table 2 for indicative purposes.

Table 2. Dairy pond effluent analysis for samples taken in SE Queensland

Nutrient	Dairy effluent concentration (in mg/L)[a]	Nutrients in 1 ML of effluent
Nitrogen (N)	158	158 kg
Phosphorus (P)	35	35 kg
Potassium (K)	263	263 kg

[a] Skerman et al. 2006.

As seen in tables 1 and 2 the nutrient content of dairy effluent can mean quite a large amount of nutrients available for pasture or crop growth. Effluent volume will vary from one dairy to the next, but on average the effluent production from a 100 cow dairy might be around 2.5 ML per year.

If pond storage is used the total nutrients in a year's effluent for this size dairy will be around 410kg of N, 90 kg of P and 680 kg of K.

Manure

As more and more dairies use feed pads as part of normal production, the amount of manure that needs to be managed is greatly increased. Dairy manure is fairly similar to other cattle manure from beef feedlots, and contains N, P and K along with some trace elements. Table 3 below shows a typical composition for fresh dairy manure.

Table 3. Typical characteristics of dairy manure

Component	Fresh manure (% of dry weight)	Nutrients in 1 t fresh manure (assuming 40% moisture)
Moisture	30-50%	
N	3*	18 kg
P	0.7	4 kg
K	3.6	16 kg

DPI&F DairyBal, 2005. *Assumes 50% N excreted in the manure is lost via volatilisation from the pad.




Fresh or stockpiled manure will contain some moisture, varying from very high (>50%) to low (<25%) depending on management and climate. Accumulated solids from a sediment trap have a very high moisture content when removed and this material usually needs to be dried for some time before spreading.

Moisture content has a large affect on the amount of nutrients that are in the ‘as spread’ manure. This is because nutrient analyses (Table 3) are done on dry manure, and any moisture present will have a dilution effect on the total amount of nutrients being spread.

For instance, if the manure is only 60% dry matter (40% moisture) then only 60% of the nutrients in the dry weight analysis are actually in the manure being spread. For a 100 head dairy where the cows are kept on the feed pad constantly, the annual production of manure is estimated at about 131 t[1].

If manure is stockpiled for a year it may loose a further 30-50% of its bulk, leaving 65 to 90 t available for land application.

Stockpiled manure can also loose 30% of the total N, leaving around 2% N in the stockpiled product. This loss will not occur for P and K as these elements are not as volatile as N. Generally, because the overall mass of the manure decreases during stockpiling, the percentage of P and K can increase slightly compared to fresh manure.

Manure from dairy cows (as with other cattle manure) is likely to contain a range of trace elements that may be valuable as fertiliser. These include; copper, zinc, boron, magnesium, manganese, calcium, sulphur and iron. Depending on the nutrient status of the soil, these elements may boost plant production.

It should be noted that not all the nutrients in dairy manure or effluent are present in a plant available form. Nutrient availability can change because of age and handling, and may vary from 0 – 80%. In general, less than 50% of the N, 40-60% of the P and over 70% of the K is likely to be available in the first season for stockpiled manure (for more information, see the fact sheet in this series titled; How much should I apply?).

Dairy effluent and manure are valuable by-products of milk production that can be reused on farm to produce fodder to go back into the system. These by-products need to be used as part of a nutrient management plan to ensure sustainable usage and save on inorganic fertiliser costs. Further information can be found in the Queensland Dairy Farming Environmental Code of Practice.

Some other fact sheets in this series:

- Typical Composition – Chicken spent litter
- Typical Composition – Piggery spent bedding
- Typical Composition – Feedlot manure

- Animal by-products – What are they worth?
- Animal by-products – How much should I apply?
- Animal by-products – Managing metals
- Animal by-products – Managing weed seeds

References and further reading:

Skerman, A, Kunde, T & Biggs, C 2006, Nutrient composition of dairy effluent ponds, Final report to subtropical dairy South-East Qld Subregional team, DPI&F, Queensland.

QDO and QDPI&F 2004, ‘Queensland Dairy Farming Environmental Code of Practice’ Queensland Department of Primary Industries and Fisheries.

Making the Most of Animal By-Products

FACTSHEET SERIES – Fact Sheet Number 8

Updated: 19/3/2007

TYPICAL COMPOSITION – Feedlot Manure

Feedlot manure can be sourced in several forms including; **fresh** harvested from the pen, **stockpiled** (short or long term) or **composted**.

The composition of manure changes depending on the age and treatment of the manure after it is removed from the pen. Because the composition can change, it is important to get manure tested for nutrient content.

Over time manure will break down because of microbial activity, and some nutrients (mainly nitrogen – N) can be lost to the atmosphere. In general, this means that older manure has less nitrogen and less organic matter (OM) than it had originally. There is also a significant reduction in the moisture percentage.

While there is less N in older manure (stockpiled manure), some other nutrients that aren't lost to the environment will have higher concentrations because of the lower OM percentage.

Because of this, stockpiled manure has a higher percentage of phosphorus (P) and some other elements than fresh manure.

Composition

Understanding the composition of feedlot manure is very important in order to work out the value of the manure as a fertiliser and soil conditioner.

The typical composition of stockpiled feedlot manure and a representative composition of composted manure from a local feedlot are given in Table 1 below.

Table 1. Characteristics of Feedlot Manure

Component	Composted[a]	Stockpiled[b] (on dry basis)
Dry matter	65	73
pH	-	7
Total Nitrogen	2.1	2.2
Ammonium Nitrogen	-	0.04
Total Phosphorus	0.8	0.8
Potassium	2.4	2.3
Sodium	0.2	0.6
Chloride	-	1.4
Calcium	3.2	1.6
Sulphur	0.6	0.4
Zinc	0.04	0.2
Boron	0.01	0.07
Copper	0.01	0.03
Manganese	0.02	0.6
Iron	0.7	2.1
Magnesium	0.9	0.9

[a] Data sourced from local southeast Queensland feedlot

[b] Watts et al. (1994) - interpreted from Powell (1994).

Because manure has moisture in it when you buy it, the actual amount of nutrients per tonne is lower than the analysis reading because they are diluted with the water.

Nutrient availability

It is important to note that not all of the nutrients in manure are available to plants as soon as it is spread. This is because the nutrients can be 'tied up' in the organic matter. These nutrients will become available over time as they are mineralised. (For further information see the fact sheet in this series – 'Animal by-products - how much should I apply').




Composted feedlot manure

While a large proportion of feedlot manure is sold after stockpiling, some operators choose to process the manure more by composting before it is taken off site. With composting the following transformations generally occur:

- The volume is 20-60% lower than the original compost mix
- The moisture content is 25-40%
- The weight is up to 50% lower than the original compost mix
- The carbon to nitrogen ratio is generally below 20:1
- The compost has an earthy smell, but does not release offensive odours.

Composting is quite a variable process depending on the management applied. This makes generalising difficult and it is recommended that nutrient analyses are carried out on compost batches to allow comparison.

Composting has added advantages by reducing pathogen and weed seed densities, and by improving the uniformity of the product which aids spreading. However, compost may have lower availability of the nutrients compared to stockpiled manure.

Composted products are typically more consistent and friable products compared to non-composted products, as a result of the mixing and turning. It adds value to the manure by generating a more stable product that provides slow release nutrients and conditions soil.

Because of the differences in the age of manure and the treatment that may be applied, it is important for buyers to have manure tested for important nutrients before making decisions about management.

References and further reading:

Powell, E 1998, 'Feedlot Manure a Valuable Fertiliser', Evan Powell Rural Consultants, Dalby, Queensland.

Watts, PJ, Tucker RW, Gardner, EA, Casey, KD & Lott, SC 1994, 'Characteristics of feedlot waste', In PJ Watts & RW Tucker (eds), *Designing better feedlots*, Publications no. QC94002, Department of Primary Industries, Queensland.

Wylie, P 2004, 'Making money from feedlot manure', Horizon Rural Management, Queensland.

Some other fact sheets in this series:

- Typical Composition – Chicken spent litter
- Typical Composition – Piggery spent bedding
- Typical Composition – Feedlot manure

- Animal by-products – What are they worth?
- Animal by-products – How much should I apply?
- Animal by-products – Managing metals
- Animal by-products – Managing weed seeds

Making the Most of Animal By-Products

FACTSHEET SERIES – Fact Sheet Number 9
Updated: 23/3/2007

TYPICAL COMPOSITION – Chicken litter

Spent litter from meat chicken production is a valuable nutrient source for grazing or cropping enterprises.

Spent litter can reduce the need for commercial fertiliser and lower the cost of crop production. Spent litter also acts as a 'slow release' fertiliser, as not all the nutrients contained in the litter are immediately available for plant growth. This allows one application of litter to provide nutrients for several seasons.

However, spent litter, like other organic manures, is not a balanced fertiliser and some nutrients need to be added via inorganic fertilisers to meet crop or pasture requirements. The application of spent litter also needs to be carefully managed, since inappropriate and over application can result in a threat to the environment and risks to animal health from botulism (For further information see the fact sheet in this series – 'Management - health risks with by-product reuse').

Spent Litter Composition

The composition of spent litter can vary to some extent between different chicken farms in response to differences in management (stocking density and number of batches), clean litter type and feed wastage.

This makes predicting the average nutrient content of spent litter difficult and the figures should be used for indicative purposes only. To properly assess the nutrients in spent litter the most accurate way is to gain an analysis from the batch supplied.

Another source of variation in the composition of spent litter comes from the amount of nitrogen (N) lost as ammonia. Again this is hard to predict, however in general terms the N content of manure will decline over time if stockpiled or used for multiple batches of chickens.

Nitrogen can also be lost from litter in the meat chicken shed, and losses may be highly variable and will depend greatly on the litter moisture content. Generally, wetter litter will produce greater ammonia volatilisation.

Table 1 shows measured chemical and physical properties of spent litter that may be used for indicative purposes.

Table 1. Measured average and ranges of the composition of spent litter

Amounts given on a % DM basis	Average	Range
pH	8.1	6.0 – 8.8
Dry matter %	75	40 – 90
Nitrogen (N)	2.6	1.4 – 8.4
Phosphorus (P)	1.8	1.2 – 2.8
Potassium (K)	1.0	0.9 – 2.0
Calcium (Ca)	2.5	1.7 – 3.7
Magnesium (Mg)	0.5	0.4 – 0.8
Sodium (Na)	0.3	0.3 – 0.5
Sulphur (S)	0.6	0.5 – 0.8
Carbon (C)	36	28 – 40
Weight per m^3 (kg)	550	500 – 650

Griffiths 2004

Nutrient Availability

Most nutrient uptake by the plant occurs when the nutrients are in the inorganic form. Not all the nutrients applied in spent litter for a crop are available to the plant in that year. Some organic elements must be mineralised to the inorganic form by microbial decomposition before they become available for plant uptake.

The availability of nitrogen in the first year of application can vary greatly, from 30% to 80% depending on the spreading method and the environmental conditions.



Nitrogen in spent litter is present in both the organic and inorganic forms. Up to one-third of the nitrogen in the spent litter can be in the ammonium form, while the rest is in the organic form. After the first year of application about 25 – 50% of the organic nitrogen is likely to mineralise and become available to plants.

However, mineralised nitrogen (nitrate and ammonium) is also highly mobile and can be readily leached through the soil profile or volatilised. It is likely that spent litter applied to the soil surface and not incorporated will loose a significant amount of the ammonium to the atmosphere as ammonia gas. If possible it is recommended that spent litter is turned in within 48 hours of application to avoid this loss.

Spent litter has more than N,P,K !

Nitrogen (N), phosphorus (P) and potassium (K) are the three nutrients most commonly applied as fertiliser, but it is worth considering the other elements available in spent litter also.

For instance, at 2.5% Calcium, 10 tonnes of spent litter has about the same amount of calcium as 1 tonne of gypsum.

Other fact sheets in this series:

- Typical Composition – Piggery spent bedding
- Typical Composition – Feedlot manure
- Animal by-products – What are they worth?
- Animal by-products – How much should I apply?
- Animal by-products – Management of metals
- Animal by-products – Management of weed seeds

References and further reading:

Griffiths, N 2004, *Best practice guidelines for using poultry litter on pastures*, New South Wales Department of Primary Industries.

Making the Most of Animal By-Products

FACTSHEET SERIES – Fact Sheet Number 10
Updated: 19/3/2007

TYPICAL COMPOSITION – Piggery Spent bedding

Piggery spent bedding is the by-product of pork production, where pigs are housed in open sheds on straw, sawdust or a similar bedding material.

Spent piggery bedding contains essential nutrients that are used by plants, including nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, manganese, copper, zinc, chlorine, boron and iron. These nutrients, together with soil conditioning properties make spent bedding a valuable soil amendment and fertiliser.

Spent bedding also acts as a 'slow release' fertiliser, as not all the nutrients contained in the litter are immediately available for plant growth. This allows one application to provide nutrients for several seasons.

However, spent bedding, like other organic manures, is not a balanced fertiliser and some nutrients need to be added via inorganic fertilisers to meet crop or pasture requirements. The application of spent bedding also needs to be carefully managed, since inappropriate and over application can cause a threat to the environment.

Composition

The composition of spent bedding can vary to some extent between different piggeries in response to differences in management (stocking density, pig age and type), type of bedding material used and feed wastage.

This makes predicting the average nutrient content of bedding more difficult, and the figures presented here should be used for indicative purposes only. To properly assess the nutrients in spent bedding the most accurate way is to get an analysis done by a laboratory.

Another source of variation in the composition of spent bedding comes from the amount of nitrogen (N) lost as ammonia.

Again this is hard to predict, however in general terms the N content of manure will decline over time if the bedding is stockpiled or composted.

Table 1. Composition of piggery spent bedding from grower / finisher pigs kept on straw

Units are % dry basis unless noted	Fresh	Compost
Moisture (% wb)	29 - 54	20 – 64
pH	5.7 - 7.8	8.5
N	0.6 - 2.1	1.2 - 3.3
P	0.2 - 1.1	0.7 - 2.5
K	0.6 - 1.4	1.3 - 2.8
Cl	0.6 - 1.0	0.4
Na	0.2 - 0.4	0.4 - 0.6
Ca	0.4 - 0.9	2.1
Mg	0.1 - 0.2	0.8
S	0.1 - 0.2	0.4
Cu	0.01 - 0.03	0.05
Mn	0.01 – 0.02	0.03
Zn	0.01 - 0.06	0.05
Al	-	4.4
Fe	1.6	1.6
B	-	0.01
Bulk Density (t/m3)	-	0.8

Nicholas et al. 2006

Nutrient Availability

Not all of the nutrients present in spent bedding is available for plant growth at the time of application. This is because the nutrients are present in different forms.

Photo 1. *Stockpiled piggery spent bedding*

Nitrogen can be present in spent bedding as ammonium-nitrogen, organic-nitrogen and nitrate-nitrogen. The amount of organic nitrogen available for plant uptake is the ammonium nitrogen plus the amount of organic nitrogen that mineralises during the growing season. Remaining nitrogen will become available in the following growing seasons provided it is not lost from the soil through volatilisation or leaching.

The availability of nutrients should be taken into consideration when developing a fertiliser program which includes using spent bedding. It is recommended that chemical fertilisers are used to supplement the manure applications, particularly for nitrogen.

Spent bedding has more than just nutrients!

The nutrient content of spent bedding might be the main reason to spread it on the field, but there are real benefits from increased organic matter.

Over time, increased organic matter can improve soil structure, improve root penetration and increase moisture holding capacity!

References and further reading:

Nicholas, PJ, McGahan, EJ & Tucker, RW 2006, *Producer Guidelines for Use of Spent Bedding*, Project No. 1969, Australian Pork Limited, Canberra, Australia.

Some other fact sheets in this series:

- Typical Composition – Chicken spent litter
- Typical Composition – Feedlot manure
- Typical Composition – Piggery sludge

- Animal by-products – What are they worth?
- Animal by-products – How much should I apply?
- Animal by-products – Managing metals
- Animal by-products – Managing weed seeds

Making the Most of Animal By-Products

FACTSHEET SERIES – Fact Sheet Number 11
Updated: 19/3/2007

TYPICAL COMPOSITION – Piggery Sludge

Conventional pork production creates a supply of solid manure (sludge) as a by-product of pond treatment. This material can be very high in nutrients which can be used as a fertiliser and soil conditioner.

Sludge is the solid manure that accumulates at the bottom of the effluent pond, which collects all the manure from a conventional, water cleaned piggery. This material is cleaned out of the ponds infrequently (2-3 year intervals – longer with large ponds) by draining the ponds and cleaning the sludge out with an excavator, dozer or tanker. Because the sludge accumulates over a long period of time, it can have a very high nutrient content. After sludge is cleaned out of the ponds it is usually stockpiled to dry out before land application or sale.

Composition of piggery sludge

Piggery sludge can vary widely in nutrient composition, and the values supplied are for indicative purposes only (see Table 1 below).

Table 1. Typical composition of piggery sludge

Component	Piggery sludge in-situ (mg/L)[a]	Piggery sludge (calculated nutrient % on dry basis)
Moisture (% wb)	87	
pH	7.4	
Nitrogen (N)	3430	1.5*
Phosphorus (P)	4710	4.1
Potassium (K)	750	0.7
Sulphur (S)	1990	1.7
Copper (Cu)	1062	0.9
Iron (Fe)	1120	1.0
Manganese (Mn)	1035	0.9
Zinc (Zn)	3184	2.8
Calcium (Ca)	7120	6.2
Magnesium (Mg)	1920	1.7
Sodium (Na)	530	0.5
Selenium (Se)	0.47	0.0
Chloride (Cl)	500	0.4

[a] APL 2006. *This value assumes a 50% loss of N during the drying process.

As can be seen from the nutrient analysis, piggery sludge has a high nutrient content compared with many animal by-products, especially in respect to phosphorus (P). However, these values could vary by more than 50% above or below the quoted numbers. The concentration of nitrogen is likely to vary widely because a large amount of the total N is in the ammonium form. This form of N will volatilise as ammonia gas very readily upon drying. If purchasing piggery sludge it is recommended that a nutrient analysis be collected to find out the nutrient composition of the product.

Nutrient availability

Not all nutrients supplied by organic by-products are available for plant growth. This is because many of the nutrients may be in the organic form. Some research has shown that about 60% of the total P in sludge is in the available form. It is likely that a large percentage of the K will be available, whereas nitrogen will vary widely.

Trace elements

The trace elements in piggery sludge may be highly valuable for some soil types. For instance, average calcium levels can be very high, and this can offset the use of lime or gypsum if these products are regularly applied.

Because the levels of some metals are also very high, care should be taken to apply only low application rates of sludge to agricultural land compared with other animal by-products. This will ensure that a build-up of metal does not occur over time. It is also recommended that sludge is not applied to horticultural crops without incorporation and careful soil monitoring to ensure that high levels of metal are not taken up by crops.




Application

Application of piggery sludge, unlike other animal by-products is likely to be very low. This is because of the very high nutrient content of the product. For example, a 1 tonne application of stockpiled sludge (assume 30% moisture) will supply about as much P as 300kg of single super phosphate. Because of the high levels of some metals, it is suggested that sludge be applied to meet the P demands of a crop or pasture at relatively low rates (less than 3t/ha). If the product is used on the same field for more than 2 applications it is suggested that soil samples be taken to monitor the level of metals and ensure that these do not rise excessively.

Some other fact sheets in this series:

Typical Composition – Chicken spent litter
Typical Composition – Piggery spent bedding
Typical Composition – Feedlot manure

Animal by-products – What are they worth?
Animal by-products – How much should I apply?
Animal by-products – Managing metals
Animal by-products – Managing weed seeds

References and further reading:

APL 2006, *National environmental guidelines for piggeries*, project no. 1832, Australian Pork Limited, Canberra, Australia.

Australian Government
Department of Agriculture, Fisheries and Forestry
National Landcare Programme

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MANAGEMENT – Salt in Animal By-Products

Animal by-products contain salts, particularly sodium chloride, which needs to be managed to ensure sustainability of the land resource.

Salts are a natural part of the environment, and are added to the soil through soil formation, hydrologic processes and rainfall. While large amounts of salt can be added to agricultural land with irrigation water or effluent, relatively small amounts are added with solid animal by-products such as manure, unless very high application rates are used.

It should be noted that the salts contained in animal by-products are not all damaging. Solid by-products contain calcium, magnesium, potassium, nitrate, phosphate and sulphate salts. Many of these are beneficial plant nutrients.

Salinity is measured by the **electrical conductivity (EC)** of a soil water extract and is affected by the texture of the soil. Because of the additional salts found in solid by-products, the EC of some solid animal by-products can appear high despite having a relatively low risk of causing soil salinity or sodicity. In order to work out the risk of causing salinity, it is more useful to consider the actual amount of salt (particularly sodium and chloride) that is being applied with the by-product per hectare.

Importantly, effluent can have a far higher concentration of salts than manure. This fact sheet deals specifically with solid by-products (manure) and will not discuss effluent salt loads in detail. If applying effluent you need to carefully work out the salt loads being applied to reduce the risk of land degradation. There are several factors which determine the risk of salinity and sodicity from applying animal by-products, including:

- The salt concentration in the by-product
- The application rate and total amount of salt applied
- Climatic conditions affecting salt movement
- Salinity and sodicity management

Is salinity a risk?

There are many natural salt affected areas in Australia, and growing amounts of salt affected areas that have been accelerated by management. Mostly this is in response to changes in water movement and vegetation management in the landscape.

The first step to working out the risk of salinity from using animal by-products is to know if your property is already affected. Table 1 below shows some EC levels that indicate soil salinity.

Table 1.Soil salinity criteria using $EC_{1:5}$ for four ranges of soil clay content

Plant Salt Tolerance Grouping	EC_{se} Range dS/m	Corresponding $EC_{1:5}$ Based on Soil Clay Content (dS/m)				Soil Salinity Rating
		10-20% clay	20-40% clay	40-60% clay	60-80% clay	
Sensitive crops	<0.95	<0.07	<0.09	<0.12	<0.15	Very low
Moderately sensitive crops	0.95-1.9	0.07-0.15	0.09-0.19	0.12-0.24	0.15-0.3	Low
Moderately tolerant crops	1.9-4.5	0.15-0.34	0.19-0.45	0.24-0.56	0.3-0.7	Medium
Tolerant crops	4.5-7.7	0.34-0.63	0.45-0.76	0.56-0.96	0.7-1.18	High
Very tolerant crops	7.7-12.2	0.63-0.93	0.76-1.21	0.96-1.53	1.18-1.87	Very high
Generally too saline for crops	>12.2	>0.93	>1.2	>1.53	>1.87	Extreme

Shaw et al. 1987

Generally, soils are too saline for crop growth where $EC_{1:5}$ is >1.53 dS/m (in soils with 40-60% clay). In soils with 10-20% clay, an $EC_{1:5}$ of >0.93 dS/m is considered too saline for crop growth (see Table 1). It may be a good option to sample soils in the area where by-products are to be applied.




The EC measurement from a soil test can be used to work out the salinity level from Table 1 above. If there is a concern over salinity levels a good option is to carry out soil tests every year or two so that any changes in salinity will be picked up.

The other concern with applying animal by-products comes from sodium. Sodium contributes to soil degradation, known as sodicity, by breaking down structure, causing dispersion and hard setting of clay soils. Sodicity is measured by the **exchangeable sodium percentage – ESP**) of the soil. ESP is a measure of the sodium in the soil relative to other cations, including calcium, magnesium and potassium. Because of this, adding sodium to a soil can be offset by adding other cations (calcium and magnesium) which are found in gypsum. In general, a soil is considered sodic if the ESP is above 6% in the surface soil. Above this level, soils are likely to start showing signs of structural decline such as hard setting and surface sealing. This can be managed by adding gypsum to lower the relative amount of sodium in the soil exchange.

Perhaps the best way to determine salinity or sodicity risks from solid by-products is to estimate the total salts applied per hectare with the by-product. This requires knowledge of the amount of salt and the application rate of the by-product. Some levels of sodium and chloride are shown in Table 2 below.

Table 2. Sodium and chloride concentrations in some animal by-products

	Feedlot Manure (stockpiled)	Meat chicken spent litter	Piggery spent bedding
Sodium (Na)	**0.6%**	**0.3%**	**0.3%**
Na / t manure	***4 kg***	***2 kg***	***2 kg***
Chloride (Cl)	**1.4%**	**-**	**0.8%**
Cl / t manure	***10 kg***		***6 kg***
EC (dS/m)	**12.4**	**6.8**	**6.5**

The above table shows a wide range of EC readings for these by-products, however the actual amount of salt applied to land is quite low (see example 1). Experience in Queensland has indicated that salinity and sodicity have rarely been shown to be a problem from manure usage and unless very sensitive crops are being grown, the risk of reducing yields or degrading soils from manure reuse is quite low[2].

Climate effects

Climate has a large effect on the risk of salinity or sodicity from manure usage.

In general, higher rainfall areas are at a lower risk of salinity because salts added to the soil will be leached through the root zone. In lower rainfall zones (<500mm) salts are more likely to remain in the root zone unless irrigation water is applied.

Example 1:

Stockpiled feedlot manure – sodium and chloride;

Sodium (Na) = 0.6%, Chloride (Cl) = 1.4%

Dry matter = 70% (Moisture = 30%).

Calculate Na content on wet basis;

Na content   Dry matter %

$$= 0.6 \times 0.7$$

= **0.4 % Na** as applied @ **30% moisture**

Using the same calculation gives **1 % Cl**

Calculate **kg** of **Na** & **Cl** applied **per tonne**

Na = 0.004 x 1000 = **4 kg**

Cl = 0.01 x 1000 = **10 kg**

At **10 t/ha** application rate this = **40 kg of sodium and 100 kg of chloride**

The example above shows that the added amount of sodium and chloride in manure is relatively low. In perspective, 100 kg of chloride per ha = 1 mg/kg change in the soil if all the chloride remains in the topsoil. If there are concerns about the impact of this on salinity then soil monitoring should be carried out before and after application to observe any changes.

Elevated sodium levels are managed by applying gypsum (at approximately 2.5t/ha). It is unlikely that this will be necessary because of manure application because of the calcium and organic matter that is also applied, but as always this should be monitored by soil testing.

References and further reading:

[1] Rengasamy, P & Bourne J 1997, 'Managing Sodic, Acidic and Saline Soils', Cooperative Research Centre for Soil and Land Management, Glen Osmond.

[2] Skerman, A 2000, Reference manual for the establishment and operation of beef cattle feedlots in Queensland, Information Series QI99070, Queensland Cattle Feedlot Advisory Committee (FLAC), Department of Primary Industries, Queensland.

Shaw, RJ, Hughes, KK, Thorburn PJ and Dowling AJ 1987, 'Principles of Landscape, Soil and Water Salinity – Processes and Management Options. Part A.' In "Landscape, Soil and Water Salinity". *Proceedings of the Brisbane Regional Salinity Workshop*, Brisbane, May 1987. Queensland Department of Primary Industries Conference and Workshop Series QC87003. Brisbane.

Department of Natural Resources (DNR) 1997, *Salinity management handbook*, Scientific Publishing, Resource Sciences Centre #222, Department of Natural Resources, Queensland.

Making the Most of Animal By-Products

FACTSHEET SERIES – Fact Sheet number 13
Updated: 19/3/2007

MANAGEMENT – Weed seeds in Animal By-Products

Weed seeds can be found in some animal by-products. These seeds generally originate from the animal feed and or bedding material. Because animal feed may be sourced from a wide region, weeds can be transferred widely through animal by-products if they are not managed correctly.

Weed seeds that enter the animal in the feed can pass through the digestive tract and remain viable, and may even germinate more rapidly because of the digestive process.

Small seeds with hard seed coats are the most likely to remain intact when feed is crushed or rolled, and can pass through the digestive tract of an animal and continue to be viable in the manure.

Weed seeds may also enter the system with the bedding material, particularly straw-based bedding. It can enter the bedding material during the harvest of the crop, or during transport and storage.

Generally, when animal by-products are applied in areas close to the feed and bedding source, weed seeds in the product may well be present in the application area. However, in this case by-products application can add to the weed seed bank of the paddock.

If the feed or bedding material is sourced from many regions, the number of weed seed species present in the animal by-product may increase and new weeds may be introduced to application areas.

Comparing animal by-products

The type of animal digesting the weed seed can have an effect on the viability of the seed once passed through the animal. Poultry are more efficient at breaking down seeds, and generally have minimal viable seeds in their manure.

Sheep and pigs are considered the next most effective at digesting weed seeds, while cattle are the least effective and have the highest risk of contamination.

Management options

Weed seed transfer to application areas via animal by-products can be minimised by:

- Sourcing stockpiled or composted animal by-products
- Gaining a weed germination test of the animal by-product prior to land application

Composting and stockpiling can reduce the number of viable weed seeds in an animal by-product because the high temperatures reached in the pile effectively kill the seeds. However, the effectiveness of composting manure to minimise weed seed depends on:

- The temperatures reached in the composting process
- Length of time all material exposed to these temperatures
- Available moisture
- Species of weed

Research[2,4] has shown that temperatures required to eliminate seed viability are species dependant. The minimum temperature ranges from 39 - 60°C for a minimum of three consecutive days.

To manage the risk of weed seeds, producers can carry out the following precautions when purchasing an animal by-product:

- Ask how the product has been stored and for how long, and if the product has been partially or fully composted. This can give an indication to the potential for weed seeds to be a problem after utilisation.




- If concerned about weed seeds in a by-product, a weed seed germination test can be done at a local laboratory for approximately $40. A 100 g sample of the material is usually required, but this should be checked with the laboratory prior to submission.

It should be noted that in weed establishment in a pasture or cropping situation depends on the overall management of the property, and this may reduce the threat of weeds from manure if good weed management is already practiced.

References and further reading:

[1]Blackshaw, RE, & Rode LM 1991, Effect of ensiling and rumen digestion by cattle on weed seed viability, *Weed Science*, **39**, 104–108.

[2]Grundy, AC, Green, JM and Lennartsson, M 1998, The effect of temperature on the viability of weed seeds, *Compost Science Utilisation*, **6**, 26–33.

[3]Laflamme, P 2006, Weed Prevention, last updated 9 August 2006, accessed 20 December 2006, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm5044

[4]Larney, FJ & Blackshaw, RE 2003, Weed Seed Viability in Composted Beef Cattle Feedlot Manure, *Journal of Environmental Quality*, **32**,1105-1113.

[5]Manitoba Agriculture, Food and Rural Initiatives (MAFRI) 2001, Weed Seeds in Manure, last updated June 2001, accessed 29 October 2006, http://www.gov.mb.ca/agriculture/soilwater/manure/fdb01s05.html

Some other fact sheets in this series:

- Typical Composition – Chicken spent litter
- Typical Composition – Feedlot manure

- Animal by-products – What are they worth?
- Animal by-products – How much should I apply?
- Animal by-products – Managing metals

MANAGEMENT – Legal Issues with Reuse

All users of animal by-products need to follow general and specific laws related to the reuse of these products. Functioning within these laws and guidelines will ensure sustainable use of these products with respect to the environment and other members of the community.

Intensive animal production (piggeries, beef feedlots, meat chicken farms) are regulated industries with laws and guidelines being enforced by the DPI&F and the EPA. There are restrictions over the reuse of animal by-products on farm and these must be followed to maintain a licence of operation. Dairy farmers are encouraged to follow the Queensland Dairy Farming environmental code of practice, however this is not mandatory.

When reuse of animal by-products occurs on a different property to where it was produced (i.e. if manure is sold to a second party) the specific laws related to intensive livestock production do not apply. However, users are responsible for safe and environmentally sound reuse under the **Environment Protection Act 1994** (state law administered by the Environmental Protection Authority (EPA)). This law is focused on maintaining the quality of the environment and preventing the risk of environmental harm. All people have a general environmental duty of care to carry out operations in a way that do not cause environmental harm. These broad based laws aimed to cover many areas of the environment including water, air, land, noise and waste management which are explained by a series of environmental policies put forward by the Queensland EPA, including the:

- Environmental Protection (Air) Policy 1997
- Environmental Protection (Noise) Policy 1997
- Environmental Protection (Water) Policy 1997
- Environmental Protection (Waste Management) Policy 2000.

These policies provide a legal framework to ensure air, noise, and water quality is improved or protected.

The laws are not aimed at being restrictive to general farming operations and in most cases good management practices will ensure that the requirements of the law are met. The main concerns with respect to animal by-product reuse come from:

- Risk of harm to water sources (surface and groundwater)
- Risk of harm to land (contamination)
- Risk of harm to animal health
- Risk of harm to community amenity.

Risk to water sources

Animal by-product reuse can result in large amounts of nutrients being applied to land, and this can create a risk to water quality in streams and underground aquifers. An immediate risk to surface water comes from spreading by-products too close to water courses and subsequent erosion that carries the product into the watercourse. There is also a long term risk from increasing nutrients (particularly nitrogen – N and phosphorus – P) to the surface soil leading to nutrient transport in runoff. This can be managed by:

- Applying by-products no less than 100m from a watercourse and / or maintaining an appropriate vegetative buffer
- Timing application when dry weather is forecast to minimise erosion losses
- Not applying by-products to steep slopes where erosion is likely
- Incorporating by-products where possible to limit losses
- Ensuring surface nutrient levels are not excessively high.

Safe nutrient levels in the surface soil depend on soil characteristics including clay and pH levels. For instance, Table 1 shows suggested maximum levels for phosphorus in topsoil. It is recognised that some systems may exceed these levels and information should only be used to trigger investigation.




Table 1. Suggested maximum available P levels in the topsoil for manure / effluent reuse areas

Clay content	pH	Colwell phosphorus (mg/kg)
Less than 30%	Less than 7	31
Less than 30%	More than 7	59
More than 30%	Less than 7	75
More than 30%	More than 7	85

Skerman 2000.

The risk to ground water comes from nutrients seeping through the soil with water. This risk is mainly from high N levels, although P can leach if very high amounts of by-product are applied over time. Nitrogen in groundwater can cause risk to animal and human health from nitrate and nitrite poisoning. This risk can be managed by:

- Balancing nutrient applications with plant requirements to minimise nutrient losses
- Planting deep rooted crops or pastures to use nutrients that are at the bottom of the root zone
- Timing nutrient application to avoid times of high drainage
- Spreading by-products no less than 100m from a groundwater bore.

Risk to land

The main risk to land from animal by-product reuse is from the build-up of very high levels of nutrients or contaminants. Animal by-products contain high levels of P compared to N. If by-products are applied as a N fertiliser over time excessive soil P levels can occur. These levels may take many years to decline. By-products can contain metals, elements and compounds that could also cause contamination of the land if very high amounts are applied over time. This risk can be managed by:

- Keeping paddock records of by-products application and managing nutrient levels
- Monitoring paddocks that have received by-products to keep nutrient and metal levels in check
- Applying by-products to match plant demand for P.

For producers of animal by-products who sell the product off farm, information needs to be supplied to buyers showing composition and suggested application rates to minimise risk. Records should also be kept of all by-products taken off site.

Risk of harm to animal health

The main risk to animal health comes from the consumption of animal by-products by farm animals. Under the stock act (1915) people must not feed any material to animals that are likely to cause disease. Two main disease concerns are botulism and BSE in ruminants (particularly cattle) from consumption of chicken litter or animal by-products. (BSE is precautionary – not present in Australia). Further information is available from the Queensland DPI&F on BSE and Botulism) Because of these disease risks it is illegal to allow cattle access to poultry litter or manure. The best management practices to prevent animal health risks are:

- Preventing livestock access to stockpiled manure or litter
- Ensuring that there is a 3 week break between applying animal by-products and livestock grazing.

See further information on pathogens in the 'Management – health risks' fact sheet.

Nutrient imbalances can also create animal health problems. In respect to animal by-product usage one issue of concern can come from high applications of potassium, which can lead to magnesium deficiency and grass teteny in grazed pastures.

Risk of harm to community amenity

Harm to community amenity is likely to be related to problems with odour or dust from applying animal by-products. Generally, odour problems are only likely to occur for 1 to 2 days. Dust can be a problem if the by-product is very dry, and dust can carry a long distance on windy days. To avoid problems with neighbours or other sensitive receptors (schools, community halls etc), it is suggested that by-products application is:

- Timed for mid-week, not on weekends.
- Spread no closer than 200m from a rural residence
- Spread no closer than 20m from a property boundary
- Spread no closer than 50 m from a minor road (<50 cars/day) and 100m from a road with >50 cars/day
- Carried out after neighbours are informed (odour is not likely to remain for more than a day or two).

These suggestions are not comprehensive, but they attempt to cover the main areas of concern that by-product application is likely to create. In most cases, following best management practices on your farm will ensure that environmental harm is minimised and the community is not affected, a win-win for all parties.

Further reading and references:

Queensland DPI&F, Queensland Dairy Farming Environmental Code of Practice. Available at: http://www2.dpi.qld.gov.au/environment/1235.html

Skerman, A 2000, Reference manual for the establishment and operation of beef cattle feedlots in Queensland, Information Series QI99070, Queensland Cattle Feedlot Advisory Committee (FLAC), Department of Primary Industries, Queensland.

Making the Most of Animal By-Products

FACTSHEET SERIES – Fact Sheet Number 15

Updated: 19/3/2007

MANAGEMENT – Metals in Animal By-Products

Animal by-products contain a range of metals, usually at relatively low levels. However, these metals can build up on farming land if high application rates are used continuously and the levels of metals are not managed.

Not all metals present in animal by-products are a problem. Some metals, including copper (Cu), zinc (Zn) and iron (Fe) are essential plant nutrients and are required at low levels in agricultural soils. Other contaminants, including arsenic (As) for example, are toxic to animals and must be maintained at low levels in the food chain.

Metals from animal by-products may accumulate in soils and can affect plant growth and soil organisms when toxic levels are reached. Metals can become mobile in the soil and potentially pollute surface and ground water systems.

Metals can also enter the food chain via pasture grazed by livestock, or vegetable crops where animal by-products are used as a fertiliser. With management, these risks can be minimised to ensure that agricultural produce is not contaminated.

Metals in animal by-products originally come from the animal feed (and bedding) which then becomes part of the by-product. While some metals are taken up by the animals, some will always pass through into the manure. The concentration of different metals will vary between animal by-products because management, feed and bedding materials and conditions differ between livestock operators.

What is the risk?

Most animal by-products have a relatively low level of metal contamination. As there are different acceptable concentrations depending on the metal, some levels may appear high but still be in the acceptable range.

High levels of copper and zinc may be found in piggery and poultry litter because they are common feed additives. However, these levels are not likely to exceed the guidelines for land application (Natural Resource Management Ministerial Council - NRMMC 2004). These guidelines were written for biosolids compost reuse, however they represent the clearest outline of acceptable by-product contamination levels for all crops (see Table 1 and Table 2).

Table 1. Limits for contaminants in compost, soil conditioners and mulches for land application (concentrations in mg/kg)

Contaminant	NRMMC
Arsenic	60
Cadmium	20
Chromium (total)	500-3000
Copper	2500
Lead	420
Nickel	270
Selenium	50
Zinc	2500

[5] NRMMC 2004

Table 2. Example metal concentrations in some animal by-products (concentration in mg/kg)

Variable	Meat Chicken spent litter[1]	Piggery spent bedding (fresh)[2]	Feedlot manure (stockpiled)[3]
Arsenic	13.8	-	-
Cadmium	0.2	1	-
Chromium	7.1	-	-
Copper	140	200	300
Lead	2.0	-	-
Nickel	5.6	-	-
Selenium	0.9	-	-
Zinc	480	350	1500

[1] Nicholas et al. 2005 [2] Nicholas et al. 2006
[3] Watts et al. 1994




Cadmium (Cd) and lead are metals of concern to fresh produce growers, though lead is generally considered less of a risk than cadmium. When cadmium is mobilised, plant uptake can occur. Plant uptake of cadmium increases where soils are very sandy, saline or acidic, low in zinc or organic matter, and if irrigation water is salty. Cadmium levels in animal by-products are generally below guideline limits, however, testing of soils and the animal by-product being applied is useful to ensure levels are acceptable.

Management options

Metals do not need to become a problem if they are well managed. It is suggested that farmers using animal by-products carry out the following steps to minimise the risk of metal toxicity or contamination of produce:

- Request a representative analysis of the product from the by-products producer prior to purchase.
- Ensure that excessive levels of metals are not being applied by calculating the rate of metals being put on with animal by-products (i.e. concentration of metal x by-product application rate / ha).
- Undertake soil tests regularly to ensure the metal concentrations in the soil are below acceptable levels for plant growth, animal health and toxicity in plant material (particularly for horticulturists).
- Do not apply by-products if rain is forecast to minimise runoff into surface waters.

NOTE: Managing risks on horticultural farms

Cadmium and **lead** are the elements of greatest concern for contamination of produce - however lead is less likely to be a problem [6]. **Root crops** and **leafy vegetables** are at the greatest risk[6].

Management:

- **Test soils** for cadmium and lead
- Have animal by-products analysed for cadmium before application to ensure levels are below the guideline limits
- If soil conditions are favourable for cadmium uptake, have produce tested before sale

Some other fact sheets in this series:

- Typical Composition – Chicken spent litter
- Typical Composition – Feedlot manure
- Animal by-products – What are they worth?
- Animal by-products – How much should I apply?
- Animal by-products – Managing weed seeds

References and further reading:

[1] Nicholas, PJ, Redding, M, Devereux, J, Kelsey, G, McGahan, EJ, Tucker, RW, Heinrich, NA 2006, 'Developing Guidelines for Use of Spent Deep Litter Bedding – Final Report. Project No.1969, Australian Pork Limited, Canberra, Australia, June 2006.

[2] Nicholas, PJ, Hewitt, S, Blackall, PJ, Chinivasagam, HN, Runge, GA, Klepper, K., & McGahan, EJ, 2005, *Literature Review and Risk Assessment for the Safe and Sustainable Utilisation of Spent Litter from Meat Chicken sheds*. Rural Industries Research and Development Corporation, Barton, ACT.

[3] Tucker, RW & McGahan, EJ 2004, *National environmental guidelines for piggeries: first edition*, project no. 1832, Australian Pork Limited, Canberra, Australia.

[4] Watts, PJ, Tucker RW, Gardner, EA, Casey, KD & Lott, SC 1994, 'Characteristics of feedlot waste', In PJ Watts & RW Tucker (eds), *Designing better feedlots*, Publications no. QC94002, Department of Primary Industries, Queensland.

[5] NRMMC 2004, Guidelines for Sewerage Systems Biosolids Management, Natural Resource Management Ministerial Council, Australian Water Association, Artarmon, NSW.

[6] AFFA 2001, 'Guidelines for on-farm food safety for fresh produce, Department of Agriculture, Fisheries and Forestry Australia, Canberra.

Making the Most of Animal By-Products

FACTSHEET SERIES – Fact Sheet Number 16
Updated: 2/5/2007

MANAGEMENT – Health risks with by-product reuse

Animal by-products contain a range of organisms, including some that can cause disease or illness in animals or humans. These disease causing organisms are called pathogens. Pathogens that can be transmitted between animals and humans are called zoonotic pathogens.

Handling or contact with animal by-products, including raw manure and effluent can allow transmission of these pathogens to animals and humans if correct management procedures are not followed. However, there are many factors that influence the likelihood of infection.

The **survival** of pathogens in the environment is dependant upon moisture, soil type, temperature, UV light exposure, soil biota and heat.

In general, if an animal by-product is heated to > 50°C, dried out or exposed to UV light, a large amount of the pathogens are likely to be inactivated. These conditions may occur in stockpiling, composting and spreading processes, however it is still recommended that users act with caution.

In Australia only a small amount of research has been carried out on the amount of pathogens in animal by-products, or the risk of infection. While infection rates are relatively low on a per capita basis, concerned individuals are encouraged to view the DPI&F website, animal industries, health pests and diseases, http://www.dpi.qld.gov.au/cps/rde/xchg/dpi/hs.xsl/27_127_ENA_HTML.htm

Animals may be carriers of some zoonotic diseases while not necessarily being affected by the disease. Animals are potential carriers of a number of zoonotic pathogens, including those outlined in Table 1, 2 and 3 representing cattle, pigs and poultry. However, these lists are by no means comprehensive. Currently there is industry research being carried out on the risk of infection from manure and these projects will improve the knowledge base on the topic over time. Table 1, Table 2 and Table 3 show the pathogens that may be present in cattle, pig and poultry by-products. However, these lists are not comprehensive.

Table 1. Pathogens that may be present in cattle by-products

Pathogen Group	Pathogen
Bacteria	*Bacillus anthracis* *Campylobacter jejuni, C. lanienae* *Clostridium perfringens,* *Cl. botulinum* *Coxiella burnetii* (Q Fever) *Enterococcus* spp. *Leptospira interrogens* *Legionella pneumophila* *Listeria monocytogenes* *Mycobacterium tuberculosis* *Salmonella* spp. *STEC, - *Yersinia enterocolitica, Y. pseudotuberculosis*
Protozoa	*Cryptosporidium parvum* *Giardia intestinalis, G. lamblia*

* STEC - Shiga toxin producing *E. coli* such as *Escherichia coli* 0157:H7

Table 2. Pathogens that may be present in pig by-products

Pathogen Group	Pathogen
Bacteria	*Leptospira interrogens* *Pseudomonas pseudomallei* (Melioidosis) *Clostridium perfringens,* *Cl. botulinum* *Salmonella* spp. *Campylobacter jejuni/coli* *Enterococcus* spp *Yersinia enterocolitica, Y. pseudotuberculosis*
Protozoa	*Giardia lamblia* *Cryptosporidium parvum*




Table 3. Pathogens that may be present in poultry by-products

Pathogen Group	Pathogen
Bacteria	*Campylobacter jejuni/coli* *Clostridium perfringens,* *Cl. botulinum* *Enterococcus spp* *Listeria monocytogenes* *Salmonella spp.*

Measuring contamination

Certain **indicator species** are used to assess contamination of soil and water, by measuring the **total coliform bacteria, faecal coliform bacteria or *E. coli***. *E. coli* bacteria are a subset of faecal coliform and are faeces specific, hence they are the most indicative of faecal contamination.

What is the risk?

There is very little information about the infection rate of people in Australia from handling animal by-products (manure/effluent). The relatively few cases of these diseases reported each year come mostly from people handling animal products frequently (i.e. abattoir and dairy workers).

However, it is known that pathogens from animal by-products can persist in surface water and groundwater for periods of < 1 day to several weeks or even months. For this reason care should be taken with the spreading of untreated animal by-products where human contact is likely.

In manure application areas, most pathogens generally loose their infectivity within three months. Many bacterial pathogens of common concern (e.g. Shiga toxin producing *E. coli* such as *E. coli* H157:O7, *Salmonella*, *Campylobacter* etc) find it difficult to survive or multiply in the soil, air and water[1], except under ideal conditions.

Note: Exposure to pathogens may not necessarily result in illness. Infection will depend on the ability of the pathogen to infect humans, infectious dose of the pathogen, and the transfer of the pathogen into the body and the ability of the body to combat infection.

Managing the health risk

Treating by-products before land application can reduce pathogen concentrations. Generally, thermophilic processes (e.g. **composting** at 50°C-60°C) are able to produce large pathogen reductions[2], however this may not remove all pathogen risk. Human and animal health risks can be minimised by applying best practice environmental management principles when applying by-products to land.

These include:

- Ensuring workers handling manure apply good personal hygiene practices
- Preferentially applying manure / effluent to grain / forage crops rather than pastures
- Applying effluent or manure to freshly grazed pasture, maximising the light exposure and time period before next grazing.
- Withhold stock from pastures during and after spreading (restrict access for at least 3 weeks post spreading – particularly with cattle where poultry litter is spread).
- Incorporating manure into the soil within 24 hours to minimise contamination from wind drift or rainfall runoff.
- Minimise the chance of direct contact between by-products and the edible part of fresh produce.
- Not applying untreated manure within 60 days of harvest when there is a significant risk of direct or indirect contact with the edible part of fresh produce[3].
- Composting or aging the manure to reduce microbe levels. Composting is more effective than aging.
- Vaccinating cattle against botulism.
- Ensuring uncomposted manure or litter do not contain animal carcasses.

If stockpiling manure on-farm, locate the pile to:

- ensure livestock cannot gain access (in particular it is illegal to feed or allow cattle access to poultry litter to prevent botulism and BSE risk).
- avoid contamination from wind drift on to adjacent crops and harvested produce.
- ensure rainfall runoff doesn't contaminate water sources[4].

References and further reading:

[1] Harter, T 2006, How long will animal-derived (zoonotic) pathogens persist in groundwater and surface water?, Pathogen Resources – FAQ's, National Livestock and Poultry Environmental Learning Center, accessed 21 November 2006, http://lpe.unl.edu/pathogen2.html

[2] Sobsey, MD, Khatib, LA, Hill, VR, Alocilja, E & Pillai, S 2001, Pathogens in Animal Wastes and the Impacts of Waste Management Practices on their Survival, Transport and Fate, National Center for Manure and Animal Waste Management, White Paper Summaries.

[3] Department of Agriculture, Fisheries and Forestry (DAFF) 2004, *Guidelines for On-Farm Food Safety for Fresh Produce*, second edition.

Koelsch, R 2006, What is a pathogen? A zoonotic pathogen?, Pathogen Resources – FAQ's, National Livestock and Poultry Environmental Learning Center, accessed 21 November 2006, http://lpe.unl.edu/pathogen2.html.

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