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Use of biosolids in agriculture

Leonie Martin
Advisory Agronomist (Biosolids), Cowra

Graeme Kelso
Advisory Agronomist (Biosolids), Bathurst

Introduction

In the early 1990s the Department of Agriculture and Sydney Water Board collaborated on a 10-year, comprehensive research program on the use of biosolids on land. The program arose from increased government and public concerns about ocean disposal of wastewater and the recognition of the potential beneficial properties of biosolids products. The research program identified the agronomic and soil fertility benefits of biosolids application in a number of production systems and showed that environmental or health risks associated with its use could be minimised by simple management practices. The research also aided in the creation of the *Environmental Guidelines – Use and Disposal of Biosolids Products* (the NSW Guidelines), published in 1997 by the NSW EPA and is available from the NSW Department of Environment and Climate Change.

This program was the foundation for Sydney Water's current biosolids application program.

What are biosolids?

Biosolids are primarily the nutrient-rich organic solid material produced by the municipal waste-water treatment process, previously referred to as sewage sludge. Wastewater solids become biosolids when they are stabilised by digestion or other treatment process and can be beneficially used in agriculture as either a liming agent or fertiliser.

Biosolids products that are rich in nutrients can be beneficially used as a soil conditioner for land application. Landholders often seek alternatives to conventional fertiliser and want a product that offers a competitive price and value for money. Biosolids offer landholders high levels of organic matter, as well as nitrogen (N), phosphorous (P) and other nutrients essential for plant and crop growth. Biosolids also contribute to soil properties such as structure, moisture retention, moisture content and cation exchange capacity. The nutrients in biosolids are slow release with 15–25% of the N and P becoming available in the first year and the remainder over subsequent years.

Research has shown that biosolids used according to the NSW Guidelines can help to improve soil quality and subsequent crop yields over time.

Biosolids can also contain low levels of heavy metals and pathogens. It is important that these meet the requirements set out in the current NSW Guidelines. Prior to any land application an environmental impact assessment is necessary to assess its suitability for biosolids application. The assessment is a mandatory part of the biosoil program and is undertaken by Sydney Water and NSW DPI staff.

Figure 1 shows the two main market sectors for 2007/08 (agriculture and composting). Land rehabilitation within the mining industry is another market sector but was not utilised in 2007/08. These markets are directed at improving soil and plant health by adding nutrient-rich biosolids to the soil.

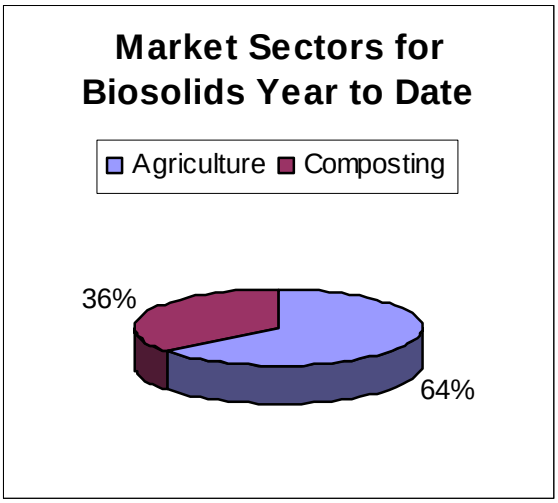
Physical properties of biosolids

Sydney Water has at times produced two biosolids products: dewatered biosolids (DWB) and lime amended biosolids (LAB).

Lime-amended biosolids (LAB)

Lime in the form of calcium oxide can be added to dewatered biosolids to help reduce odour and destroy pathogens. The end product contains significant levels of hydrated lime and some calcium carbonate. Its alkalinity (pH about 12) ensures that the product has undergone a significant reduction of pathogens. It is used as a substitute for agricultural lime, with a liming value

Fig. 1. Market sectors for biosolids use 2007-2008 (Sydney Water, Residuals Management Business Performance Report, November 2008.



and solids content varying from 30% to 40%. It generally contains low levels of nitrogen and phosphorous and is approximately 30% organic matter.

LAB has some odour of ammonia, due to its strong alkaline nature, which converts much of its nitrogen to ammonia gas. It is applied at a rate to provide the same liming effect as the recommended rate of agricultural lime on that soil.

Dewatered biosolids

Dewatered biosolids (DWB) is widely used for land application in rural areas.

A centrifuge or belt press is used to dewater biosolids to approximately 20% solids. The product contains a range of plant nutrients, but its main benefit to agriculture is its nitrogen, phosphorous and organic matter levels, improving soil fertility and physical properties.

DWB is black, with an appearance of moist organic soil. It can be quite odorous at times and this can linger for several weeks after application depending on the weather conditions. The quality of the product often determines the level of odour.

Biosolids are spread on the soil surface. The NSW Guidelines require that it be incorporated into the soil within 36 hours of application.

Organic matter

Biosolids contains high levels of organic matter and this is one of the main reasons people want to use it. The organic matter of biosolids used in NSW ranges from 40% to 60% (Table 1) and is much needed in degraded Australian soils. Organic matter improves soil physical quality and root environment by increasing soil water holding capacity and improving soil aggregation and by reducing soil bulk density. Application of biosolids can also increase soil cation exchange capacity. Plants are better able to withstand dry periods, extract water and utilise nutrients. The high level of organic matter present in biosolids can also help to decrease the availability of heavy metals for plant uptake. These effects should persist for several years after application, depending on climatic conditions, soil structure and management. Organic matter supplied by biosolids application may also encourage the growth of beneficial soil microbial populations that inactivate pathogens and are important in nutrient cycling and availability and contribute to soil physical properties. This illustrates the varied benefits of organic matter for soil health.

Microbiological properties of biosolids

An important question with biosolids use in agriculture is what health risks do pathogens in biosolids pose for animal and human health.

Wastewater treatment processes are designed to reduce the pathogen numbers in biosolids. Although bacteria numbers decrease with time after application some can persist for some months after biosolids application, and can even increase. This does not in itself pose a significant health risk, although usual hygiene practices apply when handling the product. Research has shown that management of areas treated with biosolids according to the NSW Guidelines minimises risks to the health of humans and grazing animals either directly or through the food chain.

Chemical properties of biosolids

The chemical properties of biosolids are affected by various factors:

- wastewater quality – extent of industrial pre-treatment
- extent of wastewater treatment – primary, secondary, tertiary
- process applications – use of chemicals
- methods for stabilisation (e.g. lime treatment).

Nutrients

DWB has considerable potential as a fertiliser because of the nutrients it contains, a proportion of them in slowly available forms. Some of these are listed in Table 1. The guiding principle for land application of biosolids to protect the environment is to supply nutrients at rates that equal the requirements of the crops and pastures.

The NSW Guidelines takes this into account for nitrogen with the concept of nitrogen limited biosolids application rates (NLBARs). This equates to 57–95 kg/ha of available N in the first year of application. There is also 45–75kg/ha of

Nutrient	%	Range (mg/kg)
Total Nitrogen (N)	2.9–5.1	29900–51600
Total Phosphorous (P)	1.05–4.26	10500–42600
Potassium (K)	.034–0.74	340–7410
Calcium (Ca)	0.9–2.4	8820–24100
Magnesium (Mg)	0.1–0.5	1000–5760
Sulphur (S)	0.5–2	5390–20000
Zinc (Zn)	.03–0.1	331–1490
Organic Matter	40–60	*

Table 1. Nutrient concentrations in Sydney Water dewatered biosolids (mg/kg) (Sydney Water database 2007)

available P in the first year. NSW DPI's research program showed growth responses in field crops, vegetables, perennial fruit crops and pastures to biosolids application over several years after application.

Metal contaminants

Biosolids also contain trace element contaminants that result from industrial and commercial wastes being released into the wastewater system. Wastewater treatment with chemicals such as lime and iron chloride affects the composition and chemical form of metal contaminants. The chemical form of metals influences their solubility and hence mobility in the soil or uptake by plants. Similarly, the method of biosolids processing and stabilisation also affects the characteristics of chemical contaminants.

Biosolids undergo extensive sampling and analysis of a range of metal contaminants to determine the final grade for classification of the product. The biosolids are divided into five contaminant grades from A to E (A the least contaminated) with the final product classification determined by the lowest grade for any one contaminant. Most of the product going into the land application program is contaminant grade C. NSW Guidelines and USEPA Limits for Biosolids suitable for agricultural land application are compared in Table 2. This shows that NSW is very conservative with its limits in comparison to limits set by the USEPA. If the product does not meet these specifications, it is blended into compost or mixed and re-graded and re-tested before being used for agriculture.

Biosolids cannot be re-applied to the same paddock within five years unless the pH of the soil is 5.5 or higher. This ensures that there is no build up of metal contaminants in the soil. This is

Contaminant	Acceptance levels for C grade biosolids (mg/kg^3 dry soil) NSW EPA	Acceptance levels, 1995 USEPA Part 503 (mg/kg dry soil)
Arsenic (As)	20	75
Cadmium (Cd)	20	85
Chromium (Cr, Total)	500	--
Copper (Cu)	2,000	4,300
Lead (Pb)	420	840
Mercury (Hg)	15	57
Nickel (Ni)	270	420
Selenium (Se)	50	100
Zinc (Zn)	2500	7,500
DDT/DDD/DDE	1.0	*
Aldrin	0.5	*
Dieldrin	0.5	*
Chlordane	0.5	*
Heptachlor	0.5	
Heptachloro	0.5	*
benzene	0.5	*
Lindane	0.5	*
Benzene Hexachloride	1.0	*
PCBs		

Table 2. Acceptable biosolids contaminant levels for agricultural use in Australia and United States (mg/kg dry weight of soil). (NSW EPA Biosolids Guidelines, USEPA 1995, Part 503 Regulation).
** information unavailable*

simply a safety measure to minimise heavy metal uptake by plants.

Do heavy metals from biosolids application create environmental or health issues? The NSW DPI research program in a long term grazing trial showed that biosolids applied and managed according to the NSW Guidelines did not pose a risk to plants, grazing animals or the environment. To place heavy metals in context, they occur naturally in the soil at varying concentrations. They can also occur in inorganic fertilisers, as they are part of the mineralogical composition of the mined materials.

Conclusion

Biosolids offer a nutrient-rich alternative to conventional inorganic fertilisers. Its agronomic value for crop and pasture production extends beyond conventional fertiliser and the benefits from the product should last for more than twelve months depending on weather conditions.

Table 3 can be used as a comparison between biosolids and some common inorganic fertilisers and clearly shows that over time biosolids becomes the cheaper alternative source of

Fertiliser	Application Rate (kg/ha)	N Applied (kg)	P Applied (kg)	K Applied (kg)	S (kg)	Nitrogen $/kg	$/t Nov 2008 (Inc GST)	$/ha 2008 (Inc GST)
Single Super	125	0	11.25	0	13.7	0	594.00	74.25
DAP	100	18	20	0	5	3.36	1749.00	174.90
MAP	100	10	22	0	1.6	6.05	1859.00	185.90
Biosolids 15–25% In 1st year	50 t/ha	380 57–95 kg/ha	300 45–75 kg/ha	0.2	10.5 100	0.26	2.00	100.00

Table 3. Purchase price comparisons of biosolids to common fertilisers (data current as at 5 November 2008). Note: While the cost to the general public for biosolids is $2/t this does not reflect the actual cost of production.

fertiliser nutrients. With the increasing cost of fertiliser many landowners are turning towards using biosolids and those who have tried biosolids have continued to do so.

Biosolids can contain some contaminants. The treatment processes and management after land application described in the NSW Guidelines minimises any health or environmental risks posed by these contaminants.

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Further information

For more information on the Biosolids Program contact:

Leonie Martin, Advisory Agronomist (Biosolids), NSW DPI, Cowra ARAS, Binni Creek Road
Cowra NSW 2794
Ph: 02 6349 9744

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