Pasture Productivity using Biosolids on a Light Sandy Soil

Mornington Peninsula 2017

Demonstrating Sustainable Farm Practices

CLEANAWAY

South East Water

Australian Government

National Landcare Program

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wpcln Western Port Catchment Landcare Network

South Gippsland Landcare Network

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Introduction

The aim of this three-year demonstration trial was to assess how the use of biosolids could improve the fertility, soil structure, and hence pasture production on a Mornington Peninsula property with a sandy textured soil.

The soils in this area are described as loamy sands with colours ranging from greyish brown to brownish yellow. Organic matter content influences the soil colour. They are low in fertility and lack moisture holding capacity. They are easily cultivated and with increased organic matter and use of fertilisers can become highly productive.

The farm is 61 ha and owned by Alistar and Susan Young. It is situated in a Green Wedge Zone of the Mornington Peninsula Shire. The landform is early Pleistocene Aeolian (windblown) sediments and dunefields.

Figure 1: Paddock before the biosolids were applied displaying patchy pasture and bracken fern

A farming background in New Zealand with sheep grazing and managing orchards led to the aim of purchasing a rural lifestyle property. When Alistair and Susan purchased the farm in 2011, it was very run down and no fertiliser had been applied since the 1950's. It was covered with bracken fern and kikuyu and occupied by approximately 600 kangaroos.

Initially the property was stocked with 30 Angus steers on 3 paddocks with only isolated water sources. There are now 12 fenced paddocks with dam water, and kangaroos have decreased to about 30-40. It is currently stocked with 40 cattle (Shorthorn/Limousine cross), 150-170 Wiltipole and Wiltshire sheep and a small flock of Dorpers. The lambs are not weaned but do receive supplementary silage, and pasture.

Figure 2: Alistair Young and consultant David Stewart viewing the disced soil after application of biosolids

About 100 round bales of hay and 350 silage rolls have been cut this 2017-2018 season.

The major objective for Alistar and Susan was to improve the productive base of the farm as quickly as possible, and the use of biosolids was considered by them to be the most cost effective approach. Biosolids have previously been trialled successfully in Australian agriculture (McLaughlin et al, 2008). There are very strict controls on the use of biosolids and a rigorous monitoring regime is adhered to by South East Water (SEW) and other water authorities.

The demonstration trial established in 2014 generated considerable interest from other farmers keen to see whether the use of biosolids was a cost effective approach to improve soil fertility and increase pasture productivity. South East Water in conjunction with Cleanaway supplied, spread and incorporated the biosolids which were sourced from the Boneo Water Recycling Plant.

South East Water initially took baseline soil samples with additional analyses to monitor changes due to biosolids application.

Lime was applied prior to the spreading of biosolids. Improved pasture species was sown after biosolids incorporation and preparation of seed bed. Alistair and Susan Young believe that the results have been remarkable with productive pastures resulting.

Poultry litter is widely used by landowners across the region to increase soil fertility. It was therefore considered important to trial this input to see how the pasture and soil responded to poultry litter in comparison to the biosolids.

Figure 3: Wiltipole and Wiltshire sheep

Figure 4: Shorthorn/Limousine cross

Figure 5: Pasture after biosolids application

Trial Design and Set-up

Control area

The control area was set up and designed to have no nutrients (in the form of biosolids and poultry litter) applied. Unfortunately during the demonstration, a contractor applied poultry litter on to the control area by mistake. As a result, the control area results are not reported.

Figure 6: Application of biosolids

Poultry litter application area

Poultry litter was applied in 2014 at 3 t/ha, and a further 3 t/ha of poultry litter was spread in 2017. Lime was also applied to this area at the rate of 2.5 t/ha in 2015.

Biosolids application area

The demonstration site was comprised of bracken-infested pasture. In March 2014, the weeds and bracken were sprayed out and lime applied at 2.5 t/ha.

In partnership with South East Water and Cleanaway, 140 t/ha wet weight or 83 t/ha dry weight of biosolids from the Boneo Water Recycling Plant was applied to this area in March 2014.
After the biosolids were spread, the application area was disced, power harrowed and pasture species were sown. Pasture species included a blend of annual tetraploid and diploid ryegrasses and Italian ryegrasses comprising "Feast Two, Jeanne and Knight".

Figure 7: Incorporation of biosolids and cultivation prior to sowing new pasture

In March 2017, an additional application of 32 t/ha wet weight or 16 t/ha dry weight of biosolids from the Boneo Water Recycling Plant was applied. After the biosolids were spread, the area was disced, power harrowed and perennial pasture species were sown.

Comment on biosolids production and analysis

South East Water produced the Boneo biosolids used in the trial through aerobic digestion, which was then stablised in anaerobic sludge lagoon, dewatered and dried via solar dryers or sludge drying pan then stockpiled for more than 1-3 years to obtain highest treatment grade (T1) product.

The analyses of the two different types of biosolids used in 2014 (Stockpile RSD2010 and Stockpile R2010A) for the demonstration trial are tabulated in Table 1 below. Generally, pure biosolids indicate higher levels of nitrogen, phosphorus, calcium and sulphur compared to clay biosolids. Analysis of the two different types of biosolids used in 2017 (Stockpile RSD2015 and Stockpile R2014) is also provided in Table 1.

The biosolids were tested for *E. coli*, Salmonella and enteric viruses to meet strict microbiological criteria for treatment grade T1. The biosolids were classified as contaminant grade C2, due to the occurrence of cadmium, copper, mercury, selenium and zinc. T1C2 biosolids are suitable for agriculture and a range of other uses (South East Water, 2014).

Table 1: Biosolids and Poultry litter Analyses

	2014 application		2017 application		Poultry Manure *
	Stockpile RSD2010 – Pure biosolids	Stockpile R2010A – Clay biosolids	Stockpile RSD2015 – Pure biosolids	Stockpile R2014 – Clay biosolids	
Analytical results provided by ALS Laboratory, Scoresby, Victoria					
Total Kjeldahl Nitrogen, TKN (%)	0.68	1.18	3.04	1.54	-
Total Phosphorus, TP (%)	1.92	0.89	3.40	1.22	-
Total Solids (%)	44	64	37	52	-
pH 1:5 $CaCl_2$ (pH units)	7.5	7.6	6.8	7.3	-
Analytical results provided by Environmental Analytical Laboratory, Lismore, NSW					
Total Nitrogen (%)	2.72	1.20	-	-	3.0-4.7
Total Phosphorus (%)	1.90	0.74	-	-	1.5-2.1
Total Potassium (%)	0.17	0.13	-	-	1.89-1.97
Total Sulphur (%)	1.19	0.66	-	-	0.60
Total Carbon (%)	20	10	-	-	33-37
Total Calcium (%)	3.73	2.22	-	-	2.40
Total Magnesium (%)	0.38	0.24	-	-	0.52
Total Sodium (%)	0.13	0.10	-	-	0.51
Electrical Conductivity (1:5 water) (dS/m)	6.4	4.1	-	-	10.0
pH 1:5 water (pH units)	6.5	7.0	-	-	6.7-7.0
Carbon: Nitrogen ratio	7	9	-	-	11

* Analyses from a range of inputs used in farm trials across the Western Port Catchment

There is concern across the farming community in regard to a range of unregulated compounds including endocrine disruptors, fire retardants, pharmaceuticals and new compounds that might pose a threat to both the environment and human health (Darvodelsky, 2011).

A report on Biosolids by the Department of Sustainability, Environment, Water, Population and Communities sees these compounds as "often more important for persistent chemicals than human health impacts". Their summary statement concludes that "overall the risks to human and environmental health from biosolids use are considered to be extremely low" (Darvodelsky, 2011).

Organic matter analysed at 34% in pure biosolids and 17% in clay biosolids. The corresponding carbon nitrogen ratio was 7 and 9, respectively. This carbon:nitrogen ratio means that more than 25% of the nitrogen will be mobilised during the first twelve months. The pH (1:5 water) recorded 6.5 in pure biosolids and 7.0 in clay biosolids which is regarded as an optimum level for mineral availability and microbial soil life.

Testing Protocols

Initial pre-trial testing and monitoring criteria was based on assessment of the soil's physical, biological and chemical characteristics. A full soil analysis was taken and annual soil tests were repeated at the end of each year and pasture yields were monitored with an electronic 'GM Pro' Pasture Meter. Pasture cages were used due to the high numbers of kangaroos on the farm at the commencement of the demonstration.

Figure 8: Collecting soil samples for analysis

Figure 9: Pasture growth under cages

Figure 10: Cultivated trial paddock illustrating the sandy texture of the soil

Analysis of Results

Physical observations - The baseline soil assessment indicated a sandy topsoil with depth greater than 200 mm. It had poor physical characteristics with most prominent soil constraints being identified as a lack of soil structure due to its texture and low moisture holding ability. Pasture composition was poor with high weed burdens and bracken fern dominating. Physical observations of the soil at the conclusion of the trial indicated a darker colour with an obvious increase in organic matter.

Table 2: Soil analysis (0-10 cm depth)

Soil test	Baseline: Dec 2013 (pre-application of biosolids ALS analysis)	*Control Dec 2014 (EAL analysis)	Poultry Litter Dec 2014 (EAL analysis)	Poultry Litter Dec 2017 (EAL analysis)	Biosolids Dec 2014 (EAL analysis)	Biosolids Dec 2017 (EAL analysis)
pH (1:5) $CaCl_2$ (pH units)	4.00	4.67	4.21	4.28	6.24	5.82
Available calcium (mg/kg)		318	312	406	894	756
Available magnesium (mg/kg)		154	183	196	134	122
Available potassium (mg/kg)		163	153	124	169	103
Olsen P (mg/kg)	17	14	27	17	55	64
Colwell P (mg/kg)		29	50	62	214	271
Nitrate N (mg/kg)		6.2	34.3	1.2	11.7	9.2
Sulphur (mg/kg)		10.3	25.1	11.0	16.9	13.0
Total Nitrogen (%)	0.12	0.28	0.61	0.32	0.24	0.69
Organic matter (%)	2.4	7.7	15.8	8.5	5.8	17.0
Total Carbon (%)	1.4	4.4	9.0	4.9	3.3	9.7
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	3.00	7.53	9.72	11.33	10.92	8.60
Exchangeable Calcium %	36	56	54	58	74	76
Exchangeable Magnesium %	9	31	33	27	14	14
Exchangeable Potassium %	6	8	6	4	5	4
Exchangeable Sodium %	2	2	6	5	2	2
Calcium:Magnesium ratio		2	2	2	5	5
Exchangeable Aluminium %	2	0.6	0.5	0.3	0.9	0.2
Carbon:Nitrogen ratio	12	16	15	15	15	14

*No biosolids and no Poultry litter applied

Soil analyses

Full soil analyses were taken from the biosolids and poultry litter application area over the 3 years of the demonstration. South East Water has provided analyses including heavy metals, pesticides and microbiological profile for the biosolids application area (South East Water, 2014 and 2017).

These results are monitored and application rates adjusted to avoid build-up of any heavy metals, particularly cadmium.

Changes in soil analyses over the trial period from the control to the Poultry Litter application area

- Available calcium increased from 318 to 406 mg/kg
- Colwell P increased from 29 to 62 mg/kg

Changes in soil analyses over the trial period from the control to the Biosolids application area

- pH increased from 4.67 to 5.82
- Available calcium increased from 318 to 756 mg/kg
- Olsen P increased from 14 to 64 mg/kg
- Colwell P increased from 29 to 271 mg/kg
- Total nitrogen increased from 0.28 to a high 0.69%
- Organic matter increased from 7.7 to 17%
- Exchangeable calcium percentage increased from 55.6 to 76.2%
- Exchangeable potassium percentage decreased from 7.7 to 3.5%

Pasture yield and quality

Biosolids application area

The quality of the pasture was variable with capeweed prominent in open areas in late spring. At times pasture monitoring could not be taken due to recent pasture sowing or extremely dry conditions. When this is taken into consideration the total yield of the biosolids is very similar to that seen in the area where the poultry litter was applied.

Table 3: Pasture Yield

Date	Biosolids application area (kg/ha)	Poultry litter application area (kg/ha)
2015	8,840	6,622
2016	6,833	6,213
2017	8,363	10,771
Total	**24,036**	**23,606**

Alistair commented that, “overall pasture had improved markedly with high value species more apparent and the disappearance of most weeds and bracken fern”. This was easily seen when comparing before and after photos. Alistair also commented that, the perennial pasture performed significantly better than the annual grasses after 2014 application. As a result, he only sowed perennial pasture in 2017 after the biosolids were applied. The fencing of paddocks reduced grazing pressure from kangaroos.

Figure 11: Biosolids treatment area – before and after biosolids application and pasture renovation

Poultry litter application area

Pasture yield on the poultry litter application area was very comparable to the biosolids application area over the three years, however, the pasture was less weedy to start with. The pasture yield in this area increased significantly in the final year. There was more kikuyu in this area and performed well over the summer period. Whereas the biosolids area was sown with ryegrasses which slowed significantly over the summer period.

Cost of inputs and management on demonstration areas

Table 4: Establishment and ongoing costs	$/ha*
Biosolids application area	
March 2014, pasture, weeds and bracken were sprayed out	100
2014 Lime applied at 2.5 t/ha	300
2014 Biosolids applied at 83 t/ha (dry weight)	0
Purchase and sowing of ryegrass (annual & perennial)	100
March 2017, pasture, weeds and bracken were sprayed out	100
2017 Biosolids applied at 16 t/ha (dry weight)	0
Purchase and sowing of perennial ryegrass	100
Biosolids Total (x2 applications)	**$700**
Poultry litter application area	$/ha
September 2014 poultry litter was applied at 8 m^3 (3 t/ha) (inc spreading)	115
2015 Lime applied at 2.5 t/ha (bulk delivery)	200
September 2017 poultry litter was applied at 8 m^3 (3 t/ha) (inc spreading)	136
Poultry litter Total (x2 applications)	**$451**

* Costs provided by Alistair and Susan Young

Summary

This project had a very successful outcome in terms of demonstrating how a marginal sandy soil with low fertility, a high weed burden, and grazing pressure from wildlife could, with corrective action, be turned into a productive pasture based enterprise with the use of biosolids. From a whole farm planning perspective, improved fencing subdivision and supply of water to smaller paddocks, along with the addition of biosolids to address soil physical and chemical deficiencies were important management changes, which led to increased pasture production.

The turnaround in soil fertility has largely been made by the use of biosolids from the South East Water Boneo Water Recycling Plant. This soil amendment has increased almost all major soil nutrient elements resulting in the change from a degraded pasture to one with a better balance of nutritional species and one capable of accommodating the current stocking rate of sheep and cattle.

Key learnings from demonstration

- **A whole farm planning perspective was an essential component of the successful turnaround of the property.**
- **The fencing of new paddocks and the supply of water made for easier stock handling.**
- **The use of biosolids was shown to improve soil fertility on the area it was applied.**
- **Monitoring of soils is essential in the use of such a locally available resource to ensure appropriate input levels were made and that possible build-up of heavy metals was avoided.**
- **Importantly, inputs were based on indicated deficiencies in soil physical and chemical characteristics.**

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