Layer Hen Manure Analysis Report

A report for the Australian Egg Corporation Limited

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Foreword

Effective manure reuse is closely linked to the composition of manure. Over time, changing management practices may lead to changes to manure composition and subsequent value. This report provides updated data on the average composition of layer hen manure from divergent management systems, which can be used to inform producers and users of layer hen manure and spent litter.

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This report is an addition to AECL's range of research publications and forms part of our R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry.

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Executive Summary

Poultry layer manure and litter composition data is essential for accurately determining sustainable application rates of manure to crops and pastures. Concentration of major plant nutrients and manure properties such as moisture levels will largely determine the usability and sale value of manure and litter.

This study collected some 20 samples of manure and litter from 5 different layer production systems from all major production regions in Australia. Compared to composition data previously reported for Australian layer manure and litter, there are several notable trends, particularly with respect to nitrogen, phosphorus, calcium and moisture levels.

In layer manure from caged systems, all the above mentioned parameters are higher than have been previously reported. This is likely to be the result of changed management systems from high rise sheds to belt manure removal, though this does not explain all the differences.

Nitrogen levels in layer manure from caged systems (13 samples) averaged 5.6%, with a range of 3.4 – 7.5% which is higher than previously published data and is likely to be the result of lower residency times for manure in sheds and higher manure moisture content. No dietary effect could be demonstrated from the data available. Nitrogen levels in poultry layer spent litter averaged 2.7% which is lower than previously reported and is similar to levels reported for meat chicken spent litter.

Phosphorus levels for layer manure from caged systems averaged 2.5% with a range of 1.1-3.7%. This is 0.5% higher than previously reported Australian data. Phosphorus levels in spent litter averaged 1.6%. This is slightly higher than previously reported Australian data.

Potassium levels in layer manure from caged systems averaged 2.1% while levels in spent litter averaged 1.5%.

Carbon levels were higher than reported in the literature (averaging 35.6%). Significant levels of other valuable nutrients, notably calcium which averaged 11.3% for layer manure from caged systems, compared to 3.9% previously reported in the literature. Sulphur and a range of micro nutrients are also present in poultry layer manure and litter.

Moisture levels in layer manure from caged systems tend to be 25 - 35% higher than previously reported Australian data. The average moisture level for caged systems is 57.6%, with a range from 31 – 73.7%. Samples showing high moisture levels are typically produced from belt manure removal systems without drying fans or from systems where fans run for only short periods in the day. The trend towards higher moisture levels has decreased the handling characteristics of layer manure and is likely to decrease the maximum transport distance that manure can be hauled.

One manure sample from a belt system achieved moisture levels of 32.4% where drying fans are run for 20 hours / day, suggesting that manure from these systems can be dried substantially to improve handling characteristics. Moisture levels in spent litter are relatively low (average 20.8%) which will contribute to ideal handling characteristics.

A range of contaminants were analysed including heavy metals and salt (sodium). All levels were well below reported thresholds. Arsenic levels were lower than previously observed, averaging only 1 mg/kg across all samples.

1. Introduction

The composition of layer hen manure will determine the nutrient value and 'usability' of the product for land application. These factors also determine the potential sale value of the product. Composition varies depending on a range of factors including:

- Shed management (high rise, belt manure removal, drying, barn etc),
- Diet formulation,
- Age of the manure post excretion.

Generally, manure from caged systems have a higher nutrient analysis compared to barn or free range systems, and within the caged systems (belt manure removal with/without drying or high rise sheds) there can be differences also.

Diet formulation can have a significant effect on composition, largely related to the crude protein and phosphorus levels in the diet. Manure composition also depends on the length of time the manure has been stockpiled. Generally the carbon and nitrogen content of manure will decline as the stockpiling time is extended, while other nutrients such as phosphorus are concentrated.

The only known Australian data set on manure composition previously published is from the Environmental Code of Practice for Poultry Farms in Western Australia (Department of Environmental 2004). These data are shown in Table 1.

Table 1 – Published Composition Data for Poultry Layer Manure

		Layer manure – caged systems			**Barn / Free range layer hen litter**		
Amounts given as a % on dry matter basis	Units	Range		Average	Range		Average
Moisture (% of solids)	%	7	46	30	22	29	25
pH		-	-	8	-	-	8
Dry density (kg/m3)	kg	-	-	550	320	600	550
Calcium	%	3.6	6	3.9	0.1	1.7	1.4
Organic Carbon	%	-	-	29	-	-	38
Chloride	%	-	-	2.4	-	-	1.3
Iron	%	0.1	0.56	0.3	0.53	1	0.8
Magnesium	%	0.2	0.7	0.5	0.1	0.4	0.3
Total Nitrogen	%	1.3	7.2	4.6	1.7	6.8	4.1
Ammonium - N	mg/kg	2000	30000	14000	100	2000	300
Phosphorus	%	0.5	3.4	2	0.8	2.6	1.4
Potassium	%	1.2	3.2	2.1	1.3	4.6	2.1
Sulphur	%	-	-	0.4	-	-	-
Arsenic	mg/kg	-	-	30	-	-	-
Boron	mg/kg	-	-	20	-	-	-
Copper	mg/kg	-	-	20	-	-	-
Manganese	mg/kg	-	-	300	170	320	270
Zinc	mg/kg	-	-	350	-	-	-
Sodium	%	0.2	0.74	0.42	0.07	0.53	0.33

Reproduced from the Environmental Code of Practice for Poultry farms in WA (Department of Environment 2004)

Data have also been presented for meat chicken spent litter (Griffiths 2004 - Table 2) which can be used for comparison with layer hen spent litter from free range and barn systems.

Table 2 – Average Composition of Meat Chicken 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

1.1. Potential Contaminants in Poultry Layer Manure

A range of potential contaminants may appear in poultry layer manure depending on dietary additives and ration formulation. Thresholds for a range of contaminants have been established by different authorities (NRMMC 2004, NSW EPA 1997, VIC EPA 2004 - see Table 3). Of these, arsenic contamination has been reported in poultry layer manure previously (ref. Table 1).

Table 3 – Concentration Limits for Contaminants in Compost, Soil Conditioners and Mulches for Land Application (concentrations in mg/kg)

Contaminant	NRMMC	NSW EPA	VIC EPA
Arsenic	60	30	60
Cadmium	20	-	-
Chromium (total)	500-3000	-	-
Copper	2500	2000	2000
Lead	420	-	-
Nickel	270	-	-
Selenium	50	-	-
Zinc	2500	3500	2500

NRMMC (2004), NSW EPA (1997), VIC EPA (2004)

These contaminants, with the exception of selenium, were analysed as part of this research and are discussed in chapter 3.

2. Methodology

Manure samples were collected from 20 layer farms from all states of Australia. These farms represented five shed or production systems that may contribute to variability in manure composition, namely:

- Caged layer sheds with belt manure removal – no manure drying and manure removal every 1-7 days
- Caged layer sheds with belt manure removal – with manure drying and manure removal every 1-7 days
- Caged layer sheds – high rise with manure removal approximately once per year
- Barn layer sheds with litter (generally sawdust) – manure removal generally once per year
- Free range systems where manure accumulates within the roost and is generally removed once per year

Samples were collected from at least four farms representing each system (apart from barn systems where only 2 samples were collected) and results are presented for each system separately, along with an average of all cage systems and an average of all free range and barn systems.

In addition to the sampling, egg producers were asked to complete a simple survey with details regarding management system, diet and the age of the manure at the time of sampling (see Appendix 1 – Questionnaire).

All samples were collected by farmers, packaged in cooler boxes and promptly couriered to FSA Consulting in Toowoomba. This was done in accordance with an established procedure (see Appendix 2 – Sampling Procedure). Samples were stored in a freezer prior to analysis in batches. The samples were analysed for a range of agriculturally relevant nutrients, properties and contaminants at SGS Agritech Toowoomba, a NATA accredited laboratory (see Appendix 3 – Laboratory Results).

Table 4 – Nutrient and Contaminant Parameters Analysed in Layer Hen Manure Samples

General Properties	Plant Nutrients – Macro	Plant Nutrients - Micro	Potential Contaminants
Moisture	Total Nitrogen	Iron	Sodium
Electrical Conductivity	Ammonium Nitrogen	Magnesium	Arsenic
pH – Water	Nitrate nitrogen	Boron	Cadmium
Organic Carbon	Total Phosphorus	Copper	Chromium
	Orthophosphorus	Zinc	Lead
	Potassium	Manganese	Nickel
	Calcium	Molybdenum	
	Sulphur		

3. Results and Discussion

The results will be discussed in separate sections with reference to the major agronomic properties (emphasis on nitrogen, phosphorus and potassium), handling properties (moisture), carbon content and contaminants in manure. Additional information included from the surveys is included where relevant. These results have not been statistically analysed and all comments can only be considered as observed trends.

3.1. Caged Layer Manure Analysis Results

Table 5 presents manure analyses for caged layer hens housed in sheds with manure belts. Most of these sheds have been constructed in the past 5 years and incorporate controlled climate systems, however these sheds have not been fitted with fans to dry manure that accumulates on the belts.

Table 5 –Manure Analysis Results for Caged Layer Hen Systems with Belt Removal and No Manure Drying

Parameter	Units	Range		Average
Moisture	%	51.0	73.7	64.2
pH - Water		5.7	6.5	6.2
Electrical Conductivity	dS/m	12.1	15.4	14.1
Organic Carbon	%	37.3	39.4	38.0
Nitrogen	%	4.8	7.1	5.9
Ammonium Nitrogen	mg/kg	1038	10610	7480
Nitrate-N	mg/kg			<200
Phosphorus	%	1.1	2.4	2.0
Ortho-phosphorus	mg/kg	1286	6246	3767
Potassium	%	1.7	2.5	2.1
Calcium	%	7.7	14.0	10.2
Sulphur	%	0.4	0.5	0.5
Magnesium	%	0.6	0.6	0.6
Copper	mg/kg	39	74	58
Manganese	mg/kg	320	480	430
Iron	mg/kg	430	2000	1066
Zinc	mg/kg	380	430	398
Molybdenum	mg/kg	3	8	6
Boron	mg/kg	4	25	16
Sodium	%	0.3	0.4	0.4
Arsenic	mg/kg	<1	1	1
Cadmium	mg/kg			<1
Chromium	mg/kg	4	7	5
Nickel	mg/kg	5	9	6
Lead	mg/kg	2	6	3

Samples – n = 5

Table 6 presents manure analyses for caged layer hens housed in sheds with manure belts with manure drying fans fitted. Fans are operated for between 4 hours and 22 hours per day, corresponding to highly variable moisture levels for these samples.

Table 6 –Manure Analysis Results for Caged Layer Hen Systems with Belt Removal and Manure Drying

Parameter	Units	Range		Average
Moisture	%	32.4	69.8	53.6
pH - Water		5.9	6.9	6.3
Electrical Conductivity	dS/m	4.8	15.7	10.4
Organic Carbon	%	34.2	40.7	37.5
Nitrogen	%	4.9	7.5	6.0
Ammonium Nitrogen	mg/kg	91	17780	5418
Nitrate-N	mg/kg			<200
Phosphorus	%	2.1	3.1	2.6
Ortho-phosphorus	mg/kg	594	6492	2680
Potassium	%	1.6	1.8	1.7
Calcium	%	8.0	15.9	12.4
Sulphur	%	0.4	0.6	0.5
Magnesium	%	0.5	0.6	0.5
Copper	mg/kg	36	61	46
Manganese	mg/kg	370	440	413
Iron	mg/kg	690	1300	1008
Zinc	mg/kg	330	470	405
Molybdenum	mg/kg	3	7	5
Boron	mg/kg	<0.01	9	5
Sodium	%	0.2	0.8	0.4
Arsenic	mg/kg	<1	1	1
Cadmium	mg/kg			<1
Chromium	mg/kg	4	15	9
Nickel	mg/kg	5	12	8
Lead	mg/kg	1	3	2

Samples – n = 4

Table 7 presents manure analyses for caged layer hens housed in high rise sheds where manure is stored beneath the shed for the total period of time the batch is housed for (typically about 60 weeks). Samples were collected from within the sheds and represent a variation in the age of manure from approximately 20 – 50 weeks. Older manure will tend to have lower amounts of carbon and nitrogen because of the biological breakdown of the manure.

Table 7 –Manure Analysis Results from High Rise Caged Layer Hen Systems

Parameter	Units	Range		Average
Moisture	%	31.0	66.9	53.4
pH - Water		6.1	7.6	6.7
Electrical Conductivity	dS/m	10.3	18.0	15.5
Organic Carbon	%	25.6	40.0	32.3
Nitrogen	%	3.4	5.9	5.0
Ammonium Nitrogen	mg/kg	1713	13400	5446
Nitrate-N	mg/kg	<200	486	272
Phosphorus	%	2.1	3.7	2.9
Ortho-phosphorus	mg/kg	3293	11358	5986
Potassium	%	1.7	3.8	2.6
Calcium	%	7.0	15.1	11.6
Sulphur	%	0.5	0.8	0.7
Magnesium	%	0.5	0.9	0.7
Copper	mg/kg	31	82	57
Manganese	mg/kg	450	520	490
Iron	mg/kg	680	2500	1463
Zinc	mg/kg	280	540	433
Molybdenum	mg/kg	2	6.4	5
Boron	mg/kg	6	34	17
Sodium	%	0.3	0.6	0.4
Arsenic	mg/kg	<1	1	1
Cadmium	mg/kg			<1
Chromium	mg/kg	4	9	6
Nickel	mg/kg	5	9	7
Lead	mg/kg	1	2	1

Samples – n = 4

Table 8 presents manure analyses for layer hens from all caged housing systems. This provides a benchmark for all manure management systems and captures the maximum variation in the results.

Table 8 – Averaged Manure Analysis Results for All Caged Layer Hen Systems

Parameter	Units	Range		Average
Moisture	%	31.0	73.7	57.6
pH - Water		5.7	7.6	6.4
Electrical Conductivity	dS/m	4.8	18.0	13.4
Organic Carbon	%	25.6	40.7	35.6
Nitrogen	%	3.4	7.5	5.6
Ammonium Nitrogen	mg/kg	91	17780	6220
Nitrate-N	mg/kg	<200	486	222
Phosphorus	%	1.1	3.7	2.5
Ortho-phosphorus	mg/kg	594	11358	4115
Potassium	%	1.6	3.8	2.1
Calcium	%	7.0	15.9	11.3
Sulphur	%	0.4	0.8	0.5
Magnesium	%	0.5	0.9	0.6
Copper	mg/kg	31	82	54
Manganese	mg/kg	320	520	443
Iron	mg/kg	430	2500	1170
Zinc	mg/kg	280	540	411
Molybdenum	mg/kg	2	7.9	5
Boron	mg/kg	<0.01	34	13
Sodium	%	0.2	0.8	0.4
Arsenic	mg/kg	<1	1	1
Cadmium	mg/kg			<1
Chromium	mg/kg	4	15	7
Nickel	mg/kg	5	12	7
Lead	mg/kg	1	6	2

Samples – n = 13

Table 9 presents spent litter analyses for free range and barn layer hens. Most samples were collected from the shed floor or from an outdoor stockpile after removal from the shed. The samples ranged from 20 – 100 weeks in age.

Table 9 – Analysis Results for Free Range and Barn Layer Hen Spent Litter

Parameter	Units	Range		Average
Moisture	%	10.7	33.5	20.8
pH - Water		6.1	7.6	6.9
Electrical Conductivity	dS/m	7.2	11.9	9.5
Organic Carbon	%	26.8	37.8	32.3
Nitrogen	%	1.9	3.9	2.7
Ammonium Nitrogen	mg/kg	322	3827	1941
Nitrate-N	mg/kg	<200	1312	384
Phosphorus	%	1.0	2.4	1.6
Ortho-phosphorus	mg/kg	933	3100	2052
Potassium	%	0.8	1.7	1.5
Calcium	%	8.0	14.0	10.6
Sulphur	%	0.3	0.7	0.5
Magnesium	%	0.4	1.2	0.6
Copper	mg/kg	23	47	38
Manganese	mg/kg	230	410	347
Iron	mg/kg	1200	8700	3514
Zinc	mg/kg	170	370	288
Molybdenum	mg/kg	2	14	5
Boron	mg/kg	<0.01	19	8
Sodium	%	0.2	0.7	0.5
Arsenic	mg/kg	<1	3	2
Cadmium	mg/kg			<1
Chromium	mg/kg	15	158	44
Nickel	mg/kg	8	53	19
Lead	mg/kg	1	5	2

Samples – n = 7

3.2. Agronomic Properties of Layer Hen Manure

Layer Hen Manure – Caged Systems

Nitrogen is a valuable plant nutrient required in large quantities by crops and pastures. High nitrogen levels have traditionally been a highly valued attribute of poultry layer manure.

Nitrogen levels in caged layer manure may vary depending on diet and manure handling conditions. Within the 13 samples collected from across Australia and from a range of management systems (belt manure removal with/without drying, high rise) nitrogen varied from 3.4 – 7.5% with an average of 5.6%. This is a similar range to Australian data from the literature, as presented (Table 1) and is a higher than the average value of 4.6% reported in the Environmental Code of Practice for Poultry farms in Western Australia (Table 1 – Department of Environment 2004). This increase is most likely to be in response to the shift to belt manure removal systems which corresponds to fresh manure (generally less than 7 days removal cycle) and higher moisture levels compared to older style high rise sheds.

Nitrogen in poultry manure is primarily excreted in the form of uric acid, which is rapidly converted to ammonia (NH_3) and released as a gas. Within poultry manure, ammonia accumulates rapidly after excretion and remains in the liquid fraction of the manure in the ammonium ion form, NH_4^+. As manure dries under the influence of ambient conditions (such as in some high rise and litter based systems) or through fan drying, nitrogen is lost from the manure. This is the likely cause of lower nitrogen levels in high rise and belt drying systems, though the differences are only slight. It is notable that the lowest nitrogen level in the belt drying system is also the driest manure sample (32.4% moisture). This shed runs drying fans for approximately 20 hours per day. No diet effect could be established with respect to nitrogen levels.

Phosphorus is a highly valuable component of poultry layer manure which can contribute the greatest dollar value to manure because of the high price of comparative phosphorus fertilisers. Phosphorus levels measured across the 13 caged manure samples range from 1.1 – 3.7%, averaging 2.5%. This is higher than the previously reported level of 2% (see Table 1). The lowest level recorded for phosphorus (1.1%) was from caged hens in a belt manure removal system fed a vegetarian diet, however on discussion with the manager of this facility no further explanation could be given to explain this low value. The higher levels recorded (above 3%) were from high rise systems with long manure residence times. The likely driver of these higher levels is the breakdown of manure under the sheds which result in concentration of conservative elements such as phosphorus.

Potassium levels in poultry layer manure range from 1.6 – 3.8%, averaging 2.1% (see Table 8). This is the same as levels previously reported (see Table 1). Potassium is a highly valuable nutrient required in high quantities by crops and pastures, particularly for hay or vegetable production where high amounts of potassium are removed (in leaf and stems) from fields annually.

Other nutrients of value in caged poultry layer manure include calcium (which averages above 11%), sulphur (0.5%) and a range of micro nutrients. When layer manure is applied at rates suitable to meet crop phosphorus requirements, the supply of micro nutrients will often be sufficient to overcome minor soil deficiencies and this is a valuable property of layer manure.

Free Range and Barn Layer Hen Spent Litter

Seven spent litter samples were collected from 4 free range and 3 barn systems throughout Australia. Free range and barn layer hen manure is deposited in sheds spread with a litter substrate (commonly sawdust, straw or rice hulls). The litter is typically left in the sheds for over 12 months depending on the length of the laying cycle of the hens.

The combination of the dilution effect of the added substrate and long residence times tends to lead to lower nutrient levels in the spent litter samples, as shown when comparing Table 8 and Table 9.

Nitrogen levels in the spent litter samples ranged from 1.9 – 3.9% with an average of 2.7% (Table 9). This is lower than the average level of 4.1% reported in Table 1. Collected spent litter samples ranged from 30 to 100 weeks old, which may have contributed to the low nitrogen levels reported. These levels are similar to those reported for meat chickens on litter (Griffiths 2004 – see Table 2).

Phosphorus levels in spent litter range from 1 – 2.4% with an average of 1.6%, which is slightly higher than the level reported previously (see Table 1). This level of phosphorus is relatively similar to those measured in meat chicken litter (Griffiths 2004).

Potassium levels in spent litter range from 0.8 – 1.7%, averaging 1.5%. This is lower than the level previously reported in Table 1. Spent litter from free range and barn systems is a valuable source of potassium, though levels tend to show the effects of dilution with the litter substrate.

Other nutrients of value in spent poultry layer litter include calcium (average 10.6%), sulphur (0.5%) and a range of trace elements. The high levels of calcium are one valuable difference between spent litter from poultry layer hens compared to meat chickens or other animals such as pigs.

3.3. Handling Properties of Layer Hen Manure

Layer Hen Manure – Caged Systems

Caged layer manure samples tend to be higher in moisture (averaging 57.6% - Table 8) compared to previously reported levels (Table 1). Generally this is related to the changes to shed designs from high rise to belt systems with more frequent manure removal. Several belt manure removal systems recorded moisture levels in the order of 70%, which makes handling of the manure difficult and increases cartage costs because of the high volume of water moved with the manure.

The range in moisture levels reported from the 13 samples was 31 – 73.7%, with the lowest levels reported from high rise cage systems and (1) belt system where drying fans were run constantly for 20 hours / day. Several sheds fitted with drying fans still showed relatively high moisture levels in manure (60-69.7%) where fans were run for less than 9 hours per day.

This trend to higher moisture levels reduces the handling and transport options for poultry layer manure and will have a negative effect on sale value. Considering this, research into the cost and effectiveness of manure drying and the frequency of belt emptying may improve the handling of manure significantly if this can be shown to be cost effective.

Because of the high moisture levels recorded in many samples, poultry layer manure from caged systems tends to have a high mass to volume ratio of up to 1 tonne per m^3 as estimated by poultry producers. The dry matter content is approximately 350 kg / m^3, with moisture adding the additional mass. This compares to 550 kg / m^3 previously reported (Table 1). Manure is typically sold on a 'per m^3' basis, consequently the dry mass is very important for accurately calculating the nutrient content and subsequent value of the manure. Few poultry farms surveyed had accurate mass to volume data available, therefore the figure presented above can only be considered approximate. Further measurements are recommended to assess the true dry matter mass to volume ratio.

Free Range and Barn Layer Hen Spent Litter

Free range and barn layer spent litter has significantly lower moisture levels (average = 20.8% - Table 9) compared to caged layer systems. This average is slightly lower than previously reported (25% see Table 1).

The lower moisture levels in spent litter improve the value of this product from the perspective of handling and transport.

3.4. Carbon Content in Layer Hen Manure

Layer Hen Manure – Caged

Carbon is a valuable soil additive and is a potential energy component in layer hen manure from caged and litter based systems. Carbon is the largest component of manure from caged systems after moisture. Carbon from in manure from caged systems is made up of undigested components of the diet. Average carbon levels in caged layer manure measured 35.6% which is higher than previously reported (29% - see Table 1). Carbon levels tended to be higher from fresh manure collected from belt systems (38%) compared to high rise sheds (32.3%). The lowest level of carbon was reported from a high rise shed (25.6%) where manure had been stored beneath the shed for an estimated 80 weeks. In this time a significant amount of carbon will be lost to the atmosphere as carbon dioxide and methane gases.

The carbon proportion of the manure is a valuable soil additive. Carbon builds soil health by improving soil structure and improving the biological activity of soil through providing an additional substrate for soil biota. This is an important property of layer manure and can be seen as a valuable agronomic component.

More recently, residual carbon in layer manure has been identified as a potential energy source. In layer manure, this carbon could be accessed for gas or electricity production through bio-digestion or other processes to offset farm electricity and gas requirements. Considering the higher carbon levels observed in fresh manure samples from belt systems and the high moisture levels in these samples, bio-digestion offers potential as a technique for processing manure. In addition to digestion, nutrient extraction techniques can be explored which may allow valuable nutrients to be recovered and sold as more traditional chemical fertilisers.

Free Range and Barn Layer Hen Spent Litter

Spent litter tends to have slightly lower carbon levels than fresh caged manure. This is primarily related to the long residence times of manure and litter within sheds which allows for significant levels of carbon breakdown into carbon dioxide and potentially methane. Carbon present in litter samples will also comprise carbon from the litter substrate which may be more resistant to breakdown when applied to soil. This is a valuable agronomic component to spent litter. Spent litter may also be used as a substrate for energy production as discussed above.

3.5. Potential Contaminants in Layer Hen Manure

Layer Hen Manure – Caged Systems and Spent Litter

Low levels of salt, heavy metal and arsenic contamination were observed in the 20 poultry layer manure and litter samples collected. In all samples, the reported levels are below the thresholds reported in Table 3. It should be noted, however, that lower thresholds may be required for some crops that are susceptible to heavy metal accumulation, particularly leafy vegetables grown for human consumption. Further guidelines for horticultural crops should be reviewed prior to use of poultry layer manure and sampling of each manure batch should be undertaken.

Sodium is a potentially detrimental element when applied to agricultural soils in large quantities. Sodium levels measured in the 20 poultry manure and litter samples ranged from 0.2 – 0.8% and averaged 0.4-0.5%. There are no threshold levels for sodium, however, based on recommended application rates for poultry layer manure or litter (less than 10 m^3/ha/yr), these levels are not expected to be of concern.

Potential contaminants include two metals that are required by plants in small quantities for normal growth, these are zinc and copper. Zinc and copper levels in poultry layer manure and litter are well below the levels indicated in Table 3 of 2500 – 3500 mg/kg for zinc and 2000 – 2500 mg/kg for copper. The highest recorded zinc level in all samples was 540 mg/kg, while the highest level of copper was 82 mg/kg.

Arsenic levels measured in the 20 samples were lower than manure analyses previously reported in Table 1. No sample measured higher than 1 mg/kg and the majority of samples were below the detectable limit. This is well below the lowest threshold (30 mg/kg) reported by the NSW EPA (1997).

Likewise, measured cadmium levels in all manure and litter samples were below the detectable limit. Chromium levels ranged from 4 – 158 mg/kg in all samples, with all but one sample being below 40 mg/kg which is well below the NRMMC (2004) thresholds of 500-3000 mg/kg.

Lead contamination was low, with the highest sample measuring 6 mg/kg which is well below the threshold (420 mg/kg) as reported in Table 3. Nickel contamination was low, with levels ranging up to 53 mg/kg. Most levels were less than 15 mg/kg however. The NRMMC (2004) threshold for nickel is 270 mg/kg.

4. Conclusions

Poultry layer manure and litter composition data are essential for accurately determining sustainable application rates of manure to crops and pastures. Concentration of major plant nutrients and manure properties such as moisture levels will also determine the usability and sale value of manure and litter.

This study collected some 20 samples of manure and litter from 5 different layer production systems from all major production regions in Australia. Compared to data previously reported for Australian layer manure and litter, there are several trends that can be observed which are likely to be the result of new management systems (belt manure removal) which produce manure with significantly shorter in-shed residence times compared to high rise sheds.

Nutrient levels in layer manure from caged systems are notably higher for nitrogen, phosphorus and calcium, as is moisture. Dietary effects may be contributing to these changes, however no diet data were available from previously published data for comparison.

Higher nitrogen levels are likely to be the result of lower residency times for manure in sheds and higher manure moisture content. It is not known if other affects such as diet have contributed to this. Nitrogen levels in poultry layer spent litter were 1.4% lower than previously reported and are similar to levels reported for meat chickens.

Phosphorus levels for layer manure from caged systems tend to be 0.5% higher than previously reported. However, the range in phosphorus levels is quite high (1.1 - 3.7%) which will have a significant effect on the ideal application rate and potential value of layer manure. Phosphorus levels in spent litter (average 1.6%) tend to be lower than caged layer manure as a result of the dilution of manure with the litter substrate. This is slightly higher than previously reported.

Potassium levels in layer manure from caged systems (average 2.1%) indicate a significant resource value from this nutrient which should not be overlooked. This is the same as previously reported. Potassium levels in spent litter averaged 1.5%.

Significant levels of other valuable nutrients, notably calcium (average 11.3% for layer manure from caged systems), sulphur and a range of micro nutrients are also present in poultry layer manure and litter.

The handling characteristics of layer manure are primarily determined by moisture content. Moisture levels in caged layer manure samples tend to be approximately 25 – 35% higher than previously reported, with several systems producing manure with more than 70% moisture. This manure is typically from belt manure removal systems without drying fans. This trend towards higher moisture levels has decreased the handling characteristics of layer manure and is likely to decrease the maximum transport distance that manure can be hauled. High moisture manures also pose spreading problems and are best handled through traditional 'muck spreaders'. These spreaders are generally less able to apply manure at low levels with accuracy.

One manure sample from a belt system with drying fans run for 20 hours / day showed moisture levels of 32.4%, suggesting that manure from these systems can be dried substantially to improve handling characteristics. Moisture levels in spent litter are relatively low (average 20.8%) which will contribute to ideal handling characteristics.

A range of contaminants were analysed including heavy metals, salt (sodium) and arsenic. All levels were well below thresholds reported by the NRMMC (2004), NSW EPA (1997) and VIC EPA

(2004). Arsenic levels were well below that previously observed, averaging only 1 mg/kg across all samples.

For belt manure removal systems, it is recommended that a small scale project is established to investigate the cost benefit of manure drying systems and the optimum fan run times to dry manure to below 40%. This would result in a significantly improved product (better handing properties, spreading properties and longer possible haulage distances) which should all improve the dollar value of manure.

Considering the high carbon, moisture and nutrient levels present in poultry layer manure from newer caged systems with belt removal, further investigation into manure processing (such as bio-digestion) should be pursued. This could result in significant energy production and nutrient recovery for larger enterprises and may represent the best manure handling option, particularly for high moisture manure.

Considering the range in nutrient concentration across different shed management systems, egg producers are encouraged to take annual analyses of manure to develop a dataset for their own system. This will inform sustainable application rates and determine the best sale value for the manure or litter.

5. References

Department of Environment 2004, *Environmental Code of Practice for Poultry Farms in Western Australia*, Department of Environment, Perth, Western Australia.

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

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

NSW EPA 1997, Environmental Guidelines for Use and Disposal of Biosolid Products, Department of Environment and Conservation, Sydney NSW.

VIC EPA 2004, Guidelines for Environmental Management-Biosolids Land Application, EPA, Southbank, VIC.

Appendix 1 – Questionnaire

Manure Collection Questionnaire - Please answer all questions relevant to your management system.

1- What is the approximate age of hens where the manure was collected?

___

2- Where did you collect the manure samples from (i.e. In the shed? Outdoor pile?)

___

We would like to work out the bulk density of manure, can you provide the following information:

3- The volume and mass of manure per truck load (you could calculate this by weighing truck loads over a weighbridge and recording the volume of the truck in m3)

___

4- Do you know the mass and/or volume of manure produced per 1,000 hens / year

___

5- For barn systems, what is the litter substrate? How much did you add to the shed (in m3)?

___

6- Please state your shed manure system (i.e. belt, high rise, barn with litter):

___

7- For manure belt systems, do you have a manure drying system?

___

8- If you have manure drying, how often do you run the fans?

___

9- If you have a belt, how often do you empty the belt (what is the frequency of removal from the shed)?

___

10- Is your diet base wheat, barley, sorghum, other (please state)?

___

Appendix 2 – Sampling Procedure

Manure Sample Step-by-Step Procedure

Equipment required: gloves, a shovel or hand trowel, a clean bucket, two zip–lock bags and a cooler with ice (for storing and transporting the sample).

The sampling procedure is as follows:

1. Label the zip-lock bag with permanent marker, including property name, date, sample type and a description of where the sample was taken from, i.e. 'layer shed no. 1'.

2. Using gloves, sample manure after it is removed from the shed (if possible*). We would like fresh manure, similar to what is available for utilisation. Shed cleanout will help mix the manure / litter making it easier to get a representative sample.

3. Collect approximately 25 sub-samples from throughout the pile with the shovel and mix these in the bucket.

4. After the sub-samples are mixed together, collect the final sample (about 1kg) and place in the labelled, zip-lock bag. Place a second bag over this for protection and seal carefully.

5. Place the bagged sample in the disposable cooler with ice packs for transportation. Tape cooler closed.

6. If the sample is to be stored for more than 48hrs, it should be refrigerated or frozen.

7. Contact AECL to arrange a courier for your manure sample

8. Complete the survey and fax or post to FSA Consulting

* If sampling must be done within a shed (i.e. in a barn laid system prior to clean out) it is necessary to collect a large number of sub-samples (30-40) throughout the shed, covering areas with high and low amounts of manure coverage to get a representative sample. These samples should include surface and sub-surface litter. Sampling should be done as close as possible to the end of the cycle to be representative of the spent litter that will be available for utilisation.

Appendix 3 – Laboratory Results