

Investigation into the Sludge Produced by a Slurry dewatering Project for the Use as a Fertiliser – Containing Moisture and Nutrient Analysis

by Thomas Edds

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Investigation into the Sludge Produced by a Slurry dewatering Project for the Use as a Fertiliser – Containing Moisture and Nutrient Analysis

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Abstract

The intensification of agriculture has been identified as one of the biggest contributors to pollution of water courses. Therefore, there has been growing research into environmental impacts of agriculture and how the impacts can be reduced. The dairy industry produces slurry as a by-product of production as dairy cows are housed in a barn during winter months. If this slurry was allowed to run straight into the water course would cause major pollution problems such as eutrophication. Therefore, there are regulations in place to mitigate this problem and they are outlined in this report. Coleg Sir Gar Farm have been working on a dewatering project for the slurry produce on their dairy farm. The processes involved in the dewatering project are explained in this report. The project produces a sludge which is the focus of study in the project. The slurry is analysed for moisture content and nutrient levels to assess if it suited for use as a fertiliser. This research indicated that the sludge produce could benefit from composting to produce a more viable fertiliser product. The process involved in composting and biological activity that take place is explained in this report.

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1 Aims and Objectives

This project aims to investigate the product produce by the Power and Water/Coleg Sir Gar dewatering project which is currently been undertaking on a west wales farm. The existing project processes slurry from the dairy farm that houses 500 cows to produce clean water and a dry sludge or manure type product. The objective of this project is to understand the current dewatering process and operation, the current directives driving the dewatering project, the environmental impacts currently faced within agriculture and to look at the manure type product (Dried Sludge) produce by the process as the use as fertiliser.

The dried sludge has the potential to be used as fertiliser, to understand the potential better this project aims to investigate the moisture content, nitrogen, phosphorous, potassium levels and investigate how the product could be processed to produce an organic fertiliser product. This product could help pay back some of the ever-rising costs and reduce the environmental impacts of agriculture.

2 Timing Plan

Moisture Analysing -January 23rd till February 27th

Nitrogen Testing – February 23th till February 27th

Potassium Testing – February 27th till March 27th

Phosphorous Testing - February 27th till March 27th

3 Research

College Sir Gar's farm is situated 3 miles outside of Llandeilo and 14 miles from Carmarthen town centre and is the home of the Agriculture Research centre. The farm has 500 milking cows that are split into two herds for different herd management strategies. The herds are kept in the barn during winter months and the slurry produced from this procedure needs to be collected and managed correctly to coincide with the nitrate directive discuss further in this document. A typical dairy cow produces around 40kg of manure for 450kg of live weight per day (David B, 1998), after a discussion with the site manager at the farm the average weight of the cows on the farm is around 600kg. So, from the average amount of manure produces on the farm can be calculated (equation 1).

$$\left(\frac{40}{450}\right) * 600 * 500 = 26666.3kg \text{ of manure per day}$$

Equation 1 - Average Manure Produce Per Day Calculation

3.1 Water Pressures, Problems and Challenges

Water is inherently linked to this project it may be seen as the fundamental driving factor that has led to this research being carried out after all it is the current arising water problems that drove the dewatering project which then lead on to this project, but what are these current problems?

The pressure is forever growing on the demand for clean water, the population is continuing to rise which in turn increases pressure on supply. Alongside this growth, water courses are being closely monitored regarding pollution, regulations and control methods have or are going to be introduced. Climate change also provides a long-term pressure, with the global hydrological cycle expected to intensify bringing more floods and droughts on average, and the contrast between wet and dry places as well as seasonal changes expected to increase.

Over the recent decades problem has grown on the agriculture regarding water. There has been more control enforced regarding effluent from industry and human settlements, and there's been an intensification of agriculture which coincides with population growth. This has resulted in the identification of agriculture as now one of the greatest contributors to water pollution.

Agriculture impacts water quality through the release of nutrients (nitrogen and phosphate) this can be through soil management and incorrect fertiliser application for example over dosing, there is a chance of chemical pollution from the application of pesticides and biological contamination from microbiological organisms in manure. The farmland soil also erodes away into water courses which impacts water quality. Within the UK around 60% of

the nitrates and 25% of the phosphorous in water bodies are expected to have agricultural related origins. When looking at the sediment polluted water bodies around 75% of the sediment is suspected to have derived from farming origins. The impact of these pollutants has led to around on average 50% of the UK's water bodies not meeting good ecological standards (Holden, 2017).

Now what's the challenge? Within agriculture, pollution can occur from what is known as point source - which is source that be easily identifiable like a leaking slurry store, or it can occur diffusely from run off from fields. Diffused pollution is often difficult to isolate and can be from several contributors from different farms within an area. The pollution does not always occur locally, as the contaminants can run down stream causing other areas to be affected. There is also the possible impact of climate change which could alter run off path ways, flow volumes and the transfer of pollutants. Considering this, farmers need to introduce better water impact management systems and gain more understanding of how they are affecting the water courses. With the likelihood that agriculture will continue to intensively the challenge is to improve production while reducing environmental impacts (Holden, 2017).

3.2 Nitrate Directive

The Nitrate directive was set up in 1991 to help protect surfaces waters, ground water, coastal waters and estuaries from pollution by nitrates of agricultural origin with aim to mitigate against the problem of eutrophication and lessen the concentration of nitrogen within both surface and ground waters. This legalisation required member state to:

- Analyse and Monitor nitrate levels and trends in surface and ground water
- Implement good agricultural practice through the code of practice, this also includes the application of fertiliser, manure and sewage sludges.
- Identify and designate Nitrate vulnerable zones (NVZs) these are waters which contain levels of nitrates (NO^3) exceeding 50mg/l an action plan must be introduce in these zones aiming to reduce the input of pollution from both point source and diffuse source (Gray, 2005).

The standards set out in this directive are not mandatory but there are other legislation in place such as the Surface Water Directive and the Drinking Water Directive which set the standard of 50mg/l of NO^3 in 95% of samples (Gray, 2005) therefore this directive follows them same standards.

On land within an NVZ farms must compile with:

The Nitrate prevention Wales Regulations of 2013

The Water Resources (control of pollution) (Silage Slurry and Agricultural Fuel Oil) (Wales) Regulations 2010 (SSAFO) which relates to the storage of silage and slurry. Some of the regulations are summarised below.

1. Record Keeping

Farmers must keep complete all record for 5 years and have them available for inspection on the following (NVZ Guidance and Workbook):

- Calculation showing existing manure storage capacity
 - The area of the holding
 - Number of Livestock and time spent on the holding during the previous calendar year
 - Calculation of Nitrogen produce by livestock during the Previous calendar year
 - Date, Quantities, details of recipients of any livestock manure transport in or off the farm
 - Dates when field sites are used for poultry and solid manure and the location.
 - Nitrogen Fertiliser plan, showing soil nitrogen supply, estimated month of month planting, crop nitrogen requirement, nitrogen supply from manure and nitrogen fertiliser required
 - Record of yields and grassland management
 - Field records of Nitrogen fertiliser spreading
 - Risk map of holding if spreading manure
 - Livestock storage period, the number and type of livestock in building or hard standing
2. Make sure nitrogen application rate does not exceed the crops N max
3. Limit the rate of application of organic manure to 250kg of nitrogen per hectare per year.
4. Limit the organic manure applied to land to 170kg of total nitrogen per hectare per year
5. Apply Nitrogen fertiliser as accurately as possible
6. Slurry must be spread at a low trajectory and if continues application no more than 2ml per hour.
7. Slurry must be incorporated into soil within 24hrs
8. Farmer must provide efficient storage for slurry produced for the following periods
- 1 October to 1 April (6 month) for pigs and poultry
 - 1 October to 1 March (5 months) for other livestock
9. Manure must be stored either:
- In a vessel

- On an impermeable surface
- In a roofed building or
- In an appropriate temporary field heap

3.2.1 Eutrophication

Eutrophication is the name given to areas of water whereby there is an abundance of growth factors such as nutrients, sun light or carbon dioxide which cause rapid alga or plant growth, this rapid growth can lead to water be uninhabitable for other species. Although eutrophication occurs naturally over time, human activities have played a part in acceleration and the extent of the problem. Through point and diffuse source discharge of nutrients such as nitrogen and phosphorus into water courses known as Cultural Eutrophication this can have a dramatic effect on drinking water, Recreational water and fishes. Eutrophication can also be used as a tool to improve productivity and increase density of important fishes (Chislock, Doster, Zitomer, & Wilson, 2013).

When eutrophication occurs in salt water bodies is usually down to an overloading of Nitrates and within fresh water bodies eutrophication is generally caused by phosphorus overloading. Severe algae blooms that occur due to eutrophication can lead to toxic conditions. As the plants or algae die and decompose the water becomes anoxic due to the decomposing organic matter using up the oxygen, this leads to the wildlife within the water body dying or leaving the affected areas. This causing an unbalance within the eco system which will lead to the water being unusable for recreational and other activities and tends to lead to the water not being fit for human consumption (European Environment Agency, 2000).

3.3 Slurry Dewatering and Purification Process

The statistics over last six years from National Resources Wales have shown that between 85 and 120 pollution incidents per year have been caused by Welsh dairy or beef farms with suspected 60% of them from dairy farms. Alongside these incidents, there has been a downturn in dairy industry which has led to less funds being available to meet the stringent slurry/silage storage needs. Power and Water (P&W) Wales have been working in collaboration with the Sir Caron 'Prosiectsllyri Project' with an aim to produce an economically and environmentally viable slurry management system to help address the issues with agriculture impact of the environment. The project was hoping to improve slurry management by providing an alternative to traditional slurry management and to reduce air and water pollution but also creating a source of water cleaning enough for reuse or safe discharge. The solution produced by the project applied P&W's Sonoco sono-

electrocoagulation technology alongside an advanced oxidation process (AOP). The project can destruct and remove pathogens and high levels of recalcitrant organics (Organics resistant to decomposition) which resulting in water clean enough to be reused on the farm or discharged into the watercourse. During this process most of the water content is removed from the slurry which makes it easier to store, manage and spread back onto the land (Power and Water, 2017).

The layout and process of the project can be seen in figure 1. The slurry is feed from the storage facility into the centrifuge - this is where most of the solids of extracted, the remaining effluent then passes through to the sono-electrocoagulation primary treatment unit - where the remaining solid are separated and finally through the oxidation secondary treatment unit to produce clean water. The dry sludge produce by this process contains the nutrients that have the potential as a fertiliser.

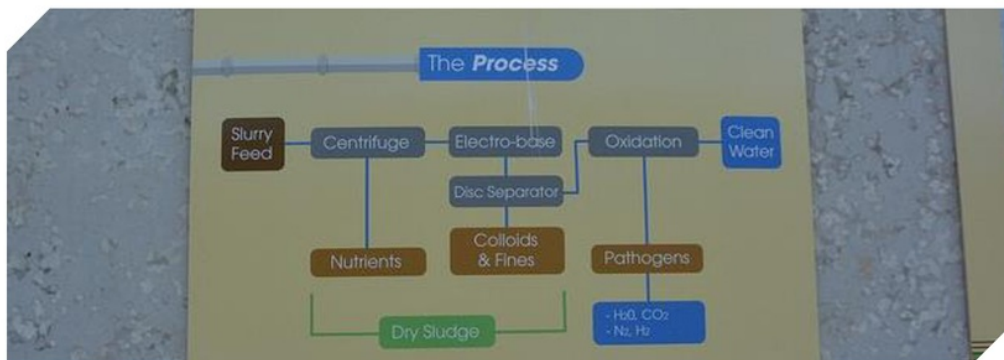


Figure 1 - Slurry Dewatering and Purification Process

3.3.1 Separator

The project has used two types of separator units used to remove most of the solids from the slurry, a centrifuge separator and a screw press. Centrifuge separators work through sedimentation and centrifugal force. In a conventional unit the slurry is fed through a stationary tube along a centre line of a rotating screw conveyor, which is installed inside a conical bowl. The conical bowl rotates around at a slightly greater speed than the screw. The slurry leaves the end of the feed tube, accelerated and distributed to the purify of the bowl. The solids settle through the liquid via centrifugal force and are conveyed up the screw conveyor to the beach end. While the liquid is discharged over wires on the other end. The process can be seen in figure 2.

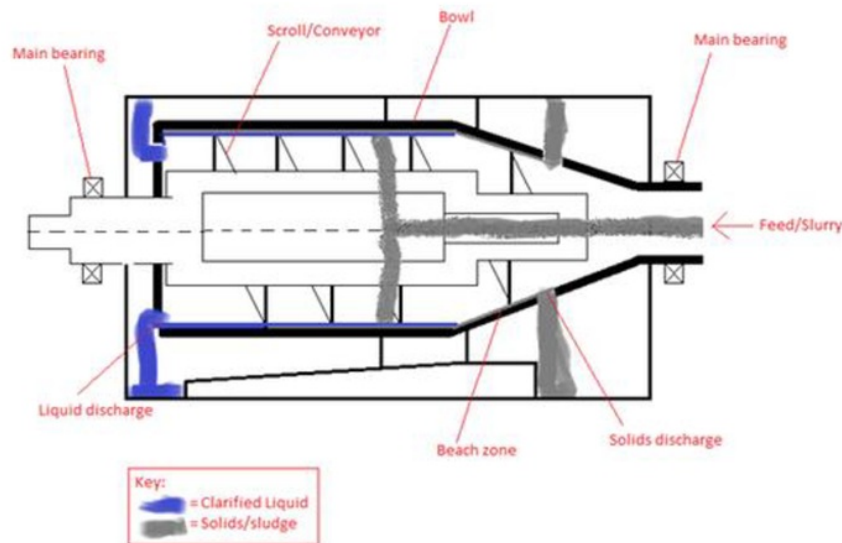


Figure 2 - Centrifuge Separator

3.3.2 Sono-Electrocoagulation

One of the major issues the world is facing is the need to for clean water, even more so for the third world countries. There a wide range of treatments known, biological process like nitrification, denitrification and phosphorus removal and physical chemical processes such as filtration, air stripping, ion exchange and reverse osmosis.

In recent years there has been a development in electrochemical processes in which there is no need for the addition of chemicals. They include electrocoagulation, electro filtration and electrodecantation. It is the process of electrocoagulation that has been utilised as the primary treatment in the Power and Water slurry dewatering project.

Coagulation is the process where particles in colloidal suspension are neutralise by mutual collision with counter ions, to form flocs and then can be separated via filtration and /or flotation. It is accepted that coagulation is achieved by a reduction in net surface charge of particles so when they come close enough the van der Waals forces hold them together. For this process to work a coagulant agent is required and is in the form of a chemical substance which can lead to pollution further downstream. Electrocoagulation (EC) does not require the addition of a coagulant agent instead the coagulant in applied by electrolytic oxidation of an appropriate anode material. The charged ionic species are then removed by reacting with the ions of an opposite charge or with flocs of metallic hydroxides within the wastewater. An electrocoagulation reactor is made up of an electrolytic cell consisting of parallel cathodes and anodes with conducting metal plates in between. When an external power supplied is applied, the anode will electrochemically corrode due to oxidation and the cathode will be

subjected to passivation. These conducting metal plates are known as 'sacrificial electrodes'. These sacrificial electrodes lower the potential for dissolution of the anode and passivation of the cathode (Mollah, Schennach, Parga, & Cooke, 2001) (Eyvaz, Kirlaroglu, Aktas, & Yuksel, 2009).

The advantages and disadvantages can be found below

Advantages:

1. Simple and Easy to use equipment
2. Provides palatable, clear, colourless and odourless water
3. Low sludge producing technique, sludge tends to be readily settleable
4. EC produces flocs similar to conventional coagulation except flocs tend to be larger, containing less water and are acid resistant leading to a more stable floc
5. Produce effluent with lower total dissolved solids (TDS) compared to chemical treatments, meaning lower cost water recovery.
6. EC can remove the smallest of colloidal particles
7. No chemicals are added, avoids the problem of over supplying coagulant agent which can lead to pollution further downstream of treatment.
8. Gas bubbles created and can be utilised to carry pollutants to top of the solution where they can be removed
9. Electronically controlled so fewer moving parts requiring maintenance
10. Could be run off solar power

Disadvantages

1. Sacrificial electrodes dissolve into solution and therefore require regular replacement
2. Electricity maybe expensive
3. Impermeable oxide film can be formed on cathode which leads to poor efficiency.
4. High conductivity of wastewater suspension is required
5. Gelatinous hydroxide may solubilize

3.3.3 Oxidation

In this secondary treatment unit, the method of purification is achieved through a similar process to the self-purification process that occurs naturally in our watercourses and often involves many of the same organisms. Hydrophobic organisms remove organic matter, the organic matter is broken down by biological oxidation and biosynthesis (Gray, 2005).

3.4 The Dry Sludge

The sludge produce by the dewatering project is a manure like product consisting of undigested cow feed and hay that can be stacked in the nearby shed. As the dewatering project uses two types of separator there are two types of dries sludge available with the potential to be used as a fertiliser. These sludge's have the potential to be processed into fertiliser pellet, to achieve this the moisture content and nutrient content need to be analysed. This section of the report investigates the nutrients available in the sludge and their relationship to plants, also this section contains information regarding composting of the sludge, its benefits and processes that should be employed in relation to government regulations.

3.4.1 Nutrients

Plant growth relies on at least 17 elements, called plant nutrients. These are split into 3 groups. The first of which contains carbon, oxygen and hydrogen and are the basic ingredient of all plants. They are responsible the product produced via photosynthesis, a simple sugar $C_6H_{12}O_6$. The carbon and oxygen come from carbon dioxide and the hydrogen from the water. Oxygen from the water is then given off by the plant to the atmosphere and is an essential supplier to the oxygen we need to breath. The second group known as macronutrients due to their relatively large usage by plants consist of nitrogen, phosphorus, potassium, sulphur, calcium and magnesium. The last groups known as micronutrients due to the relatively small usage by plants consist of iron, zinc, manganese, copper, boron, molybdenum, nickel and chlorine (Eash, Green, Razvi, & Bennet, 2008).

The role of these nutrients varies. Each nutrient play one or more parts in the plant's energy production and growth. For example Calcium, is used as calcium pectate and is used to build the plants stem walls, Phosphorous is thought to play a role in the transfer of energy throughout the plant system aided in growth and enzymes in plants have been found to contains iron and copper (Eash, Green, Razvi, & Bennet, 2008).

The first three of these element carbon, hydrogen and oxygen are supplied naturally to the plant by the carbon dioxide and the water. All the other elements are supplied through the soil, although some can also be taking up by the leaves. The nitrogen in soils would have originated from the earths atmosphere and makes up 78% of it. The nitrogen in the atmosphere is in a gas form that the plants cannot use. Therefore, it must go through a transformation to be made available to plants as Ammonium (NH_4^+) or Nitrate (NO_3^-) which is part of the nitrogen cycle. The nitrogen cycle consists of nitrogen fixation, Ammonification, Nitrification and Denitrification (figure 3). Nitrogen in soil is usually found in the form of organic matter, therefore it needs to undergo mineralisation to be made available for plants.

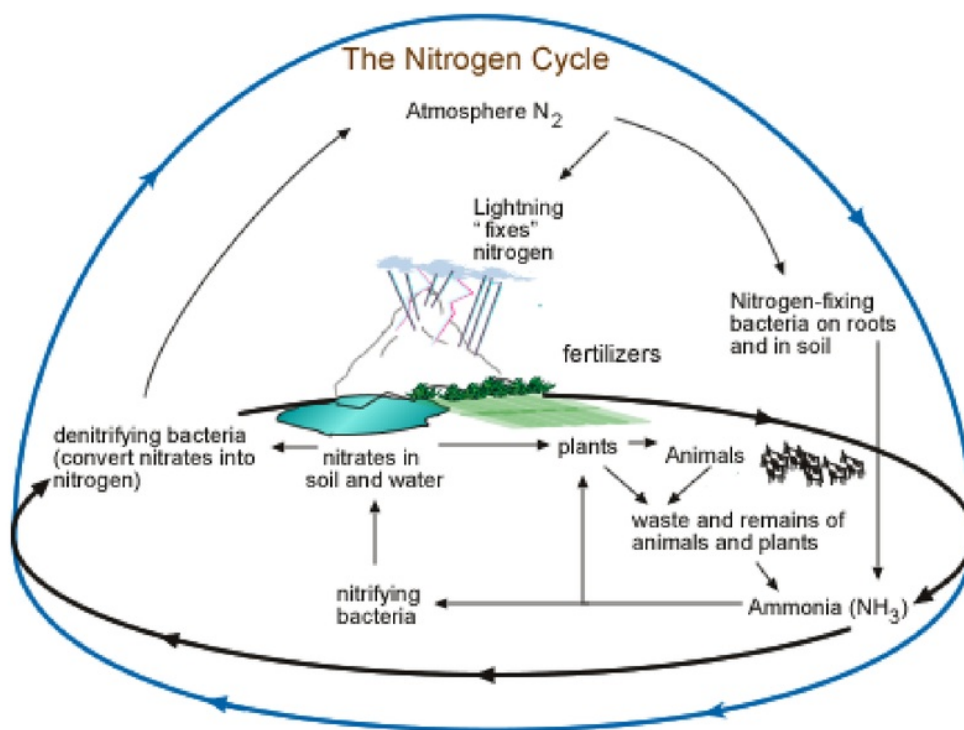


Figure 3 - The Nitrogen Cycle

The dried sludge is expected to contain the macronutrient's nitrogen, phosphorous and potassium. The most common element deficiency in agricultural soils for most crops is Nitrogen followed by phosphorus and then potassium. Sampling of soil is carried out on most farms to help determine the amount of additional nutrients that are required, depending on the crop they are producing. There are Nutrient management plans which involve sampling testing and adapting the soil by the application of different nutrients via chemical or organic fertilisers. These fertilisers would be supplied with a nutrient guarantee that is expressed usually in three numbers relating to Nitrogen, Phosphorus and Potassium (NPK). The number is displayed 20-10-15 which indicates the percentage of each nutrient. The first number represents the Nitrogen content, the second Phosphorous and the third potassium. These numbers are particularly useful to farmers to implement a successful nutrient management plan. These numbers are found on chemical fertilisers but there are organic fertilisers available that indicate NPK values.

3.4.2 Composting Process

The sludge could also be composted to produce a more viable fertiliser as the application of composted fertiliser to lands can greatly improve the most unproductive of lands. The essential nutrients Nitrogen, Phosphorus and Potassium are usually present in most organic wastes, are in complex organic form which are difficult for crops to uptake. Composting transforms these organic nutrients into inorganic form which are more suitable for crop uptake. And as inorganic nutrients are mostly in insoluble form this helps to stop loss of nutrients into the environment through leaching (Polprasery, 1996). Composted fertiliser can help mitigate against the growth of unwanted weeds in crops as weed seeds can remain in un-composted manure. This helps to reduce the need for herbicide or tillage need to control weed levels. Larney and Blackshaw (Larney & Blackshaw, 2003) carried out a study into the viability of seeds in composted livestock manure which show that after 42 days of composting the most difficult to kill weeds did not germinate. The composting process reduces volume and density by approximately 50% to 65%, this reduction in volume and density helps to reduce cost in handling and storage and also kills pathogens alive in the manure (Augustin & Rahman, 2010).

A typical composting procedure is the windrow method, this consist of piling the manure into piles of around 1.5m to 2.5m in height and space around the pile will need to be left to account for the turning methods. Turning needs to be carried out to aid in the distribution of temperature throughout the pile and to supply the oxygen to the bacteria required for a successful compost. Temperatures within a composting pile caused by biological activity can reach 55°C, it is at this temperature that pathogens are destroyed (Allance, 2014). The microorganism responsible for turning manure into compost require aerobic conditions for the reactions too take place. Anaerobic conditions can occur if turning is not regular enough which can lead to a rotten egg smell and slowing down the composting process (Augustin & Rahman, 2010). Turning can be carried out in relation to temperature. Temperature measurements should be taken at various location throughout the pile using temperature probes. High temperatures can impede the process by destroying the microbes needed for the aerobic digestion (Morse, 2001).

An inefficient carbon nitrogen ratio can cause excessive high temperature, this usually is caused by too much nitrogen. By adding a carbon source, the balance can be restored (Augustin & Rahman, 2010). The C/N ratio should be kept between 20:1 and 40:1 (Augustin & Rahman, 2010), the carbon content needs to be higher than that of the nitrogen content as the carbon is metabolised and released as carbon dioxide during the process. Too little carbon and nitrogen will be lost as ammonia (the rotten egg smell). Table 4-1 shows typical C/N ratios for some common composting materials taken from (Augustin & Rahman, 2010).

Table 3—1 – Typical C/N Ratios for Common Composting Materials

Material	C/N Ratio
Cattle Manure	19:1
Corn Stalk	68:1
Dairy Manure	20:1
Horse Manure	30:1
Wheat Straw	127:1
Wood Chips	600:1
Straw	80:1

Augustin also identifies how to calculate the required percentage of each materials to achieve the required C/N ratio using the Pearson Square method. Number 1 shows the typical C/N ratio for straw, number 2 shows the typical C/N ratio for beef manure, number 3 is the difference between the beef manure and straw ratios, number 4 is the required ratio of C/N, number 5 is the difference between the required ratio and the beef manure ratio divided by the dividing factor (number 3). Multiplying this number by 100 gives the percentage required of straw, number 6 shows the difference between the straw ratio and the required ratio divided by the dividing factor and again multiplied by 100 to get the percentage.

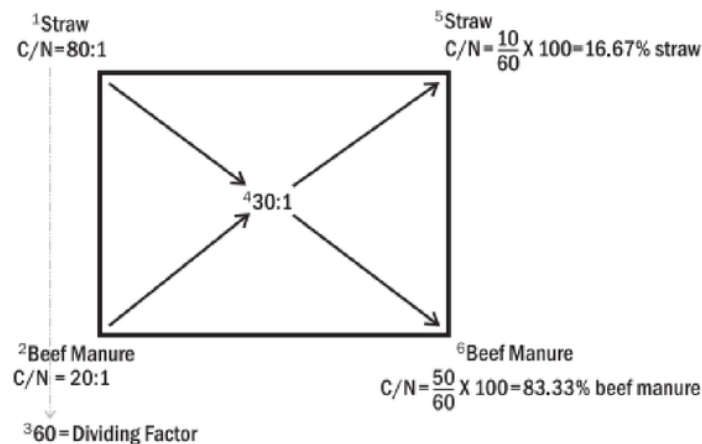


Figure 4 - Calculating C/N Ratio Using the Pearson Square Method.

This Pearson square method could be to optimise the composting process of the dry sludge produce from the dewatering project. The dry sludge already contains some straw or hay as

the sludge is collected from the cow's winter housing barn therefore the typically value of C/N ratio could be estimated using the above method and typical values.

3.4.2.1 Aeration

As mention in the previous section turning is essential to the composting process. The turning of the pile help incorporated oxygen, homogenizes and breaks ups solid masses. Also, by turning this allows the manure to achieve more contact time with the microbes required to compost. There are several methods of turning that have been produce the most commons methods are a windrow turner or a bucket tractor. There are self-propelled turners available that do not require power from another apparatus and turners that attach to tractors using the power from the tractor itself.

When producing compost, the selection the right turner is essential, this is helped by determining the amount of manure that is going to be composted. Bucket tractors or skid steers are good for a small operation or testing compost but for larger projects there maybe a requirement for turner implements. These tuning implements vary is sizes, they can range from 1.8m wide up to 6m feet wide. The larger the turner the more meters can be covered per hour, lower costs in the long run. The turning process is quite slow therefore the apparatuses that the turner maybe attached to need have a creeper gear. As the manure composts the turning becomes easier, there are turners available that are cable of cleaning the storage pen alongside turning the piles. This helps reduce time, space and money on removing the pile form the shed for turning (Augustin & Rahman, 2010).

3.4.2.2 Moisture Control

Water is an essential ingredient to the composting process, the biological activity that takes place in the compost pile is reliant on the moisture content present. Therefore, an optimum moisture level is important to the decomposition of organic wastes. A low moisture content can slow the biological process and too high a moisture content can cause leaching of nutrients and pathogen from the compost pile and in aerobic conditions water can block the air passage ways in the pile. Polprasery states that a moisture content between 50% and 70% is most suited for composting (Polprasery, 1996). This level should be maintained at different period of the process. The moisture content can be altered by the addition of buking materials or water. Ideally the moisture content should be controlled until the thermophilic period of the process in reach, this period is evident by a decrease in temperature and the appearance of second and third level consumers such as beetles and centipedes.

3.4.2.3 Regulations on composting

Composting sites in the United Kingdom need to be approved and regulated according to government guidelines. The site will need to be approve by the Animal and Plant Health

Agency (APHA) by completing the ABPR11 form. After applying through the ABPR11 form the site must be validated by APHA inspectors. The inspectors will visit the site to check machinery and set ups and to ensure the site operator understands how to control risks and how the site works. Plans need to be drawn up showing how the site works, following the government guidelines on how to run a composting site. The site will go through a validation period, during this period the site must provide samples of the compost that is being produced for testing. A sample must be taken from each batch produced or if using continuous composting method once a week. The samples must pass 12 consecutive tests for each bacterium before the site is validated. The site will be permitted to sell the first product from a batch by batch production site after 4 clear test results (Department for Environment, Food & Rural Affairs and Animal and Plant Health Agency, 2014).

The site must meet standards depending on what type of material is being composted. The compost that would be produced within this project would fall into Category 2 of animal by products (ABPs) and would need to meet British standards as opposed to EU standards for Category 3 ABPs.

Table 3—2 British Composting Standards for Category 2 ABPs

System	Minimum Temp	Minimum time at Minimum Temperature	Maximum Particle Size
Composting (Closed Reactor)	60°	2 Days	400mm
Biogas	57	5 Hours	50mm
Composting (Closed Reactor)	70	1 Hour	60mm
Composting (Housed Windrow)	60	8 Days	400mm

3.5 Similar Fertiliser Available

There a range of organic fertiliser available made from various base materials. Details on some of these fertilisers will be outlined in this section.



Figure 5 - 6x Organic Fertiliser Pellets

6x organic fibrous fertiliser seen in figure 5. This fertiliser is made from pelleted chicken manure, it is advertising as 100% natural fertiliser made from composted farm yard manure. The NPK value is provided with this product and stands 3-2.5-2 and is available is 15kg bags ranging in price from £15 to £20.



Marshall's organic extra soil supplement as seen in figure 6 is another soil supplement made from farm yard manure. There is no indication of NPK values with this product, but it is advertised as containing "essential trace elements". It is sold between £22 and £25 for a 4ltr sack which weighs in around 22kg. This product can also be soaked in water to ease application and a user manual is provided with the product.

3.6 Pelletising Process

Composts are sometimes pelleted to reduce volume, which aids in transport and storage of the product. Pelletising is densification of a product to produce a small dense pellet. The process is usually achieved through a pre-treatment of raw material such as drying, fed through a pellet machine which compresses raw material into a die, the pellets are extruded and then sent for further drying to harden the pellet. The pelletisation of compost has been successfully achieved and studies have been carried out into how moisture content affects the overall pellet (Chew, et al., 2018).

4 Work Carried out

4.1 Moisture Content

The moisture content of the dried sludge was the first component to be analysed. Understanding the moisture content would lead to great understanding of how the product could be process further it not a suitable fertiliser product. It is expected that not all the batches of dried sludge produce would be of the same moisture content therefore multiple batches will be tested. Alongside this, samples will be taking from different areas of the dried sludge batch to give a better understanding of the overall moisture content. Understanding the moisture content will also give a guide on how the sludge will compost as mention in section 4.4.2.

Samples were collected on a weekly basis for 6 weeks starting from January 23rd to February 27th of 2019. This had been arranged with the plant operator at the Coleg Sir Gar Farm. During each visit three samples were taken from the two different dried sludge pile and tested for total solids and hence moisture content using the sites own moisture analyser. The moisture analyser used detects total solid percentage (TS) threw the use of even distributed heat and homogenous drying. From the three samples 10g was used to in the moisture analyser a this was about as much as the site analyser could take.

As a comparison the 6x fibrous fertiliser will also be tested for moisture content. This product is likely to be the closet to the product that could be produce from the dried sludge. It is also in a pellet form so will help to give some understanding as too what moisture content the dried sludge fertiliser would need to be to be pelleted.

4.2 Nitrogen (N)

The nitrogen level will be tested first using simple test kit purchase from Hanna instruments. The test kit contains a pipette, a colorimetric chart, a sampling tube and a nitrogen reagent. This kit will determine there is a trace, low, medium or high level of nitrogen within the dried sludge. The idea is that this test will be carried out to give basic understanding into which of the separator unit produced the most viable dried sludge product.

Four samples of the dried sludge for each device were collected from different areas of the piles, the four samples were then mixed together in clean bucket. A sample weighing 130g as recommended in the kits instructions was then taken for that mixture and then place in another clean bucket. Two litres of bottled water were then added and mix with the sample to the point whereby are the sludge has moistened. The mixture was then allowed to stand for 24hrs. The mixture then became almost clear as the sludge settled.

After 24hours the pipette was used to transfer 2.5ml into the test tubes and the Nitrogen reagent was then added. The cap was then replaced on the test tube and then the solution needed to be mixed for 30seconds. The reagent then reacted with the solution to produce a pink colour. This pink colour produced was then matched against the colour chart provided to reveal the nitrogen level. This procedure was repeated over a period of 4 weeks.

4.3 Phosphorous (P)

The phosphorous level will also be tested using a test kit purchased from Hann Instruments. This test kit for phosphorous contain similar content to that of the nitrogen test kit except this time containing a phosphorous reagent.

Four samples were again collected from different areas of the sludge produced by the different separating devices and mixed together in a clean bucket. A sample weighing 130g recommended by the kit instructions was taken from the mixed solution. This sample was then mixed with 2L of bottle water in another clean bucket. The moisture was then adequately stirred together and left to stand for 24hrs. The mixture again almost become clear.

After the 24hrs a pipette was used to extract 2.5ml of the solution into a test tube. The reagent supplied with the test kit for phosphorous was then added and the cap was fitted to the test tube. The solution was then mixed gently and left for the 30 seconds. After 30 secs the solution turned a blue colour, which was then match against the colour metric chart provide with the test kit to identify the level of phosphorous.

4.4 Potassium (K)

The potassium level was also tested using a test kit purchased from Hanna Instruments. The test for potassium was again like the nitrogen and phosphorous kit contain a pipette, test tube, reagent but his time turbidimetric chart.

The Samples were again collected in from the sludge batches in set of four from different areas and mixed together in clean bucket. A sample weighing 130g as specified by the kit instruction was then taken from the mixed sample and place in another clean bucket. This sample was then mixd with 2L of bottled water and left to stand for 24hrs.

After the 2hrs a pipette was used to extract 2.5ml of the solution into the test tube, the potassium reagent was then added to the solution and mixed well for 30 seconds. The

reagent then reacted to the solution producing a blue colour. The turbidimetric chart was then used to determine the potassium level.

5 Results

5.1 Moisture Content

The results from the moisture content analysis were collected and shown in table 6-1 & 6-2. A range can be seen in the data collected and the average TS for the testing can be seen. The test carried out gave the total solid content, the moisture content is that of the remaining percentage (Chew, et al., 2018).

The results for the dried sludge from the screw press separator (table 6-1) showed that the moisture content varied throughout the testing period. The result shows a range from 25.01 % to 35.66 % and an average value for the whole testing period of 29.77%. From this it can be calculated that the moisture content of samples taken over testing period would be 70.23%.

Table 5—1 - Showing Total Solid % For Samples Collected from The Screw Press Separator

Screw press Total Solid %				
	Sample 1	Sample 2	Sample 3	Average
Jan 23rd	28.67	27.85	28.74	28.42
Jan 30th	26.92	25.01	26.4	26.11
Feb 6th	27.01	28.91	27.56	27.82
Feb 13th	34.55	35.66	35.01	35.07
Feb 20th	32.72	31.08	33.45	32.41
Feb 27th	28.98	29.87	27.5	28.78
			Total Average	29.77

The results for the dried sludge from the centrifuge press (table 6-2) showed that the moisture content varied throughout testing period. The result found showed a range of 20.26% to 31.78, found on Jan 30th and Feb 20th respectively. The average TS for testing period was calculated and found to be 24.51%. From this it can be calculated that moisture content for the samples taking over the testing period to be 75.49%.

Table 5—2- Showing Total Solid % For the Sample Collected from the Centrifuge Separator

Centrifuge Total Solids %				
	Sample 1	Sample 2	Sample 3	Average
Jan 23rd	23.4	22.97	23.55	23.30
Jan 30th	20.26	21.88	21.05	21.06
Feb 6th	23.44	22.98	23.6	23.34
Feb 13th	22.38	22.04	21.65	22.02
Feb 20th	31.78	30.78	32.15	31.57
Feb 27th	25.88	26.43	25.01	25.77
			Total Average	24.51

5.2 Nitrogen

The results from the nitrogen testing are shown in table 6-3. It was found that the level of nitrogen found differed between the two separator units. The sludge from the centrifuge unit was found to have low to medium levels of nitrogen on two occasions, this could be down to weather conditions during the time of testing. On the other hand, the sludge from the screw press was found to contain medium to high level on two occasions. On further inspection of the data on the test days where by the centrifuge was found to have a low to medium nitrogen content the screw press was found to have a medium nitrogen content. similarly, on the days the centrifuge dried sludge was found to contain a medium level of nitrogen, the screw press displayed a medium to high level of nitrogen. This could be an unusual condescendence, or it could be related to the weather on the day effecting the results.

Table 5—3 - Showing Nitrogen Levels for Dried Sludge from the Two Separator Units

Week	Centrifuge	Screw Press
1	Low to Medium	Medium
2	Medium	Medium to High
3	Low to Medium	Medium
4	Medium	Medium to High

5.3 Phosphorous

The results from the phosphorous test are shown in table 6-4. The result show that the phosphorous level detected by the proposed test were all found to be low in both dried sludge products. The level of phosphorous was expected to be similar to the level of nitrogen found. N. Each Explains how the ratio of N to P in cow manure is expected to be around 1:1 to 1:2 (Eash, Green, Razvi, & Bennet, 2008). This could be due to some of the phosphorous being carried into the next stage of the dewatering treatment and maybe present in the smaller amount of sludge produce by the sono-coagulation process. This sludge could be further investigated to validate this theory.

Table 5—4 Showing Phosphorous Levels for Dried Sludge from the Two Separator Units

Week	Centrifuge	Screw Press
1	Low	Low
2	Low	Low
3	Low	Low
4	Low	Low

5.4 Potassium

The results from the potassium level testing are shown in table 6-5. The result show that the dried sludge from the centrifuge separator unit was found to contain a high level of potassium on three occasions and the screw press dried sludge show medium levels of potassium on three occasions. Again, this could be down to a loss of potassium through to the next stage of treatment. Potassium levels within cow manure are usually found in higher qualities than that of nitrogen and phosphorous (Eash, Green, Razvi, & Bennet, 2008). So, the medium levels found in screw press dried sludge were not expected.

Table 5—5 Showing Potassium Levels of the Dried Sludge from the two Separator Units

Week	Centrifuge	Screw Press
1	High	Med
2	High	Med
3	Med	High
4	High	Med

6 Discussion and Conclusions

The moisture content of the dried sludge produce by both the centrifuge and screw press separator was successfully analysed. Average moisture content values were found for both dried sludges. The centrifuge press sludge was found to contain a moisture content of 75.49% on average over a period of 6 weeks and the screw press was found to contain a moisture content of 70.23% on average over a period of 6 weeks. This result is only based on the data collected over that period. The moisture content of the two products could change in respect to weather and seasons although less sludge will be processed during the summers months as the cows are not house in barn full time. To gain a better understanding of the moisture content in the dried sludge a more comprehensive study could be carried out by collect more data at different times and recording the weather data alongside this. Although the moisture content concluded by this project does give some understanding into the moisture content of the sludges produce by the dewatering project.

The average moisture content found in the dried sludge produce from the screw press separator in this project was found to be 70.23% this could be bulked up with some bulking materials to lower the moisture content to allow for composting (Polprasery, 1996). Composting of the dried sludge produce be the screw press would be a viable option to producing a fertiliser. The next step proposed by this study would be to build a windrow compost pile on site to develop the screw press sludge into a viable product.

The nutrient content of the dried was successfully although not fully analysed. Both sludges were found to contain the essential elements for plant growth, but the actual content was not fully understood. The nutrient levels found varied between the separator units with screw press sludge showing higher levels of nitrogen, the centrifuge press sludge showing higher levels of potassium and the level of phosphorous was found to be low in both sludges. The sludges could be analyse in a soil testing laboratory which would provide full analysis of the content of the content of the dried sludges (Pierzynski, Sims, & Vance, 2005). This would give a greater understanding into the nutrient content are where to take the project next.

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