FORTH RESCOURCE MANAGEMENT: OPEN WINDROW COMPOSTING SITE

Windrow TX®

ABSTRACT

An evaluation of the effectiveness of a new lightweight, air and vapour permeable nonwoven polypropylene textile for use in covers in open windrow composting.

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Forth Resource Management: Open Windrow Composting Site, Windrow TX®

An evaluation of the effectiveness of a new lightweight, air and vapour permeable nonwoven polypropylene textile for use in covers on open windrow composting sites.

Project Partners: Don & Low Ltd, James Hutton Institute, Forth Resource Management Ltd.

Location: Forth Resource Management Recycling Centre, Braehead, Edinburgh

Duration: March 2016 – February 2017

Authors: Ron Wheatley, James Hutton Institute. Lesley Haynes, Don & Low Ltd Nonwovens.

Study Objectives

The site trial at Forth Resource Management, Braehead, Edinburgh, was conducted to quantify the effectiveness and additional benefits of using a lightweight, air and vapour permeable nonwoven textile as a cover for open windrow composting.

For the purpose of the trial, Don & Low produced a 150g/m^2 polypropylene nonwoven textile, with enhanced chemical and UV resistance. The material was designed with high water repellence to shed water and to provide a physical barrier to the release of dust, odours and bioaerosols, whilst still allowing the windrow underneath to 'breathe.' This latest generation nonwoven textile was specifically designed to address some of the shortcomings associated with using more traditional and heavier weight covers in open windrow composting sites.

The following parameters were assessed, either qualitatively or quantitatively, in partnership with James Hutton Institute and Forth Resource Management Ltd:

1. Ease of handling of the covers on site
2. Durability of these new covers
3. Moisture control
4. Leachate reduction
5. Processing temperature & temperature distribution within the windrow
6. Odour reduction
7. Reduction in dust, flies and birds
8. Overall impact on quality of compost and length of composting cycle.

Introduction

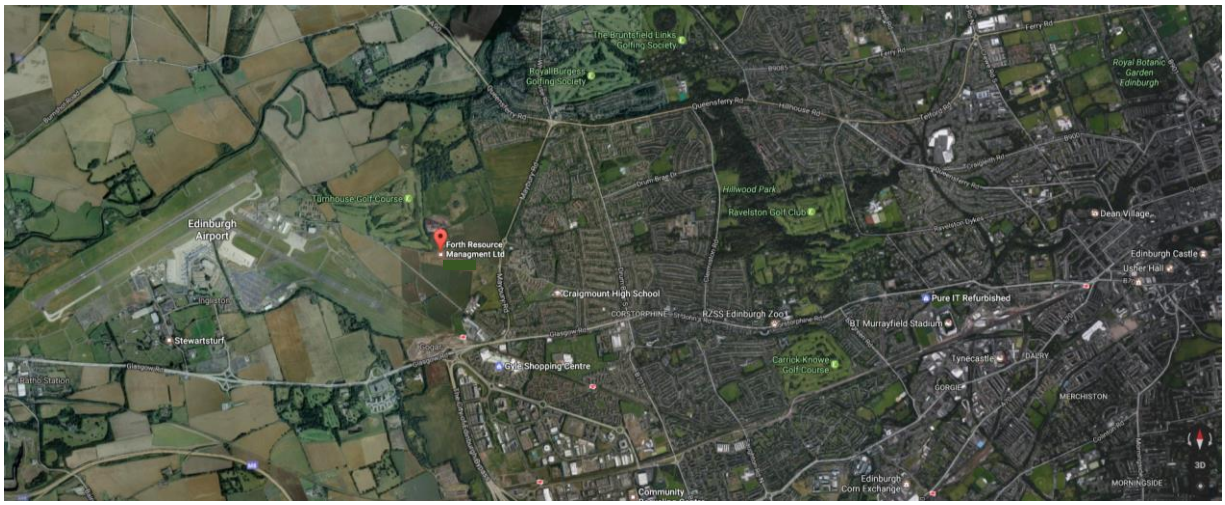
Don & Low Ltd. are a UK based, and internationally renowned, manufacturer of innovative, high performance woven and nonwoven polyolefin technical textiles. Their international success has been based on an outstanding reputation for quality, developing new technology and customer service. As a market leader in the manufacture of technical textiles, embracing change has become a way of life within Don & Low. As part of the Thrace Group, their solutions can be found in a variety of markets and applications, globally.

Don & Low have developed a nonwoven textile for compost covers designed to maximise the function of breathability and durability, whilst minimising the critical dimension of weight. A case study, in partnership with the James Hutton Institute and Forth Resource Management Ltd, was established to quantify the benefits and effectiveness of using this latest generation of breathable textile, on open windrow installations. The textiles' ability to aid compliance with The Pollution Prevention and Control (Scotland) Regulations 2012 (PPC), that require operating sites to use Best Available Techniques (BAT) to reduce emissions, was also assessed.

The James Hutton Institute (JHI) is a globally recognised research organisation delivering fundamental and applied science to drive the sustainable use of land and natural resources. A previous study by the JHI highlighted opportunities for breathable covers on open windrow installations. A study on available compost covers found that existing covers were not extensively used and that the covers should be light and easy to handle with good durability. Currently there is no regulatory requirement to cover open windrows, however covers could be required for odour control at sites near urbanisation.

Forth Resource Management Ltd. (FRM) were established in 2002 with the aim of providing a sustainable recycling solution for garden waste, generated across South East Scotland. FRM now turn locally collected garden waste into compost that is sold to gardeners, landscapers and farmers. FRM process 70,000 tons per year– the majority of which is delivered by East Lothian, Midlothian, Edinburgh and the Scottish Borders Council. FRM are an ideal composting partner for this case study as they are proactive and interested in improving the composting process; as well as looking for solutions to satisfy SEPA.

FRM Braehead site is located to the west of Edinburgh, near the airport. There are residential areas in close proximity to the North East, East and South East of the site.



The Composting Process

Composting is a natural process in which micro-organisms break down organic matter in the presence of air. The composting process relies on aerobic micro-organisms, which require oxygen and produce carbon dioxide and water. During the process a large amount of energy is released in the form of heat; leading to elevated temperatures within the composting material. Additionally, leachate, various gases, together with particulate and bioaerosols emissions are produced.

Many factors influence microbial activity within a compost pile; however, these should not be considered in isolation. Changing one factor may have a positive or negative effect on other factors and on the process overall. The key parameters include; Carbon: Nitrogen ratio, moisture content, pore space, oxygen content, process temperature, temperature distribution and pH levels.

An important composting condition is that the raw materials should be appropriately mixed to provide the correct nutrients needed for microbial growth and activity, which includes a balanced supply of carbon and nitrogen. There should also be sufficient moisture to permit biological activity without hindering aeration; as well as oxygen being at levels that support aerobic organisms and temperatures that should encourage active microbial activity from thermophilic micro-organisms. To this end breathable covers prevent windrows from drying out by winds and, conversely, prevent the windrow from becoming saturated in wet weather.

Typically, the phases of composting at a site consist of:

- Pre-acceptance and acceptance of waste
- Pre-processing
- Sanitisation
- Stabilisation /Curing/ maturation
- Post processing

Pre-acceptance and acceptance of waste

Waste is delivered by Edinburgh Council garden waste collection vehicles; as well as landscape gardeners. FRM check the paperwork and record where the waste has come from. The load is inspected and accepted or rejected.

Pre-processing

Once accepted onto the site, feedstock is pre-processed to:

- remove large branches, logs and plastic waste along with other non-biodegradable materials e.g. grit & metal
- provide a uniform small particle size feedstock for efficient composting
- protect the downstream plant components from physical damage

Pre-processing consists of reception and storage, shredding and blending of materials.
It is at this point that the materials are formed into windrows for the composting process to commence

Sanitisation

The aim of the sanitisation phase is to reduce the loading of pathogens to an acceptable level and kill weed seeds. The sanitisation phase is characterised by an increase in temperature (between 55° and 80°C), high oxygen demand and significant reductions in volatile solids. This temperature rise is autothermic, i.e. the microbes in the composting mass generate heat as they break down readily available organic matter. The sanitisation period typically lasts for 2 weeks.

Stabilisation / Curing / Maturation

Once the sanitisation stage is completed, the waste will still be highly biodegradable and a further period of active composting is required – known as stabilisation. This is carried out at temperatures that support growth of thermophilic organisms e.g. normally between 43^{o}C and 70^{o}C. FRM turn the windrows when the temperatures drop, introducing more oxygen back into the windrow to allow the composting process to continue. Once the majority of the easily digestible organic material has been consumed, the rate of heat release will drop and the material will move into the curing/maturation phase. During this phase the oxygen demand is reduced and temperatures will gradually fall as the material cools. The total time from start to finish takes approximately 12 -14 weeks.

Post Processing

The post processing phase involves a combination of screening, blending and bagging to produce a quality, saleable product. The final screening stage produces a 10mm fraction together with an oversize fraction which is reincorporated to the start of the process. FRM produce various blends of compost and also use additives such as sand and seaweed to enhance the final product.

The Experiment: Windrow TX®

Nonwoven Compost Cover Textile Development

Don & Low has extensive experience in the manufacture of breathable, synthetic nonwoven fabrics and already manufactures a 3-layer laminated breathable textile used in a cover for in-vessel composting. A need was identified, however, for a lighter weight, cost effective solution for covering open windrows to control moisture content and odours during processing. The lifetime of the product has been optimised via the use of a unique blend of chemically resistant UV stabilisers, additional hydrophobic repellence and antioxidants to offer additional thermal resistance. A product with a useable life time of more than two years is required by the processors.

For the purpose of this trial at FRM, Don & Low produced a lightweight, air and vapour permeable 150g/m^2 polypropylene nonwoven textile, with enhanced chemical and UV resistance. The material sheds water, offering a physical barrier to the release of dust, odours and bioaerosols whilst still allowing the windrow underneath to 'breathe.'

The Site Overview

The FRM, Braehead, site has 9 to 10 large windrows (approximately 6m wide x 3m high x 30m long). The composting process takes approximately 14 weeks before the compost is ready to be screened to a variety of particle sizes, subject to its intended use. The type of waste being received at the site varies depending on the season. In spring the material is woody in nature and the carbon to nitrogen ratio is high which can slow down the process, meaning the windrows may not reach sufficient temperatures to support the composting process. In order to try and speed up the process FRM remove a high percentage of this woody material. In the summer, there are a lot of grass cuttings which have a relatively small size, and a very low carbon to nitrogen ratio which leads to ammonia being produced. The shredded material is mixed with the oversize fraction from the final screening stage this helps to give the windrow some structure and reduces compaction. Due to the location of the site (surrounded on 3 sides by residential properties) and the odours produced whilst turning, FRM can only turn the windrows if the wind is coming from the east which can mean turning through the night.

For the purpose of the trial the fabric, which is manufactured in rolls 3.1m wide, was stitched together to form rectangular sheets measuring 12m x 35m. Each sheet weighed approximately 65Kg. These covers were of a very basic design with eyelets around all edges to allow for ropes or weights to be attached as a means for tethering the sheets. Initially only two covers were used at the site. These covers were placed on two windrows that were at the stabilisation stage of the process. The covers remained on these two windrows as they transitioned through the compost process moving down the site until the material was screened and then they were returned to the start of the process again. It was only when repeated complaints for odour (coming from the uncovered windrows) were received in July 2016 that four covers were put to use.

In August 2016 FRM proposed covering all the windrows; therefore, four extra covers were delivered in November 2016.

Factors Assessed and The Results

To ensure information received from FRM was consistent and relatively easy to collate, a form was devised that used a scoring system (1 being Poor and 5 being Excellent) to determine the appearance, ease of putting on and off, and odour release. There was also a column to record weather conditions at the times the covers were being handled, as windy conditions can give added difficulty with manoeuvring the covers.

Blank Data Collection Form**:**

Date	Cover No.	Appearance	Ease of Use				Odour	Weather Conditions	Comments
			Putting On		Taking Off				
		Scale 1-5	Scale 1-5	Time No. persons	Scale 1-5	Time No. persons	Scale 1-5		

Scale: 1= Poor 3= Acceptable 5= Excellent Braehead site FRM March 2016

The parameters relating to the nonwoven cover (Windrow TX®) included:

1. Ease of handling of the covers on site
2. Durability of the covers
3. Moisture control
4. Leachate reduction
5. Processing temperature and temperature distribution within the windrow
6. Odour reduction
7. Reduction in dust, flies and birds

Each of these parameters is discussed in detail in the following pages.

1. Handling the Covers

To begin with only two covers were used so that a suitable method for securing them could be found. These two covers were to stay on the same two windrows throughout the full cycle e.g. approximately 4 months. Newly formed windrows that consisted of freshly screened material and the oversize fraction were not to be covered due to concerns that they may become too dry and catch fire. Large logs and twigs were initially used to pin the covers down. FRM eventually opted for using railway sleepers to hold the covers in place. One was placed on the top in the middle and then a sleeper was suspended on each end (using rope threaded through the eyelets) to tension the cover.

When the two new covers were installed for the first time, FRM did comment on how light the new covers were and how easy they were to manoeuvre. The covers were also prone to sliding off. It was noted that the covers, once in use, became heavier when wet and began to get coated with a layer of mud and dirt (mud and water collects in the gullies). The water ponding round the edges contributed to holding the covers down. FRM are more confident of the covers not moving when it is wet. It was critical that the covers were centred properly on the windrows, so when the windrow sinks the covers can then slip down the sides; however, once the sleepers were used to anchor the covers, movement was no longer a problem.

Before this trial commenced, FRM had already purchased 2 breathable compost covers which came with an attached net to weigh them down; however, the covers would not sit on the top of the windrow and had a tendency to slip to one side particularly after it rained. FRM believed the rain was making one side of the cover heavier which caused it to slip. FRM also found it difficult to manoeuvre these covers as the net was very abrasive and shredded the gloves of the workers. Also, because the covers were very heavy (approximately 500g/m^2 compared to the 150g/m^2 lightweight covers) it required 3 people to handle the covers compared to the 1-2 people for these new lightweight covers.

FRM have devised a method for putting on and taking off the lightweight covers. This involves the covers being folded correctly when they are removed to allow for easier installation and when the covers are taken off, the long edges are folded up to the top of the windrow. It is then pulled off with the bucket loader and rolled up. When it is put back on the cover is placed on the top of the windrow where it is unrolled along the top and then the sides are folded down. The covers have been put on by one person (if there is no wind) but the job is far easier with two. At the start of the trial it was taking about 30-60 minutes to put a cover on but by July this was down to 15 minutes per cover.

Pulling the cover off with the loader is not ideal, as the cover may catch on twigs or branches in the windrow. If this was not carefully monitored these could have caused tears in the cover.

In future the ideal method for handling the covers, to ensure minimal damage, is to build a wall at the north end of the site at right angles to the windrows and use a winder. FRM have discussed installing winders on site.

2. Durability of Fabric

After 9 months in situ the covers have shown no sign of degradation from the sun, wind and rain, nor damage from the heat or chemical reactions produced during the composting process.

There is some damage to the ends of the covers due to the method used for pulling them off the windrows using the digger. The end of the cover is gathered together with a chain wrapped around it and attached to the hydraulic arm. This should be eliminated if winding gear is installed. There are a few small holes which are due to the covers catching on the windrow material whilst being pulled off and on. In general, they have worn very well.

Where damage has occurred, this has been mended using cable ties and roofing underlay tape. The project co-ordinator has re-iterated to the workforce that the covers have to be handled with care. Covers should not be positioned using machinery and that when pulling them off it's good practice to stop the operation if there is any resistance, as this may be due to the cover catching on a branch which if pulled could cause the cover to tear.

From the information collected on the durability of the fabric, it would appear that the majority of the damage was caused by rough handling. The design of the cover may also require a small change to allow for the use of mechanisation e.g. for taking off and putting on.

As long as the covers are handled with care, the material itself is acceptable for use in this application and should have a lifetime of two or more year's, dependant on geographical location, site conditions and usage.

3. Moisture Control

Moisture content has an important effect on the efficiency of the composting process. The optimum moisture content for composting depends upon the water holding capacity of the composting mixture. If the moisture level is too high for a particular mixture, the void spaces may be filled with water which compromises aeration. Unacceptable levels of leachate may also be produced with associated odour and water pollution problems. Considerable quantities of nitrogen and other nutrients may be lost as leachate. If the moisture level is too low micro-organism activity will slow down.

Measurement of moisture on site was subjective. The cover protects the windrow from the ingress of rain and also prevents the drying action of the wind and sun. The composting action requires water, but too much can be detrimental to the process. Moisture is also a by-product of the process and the cover allows for water vapour to escape thus, keeping a balanced system.

At the start of the trial, March 2016, when the cover was first taken off (after 3 weeks) it was noted that the covered windrow was significantly lighter (dryer) than the one next to it, but that the composting action was good. At the end of May after 14 weeks when the covered windrows had reached the time to be screened, the weather was very dry and sunny and it was difficult to discern a difference between the covered and uncovered windrows.

FRM have commented that when a windrow has been covered for the full 12-week cycle, the compost has been drier and less clumped together thus making screening easier.

On a subsequent visit the difference in the moisture content was quite noticeable, as the picture below shows the lighter brown compost under the covered windrow and the darker compost on the uncovered windrows to the right.

When the covers were removed to turn the windrows at the beginning of September, the steam that was released was phenomenal, like a thick fog. This demonstrates that valuable moisture is being retained by the covers, preventing the windrows from drying out excessively.

4. Leachate Reduction

The covers prevent rain water entering the windrow. SEPA BAT states that nitrogen and other nutrients may be lost in leachate if the compost becomes too moist. Leachate may contain ammonia, and have both a biochemical oxygen demand (**BOD**) and chemical oxygen demand (**COD**), together with suspended solids. The leachate at FRM is collected in a tank which has to be emptied by tankers. If it rains the drains to the tank can get blocked off and the run off, then goes through two reed beds on the site. The amount of leachate collected cannot be measured, as the drains have to remain open when the site is shut, this means that if it rains the rain water is also collected in the tank.

It has also been noted that throughout the composting cycle there is very little leachate from the covered windrows, compared to those that are uncovered. This is even more noticeable after periods of heavy rain. See images below.

A previous study (McGill University, Canada) concluded that the use of covers reduced leachate volumes which resulted in better retention of mineral elements in the compost.

5. Windrow Temperature

Process temperature and temperature distribution within the windrow varies throughout the composting process and throughout each compost batch. It is generally accepted that maintaining temperatures between 45^{o}C and 80^{o}C allows for effective composting. To ensure thorough treatment and to produce high quality compost, the entire batch must reach the required time/temperature combination as defined in PAS 100- Specification for composted materials.

Temperatures are taken at three points along the windrows (both ends and the middle) at a depth of about a metre.

The temperature readings have been averaged for Sanitisation and Stabilisation / Curing / Maturation.

Sanitisation: Uncovered average 63ºC, covered 71ºC.

Stabilisation /Curing/ Maturation: Uncovered average 69ºC, covered 74ºC.

The covered windrows have regularly had higher temperatures for each stage. This is particularly good for the sanitisation stage.

More significantly the temperatures have been more consistent across the whole windrow. This appears to be due to the protection the covers offer from wind and rain. A typical table of values is illustrated below:

Temperature	Windrow	South	Middle	North
uncovered	**6C**	82	69	59
uncovered	**7A**	77	73	67
uncovered	**7B**	60	62	64
Covered	**7C**	69	69	70
Covered	**8A**	68	67	66
Covered	**8B**	65	68	64

Individual covered windrows typically show a 1 to 4ºC variation in temperature along their length; whereas uncovered windrows can vary from 4 to 23ºC difference along their length.

The temperature readings for stage 1 of the trial have been taken during late spring and the summer when ambient figures are consistently in double figures. It will be interesting to see if the covers make a difference to the composting process when the ambient temperatures are in single figures.

FRM monitor temperatures and turn the windrows to dissipate the heat, however this has to be done at times with a favourable wind direction or carried out at night time in consideration of the neighbouring residential areas.

Tommy Dale – Managing Director of FRM, thought that the insulating layer on the surface of the covered windrows was thinner than that of the uncovered windrows and that the chemical reactions were taking place nearer the surface thus giving a higher yield. It was hoped that by using the covers processing time could be reduced by a week.

6. Odour Reduction

Any increase in odour is a major concern for FRM and although odour is part of the process during aerobic composting, excessive odours can be due to anaerobic conditions when micro-organisms have to metabolise compounds other than oxygen e.g. sulphates, which results in hydrogen sulphide being generated. This will then be released when the material is turned or processed.

FRM is situated beside Turnhouse Airport but there are also residential areas to the north east, east, and south of the site. The predominant wind direction is from the west, which takes any odours from the site across the nearby residential areas.

Tommy Dale - Managing Director of FRM, said that the covers had noticeably reduced the volume of steam escaping from the windrows and that this steam also carried odours. Without the covers, it would have been difficult for FRM to keep composting substantial volumes on this site. FRM have changed their working plan to state that covers are to be used on all windrows and this has been approved by SEPA.

FRM have had no substantiated complaints about odour since they have covered the newly shredded windrows.

7. Dust, Flies and Bird Reduction

The cover prevents the compost particulates from being blown around by the wind. As the windrows are covered they are less likely to be dried out by the wind and the sun. This keeps the compost moist and reduces the amount of dust during screening.

The cover also prevents access to the compost material beneath and therefore reduces the number of flies, as they are only able to get access to the compost at the edges.

Seagulls were of particular concern for FRM but the covers have helped to reduce their presence. They used to bury into the windrow but are now unable to do that. FRM previously hired a falconer to deter birds, but this is no longer required.

Study Summary

1. Ease of use

The nonwoven textile allows for a lighter weight cover than traditional covers and can be more easily handled e.g. approx. a third of the weight of the current traditional covers that were already in use at FRM. During the trial they were able, on some occasions, to be put on and taken off by one person (weather conditions permitting). The traditional cover could not be handled by one person and ideally needed three to four. The lightweight covers can be taken off or put on in 15 minutes if folded correctly. FRM are particularly keen for these lighter weight covers to be available for sites operated by one operative.

Covers made from the lighter weight nonwoven textile have to be handled with care to ensure they are not unnecessarily damaged. The use of a winder system would help prolong the lifetime of the covers.

2. Durability of covers and ease of fabrication

Due to the special additive package used in its manufacture, the fabric is able to withstand the chemical reactions taking place inside the windrows, the heat generated by the process and UV resistance giving a predicted lifetime of 2 years (this will be monitored). The material can be easily fabricated into covers.

3. Covers prevent windrow from becoming waterlogged, compost is drier for the screening process.

The windrow is able to breathe but the covers shed off rain and snow, preventing the windrows becoming waterlogged. The compost is less clumped and easier to screen at the end of the process.

4. Reduction in Leachates

The covers reduce the amount of leachate produced, as the rain and snow is unable to penetrate the cover into the windrow. Some of the moisture generated by the chemical reactions is recycled within the process but the majority will pass as water vapour through the covers.

5. Higher and more consistent temperatures along the length of the covered windrow

The average temperatures recorded were consistently higher for covered windrows compared to uncovered, during the same processing period. Importantly, the temperatures

along the length of the covered windrows were within 1 - 4ºC whereas uncovered varied from 4 – 23ºC.

6. Odour Reduction

FRM have had no substantiated complaints about odour since they have covered the newly shredded windrows. The covers suppress the odour and without the covers it would have been difficult for FRM to keep composting substantial volumes on this site. FRM have changed their working plan to state that covers are to be used on all windrows and this has been approved by SEPA.

7. Reduction in the number of dust, flies and birds

The covers prevent the windrows from drying out and therefore reduce the amount of dust that could be generated. The covers prevent the birds from accessing the windrows and greatly reduce their numbers on site. FRM had a terrible problem with seagulls but the covers have reduced their presence on site.
The number of flies has also reduced, as they can only access the covered compost around the edges.

Conclusion

The covers produced from the lightweight nonwoven textile met all of FRM's requirements. Handling was easier than the currently available covers.

Covered windrows had a more consistent, and slightly higher, temperature profile throughout the windrow.

Processing time was slightly reduced and the end product was easier to screen. Environmental concerns with the use of windrows, such as the release of odours to the atmosphere and leachate, with a high BOD, to groundwater were also significantly reduced.

Tommy Dale – Managing Director of FRM, said that by using the covers they hoped to increase the yield and reduce processing time. He also said "if it hadn't been for the covers FRM would have found it difficult to keep composting substantial volumes at the Braehead site".