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Survival of foodborne pathogens in food waste derived compost and anaerobic digestate

Key external stakeholders:

Compost and anaerobic digestate producers, ready

Practical implications for stakeholders:

- The data generated as part of his project highlight the potential risk posed if food waste derived compost and anaerobic digestate are contaminated with human pathogens such as *Listeria monocytogenes, Salmonella* and *Escherichia coli* O157. It highlights the importance of ensuring that pasteurisation and separation processes are carried out correctly and that finished products should be protected from recontamination.

Main results:

- The use of the ISO methods designed for bacterial pathogen detection in foodstuffs is not optimal for detection of these disease causing agents in anaerobic digestate.

- *Escherichia coli* O157:H7, *Listeria monocytogenes* and *Salmonella enterica* all demonstrated the ability to survive in stored anaerobic digestate (AD) and composted waste (CW) derived from food waste for an extended time, particularly at 10°C.

- Both *S.* Senftenberg and *E. coli* O157:H7 possess the ability to internalise lettuce if the plant is grown in growing media amended with contaminated food waste derived CW and AD.

Opportunity / Benefit:

This study demonstrates the importance of ensuring that pasteurisation and separation processes in composting and anaerobic digestion facilities are carried out correctly, to ensure that bacterial pathogens which may be present in compost / AD feedstock are eliminated. All efforts should be made to ensure that the final product is isolated/ separated to prevent subsequent recontamination. Methods for detecting bacterial pathogens such as *L. monocytogenes, Salmonella* and *E. coli* O157 in matrices such as compost, and particularly AD, need to be optimised.

Collaborating Institutions:

University College Dublin (UCD)

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1. Project background:

The global need to divert organic (food) waste from landfill has led to the implementation of new European regulations and therefore alternative waste disposal streams must be utilized fully. Composting and anaerobic digestate (AD) are two such treatment options. Both composting and anaerobic digestion are not only identified as sustainable methods of waste treatment and volume reduction, but also create valuable soil amendments with significant fertiliser value, as either the main product or as a by-product. However, the use of food waste derived compost and AD as soil amendments can be limited, due to the perceived food safety risk associated with the feed stocks. In order to address this concern this project focused on the detection and survival of three bacterial pathogens, *Listeria monocytogenes*¸ *Salmonella* spp and *E. coli* O157 in food waste derived compost and AD and the impact if contaminated products are used for the propagation of food crops.

2. Questions addressed by the project:

- Are culture based bacterial detection methods designed for food products suitable for use with compost and AD?
- Is pasteurisation effective at eliminating pathogens from food waste derived compost and AD?
- Can foodborne pathogens survive long-term in the harsh compost and AD environments and if so are there alterations to their phenotype?
- If food waste derived compost or AD contaminated with bacterial pathogens is used as a soil amendment are the pathogens transferred to the plant?

3. The experimental studies:

In general the methods used for assessing the presence of *Salmonella, Listeria monocytogenes* and *E. coli* O157 in compost and AD are the food based ISO methods (ISO6579, ISO11290 and ISO16654 respectively). The suitability of these assays for working with compost and AD was evaluated, as well as assessing the suitability of the use of a single enrichment broth (SEL) for all three organisms. Additionally, the survival potential of these three foodborne pathogens was examined in food waste derived compost and AD, with temperatures selected based on those most likely to be encountered in Irish production facilities. The thermal inactivation time for each pathogen in both matrices was also assessed. Phenotypic adaptation of the pathogens following exposure to food waste derived compost and AD was also examined. In addition the ability of the pathogen to be internalised by lettuce, if contaminated food waste derived compost and AD were used as a growth substrate was investigated.

4. Main results:

- The use of the ISO methods designed for pathogen detection in foodstuffs was found to be not optimal for pathogen detection in AD. The use of a single pre-enrichment broth enhanced pathogen recovery and the SEL method was found to be comparable to the ISO method for the detection of *S.* Enteriditis and *L. monocytogenes* in compost.

- *E. coli* O157:H7, *L. monocytogenes* and *S. enterica* all demonstrated the ability to survive in stored AD and CW derived from food waste for an extended time, particularly at 10°C. The recontamination of both CW and AD therefore may pose a potential food safety risk and as such separation/ isolation of finalized products should be strictly adhered to.

- Thermal inactivation of *E. coli* O157:H7, *L. monocytogenes* and *S. enterica* at both 55 and 60°C is effective to eliminate these pathogens in food waste derived AD and CW occurs after less than ten minutes of exposure. This indicates that pasteurisation as outlined by the regulations, if undertaken correctly, is effective in inactivating each pathogen in both food waste derived CW and AD.

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- Exposure to CW and AD over a 28- day period has little phenotypic effect on pathogens, in terms of nutrient metabolism, motility and biofilm formation potential.

- Both *S.* Senftenberg and *E. coli* O157:H7 possess the ability to internalise lettuce into the root structure if the plant is grown in growing media amended with contaminated food waste derived CW and AD. The rate of internalisation however is heavily dependent on external factors, such as temperature and inoculum level.

5. Opportunity/Benefit:

With regulations driving the use of more sustainable methods such as compost and anaerobic digestion for treating food waste it is vital that there is an increased understanding of the risk posed by foodborne pathogens in such products. The results of this study demonstrated that, if implemented correctly, pasteurisation is effective at killing bacterial foodborne pathogens in compost and AD. However, if recontamination of the product occurs the pathogens, particularly *L. monocytogenes*, can survive for extended periods at outdoor temperatures encountered in Ireland. This is a concern if products are stored unprotected for long periods. Furthermore, *L. monocytogenes* and *E. coli* O157 are not routinely tested for in these substrates which may pose a potential risk. However, detection methods for these matrices need to be optimised before they can be used routinely. Laboratory based experiments demonstrated that pathogen internalisation of lettuce can occur if the growth medium is contaminated but it is impacted by environmental factors such as temperature.

6. Dissemination:

Main publications:

Murphy S, Gaffney M, Fanning S and Burgess CM (2016) Potential for transfer of *Escherichia coli* O157:H7, *Listeria monocytogenes* and *Salmonella* Senftenberg from contaminated food waste derived compost and anaerobic digestate liquid to lettuce plants. *Food Microbiology,* 59:7-13.

Popular publications:

Murphy S., D. Walsh, M. Gaffney, S. Fanning and C.M. Burgess (2015) Assessing the Survival of *Escherichia coli* O157:H7 *Salmonella* Enteritidis and *Listeria monocytogenes* in Compost and Anaerobic Digestate. Society for General Microbiology Irish Division Meeting: Microbial Interfaces, 17-19 June 2015, Galway, Ireland.

Murphy S., D. Walsh, M. Gaffney, S. Fanning and C.M. Burgess (2014) Assessing the Survival of *Escherichia coli* O157:H7 *Salmonella* Enteritidis and *Listeria monocytogenes* in Compost and Anaerobic Digestate. 17th World Congress of Food Science & Technology from August 17th - 21st, 2014, Montreal, Canada.

Murphy S, D Walsh, M Gaffney, S Fanning and C Burgess (2014) – Investigation into the survival potential and inactivation of *Escherichia coli* O157:H7, *Listeria monocytogenes* and *Salmonella* species in compost and anaerobic digestate derived from food waste. Walsh Fellowship Seminar, Johnstown Castle, Wexford, December 5th 2014.

Murphy, S., Gaffney M., Fanning S. and C.M. Burgess (2013). Assessing the survival of *Salmonella* spp, *Escherichia coli* O157:H7 and *Listeria monocytogenes* in compost and anaerobic digestate. 42nd Annual Food Research Conference, June 27th-June 28th, 2013, Teagasc Food Research Centre, Ashtown, Dublin.

Murphy, S., Gaffney M., Fanning S. and C.M. Burgess (2013). A method for the detection of *Salmonella* Enteritidis, *Escherichia coli* O157:H7 and *Listeria monocytogenes* in compost and anaerobic digestate. 42nd Annual Food Research Conference, June 27th-June 28th, 2013, Teagasc Food Research Centre, Ashtown, Dublin.

Murphy, S., Gaffney M., Fanning S. and C.M. Burgess (2013). Development of a method for detection of *Salmonella* species, *Escherichia coli* O157:H7 and *Listeria monocytogenes* in compost and anaerobic digestate. Teagasc Agricultural Research Forum. March 11th-March 12th 2013, Tullamore, Co. Offaly.

Murphy, S., Gaffney M., Fanning S. and C.M. Burgess (2013). A Method for the Detection of *Salmonella* species, *Escherichia coli* O157:H7 and *Listeria monocytogenes* in Compost and Anaerobic Digestate.

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Society for General Microbiology Irish Branch Spring Meeting, March 21st-March 22nd 2013, University College Dublin.

7. **Compiled by:** Kaye Burgess and Michael Gaffney

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