EXCERPTS FROM THE DOCUMENT: "RESEARCH CONCERNING HUMAN PATHOGENS AND ENVIRONMENTAL ISSUES RELATED TO COMPOSTING OF NON-GREEN FEEDSTOCKS"
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The following is 7 pages of excerpts from this document. For more details, refer to the main text of the document. Copies of the 68-page report are available electronically be sending your e-mail address and the title of the requested report to William Alsdorf at alsdorf.william@deq.state.or.us.

I. EXECUTIVE SUMMARY (pages i to ii in the document)

This document evaluates the research and United States Environmental Protection Agency regulations on pathogens as they may pertain to composting of non-green feedstocks. Oregon Department of Environmental Quality's (ORDEQ) definition of non-green feedstocks includes animal parts and by-products, mixed materials containing animal parts and by-products, dead animals, and municipal solid waste (MSW). Non-green feedstocks do not include biosolids, manures, or green wastes. This report will not focus on MSW because it is not currently composted in Oregon.

The main sections of this document are:

- Pathogen destruction during composting
- Description of composting techniques
- Public health concerns related to the use of composted non-green feedstocks
- Human pathogens in non-green feedstocks that could impact worker and public health
- Human pathogens in non-green feedstocks: dissemination and transmission
- Health impacts of pathogens in non-green feedstock composting operations and/or compost
- Public health risk from consuming foods grown in pathogen-contaminated, finished compost
- Testing protocols for pathogens in non-green feedstocks
- Pathogen contamination during composting
- The relevance and adequacy of USEPA 40 CFR Part 503 regulations to non-green feedstocks
- Bioaerosols at composting facilities
- Laboratory procedures and laboratories that may be able to test non-green feedstocks and compost
- Water quality issues
- Research needs

The main findings were:

- There are very little data on pathogens in non-green feedstocks. Most of the available data is on sewage sludge and biosolids. Some data are available on MSW and green wastes.
- Pathogens are very effectively destroyed by composting, provided that temperatures exceeding 55^{o}C (131^{o}F) are reached and maintained throughout the mass of material that is being composted for a given amount of time. The length of time depends on the methodology employed.
- Non-green feedstocks are being composted in several states. Animal carcasses also are being composted in several states, including Alabama, Maryland, and Utah. Several institutions have methods for composting dead animals.
- USEPA and the scientific community recently reviewed the adequacy of the use of fecal coliforms and *Salmonella* as effective indicator organisms for the presence of pathogens in sewage sludge, manures, and similar products. It was concluded that at the present time, these are

the best indicator organisms for testing of compost made from non-green feedstocks; they are easily measured, and the cost of testing is relatively low.
- Design of composting facilities and their proper operation can adequately prevent contamination of the final product, groundwater contamination, and contamination of surface water.
- There is very little potential for properly prepared, finished compost to affect public health or animals.
- The data regarding workers at composting facilities has shown that workers have not been affected over the past 20 years. Workers are the most exposed individuals to pathogens and bioaerosols. Workers need to exercise proper hygienic practices.

In conclusion, properly designed and operated non-green feedstock composting facilities should not present a public health or worker health threat.

The most important research needs are:

- Better data on pathogen destruction in non-green feedstocks
- Data on the destruction of animal pathogens in animal carcasses
- Development of sampling methods for pathogens in large animal carcasses
- Evaluation of low-key composting technologies, such as passive aerated piles, low windrows, and stacked piles, as to the effectiveness of pathogen destruction when using non-green feedstocks

II. Table 1-4 is an excerpt from Section 1.2.3.7 in the document and is a matrix relating health aspects to appropriate techniques, odor potential, aerosolization potential, cross-contamination potential, and water quality impacts for composting of all non-green feedstocks (ratings are 1 to 5, with 1 being the worst and 5 being the best).

Table 1-4: Matrix Relating Health Aspects to Appropriate Techniques, Odor Potential, Aerosolization Potential, Cross-contamination Potential, and Water Quality Impacts for All Non-green Feedstocks

Method	*Pathogen Destruction*	*Odor Potential*	*Aerosols Emissions*	*Cross-Contamination*	*Water Quality* Runoff Leachate*	
Passive Aerated Pile	2	3	4	3	4	4
Aerated Static Pile	5	4	4	4	4	4
Windrow	4	3	1	2	3	3
Bin	3	3	4	4	5	5
Stacked Pile	2	3	4	3	4	4
In-vessel	5	5	5	5	5	5
Container	5	5	5	5	5	5

* Depends on the infrastructure associated with the method of composting. See section on water quality. Water quality parameters include BOD (biological oxygen demand), nitrogen, phosphorus and other chemical constituents.

III. Table 2-4 is an excerpt from Section 2.2.4.3 in the document.

Table 2-4: Pathogens and Their Sources

Organism	*Mixed Food Waste*	*Dairy Products*	*Meat Products*	*Cattl e*	*Poultry*	*Fish*
Salmonella	X	X	X	X	X	X
Shigella	X	X	X			X
E. coli	X	X	X	X	X	X
Listeria monocytogenes	X	X		X		
Yersinia enterocolitica	X		X		X	X
Vibrio cholerae						X
Campylobacter jejuni	X	X	X	X	X	
Staphylococcus aureus	X	X	X	X	X	
Hepatitis A virus	X	X	X			
Norwalk virus group	X					X
Cryptosporidium parvum				X		
Giardia lamblia	X	X			X	
Mycobacterium paratuberculosis				X		
Streptococcus	X	X	X			X
Vibrio						X

IV. The following excerpt is from Section 3.6 in the document. See also Section VIII of this summary. The prevention of dissemination and transmission of pathogens can be achieved in several ways:

- Delivery of non-green feedstocks in closed containers
- Discharge of containers or bulk feedstocks onto a tipping floor in a building
- Incorporation of the feedstocks as soon as they are delivered to the facility into the composting process

The different composting systems or technologies vary in their potential to disseminate and transmit pathogens. Outdoor windrow systems will have the greatest potential for dissemination of pathogens through emissions and vectors. Turning windrows could release airborne pathogens. Stacked piles, passive aerated piles, and aerated static piles with a compost cover will not attract vectors or have the potential for airborne pathogens. Enclosed systems or containerized systems will have the least potential for pathogen dissemination through emissions and vectors.

Based on these studies, there is no evidence that the health of the public or workers at composting facilities involved with biosolids, MSW, or yard materials has been compromised.

V. The following paragraphs concern worker exposure to pathogens and are excerpts from Section 4.2 in the document.

There are several preventive measures that could be implemented at non-green feedstock facilities that would reduce potential risk to the public or workers. These include:

- Reducing dust and particulates
- Maintaining proper moisture during the composting operations
- Reducing dust by installing sprinklers over screens and hoppers
- Reducing the potential for vectors

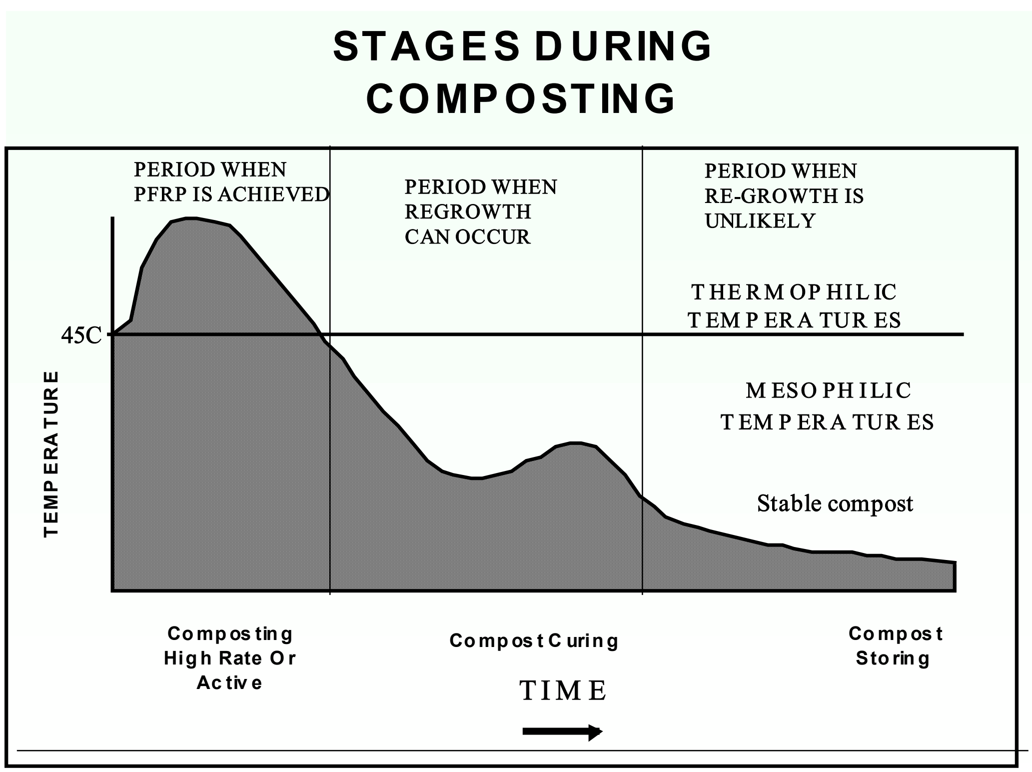
- Keeping the site clean
- Sprinkling lime over puddles and stagnant water, which reduces odors and vectors
- Controlling mosquitoes
- Keeping site graded to reduce puddling
- Keeping feedstocks in closed containers
- Mixing feedstocks immediately into active composting piles
- Keeping bulking agent on hand so it can easily and quickly be mixed with feedstock to increase porosity and reduce potential for odors and vectors
- Controlling run-on of water to facility

VI. The following paragraphs concern indicator organisms and are excerpted from Sections 6.5 and 6.6.

At present, fecal coliform bacteria and *Salmonella* are the best indicator organisms. Fecal coliform analysis is less expensive, and this organism can be used as the indicator organism when present in high concentrations. An organism must be present to be effective as an indicator.

Where non-green feedstocks contain animal remains as well as food products, *Salmonella* is the best indicator organism. Since *Salmonella* can regrow, it is important to avoid recontamination of the compost. Compost should be sampled as close as possible to the time when it is to be distributed for use. Fecal coliforms can be used as the test indicator organism when they are present in the feedstock in high numbers.

VII. The following graph is an excerpt from 7.3.1.3.2 in the document.



VIII. The following paragraph is an excerpt from Section 7.3.3 in the document. It says on-site contamination by pathogens can occur under several conditions:

- Contamination from the feedstock to finished compost by using contaminated equipment
- Contamination of finished product with unfinished compost containing pathogens
- Contamination of the finished product by runoff containing pathogens (This is primarily a matter of proper site design and is usually not the source of contamination.)

Preventative measures can be achieved by using separate equipment to handle the feedstock, unfinished compost, and finished compost. If a single FEL is used, then the bucket needs to be cleaned between various operations, or the bucket can be removed and a clean bucket used.

IX. The following paragraphs are from Sections 8.3 and 8.4 in the document. They concern Conclusions and Justification for Why the USEPA Regulations Make Sense for Non-green Feedstocks.

The USEPA 40 CFR Part 503 regulations make sense for feedstocks containing mixed food waste, in part because food wastes and accompanying pathogens are bound to be present in existing wastewater. Class A biosolids have not resulted in any reported disease outbreaks. In addition, the time and temperature requirements for composting food waste feedstocks are more than adequate for inactivating microorganisms such as *Ascaris ova*, which are considered to be much hardier than most pathogens of concern. Because they appear to be ubiquitous in food waste feedstocks, *Salmonella* sp. should be an excellent means for verifying that adequate composting conditions have been achieved.

A number of unknowns exist in terms of applying the USEPA 40 CFR Part 503 regulations to animal carcasses and fish. Carcass composting systems have not been studied nearly to the extent that biosolids operations have been scrutinized. Senne, et al., (1993) reported that avian viruses were effectively destroyed by composting when temperatures exceeded 55^{o}C (131^{o}F). Similar data were reported by the University of Maryland (Murphy, 1990).

For non-green feedstocks other than large animals (e.g., cows), USEPA's PFRP criteria should be very adequate. It is important that good monitoring procedures be maintained. It is important to substantiate that all areas of the composting pile have been subjected to the proper temperatures. It is also recommended that the compost from feedstocks containing high levels of fecal coliform bacteria or *Salmonella* sp. be periodically examined for these organisms.

X. The following paragraphs are from Sections 10.3 and 10.4 in the document.

There are several laboratories that do microbiological analysis on solid samples. It is important to find out if the laboratory has had experience in determining pathogens and indicator microorganisms in compost. Laboratories that have had experience only with liquid samples may not be able to accurately analyze for compost or soil.

The following are some laboratory analytical costs and ranges:

Fecal coliform	$35-45
Salmonella	$65-150
Total nutrient analysis for manure and compost	$50
Lagoon water analysis	$55

XI. Table 11-1 is an excerpt from Section 11.2.1.1 in the document.

In one study, initial food waste feedstocks had the following pathogen and metals concentrations (Herrera Environmental Consultants, Inc., 1994):

Table 11-1: Some Pathogens and Heavy Metals in Mixed Food Waste Feedstock

Contaminant	*Concentration*	*Recommended Levels*
Total coliform	5.7×10^6 MPN/gram	---
Fecal coliform	2.1×10^4 MPN/gram	<1,000 MPN/gram
E. coli	3.5×10^3 MPN/gram	ND
Fecal streptococci	7.5×10^6 MPN/gram	ND
Enterococci	1.1×10^6 MPN/gram	ND
Staphylococcus aureus	1.5×10^2 MPN/gram	ND
Boron	44 mg/kg	50 mg/kg*
Copper	18 mg/kg	500 mg/kg
Lead	1.3 mg/kg	200 mg/kg
Zinc	53 mg/kg	1,500 mg/kg

*Toxicity can occur when Boron is between 50 and 200 mg/kg, depending on plant species.

XII. The following paragraphs are excerpted from Sections 11.3.1.1, 11.3.2.2, 11.4 and 11.5.5. These paragraphs concern ***pathogens:***

- ***as related to different composting systems;***
- ***in surface water runoff; and***
- ***in ground water.***

It is always preferable, regardless of the composting system, to conduct a composting operation on an impermeable surface; however, this could be expensive. The following lists the various systems and indicates their potential for the need of a physical barrier to protect groundwater.

- Windrow – This system is apt to produce leachate and, depending on site conditions and depth to groundwater, may need a physical barrier. Many windrows are small and have a large surface area. Precipitation falling on such windrows could produce leachate.

- Piles – Passive, aerated, or stacked. Since these systems are turned infrequently or not at all during the composting stage, leachate is not usually produced. Leachate could be produced if the feedstocks placed in the piles contain free water. Rainfall falling on large piles will penetrate, be absorbed and not produce leachate. Unpublished data during studies by USDA showed that leachate was not generated even when nine inches of precipitation occurred. Runoff was produced. [Comment from DEQ: E & A defines "leachate" as liquid that travels through a compost pile and out the bottom. DEQ defines "leachate" as liquid that contacts the pile and becomes runoff (can flow off of surface). Therefore, conclusions about leachate presented in this report may not apply to DEQ regulated facilities.]

- Containers or enclosed systems – These systems do not need a physical barrier, as they are not exposed to precipitation.

The potential for contaminated runoff to occur would be during the feedstock preparation and composting stages. There is little potential for compost to contaminate the runoff with pathogens during the final period of curing and storage stages since the pathogens should have been destroyed by that time. The runoff could be contaminated with chemical constituents, such as nitrogen compounds, phosphorus, heavy metals (low levels), organic compounds, and particles.

Several studies have indicated that leachate produced from both green and non-green feedstock composting operations may contain high concentrations of pathogens, organic compounds, nutrients, and/or metals, which can negatively impact water quality. Management practices should be implemented to minimize the amount of wastewater produced, and recommended protection mechanisms should be constructed to protect water resources.

XIII. These paragraphs are from Section 12.0 in the document and cover TOPICS NEEDING FURTHER RESEARCH AND INFORMATION.

Time-temperature relationship for non-green feedstocks. Because most of the existing data is from composting of sewage sludge and biosolids:

- There is a lack of data on the effect of composting on animal pathogens.
- There is little data on pathogen reduction techniques for composting of large animal carcasses.
- Many of the methods used (e.g., windrow composting or passive aeration) do not achieve PFRP. At lower temperatures, it is important to know the time-temperature relationship for reduction of pathogens.
- More data is necessary on facility design and process controls for mixed food waste and for testing parameters for compost made from mixed food waste.

Sampling and sample preparation.

- The current sampling procedures are principally geared toward homogenous material, such as compost, water, or soil. Food wastes and relatively small material could be ground in order to obtain a uniform sample. This is typically done with plant material for analysis.
- No sampling procedures for carcasses could be found.

Low-key composting techniques.

- There are little data on temperature uniformity for several low-key composting techniques such as stacked piles, and passive aeration.
- The data on temperature variability for stacked piles and passive aeration are scarce.
- There is a need to identify the most efficient design to achieve temperature that will result in pathogen destruction.

Water quality.

- There are no data on water quality with regard to pathogens and very limited data on other water quality criteria from non-green feedstock composting facilities.
- There are very little data on pathogens in runoff or groundwater from green waste composting facilities, and the data are not comparable to non-green feedstock composting facilities.

Copies of the 68-page report are available electronically be sending your e-mail address and the title of the requested report to William Alsdorf at DEQ at alsdorf.william@deq.state.or.us.

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