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**“Compost: Your Trash, Nature's Treasure”**

*(October/November 2017 Issue)*

**Teacher’s Guide**



**Teacher's Guide for**

***“Compost: Your Trash, Nature's Treasure”***

**October/November 2017**

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# Connections to Chemistry Concepts

|  |  |
| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Chemical reactions** | Teachers can use examples of composting for some decomposition reactions and relate biochemical processes to chemical reactions. |
| **Reaction rates** | The reaction rate of composting organic materials is partially dependent upon the particle size of the organic material and the temperature. Incorporating these concepts into a discussion of factors affecting reaction rates may provide a different perspective for some students. |
| **Thermodynamics** | The heat energy produced from the decomposition reactions occurring during both aerobic and anaerobic composting are significant. Pictures of compost piles in cool weather producing enough heat to see condensing water vapor rising from them may be interesting for students. The heat produced during composting is an important product and factor in composting. |
| **Environmental chemistry** | Students may not understand the impact on greenhouse gases and global climate change that rotting food wastes in landfills and composting food wastes in commercial anaerobic digesters may have on the environment. The methane and carbon dioxide gases formed during anaerobic and aerobic composting are classified as greenhouse gases and may be generated in significant quantities. |
| **Organic chemistry** | Composting can produce a variety of organic compounds. Most students will not be familiar with the organic acids or amines that can be formed during composting. Connecting the malodor from improper composting to organic acids like butanoic (butyric) or hexanoic (caproic) acid, or to ammonia and various amines, could help students make connections between organic compounds and their properties, including odor. |

# Teaching Strategies and Tools

## Standards

* Links to **Common Core Standards for Reading**:

**ELA-Literacy.RST.9-10.1.** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

**ELA-Literacy.RST.9-10.5.** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

**ELA-Literacy.RST.11-12.1.** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

**ELA-Literacy.RST.11-12.4.** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

* Links to **Common Core Standards for Writing**:

**ELA-Literacy.WHST.9-10.2F.** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

**ELA-Literacy.WHST.11-12.1E.** Provide a concluding statement or section that follows from or supports the argument presented.

* Links to **Next Generation Science Standards**

**HS-PS1-5.** Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

**HS-LS2-3**. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

**HS-ETS1-2. Design** a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering

* + **Disciplinary Core Ideas**:
* LS2.B: Cycles of matter and energy transfer in ecosystems
* PS1.B: Chemical reactions
* ETS1.C: Optimizing the design solution
	+ **Crosscutting Concepts:**
* Cause and Effect
* Systems and System Models
* Energy and Matter
	+ **Science and Engineering Practices:**
* Developing and using models
* Planning and carrying out investigations
* Constructing explanations and designing solutions

**Nature of Science:**

* Scientific knowledge assumes an order and consistency in natural systems

## Vocabulary

**Vocabulary** and **concepts** that are reinforced in the October/November 2017 issue:

* + Equilibrium
	+ Solute and solvent
	+ Electrolyte
	+ Ions
	+ Lipids
	+ Osmosis
	+ Metallic and nonmetallic
	+ Igneous, sedimentary, metamorphic rocks
	+ Composting
	+ Aerobic and anaerobic
	+ Carcinogen
	+ Heavy metals
	+ Amalgam
	+ Polymerization
	+ Composites

# Reading Supports for Students

The pages that follow include reading supports in the form of an Anticipation Guide, Reading Strategies, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are provided to help students as they prepare to read and in locating and analyzing information from the article.

The borders on these pages distinguish them from the rest of the pages in this Teacher’s Guide—they have been formatted for ease of photocopying for student use.

* **Anticipation Guide (p. 8):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.
* **Graphic Organizer (p. 9):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

* **Student Reading Comprehension Questions (p. 10-11):** The Student Reading Comprehension Questions are designed: to encourage students to read the article (and graphics) for comprehension and attention to detail; to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment; and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.
* Most of the articles in this issue provide opportunities for students to consider how understanding chemistry can help them in their personal lives.
* To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles.
* You might also ask them how information in the articles might affect their health and/or consumer choices. Also ask them if they have questions about some of the issues discussed in the articles.
* The Background Information in the *ChemMatters* Teachers Guide has suggestions for further research and activities.

“Compost: Your Trash, Nature's Treasure”, *ChemMatters*, October/November 2017 Issue

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Anticipation Guide

“A Close-up Look at the Quality of Indoor Air” (*ChemMatters*, April/May 2016 Issue)

**Directions:**  ***Before reading the article*,** in the first column, write “A” or “D,” indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Organic waste produces gaseous air pollutants whether it exposed to air or not.
 |
|  |  | 1. So far, we have not figured out how to use the methane produced in landfills to generate electricity.
 |
|  |  | 1. Composting helps reduce methane emissions.
 |
|  |  | 1. Aerobic composting produces carbon dioxide, water vapor, and compost which can be used to enrich soil in gardens.
 |
|  |  | 1. Two types of bacteria commonly found in organic waste grow best at different temperatures.
 |
|  |  | 1. The heat generated by bacterial reaction in a compost pile can kill disease-causing bacteria and weed seeds.
 |
|  |  | 1. Backyard composting is best done with both plant and animal matter.
 |
|  |  | 1. Bacteria in compost grow best when there is about 20-25 times as much carbon as nitrogen in the food waste.
 |
|  |  | 1. Composting can help mitigate climate change.
 |
|  |  | 1. Some large cities have municipal composting programs.
 |

## Graphic Organizer

“Compost: Your Trash, Nature's Treasure”, *ChemMatters*, October/November 2017 Issue

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: ***As you read***, complete the graphic organizer below to describe the differences between aerobic and anaerobic composting.

|  |  |
| --- | --- |
| **Aerobic Composting** | **Anaerobic Composting** |
|  |  |
|  |  |
|  |  |
|  |  |
| **Similarities of both types of composting** |

**Summary:** On the back of this paper, explain the meaning of the title of the article in 20 words or less.

## Student Reading Comprehension Questions

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name

“Compost: Your Trash, Nature's Treasure”, *ChemMatters*, October/November 2017 Issue

**Directions**: Use the article to answer the questions below.

* 1. What are the four common chemical elements comprising organic wastes?
	2. List four products of the decomposition of organic waste under anaerobic conditions.
	3. What is the source of 15.4% of human-related annual methane emissions?
	4. What is composting?
	5. How does anaerobic composting work?
	6. What are the end results of aerobic composting?

**Student Reading Comprehension Questions, cont.**

“Compost: Your Trash, Nature's Treasure”, *ChemMatters*, October/November 2017 Issue

* 1. What is the favored option for composting (a) food waste, and (b) yard waste?
	2. Which type of aerobic bacteria grows best at moderate temperatures?
	3. Generally, biological organisms need a ratio of 25:1 of which two elements?
	4. List two factors that affect the aerobic composting process.
	5. Why is it not wise to use wastes like dog and cat feces in a backyard composting pile?

## Answers to Student Reading Comprehension Questions

1. **What are the four common chemical elements comprising organic wastes?**

*Four common elements comprising organic wastes are carbon, hydrogen, oxygen, and nitrogen.*

1. **List four products of the decomposition of organic waste under anaerobic conditions.**

*Four products of the anaerobic decomposition of organic wastes are methane, carbon dioxide, organic acids, and ammonia.*

1. **What is the source of 15.4% of human-related annual methane emissions?**

*Landfills are the source of 15.4% of human-related annual methane emissions.*

1. **What is composting?**

*Composting is the microbial breakdown of organic materials into simpler components which can be used to fertilize soil.*

1. **How does anaerobic composting work?**

*Anaerobic composting works similarly to the way a landfill works. First, the waste is ground up. Then these chunks are placed in a closed container called a digester. In there, anaerobic microbes digest the organic matter, producing methane and a slurry called digestate.*

1. **What are the end results of aerobic composting?**

*The end results of aerobic composting are carbon dioxide, water vapor, and a dark organic material called compost.*

1. **What is the favored option for composting (a) food waste, and (b) yard waste?**

*The favored option for composting food waste is an anaerobic digester.*

*The preferred process for composting yard waste is aerobic composting.*

1. **Which type of aerobic bacteria grows best at moderate temperatures?**

*Mesophilic aerobic bacteria grow best at moderate temperatures.*

1. **Generally, biological organisms need a ratio of 25:1 of which two elements?**

*Generally, biological organisms need a 25:1 ration of carbon to nitrogen.*

1. **List two factors that affect the aerobic composting process.**

*Two factors that affect the aerobic composting process are*

*the temperature of the compost pile, and*

*the right amounts of carbon and nitrogen.*

1. **Why is it not wise to use wastes like dog and cat feces in a backyard composting pile?**

*Dog and cat feces should not be used in a backyard composting pile because the compost pile may not be large enough to generate enough heat to kill disease-causing organisms like worm eggs.*

# Possible Student Misconceptions

1. **“Composting is smelly and attracts pests.”** *When backyard composting is done properly there are no offensive odors or pests. The odors and pests are typically associated with people attempting to compost inappropriate materials, including pet feces, meat scraps, and fatty or oily foods. The solid end product of aerobic composting is a dark-brown or black solid that has an earthy odor.*
2. **“Composting takes too long.”** *The composting reactions are an example of factors affecting reaction rates. Composting can be completed in about six weeks—if the pile is properly turned and aerated to provide oxygen (remember, it’s aerobic!), if the pile is at optimal temperatures and contains the correct ratio of brown and green starting reactants, and if the material to be composted is smaller in particle size. Otherwise, it can take more than a year to compost naturally.*
3. **“Composting is too complicated!”** *Compost happens. It is a natural biological reaction which occurs without human intervention. However, with human assistance, the composting process can be accelerated and the final compost product can be useful. While there are ideal conditions, ratios of materials, and other factors to consider, it is not an exact science. Just jump in and get started.*

# Anticipating Student Questions

1. **“I live in the middle of the city. Can I still compost?”** *Yes! A compost pile can take up as little as a 3 foot x 3 foot x 3 foot volume. So even small city yards can have a productive compost pile. Of course, a larger area will allow composting of more material. Commercial composting containers designed for city or condo living can be purchased that are easily used. Even if you live in a large apartment complex with no individual yard space, the apartment management may be open to beginning a composting pile for the residents—but be sure to ask permission before starting.*
2. **“I heard of composting using earthworms. Would it help to add earthworms to my compost pile?”** *Composting using earthworms is certainly an effective technique. However, the process of earthworm (vermiculture) composting and backyard (aerobic) composting are very different. The traditional backyard composting pile gets too hot from the decomposition reaction for the earthworms. So, it is not advisable to add earthworms to your compost pile. If you would like more information on vermiculture, please see* [*https://www.treehugger.com/green-food/vermicomposting-and-vermiculture-worms-bins-and-how-to-get-started.html*](https://www.treehugger.com/green-food/vermicomposting-and-vermiculture-worms-bins-and-how-to-get-started.html)*.*
3. **“If anaerobic composting releases greenhouse gases including methane and carbon dioxide, is it bad for the environment to compost?”** *Great question; but it is very complex! Certainly, methane and carbon dioxide gases contribute to global greenhouse conditions. However, we must consider what would have been the end products if the materials had not been composted; would those products have been more detrimental? Using large anaerobic composting digesters, the methane can be captured and used productively rather than releasing it into the environment. One must also consider the fuel used to run the digester (diesel or methane), the distance the organic matter is hauled (transportation exhausts), and the end use of the compost. Sequestering the carbon in the solid organic compost is beneficial rather than the carbon dioxide formed by decomposition or burning being released into the air. Most scientist believe that composting is preferable to other alternatives; however, the merits must be weighed on a case-by-case basis.*

# Activities

**Labs and Demos**

**Composting lab:** For the 2003 Earth Day observance, ACS published "Chemistry and Compost", providing background and a lab activity for students in grades 8–12 on composting, with instructional notes for the teacher and student procedures. Students prepare and compare bioreactors for several waste materials. (<https://www.acs.org/content/dam/acsorg/greenchemistry/education/resources/chemistry-and-compost.pdf>)

**Anaerobic decomposition of organic matter lab:** "Biogas from Biomass" and "A Methane Generator" are two student lab activities with suggested variations for research and numerous student materials. One possible modification to the labs would be to use Mylar balloons in place of latex balloons for collecting the methane/biogas because other sites report better results when using Mylar balloons due to gas permeability with latex. (<http://energysafekids.org/ugi/wp-content/uploads/2013/11/Esk-Biogas-From-Biomass-131104.pdf>)

**Simulations**

**Composting virtual lab:** Students control three parameters of home composting: brown to green balance, water concentration, and number of compost turns per month, and an efficiency meter rates how well the chosen parameters worked to produce compost. The Web site contains sidebar directions where teachers could use the activity as a virtual lab; but for high school students, it may work best as a simulation. (<http://www.glencoe.com/sites/common_assets/science/virtual_labs/ES01/ES01.html>)

**Media**

**Composting PowerPoint:** "Compost" (51 slides) presents the science of composting as chemistry and physics subsections (and a biotic section that is not labeled as such). Mesophilic and thermophilic phases of composting are discussed, and several charts and graphs, as well as pictures, complement the presentation. (<https://ic.ucsc.edu/~cshennan/envs133/lecture_notes/compostPresentation08.ppt>)

**Composting infographics:** The Visually Web site provides numerous infographics related to composting. Titles include "How to Compost in Your Apartment", "Composting 101—What's In, What's Out?", "Mining Black Gold: The Comprehensive Guide to Composting", "Chart—Things to Compost", and many more. (<https://visual.ly/tag/composting>)

**Lessons and Lesson Plans**

**Composting lessons and activities:** *Do the Rot Thing: A Teacher's Guide to Compost Activities* is a 68-page guide with high school level activities, including an introductory activity, four different composting activities, three worm composting activities, and four projects to help inform others about composting. (<http://www.cvswmd.org/uploads/6/1/2/6/6126179/do_the_rot_thing_cvswmd1.pdf>)

**Classroom composting:** *Composting in the Classroom: Scientific Inquiry for High School Students* is a 126-page book published by Cornell University that includes sections on "The Science of Composting", "Composting Bioreactors and Bins", "Getting the Mix Right", "Monitoring the Composting Process", "Compost Properties", "Compost and Plant Growth Experiments", and "Composting Research". Suggestions for numerous classroom activities and research opportunities are provided throughout the publication. (<http://cwmi.css.cornell.edu/compostingintheclassroom.pdf>)

**Projects and Extension Activities**

**Student research ideas for composting:** Cornell University suggests ideas for research about composting in "Ideas for Student Research Projects", which include compost ingredients, microorganisms, compost physics, worm composting, and effects of compost on plant growth. There is very little support provided, so students and teachers must design and collect data on their own. (<http://compost.css.cornell.edu/ResearchIdeas.html>)

**Build a classroom or home bioreactor:** The Cornell University composting Web site details "Building a Two-Can Bioreactor", for use at home or in a classroom, from a 32-gallon and a 20-gallon plastic garbage can. Students could build and operate the bioreactor at school, use the leachate and compost produced in a garden, and test variations on the design. (<http://compost.css.cornell.edu/garbagecans.html>)

# References

**The references below can be found on the *ChemMatters* 30-year DVD, which includes all articles
published from the magazine’s inception in October 1983 through April 2013; all available Teacher’s Guides, beginning February 1990; and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [**http://ww.acs.org/chemmatters**](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab to the left, directly under the “*ChemMatters Online"* logo and, on the new page, click on “Get the past 30 Years of *ChemMatters* on DVD!” (the icon on the right of the screen)**

**Selected articles and the complete set of
Teacher’s Guides for all issues from the past three
years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMatters Online”*.**

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 Instead of using plastic bags made from petroleum (which do not decompose readily), scientist are researching the use of polylactic acid (PLA) synthesized from corn for a bioenvironmentally-degradable polymer that can be composted. The article discusses how a variety of PLA products can be better for the environment because they will break down or compost in landfills. (Black, H. Putting a High Grade on Degradables. *ChemMatters*, 1999, *17* (2), pp 14–15)

 A more recent article from April 2010, "Plastics Go Green", updates the use of plant-based plastics including polylactic acid (PLA) to replace petroleum-based polymers and includes an activity for making your own compostable plastic with cornstarch. One section of this article is devoted to composting bioplastics and discusses the compostable PLA plastic. (Washam, C. Plastics Go Green. *ChemMatters*, 2010, *28* (2), pp 10–12)

 The April 2012 Teacher's Guide for "Microbes and Molasses: A Successful Partnership" Includes information on composting as a simple method of bioremediation in the “Background Information” "More on bioremediation" section. The “In-Class Activities” section of the article includes links to the breakdown (composting) of motor oil, starch, and anaerobic fermentation.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 The process of co-composting is important for managing huge volumes of cattle manure throughout the world. This article describes working with various animal manures, as well as municipal solid waste, and sludge from waste water treatment. Anwar, J.; et al. Characterization and Recycling of Organic Waste after Co-Composting—A Review. *Journal of Agricultural Science.* 2015, *7* (4), pp 68–79.

 This publication reviews the existing literature on compost leachates, including the chemical and physical properties of the leachates, and provides a discussion of the chemical and physical properties of the composting feedstocks, the compost, and the compost leachate. A brief summary of the biochemical processes occurring in composting, and environmental considerations are included in the report. (Chatterjee, N.; et al. *Chemical and Physical Characteristics of Compost Leachates—A Review*. Washington State University: Puyallup, WA, 2013). This publication is also available online at <https://www.wsdot.wa.gov/research/reports/fullreports/819.1.pdf>.

# Web Sites for Additional Information

**Composting at home**

 The U.S. Environmental Protection Agency (EPA) provides information for "Composting at Home". Sub-sections include “Composting Basics”, “Benefits of Composting”, and “How to Compost at Home”. (<https://www.epa.gov/recycle/composting-home>)

 The Home Composting Made Easy Web site contains sections on "Why Compost”, “Setting up Your System", "Composting Basics", "How to Compost", "Compost Problems", plus "Links & Resources". Sub-sections within these sections provide readers with information, pictures, and practical suggestions. (<http://www.homecompostingmadeeasy.com/compostsystems.html>)

**Composting at school**

 Cornell Composting is a bonanza of information, activities, and references centered on composting. The introduction page includes links to "Science and Engineering", "Composting in Schools", and "Composting Fact Sheets". (<http://compost.css.cornell.edu/index.html>)

 “Composting for Students and Teachers” is a Web page from the US Composting Council with resources and descriptions of links for further information on various aspects of composting. Not all activities are aimed at high school, but many are appropriate. (<https://compostingcouncil.org/composting-for-teachers-and-students/>)

**Composting food wastes**

 Charles Vigliotti plans to use New York City food waste to fuel his private anaerobic composter on Long Island. He started with aerobic composting techniques, but the volume of waste as well as the odors and pests have convinced him to build a multi-million dollar anaerobic facility to process food wastes. (<https://www.nytimes.com/2017/02/15/magazine/the-compost-king-of-new-york.html?_r=0>)

 The U.S. EPA has a robust composting Web site, "Reducing the Impact of Wasted Food by Feeding the Soil and Composting". This site has information on backyard composting, as well as organizational, business, and community composting. (<https://www.epa.gov/sustainable-management-food/reducing-impact-wasted-food-feeding-soil-and-composting>)

**The problems of food waste**

 Why is nutritious food being thrown out? "Farm toLandfill: The Cost of Food Waste in America" hopes to enlighten readers on why 40% of the food that is produced in the U.S. is never consumed. (<http://www.huffingtonpost.com/entry/farm-to-landfill-the-cost-of-food-waste-in-america_us_57c56101e4b0c936aababbed>)

 "Food Wastage Footprint: Impacts on Natural Resources"is a report from the Food and Agriculture Organization (FAO) of the United Nations that details the environmental impact of wasted food along the entire food chain for the world. The carbon and water footprints of food production are addressed in the extensive report. (<http://www.fao.org/docrep/018/i3347e/i3347e.pdf>)

**Municipal solid food waste**

 *Municipal Solid Waste (MSW) Composting Fact Sheets* is a part of the wealth of resources on the Cornell Composting Web site. The seven fact sheets in this series include "Physical Processing", "Biological Processing", "Strategies for Separating Contaminants", "Potential Effects of Heavy Metals on Plants and the Environment", "Issues in Risk Assessment", "Issues in Policy and Regulation", and "Key Aspects of Compost Quality Assurance/Composting Resources". A "Composting Glossary" is included on the Web site as an extra. (<http://compost.css.cornell.edu/MSWFactSheets/msw.fs.toc.html>)

 *Overview of Food Waste Composting in the U.S.* presents a comprehensive overview of the quantity, sources, and challenges of dealing with food waste in the U.S. Different methods of processing the wasted food are described, with examples of places where the methods are in use. (<http://www.seas.columbia.edu/earth/wtert/sofos/Ulloa_Food%20Waste%20Composting_EEC_July2008.pdf>)

**The chemistry of composting**

 **"**Basic Principles of Composting" is a 12-page publication from the Louisiana State University Agricultural Center that explains the chemical factors involved in composting, including oxygen, temperature, moisture, nutrients, pH, and time. Equations for determining the optimal mix of carbon, nitrogen, and water are provided. (<http://seafood.oregonstate.edu/.pdf%20Links/Basic-Principles-of-Composting-LSU.pdf>)

 "Compost Quality Analysis" provides information from the analysis of common home-produced compost in the United Kingdom. The chemical characteristics of home compost are thoroughly discussed, charted, and analyzed in the two-year study. (<http://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/environmental-and-water-resource-engineering/ecwm/phase-1/Section-6.PDF>)

**Methane**

 "Main Sources of Methane Emissions" provides an overview of the sources of the potent greenhouse gas methane in our environment. Pie charts of human and natural sources of methane clarify the problem. The issue of methane from landfills and wastes is addressed. (<https://whatsyourimpact.org/greenhouse-gases/methane-emissions>)

 "Greenhouse Gases and the Role of Composting: A Primer for Compost Producers" is a factsheet from the U.S. Composting Council. This publication looks at the relationship between composting and greenhouse gases, including methane. (<https://compostingcouncil.org/wp-content/uploads/2016/05/GHG-and-Composting-a-Primer-for-Composters-final.pdf>)

# About the Guide

Teacher’s Guide team leader William Bleam and editors Pamela Diaz, Steve Long and Barbara Sitzman created the Teacher’s Guide article material.

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Articles from past issues of *ChemMatters* and related Teacher’s Guides can be accessed from a DVD that is available from the American Chemical Society for $42. The DVD contains the entire 30-year publication of *ChemMatters* issues, from February 1983 to April 2013, along with all the related Teacher’s Guides since they were first created with the February 1990 issue of *ChemMatters*.

The DVD also includes Article, Title, and Keyword Indexes that cover all issues from February 1983 to April 2013. A search function (similar to a Google search of keywords) is also available on the DVD.

The *ChemMatters* DVD can be purchased by calling 1-800-227-5558. Purchase information can also be found online at <http://tinyurl.com/o37s9x2>.