COLUMBIA UNIVERSITY
School of Professional Studies

Master of Science in Sustainability Management

**Solid Waste Management PS5210**
**Tuesday 6:10 pm – 8:00 pm**
**3.0 credits**


| | |
|---|---|
| **Instructor:** | Haralambos V. Vasiliadis, Ph.D., P.E., DEE, D.WRE, CIH<br>917.488.0507<br>hv2202@columbia.edu |
| **Office:** | Conference Room B17 North at 2929 Broadway (between 114th and 115th Streets) |
| **Office Hours:** | Tuesday 6:30 pm - 8:00 pm – by appointment only |
| **Response Policy:** | Call me, text me, or email me preferably Monday thru Friday from 11:00 a.m. to 1:00 p.m. and from 3:00 p.m. to 4:00 p.m. I will respond typically within 24 hours |
| | |
| **F/TA:** | [Name, title, email address and phone number] |
| **Office Hours:** | [Time and location] |
| **Response Policy:** | [Include a statement about your preferred means of communication and when students should expect a response from you. Will you be available 24/7 or during the workweek only? Will you generally respond within 12 or 24 hours?] |


## Course Overview

The course covers management aspects of solid waste:

(a) Course overview

The main topics covered in this course include generation of solid waste in municipal, commercial and industrial sectors with proper identification and characterization of various waste streams involved with emphasis on waste prevention in terms of mass, volume and toxicity at the source, along the processing phase and at the disposal facility, as well as waste minimization by waste reuse and recycling in major commercial and industrial sectors (such as paper, glass, plastics, metals, wood, tire, electronics and construction/demolition wastes) including analysis of state-of-art technologies.

In addition, various collection and transport methods are covered along with all typical disposal methods, including incineration, sanitary landfill, composting, recovery and reutilization. Economic evaluations of factors affecting selection of disposal methods and its impact of reuse/recycling along with all applicable local, state and national legislative trends and regulatory requirements.

Furthermore, examples of public and private reuse and recycling programs in New York City are covered.

Finally, sustainability-related topics are covered, including, but not limited, to:

- Impact of reuse and recycling of wastes on $CO_2$ emissions, urban sustainability and global warming.
- Impact on waste quantities and characteristics due to urbanization, climate change, (national) wealth, life-style, consumption patterns and cultural behavior.
- Innovative eco-centered waste management methods and state-of-the art technologies used to process materials for reuse and recycling

(b) The course is an elective offering in the MS in Sustainability Management program. The course will be opened, space-permitting, to cross-registrants from other fields and/or Columbia University programs including the broader School of Professional Studies, School of International and Public Affairs and Graduate School of Arts and Sciences.

(c) Larger programmatic goals: …

## Learning Objectives



Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition,** Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3.
Available as an E-Book from Wiley at: https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493

By the end of this course, all students should be able to:

- Demonstrate a broad understanding of the solid waste issue, perceive it as a critical sustainability issue, make inference through critical thinking and be able to implement an effective reusing and recycling plan in the municipal, commercial, and industrial sectors. [L1]
- Examine real-life applications where each person can have a noticeable contribution in addressing the solid waste issue by considering/adopting primarily the "5R" approach/policy: Reducing, Reusing, Recycling (reprocessing and recovering), Rejecting solid waste and Reacting to solid waste (as needed). [L2]
- Analyze real-world case studies and compare the means and methods used to optimize the management of solid waste, and more particularly of recyclable wastes. [L3]
- Assess the environmental life cycle of materials. [L4]
- Compare technologies used to process materials for reuse and recycling in major sectors. [L5]
- Evaluate the environmental impact of solid waste applications. [L6]
- Relate and rate the specialized reuse and recycling programs in New York City and other cities in the US. [L7]

## Readings

The required core references and recommended ones are listed below.

*Core Texts:*

1. Sustainable Solid Waste Management: A Systems Engineering Approach, N-B Chang and A. Pires, IEEE/J. Wiley, Inc., 2015, ISBN: 9781-118-45691-0
2. Sustainable Solid Waste Management, J. W. C. Wong, R. Y. Surampalli, A, Selvam, R. D. Tyagi, ASCE, 2016
3. Handbook of Solid Waste Management, G. Tchobanoglous and F. Kreith, McGraw-Hill, Inc, 2nd Edition, 2002, ISBN: 0-07-135623-1
4. Disposal and Management of Solid Waste – Pathogens and Diseases, E. Epstein, Editor, CRC Press, 2015

*Other Readings (references 2-8 will be provided in electronic format):*

1. Introduction to Environmental Engineering, M. L. Davis and D. A. Cornwell, McGraw-Hill, 5th Edition, ISBN: 978-0-07-340114-0 – Ch 2: Materials Balances, Ch. 3: Risk Assessment, Ch. 11: Solid Waste Management, Ch. 12: Hazardous Waste Management
2. Life-Cycle Analysis of Integrated Waste Management, O. Parkes et al, Elsevier, 2015 (article)
3. Manual on Municipal Solid Waste Management, India, 2000
4. Municipal Solid Waste Management Manual, Part I, India, 2015
5. Solid Waste Disposal Facility Criteria – Technical Manual, EPA, 1993
6. Municipal Waste Management, United Kingdom, 2013
7. Solid Waste Landfill – Design Manual, Washington State, 1987
8. Waste Reduction Manual, Washington State, 1994

*Columbia University Information Technology*

Columbia University Information Technology (CUIT) provides Columbia University students, faculty, and staff with central computing and communications services. Students, faculty, and staff may access University-provided discounted software downloads (https://columbiait.onthehub.com/).

*Columbia University Library*

Columbia's extensive library system ranks in the top five academic libraries in the nation, with many of its services and resources available online: https://library.columbia.edu/.

*SPS Academic Resources*

The Office of Student Affairs provides students with academic counseling and support services such as online tutoring and career coaching: http://sps.columbia.edu/student-life-and-alumni-relations/academic-resources.

## Course Requirements (Assignments)

Each student should write an essay for one of the following four (4) case studies and for one of the following five (5) research topics. Other case-studies and/or reading assignments could be proposed.

*Case Studies:*

1. Is America drowning in garbage? Now robots are being on duty to help solve the recycling crisis. The U.S. is facing a recycling crisis that is burying cities and towns in tens of millions of tons of garbage a day. The situation is dire for many cities and towns as recycling costs skyrocket, so more garbage is ending up in landfills and incinerators. Companies and municipalities are turning to AI-assisted robots to help sort garbage in recycling plants. Will this AI-assisted approach help in the positive direction? [www.cnbc.com – "America is drowning in garbage…"]
2. Is Japan's recycling system the most complicated in the world? It sure feels like it sometimes. For example, household waste must of course be separated into burnable and non-burnable, but after that there's a dizzying array of recycling categories to break your non-burnables into. Since Japan is a relatively small country without masses of land to use for burying waste, the vast majority of waste used to be incinerated. However, due to increasing ecological awareness, new legislation attempts to minimize the amount of waste being burnt and promote recycling. The problem lies not only in the array of recycling categories, but also in the apparent overlap between them: the grey areas. What is the reasoning behind this? [soranews24.com – "Recycling in Japan…"]
3. An African city is turning a mountain of trash into energy. Could this turn one of Africa's most challenging social problems, the management of waste, into a source of new wealth? [weforum.org – "This African city is turning a mountain of trash into energy"]
4. Compare the option of allowing residents to enter into individual contracts with haulers on a household-by-household basis (i.e., unregulated solid waste collection and transportation) against a citywide pickup program with reference to a) cost and impact of transportation, b) lack of official waste quantity generation estimates, c) control of disposal and overall ultimate management methods and practices, etc. [https://www.minnpost.com/metro/2019/09/st-pauls-epic-fight-over-trash-collection-explained/]

*Research Topics:*

1. Solid waste treatment and disposal: effects on public health and environmental safety, Hamer G., 2003 - https://www.ncbi.nlm.nih.gov/pubmed/14623044
2. Waste Mismanagement in Developing Countries: A Review of Global Issues, Navarro Ferronato and Vincenzo Torretta, 2019 - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6466021/
3. Solid Waste Management in Developing Countries: Status, Perspectives and Capacity Building, L.F. Diaz, CalRecovery, Inc., Concord, California USA, Intergovernmental Preparatory Meeting for CSD-19, United Nations Headquarters, New York, USA -- March 3, 2011 - https://sustainabledevelopment.un.org/content/documents/ldiaz.pdf
4. A Systems Approach to Community Engaged Solid Waste Management, Rachael Marshall, 2013 - https://ec.europa.eu/echo/files/evaluation/watsan2005/annex_files/WEDC/es/ES07CD.pdf
5. RCRA's Critical Mission & the Path Forward, 2015 - https://www.epa.gov/sites/production/files/2015-09/documents/rcras_critical_mission_and_the_path_forward.pdf

Student should use at least 3 references to complete each task. Both essays will be presented by each student on the day of the final exam. Electronic copies of the essays and presentations (both in editable and pdf format) should be submitted prior to the final presentation. Periodic meetings to evaluate the status and potential of each essay are highly recommended. A "mid-term" evaluation will be conducted



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## Evaluation/Grading

The final grade will be calculated as described below:

FINAL GRADING SCALE

| Grade | Percentage |
|---|---|
| **A+** | 98–100 % |
| **A** | 93–97.9 % |
| **A-** | 90–92.9 % |
| **B+** | 87–89.9 % |
| **B** | 83–86.9 % |
| **B-** | 80–82.9 % |
| **C+** | 77–79.9 % |
| **C** | 73–76.9 % |
| **C-** | 70–72.9 % |
| **D** | 60–69.9 % |
| **F** | 59.9% and below |

| ASSIGNMENT | % Weight |
|---|---|
| Participation | 10 |
| Case Study assignment progress | 10 |
| Case Study assignment mid-term presentation and report | 15 |
| Case Study assignment final presentation and report | 20 |
| Research assignment progress | 10 |
| Research assignment mid-term presentation and report | 15 |
| Research assignment final presentation and report | 20 |

## Course Policies

*Participation and Attendance*

You are expected to complete all assigned readings, attend all class sessions, and engage with others in online discussions. Your participation will require that you answer questions, defend your point of view, and challenge the point of view of others. If you need to miss a class for any reason, please discuss the absence with me in advance.

*Late work*

Work that is not submitted on the due date noted in the course syllabus without advance notice and permission from the instructor will be graded down 1/3 of a grade for every day it is late (e.g., from a B+ to a B).

*Citation & Submission*

All written assignments must use [citation format], cite sources, and be submitted to the course website (not via email).

## School Policies [Include all school/university policies as written below.]

*Copyright Policy*

Please note—Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.



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*Academic Integrity*

Columbia University expects its students to act with honesty and propriety at all times and to respect the rights of others. It is fundamental University policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University community is unacceptable and will be dealt with severely. It is essential to the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based. Academic honesty in class assignments and exams is expected of all students at all times.
SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and

Community Standards posted at http://sps.columbia.edu/student-life-and-alumni-relations/academic-integrity-and-community-standards. You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

*Accessibility*

Columbia is committed to providing equal access to qualified students with documented disabilities. A student's disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website: https://health.columbia.edu/services/ods/support.

*Class Recordings*

All or portions of the class may be recorded at the discretion of the Instructor to support your learning. At any point, the Instructor has the right to discontinue the recording if it is deemed to be obstructive to the learning process.
If the recording is posted, it is considered confidential and it is not acceptable to share the recording outside the purview of the faculty member and registered class.

## Course Schedule/Course Calendar

| No | Date | Topic (T), learning objectives [L#], reading assignment (R) and pertaining questions (Q) |
|---|---|---|
| 1 | 2020.01.23 | T: Integrated solid waste management (ISWM), sources and quantities [L1, L2]<br><br>R: Chapter 1 of Textbook No. 1, Chapter 1 of Textbook No. 2<br><br>Q: What is the distinction between materials and wastes? Are materials reusable, recovered, recyclable, etc. and wastes discarded, abandoned, burned/incinerated, etc.? Is ISWM a comprehensive and effective program to protect human health and the environment? What are the major activities involved in ISWM and what is required to make this program comprehensive and effective? |
| 2 | 2020.01.30 | T: Federal, State and City/Local legislation, (i.e., RCRA, CERCLA, TSCA, etc.) [L1]<br><br>R: Chapter 4 of Textbook No. 1<br><br>Q: Is the SW-related legislation really complicated? Is full compliance with all applicable rules and regulations feasible? Are there grey areas? Could legislative evaluation and oversight improve the legislative decision-making process by providing information about the performance of agencies and programs? Could updating the solid waste laws solve problems related to financing, enforcement, public awareness, definitions, roles/responsibilities, etc.? |
| 3 | 2020.02.06 | T: Types and characteristics of waste streams [L1] |



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| | | |
|---|---|---|
| | | R: Chapter 2.1 – 2.4 of Textbook No. 1, Chapter 2 of Textbook No. 2, Reference 1<br><br>Q: How critical is the lack of accurate and reliable data and analytics in all phases of solid waste management? |
| 4 | 2020.02.13 | T: Management of RCRA-regulated hazardous and universal wastes, TSCA-regulated wastes (PCBs, Asbestos, etc.), special wastes [such as, batteries, used oil, scrap tires, construction and demolition debris (C&D), computer (e-waste) and other electronic solid wastes (e-waste), household hazardous wastes, biosolids, etc.], as well as healthcare/medical and radioactive wastes, etc. [L1]<br><br>R: Chapter 2.5 of Textbook No. 1, Chapters (Introduction and Conclusions) 12, 13, 14, 15 and 16 of Textbook No. 2, Chapters 10 (entire chapter) and 11 (description and characteristics only of various Special Wastes) of Textbook No. 3, and HV Notes - [for healthcare/medical waste: Textbook No. 4 and for radioactive waste: 10 CFR Part 20 and HV Notes]<br><br>Q: Why are there so many toxic household products (biocides, bleaches, paints, etc., including prescription and OTC drugs) and how do they expect us to manage them properly? |
| 5 | 2020.02.20 | T: Collection and transportation of solid waste [L1]<br><br>R: Chapters (selected topics) 15 and 19 of Textbook No. 1, Chapter 3 of Textbook No. 2, and Chapter 7 of Textbook No. 3<br><br>Q: Could system analysis methods and optimization techniques in conjunction with real-time GPS systems improve the overall performance? |
| 6 | 2020.02.27 | T: Source quantity and toxicity reduction (including reuse) [L5]<br><br>R: Chapter 4 of Textbook No. 2, Chapter 6 of Textbook No. 3, Reference 8<br><br>Q: How can I reduce my trash? Are there any practical and effective ways? Is there a promising outcome by doing this? |
| 7 | 2020.03.05 | T: Recycling and markets and products for recycled materials [L1, L2]<br><br>R: Chapter 17 of Textbook No. 1, Chapter 5 of Textbook No. 2, Chapters 8 and 9 of Textbook No. 3<br><br>Q: Is public awareness of the need to recycle high? Does the public experience “grey areas”? For example, is an empty pizza box considered recycled paper? Or is it burnable? Paper packages? “Other”? And if a bottle is made of a different type of plastic to the standard PET, is still a “pet bottle”, or is it just “plastic”? Why is it hard to recycle given that many municipalities complain that residents fail to participate? Is recycling really effective? What are we doing with the recycled material? How can we balance the demand and supply of recycled materials? What is the right method to recycle? Are we doing the right thing? |
| 8 | 2020.03.12 | **Mid-term evaluation of Case Study and Research Topic assignments** |
| -- | 2020.03.19 | Spring Recess [Mon. March 16, 2020 to Friday, March 20, 2020] |
| 9 | 2020.03.26 | T: Composting [L1, L2]<br><br>R: Chapters 8 and 9 of Textbook No. 2, Chapters 12 (12.1, 12.5 and 12.7) and 15 (15.1 – 15.3) of Textbook No. 3, Reference 1<br><br>Q: Why composting sounds such a promising management method but it is not becoming popular? |
| 10 | 2020.04.02 | T: Incineration: waste-to-energy combustion and emission control [L1, L2]<br><br>R: Chapter 17 of Textbook No. 1, Chapter 7 of Textbook No. 2, Chapter 13 of Textbook No. 3, Reference 1<br><br>Q: Why European countries have an extensive incineration program compared to US? |
| 11 | 2020.04.09 | T: Land disposal: Landfilling [L1, L2] |

| | | |
|---|---|---|
| | | R: Chapter 18, 19 and 20 of Textbook No. 2, Chapter 14 of Textbook No. 3, Reference 1 and 7<br><br>Q: Is there a real issue with landfills? Are we running out of space? Are the issues related to toxins, leachates (i.ee., groundwater contamination), greenhouse gases (methane gas formation and mitigation), disease vector hazards, etc. from landfills really critical? What are the economic and environmental issues of landfills? Is "not in my backyard (NIMBY)" a real politico-social issue and is this opposition play a significant role in stakeholders decision making? Is it an unsustainable form of waste management? What are the 7 federal and the 6 performance-based criteria for municipal solid waste landfills? |
| 12 | 2020.04.16 | T: Social and economic concerns, Risk assessment and management, and Life-cycle analysis (LCA) [L1, L2, L6]<br><br>R: Chapters 3, 5 and 10 of Textbook No. 1, Chapter 22 of Textbook No. 2, Chapter 16 of Textbook No. 3, References 1 and 2<br><br>Q: What types of improvement are required at each phase of a LCA, which stands as the pre-eminent tool for estimating environmental effects caused by products and processes from 'cradle to grave' and despite its popularity and codification by organizations, to address individual problems, to bridge existing gaps, to overcome limitations, to address current challenges (such as allocation, uncertainty, biodiversity, etc.) as well as to provide a unified treatment in order to achieve a robust, sustainable and credible use of LCA? |
| 13 | 2020.04.23 | T: Innovative approaches to solid waste management [L3, L7]<br><br>R: Chapters 6, 7 and 8 of Textbook No. 1, HV Notes<br><br>Q: NYC Department of Sanitation's "Zero Waste Initiative: NYC's ambitious goal to send zero waste to landfills by 2030, knowing that about a third of New Yorkers' waste can be recycled through the City's curbside recycling program, another third can be recovered through the City's organics programs, and another 10% (textiles, electronic waste, harmful household products, and plastic bags) can be diverted through donations and take-back programs. Instead of sending trash to a far-away landfill or incinerator, pledge to reduce, reuse, and recycle!" Is such an initiative ambitious? Is it realistic and feasible? |
| 14 | 2020.04.30 | T: A holistic approach for sustainable material management (SMM) [L1, L2, L6]<br><br>R: Chapters 13, 14, 16 and 18 of Textbook No. 1, HV Notes<br><br>Q: Is EPA transitioning from focusing on integrated solid waste management (ISWM) to focusing on sustainable materials management (SMM), which refers to the use and reuse of materials across their entire life cycle in order to conserve resources, reduce waste, and minimize the environmental impacts of materials? Could this transitioning achieve solid waste management is a sustainable manner? What does sustainability mean in this case? Sustain what? |
| -- | 2020.05.07 | Last day of classes: Monday, May 04, 2020<br>Study Days: Tuesday, May 05, 2020 to Thursday, May 07, 2020 |
| **15** | **2020.05.14** | **Final Exam [Friday, May 08, 2020 to Friday, May 15, 2020]– Presentation of Essays** |

## School Policies and Expectations:

1. Academic Integrity – Full compliance with the Code of Academic and Professional Conduct is required. Any violations will be reported to the Associate Dean for Students Affairs. The Code of Academic and Professional Conduct can be viewed online:

   http://sps.columbia.edu/student-life-and-alumni-relations/academic-integrity-and-community-standards

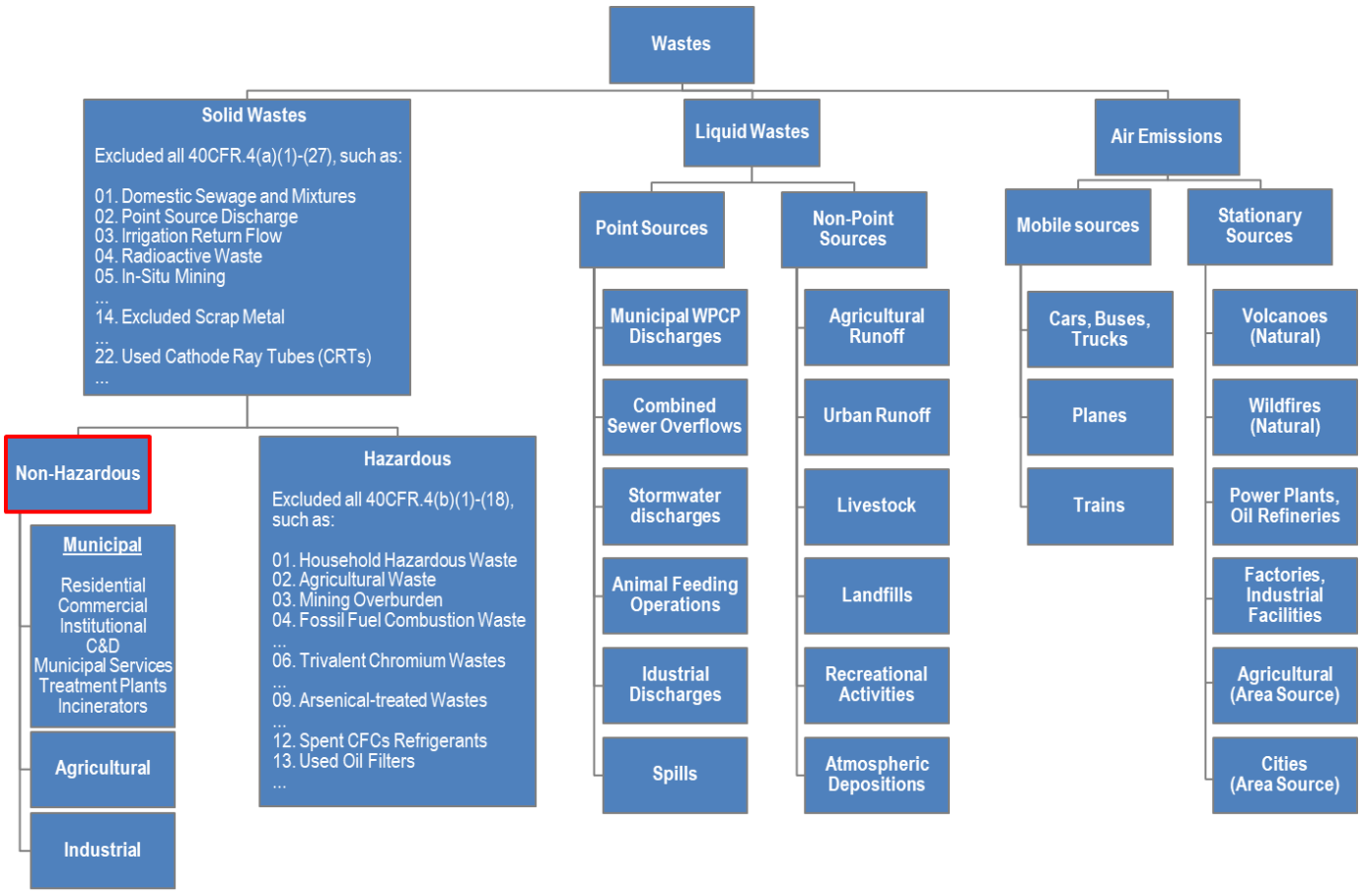
2. Accessibility Statement – Columbia University is committed to providing equal access to qualified students with documented disabilities. For more information regarding this service, please visit the University's Health Services website:

   http://health.columbia.edu/disability-services

## Background:

A **solid waste** is any discarded material (abandoned, recycled, considered inherently waste-like, or military munition). As per NYS DEC, solid waste is any garbage, refuse, sludge, etc. and other discarded materials including **solid, semi-solid, liquid, or contained gaseous material**, resulting from municipal, commercial, industrial, mining and agricultural activities and operations. Other types of wastes are liquid wastes (from point and non-point sources), air emissions (from mobile sources or stationary sources, and other types of wastes, such as healthcare/medical and radioactive wastes.

Other types of wastes are **liquid wastes** (from point and non-point sources) and **air emissions** (from mobile sources or stationary sources. A waste classification is shown below.




In US, on average, we recover (through recycling and composting) 1.51 pounds (34.3%) of our individual waste generation of **4.40 pounds per person per day**. In 2013, Americans generated about **254 million tons of trash** and recycled and composted about 87 million tons of this material. Improperly managed solid waste poses a risk to human health and the environment, it may result in safety hazards from fires or explosions, and increases greenhouse gas (GHG, such as water vapor, carbon dioxide, methane, nitrous oxide, and ozone) emissions which contribute to climate change.



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**Solid waste management (SWM)** has been an integral part of every human society. As per US-EPA, SWM is a challenge because waste generation increases with population expansion and economic development. Improperly managed solid waste poses a risk to human health and the environment. Uncontrolled dumping and improper waste handling causes a variety of problems, including contaminating water, attacking insects and rodents, and increasing flooding due to blocked drainage canals or gullies. In addition, it may result in safety hazards from fires or explosions. Improper waste management also increases greenhouse gas (GHG, such as water vapor, carbon dioxide, methane, nitrous oxide, and ozone) emissions which contribute to climate change. Planning for and implementing a comprehensive program for waste collection, transport, and disposal – along with all activities to prevent or recycle waste- can eliminate these problems.

**Integrated Solid Waste Management (ISWM)** is a comprehensive a) waste prevention, b) waste recovery (recycling and composting), and c) disposal (incineration and landfilling) program to protect human health and the environment. An effective ISWM system considers how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment. ISWM involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions. The major ISWM activities are waste prevention, recycling and composting, and combustion and disposal in properly designed, constructed, and managed landfills. Each of these activities requires careful planning, financing, collection, and transport. The concept of ISWM can be summarized as:

**ISWM = [Waste Prevention] + [ Recycling and Composting] + [Disposal: Combustion and Landfilling]**

a. **Waste Prevention**. Waste prevention (also called "source reduction") seeks to prevent waste from being generated. Waste prevention strategies include using less packaging, designing products to last longer, and reusing products and materials. Waste prevention helps reduce handling, treatment, and disposal costs and ultimately reduces the generation of methane.
b. **Recycling and Composting**. Recycling is a process that involves collecting, reprocessing, and/or recovering certain waste materials (e.g., glass, metal, plastics, paper) to make new materials or products. Some recycled organic materials are rich in nutrients and can be used to improve soils. The conversion of waste materials into soil additives is called composting. Recycling and composting generate many environmental and economic benefits. For example, they create jobs and income, supply valuable raw materials to industry, produce soil-enhancing compost, and reduce greenhouse gas emissions and the number of landfills and combustion facilities.
c. **Disposal (landfilling and combustion)**. These activities are used to manage waste that cannot be prevented or recycled. One way to dispose of waste is to place it in properly designed, constructed, and managed landfills, where it is safely contained. Another way to handle this waste is through combustion. Combustion is the controlled burning of waste, which helps reduce its volume. If the technology is available, properly designed, constructed, and managed landfills can be used to generate energy by recovering methane. Similarly, combustion facilities produce steam and water as a byproduct that can be used to generate energy.

Whereas, ISWM is based on the "cradle-to-grave" concept (considering the entire life-cycle analysis and assessment of a product from the stage of selecting the raw materials for the manufacturing of such product to the final disposal of it), **sustainable ISWM** should be viewed as a humanity's target goal of establishing/maintaining a human-ecosystem equilibrium (homeostasis). Furthermore, **holistic approaches** should be considered as attempts to recognize the interconnectedness of various components and aspects that form the larger system, such technical and environmental, economic and social, and political and cultural.

A **holistic approach for sustainable ISWM** planning process is shown below:



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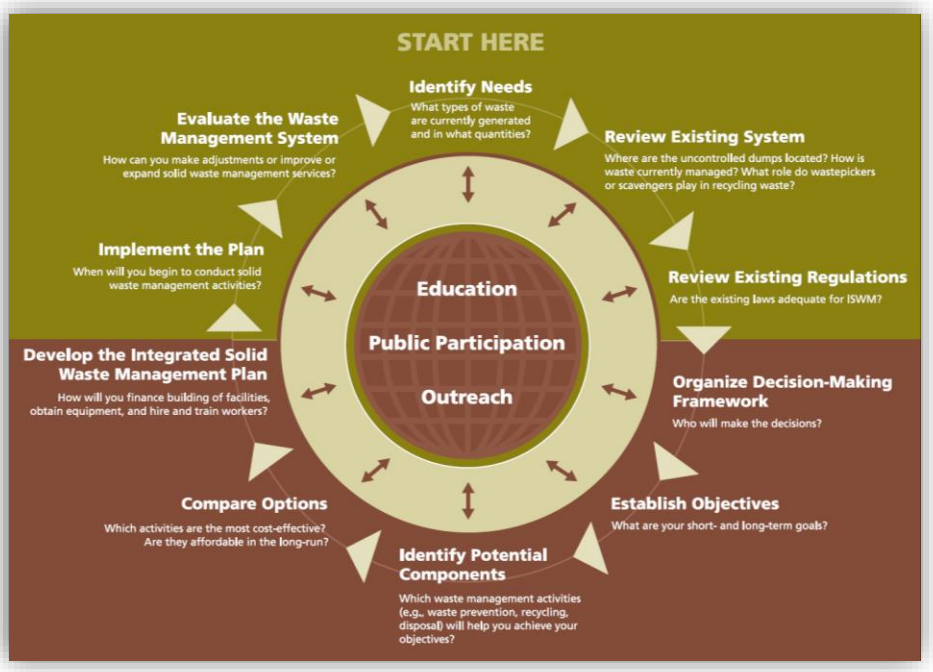


To address the global and local impacts of waste generation and disposal, sustainable waste management systems must be planned, developed, and operated within the framework of local resource availability, social participatory approaches, economics, and environmental concerns. A sustainable solid waste system may support cities to deliver a **holistic approach** to waste management operations through improved disposal, collection and transportation, better recycling, organics utilization, landfill diversion and alternative disposal. By understanding the benefits and disadvantages of various management technologies, local decision makers can best allocate resources, select processes and vendors, and develop policies and procedures to meet the community's needs while reducing emissions.

Most of the latest efforts focus on "**Zero Waste**" and/or "**Zero Landfilling**" which is certainly expensive for weaker economies, yet a challenge for stronger ones. The **NYC Department of Sanitation (DSNY)**, which is the world's largest sanitation department, collects more than 10,500 tons of residential and institutional garbage and 1,760 tons of the recyclables each day. While efficiently managing solid waste and clearing litter or snow from 6,300 miles of streets, DSNY is also a leader in environmentalism committing to sending zero waste to landfills by 2030.



Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition,** Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3.
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