EDUCATIONAL ACTIVITY KIT

A FLUSH AWAY FROM THE FIELD

Grade 7 to 9 and Grades 11 and 12
(Secondary Cycle 1 and up)

Agriculture is a necessary activity that allows us humans to meet our needs for food, fuel, fibre and even medicine. But what kind of impact does cultivating land and raising livestock have on the environment? Can potential negative impacts be reduced or mitigated?

This series of inquiry based activities helps students understand the less obvious connections between our everyday lives and farming, while developing critical thinking and research skills.

Science and Society

Appendices

The Museum would like to thank Environment and Climate Change Canada for its contributions towards updating this Educational Activity Kit.

Ingenium

CANADA AGRICULTURE AND FOOD MUSEUM
MUSÉE DE L'AGRICULTURE ET DE L'ALIMENTATION DU CANADA

Canada

A FLUSH AWAY FROM THE FIELD

Exploring the Risks and Benefits of Using Municipal Biosolids in Agriculture

Did you know that sewage wastes coming from your home could be helping a farmer grow food?

Municipal biosolids, the by-product of wastewater treatment, are a valuable input on agricultural fields. This "human manure" is rich in **organic matter** and **nutrients**, which help enrich the soil and feed crops and soil life. However, biosolids can contain low concentrations of substances that are known **environmental pollutants**, and their use is heavily regulated. Though current research demonstrates that biosolids are safe to use in agriculture, some groups are still concerned about their long term effects on human and environmental health. Do the benefits of using this resource outweigh the risks? How does agricultural use of biosolids improve our environmental **sustainability**?

In this module, students will discover how wastewater treatment technology, environmental pollution and sustainable agriculture are interconnected. They will learn about the process used to clean pollutants from water, and discover a governmental initiative tracking pollutant releases across Canada. Finally, students will create a journalistic product and draw their own conclusions on the costs and benefits of using biosolids in agricultural fields.

Objective

These activities will help build students' ability to formulate questions, to find and filter information, to think critically and to present their findings to a specific audience.

Building up knowledge

The module consists of four parts, arranged in a sequence that encourages students to ask questions and develop their knowledge on the topic before integrating it in a final product.

Each part of the module may also be executed as a stand-alone activity.

Kickoff ***Waste and Pollution***

Spark curiosity and assess existing knowledge.

Part 1 ***Wastewater treatment***

Explore various online content to learn about the steps and by-products of water treatment technology.

Part 2 ***The National Pollutant Release Inventory***

Use a database to assess which pollutants wastewater treatment facilities report to the Government of Canada.

Part 3 ***Biosolids in agricultural fields: risks and benefits***

Gather information from various online sources and create a short journalistic product.

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Canada

SKIM THE SURFACE

Waste and Pollution

Nature does not waste. Elements which make up living things move through the Earth system and are recycled at every turn. This recycling of elements is vital for the functioning of ecosystems.

In this activity, students will reflect on how our consumption of natural resources creates wastes and pollution, and explore the ways we try to re-use this waste.

Students will understand that

-Human activity has an impact on the environment,
-Humans create many types of wastes,
-Pollution happens when human-made wastes contaminate the environment.

Learning methods

-Look at and discuss photographs of human environmental impact
-Brainstorm the ways we create waste at home
-Reflect on "pollution"

1. Spark curiosity with art

Edward Burtynsky is a Canadian photographer who documents the impact of human activity on the environment, through beautiful and powerful landscape imagery. His photographs show how we extract, transform and dispose of natural resources, changing the planet as we do so.

Invite students to **react** to a selection of photographs from his collection (suggestions on next page), found at www.edwardburtynsky.com/projects/photographs, and to **discuss** them together.

Guiding Questions

- What do you **see** in this photo?
- How does this photo make you **feel**?
- What do you think the artist was trying to **show** or **say**?
- **Imagine** humans disappeared from the planet, what would these scenes look like after one hundred years? One thousand years?

Image Suggestions (www.edwardburtynsky.com/projects/photographs)

Series	Photo Titles
Anthropocene	Dandora Landfill (#1, #3)
Oil	Oxford Tire Pile (#1, #5, #8 , #9ab); Sikorsky Helicopter Scrapyard; Jet Engines
China	China recycling (#8, #9, #12, #18, #22)
Tailings	Nickel Tailings (#30, #34-35)
Urban Mines	Densified Oil Filters #1; Densified Oil Drums #4; Ferrous Bushling (#7, #9, #17, #18)

2. Discuss—What is waste?

Lead a short discussion to help students reflect on the idea of waste.

Guiding questions:

- How would you **define** the word "waste"?
- How is waste **created**?
- Is there waste in **nature**?
- What does **decomposition** mean? What does **accumulation** mean?
- In what ways can waste be **useful**?
- How does nature deal with our waste? What are some **impacts** of our waste in the environment?
- Is waste produced in your home the same as waste produced by **industries, businesses and institutions**? How is it similar, how is it different?

3. Brainstorm—How do we waste?

Do a group brainstorm to help students understand how **waste is a product of our everyday lives**, and how we must find ways to **mitigate its spread and accumulation**, to avoid contaminating the environment.

a. Divide the class into smaller groups. Have students write down on sticky notes the different types of waste they produce at home, for example, "organics" or "food scraps". (One idea per sticky note)

Suggestion: Make a race out of it; the first group to come up with 5 categories wins.

b. Have students affix their sticky notes to a common wall or board. If students haven't come up with body waste and grey water, or sewage, as categories, hint them towards it. As a group, sort them into two categories: *re-used/recycled*, and *landfill/incinerated*.

⇒ most of the household wastes should be at least reusable. This gives the opportunity for a discussion on why we do not reuse or recycle all materials.

Suggestion: This can be a Venn diagram, as some items can be partly recycled, if disposed of properly, such as paints and electronics, or some items could be recycled but often aren't because it isn't practical or technology isn't widely adopted.

c. If time permits, try to identify your locality's recycling or reuse strategies for the waste categories identified, or ask students to do a quick internet search to fill their knowledge gaps.

Possible Answers (*generally speaking, does not represent the total range of wastes and fates*)

Type of household waste (what is it)	What to do with it (how does it get out of your home)	Possible fate (Where does it end up, its final destination)
Paper, cardboard, plastic, and metal (recyclables)	Put it in the recycling bin	Broken down and recycled into new products
Food scraps	Put it in compost bin or outdoor heap	Decomposed into compost used as fertilizer and soil conditioner in agriculture
Old electronics	Bring it to an electronics disposal centre	Useful materials separated and recycled into new products, proper disposal of the rest
Hazardous waste (paint, medicines, cleaning products, fertilizers, motor oil, fluorescent light bulbs, batteries…)	Bring to hazardous waste facilities	Recycled, incinerated (and energy produced), disposed of in engineered hazardous waste landfill facilities
Broken toys, furniture, worn textiles, building materials, soft plastics, broken glass…	Put in the garbage (typically), some can be recycled or reclaimed	Landfill, some can be recycled or upcycled
Grey water (shower, sink, washing machine…)	Goes in sewers or in a septic system	Cleaned and returned to the environment
Human body wastes	Flush it down the toilet, goes into sewers or septic system	Removed from the water, treated, then used as fertilizer on farms and in land reclamation, or incinerated / buried in landfills

4. Reflect

Present the idea that if not **reduced** at the source, **re-used** or **recycled** somehow, these wastes will enter and accumulate in the environment, creating pollution. Have the students share their thoughts on the following:

- What is pollution?
- Can you think of real world examples of pollution?
- Does all our waste pollute the same amount?
- How can Canadians reduce their waste?

GO WITH THE FLOW

Wastewater Treatment and Biosolids

By this point, students have a good idea of the impact humans can have on the planet. They know how we produce waste, and how we find ways to reuse some of it. Time to focus on a specific type of waste; municipal sewage.

Here, students learn about the process of wastewater treatment, its inputs and outputs, and seek out information on their community's biosolids re-use or disposal strategy.

Students will understand that

-Sanitation is an important technology that protects both human and environmental health
-Wastewater treatment plants remove many pollutants from wastewater
-The solids removed from wastewater can be safely reused in agricultural fields

Learning methods

-Explore web resources
-Draw a flowchart
-Watch a video
-Reflect on "pollution"

Wastewater Treatment

1. What do you know about sanitation?

Lead the activity by quickly researching the following questions with your students.

Guiding Questions

- What is a **sewer**? Does your home connect to one?
- How long ago did people **invent** sewers?
- What was city-life like before sewers and **water treatment**?
- Are there places in Canada and in the world where people don't have **sanitation**?
- Why is it important to have ways to contain and treat our **body wastes**?
- What do countries do when they don't have wastewater **infrastructure**?

Helpful Links

World Health Organization: Sanitation Factsheet bit.ly/2FTqqRp

Government of Canada: Threats to Ecosystems - Sewage Treatment bit.ly/2sUBOyZ

Canadian Public Health Association: Sewage and sanitary reformers vs. night filth and disease bit.ly/2sVYBQ1

2. Online search—Where does MY waste go?

Together, find the nearest wastewater treatment facility on an online map.

⇒ If you are in a rural or remote area without this infrastructure, discuss what happens to the body wastes and grey water that are produced in your community.

3. Flowchart—How is water cleaned?

Have students draw a diagram or flowchart of the movement of their wastewater through their local system, and back to the environment, including the steps involved in processing the water (it could be a septic field for rural students).

⇒ Explore the local water treatment facility's website to find information on how wastewater treatment technology works, or refer to the video presented below.

Biosolids

1. What does wastewater treatment have to do with agriculture?

a. Watch the following video by the *Water Environment Association of Ontario*.

Biosolids – Naturally Sustainable
(length: 18 min 37 sec)
www.weao.org/biosolids-video
see next page for summary of video

b. Take time to discuss the video. What are students' reactions to the information in the video? Do they have any concerns? What new information did they learn?

Guiding questions:

- What happens to the solid parts of **sewage**?
- What does research presented in the video say about the use of **biosolids** in agriculture?
- How do you feel about the idea of using **treated human waste** to feed crops ?

Video Summary: "Biosolids – Naturally Sustainable"

- **Sustainability** is about meeting our needs without compromising the needs of generations to come.
- We aim to **emulate nature** in the way we manage our waste.
- **Municipal biosolids**, an organic, nutrient rich material, can be reused in agriculture. If discharged to the environment untreated, it would cause problems.
- There are two major challenges: the **volume** of material (each household in Ontario produces 1.2 cubic meters of dry solids annually), and the **quality**.
- All products flushed down the toilet and poured into drains end up in **wastewater treatment facilities.**
- Scientists, agronomists, and human health experts are continuously **studying and monitoring** the process, striving to increase our understanding of biosolids and of any potential impacts of contaminants they contain.
- Researchers have studied specific constituents of biosolids, like nitrogen, phosphorus, pharmaceuticals, heavy metals (like lead cadmium and mercury), and personal care products, and the different streams these **contaminants** can take in the environment.
- They were able to detect **pharmaceuticals** in soil amended with biosolids at levels of 1 nanogram (one billionth of a gram) per litre, or 1 part per billion (1 ppb), which is like one drop in 20 Olympic sized swimming pools.
- Appling biosolids on fields had no impact on populations and avoidance behavior of **worms and springtails**.
- No measurable detrimental impacts on the environment when **best management practices** and **regulations** are strictly adhered to.
- Biosolids are tested and must meet **provincial standards** of quality stated in the *Ontario Nutrient Management Act.*
- Biosolids help farmers **increase their yields,** allow us to capture **carbon** and **nutrients**.

2. Investigate - In my backyard?

At this point, students might wonder if there are any biosolids applied in their communities. They may visit their municipality or city's website and see if there are any details on how their community deals with biosolids. Discuss the findings as a group.

⇒ Some cities are very proactive and open about the issue (such as the City of Ottawa), it might be more difficult to find information for smaller communities.

⇒ If there is no information available on the community's web site, students may search for any news articles on the topic, in their region.

⇒ Students in remote and rural communities can try to figure out the path their solid sewage takes in the environment.

A tractor injects liquid biosolids into the soil.

GOING DEEPER

The National Pollutant Release Inventory

The **National Pollutant Release Inventory** (NPRI) was launched in 1993 by the Government of Canada, and is a program of Environment and Climate Change Canada. The purpose of the NPRI is to **track polluting substances** that are released to the environment by various facilities across Canada. Facilities include businesses, industries and institutions. The registry currently tracks 300 pollutants of environmental and human health concern.

The information gathered from polluting facilities helps decision-makers to develop policies which **reduce risk for human and environmental health**. Reporting to the NPRI is mandatory, but the database does not represent the entirety of pollutants released in Canada as not all substances are tracked by the NPRI. Some facilities might not meet the requirements to report to the NPRI (ex: small wastewater treatment facility in rural area).

The data collected is **publicly available**. This information can be useful to research scientists in many different fields of study just as it can be to citizens seeking to better understand pollutant releases in their communities.

In this activity, students will learn how to use the NPRI to find information on pollutants released to the environment by wastewater treatment facilities in their communities and in Canada.

Students will understand that

-The Government of Canada keeps track of pollutants released to the environment
-Information on pollutants and their releases is available online
-Nitrogen, phosphorous and some heavy metals are pollutants wastewater treatment facilities remove from water

Learning methods

-Explore web resources
-Search for information in a web database
-Present findings to peers

Wastewater and the Environment in Canada

1. Introduce the **National Pollutant Release Inventory**

   Briefly explain the purpose of this government initiative and have students explore the "About the National Pollutant Release Inventory" section of the NPRI website to better understand the "who, what, when, why and how" of NRPI data collection.

   ⇒ Government of Canada – NPRI: About (bit.ly/2Us3f45)

2. Have students consult the NPRI **Sector overview on Wastewater** (bit.ly/2QJQYut)

   ⇒ You may also access it by going to canada.ca/NPRI, clicking on "Pollution Data and Reports" and then under "Reports", clicking "NPRI sector overview: wastewater"

Guiding questions

- Why is it important for the Government of a country to **track pollutants** released to the environment? How can it be useful?
- Do any other countries have a **similar program** in place?

  ⇒ France: Registre des émissions polluantes, U-S. :Toxic Release Inventory Program, Europe: European Pollutant Release and Transfer Register.

Explore the NPRI Database

Give students the **"How-To" handout** found at the end of this activity, which will lead them to the data search page (bit.ly/2SA2adc). Have them create a query to find out if their local wastewater treatment facility reports to the NPRI. If it's not the case, tell them to find the nearest reporting wastewater treatment facility.

⇒ Compare the data from your local wastewater treatment facility with that of a smaller or larger city.

⇒ Your local facility doesn't report to NPRI? You may find a clue as to why in the "Summary of Reporting Requirements" section of the website.

Guiding questions

- Which substances do wastewater treatment facilities **report** to the NPRI?
- Are the substances reported by facilities in **large urban centres** the same as in smaller communities? If there are differences, explain why that may be.
- Which of the reported substances could be **useful** in agriculture?
- Which of these substances **wouldn't** you want to add to agricultural soil?
  - ⇒ Important note: not all of the pollutants that are listed for a wastewater facility get into biosolids.

Short research and presentation

a. Divide the class in small groups and have them follow instructions in the "How-to" guide to find out details about the pollutants released by the facilities, and the types of releases.

b. Have students use their new NPRI database query skills to create a profile of one of the pollutants released by a wastewater treatment facility. They will present this pollutant to the rest of the class.

- ⇒ What is it (what class of chemical is it, appearance, chemical properties)
- ⇒ Where did it come from?
- ⇒ What are its environmental effects?
- ⇒ Are there any known effects on human health?
- ⇒ Are there any rules or laws in place to govern the use or release of this substance?
- ⇒ Include one fun fact about this substance (historical tidbit, something surprising, anecdote, etc…)
- ⇒ Any other pertinent information

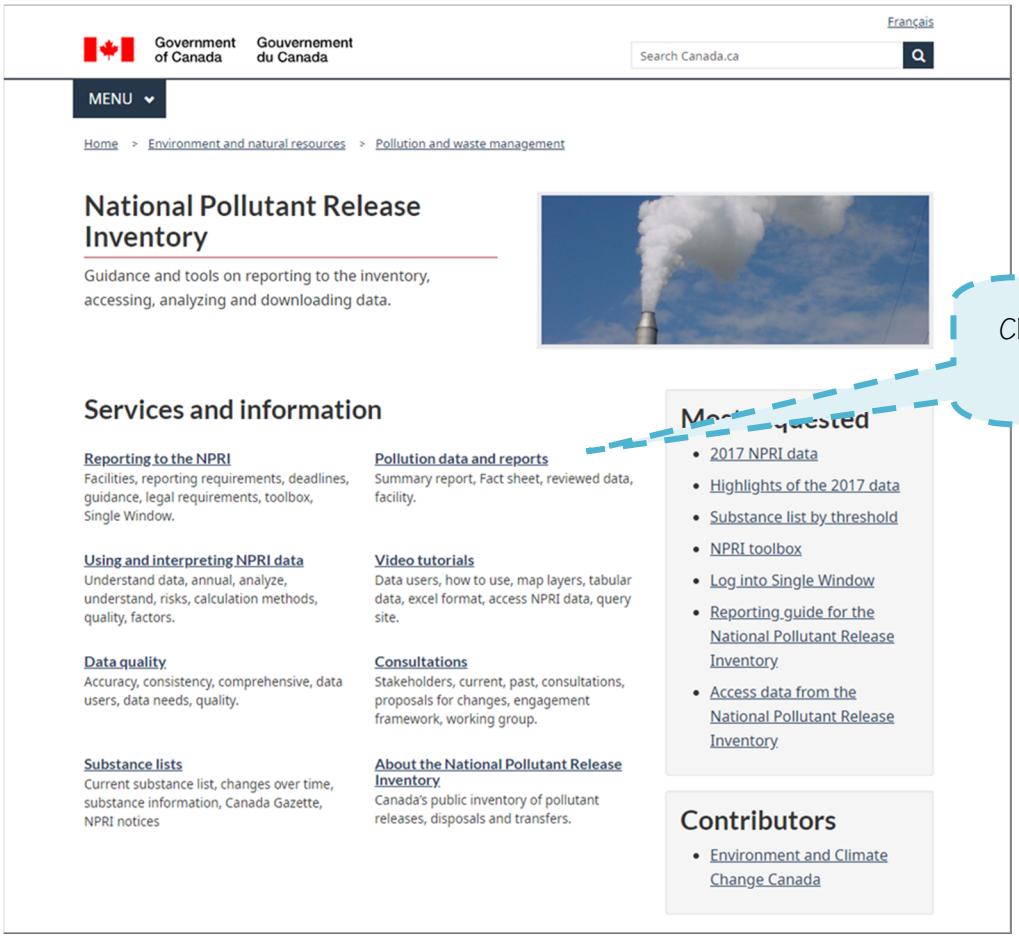
HOW-TO

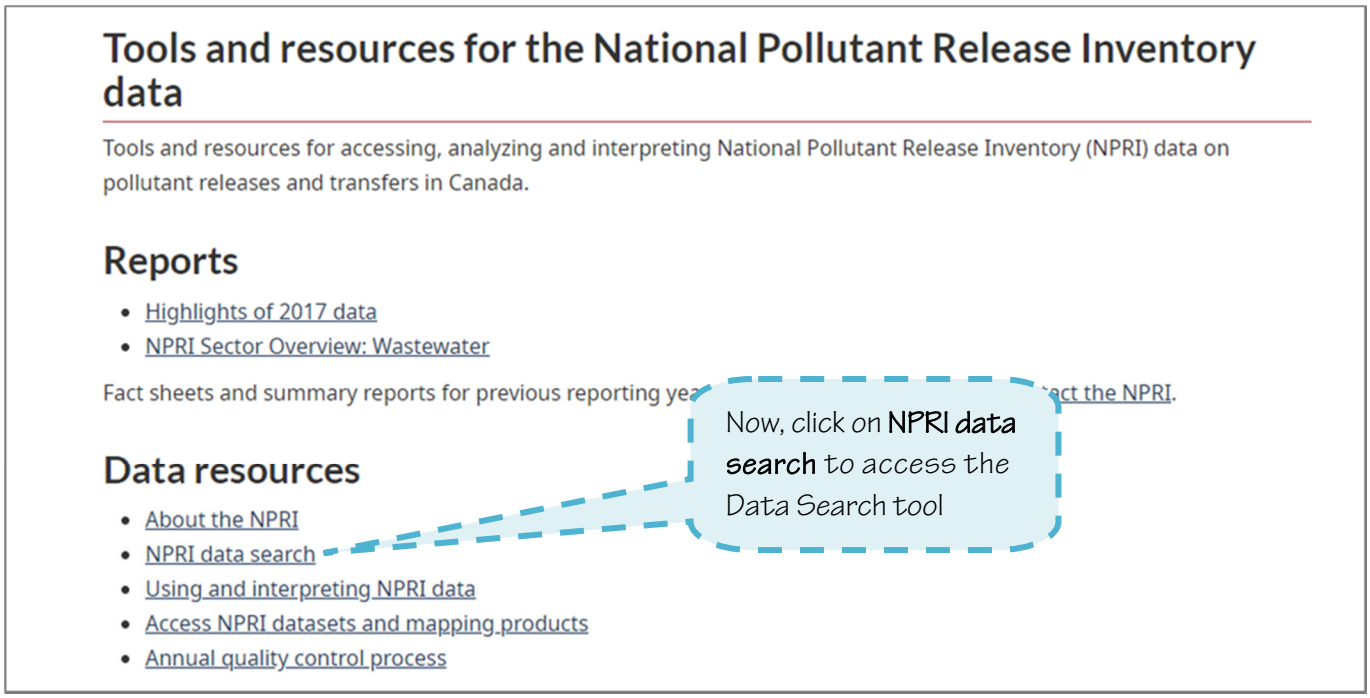
Access Data in the National Pollutant Release Inventory

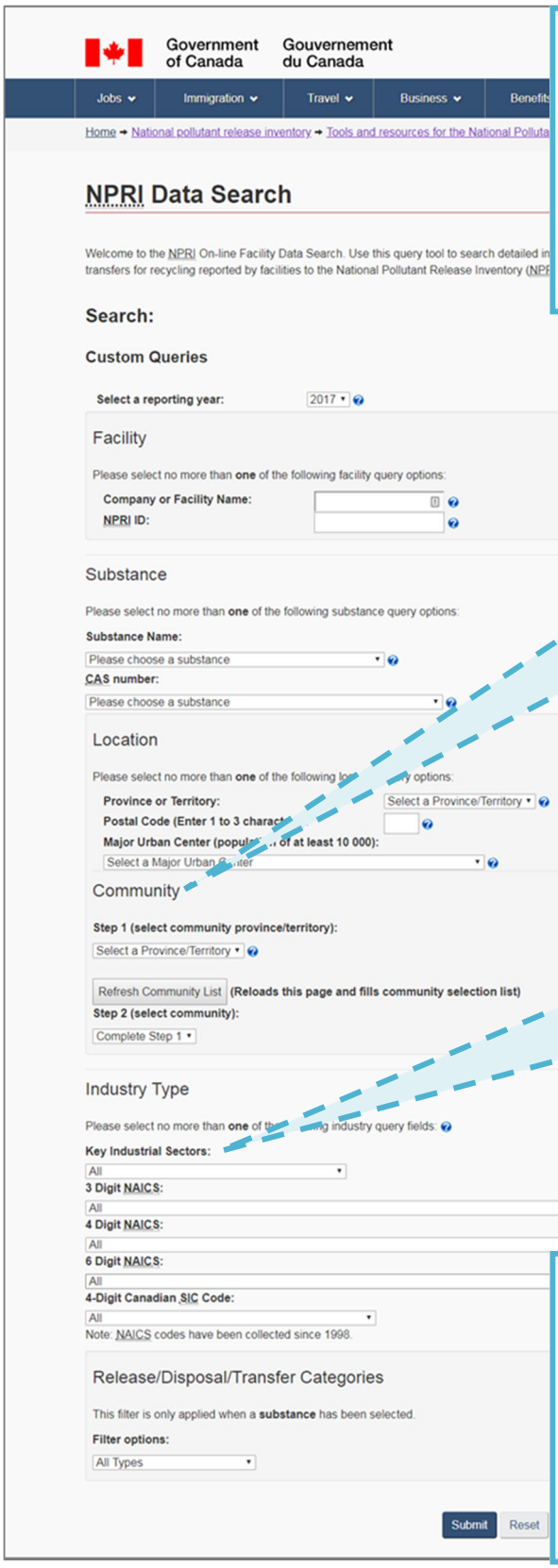
In this activity, you will learn about the pollutants released by wastewater treatment facilities, as well as how and where they were released. This guide will help you create a query to find this information in the National Pollutant Release Inventory (NPRI). Follow the instructions in the blue boxes and answer the questions you encounter in the guide.

First, type **canada.ca/NPRI** in your browser's address bar to access the website.

From the homepage, you may explore the different sections, such as *About the National Pollutant Release Inventory* to learn about this governmental program and how it operates and to help you answer the questions.




Tools and resources for the National Pollutant Release Inventory data
Tools and resources for accessing, analyzing and interpreting National Pollutant Release Inventory (NPRI) data on pollutant releases and transfers in Canada.
Reports
Highlights of 2017 data
NPRI Sector Overview: Wastewater
Fact sheets and summary reports for previous reporting ye
act the NPRI.
Data resources
About the NPRI
NPRI data search
Using and interpreting NPRI data
Access NPRI datasets and mapping products
Annual quality control process
Now, click on NPRI data search to access the Data Search tool



This tool will allow you to research pollutant releases in your community and in the rest of Canada. Take a look at the different criteria you can search by.

Q1: Does your local wastewater facility report to the NPRI? Find out by following the steps below.

Search for your local facility by using the fields found under **Community**

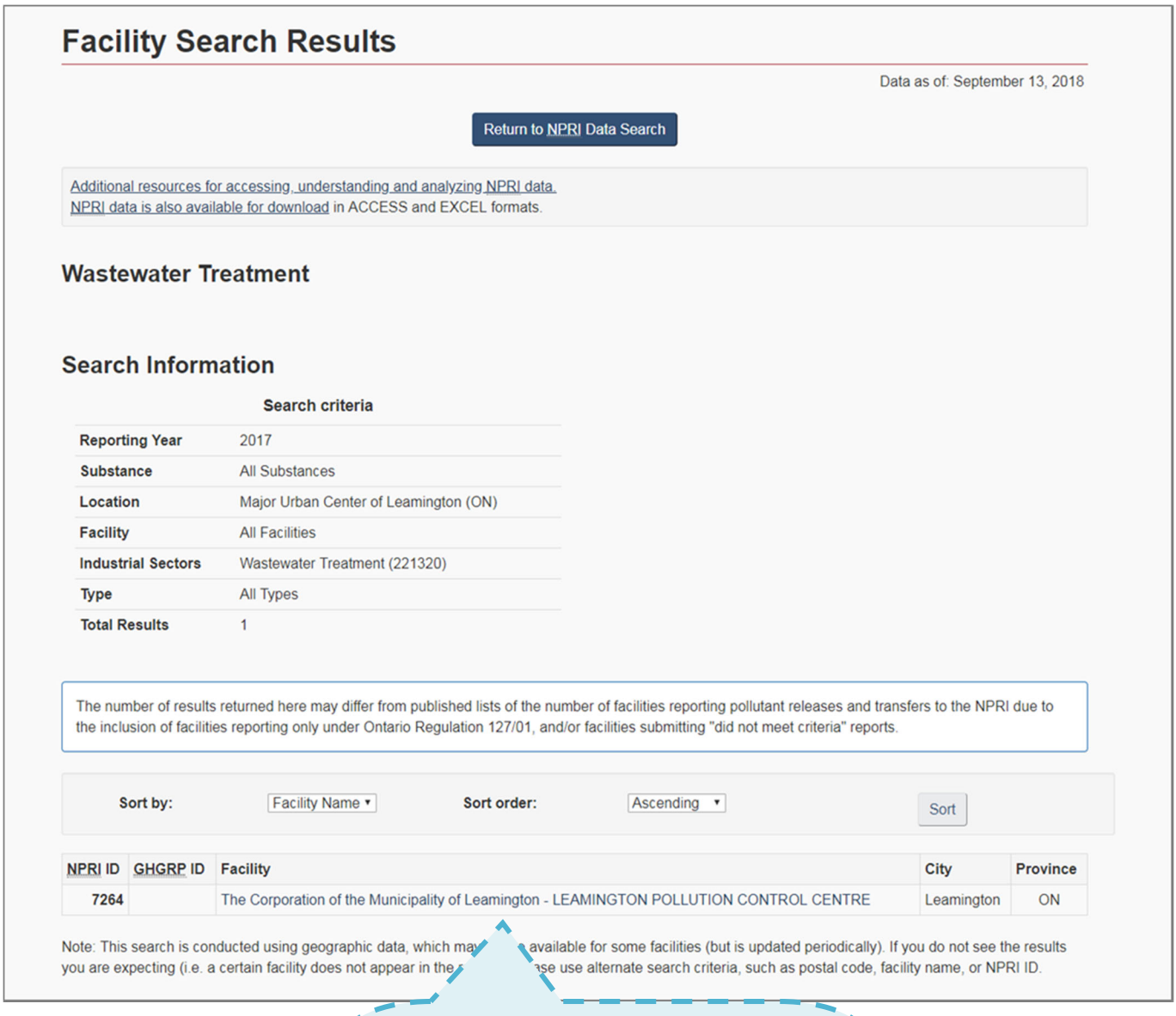
(ex: step 1 – Ontario, click "refresh community list", step 2 – Leamington).

Then, select **Wastewater Treatment** from the **Key Industrial Sectors** drop-down menu. When done entering your information, click **Submit,** at the bottom of the page.

If after clicking **Submit**, there are no results, you may try again, but only insert your province in the **Location** section. This will allow you to see all reporting wastewater treatment facilities in your province.

Q2: Why wouldn't a wastewater treatment facility report to the NPRI?

If your community's wastewater treatment facility (or facilities) reports to the NPRI, your result will look something like this:



Facility Search Results

Data as of: September 13, 2018

Return to NPRI Data Search

Additional resources for accessing, understanding and analyzing NPRI data.
NPRI data is also available for download in ACCESS and EXCEL formats.

Wastewater Treatment

Search Information

Search criteria	
Reporting Year	2017
Substance	All Substances
Location	Major Urban Center of Leamington (ON)
Facility	All Facilities
Industrial Sectors	Wastewater Treatment (221320)
Type	All Types
Total Results	1

The number of results returned here may differ from published lists of the number of facilities reporting pollutant releases and transfers to the NPRI due to the inclusion of facilities reporting only under Ontario Regulation 127/01, and/or facilities submitting "did not meet criteria" reports.

Sort by: Facility Name Sort order: Ascending Sort

NPRI ID	GHGRP ID	Facility	City	Province
7264		The Corporation of the Municipality of Leamington - LEAMINGTON POLLUTION CONTROL CENTRE	Leamington	ON

Note: This search is conducted using geographic data, which ma available for some facilities (but is updated periodically). If you do not see the results you are expecting (i.e. a certain facility does not appear in the se use alternate search criteria, such as postal code, facility name, or NPRI ID.

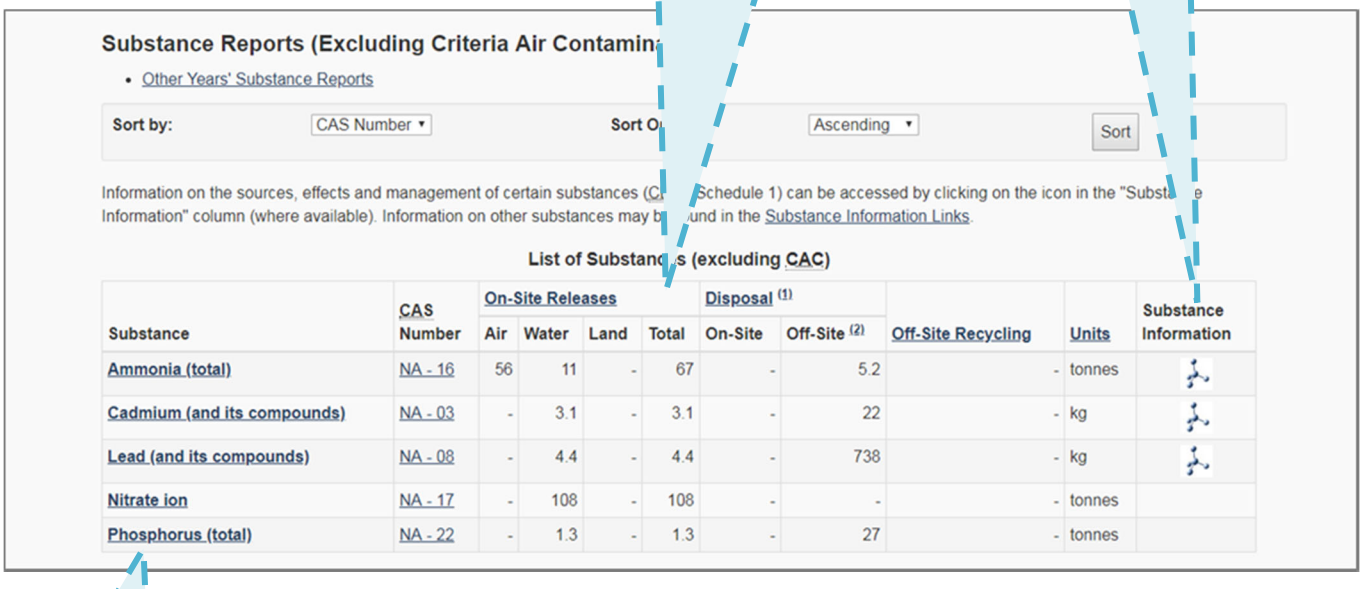
Now, click on the facility name to obtain details on it and the substances it reports to the NPRI.

Scroll down the **Facility and Substance Information** page until you find the data table. This is where you will learn about the substances reported, and details of how they were released or disposed of, and in what quantities.

Click on "**On-Site Releases**" and "**disposal**" for details on releases of all substances.

Q3: What is the difference between an on-site release and a disposal?

Find details on a substance in **Substance information**



Substance Reports (Excluding Criteria Air Contamin

- Other Years' Substance Reports

Sort by: CAS Number Sort O Ascending Sort

Information on the sources, effects and management of certain substances (C Schedule 1) can be accessed by clicking on the icon in the "Subst e Information" column (where available). Information on other substances may b und in the Substance Information Links.

List of Substanc s (excluding CAC)

Substance	CAS Number	On-Site Releases				Disposal (1)		Off-Site Recycling	Units	Substance Information
		Air	Water	Land	Total	On-Site	Off-Site (2)			
Ammonia (total)	NA - 16	56	11	-	67	-	5.2	-	tonnes	
Cadmium (and its compounds)	NA - 03	-	3.1	-	3.1	-	22	-	kg	
Lead (and its compounds)	NA - 08	-	4.4	-	4.4	-	738	-	kg	
Nitrate ion	NA - 17	-	108	-	108	-	-	-	tonnes	
Phosphorus (total)	NA - 22	-	1.3	-	1.3	-	27	-	tonnes	

Click on a **substance** to find a detailed report on its releases.

Q4: What does "land treatment or application farming" mean?

Q5: Can you judge the environmental impact of pollutants released, simply by looking at this data? Why or why not?

Tip: try looking at the Using and interpreting NPRI data section, accessible from the NPRI homepage.

Bonus research question: How does the type of sewer system in place in a city affect a wastewater treatment facility's capacity to reduce its direct releases to the environment?

JOURNALISTIC REPORT

Risks and Benefits of Using Biosolids in Agriculture

This activity will allow you to integrate the knowledge you have gathered on the wastewater treatment process, pollutants, and the use of biosolids in agriculture. Research the various facets of this environmental issue and present the risks and benefits of using biosolids in agriculture in an informative media production.

Imagine . . .

You are a reporter working for a news agency in a rural Canadian community. Mr Jones (a loyal reader) has written in after receiving a letter from his municipality, notifying him that his cash crop farming neighbour would soon be applying biosolids to one of his fields. He is concerned about the smell, and the environmental impact of this practise, and doesn't think the community should allow farmers to use waste-water sludge to fertilize their fields. You don't know much about biosolids but as a good journalist, and responsible citizen, you decide it is worth looking into.

Use your research skills and the resources you have learned about (such as the NPRI database) to create a fact-based journalistic product, presenting the issue to a wider public, while addressing Mr Jones' concerns. This can be in written form, it could be a video, an infographic, a news segment, a talk show, or even an interview - be creative! It is your job to uncover the benefits, potential risks (and how we minimize them) of using biosolids and help the citizens of your town understand the issue better.

Remember, a good journalist will try to see all sides of a story and not only present one aspect!

> **Tip:** Do a web search for existing news articles about citizens' reactions to biosolids being spread in farmers' fields in their communities.

Questions to help you get started

- ⇒ Who is this story about? What is this person concerned about? What information could you present to help them better understand the issue?
- ⇒ Is the application of biosolids in fields a new practise?
- ⇒ Where would the biosolids go if we weren't putting them in our fields?
- ⇒ Why would farmers want to apply biosolids to their fields?
- ⇒ How do biosolids help build healthy soil?
- ⇒ How do remote communities (with or without infrastructure) manage waste?
- ⇒ Can Canada follow waste management strategies used in other countries?
- ⇒ What do the different groups say? (Government, scientists, non-governmental organization, industry)

A Few Useful Resources

Ontario Ministry of Food and Rural Affairs (OMAFRA)—Sewage Biosolids
bit.ly/21DkdlV

Environnement et lute contre les changements climatiques—Fertilizing Residuals
bit.ly/2WWkZGC

Canadian Council of Ministers of the Environment—Biosolids Resources
bit.ly/2GTrAso

Canada Office of the Auditor General—Regulation of biosolid-based fertilizers under the *Fertilizers Act*
bit.ly/2Gr4T2M

Health Canada - Management of toxic substances
bit.ly/2vY48q7

Health Canada - Environmental Contaminants
bit.ly/2DChNHo

APPENDIX A

Background Information

Notes on Biosolids

- In cities, everything we flush down the toilet and pour down the drain ends up at municipal **wastewater treatment facilities**, which cleans water before releasing it back into the environment.
- These facilities extract the solid waste, or **sewage sludge**, from the wastewater and treat it to form **biosolids.**
- Municipalities are required to find a way to use biosolids in a **beneficial** way; such as composting it and applying it to agricultural fields, or combusting it for energy production. If not possible, they must dispose of it by storing it in a landfill or incinerating it.
- Farmers can apply biosolids in their fields as a **soil amendment** and **fertilizer,** a practice that goes back centuries.
- Biosolids are a good complement or substitute to synthetic fertilizers as they contain both **plant nutrients** and **organic matter**.
- **Organic matter** feeds soil-dwelling organisms and, over time, improves soil structure and function thus reducing problems like runoff and erosion (symptoms of soils lacking organic matter).
- Biosolids can contain low concentrations of **pollutants**, which could potentially **contaminate** the fields they are applied to, if overused.
- Food grown on heavily contaminated land takes up the pollutants from the soil and it can be **risky for human health** to consume it.
- Biosolids are constantly **tested and evaluated** in labs to ensure the concentrations of pollutants and pathogens they contain are many times lower than the levels identified as "tolerable" (meaning no serious health effects are expected) by humans.
- **Academic** and **governmental researchers** are continuing to investigate the long-term impacts of using biosolids in agriculture. When **best practises** and **government guidelines** are followed, there is no evidence that the use of treated biosolids as fertilizer poses a significant risk to environmental and human health.

Notes on Fertilizer Use on Farms

- For crops to grow properly, they need the **right proportions** of macro and micro nutrients.
- Farmers **test** soil samples from their field to find out which nutrients are present and in what amounts. They apply fertilizers in accordance with these results and the nutrient requirements of the next crop.
- Laws and directives guide farmers on when, how and where to apply fertilizers, to minimize **losses to the environment** (runoff and leaching).
- Fertilizers are either **synthetic** (manufactured), **inorganic** (mined), or **organic** (from a **biological** source, like animal wastes and crop residues).
- Synthetic and inorganic fertilizers only contain **macro** and some **micro nutrients**.
- Organic fertilizers usually contain lower concentrations of the nutrients, but also contain **organic matter**.
- Organic matter is essential to the soil food web and to **soil structure**. It acts as a glue and a sponge, and as food for decomposers.
- **Livestock farmers** have better access to organic fertilizers, since their animals produce manure. However, they typically complement with synthetic and inorganic fertilizers to meet the needs of their plants.
- **Cash crop (soya, corn, wheat, canola…)** farmers might rely more on synthetic and inorganic fertilizers, since they often tend to have large parcels of land and no animals to produce manure.
- Biosolids offer farmers an economical tool to **enrich** their soils with organic matter, while reducing their reliance on synthetic and inorganic fertilizers.
- For municipalities, agricultural use of biosolids is an economical and **environmentally conscious** way to manage and re-use a waste product.

APPENDIX B

Web Resources for Teachers

The City of Ottawa: Wastewater education, reporting and statistics

An overview of the wastewater treatment Process, Step-by-Step

bit.ly/2DGk1Hb

The City of Ottawa: Biosolids

An example of municipal biosolids beneficial use program

bit.ly/2RSdTUX

The City of Ottawa: Biosolids Quality Data

Downloadable data, results of biosolids lab tests for contents in pollutants and pathogens

bit.ly/2UoOErw

Canadian Council of Ministers of the Environment: Biosolids resources

Publications (research, policy and guidance documents) on the use of municipal biosolids

bit.ly/2GTrAso

Government of Canada: Water Indicators

Detailed information on issues affecting water quality in Canada

bit.ly/2RSdh1o

Ontario Ministry of Food and Rural Affairs (OMAFRA)—Sewage Biosolids

A biosolids factsheet

bit.ly/21DkdlV

Environnement et lute contre les changements climatiques—Fertilizing Residuals

Information, frequently asked questions, guidelines, technical and scientific articles, legal and regulatory framework, and other links

bit.ly/2WWkZGC