LES 3

O B S E R V A T O R Y
ENVIRONMENTAL SCIENCE AND TECHNOLOGY (EST)
Teacher's Guide A
Second Year of Secondary Cycle Two

GRANDMA'S RECIPES

STUDENT LOG

WORKING DOCUMENTS

EVALUATION DOCUMENTS

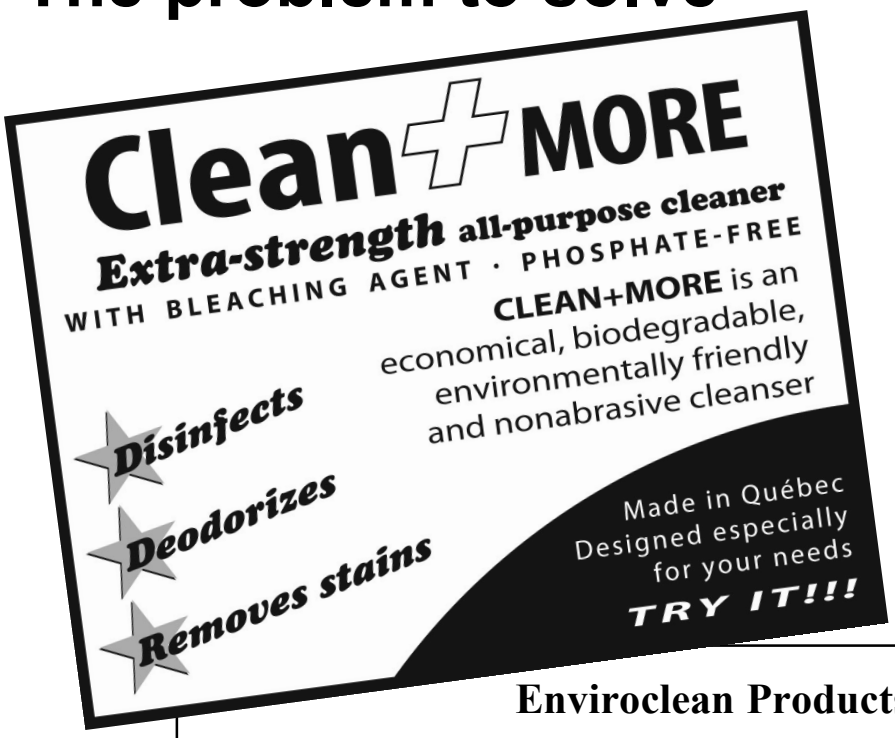
INFORMATION DOCUMENTS

PROCEDURE AND EVALUATION: SSC1 – SCIENCE

Observatory / Guide
11129-A

Name: _____ Group: _____ EST

The problem to solve



Enviroclean Products Inc.

Memorandum

To: Department of Research and Development; Marketing Department

Date: May 29, 2009

Subject: Summary of the decisions made at the meeting of May 25

As you all know, the market has been flooded with supposedly eco-friendly products. Our company wants to carve out a niche in the market by creating a range of truly green products, certified by EcoLogo^{M} (Environment Canada's labelling program for environmentally friendly products).

This spring, we are launching the development of a new environmentally safe cleaning product, based on tried and true recipes: what our grandmothers used to do. The new product will meet the following criteria:

- It must be in aqueous solution.
- It must contain at least one of the following substances: vinegar, baking soda, washing soda or table salt.
- It must be shown to be as effective as a commercial cleaning product.
- The marketing department must create a label indicating the product contents and the molar concentration of the chemical ingredients (when relevant) and highlighting the advantages of the product (in particular, its effectiveness and low environmental impact).

In this context, you will play the role of a chemist who must develop an environmentally friendly product and test its effectiveness. You then will take on the role of the designer of the product label.

Name: _____ Group: _____ EST

Creating the context

I ask myself questions

1. What is a polyatomic ion?

2. Find four examples of polyatomic ions in the information documents. Identify them by name and by chemical formula.

3. What is a mole?

4. How many entities are there in a mole?

5. How would you calculate the number of molecules in 250 mL of your cleaning product?

6. What is the molar mass? What is its unit of measurement?

7. How do you determine the molar mass of an element?

Name: _____ Group: _____ EST

Creating the context (*continued*)

8. How do you determine the molar mass of a compound?

9. What mathematical formula can you use to convert the mass of a substance (in grams) into moles? Identify each variable and its unit of measurement.

10. What is the concentration of a solution?

11. What is molar concentration? What is its unit of measurement?

12. What mathematical formula can you use to calculate the molar concentration of a solution? Identify each variable and its unit of measurement.

13. What is the chemical formula for sodium bicarbonate? Explain the rules you use to identify it.

Name: _____ Group: _____ EST

Creating the context (*continued*)

14. How would you prepare 50 mL of a 0.25 mol/L potassium nitrate solution? Show your method and calculations.

15. If 750 mL of solution contains 3.5 g of calcium chloride, what is the molar concentration of this solution? Show your method and calculations.

16. What is the nitrogen cycle?

Name: _____ Group: _____ EST

Creating the context (*continued*)

17. How do cleaning products affect the nitrogen cycle? Explain your answer.

18. What is the phosphorus cycle?

19. How do cleaning products affect the phosphorus cycle? Explain your answer.

20. What is wastewater treatment?

Creating the context (*continued*)

21. What are the main methods of treating wastewater? Describe the situations in which each method is preferred.

22. What impact does the use of cleaning products have on wastewater treatment?

23. Name and describe other means of decontaminating an environment, apart from wastewater treatment.

I must

24. What are the independent and dependent variables in your tests?

Creating the context (*continued*)

25. Reformulate the goal of the problem-solving activity.

I think

26. Do you think that environmentally friendly cleaning products based on traditional recipes are as effective as commercial products? Explain your answer.

27. What type of green cleaning product would you like to develop? Write the recipe for this product.

Reflection

	Yes	No
Do I fully understand the concepts covered in this situation?	☐	☐

Name: _____ Group: _____ EST

Planning the problem solving

I plan

1. Make a list of the materials you will need to conduct your experiment.

2. Write out the protocol for the experiment.

Name: _____ Group: _____ EST

Planning the problem solving (*continued*)

3. Prepare a table for recording your observations and give it a title. Remember to do a control test.

4. What safety rules should you follow during your experiment?

_____

_____

_____

_____

_____

Reflection

	Yes	No
Have I considered other approaches to conducting my tests?	☐	☐

Name: _____ Group: _____ EST

Initiating the problem solving

I experiment

1. Conduct the experiment. Record your observations in the table you have prepared.

2. When relevant, calculate the molar concentration of the ingredients of your cleaning product. If it is not relevant, explain your answer.

Name: _____ Group: _____ EST

Initiating the problem solving (*continued*)

3. Did you alter your plan of action during the experiment? If so, explain your answer.

4. Did you work safely during the experiments? Justify your answer with at least two examples of safety-conscious behaviour.

Reflection

	Yes	No
Did I record and justify each of the changes I made to my plan of action?	☐	☐

Name: _____ Group: _____ EST

Analyzing results and drawing conclusions

I analyze my results

1. Is the environmentally friendly cleaning product you have created as effective as its commercial counterpart? Justify your answer.

2. Compare the environmental impact of each of the test products.

Name: _____ Group: _____ EST

Analyzing results and drawing conclusions (*continued*)

3. What are the advantages of your cleaning product? Name at least two.

4. What are the disadvantages of your cleaning product? Name at least two.

5. Are your tests reliable? What factors did you take into consideration to ensure their reliability?

6. What are the possible sources of error in your experiment? Suggest a way to eliminate them.

Analyzing results and drawing conclusions (*continued*)

I draw my conclusions

7. Make a list of the ingredients of your cleaning product. When relevant, specify the molar concentration.

_____

_____

_____

_____

8. What conclusion can you draw from your experiment? Write a short text that you could include on the label of your environmentally friendly cleaning product.

_____

_____

_____

_____

_____

9. Draw the label for your environmentally friendly cleaning product in the space below.

Name: _____ Group: _____ EST

My evaluation

Use the evaluation grid on the following page to evaluate yourself. Write A, B, C, D or E in the "Me" column of the chart below.

SSC1—Seeks answers or solutions to scientific or technological problems				
Criteria*	**Observable indicators**	**Me**	**Teacher**	**Comments**
1	**Creating the context** Definition of the goal and the concepts		☐ With help	
2	**Planning the problem solving** Relevance of the elements of the plan of action: materials and procedure		☐ With help	
3	**Initiating the problem solving** Accuracy of the results and calculations; compliance with safety rules		☐ With help	
4	**Analyzing results and drawing conclusions** Analysis of the results and conclusion		☐ With help	

*** Evaluation criteria**

1 Appropriate representation of the situation
2 Development of a suitable plan of action for the situation
3 Appropriate implementation of the plan of action
4 Development of relevant conclusions, explanations or solutions

Name: _____ Group: _____

Evaluation grid

SSC1 Seeks answers or solutions to scientific or technological problems

Criteria*	Observable indicators	A	B	C	D	E
1	**Creating the context** Definition of the goal and the concepts	The goal is very clearly defined and relevant to the problem to be solved. The related concepts are very clearly defined.	The goal is clearly defined and relevant to the problem to be solved. The related concepts are clearly defined.	The goal is not very clearly defined or is irrelevant to the problem to be solved. The related concepts are not very clearly defined.	The goal is not very clearly defined and is irrelevant to the problem to be solved. The related concepts are not clearly defined.	The work must be done again.
2	**Planning the problem solving** Relevance of the elements of the plan of action: materials and procedure	The list of materials is complete. The procedure is relevant and very clear.	The list of materials is almost complete. The procedure is relevant and clear.	Many elements are missing from the list of materials, OR the procedure is not very relevant and clear.	Many elements are missing from the list of materials, AND the procedure is irrelevant or unclear.	The work must be done again.
3	**Initiating the problem solving** Accuracy of the results and calculations; compliance with safety rules	All of the results and calculations are accurately recorded and relevant, AND the experiment was conducted safely.	Most of the results and calculations are accurately recorded and relevant, AND the experiment was conducted safely.	Some of the results and calculations are accurately recorded and relevant, AND the experiment was conducted safely.	The results and calculations are not accurately recorded and are irrelevant, AND the experiment was not conducted safely.	The work must be done again.
4	**Analyzing results and drawing conclusions** Analysis of the results and conclusion	The analysis of the results and the conclusion are very clear and relevant to the goal of the problem solving.	The analysis of the results and the conclusion are clear and relevant to the goal of the problem solving.	The analysis of the results and the conclusion are not very clear OR are not very relevant to the goal of the problem solving.	The analysis of the results and the conclusion are not very clear AND are not very relevant to the goal of the problem solving.	The work must be done again.

*** Evaluation criteria**

1 Appropriate representation of the situation

2 Development of a suitable plan of action for the situation

3 Appropriate implementation of the plan of action

4 Development of relevant conclusions, explanations or solutions

Name: _____ Group: _____ EST

Why switch to green cleaning products?

According to the US-based Janitorial Products Pollution Prevention Program, one in every three cleaning products contains an ingredient known to be harmful at some exposure level.[1] Common health problems associated with some cleaning chemicals include headaches, dizziness and fatigue, and in extreme cases, reproductive disorders and major organ or permanent eye damage.[2]

Data from Washington State show that about six percent of janitors experience a job-related injury from chemical exposure to cleaning products every year.[3]

Furthermore, while most cleaning products are formulated to degrade in municipal wastewater treatment plants, cleaning chemicals used to clean building exteriors can find their way into lakes, streams and other water bodies, presenting potential environmental concerns.

Source: "Pilot project highlights green cleaning products in Mexico," *Trio: The Newsletter of the North American Commission for Environmental Cooperation* [online edition], Summer 2007 (accessed May 28, 2009).

1. Janitorial Products Pollution Prevention Program, "Cleaning Chemical Injuries Fact Sheet."
2. Culver, Alicia et al., "Cleaning for Health: Products and Practices for a Safer Indoor Environment," INFORM Inc., 2002.
3. "Greening the Janitorial Business – How to Select and Use Safe Janitorial Chemicals," Workshop for NISH, U.S. Dept. of Interior, November 2001.

Wastewater treatment and household chemicals

Water isn't just used—it's recycled and reused. But wastewater treatment and purification processes can't completely restore water to its original quality. Wastewater treatment plants remove suspended solids and some of the organic matter. But most are not capable of removing the hazardous substances found in many household chemicals, making water treatment less than 100-percent effective.

So we should think about how much water we use and what we do to it. Few of us stop to think about some of the common household chemicals we pour down our drains, use in our laundry, flush down our toilets and spray onto our lawns and gardens. But we should.

The careless disposal of motor oils, paints, solvents, cleaners and other household chemicals down our toilets and drains can wreak havoc on waste treatment facilities and our aquatic environments.

There are environmentally friendly alternatives to many of these chemicals. Low phosphate and phosphate-free detergents for laundry are available. And garbage: dental floss, cotton swabs, tampons, cigarette butts should never be flushed down the toilet. Dispose of them in your regular garbage. And if you do want to dispose of chemicals you have around the house, check with your municipality to find out how to dispose of these hazardous household products. Many cities and towns have local household toxic waste depots. The regular garbage is not the place for them.

Source: Environment Canada, Great Acts for Great Lakes, "Water" [Web page] (accessed May 28, 2009).

Name: _____ Group: _____ EST

The most common potentially harmful chemicals in household cleaning products

Regulations

Since 2001, under the federal Consumer Chemicals and Containers Regulation, many cleaning products must be labelled with a hazard symbol. In addition, manufacturers must indicate on the packaging any ingredients present in concentrations greater than one percent that make the products hazardous. However, these warnings relate only to immediate, short-term risks. Another deficiency of the regulations is that manufacturers are not required to provide the complete list of ingredients on the label.

A multi-count indictment

The list below presents the most common potentially harmful chemicals, their possible long-term health effects and the types of products that contain them.

Substance	Effects	Cleaning products
Ammonia	Respiratory tract irritation	Window cleaners
Benzene*	Known carcinogen	Air fresheners, incense
Cresol and phenols*	Kidney and liver damage	Disinfectants
Formaldehyde*	Probable carcinogen, allergies	Air fresheners, antibacterial dish detergents, carpet cleaners
Glycol ethers	Male infertility	Extra-strength all-purpose cleaners
Naphtalene and paradichlorobenzene*	Possible carcinogens; eye, kidney and nervous system damage	Mothballs, stick deodorants
Nonylphenol and nonylphenol ethoxylates	At high exposures, nervous system disruption, kidney damage	Laundry detergents, all-purpose cleansers
Perchlorethylene*	Possible carcinogen	Stain removers
Pesticides	Possible carcinogens; disruption of fetal and child development; disruption of reproductive, endocrine and neurological systems	Insecticides, fungicides
Phtalates*	Probably carcinogenic, linked to reproductive system dysfunction	Perfumes in laundry detergents and fabric softeners
Sodium hypochlorite	Produces chlorine gas when mixed with ammonia and other substances; chlorine gas can burn the respiratory tract	Powdered cleansers, disinfectants, bleaching products
Toluene*	Powerful neurotoxin, memory loss, fatigue and dizziness	All-purpose cleaners

* Volatile organic compound (VOC). VOCs readily evaporate at room temperature, forming potentially toxic gases.

Source: Option consommateurs, “Household chemical products: A spotless record?” [PDF document], 2006.

Greener cleaning

BASIC INGREDIENTS

Industry is by far the largest source of hazardous and toxic chemical pollution. But many of us also contribute to pollution with the cleaning products we choose, the gardening chemicals we use and the energy we consume.

Protecting and preserving the environment starts right in your own home. Here are some recipes that will not only save you money, but they are also safer for you, for those you care about and for the environment.

Each of the ingredients listed below can be found in grocery or health food stores.

Pure soap: For generations, people washed their clothes, their homes and themselves with pure soap. Today, it is the key ingredient of many alternative cleaning recipes. Soap biodegrades safely and completely and is non-toxic. Make sure that you use soap without synthetic scents, colours or other additives. Even phosphate-free, biodegradable laundry detergent contributes to water pollution.

Vinegar (5% acetic acid): Vinegar is a mild disinfectant which cuts grease, cleans glass, deodorizes, and removes calcium deposits, stains and wax build-up.

Cornstarch: Cornstarch is an odourless powder that is great for carpet cleaning and greasy stains.

Washing soda (sodium carbonate): A key ingredient for washing clothes, washing soda cuts grease, removes stains, disinfects, and softens water. Washing soda should not be used on aluminum.

Baking soda (bicarbonate of soda): Baking soda works well as an abrasive in alternative recipes. Baking soda also deodorizes, removes stains, polishes, and softens fabrics.

Please note: There are some people who feel that ammonia and borax are other key ingredients in alternative cleaners. It is true that they are both very effective at cleaning, deodorizing and disinfecting. It is also true that they are both quite harsh chemicals, which can irritate the eyes, nose, throat and skin, and can cause headaches, nausea and chest pain.

Additionally, when ammonia mixes with certain other cleaning products, namely those that contain chlorine, poisonous gas can be created. For these reasons, we have left ammonia and borax off our list of core ingredients and out of the recipes.

Greener cleaning (*continued*)

BASIC RECIPES (*excerpt*)

All-purpose cleaner

- 125 mL pure soap
- 4 L hot water

For a clean scent and to help cut grease, add 60 mL of lemon juice.

This solution is safe for all surfaces, should be rinsed with water and is very effective for most jobs. For a stronger cleaner, double the amounts of soap and lemon juice.

Scouring powder

Use a firm bristle brush and scrub with pure soap combined with either table salt or baking soda.

Baking soda alone on a damp sponge is also effective on most surfaces. You can also personalize your scouring powder by adding an aromatic herb or flower. Put the ingredients in a blender and run until the fragrance has infused the powder.

For oven spills, scrub using straight baking soda or combine with the stronger version of the all-purpose cleaner. Remember to wear gloves when scrubbing.

Liquid dish soap

Grate a bar of pure soap into a saucepan. Cover with water and simmer over low heat until they melt together. Add some vinegar to the water for tough grease and to remove spots. Pour into a container and use as you would any liquid dishwashing soap.

Mirrors, glass and windows

Wash with pure soap and water, rinse with a solution of one part vinegar to four parts water. Use washable, reusable cheesecloth instead of paper towels.

Polishing metals

Copper: Try lemon juice and a little salt, or hot vinegar and a little salt, on a rag.

IN THE LAUNDRY ROOM (*excerpt*)

Detergent

Add 80 mL of washing soda to water as the machine is filling. Add clothes. Then add 375 mL of soap. If the water is hard, add 60 mL of soda or 60 mL of vinegar during the first rinse. For heavily soiled items, try presoaking in warm water with 125 mL of washing soda for 30 minutes. Rub the soiled areas with liquid soap or a solution of 30 mL of washing soda in 250 mL of warm water.

Source: Greenpeace Aotearoa New Zealand, "Take action: Green your life" [Web pages] (accessed May 29, 2009).

Name: _____ Group: _____ EST

Information on chemical ingredients of cleaning products

Starch

Starch ($C_6H_{10}O_5)_n$ is a complex carbohydrate that green plants use as an energy store. It is the principal component of cereals (rice, corn, wheat, etc.) and of potatoes. Different types of starch are found in the tubers, roots and stems of certain plants (potato starch, cornstarch, etc.). Starch is insoluble in cold water.

Household ammonia

Household ammonia (NH_4OH), or *ammonium hydroxide*, is a concentrated aqueous solution of ammonia (NH_3). Household ammonia is not, strictly speaking, a hazardous product. However, it releases ammonia gas, a strong irritant. Its alkaline properties make it corrosive: it is important to avoid contact with the skin and especially the eyes and to avoid inhaling the fumes.

Sodium bicarbonate

Sodium bicarbonate ($NaHCO_3$), or *sodium hydrogencarbonate*, is the product commonly called *baking soda*. It is a white compound in the form of a powder. It neutralizes acid, softens water, polishes without scratching and deodorizes. It also softens fabric and removes certain stains. Sodium bicarbonate is biodegradable and non-toxic both to the environment and to human health.

Borax

Borax ($Na_2B_4O_7 \cdot 10H_2O$), also known as *sodium tetraborate* or *sodium borate*, is a mineral ore containing boron, an element that occurs naturally in soil, rocks and water. It occurs as a powder or as flakes. It can be an irritant. It is used to decorate porcelain and to manufacture fertilizer, soap, insecticides, etc. Borax is an antiseptic.

Sodium carbonate

Sodium carbonate (Na_2CO_3) is also known as *soda ash*, *washing soda* or *soda crystals*. Although sodium carbonate has borne the name *soda* for a long time, it should not be confused with caustic soda. It is not toxic to the environment. It can be a skin irritant, however, so gloves must be worn when handling it. It reacts with most acids to produce carbon dioxide. It also causes various soluble metallic salts to separate through ion exchange.

Sodium chloride

Sodium chloride (NaCl) is a very common chemical compound: table salt or coarse salt. Sodium chloride is available in near-unlimited quantities. There are two types of reserves: rock salt and sea salt. The oldest salt deposits in the oceans are estimated to be more than 600 million years old. Salt is one of the most abundant minerals on Earth.

Information on chemical ingredients of cleaning products (*continued*)

Detergent

A detergent (or *surface active agent,* or *surfactant*) is a chemical compound, usually derived from petroleum. It can remove dirt thanks to its surface-active properties. Invented in 1930, synthetic detergents gradually replaced traditional soaps (castile soap, sugar soap). Although detergents are more effective than soap, only real soap is completely biodegradable.

In its broadest sense, a detergent is any substance used for cleaning (an all-purpose cleaner, a laundry detergent, etc.). Bleaching agents, enzymes and other substances that improve the action of the detergent, as well as perfumes and colouring, are added to these products.

Bleach

Bleach is a chlorinated whitening and decolourizing agent. It is composed of pure sodium hypochlorite (NaClO) in an aqueous solution with salt (NaCl). Using bleach has a drawback: it promotes the growth of more resistant strains of bacteria. It should not be used in septic tanks. Bleach is toxic and corrosive. It causes burns to the skin and mucous membranes (especially the eyes) when in concentrated form. Inhaling bleach can cause respiratory problems.

Lemon juice

Lemon juice contains citric acid ($C_6H_8O_7$). It cleans, eliminates odours and and removes grease. Combined with the effects of the sun, it also has whitening and bleaching properties. It is neither corrosive nor toxic. Citric acid occurs naturally in grapes, mushrooms, milk and lemons and is not at all hazardous to the environment because it biodegrades easily.

Phosphate

Phosphates (PO_4^{3-}) in cleaning products are used to soften water (so that soap is more effective), remove dirt and prevent limestone deposits. The proportion of phosphates that have made their way into natural waters because of cleaning products has dropped significantly in recent years thanks to consumer awareness and environmental efforts. However, phosphate is still the main ingredient in most dishwasher detergents.

Soap

Soap is made of natural substances (vegetable oils or animal fats). With water as a solvent, soap is used for washing or cleaning. It removes grease, which is naturally insoluble in water, by creating a bond between the grease molecules and the water. Soap comes in the form of a bar, a powder or flakes (washing powder) and may be sold in solution (liquid soap).

Soap is a salt of sodium (Na) or potassium (K) from a fatty acid. These acids are formed from a long hydrocarbon chain containing 12 to 18 carbon atoms and ending with an organic acid function, -COOH. For example, stearic acid ($CH_3(CH_2)_{16}COOH$) produces a soap with the formula $CH_3(CH_2)_{16}COO^-Na^+$.

Information on chemical ingredients of cleaning products (*continued*)

Vinegar

Vinegar is obtained from acidic apple juice, from grain or from wine. It contains approximately five-percent acetic acid (CH_3COOH), which makes it a mild acid. It is easily biodegradable.

Acetic acid gives vinegar its sour taste and sharp smell. It is an antiseptic and a disinfectant. Pure acetic acid is highly flammable and corrosive, and its fumes cause irritation to the nose and eyes. It must be handled with care. Although it is not considered carcinogenic or hazardous to the environment, it can cause burns and permanent damage to the mouth, nose, throat and lungs. A 1.0 mol/L solution (the concentration of household vinegar) has a pH of 2.4, which means that only 0.4 percent of the acetic acid molecules have dissociated.

Note: *Appendix 2 of the textbook (pp. 516–523) also provides information on the properties of common substances.*