LES 2

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

THE SUN TO THE RESCUE

STUDENT LOG

WORKING DOCUMENTS

EVALUATION DOCUMENTS

PROCEDURE AND EVALUATION: SSC1 – SCIENCE

Observatory / Guide
11129-A

ERPI

The problem to solve

Desalting seawater

Three quarters of the Earth's surface is covered in water, but unfortunately for us, it is salt water. Nevertheless, we cannot help but dream about the inexhaustible reservoirs the oceans might be if we could change all that salt water into fresh water. We could solve all the water-shortage problems affecting many countries because a large number of them have access to the ocean or, better yet, their own substantial coastlines.

Desalting seawater to make it potable (safe to drink) is actually possible. Numerous systems exist today, and many have reached the stage of industrial production. The two most commonly used processes are distillation and reverse osmosis. The principles behind them are simple.

Distillation consists in evaporating seawater, either by using heat from the sun's rays or by heating the water in a boiler. Only the water molecules escape, leaving a deposit of the salts and other substances contained in the seawater. Then, the water vapour from the distillation process is condensed to obtain fresh water that is safe to drink.

In reverse osmosis, the seawater is first treated by filtering and disinfecting it to remove the microorganisms and suspended particles it contains. Then, sufficient pressure is applied to the treated salt water to make it pass through a semipermeable membrane. Only the water molecules cross the membrane, thus providing fresh drinking water.

Source: Centre national de la recherche scientifique, "L'eau potable" [Web page] (accessed March 11, 2009). *[Translation]*

For immediate release

PRESS RELEASE

Fresh water for all

Gatineau, September 29, 2008. In its ongoing effort to promote mutual aid between populations and encourage sustainable development, the humanitarian organization *To the Rescue* is calling on young scientists to conduct experiments in desalination. The goal is to determine whether desalting seawater, by electrical or solar distillation, would be an effective way to supply drinking water to three countries where this resource is lacking.

To meet this goal, researchers must establish the relative efficiency of distillation methods with different energy sources: electrical or solar energy. Subsequently, researchers will ensure that the water obtained by these two methods meets Canadian standards for salt content in water. Finally, the young scientists will use their results to write and defend recommendations on the relevance of desalting seawater to supply certain regions of Romania, Niger and Tanzania with fresh water. In their recommendations, the scientists will also consider the economic and environmental consequences of the two methods.

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Source: Vanessa Landry
Press Secretary
To the Rescue

In this context, you will play the role of a young scientist.

The problem to solve (*continued*)

Sodium

1. Sodium is not considered to be a toxic element. Up to 5 g/day of sodium is consumed by normal adults without apparent adverse effects. Although numerous studies have shown that reducing sodium intake will lower blood pressure in hypertensives, it cannot be inferred that increased sodium intake will cause hypertension. A maximum acceptable concentration for sodium in drinking water has therefore not been established.
2. Generally, the taste of drinking water is offensive at a sodium concentration above 200 ppm. The aesthetic objective for sodium in drinking water is therefore ≤ 200 ppm.
3. To maintain a total daily sodium intake of 500 mg, as is widely prescribed for persons on a sodium-restricted diet, would require a sodium concentration in drinking water no higher than 20 ppm. Reduction of the sodium content of a number of supplies to this level would generally incur considerable expense using currently available technologies. It is therefore recommended that sodium be included in routine monitoring programmes, because levels may be of interest to authorities who wish to prescribe sodium-restricted diets for their patients. . . .

Source: Health Canada, Environmental and Workplace Health, "Sodium" [Web page] (accessed March 11, 2009).

Chloride

1. Chloride concentrations in the body are well regulated through a complex interrelated system involving both nervous and hormonal systems. Even after intake of large quantities of chloride through food and water, the chloride balance is maintained, mainly by the excretion of excess chloride via the urine. Therefore, a maximum acceptable concentration has not been set for chloride in drinking water.
2. Taste thresholds for chloride from sodium chloride, potassium chloride and calcium chloride in drinking water are 210 ppm, 310 ppm and 222 ppm, respectively; the taste of coffee is affected when brewed with water containing chloride concentrations of 400 ppm, 450 ppm and 530 ppm from the same salts. Chloride concentrations above 250 ppm in drinking water may cause corrosion in the distribution system.
3. The aesthetic objective for chloride in drinking water is therefore ≤ 250 ppm. Chloride concentrations in Canadian drinking water supplies are generally much lower than 250 ppm. . . .

Source: Health Canada, Environmental and Workplace Health, "Chloride" [Web page] (accessed March 11, 2009).

The problem to solve (*continued*)

Seawater

COMPOSITION

Seawater is composed of water and salts as well as small amounts of various other substances. Although more than two thirds of the 94 naturally occurring elements are present in seawater, most are found in minute quantities and are difficult to detect.

Salinity, which refers to the amount of salt dissolved in the water, is one of the most important properties of seawater. The average salinity of the oceans and seas is 35 g/L; salinity usually lies between 30 g/L (in the North Atlantic) and 40 g/L (in the Red Sea). Inland seas are more saline because evaporation concentrates the salt they contain. Landlocked or semi-enclosed seas thus present exceptional salinity values, from 6 g/L in the surface waters of the Baltic Sea to 300 g/L in the Dead Sea. The saltiest open sea is the Red Sea.

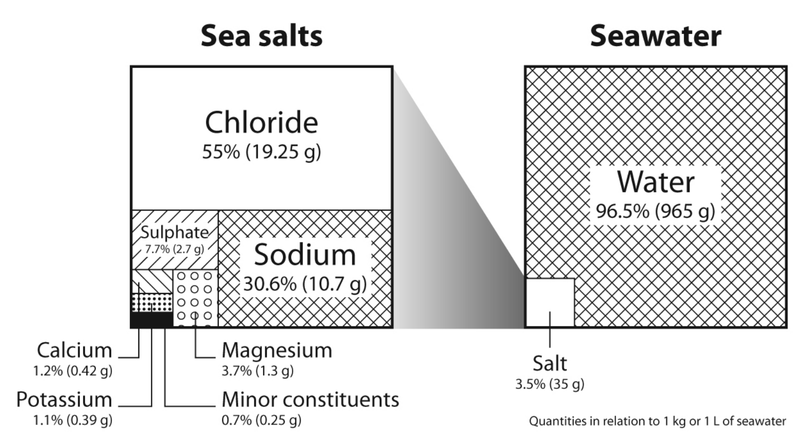
A distinctive feature of seawater is that the relative proportions of its components generally remain constant (independent of salinity). This property was discovered by the Scottish chemist William Dittmar and reveals seawater as a solution of eleven main solutes in pure water: chloride, sodium, magnesium, sulphate, calcium, potassium, bicarbonate, bromide, boric acid, carbonate and fluoride (in decreasing order of importance). Dittmar's law can thus be used to determine the salinity of seawater with one measure only: either the concentration of one of these solutes (Cl^-, for example) or one of the physical properties of the seawater at a given temperature (such as its relative density, refractive index or conductivity).

The two main salts in seawater are Na^+ and Cl^-. When combined, they form sodium chloride, or *sea salt,* which can be extracted from salt marshes to produce table salt.

The main gases dissolved in seawater are nitrogen (64%), oxygen (34%) and carbon dioxide (1.8%—which is 60 times the proportion of this gas in the Earth's atmosphere).

Principal salts in seawater with a salinity of 35 g/L		
Anions	**g/kg**	**mol/kg**
Chloride (Cl^-)	19.3524	0.54586
Sulphate (SO_4^{2-})	2.7123	0.02824
Bicarbonate (HCO_3^-)	0.1080	0.00177
Bromide (Br^-)	0.0673	0.00084
Carbonate (CO_3^{2-})	0.0156	0.00026
Fluoride (F^-)	0.0013	0.00007
Hydroxide (OH^-)	0.0002	0.00001
Cations	**g/kg**	**mol/kg**
Sodium (Na^+)	10.7837	0.46906
Magnesium (Mg^{2+})	1.2837	0.05282
Calcium (Ca^{2+})	0.4121	0.01028
Potassium (K^+)	0.3991	0.01021
Strontium (Sr^{2+})	0.0079	0.00009
Other molecules	**g/kg**	**mol/kg**
Water (H_2O)	965	53.6
Boric acid ($B(OH)_3$)	0.0198	0.00032
CO_2	0.0004	0.00001

CHEMICAL COMPOSITION OF SEAWATER



The problem to solve (*continued*)

Potability

Seawater is not potable and so should generally not be drunk by humans. The reason is salt: if we drink seawater, the amount of water we need to eliminate the salts it contains (through our urine) eventually becomes greater than the amount of water we absorb with the seawater. The nonpotable nature of seawater explains why people can experience a water shortage on a boat or an island in the middle of the ocean, as in Samuel Taylor Coleridge's famous poem *The Rime of the Ancient Mariner*:

> Water, water, everywhere,
> And all the boards did shrink;
> Water, water, everywhere,
> Nor any drop to drink.

Although the accidental consumption of small amounts of seawater is not harmful to the human body, it is impossible to survive for any length of time by drinking seawater alone. . . .

The sodium chloride content of human blood and urine is usually around nine grams per litre (0.9 percent mass), with little variation. Drinking seawater (whose salt content is 3.5 percent) temporarily increases the concentration of salt in the blood. This salt must be eliminated, which is done by using water from cells to urinate. The cells eventually die of dehydration, followed by the organs and finally the entire body.

The consequences of absorbing seawater have been studied in rats, by varying the concentration of seawater in their drinking water. As the seawater concentration rose—up to a concentration of 50 percent —the rats had to drink increasing amounts of water to urinate more often. Above a concentration of 50 percent, however, their thirst declined. Researchers warn against sudden switches from freshwater to seawater consumption (for people stranded at sea, for example); instead, they recommend gradually increasing the proportion of seawater in fresh water.

Survival guides generally advise against drinking seawater. For example, *Medical Aspects of Harsh Environments* analyzes 136 lifeboat rescues, in which the risk of death rose to 39 percent for survivors who drank seawater compared to three percent for those who did not.

Techniques exist to make seawater drinkable (desalting process). The simplest is to dilute it with drinking water until the salinity reaches an acceptable level. This technique is used to irrigate farmland. More complex techniques, such as those used on board large ships, include reverse osmosis and the use of vacuum and flash evaporators. . . .

Source: Adapted from Wikipédia, "Eau de mer" [Web page] (accessed March 24, 2008). *[Translation]* and Wikipedia, "Seawater" [Web page] (accessed May 6, 2009).

Name: ______________________________ Group: ______________ **ST**

Creating the context

I ask myself questions

1. Answer the following questions.

a) What is the concentration of a solution?

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b) What is the concentration in ppm?

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c) What is an ion?

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d) What are the main ions in seawater? Identify them by their chemical symbols, with their charges.

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e) What are the maximum acceptable concentrations (in ppm) of sodium and chloride in drinking water, according to Canadian standards?

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f) What is the taste threshold for sodium chloride in drinking water? How would you go about preparing a litre of such a solution?

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Creating the context (*continued*)

g) What is the average concentration of sodium and chloride in seawater? Write your answers in ppm.

h) What is an electrolyte?

i) What other word is used to describe the concentration of salts in seawater? What exactly does this term mean?

j) What is the overall concentration of salt in seawater?

k) What is the electrical conductivity of a solution? What determines the presence or absence of this property?

Name: ______________________ Group: __________ **ST**

Creating the context (*continued*)

2. Answer the following questions.

a) What distinguishes fresh water from seawater?

b) Drinking water usually comes from freshwater sources. What percentage of the water on Earth is fresh water?

c) What is the Earth's main freshwater reserve? Is this water easily accessible?

d) What is the greenhouse effect?

e) What are the beneficial effects of the greenhouse effect?

f) What are the harmful effects of the greenhouse effect?

Creating the context (*continued*)

g) How does solar energy reach the Earth? Which types of rays make their way to the Earth's surface?

h) Name some technological applications that make use of solar energy.

i) Do all regions of the world receive the same amount of solar energy?

j) Do the three countries in this learning situation all receive the same amount of solar energy?

I must

3. Reformulate the goal of the problem-solving situation.

Creating the context (*continued*)

I think

4. Do you think it will be worthwhile to produce drinking water from seawater?

5. What observation criteria do you think will determine whether the test method is efficient?

6. What properties do you think will determine whether the distilled water is potentially potable? Explain your answer.

Reflection

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

Name: ______________________________ Group: ______________ **ST**

Planning the problem solving

I plan

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

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2. Write out the protocol for the experiment.

Name: ______________________ Group: ______________ **ST**

Planning the problem solving (*continued*)

2. Write out the protocol for the experiment. (*continued*)

Name: ____________________ Group: __________ **ST**

Planning the problem solving (*continued*)

I plan

3. Prepare a table for recording your observations and give it a title.

4. Prepare a table for recording the properties of the different water samples and give it a title. Remember to include a control solution.

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

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Reflection

	Yes	No
Have I considered other approaches?	☐	☐

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Name: ______________________________ Group: ______________ **ST**

Initiating the problem solving

I experiment

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

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

3. Did you work safely during the experiment? 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: __________ **ST**

Analyzing results and drawing conclusions

I analyze my results

1. Is the water obtained with each distillation method potentially potable? Explain your answer.

2. What are the advantages of each of the methods? Name at least two advantages for each method.

3. What are the disadvantages of each of the methods? Name at least two disadvantages for each method.

Analyzing results and drawing conclusions (*continued*)

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

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5. Can you be sure that the water you obtained is safe to drink? Explain your answer.

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I draw my conclusions

6. What conclusion can you draw from your experiment? Is it worthwhile for Romania, Niger and Tanzania to produce drinking water by desalting seawater? Explain your answer.

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Name: ______________________________ Group: ______________ **ST**

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 formulation of the observation criteria		☐ 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 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: ____________ ST

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 formulation of the observation criteria	The goal is very clearly defined and relevant to the problem to be solved. The observation criteria are clearly identified and relevant.	The goal is clearly defined and relevant to the problem to be solved. The observation criteria are clearly identified and relevant.	The goal is not very clearly defined or is irrelevant to the problem to be solved, OR the observation criteria are not clearly identified or are irrelevant.	The goal is not very clearly defined or is irrelevant to the problem to be solved, AND the observation criteria are not clearly identified or are irrelevant.	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 and unclear.	The work must be done again.
3	**Initiating the problem solving** Accuracy of the results and compliance with safety rules	All of the results are accurately recorded and relevant. The experiment was conducted safely.	Most of the results are accurately recorded and relevant. The experiment was conducted safely.	Some of the results are accurately recorded and relevant. The experiment was conducted safely.	The results 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