FONDATION La main à la pâte
POUR L'ÉDUCATION À LA SCIENCE

Classroom Sequence

Step 3: Is clear water safe to drink? Is it pure?

Water, a rare resource to be protected (3/3)

Chemistry - mixtures and solutions
4th – 6th grade

Introduction

Topics covered	**Chemistry, mixtures, separation techniques (filtration, decantation, distillation), dissolution, wastewater treatment plant.**
Summary and objectives	During this step, students ask questions about the notions of potability and purity of water, by analyzing the composition of mineral water.
Discipline engaged	Science and Technology
Duration	1 h 30 approx.

This resource compiles work done by teachers in the *La main à la pâte* networks. The three stages of the water sequence can be carried out independently. We encourage teachers to create their own progression, adapted to their students and the time available.

To help teachers choose from the proposals, here is the order in which the activities were designed:

Step 1: Cleaning a dirty water sample
Step 2: Discovering how a wastewater treatment plant works
Step 3: Is clear water safe to drink? Is it pure?

Getting started

This resource is a follow-up to the compiled resource "Discovering Mixtures". Do not hesitate to watch the videos Billes de science #7: Tania Louis- Mélanges de liquides (Mixtures of liquids), and Billes de science #3: Tamar Saison-La Dissolution (Dissolution).

Disclaimer: These videos are in French. But we encourage you to activate the English subtitles. Just be aware that this is an automatic translation.

Activity: Is clear water safe to drink? Is it pure?

General objective: Address the notion of microscopic particle and define a pure substance as opposed to a mixture.

Summary	
Discipline	Science and Technology
Procedure and methods	In this activity, students investigate what we don't see in water: the bacteria and pollutants that may be present in non-drinking water, as well as the minerals dissolved in tap water or commercial mineral water.
Duration	1 h 30
Material	For each group of students: • A bottle of commercial mineral water or labels from different mineral water bottles, containers, salt, scales. For each student: • Worksheet 1 (optional).

Takeaways

1. Bottled or tap water is not **pure** water. Although they are not visible to the naked eye, it contains many **minerals** that are essential to our health.
2. A compound that is **dissolved** in water (such as a pollutant) does not disappear and can be dangerous to health or the environment.

Preliminary note:

This session can be quite complex for students in the 4th grade. The teacher can choose to deal with only phases 1 and 2 OR 3 OR 3 and 4. The tables can also be handed out directly to the students if they have difficulty formulating hypotheses and modelling the problem.

Lexicon

Drinkable: can be drunk without danger to health, and which meets many criteria according to the world health organization (WHO). Today, there are 56 criteria divided into five categories: physical-chemical parameters (pH, hardness), organoleptic (color, odor), microbiological (germs and micro-organisms), toxicological (heavy metals, hydrocarbons) and undesirable substances (pesticides, endocrine disruptors).
Pure: A pure substance is a compound consisting of a single chemical species.
Clear: We can see through it. Synonym: transparent.
Minerals: Natural elements that make up the earth's crust.
Dissolve: disintegrate in a liquid in which the molecules disperse.
Mineral water: water from an underground water table and containing mineral matter.
Vaporization: transformation from a liquid state to a gaseous state.
Liquefaction: transformation from a gaseous state to a liquid state.
Refrigerant: in chemistry, a glass tube used to cool steam.
Distillate: the result of distillation.
Solubility limit: the point at which the solid can no longer dissolve in the mixture. The solution is said to be saturated. A deposit of solid is observed at the bottom of the container. This deposit is called a **precipitate**. For salt, the solubility limit is about 300 g per litre of water. The solubility of salt or sugar in water is greater when hot than when cold.

Suggested procedure

Phase 1: Starting the conversation (5 min)

The teacher asks the students to summarize the previous two sessions, in order to create a link with what they have already seen. The teacher can ask, "*What did you try to do with the dirty water samples? What is the purpose of a wastewater treatment plant?*" The teacher then pours a glass of water from a mineral water bottle and shows it to the class. Then the teacher asks, "*Is this water pure?*" The teacher takes time to reflect on the word "pure," which carries very different meanings in everyday life and in science class. Students can suggest that the water in the mountain is pure or make references to the notion of purity in religion. The teacher explains that, for a chemist, "pure" refers to a **pure body**, i.e. something that contains only one component, as opposed to mixtures. The teacher can then rephrase the initial question: "*In the glass of water, is there ONLY water*?" The students take the floor to give their opinion, arguing their point of view. After a few minutes of discussion, the teacher decides to take a poll: "*Who thinks that bottled water is pure? Who thinks that bottled water is not pure*?" The teacher writes the results of the poll on the board.

Phase 2: Reading and deciphering the composition of mineral water (20 min)

The teacher now gives each student or group of students bottles of **mineral water** or water bottle labels and asks them to figure out how to answer the initial question "Is this water pure?", using the water bottle labels.

After a few minutes, the students find the composition of the water (it is compulsory on mineral waters), but do not really understand how to read it. The teacher then explains that each line corresponds to an element present in the water. The teacher can focus on the elements that the students are probably already familiar with, such as calcium (which they have heard of from dairy products), fluoride (which they have heard of from toothpaste) or bicarbonate (which refers to baking soda or household baking powder). However, not all water contains them. This is why it is interesting to distribute a variety of brands of mineral water to the students (see teachers' note).

The teacher builds a table and asks the pupils to come and write the corresponding quantities of the main elements. Once the table has been completed, the children can observe the differences between the waters and answer the initial question: bottled water and tap water are not pure, but made up of dozens of microscopic components (which cannot be seen with the naked eye).

Labels of still mineral water low in minerals labels, with moderate mineral content and sparkling water high in minerals.

From the previous labels, we can construct the following table:

Minerals in mg/L	Water low in minerals (Thirsti still)	Still water with moderate mineral content (Tsitsikamma)	Sparkling water with higher mineral content (Thirsti sparkling)
Calcium	2,4	1,7	4
Sodium	5,1	12,7	52
Total dissolved solids	75	87	217
Nitrates	0,3	1,3	< 0,2
Fluoride	< 1	0,1	0,2

Teachers'note:

- As explained above, not all mineral waters contain the same quantity of minerals and trace elements (minerals necessary for life, but in very small quantities). It is interesting to study a variety of waters during this activity, so that students can compare them. Some mineral waters are very high in minerals. This is the case with Thirsti sparkling water. Others are much less so, such as Thirsti still or Tsitsikamma water. Sparkling waters contain more minerals and, above all, bicarbonates (or hydrogen carbonate ions). These bicarbonates form a chemical equilibrium with carbon dioxide. When the bottle is opened, the pressure drops and the CO_2 dissolved in the water turns into gas. These are the bubbles found in sparkling water.

Possible extension:

- The teacher can suggest the students taste different waters to emphasize the differences between the mineral waters. They will see that some waters are saltier, others have strong bubbles that burst in the mouth. The teacher can even have the students taste a little distilled water (in small quantities, it has no impact on health), while making it clear that we should not drink distilled water, because the body needs minerals to live. Water with a low mineral content, such as Evian or Vittel water, can be used as a reference for this tasting.

Phase 3: Problems related to pollution (20 min)

The teacher asks the students about the quality of the water: "*Do you think the water quality is good in France? Do you know that many children around the world do not have running water (i.e. water that comes out of a tap)*? This could be illustrated with photographs from geography books.

Fetching water in Bhaktapur, Nepal.

Then the teacher explains that they will model polluted water with salt and water. The teacher explains what a model is: "*In order to find explanations, scientists can build models, especially when it is not easy to carry out experiments. A model is a tool that integrates knowledge and hypotheses about a phenomenon, and that makes it possible to propose explanations for this phenomenon or to predict a situation. The model must then be validated by a series of experiments that prove its suitability for the situation under study and that allow us to know its limits.*"

At the teacher's desk, the teacher weighs a quantity of salt (not exceeding 12 g, so as not to have a precipitate and not to exceed the **solubility limit**) using a scale (Roberval, kitchen, electronic, etc., depending on the availability of equipment) and dissolves it in 500 mL of water. After stirring, the teacher has the students observe the mixture and asks the question, "*Where has the salt gone*?" Some children think it has disappeared, others do not know how to answer. The teacher then asks, "*How can we tell if the salt is gone or not?*" The teacher guides the students in their thinking. The teacher asks them what separation technique they have seen in the other activities (i.e. decantation, filtration, distillation) to find out if the salt is present. The students choose to carry out a distillation experiment. The teacher explains again how it works, if the children have not yet mastered it.

Teaching note:

- The concept of distillation, if not previously introduced in class, is not essential to the success of this lesson. The students may suggest leaving the bowl of salt water in the sun so that the water evaporates naturally, or heating the water and observing the salt deposit. All of these methods are valid, but the approach chosen here allows students to review the notion of distillation, which is a somewhat complex technique.

In secondary school, the teacher can carry out the distillation in front of the students with the appropriate chemistry equipment, if it is available. If not, the teacher can use a diagram of distillation. Worksheet 1 can be projected or printed. The pupils observe the path of the water. First of all, under the effect of heating, it **vaporises**, then **liquefies**, cooled by the **refrigerant**, and is seen to flow into the receptacle in the form of a **distillate**. The salt remains in the first vessel. At the end of the distillation process, the teacher has the students observe the salt at the bottom of the container. The students can then answer their questions about the disappearance of the salt.

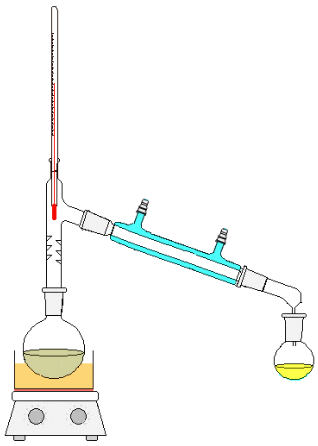


Diagram of laboratory distillation.

Possible extension:

- The teacher can accurately weigh the mass of salt they will dissolve in the water and record its weight on the board. At the end of the distillation process, the teacher weighs the salt again at the bottom of the container and the students can compare the two masses. This experiment highlights the principle of conservation of mass and illustrates Lavoisier's famous adage, "*Nothing is lost, nothing is created, everything is transformed.*"

The teacher returns to the first question of this phase, reminding the students that the salt was modelling water pollution. He explains to the students that pollution is not necessarily visible, as it was when the salt was dissolved in the water. This is why tap water is constantly monitored by professionals. They carry out hundreds of tests every day to make sure that there is no pollution. The water that circulates through the pipes, and therefore to the tap, must meet some sixty criteria to be **drinkable**. The teacher points out that tap water does meet these criteria, using the following table.

Minerals in mg/L	Potability criteria	Tap water in central Paris
Calcium	-	112.1
Sodium	200	9.0
Bicarbonates	-	285
Nitrates	50	39.7
Fluorine	1.5	0.1

Data extracted from readings taken in January 2020 in the "central Paris" zone by Eau de Paris.

Some water potability criteria and a partial analysis of the quality of tap water in the "Paris centre" sector.

Phase 4: Review and practical application (20 min)

The teacher asks the students: "*Is the mineral water you have in front of you safe to drink? If not, why not?*" The children then have to compare the potability standards for the most common minerals with the compositions of the mineral water, using the labels or water bottles from Phase 2 and the potability criteria given in Phase 3. The teacher explains that comparing the mineral contents of mineral waters consists of looking at which values are higher, equal or lower than others. To begin with, the mineral waters can be compared in pairs.

Sometimes mineral waters meet the criteria for potability, but they are not required to do so because they have medicinal properties. The teacher facilitates the discussion among the students. It is important that the children present their conclusions in an argumentative manner. The teacher can guide the argument with questions such as: "*What minerals are in too high a quantity in this water for it to be drinkable*?" The students, with the help of the teacher, come to the conclusion that mineral water can exceed certain criteria for drinkability, but only if it concerns minerals that have health benefits. The values observed in the table below or on the labels should therefore be taken in moderation. The professor can nevertheless point out that many mineral water brands try to advertise their brand using these arguments, and that we must remain critical and cautious when a mineral water is presented as "miraculous".

With the previous labels, we can build the following table:

Minerals in mg/L	Potability limits	Still water with moderate mineral content (Tsitsikamma)	Sparkling water with high mineral content (Thirsti)	Sparkling water with very high mineral content (Vichy Saint Yorre)
Calcium	-	1,7	4	103
Sodium	200	12,7	52	1172
Bicarbonates	-	87	217	2989
Nitrates	50	1,3	< 0,2	-
Fluorine	1.5	0,1	0,2	-

In green, the parameters of the mineral waters that respect the limits of potability and, in red, those that are not respected.

Conclusion (5 to 10 min)

The teacher discusses with the class what seems important to remember at the end of this activity. Here is an example of a possible written record following this discussion: "*Bottled or tap water is not pure, but it is a mixture of water and minerals. Minerals are essential for life. Sometimes pollutants can be dissolved in water. This is why tap water must meet certain criteria to be declared safe to drink. Some mineral waters do not meet these criteria, but they are still good for your health.*"

Bibliography

Eau de Paris website (only in French):
http://www.eaudeparis.fr/

The Water Information Centre website (only in French):
https://www.cieau.com/espace-enseignants-et-jeunes/les-enfants-et-si-on-en-apprenait-plus-sur-leau-du-robinet/la-definition-de-leau-potable/

Credits

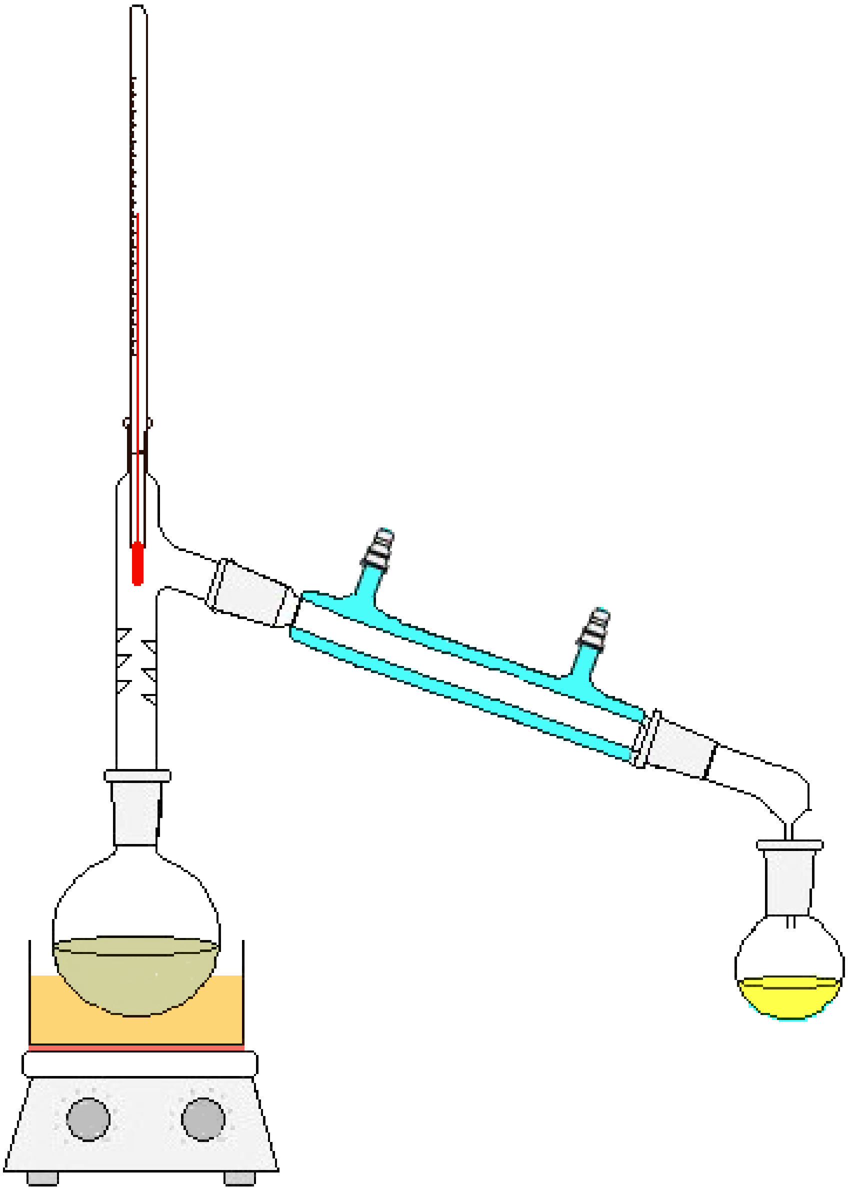
Water quality surveys in the various sectors (Paris and France) can be downloaded at this address.

The definition of a model is taken from the "Scientific Thinking, Critical Thinking" project, available here (only in French).

Water collection in Bhaktapur, Nepal: © Michel Royon/Wikimedia Commons - CC0 1.0 Universal Public Domain Dedication, available here: https://commons.wikimedia.org/wiki/File:Bhaktapur_Puits.JPG

Simple distillation apparatus, public domain, available here:
https://commons.wikimedia.org/wiki/File:Simple_distillation_apparatus.png

Workheet 1: Distillation diagram



Author
Ève Montier-Sorkine, using resources from the Fondation *La main à la pâte*

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Fondation *La main à la pâte*
43 rue de Rennes
75006 Paris
01 85 08 71 79
contact@fondation-lamap.org

Site : www.fondation-lamap.org