

Teaching and learning materials on Air pollution (Universitat Autònoma de Barcelona)

SUMMARY

This document summarizes the teaching and learning materials that are part of a Teaching and Learning sequence (TLS) around the socio-scientific issue of air pollution. Initially, this document provides a statement of why air pollution is a scientific and everyday life relevant topic to be addressed in schools. Then, a description of the teaching and learning materials including both students' and teachers' resources to work on the topic in schools have been explained.

INTRODUCTION TO THE TOPIC

Air pollution is considered one of the leading environmental risk factors (WHO, 2021). Specially, traffic is one of the most significant sources of air pollution in urban areas such as Barcelona (Criado et al., 2022; ISGlobal, 2021). Recently, research in this topic have pointed out important health effects not only in human respiratory system but also in humans cognition such as a lower working memory or cardiovascular illnesses for those who are exposed to pollution (Basagaña, 2018; Thurston et al. 2017). Thus, we need citizens' active involvement to change this situation. Therefore, these phenomena are considered a relevant topic for school science that aims to promote scientific literacy for responsible citizenship as has been highlighted in (OCDE, 2020). Using this current and relevant situation, students will be deeply considering how to improve the air quality in cities by collecting and analysing data and discussing with scientists, experts in global health, and other relevant groups (NGO, policymakers...).

PRESENTATION OF THE MATERIALS

Overview

The present materials addressed to secondary students (12-15 years old) were co-designed in collaboration with their teachers and researchers from different fields (global health, engineering...). A modular approach was followed, so that the Teaching and Learning Sequence (TLS) about clean and air pollution phenomena consists of 5 blocks. Each one including different activities sequenced following specific pedagogical criteria. From the proposed activities, teachers can choose the ones to implement. However, some of them are considered as "mandatory" to allow addressing the targeted learning aims relate to the corpuscular model of matter and specially focused on the particulate matter (PM) as pollutants, or the development of some critical thinking and inquiry skills. As part of the TLS, students are going to be involved in the process to express, evaluate and revise their own ideas about both clean and polluted air phenomena and, improving them by designing and collecting and interpreting data about the air quality in their schools. Finally, students must propose solutions for the problem and communicate them to the community. This is a sequence of material which is highly recommended that the teachers implement these activities as suggested.

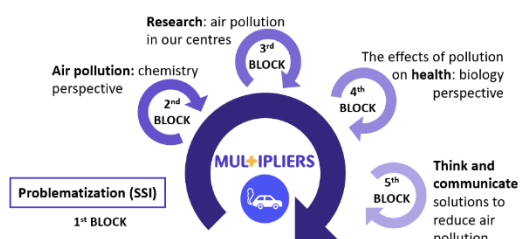


Figure 1. Structure in blocs of the modular teaching and learning sequence designed.

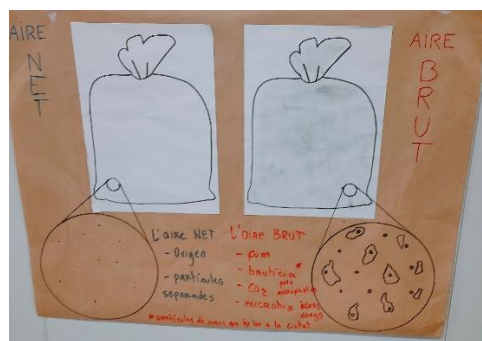


Figure 2. Students' group production after thinking on how they imagine clean and polluted air as seen with naked eye and it inside.



Figure 3. Mechanism to collect data about particulate matter pollution in their school.



Figure 4. Researchers give feedback and ideas with students during the process of design research questions about air pollution in their schools.

ACTIVITIES

A new item that summarizes the implementation of the most relevant activities in the project can be found on the MULTIPLIERS website under the title: [“Is the air in our school polluted? Students conduct their own research on air quality in Barcelona”](#).

The activities described have been thought as a part of a teaching and learning sequence (TLS) that follows a specific and chronological order:

- Activity 1. What is the problem?
- Activity 2. What do we think about clean and polluted air?
- Activity 3. Building the idea of pollution caused by PM
- Activity 4. How is scientific research carried out?
- Activity 5. Let's do our research!
- Activity 6. Making forecast about air pollution phenomena in cities
- Activity 7. Effects of pollution on human health

Activity 1. What is the problem?

The aim of this activity is to present air pollution as an important socio scientific issue (SSI) both relevant in their everyday life but also, for science. This activity is facilitated by providing students different tools including authentic news from their locals newspapers, in-person or video presentation of both different stakeholders such as researchers on air pollution or local policymakers. It is important that,

Keywords: Contextualization

Students’ resources

Are pollution are presented to the students as a socio scientific issue (SSI) using one of the proposed tasks to do so (see the Teachers’ resources section below). Additionally, in this activity has been communicated to the students the challenge that guide all the activities: they need to measure the air quality in/around their school and think actions to improve them.

Teachers’ resources

A set of possible videos, media news, policymakers/scientific visits... related to air pollution problem in the school cities have been collected. Depending on the teacher’s interest, one or other has been selected to introduce the SSI to their students. The following table includes a small abstract of the content that are included, originally in Catalan.

News from the media	News from Sabadell’s local newspaper (published in September 2022) explaining the placement of new environmental sensors to measure air quality (NO ₂ and PM), and then a Twitter thread where some people question the placement of these sensors.	Link
	News from Terrassa’s local newspaper (published in April 2022) explaining a project in which the city will monitor air quality (NO ₂ and PM10 measurement) with sensors and will publish the data in real time on a map.	Link
Scientific media	Piece of news published by ISGlobal presenting the results of a study on the relation between pollution and overweight/obesity in the population.	Link
	Infographic "7 ways in which air pollution harms your health", with data on the results obtained in different ISGlobal research.	Link
Videos	In this video, 2 researchers in air pollution introduce themselves and talk, first, about their interests, careers... and then, about, the research they are doing. As part of the video, they provide some data of the air quality in Barcelona. Finally, they challenge students to carry out their own research on air quality in their schools and think possible solutions to improve it.	Link
Visits	Both policymakers and scientific person have been offered to teachers. On these visits to the schools the person explains why they are worried about air quality, presenting some data about air pollution...	-

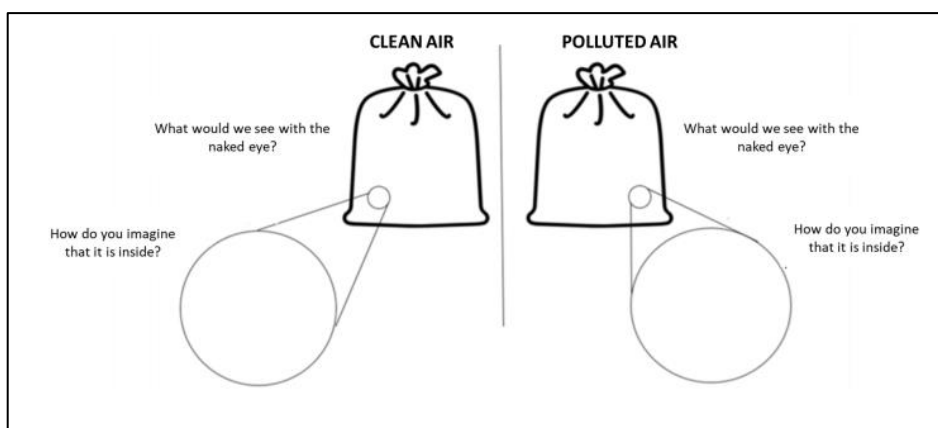
Activity 2. What do we think about clean and polluted air?

The aim of this activity is to develop the students' modelling competence by the identification of their own initial ideas about both clean and polluted air. To help them, we ask for their individual draw and description in a written form how he/she imagine clean and polluted air, both as seen with the naked eye and how they imagine it inside.

Keywords: Modelling, Initial ideas

Students' resources

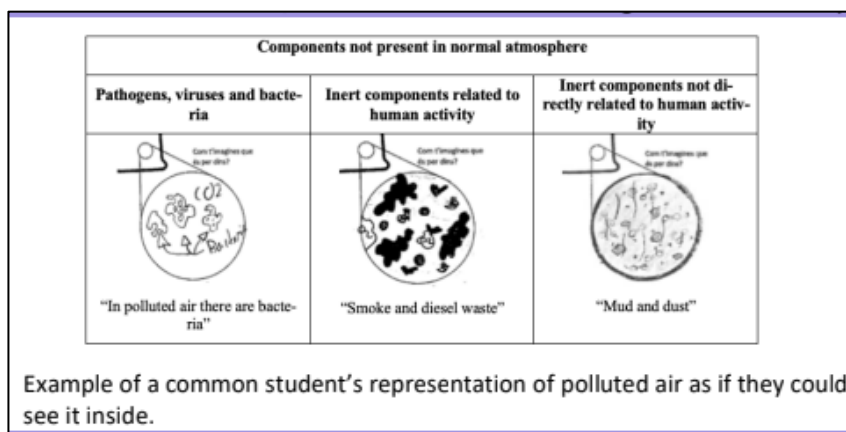
The students individually draw and describe in a written form their initial ideas about clean and polluted air. To do so, an image of transparent bags has been provided, one of them contains clean air and the other polluted air. In each of the bags students need to draw and describe first, what would we see with the naked eye (in a macroscale) and, second, how they imagine that it is inside (in a meso/submicroscale).



After the students' individual expressions of their initial models, they share their ideas with their classmates and similarities and differences between the expressed ideas about both phenomena (clean and polluted air) have been

highlighted.

Teachers' resources



To conduct the activity, there is interesting to take into consideration which are the most common representation and ideas of the students to describe the phenomena. Ideas underlined in both science education literature and recent research on this topic have been included as part of the teachers' materials ([link to them](#)).

Additional resources

You can find more information about students' initial ideas in the following research papers:

- Solé, C., Couso, D., & Hernández, M. I. (2022). Revisiting secondary students' ideas about air pollution. The challenge of particulate matter. *Chemistry Education Research and Practice*. <https://doi.org/10.1039/d2rp00117a>
- Tena È., Couso D. (2021) [What Is City Air Made of? An Analysis of Pupils' Conceptions of Clean and Polluted Air](#). In: Levriani O., Tasquier G., Amin T.G., Branchetti L., Levin M. (eds) *Engaging with Contemporary Challenges through Science Education Research*.

- Solé, C., Tena, È. i Couso, D. (2020). [¿Qué modelo de materia explica la contaminación? Explorando el modelo corpuscular en la mesoescala.](#) *Alambique. Didáctica de las Ciencias Experimentales*, 101, 30-36 Contributions from Science Education Research, vol 9. Springer, Cham. https://doi.org/10.1007/978-3-030-74490-8_11

Activity 3. Building the idea of pollution caused by PM

The aim of this activity is to build an idea of air pollution that agrees with the scientific community ones. Specifically, an idea of pollution understood as the presence of suspended particulate matter (PM) in the air has been build. To do so, first students analyse which pollutant media usually uses to describe the air quality in the cities. Then, they carry out a learning lab activity in which an analogy between the pollution obtained when an engine is burned and a peanut is burned is used.

Keywords: Modelling, learning in the lab

Students' resources

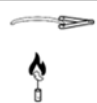


Photos about what pollutants appears in the media when they talk about air quality and pollution have been shown to the students. Then, in groups, they need to compare pollutants that appear in the media with those that appears in their initial productions (drawing and descriptions) identifying similarities and differences. They also need to identify in which state of matter is the pollutant in our atmosphere.

After a moment to share the groups' conclusion, a lab activity is proposed to the students. Using an analogy between smoke from the industry or car's exhaust pipe and smoke from burning a peanut or a piece of paper they need to observe, on the one hand, that there are things that we cannot see with the naked eye and, on the other hand, that after burning something air could contain small pieces of matter in suspension. The scientific research question, material, and the steps to do this lab activity are provided by the teacher. But, the prediction, their justification, the collection of data using both a sensor and other observational methods, the analysis, and explanation of the results and the conclusions must be taught by the students.


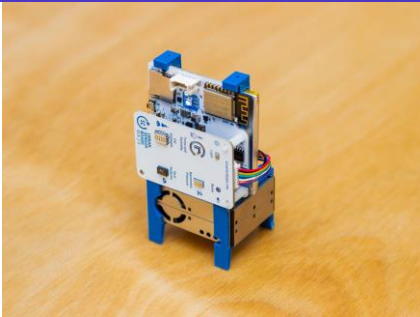
Then, a [video](#) in which a scientific person explains how they actually collect and analyse air pollution data in cities are showed to the students.

Finally, considering all the activities done and conclusions obtained from the previous activities, students' needs to write their own definition about what a particulate matter (PM) pollutant is, including explicit references to their size.

<p>What do I want to investigate?</p> <p>How if the smoke that is released when we burn a piece of paper?</p>	<p>What do I need?</p> <ul style="list-style-type: none"> • Watch glass • Wooden clamp • Peanut / piece of paper • Lighter • Wire • Cork • Electronic magnifying glass
<p>What do I do?</p> <p>While burning a peanut, I place a watch glass held by a wooden clamp over the column of smoke.</p> 	
<p>What do I think that will happen? (What do you think you will observe when you do the experiment? What will happen to the watch glass?)</p>	<p>Why do I think it will happen? (What makes you think that you will observe such results?)</p>
<p>LET'S DO THE EXPERIMENT</p>	
<p>What happened? (What did you observe? What happened to the watch glass? Can you identify any of the things you observed?)</p>	<p>Why do I think it happened? (How do you explain the results obtained? What do these results make you think about?)</p>

Teachers’ resources

Two different instruments to collect/analyse data of the smoke obtained from the peanut burning could be used in this lab-activity: a digital magnifier and a low-cost sensor.

	
<p>DIGITAL MAGNIFIER</p>	<p>LOW-COST SENSOR</p>
<p>Could help the students to build the idea that despite the is nothing to see with naked eye, some solid particles from the smoke could be seen using a magnifier and which are their approximate size.</p>	<p>Could help the student to understand how many particles a burning creates, and which are the approximate size of them (10µm, 2.5µm or 1µm)</p>

To help students to establish the relation between the experiment proposed but also to help them in the following activities, a video where a professional scientific explain how they collect data have been shown. Video is available in the following link: <https://www.youtube.com/watch?v=p2wtXKHlvMM>

Activity 4. How is scientific research carried out?

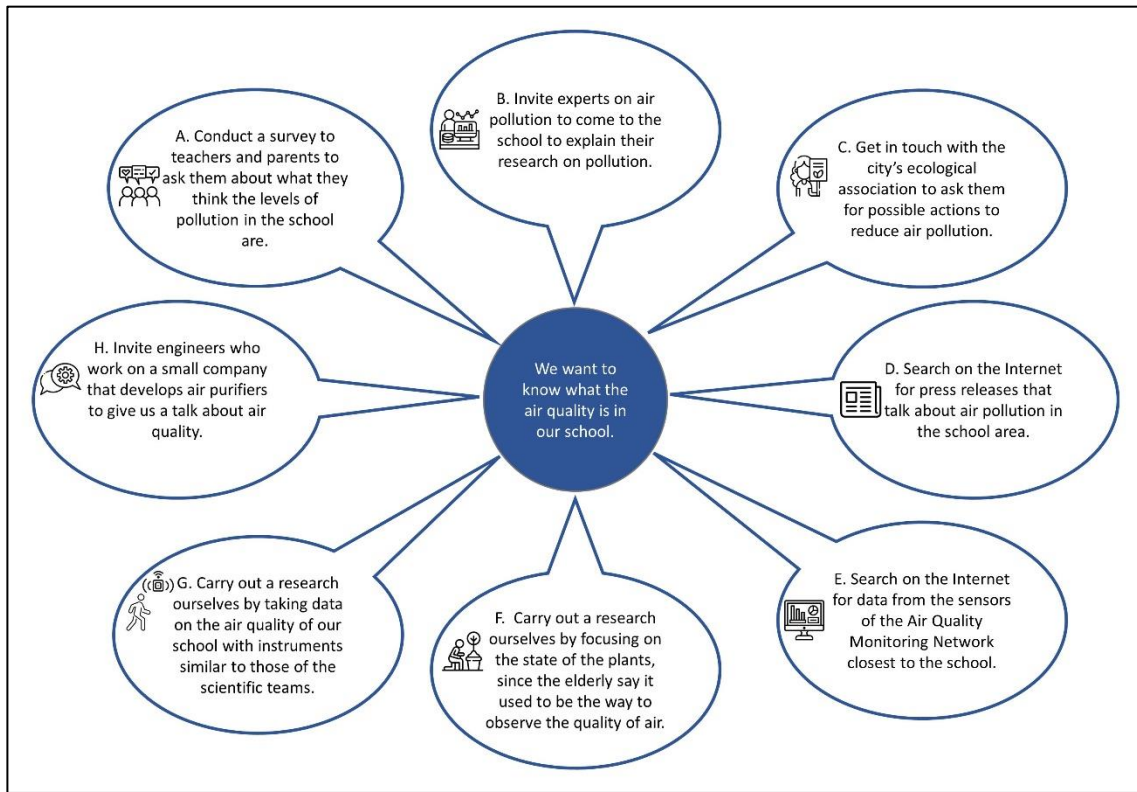
The aim of this activity is to develop students’ critical thinking about what we understand by high-quality research on science. This activity evolves in two steps: (1) reflecting about different ways of answering a scientific question; and (2) analysing the processes of carrying out research using quality criteria such as: validity, reliability, and usefulness.

Keywords: Argumentation, Critical Thinking, Jigsaw groups/debate

Students’ resources


The following no-real scenarios has been presented to the students:

“Students from other secondary school wanted to know how the air quality in their high school is. To do so, first, they made a brainstorming in which the following ideas to answer the question appears:”



Multipliers students' needs to analyse the brainstorming (see activity above) to identify and justify both: which proposals do they think will be best and worst to answer the question. After reflecting and give arguments individually, students share their ideas with their classmates.

After that, 3 different cases where research to measure the air quality have been presented to them. In different groups, students needs to analyse the quality of each research presented and to identify how its quality can be improved. To do so, students have a scaffolding tool with different questions that could help them to analyse, score and justify the quality of each part are included (see the following picture).

 What question do they want to answer?	Does the question contribute to the topic they wanted to investigate? Does the question specify what will be measured and under which conditions will it be done? Does the question relate what is to be observed/measured with what is really measured? Is it a specific question that can be answered with the resources that they have?	Score from 1 to 4 the quality of this aspect of the research: (1) Bad (2) Improvable (3) Good (4) Excellent	Justify your answer:
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Teachers' resources

As part of the materials have been included tables that underline, on the one hand, concrete questions to guide the students' discussion and, on the other hand, the main ideas to be identified and discussed in both steps (where students reflect about different ways of answering a question, and when they analyse and identify how to improve research done by others).

	CASE DESCRIPTION			Ideas to discuss with the students
	Who did it?	How is the research done?	Does the proposal help to answer the question?	
A	Students	Survey to know the opinion.	It does not answer the question of knowing air quality.	This would be good research if the aim was to know the opinion.
B	Experts	In this case they are not doing research. Experts explain concepts related with the topic.	It does not answer the question because it is a generic talk.	Although being experts, they are not performing research, and therefore it would only serve to expand knowledge in general.

A complete version of both tables is available in the following [link](#).

Activity 5. Let's do our research!

The aim of this activity is to develop the students' inquiry competence. In this sense, students in groups and helped by a specific scaffolding need to planning and carrying out their own research about air pollution in/around their school.

Keywords: Inquiry, Meet with the experts, ICT

Students' resources

A specific scaffolding tool to support students planning and carrying out authentic research have

been developed. This tool divided the process of planning and carrying out investigations in four key moments: design, initial prediction, carry out the experiment and the obtention of results and conclusions. Different driven questions (such as what do I want to investigate? what do I need?...) have been included to help students in those key moments and also in other specific moments identified.

The full version of this scaffolding is included in the following [link](#).

WHAT DO I WANT TO INVESTIGATE?
Does the question answer/contribute to the initial question about how the air quality in the school is? Are factors (what we want to observe/measure) and variables (things that are different in each case...) related? Is the question of the type "how...", "in which way...", "in what situations...", and not of the type "why..."? Is it a specific question where we can imagine what instruments will be used, what results can be...? Can we answer the question with the material and conditions we have? Is it a question that cannot be answered with "yes" or "no"? Can't we find the answer to the question on the internet, asking SIRI/ALEXA...?

*Fill in this space with your ideas after talking to your teacher

WHAT DO I NEED?
What materials do I need to do the research? How could we collect pollution? How would we look at the pollution we have collected?

*Fill in this space with your ideas after talking to your teacher

WHAT DO I DO?
What steps will we take to do the research? When will we do it? Where will we place the material/devices...? How long will we leave them? How do we make sure we always do it the same? What shall we compare with what? How many times will we do it?

*Fill in this space with your ideas after talking to your teacher

Teachers' resources

Despite the previous scaffolding could help students in the process of planning and carrying out their own research, it is essential that teacher also have an active guiding profile in this process. Some examples of good questions and helpful guidance have been included as part of the teachers' resources.

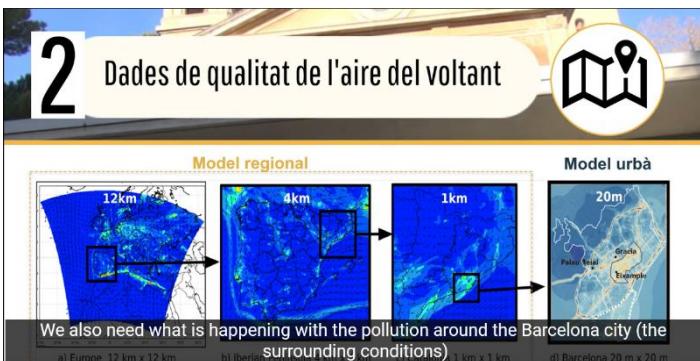
Example of students' initial and reproductive question
<ul style="list-style-type: none"> • How much pollution there is in the air? • Which are the main pollution sources in our cities • Is the garden polluted?
How can we help students
Asking students for the identification of variables that they want to research and their concretion in the experiment
Example of students' final and researchable questions
<ul style="list-style-type: none"> • A what time of the day there is more pollution in the main entrance of the school? • Is the air more polluted when there is people in a class during one hour, or when there is no people? • When there is the air more polluted in the school: during the week (Thursday and Friday) or during the weekend (Saturday and Sunday)?

Activity 6. Making forecast about air pollution phenomena in cities

The aim of this activity is to know which the air pollution data that they collected around their school is useful for. To do so, a professional scientist from Barcelona Supercomputing Centre (BSC) explains using a video how real data collected both in national station and by citizens are used to make forecast about air quality in our cities.

Keywords: Meet with the experts, researchers

Students' resources



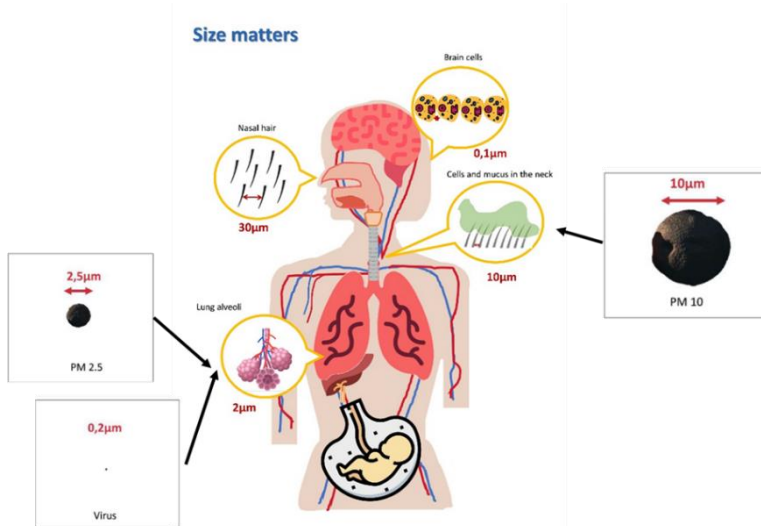
Video presents an engineering researcher that made forecast about pollution in Barcelona city using official data and also, data collected by citizen. Full video is available in the following [link](#).

Activity 7. Effects of pollution on human health

The aim of this activity is to be aware of the consequences for human health of being exposed to the air pollution and to know some of the human body passive mechanisms that protects us against the penetration of pollutants suspended in the air. To do so, students need to analyse how different particles that are usually in their air (such as, particulate matter in suspension, dust, CO₂...) may penetrate in their body and which passive mechanisms our body must prevent the intrusion of some of them.

Keywords: Modelling, jigsaw groups/debate

Students' resources



After asking students how they imagine both gases and particulate matter pollutants path inside our body, an activity focus on the relation between particle size and their penetration in our body have been proposed. In this activity students have on the one hand, a sketch of human silhouette that include human body mechanisms to protect us against the penetration of external agents (e.g. nose hairs, mucus...); and, on the other hand, different kinds of particle including particulate matter particles and gases and their approximate size. Considering sizes of both human body mechanisms and particles, students need to identify how much each

particle could penetrate in our body. Finally, some main effects associated to being exposed to high levels of pollution are underlined.

Additional resources

More information about scientific evidence that establish a clear relation between how being exposed to high levels of pollution have important effects in human health in terms not only of respiratory system, but also at cognitive or cardiovascular level you can read the following article (only available in Catalan).

- Basagaña, X. (2018). Els efectes de la contaminació en les persones: què en sabem i de què busquem evidències? *Revista Ciències*, 35, 28–34. <https://doi.org/10.5565/rev/ciencias.392>

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