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The Gems of Water

How to become a gem of water?

An illustrated guide for citizen engagement under the UNEP GEMS/Water programme

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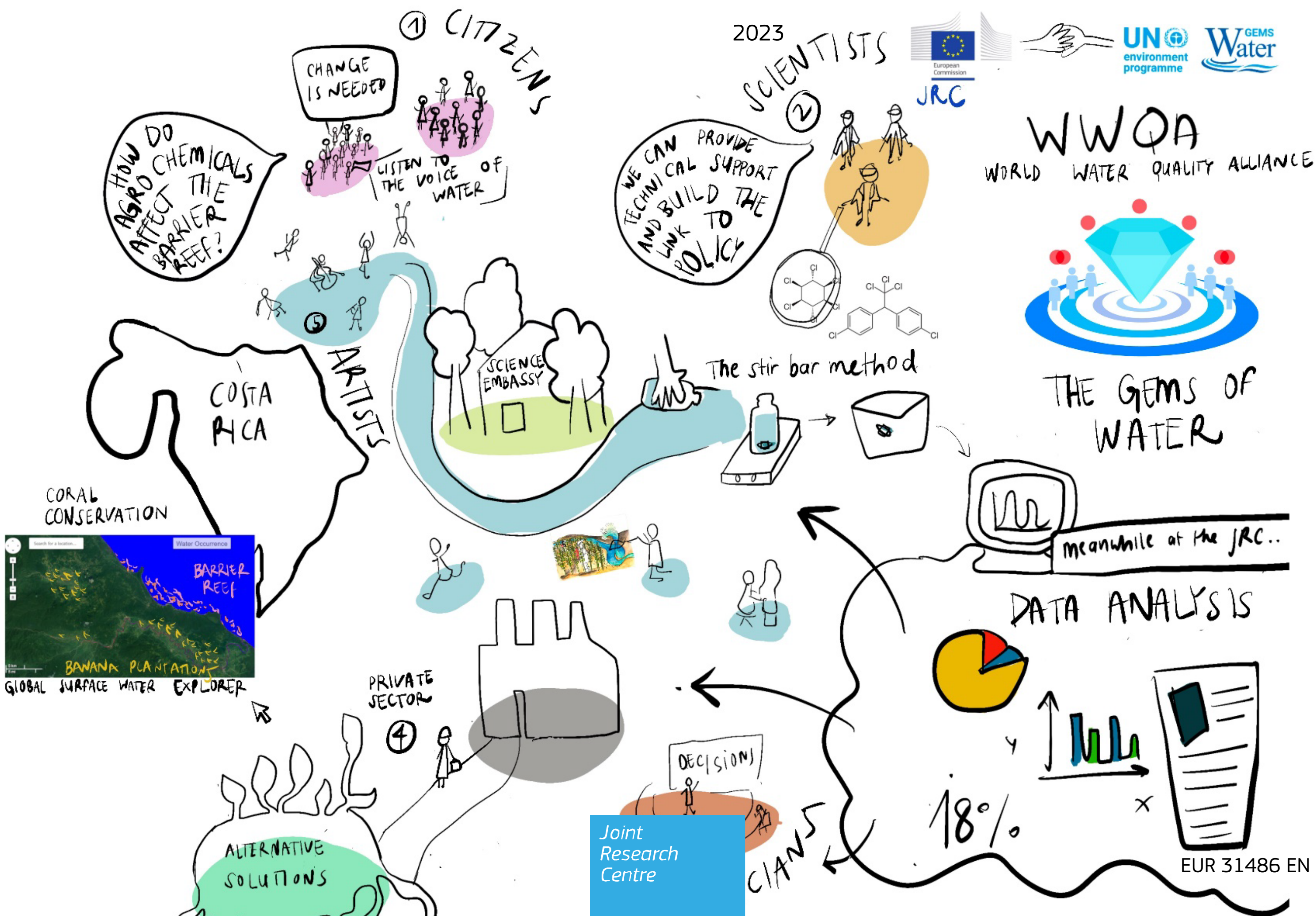

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Contents

Abstract

The Joint Research Centre (JRC), partly based in Ispra, Italy, operates as the Science Service of the European Commission Science Service. Together with the UN Environment Programme Global Environment Monitoring System for Water (UNEP GEMS/Water), the JRC established “The Gems of Water”, a capacity building project for water monitoring linking citizens to advanced measurement of organic contaminants. Such project finds its space in the Social Engagement Platform work stream of the World Water Quality Alliance. Inspired by the Renaissance period in Italy, when scientists acted as ambassadors to direct policy making and financing, “The Gems of Water” aims at creating a network of local Science Embassies consisting of citizens, non-state actors and research centres working together for a scientifically robust and continuous transfer of water quality data into knowledge and action. The expected outcomes of “The Gems of Water” include the establishment of a monitoring system that is inclusive, participatory and consistent based on implementation of novel analytical approaches to obtain a picture of in-time changes of organic contamination of waterbodies. Such objective responds to the mandate entailed in Resolution 3/10 of the UN Environment Assembly on “addressing water pollution to protect and restore water-related ecosystems”. Output channels are platforms such as the Information Platform for Chemical Monitoring (IPCHEM), Global Environment Monitoring System’s GEMStat Database, and reporting drives for Sustainable Development Goal (SDG) Indicator 6.3.2 on Ambient Water Quality, which fall under UNEP GEMS/Water. Data will further be shared in aggregated form on the World Environment Situation Room (WESR), as well as integrated into storytelling. Diverse outcomes facilitate transfer of information, from knowledge into action, sharing solutions and connecting local communities in a true water alliance.

Foreword

"The Gems of Water" activity operates basing itself on the principle of the Quintuple Helix, which supports the necessary co-creative interactions between Research, Governance, the Private Sector, Citizens, Culture and Art, to enact the effective uptake of sustainable development (Gawlik et al., 2018). Thus, local communities and citizens are enabled and facilitated, through "The Gems of Water", to become involved actively and communicate with science to improve how natural resources, and in particular water quality, have been managed so far at the local level, thus improving ecosystem and human's health. Scientific evidence and technological innovation are required to broaden the understanding of the status of water bodies and to propose alternative solutions for healthier environments. Following the framework applied in the establishment of Local Water Forums by the Social Engagement Platform of the World Water Quality Alliance (Elelman, 2022), in "The Gems of Water", local communities are involved from the very beginning to the very end of the process. While the monitoring tools and materials are provided by the JRC; local communities represented by contact organizations are being asked to identify and express their concerns regarding contextual water quality problems, to help co-design the sampling locations, participate and understand the analytical process and analyse and share results. Such structure seems to still be a condition of very few citizen science projects in the field of hydrology, where the wide majority remains contributory, with citizen science participation being limited to sampling and data collection (Njue et al., 2019). A truly co-created process requires patience and constancy, but appears crucial to build a trustful network that might support towards the addressing and resolution of water quality issues (Buytaert et al., 2014; Notermans et al., 2022).

This report, consisting of introductory background information on "The Gems of Water" project, the project scope, workflow and scientific foundation, represents one element of the technical support that the JRC is providing to the Science Embassies involved in "The Gems of Water" project. Additionally, chapter 7 introduces the link between science and art, with the intention of highlighting the important role of values and culture in the way water is perceived, experienced, managed, shared and respected. In this regard, the sampling protocol introduces a sentence to acknowledge water as a holder of information, which can give important insights to scientists, citizens, and the broader society. Furthermore, the document includes practical protocols for the sampling and extraction procedure of water samples, while the annexes include examples of the samples form, sampling site form and chain of custody. The protocols describe a method developed through various experimental exercises carried out at the JRC Water Quality Laboratory. This report represents the documentation which, along with recorded videos embedded in QR codes, helps local communities come closer to science, and, scientists come closer to local communities' water quality issues, within the framework of "The Gems of Water". The project design as well as the manual of instruction and protocol are currently being tested and will be tested at a pilot scale, where feedback loops are created to collect and improve the citizen engagement approach here presented.

Acknowledgements

We especially thank colleagues for their professional and technical contributions to this manual:

Jemma Woolmore, Video Artist, for having further broadened the boundaries of "The Gems of Water" and for establishing a first important link between science, culture and art in our everyday scientific practice.

We furthermore thank all the participants of the pilots in Mpigi, Uganda, Puerto Viejo, Costa Rica, Timisoara, Romania for their enthusiasm for "The Gems of Water" project, their feedback on the manual and support throughout.

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1 Introduction

Protecting ambient water quality is essential to guarantee a healthy life of humans and the ecosystem. This being recognized by the United Nations Environment Assembly (UNEA) (UNEA, 2017) becomes all the most relevant considering the intensifying contamination of water bodies with mixtures of hazardous chemicals of unknown effect to ecosystems and humans health, mainly pesticides, pharmaceuticals, personal care products, and industrial compounds (Dulio et al., 2018). A need to close the knowledge gap and protect the planet in more effective ways is thus recognized and lies at the core of the World Water Quality Alliance approach of combining water quality data from environmental modelling, earth observations, laboratory assessments and citizen science. A better understanding of water environments requires capturing the chemical fingerprint of water through wide screening of chemicals, identifying contamination sources and assessing the health risk related. Such information can provide scientific support to drive local policy makers to real change. The JRC and the UN collaborate in the World Water Quality Alliance to collect information and build knowledge from all sorts of data around the status of global water bodies, as requested in Resolution 3/10 of the UN Environment Assembly "Addressing water pollution to protect and restore water-related ecosystems" (UNEA, 2017). The Science Service of the European Commission, JRC works as scientific advisor and provides technical support to the policy makers of the European Union. There, the Water Quality Laboratory collects, analyses and shares data on water quality. The UN Environment Programme Global Environment Monitoring System for Water works to support water quality monitoring globally and to help achieve the goals of Sustainable Development Goal (SDG) 6, “good ambient water quality for all”. Through the establishment of “The Gems of Water” (Figure 1), a project to make people protagonists of water quality knowledge and action, citizens of communities around the world can become scientists, owners and protectors of the quality of water they use every day. This happens by taking part in water sampling campaigns, by virtually accessing laboratories facilities and participating in the detection of organic compounds with advanced measurement technology, according to a methodology and protocol which were developed at the JRC and are reported along with simplified background information.

Figure 1. “The Gems of Water” logo

@Natalia Głowacka

“The Gems of Water” logo is a reflection of the concept of support to capacity development of the World Water Quality Alliance Social Engagement Platform, by involvement of citizens in sampling and collection of data on water quality. The term "gems" is a wordplay, since this activity is part of the collaboration with the UNEP Global Environment Monitoring System, or GEMS. In particular, GEMS/Water, GEMS’ water section, is of interest to our concept. A "gem" is meant to be a person or participant (many "gems" make a "treasure"), but can also mean "data" or "information" or "knowledge", which are needed to resolve a problem related to water quality. The logo presents a gem surrounded by the human figures which are "people" or, more precisely, "citizens". Above the gem, floating red dots symbolise seven "gems". Blue circles under the crystal present the different types of water resources.

Scan the QR Code to dive into GoW!

2 “The Gems of Water” within GEMS/Water

As mentioned in the introduction, “The Gems of Water” has been conceived within an established collaboration with the UNEP GEMS/Water programme. UNEP GEMS/Water has been supporting and promoting capacity development in the field of water quality monitoring since inception in 1978, and most recently at the UNEP GEMS/Water Capacity Development Centre (CDC), based within the School of Biological, Earth and Environmental Sciences and Environmental Research Institute of the University College Cork, Ireland since 2015. UNEP GEMS/Water CDC conducts a wide range of capacity development activities around water quality monitoring and assessment globally, with a key focus on providing training opportunities in freshwater monitoring and assessment, ranging from free publicly available courses offered on the UNEP eLearning platform (eLearning.unep.org), continuous professional development courses, to advanced postgraduate diploma (PGDip) and MSc level courses (Figure 2). The CDC also provides advice globally on training strategies, materials, and organizes workshops, and supports the implementation of monitoring programmes with the help of expert advice. As such the CDC works very closely with the UNEP GEMS/Water Global Programme Coordination Unit (GPCU) in Nairobi, Kenya, and the GEMS/Water Data Centre based in Koblenz Germany, its activities are closely informed by collaboration with GEMS/Water National Focal Points throughout the globe. GEMS/Water National Focal Points are key to the advancement of global reporting on water quality, and a primary objective of the GEMS/Water CDC and the GEMS/Water programme overall is to encourage compatibility and comparability of data for use in national, regional and global assessments. The CDC encourages this by promoting standardized approaches to water quality data generation, and by providing guidance and training on all aspects of water quality monitoring and assessment and quality assurance of monitoring activities.

Figure 2. Participants in training workshop on freshwater monitoring and assessment, held in Suva, Fiji in August 2022, and coordinated by the UNEP GEMS/Water Capacity Development Centre. This particular workshop was carried out through a blended approach of both online and in-person training.

3 Zoom in "The Gems of Water"

Inspired by the Renaissance period in Italy, when scientists acted as ambassadors to direct policy making and financing, "The Gems of Water" project aims at creating a network of local Science Embassies consisting of citizens, non-state actors and research centres working together for a scientifically robust and continuous transfer of water quality data into knowledge and action.

The JRC provides training for collection and extraction of water samples, while involved Science Embassies support the use of a detection technology based on the use of the stir bar. The stir bar is a small magnetic bar coated with a rubber layer used to capture the contaminants present in the water sample and to determine their amounts. You will learn more about it in the following chapters.

You, as representative of the Science Embassy in your location, can participate in the workflow presented in Figure 3 by:

- receiving a kit, containing the stir bar and needed laboratory equipment;
- visiting a water body of interest, learn about its surroundings, land-use and potential contamination problems and participate in collecting water samples at the agreed locations;
- participating in the extraction of contaminants from the water samples, after which you'll send the stir bar back per post to the JRC, as organized and paid by the JRC with DHL system;
- virtually visiting the laboratory at the JRC in Italy where the analysis of your stir bar takes place, while learning about a method of measurement of contaminants concentrations;
- understanding the results obtained and disseminating them.

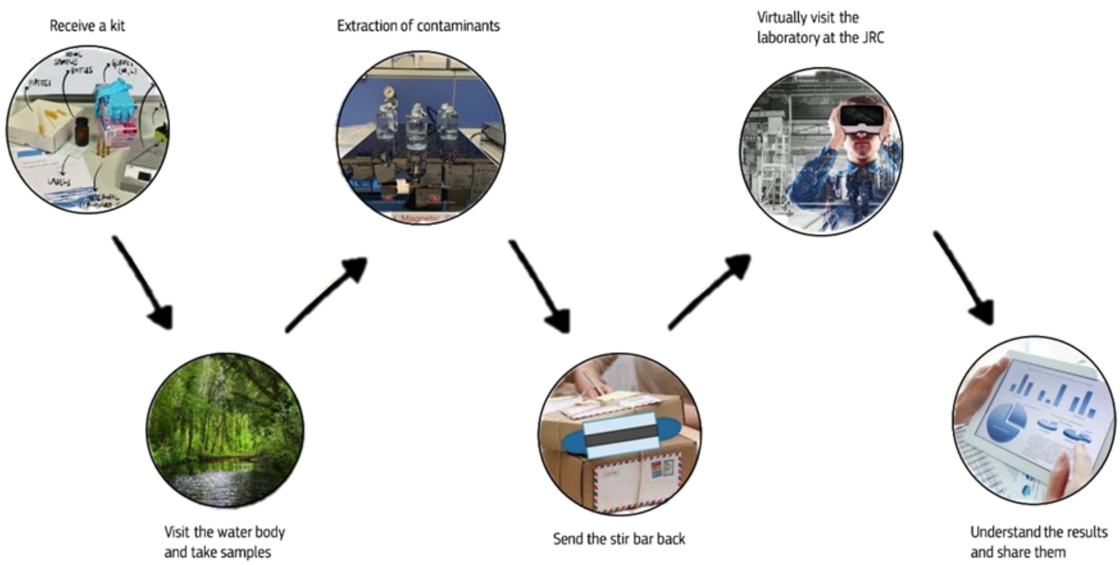

Figure 3. Schematic workflow of "The Gems of Water"

Data on your water quality will be shared with you, with data platforms, to the public and to policy makers through workshops and reports, and through artistic and cultural works.

To summarize, these are the aims of the project:

1. Collect information on the contamination of water bodies over time and understand the status of our waters.

2. Understand links between water pollution, land use, humans and ecosystem's health.

3. Increase participation and interest of citizens in water quality science, and drive change at local and global level.

4 Chemicals of emerging concern (CECs)

Scan the QR Code to learn about

While we might not be aware, chemical products occupy a relevant role in our everyday life and our consumption of industrial and agricultural products directly affect the environment and the water cycle.

These chemical products include pharmaceuticals, personal care products, pesticides and industrial chemicals. Scientists call those chemicals of "emerging concern", to indicate that the risk for humans and ecosystems is not fully understood, especially when they accumulate in water bodies over time, and because they are not present alone but as chemical cocktails.

Pollutants we have to look out for also include those substances that are already restricted according to international and European regulations, because of their known toxic effect on humans and ecosystems health. All these chemicals, called persistent organic pollutants often have in common very nasty traits: they are persistent, meaning they can stay unchanged in the environment for really long time, and they can bio accumulate, meaning that while they pass from water, soil, plants, animals their concentrations increase, and they are transported widely in the environment.

This is why it is important to monitor as many pollutants as possible: to obtain a picture of the chemical fingerprint of water, to be able to limit the concern that surrounds them and their presence, by banning, reducing their use and finding healthier alternatives. To give you a practical examples of some chemicals that are present in our everyday life and how they end up in the water, here's three:

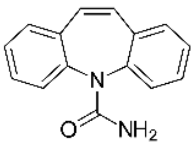

Figure 4. Carbamazepine chemical structure

Carbamazepine (Figure 4) is a pharmaceutical, it is used as treatment for epilepsy, and it ends in the water through our urines and faeces as well as through dumping of pharmaceuticals waste into the toilet, or into water bodies, by industries.

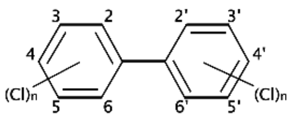

Figure 5. Polychlorinated Biphenyls chemical structure

Polychlorinated Biphenyls (Figure 5) are industrial chemicals. They were used in cooling liquids and in commercial and consumer products (such as furniture and building insulation) to prevent fires from breaking out. They are toxic, carcinogenic, and they can stay in the environment for many years. They were banned from US in 1979[1], their use restricted in the European Union in 1987[2], while worldwide they are banned under the 2001 Stockholm Convention on Persistent Organic Pollutants[3].

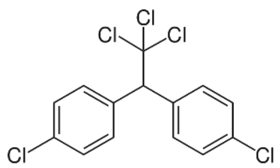

Figure 6. DDT chemical structure

DDT (Figure 6) was a commonly used insecticide, it was used to combat Malaria, but also in agriculture and livestock farming to control pests. Its toxicity is well known and that is why it has been banned in many countries starting from the 1970s[4].

Think of a product you use often in your life (could be a cream, an herbicides or a pharmaceuticals), look at the label, do you recognize any compound? Do they sound like they could cause environmental pollution? If you like, you can do a little research on them and think of all the ways it might end up in your water cycle.

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1 https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs
2 https://environment.ec.europa.eu/topics/waste-and-recycling/pcbspcts_en
3 http://chm.pops.int/TheConvention/Overview/tabid/3351/Default.aspx;
4 https://www.epa.gov/ingredients-used-pesticide-products/ddt-brief-history-and-status

5 The chemical fingerprint of water

You might be wondering how monitoring water quality pollution and policy making can go hand in hand towards the necessary sustainable change we are seeking.

Historically, water quality regulations, such as the European Water Framework Directives (European Council & European Parliament, 2000), are single substance oriented. This means that legislations require to monitor a list of 30 to 40 organic contaminants to be sure that their value respects a maximum limit in water. This system makes it easy to identify and regulate polluters, such as big industries, but does not really picture the actual status of the water bodies. It is able to collect information only on a small part of the chemical status of water, not on its whole chemical fingerprint, leaving our knowledge full of gaps and unknowns.

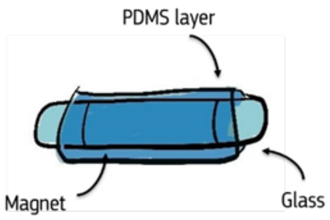
Luckily, in recent years, there has been more and more research and advancement in technology that allows to measure many more chemicals in parallel. These methods are called of wide-target screening, because they combine target measurements (looking for specific known compounds, such as DDT), and non-target screening (What else is in the water I do not know about?). These methods can be of great use because they increase our understanding of water quality. Yet, for these wide-target screening methods to become widely used and affordable, more research is needed. Only so, the shifting from a single-substance oriented policy to a more comprehensive screening, understanding and regulation of water pollution can be achieved. Dive in the next chapter to discover how the wide-screening stir bar technology can help us gather information on the chemical water fingerprint.

Do you know if there is a water regulation in your country? Are the data publicly available?

What kind of compound would you like to be included in the regulations? What compound are you mostly concerned of?

Scan the QR Code to learn about the chemical fingerprint of water!

6 The stir bar: how does it work?



The stir bar (Figure 7) is a small glass magnetic bar, coated with a sorbent layer of a silicon rubber, called Polydimethylsiloxane (or PDMS in short) (Lerch & Zboron, n.d.). The name Polydimethylsiloxane might sound intimidating, but really, the layer appears for its chemical and physical properties to be ideal for capturing organic pollutants present in water samples. PDMS is, in fact, robust, resistant to a maximum temperature of 350°C and is not ruined when in contact with other chemicals (Sargazi et al., 2020).

Figure 7. Scheme of a stir bar

@Caterina Cacciatori

When magnetic stir bars are thrown in the water samples and the samples are positioned on a magnetic stirrer for a time, the magic happens: pollutants that are more similar to PDMS than to water accumulate on the rubber layer, in a step called extraction, in this case Stir Bar Sorptive Extraction (SBSE) (Figure 8).

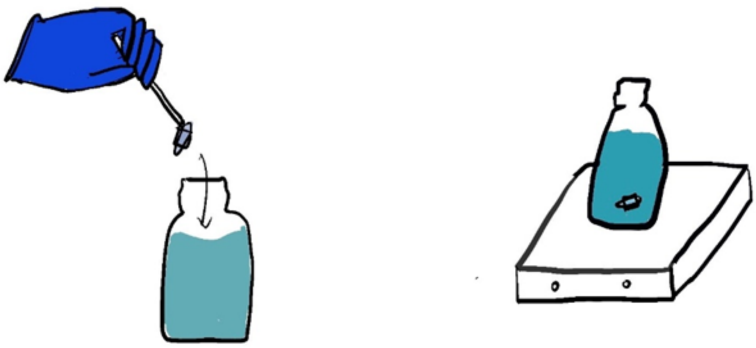


Figure 8. Simplified scheme of the extraction procedure

@Caterina Cacciatori

In fact, we say that contaminants are extracted from the water and concentrated on the stir bar sorbent PDMS layer. The extraction of pollutants from the water lasts for five hours, after which the stir bars now loaded with chemicals can be used for analysis.

The advantage of the Stir Bar Sorptive Extraction is that the procedure is simple compared to other extraction methods, with reduced use of chemicals (Lerch & Zboron, n.d.). It is considered an environmentally friendly procedure! While it is true that this type of extraction only works for compounds that present affinity to PDMS and dislike for water, aka the hydrophobic compounds, the list is yet quite long: for instance, in the method developed for "The Gems of Water" project we are able to detect up to 300 compounds!

Freely draw the stir bar and the extraction procedure as you understood it.

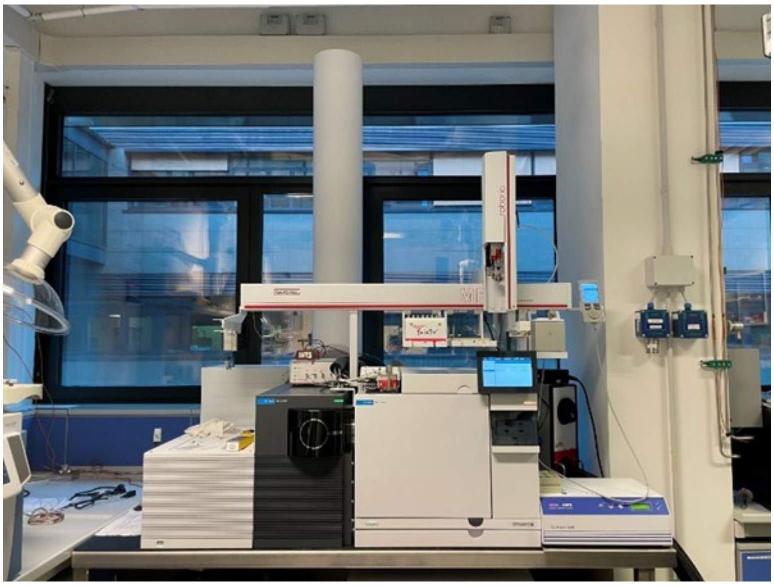
Scan the QR Code to learn about the stir bar!

7 The sample analysis procedure

What happens to the stir bars once they have reached the JRC?

Scan the QR Code to dive into the analysis

Once we have received the stir bars at the JRC, we analyse them with a thermal desorption coupled with a Gas Chromatography-Mass Spectrometry instrument (Figure 9).



Such instrument is composed of three parts: one thermal desorption unit, one gas chromatograph and one mass spectrometer, which allow for releasing the compounds from the stir bars, identifying and quantifying them, respectively.

One at a time, the stir bars are positioned in the thermal desorption unit and heated up to 300°C. This process allows that the contaminants captured on the stir bar layer to be released in gas form and to enter in the gas chromatograph.

Figure 9. Gas Chromatography – Mass Spectrometry instrument

The contaminants are then transported with an inert gas through a long thin glass column for around 30 m (!!). The time that each compounds spends in the column depends on their boiling points, weight and affinity to the column characteristics. At the exit of the column, the compounds enter in the Mass spectrometer, a detector which allows us to be able to recognize the compounds present on the stir bars and to characterize the chemical structure, by comparing it with their reference standards.

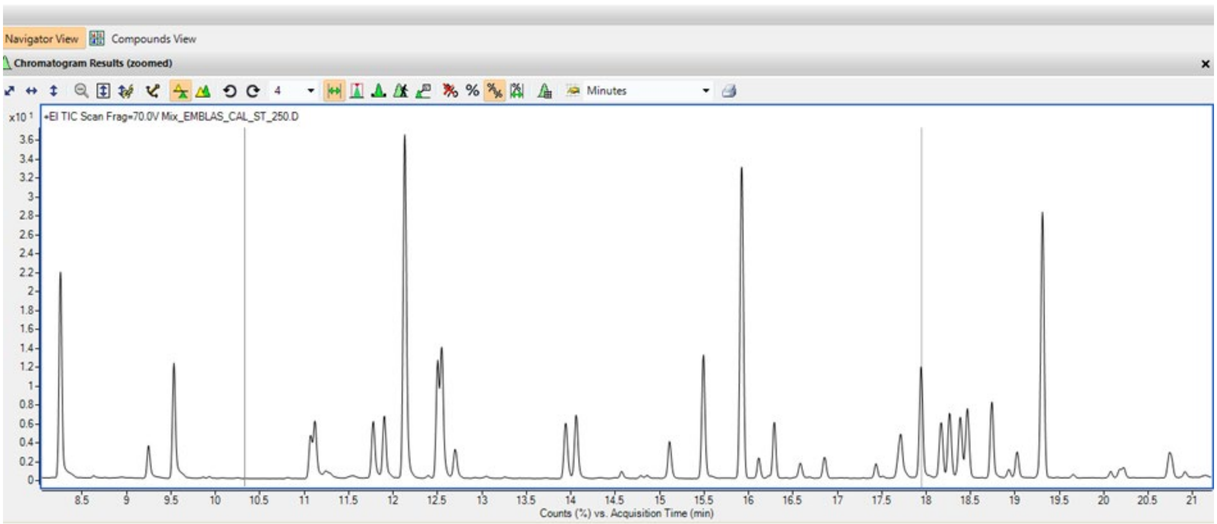


Figure 10. Example of chromatogram

The analysis results are shown in a chromatogram (x – intensity or counts, y – acquisition time), where each peak represents a compound, exiting at successive times (Figure 10). The height and area of the peaks relates to the amount of compound adsorbed on the stir bar and allows us to calculate their concentration in the water samples.

8 Water, science, culture and art

The JRC promotes with its Science and Art (SciArt) team[5] collaborations and dialogues between science and art recognizing the need to expand, exchange and share research knowledge on relevant topics to all members of society. SciArt theory reflects the spirit of "The Gems of Water" project and the vision at the base of the Social Engagement Platform of the WWQA, which believes that art and culture are essential in promoting awareness, change, revaluation and creation of water cultures, there where these have been forgotten.

Confronting with artist Jemma Woolmore[6], a reflection was born on imagining a future built on the self-healing and acceptance of our life as humans and as nature in relationship with persistent contaminants, which are now found everywhere, around and within us. As part of the self-healing process, the practice of sampling, analysing and monitoring water quality is interpreted as an act of water protection, carried out *with* water itself. Considering water as a participant of our project allows to reconsider the current scientific mind-set that still too often treats water as an object and commodity, rather than a subject that "generates and acts on relationships and meanings" (Krause & Strang, 2016). Water thus becomes a part of "The Gems of Water" engagement project and as we are grateful to all participants, as scientist and citizen scientists, we should too be grateful to water. This is why we have decided to include in our protocol for sampling (9.1) a sentence that remembers us to be grateful, present and acknowledge that by sampling, we are taking water from water bodies, which are granting us access to information they hold.

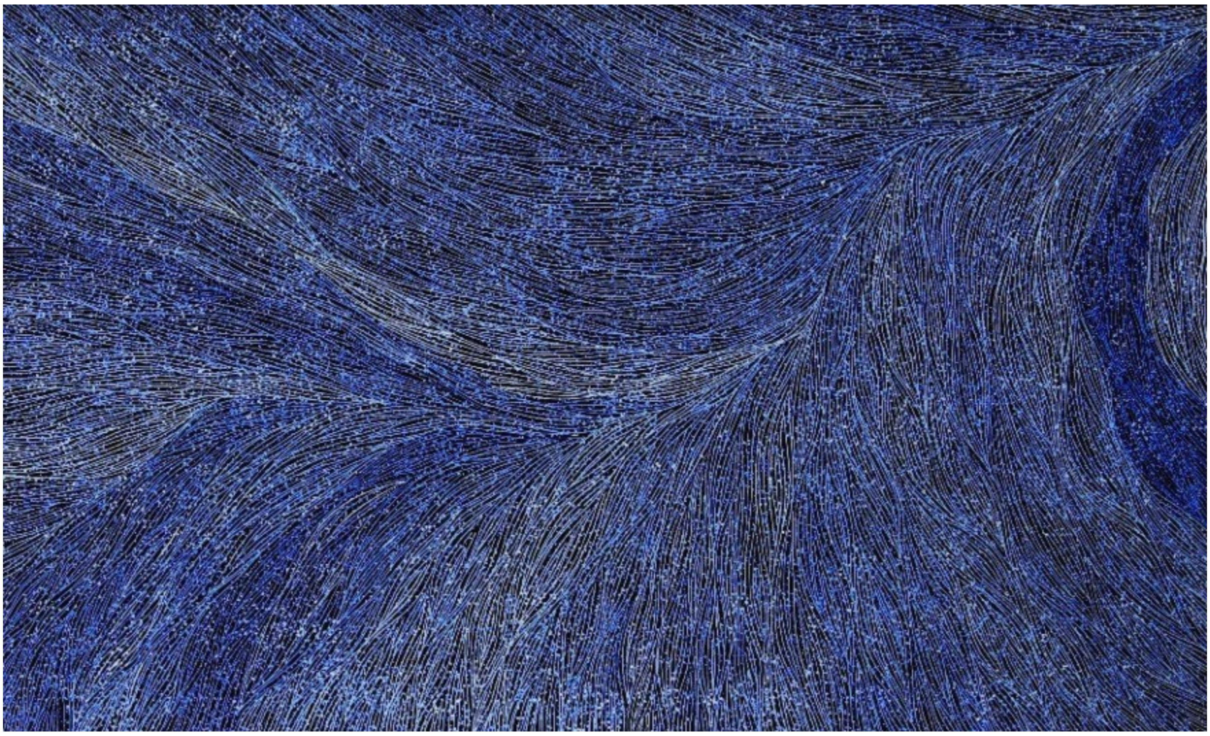


Figure 11. Water Dreaming

@Sarrita King, Jap 012007 https://japingkaaboriginalart.com/articles/water-the-centre-of-life/

[5] SciArt at the JRC https://resonances.jrc.ec.europa.eu/
[6] Jemma Woolmore https://jemmawoolmore.com/

9 Kit

The kit (Figure 12) you will receive from the JRC contains the following items:

1. "The Gems of Water" information and instruction manual with separate printouts of sampling bill, sample site form, chain of custody
2. Gloves packages in different sizes
3. Brown sample bottles with white line indicating 100 mL volume
4. Labels for sample bottles and for stir bar vials
5. Stir bars in vials
6. Magnetic stick and magnet
7. Magnetic stirrers
8. Adaptor
9. Internal standard vials, one per sample bottle, with cap for breaking
10. Pipettes, one per sample bottle
11. Sampling pole

Figure 12. Sampling and extraction kit as sent to pilot locations

10 Protocols

Please note that protocols for sampling and extraction will be provided in printed version inside the shipped kits.

10.1 Sampling instructions

- First at all, before leaving for the sampling campaign, check the list of material needed for sampling:

Table 1. Checklist of materials for sampling

Personal Protective Equipment (gloves, boots)	
Sample bottles (100 mL)	
Sampling pole	
Labels	
Pen	
Protocol	
Sampling Bill (Annex 1)	
Sampling Site Form (Annex 2)	
Mobile phone	
Box with ice packs (optional)	

Scan the QR Code to watch the sampling procedure!

- **IMPORTANT!** Do not use personal care products or mosquito repellent products 12 hours before sampling (these products can contaminate the sample and affect the quality of the results!).
- Wear proper clothing and plastic boots, if available.
- When you have arrived on the sampling site, check that the sampling can be performed safely, otherwise choose another location.
- Acknowledge and thank the water body you are sampling from, in however manner you feel more comfortable with (With a thought, a drawing, a poem, and a dance). If you like, feel free to share it with us.
- Wear personal protective equipment, such as gloves.
- Depending on the type of water you are sampling (surface water, groundwater or drinking water) follow the instruction at the end of the protocol.
- Assemble the sampling pole by fixing the parts together and fit the sample bottle in the hook.

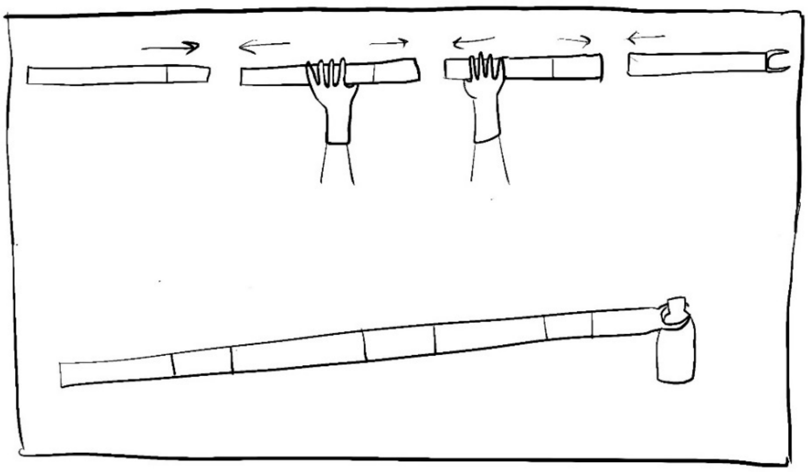


Figure 13. Schematic instruction for assembling the sampling pole

- Rinse the sampling bottle three times with the water you want to test before taking the final sample.
- Fill the bottle up to the white line, which indicates 100 mL volume.
- Fill in the label with sample name and date. The sample name can be the name of the water body or location, with a number indicating the location of sampling (in case multiple samples are taken from the same water body) and the letters a, b indicating the replicates (Example: "River_Danube_1a").

- Repeat the exact same procedure another time to have a duplicate sample (in this case you should label the sample as "River_Danube_1b").
- Take pictures and videos of the sampling site and actions. **IMPORTANT!** Do not forget to have the GPS on!
- Fill the sampling bill (Annex 1) and the sample site form (Annex 2) and record the GPS coordinates.
- Check that the water samples are carefully closed and carry them to your storing place in a box. In case you think the transport will take around 6 hours or more, please keep the samples in a box with ice packs.
- Once back at your place, store the samples in the fridge at 4°C, before carrying out the extraction of the water samples by following the extraction protocol

I. Sampling surface water

- Sampling surface water requires the use of the sampling pole. In addition, if sampling requires you to enter the water, be careful to sample the water coming towards you (from upstream), so that you do not create interference in the water sample, as in the sketch.

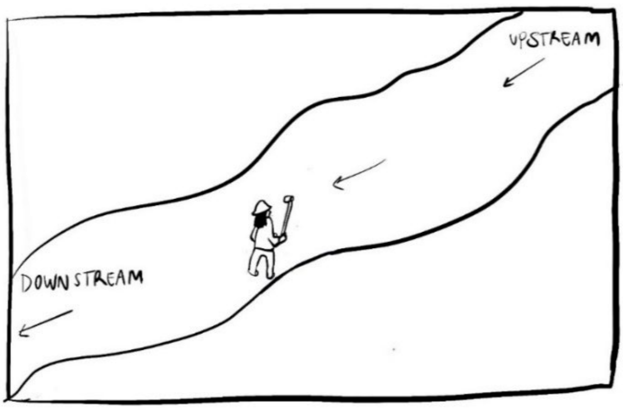


Figure 14. Schematic instruction for sampling in surface waters

II. Sampling groundwater

- When sampling groundwater, let the water flow a couple of minutes after activating the pump, before proceeding with rinsing the sample bottle and sampling. The use of sampling pole is not needed.

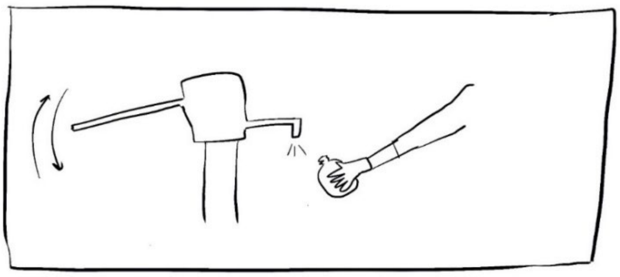


Figure 15. Schematic instruction for sampling underground water

III. Sampling drinking water

- When sampling drinking water from the tap, let the water flow a couple of minutes before proceeding with the rinsing and sampling. The use of sampling pole is not needed.

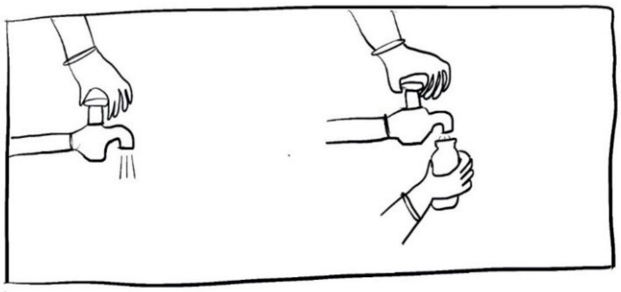


Figure 16. Schematic instruction for sampling drinking water

10.2 Extraction instructions

- **IMPORTANT!** Do not use personal care products or mosquito repellent products 12 hours before the extraction (these products can contaminate the sample and affect the quality of the results!).
- Wear Personal Protective Equipment, such as latex gloves and the lab coat.
- Set up a clean working space using the clean paper sheets we provided you.
- Prepare the materials listed in the check-list as part of the extraction procedures.

Table 2. Checklist of materials for extraction

Personal Protective Equipment (gloves, lab coat)	
Sample bottles filled (100 mL)	
Stir bars	
Vial holders	
Internal standards vials	
Breaking cap	
Pipettes	
Labels	
Pen	
Protocol	
Magnetic stirrer, adaptor	
Magnetic stick and magnet	
Mobile phone	

Scan the QR Code to watch the extraction procedure!

- Take photos and videos while carrying out the experiments!
- Depending on the availability of the magnetic stirrers, you can choose how many samples to process in parallel.
- Take out the samples you have collected and stored at 4°C or in the box with ice packs.
- Open the sample bottle and prepare the pipette.
- Gently break the internal standard vial at the neck using the dedicated white breaking cap. We recommend wrapping the internal standard vial in paper while breaking it, for additional safety.
- Use the pipette to transfer all the internal standards in the water sample. Pay attention to not lose any of the internal standard drops. It is important that the internal standard ends up in the water, not on the walls of the sample bottle.

- **IMPORTANT!** Dot not touch the stir bar with your hands! With the magnetic stick, take the stir bar from its vial and let it fall into the sample bottle, reporting the sample ID on the stir bar vial labels. Close the bottle carefully.
- Position the bottle on the magnetic stirrer. Set the rotating speed at 800 rpm and a timer for 5h (300 minutes) and start them. You can read the magnetic stirrer instructions for more information. The stir bar should be moving and mixing fast.
- You can now remove your gloves and wash your hands.
- After your timer has gone off (5h time), turn off the magnetic stirrers, put new gloves on and open the bottles again.
- From each of the bottles remove the stir bars using the magnetic stick and the magnet and put it in the original vials, according to the labels.
- Close the vials and store them in the vials holders in a refrigerated space (4°C).
- Once you have finished the extraction of all the samples, contact your local responsible person in order to organize the shipping.

How to handle the waste.

- Personal protective equipment can be thrown in the garbage bin depending on the rules of the place where you are located. For instance, in Italy gloves are thrown in the residual waste when there's no to very little contamination.
- Used pipettes, internal standard vials are glass and should therefore be thrown in recycle bin for glass, in case such is available where you are located.
- Bottles can be emptied in the sink, as the concentration of internal standards is very low. The glass bottles, after removing the labels, can be reused in a following sampling campaign, therefore we recommend to clean them by:

1. Rinsing and shaking 3 times with tap water
2. Rinsing and shaking 3 times with pure acetone, if available. Otherwise use ethanol. Ethanol can be purchased in the supermarket, in the alcoholic beverages section. It has a grade of >=96%.

   Once cleaned, the bottles should be closed with their lids and be stored in a cardboard box and protected with a layer of aluminium foil.

11 Conclusions

As exemplified by this report, in order to co-create and jointly address water quality issues so that change can be actually up taken by society, there is a need for citizens' involvement and community engagement from the very beginning of the water quality monitoring activities. Such process requires time and patience, first and foremost to build trust in the interactions between scientists and citizens. Where there is an awareness on local water quality issues, it becomes important to understand the actual needs and to assess which technologies or monitoring techniques result more appropriate depending on the context. The information and protocols presented build on a period of method development carried out at the JRC water quality laboratory, which allowed to explore simplified analytical procedures and adapt them to the global and various characteristics of the pilot Science Embassies involved in "The Gems of Water". Along with the analytical procedures, a set of basic background knowledge was put together and accompanied with video materials to facilitate the exchange of information and the understanding of why this project helps addressing water quality issues at the local level.

While bringing together "The Gems of Water" manual of information and instruction, attention was paid particularly to the importance of access, thus looking to provide information in multiple formats (Video + Paper) and to the requests of the pilot contact points in regards to languages. The manual has so far been translated to Spanish, but might be translated to other languages depending on expressed need. The development of this document has furthermore involved exchange with politicians, anthropologists and artists, thus allowing the embodiment of the Quintuple Helix principle in the design stage as well. Such approach contributes to create a robust foundation of change and promotes interdisciplinarity from within. This document represents a starting point of "The Gems of Water" and could be further improved in the future, based on feedback received by the stakeholders involved.

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Additional links

JRC website: https://joint-research-centre.ec.europa.eu/index_en

World Water Quality Alliance Website: http://wwqa.info/

UNEP World Environment Situation Room: https://wesr.unep.org/

UNEP GEMS/Water Capacity Development Centre Cork https://www.ucc.ie/en/

Surface Water Explorer: https://global-surface-water.appspot.com/#features

Stockholm Convention on POPs: http://chm.pops.int/TheConvention/Overview/tabid/3351/Default.aspx

Gas Chromatography explained by Khan Academy: https://www.youtube.com/watch?v=4Xaa9WdXVTM

List of abbreviations and definitions

CDC Capacity Development Centre

COC Chain of Custody

DDT Dichlorodiphenyltrichloroethane

GEMS/Water Global Environment Monitoring System for Water

IPCHEM Information Platform for Chemicals Monitoring

JRC Joint Research Centre

PDMS Polydimethyl Siloxane

POPs Persistent Organic Pollutants

SBSE Stir Bar Sorptive Extraction

SDG Sustainable Development Goals

UNEP United Nations Environment Programme

WESR World Environment Situation Room

List of figures

List of tables

Annexes

Please note that the sampling bill, sampling site form will be provided inside the kit in paper format.

Annex 1. Sampling bill

Name of sampled water (i.e, River Danube):		
Name of sample (i.e., River_Danube_1a):		
Sampling site location:		
Geographic coordinates (in decimal degree: N 44.8893; E 11.605) Latitude, Longitude		
Nearest town/city:	Postcode:	
Date of sampling (dd/mm/yyyy):	Local time (indicate zone):	
State:		
Country code:		
Other remarks:		
Photos taken	Yes	No

Annex 2. Sample site form

Please try to draw the map of the site and provide a picture as attachment when sending the document per email.

Sampling site characteristics

Waterbody type:

River	Lake	Stream	Farm runoff	Wastewater runoff	Underground well	Tap water	Other

At sampling if you know:

Waterbody width:	
Waterbody column depth:	

Water quality

Turbidity	None	Moderate	Strong
Colour	None	Brown	Green

Climatic conditions

Environmental temperature (°C)				
Rain	None	Little	Persistent	Duration: h/24h
Wind	None	Little	Moderate	Strong
Cloud-cover	None	Mostly clear	Mostly cloudy	100%
Other				

This information is optional, but might be useful. Tick what applies. Land use around the sampling site

Agriculture		Recreation		Construction	
Crops		Swimming		Housing development	
Grazing (cattle, sheep)		Fishing		Commercial building	
Horses		Boating		Road//Bridges	
Vegetable garden		Picnic		Construction work	
Forestry		Camp-ground		Other	
Other		Leisure park			
		Other			
Buildings		Other land uses		Bush, forests, reserves	
Urban residential		Landfill site		Wetland	
Rural residential		Mine		National park	
Industry		Heritage site		Water supply catchment	
Commercial		Other		Protected area	
School				River reserve	

Roads, bridges				Other	
Wastewater treatment plant					
Water treatment plant					
Other					

[7] The table has been modified and developed based on the Field Course Handbook by Chapman et al. (2019) and the Pesticides Detective Instruction Manual developed by Chinathamby et al. (2019)

Annex 3. Chain of custody

The Chain of Custody (COC) refers to the passages of custody from samplers to another party, such as the postal entity to which the samples are given for shipment, and finally to the receiving laboratory. Following document should be filled out by "The Gems of Water" local person of contact and remain with the samples until custody is transferred to the receiving laboratory at the JRC.

"The Gems of Water" local person of contact	Name	
	Affiliation	
	Email	
	Phone	

Kit			
Received by		Date	
Conditions		Comments	
		Signature	
Stir bar shipment			
Picked up by		Date	
Cooling	Ice/Icepack/None	Comments	
		Signature	

Disclaimer: JRC has developed this protocol using the best available knowledge. JRC assumes no responsibility or liability in connection with the use or misuse of this protocol.

7

Along with the Chain of Custody, “The Gems of Water” local person of contact should fill in this table summarizing information on the samples, sampling and extraction exercises during the monitoring campaign.

Country						
		Sampling		Extraction		
Sample names/codes	Number of replicates	Date	Storing time at T (°C)	Date	Storing time and T (°C)	Comments
Filled by:				Date, place:		

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