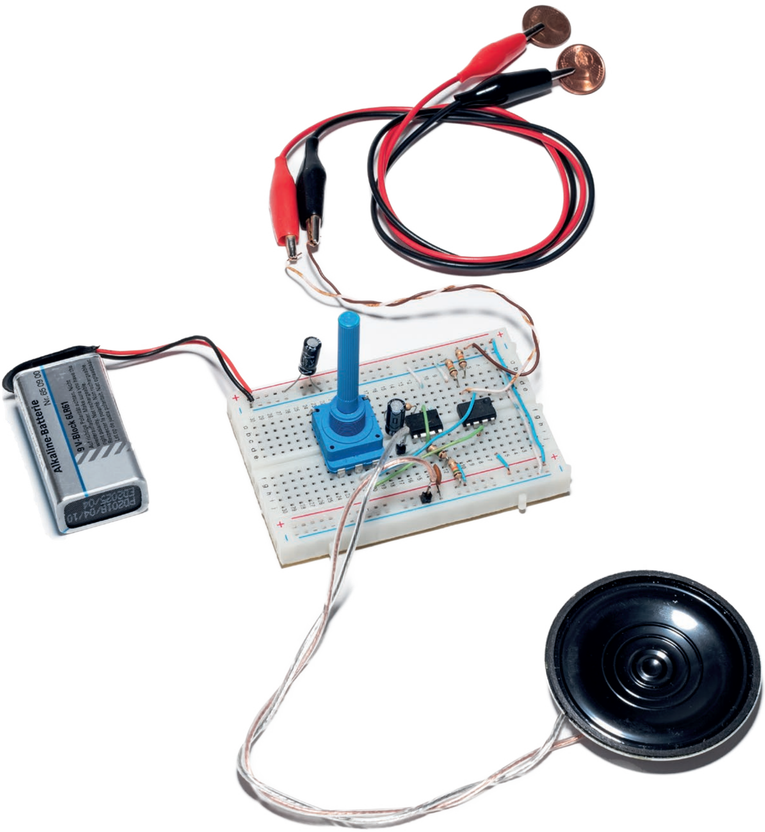
LABBOOK

3

AQUA_SONO_FORENSIC



DIY ecology, sound & citizen science

LABBOOK

AQUA_SONO_FORENSIC

DIY ecology, sound & citizen science

AUTHORS: Miha Godec, Robertina Šebjanič with support from Gjino Šutić

This lab book will guide you through the exploration of various processes of water body ecology, basic DIY water analysis, and water particles sonification, as well as present some DIY & DIWO concepts in science and art, as presented and explored in the art projects aqua_forensic by Robertina Šebjanič and Gjino Šutić, Riologia by Robertina Šebjanič and Palingenesis 2.0 by Miha Godec.

Levels of difficulty

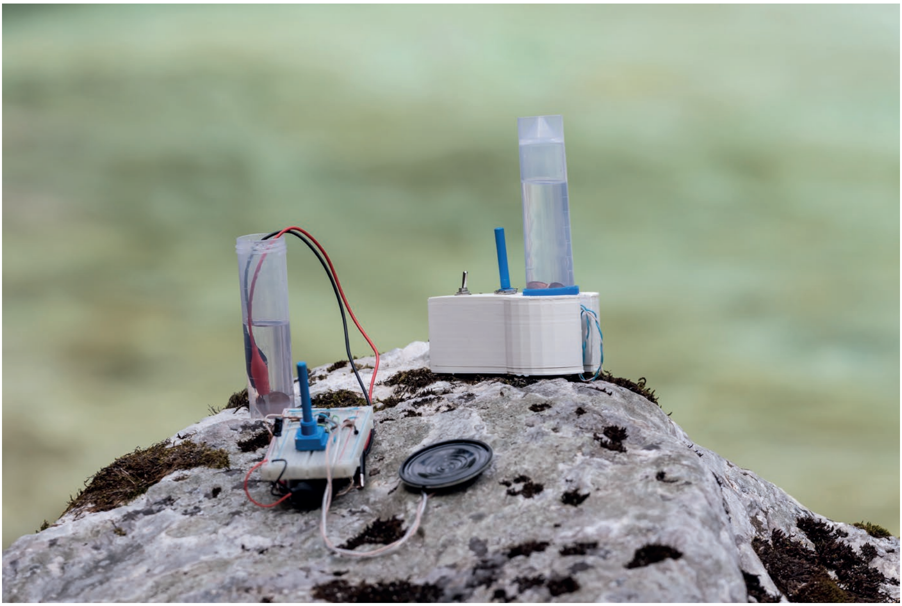
1. AN INQUIRING MIND
   Suitable for anyone
2. RESEARCHER
   I'm not familiar with the field, but I'll manage with a bit of effort
3. **EXPERT**
   I have enough knowledge to work independently
4. MASTER
   I'm quite skilled and possess an in-depth understanding of the tricks of the artistic and scientific trades
5. DEVELOPER
   I have sufficient knowledge to be capable of guiding those from categories 1–3
6. MENTOR
   I understand the content, I've mastered the technology, I develop new knowledge independently and pass it on to others

Contents

About aqua_sono_forensic

This **aqua_sono_forensic** labbook will introduce you to the problem of invisible water pollutants through three exercises. Its content stems from the ongoing aqua_forensic project, hence its goal is to make visible the invisible anthropogenic pollutants and the pattern of their effects on the water habitats.

Through a hybrid approach—combining science, DIY citizen's science & art—these topics can be investigated in local environments. Furthermore, the combination of science, art and field research is opening new doors in developing sustainable solutions and raising awareness of these problems among citizens. By conducting citizen science investigations with a forensic ecological approach to the aquatic environments, we are looking into hidden secrets. There are a lot of challenges but also potentials when working with DIY ecology and prototyping tools for water exploration.



Tools & Materials

1. TDS meter
2. Ph meter
3. Temperature meter
4. Microscope
5. 4x water sampling bottles/containers
6. 4x pipette
7. 10x microscope slides (can be bought in bulk)
8. 10x cover glass /slip (can be bought in bulk)

Ph litmus test (one container has a lot of samples)

heavy metal testing kit

Samples of water and mud

The electronic components for building a DIY TDS meter are listed in Exercise 3

1.

2.

3.

5.

6.

7.


50pcs. 26 x 76mm
Ref. D100001
Portaobjetos
Micro slides
Lames
Portaoggetti
Lâminas
deltalab

8.


deltalab
100 pcs.
24 x 50 mm

Background

Ecology is a complex issue that involves many different parameters, and the same goes for the environment and all the creatures that are sharing it. In our current ecological moment, it is imperative that we, as humans, re-evaluate our position on Earth. We postulate that by using citizen science and artistic research-based practices to personally investigate the aquatic environments around us, we can help foster respect for and awareness of one of the most delicate natural habitats on Earth; the rivers, lakes, oceans and seas.

This lab book was created to inspire anyone around the world to research, monitor and connect with the water bodies in their own environments.

THE AQUATIC ECOSYSTEM

An aquatic ecosystem[1,2], can be defined as a system, or a group of interconnected elements, formed by the interaction of a community of organisms in a marine or freshwater environment. These systems play a very important environmental role, as they recycle nutrients, purify water, recharge groundwater and allow wildlife to flourish. Biotic (living) communities and their interrelationship and abiotic environmental factors are responsible for shaping an ecosystem. Water depth, the amount of nutrients, temperature, flow and salinity are all examples of abiotic factors that have an impact on a river's networked web of organisms.

Rivers:

Collectively, all of the Earth's rivers contain about 0.0001% of the earth's water. Rivers are dynamic water bodies that are constantly changing, modifying the landscape and their own channels, with changes taking place both spatially and temporally.

It is striking to note that the flow of only 30% of the world's rivers have not been regulated by humans. In cities, they are lined with cement. Outside the cities, they are turned into reservoirs.

Some of the best-known water bodies are rivers, lakes, wetlands, oceans and seas.

Lakes:

Natural lakes are bodies of water surrounded by land and are generally found in basins, along with the courses of mature rivers, in mountainous areas, and in rift zones. All lakes are temporary across geological time scales, as they slowly fill with sediments or spill out of the basins containing them. Lakes are present on every continent and in a wide range of environments—in mountains and deserts, on plains and near the coast. Many lakes are artificial and are constructed for industrial or agricultural use, for hydroelectric power generation or domestic water supply, or for aesthetic and recreational purposes.

Wetlands:

A wetland is an area of land whose soil is saturated with moisture either permanently or seasonally.
It may also be covered partially or completely by

shallow pools. The water found in wetlands can be saltwater, freshwater or brackish. Wetlands are biologically the most diverse of all ecosystems.

Oceans and seas:

Oceans and seas cover more than 70 per cent of the Earth’s surface. Seas are found on the margins of the ocean and are partially enclosed by land. These are, in descending order by area, the Pacific, Atlantic, Indian, Southern (Antarctic) and the Arctic Oceans. Oceans and seas feed us, regulate our climate and generate most of the oxygen we breathe. They also serve as the foundation for much of the world’s economy, supporting sectors from tourism to fisheries to international shipping.

Exercise 0: (Re)connecting with the Environment

Before you start the exercises, take some time to think about the environment around you. Humans have the capacity to pause, listen, observe and recognize the diversity and quality of the surrounding environment.

This lab book offers different approaches (exercises) and practices for water monitoring that will help you explore the water bodies and their ecology. Through more active observation, each of us can find a different connection to our environment and the living organisms that cohabit with us.

With a DIY approach, through citizen science and building communities, we can collect data, conduct local observations and explore and deepen our historical knowledge of change patterns. The change itself needs to be systematic and it cannot just manifest on an individual level; instead, it has to be inter-governmental, systematic and conducted on a global scale.

This lab book aims to help illuminate the human impact on the water on a micro and macro level and support you in establishing a better strategy of empathy and solidarity with the fascinating world of aquatic flora, fauna and minerals.

Exercise 1: DIY Water Analysis

After we have connected with the environment near the waterbody, we can start the water analysis. We can use various tools and devices in the field, which will help us define the water quality and the state of the waterbody we are observing.

The six main indicators of water quality are dissolved oxygen, turbidity, bioindicators, nitrates, water acidity and water temperature. Here we will present how to measure water acidity by measuring the pH, heavy metals with test strips, and Total Dissolved Solids (TDS), which is basically a term used in water analysis to describe how many particles are dissolved in water.

Before we start the water analysis, we observe the macro life, such as plants, animals and fungi, around and inside the water body. They are important bioindicators that can reveal the state of the waterbody if some of them are out of balance.

Now let's get acquainted with the tools that we will be using!

PH METER FOR MEASURING WATER ACIDITY

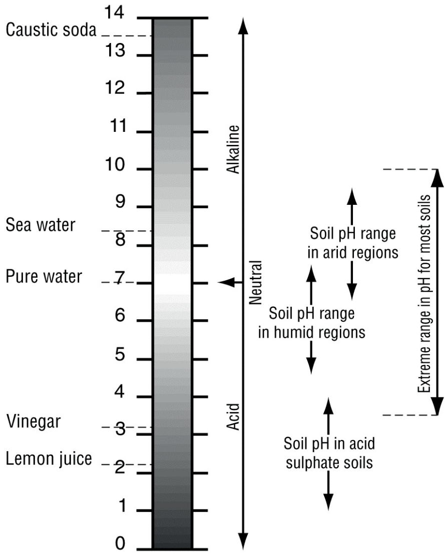
pH is a measure of the acidity/basicity of water. Acids and alkalis are chemicals that dissolve in water to form ions (atoms with too many or too few electrons). An acid dissolves in water to form positively charged hydrogen ions (H^+), with a strong acid forming more hydrogen ions than a weak one. The letters pH stand for the potential of hydrogen. pH effectively measures the concentration of hydrogen ions (that is, protons) in a substance. The pH scale was devised in 1923 by Danish biochemist Søren Peter Lauritz Sørensen (1868-1969).[3]

How to use the digital pH meter?[4]

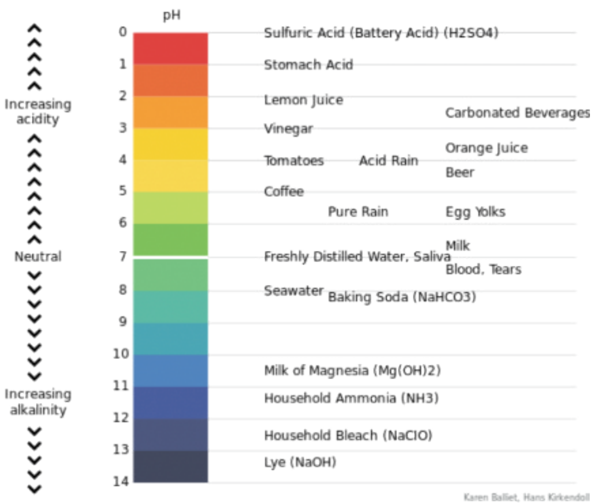
1. Calibrate the probe and meter following the manufacturer's specifications. You may need to calibrate the meter by testing it in a substance with a known pH rating and then adjusting the meter accordingly. If you are testing water outside of a lab, you may want to perform this calibration several hours before you take the meter to the field.
2. Collect a sample of the water in a clean container. The water sample must be deep enough to cover the tip of the electrode. Let the sample sit for a moment so the temperature can stabilize, then measure the temperature of the sample using a thermometer, if your pH meter does not have one built-in.
3. Adjust the meter to match the sample temperature. The probe's sensitivity is affected by the temperature of the water and the reading of the meter cannot be accurate if you do not input the temperature data. The pH of the water will also be affected by the water's temperature—pure water has a lower pH at higher temperatures and a higher pH at lower temperatures.
4. Put the probe into the sample. Wait for the meter to reach equilibrium. The meter has reached equilibrium when the measurement becomes steady.
5. Read the pH measurement of the sample. Your pH meter should provide a reading on a scale of 0-14. If the water is pure, it should read close to 7. Record your findings.

A pH reading lower than 7 indicates that the water is acidic, while a reading higher than 7 indicates that the water is basic.

Some common pH values and the pH scale



[Source: bit.ly/3Lr2dSK]



[Source: bit.ly/46fnS8b]

HEAVY METALS IN WATER | STRIP TEST

pH measuring with a litmus test strip. To get the pH measurement, the test strip is submerged in the water sample and, after a couple of minutes, compared with the scale on the back of the test kit

Heavy metals are naturally found in the earth's crust and cannot be degraded or destroyed. To a minor extent, they can enter our bodies through food and drinking water. While trace elements (such as copper, selenium and zinc) are vital for maintaining the normal metabolic functions of our bodies, they can poison humans and other organisms at higher concentrations. Heavy metals contaminating water is a huge problem, and has a significant effect on the entire food chain.

They are very dangerous if they bioaccumulate, meaning that the concentration of the metals builds up in the body of an organism over time by being stored more quickly than they can be metabolized and excreted. Heavy metals can enter a water supply via industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers and groundwater.[5]

We can use water quality test strips designed to detect heavy metals to test for their presence in water. We will conduct a simple but accurate test for a range of heavy metals: Cadmium, Cobalt, Copper, Iron, Lead, Mercury, Nickel, Zinc and other +2 valence metals. The accurate results can be seen in under 60 seconds.

The test procedure is quick and simple to perform:

1. Simply dip a test strip into 200 ml or more of the water sample
2. Move the strip back and forth for 60 seconds
3. Remove the strip from the water sample and shake once to remove the excess water
4. Wait 30 seconds and then match the colours on the colour chart.

A colour change after you dip the test strip will denote the presence of heavy metals such as Cadmium, Cobalt, Copper, Iron, Lead, Mercury, Nickel and Zinc.

Match the test strip to the chroma-graphic chart to determine whether heavy metals are present in the water sample.

Idea for a DIY project at home

If you would like to build a DIY pH meter, we recommend that you have a look here: bit.ly/3LkMDb1

TDS METER

TDS meters[6] are used in environmental science to study and monitor water quality. It is one of the standard tests the artists performed in the aqua_forensic project and that we will perform in Exercise 1.

TDS stands for Total Dissolved Solids and is a term used in water analysis to describe how many particles are dissolved in the water. The Total Dissolved Solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and some small amounts of organic matter that are dissolved in the water. Pure water by itself does not conduct electricity due to the lack of free electrons; it's the minerals and salts dissolved in the water that give it conductive properties, which we will measure. It is important to remember that the TDS reading doesn't tell us if the water is clean enough to drink! Heavy metal pollution and chemical and organic pathogens might be present in the water.

How to use the TDS meter?

A TDS meter is the perfect tool to test all kinds of waters from drinking water, aquariums, pools, spas and hydroponic systems to rivers. A home-use TDS meter is a small battery-operated, hand-held device. It has metal probes at one end that are covered by a protective cap when not in use. To perform the test, remove the cap from the probes. Turn it on, dip it in the water, and wait until you get a reading.

Compare your readings to the chart below.

Level of TDS (milligrams per litre)

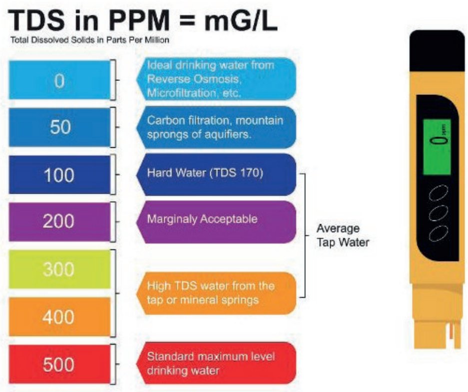
Less than 300 Excellent

300 - 600 Good

600 - 900 Fair

900 - 1,200 Poor

Above 1,200 Unacceptable



If you are measuring the water from a river, make sure you mark the location where you took the reading. Write down the numbers that are shown on the digital display of the device. The TDS is represented in mg per unit volume of the water (mg/l), which is also referred to as parts per million (ppm). The TDS level gives you an indication of the quality of the water but does not guarantee that the water is drinkable. Water is drinkable if there are no biological, chemical or physical contaminants. Metering with a TDS device is a way to get an idea of how many solids are dissolved in water and it's just one of many indicators for measuring water quality. For example, drinking water with a lot of dissolved solids like magnesium and calcium might be considered good for consumption and our health. On the other hand, a lot of minerals in the water can be a problem for the functionality and longevity of home appliances. There could also be a low value of dissolved solids in the water, which might lead us to think it's ok for consumption, but there is a hidden biological pathogen in there.

Exercise 2: Getting to Know the Microorganisms and How to Use a Microscope

THE IMPORTANCE OF WATER MICROORGANISMS

Microorganisms are simple, single-celled organisms that can be found all around the world. They largely consist of members of the plant kingdom, fungi, bacteria and protozoa. As such, they are only visible under the microscope. Some microorganisms that can often be found in various types of water include arthropods (1), bacteria (2), protozoa (3), hydra (4) and algae (5).

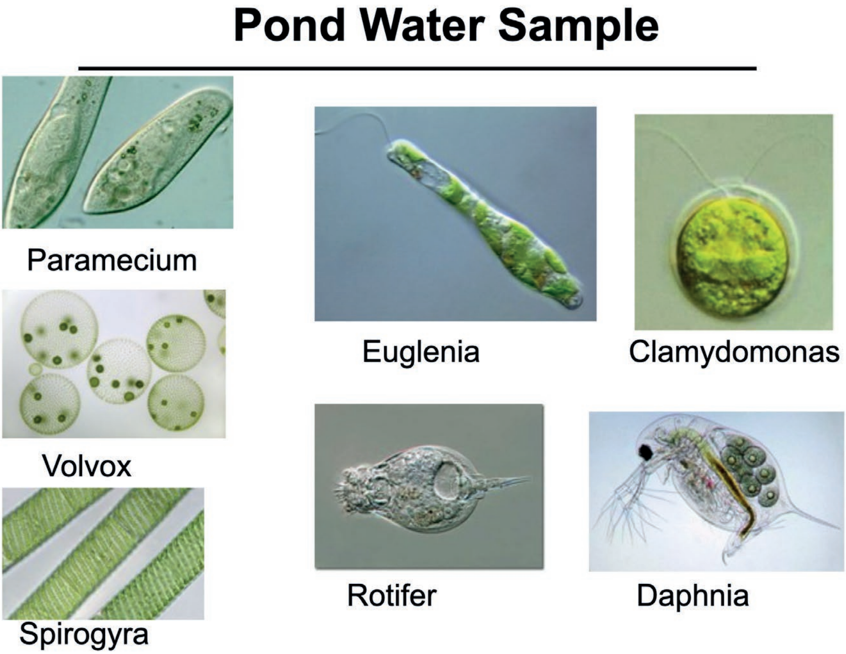
1. Arthropods include copepods, water fleas and ostracods (crustaceans). These types of microorganisms are visible to the naked eye (with the largest specimens exceeding 3 millimetres in length), and can therefore be seen without the use of a microscope. Some of the other organisms in this group include: water mites, mosquito larvae, water bears (tardigrades), shrimps and other larger crustaceans like the water louse.

2. Bacteria are microscopic, single-celled organisms that thrive in diverse environments. Some bacteria are good for the human body while others can cause diseases.[7]

3. Protozoa are freshwater single-celled microbes that feed on organic matter such as other microorganisms, organic tissues and debris.

4. Hydra is a genus of small freshwater organisms. The controversial unlimited lifespan of the Hydra has attracted considerable attention from scientists

5. Algae are a diverse group of aquatic organisms that have the ability to conduct photosynthesis. Certain algae are familiar to most people; for instance, seaweed (such as kelp or phytoplankton), pond scum or the algal blooms in lakes.[8]



Microbes also play an essential role in the natural recycling of living materials. All naturally produced substances are biodegradable, meaning that they can be broken down by living organisms, such as bacteria or fungi. The importance of microorganisms is enormous, especially when we speak about the human-microbe relationship. They are a vital component in fertile soils and water bodies. In the human body, microorganisms make up the important human microbiota, including the essential gut flora.

WHAT IS DIY MICROSCOPY?

Looking at a sample of water under a microscope will reveal the magical world of organisms that are too small to see with the human eye! DIY microscopy has become increasingly accessible in recent years. It is possible to make excellent microscopes using web cameras and to buy or make affordable clip-on microscopes for smartphones, allowing us to enter the micro-world very easily. When out in the field, it is really great to try out the more accessible clip-on smartphone microscope, as well as the Foldscope - a foldable microscope made mostly out of paper.

Have a look at this tutorial:

https://www.foldscope.com/tutorials

If you have a smartphone clip-on microscope, attach it to your smartphone, open the camera app and zoom in. If you have a small magnification lens (you can easily remove one from a laser pointer), zip-tie it to the front of your smartphone's camera lens.

Excellent instructions for making your own DIY microscope can be found on the Hackteria wiki:

https://hackteria.org/wiki/DIY_microscopy

Biotehna:

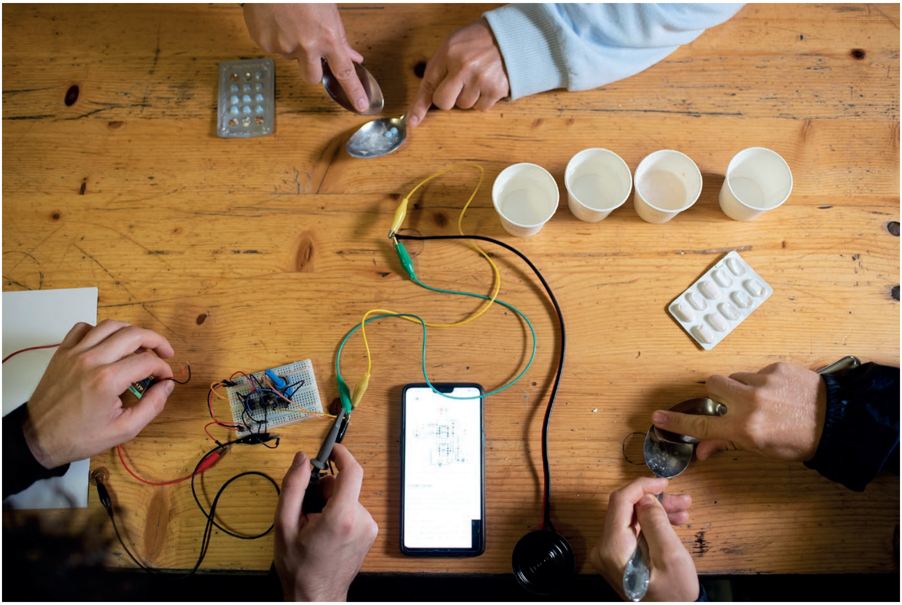
bit.ly/3sVrvC6

HOW TO HAVE A QUALITY MICROSCOPE SESSION

We suggest you do the following:

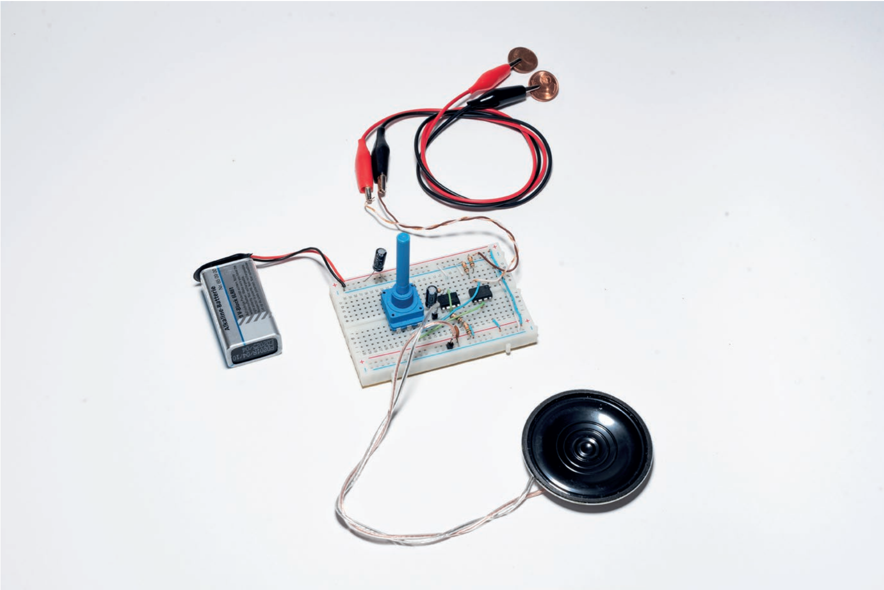
1. Collect a drop of water with a dropper or pipette.
2. Place the drop on a plate (a small, rectangular piece of glass)
3. Put another plate on top of the sample
4. Make sure the microscope is firmly secured, as even the smallest movement will hinder the quality of the observation
5. Turn on your microscope's light and enjoy the show!

Exercise 3: Dissolved Particles Sonification



INTRODUCTION[9]

In this exercise, we will create a DIY TDS meter. Instead of measuring the conductivity with an electrical conductivity meter (EC meter), we will connect speakers to it and the electrical resistance of the water will control the pitch of the sound. The cleaner the water, the lower the pitch of the sound will be, which means that the water has fewer dissolved particles. The higher the pitch means more electricity is being conducted through it, which means the water has more particles and is less clean.



This device can also be used for an interesting experiment with different medical substances. The tonality of the sound device will change when the electrodes are dipped in different water samples with different pharmaceuticals dissolved in them.

Miha Godec designed a TDS device that is able to sonify the dissolved materials in the water. The device is based on Charles Platt's Build A Water Quality Tester You Can Hear project,[10] which was published in Make magazine.

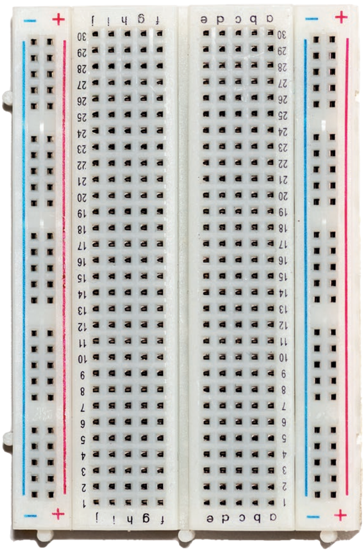
TOOLS & MATERIALS

Materials:

1. 1 x 400-pin breadboard
2. 1 x LM741 op-amp IC chip
3. 1 x 555 timer IC chip
4. 1 x 100Ω resistor
5. 4 x 15kΩ resistor
6. 1 x 100kΩ linear potentiometer
7. 1 x 100nF ceramic capacitor
8. 1 x 100μF electrolytic capacitor
9. 1 x 47μF electrolytic capacitor
10. 1 x 9V battery holder
11. 1 x 9V battery
12. 2 x patch cords with alligator clips
13. 2 x copper coins (used as electrodes)
14. 10 x jumper wires for the breadboard
15. 1 x small 8Ω loudspeaker, 5cm or 8cm diameter
16. 6 x small cups for liquid samples

*Optional small piece of plastic or plywood 4x4cm for creating a constant distance between the two electrodes

1.



2.

3.

4.

7.

6.

8.

5.

10.

11.

12.

13.

14.

15.

Test substances:

Distilled water

Salt

Pharmaceutical pills

Supplements (vitamins, magnesium and minerals)

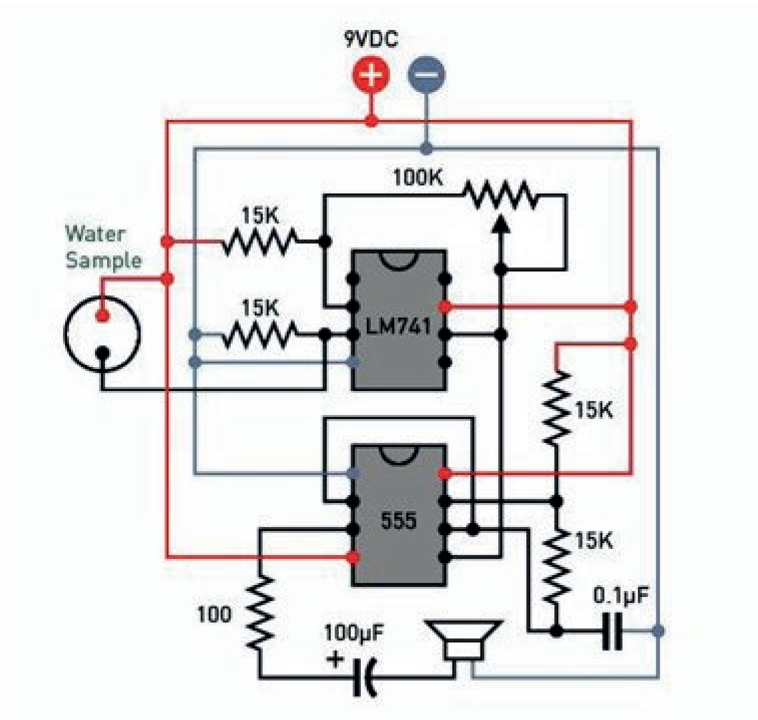
Tools:

Small pliers

Wire stripper

Wire

SCHEMATICS



Follow the schematics and assemble the circuit.
Charles Platt (Makezine, 2019) [Source: bit.ly/3RnB86F]

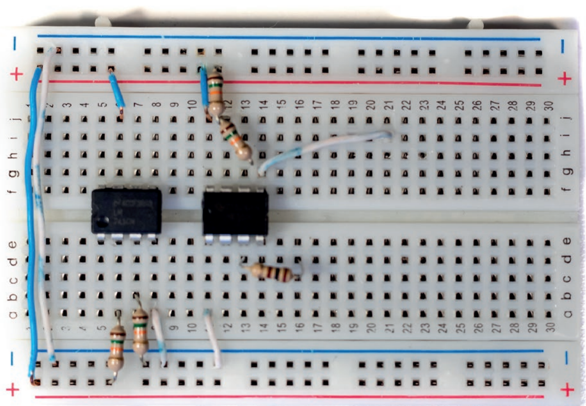
STEP BY STEP INSTRUCTIONS

Step 1

Connect the two positive and negative lines on the breadboard with a wire. Add the 5 resistors as shown in the image below and connect the jumper cables.

Place the ICs. Make sure the two ICs are oriented correctly! The half-circles on the chip should be oriented to the left. Place the LM741 chip on the left and IC 555 chip on the right, as in the photo. You can easily find a pinout diagram for both ICs on the internet.

Two 15k resistors go to the LM741 chip pins 2 and 3. The other two 15k resistors go to the 555 IC chip pin 7 and are connecting plus and IC pin 7 with the ground (through a capacitor that we will add in the next step). 100ohm resistor goes to the IC 555 pin 3.



Step 2

Add the capacitors. Make sure the two electrolytic capacitors are oriented correctly—the longer leg is the positive side, the shorter is the minus (you can also orient by the - - - marking on the side of the cap, which indicates minus).

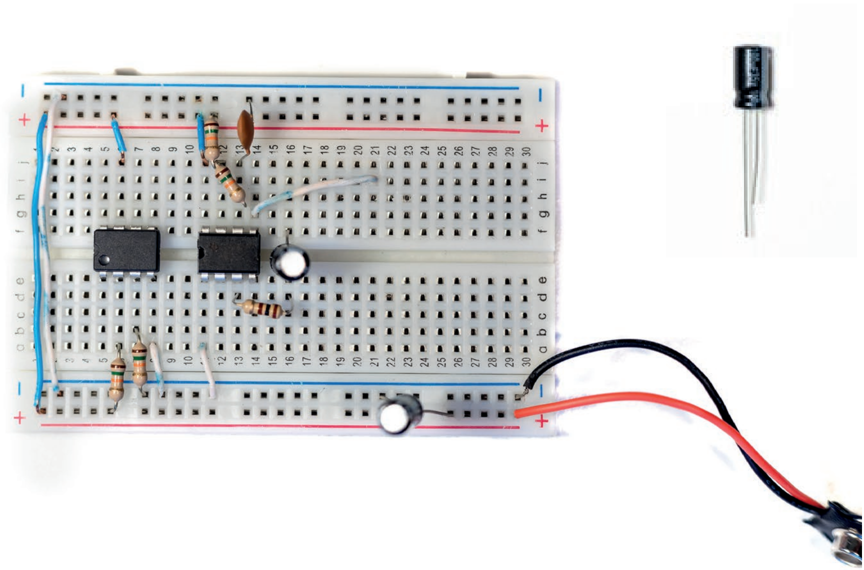
The 100µF capacitor connects pin 3 on the 555 IC (after the 100ohm resistor and before the speaker), the plus side is towards the chip.

The 47µF electrolytic capacitor connects the ground to the plus.

The 100nF ceramic capacitor (small orange with the number 104) connects the ground/minus with pin 6 on the 555 IC.

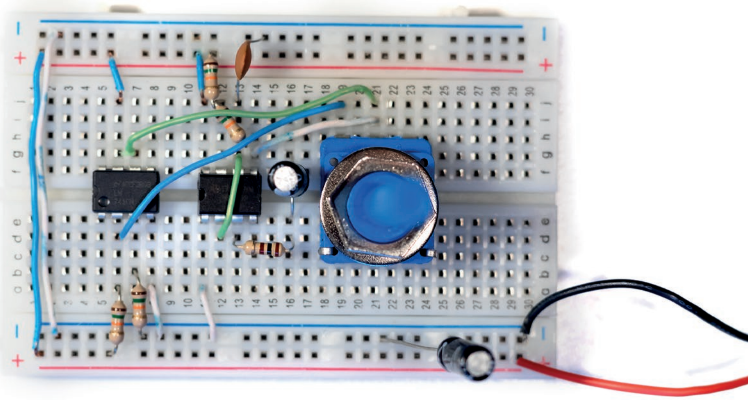
Step 3

Add the 9V battery connector to the positive (red) and negative (black) line on the breadboard.



Step 4

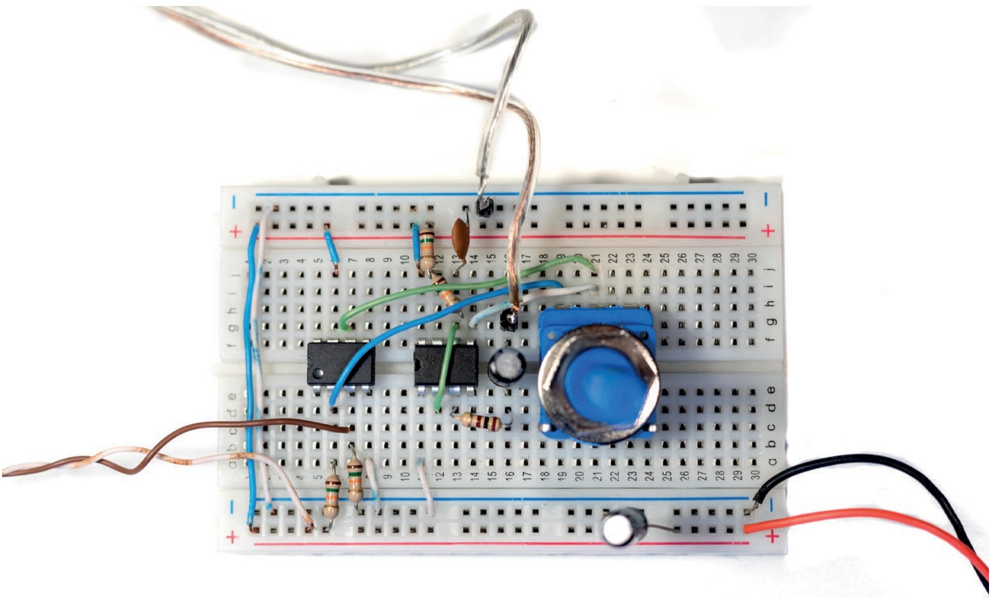
Add the 100kΩ potentiometer and connect it to the two chips. The LM741 output pin 2 goes to the left pin of the potentiometer. Connect/merge the middle pin of the potentiometer with LM741 pin 6 and 555 pin 5

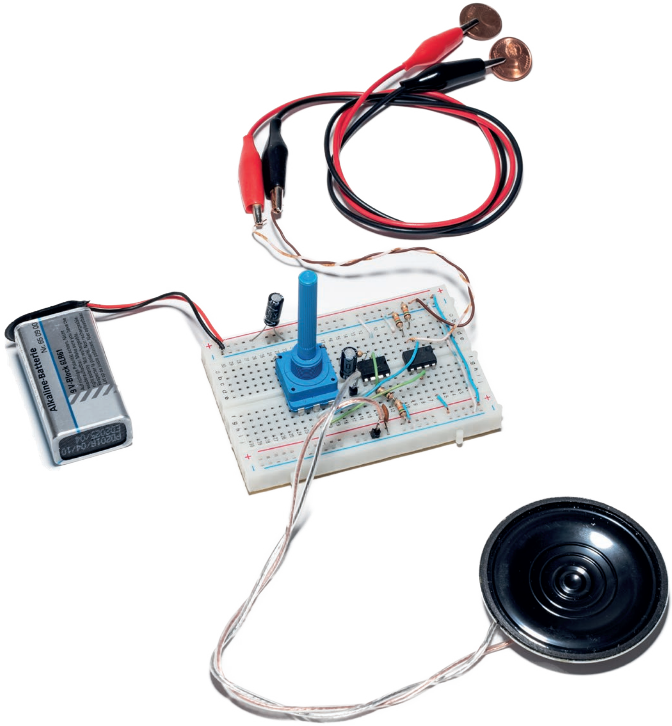


Step 5

Connect the loudspeaker and the electrodes (coins). Two electrode wires go to the plus and the other to pin 3 on the LM741 chip.

The loudspeaker connects to the negative pole of the 100μF electrolytic capacitor and the other wire goes to the ground.





TEST THE DIY TDS METER

Test the TDS meter using different water samples and compare the sound that the speaker is producing. Distilled water and salt water are used as a control* with known variables, distilled water is the least conductive and salt water conducts electricity very well, so these two readings give us the extreme values.

Note: Don’t forget to mark the water samples, so they don’t get mixed up while experimenting.

Optional: you can mount the electrodes/pennies to a piece of wood or acrylic so it is placed at a constant distance when testing in different water samples).

Use different water samples e.g.: distilled water, salt water, different concentrations of pharmaceutical pills, collected water samples, etc.

*When conducting an experiment, a control is an element that remains unchanged or unaffected by other variables.

TABLE OF MEASUREMENTS

Write down observations of the change in the pitch from the DIY TDS meter and data from the professional TDS. Observe the clarity of the water samples. Can you spot the correlation between the change of pitch and water clarity?

Location / date:

SAMPLE:	Distilled water	Saltwater	Pill #1 ________	Pill #2 ________	Pill #3 ________	________
Pitch of sound 1-10 (low-high)						
Observed water clarity 1-10 (clean-murky)						
TDS meter measurement						

About the authors

Robertina Šebjanič is an internationally awarded artist whose work explores the biological, chemical, political and cultural realities of aquatic environments and the impact of humanity on other organisms. Her projects call for the development of empathetic strategies aimed at recognising the rights of other (non-human) species. In her analysis of the Anthropocene and its theoretical framework, the artist uses the terms “aquatocene” and “aquaforming” to refer to the human impact on aquatic environments. Her works have received awards and nominations at Prix Ars Electronica, Starts Prize and Falling Walls. https://robertina.net

Gjino Šutić is a biotechnologist, post-modern intermedia artist, innovator & educator. He is the founder and director of the Universal Research Institute and Gen0 Industries. Gjino conducts research in several fields of science (such as biotechnology, bioelectronics, experimental electronics and ecological engineering) and postmodern new media art (Bio Art, Digital Art, Installation Art, Multimedia Art and Hybrid Art). http://gjino.info/, http://ur-institute.org/

Miha Godec graduated in 2014 from the Academy of Arts of the University of Nova Gorica, and soon after began his professional career as a photographer. During his studies, he upgraded his knowledge at the Portuguese school ESAD (College of Art and Design). In addition to his photographic and artistic practices, he is a lecturer for photography and virtual reality, while he independently conducts regular educational, scientific and artistic workshops. In his artistic practice, Godec, who works at the intersection of art, science and new technologies, focuses on the development of new media projects, in which he researches the consequences of the anthropogenic impact on aquatic ecosystems, experimenting with water acquisition, purification and researching the sonification properties of water. http://godec-photography.com/

Inspiration

aqua_forensic | Underwater Interception of *Biotweaking in the **Aquatocene

Robertina Šebjanič and Gjino Šutić, 2018

Supported by Ars Electronica within the EMAP/EMARE project (AT), Projekt Atol Institute (SI), UR Institute (HR) and Sektor Institute (SI)

aqua_forensic illuminates the invisible pharmaceutical chemical pollutants—the residues of human consumption. The project combines art, science and citizen science approaches in a "hunt for a phantom" and opens up the discussion about our solidarity and empathy with waters beyond human perception. It's a voyage into the relationship between the microbial seas and humans who are aquaforming the water habitats all around the planet.

aqua_forensic project at WRO bienalle, 2019.
[Photo by M.E.Koch]

Riología | Empathic Strategies in Deep Time

Robertina Šebjanič, 2019

Supported by Matadero Madrid.

Riología is a transdisciplinary project that questions the human relationship with non-human entities through various initiatives and actors. The project consists of three parts: the citizen science action with 500 volunteers conducting an analysis of the Manzanares River's ecosystem; the booklet Riología, created for the purposes of the aforementioned analysis and converting the scientific-artistic research procedure into a prototype; and the artistic visualization of the data collected in the river; showing the river's memory in deep time.

Riología photo collage from the workshop with 500 volunteers, 2019
[Photo by Matadero Madrid]

Palingenesis 2.0

Miha Godec, 2019

Supported by the MFRU festival, Pixxelpoint, UR Institute and Zavod Kersnikova.

Palingenesis 2.0 showcases one of the ways to purify polluted water, which is a pressing issue in many parts of the world. In the installation, water is the central medium with which Godec tries to create a meditative space where visitors can listen to the sound of water being purified. The title of the work Palingenesis refers to the idea of re-birth or processing, which is mentioned in various philosophical, theological, political and biological contexts.

Palingenesis 2.0 at Švicarija, Ljubljana, SI. [*Photo by Miha Godec*]

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