# What happens in the puddles?

| GLOBE | | Associated SDG(s) | Type of Activity(s) |
|---|---|---|---|
| **Sphere** | **Protocols** | | |
| Atmosphere | Air and surface temperature. Wind direction and speed. Rainfall. | 6 (Clean water and sanitation)<br>14 (Life Below Water)<br>15 (Life on land) | Exploratory |
| Biosphere | Land cover. Height of trees. | | |
| Pedosphere | Infiltration. Humidity. Temperature | | |
| Hydrosphere | Water temperature. pH. Alkalinity. Electrical conductivity. Transparency. Salinity. Nitrates. | | |
| Package | Water cycle. Water Quality Meteorology | | |

***Overview***

Students will play a crucial role in this practical exploration of their environment. They will actively observe where puddles form after rain and estimate the lifespan of these temporary wetlands. Applying their mathematical skills, they will calculate the area and depth of the puddle. Drawing on their scientific knowledge, they will measure water pH and other water quality variables. They will also identify the organisms that use the puddles for different purposes, fostering a deeper understanding of the ecosystem around them.

***Time***

2 or 3 classes

***Prerequisites***

Basic knowledge of ecosystems, ecology, conservation, and meteorology.

***School level***

Elementary and secondary school students.

***Purpose***

- Understand temporary wetlands and their importance to living things.

***Student outcomes***

- Describe the characteristics of puddles as temporary wetlands.
- Measure and record puddles to estimate their area and depth
- Characterize the water quality of the puddles and their changes over the days
- Observe and record the organisms that use puddles (reproduction, cooling, drinking water, etc.)

***Background***

After rain, it's common to find puddles in various locations. Rainwater can either infiltrate the soil or run off the surface when it reaches the ground. When there's a depression in the ground, the runoff water accumulates, forming a puddle. However, the water that forms puddles can also be part of a river or stream that starts to decrease in flow and forms puddles parallel to its course. Sometimes, the water that forms puddles comes from human activities that remove water, such as pipes or taps with leaks. The shape, size, depth of the puddle, and how long it lasts can vary greatly. Some puddles are temporary; water infiltrates or evaporates quickly, while others can last for several months, especially in areas where the terrain is not very steep. All puddles are characterized by standing water.

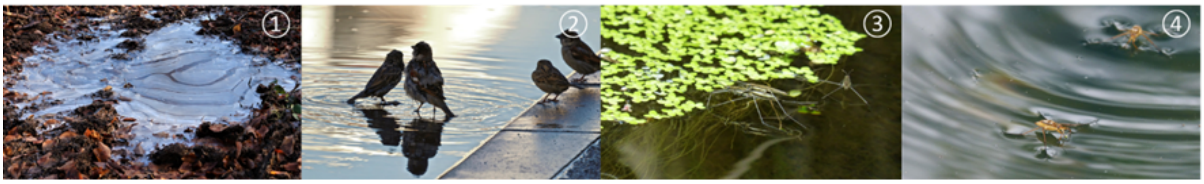



*Fig. 1. (1) Puddle with frozen surface. (2) Birds bathing in a puddle. (3) Floating plants and insects in the puddle. (4) Insects use the surface tension of water to move around. Photos: Pixabay.*

Puddles are ephemeral ecosystems that depend on environmental conditions. Once the water supply stops or weather conditions change, puddles evaporate or infiltrate the soil. This causes the aquatic habitat that had been established to disappear. Puddles can host a great diversity of organisms that have evolved to survive and reproduce in these transient conditions, such as tadpoles, snails, amphipods, daphnias, copepods, mosquito larvae, and other aquatic insects, and sometimes small fish are found. In addition, puddles are visited by other organisms, such as pets and birds, who use them to drink water or bathe on a hot day; birds often use them for food. Migratory birds use them as rest stops on their journeys. Some insects and birds get mud to build their nests. Your observations of these organisms are crucial to our understanding of these ecosystems.

Environmental conditions in puddles can change rapidly. The amount of water can increase after rain or decrease drastically due to solid evaporation and infiltration on hot, sunny days. This change in water level affects water temperature fluctuations. The temperature in the puddles depends on the sun exposure, the direction and intensity of the wind, etc. The temperature can vary significantly between day and night. In some regions, puddles tend to freeze, forming a layer of ice at the top. Puddles usually have little dissolved oxygen because the water has little movement, and oxygen decreases as the temperature rises. The influx of organic matter and other pollutants can also reduce the amount of oxygen.

For this reason, some organisms, such as mosquito larvae, have adapted to take oxygen from the air. Puddles are highly exposed to pollution, e.g., runoff can carry agricultural or industrial chemicals, motor oils, garbage, and sewage discharge (especially in urban areas). Wind and rain can cause the deposition of dust, nitrogen oxides, etc.

Due to their small size and accessibility, puddles are excellent for carrying out biodiversity research (identifying the species present in the puddle and those that visit the puddles, interactions between organisms, etc...), water quality (temperature, pH, turbidity, oxygen dissolved in water, nutrients, presence of pollutants, sources of pollution, etc.), response of organisms to environmental changes. If mosquito larvae are found, it is essential to identify the genera and species to determine if species that transmit diseases of health risk, such as dengue, Zika, and others, reproduce. It is also interesting to analyze the land cover around the pond. For example, if you have tree cover that protects the puddle from drying out, if you are exposed to agricultural pollutants, etc.

### *Guiding Research Questions*

If there are no puddles where you are, take a moment to look around. Where might puddles form in the next rain? What factors might influence this? Your curiosity and questions are critical to our exploration.

If there are puddles:

- How do you suppose the water got into the puddle you're looking at? (Due to rainfall-runoff, human activities, a decrease in the water level of a river or stream, etc.)
- How big is the puddle?
- Will it go away quickly or last a few months? Why do puddles disappear?
- Are there bird tracks or insect tracks around the puddle?
- Look into the puddle: What organisms do you find? Is the bottom visible, or is the water murky? What color is the water?
- Are organisms observed, actively swimming, or fixed on the bottom?
- Are there traces of contamination? (wrappings, oil, others)

### *Scientific concepts*

- Water cycle in rural and urban areas
- Human uses of water
- Water availability
- Water quality
- Ecology

***Materials and Tools***

- Wooden, plastic, or metal stakes
- Thread (preferably sturdy thread, not easily cut)
- Depth measuring meter
- pH strips
- Kits to measure water quality (dissolved oxygen kits, alkalinity, nitrates).
- Water transparency measurement equipment
- Conductivity measurement equipment
- Cell phone magnifiers to identify aquatic insects
- Net to capture aquatic insects
- Light-colored plastic trays to identify aquatic insects found.
- Spoon

***What to do and how to do it***

- **Beginning**

Note: Before doing this activity, check the rainfall forecast for your location.

On a rainy day in your locality, show your students the current rainfall in the world. Do you show the rain in or near your locality? Notice the differences in rainfall intensity over the last 30 minutes, 24 hours, and seven days. Does it rain in the same places or move to other areas?

Ask your students to hypothesize where puddles will likely form at school or nearby areas. How long will those puddles last? What could different agencies use them for?

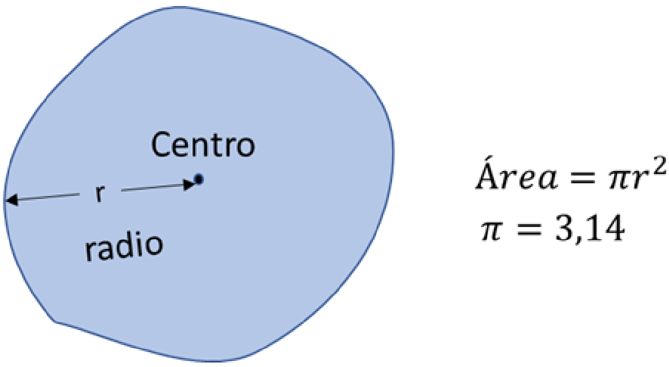
- **Development**

Divide the class into groups to make different check-ins in different puddles. At the end of the task, they switch to another puddle.

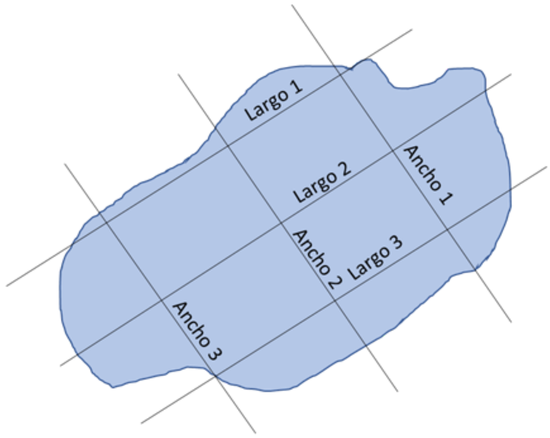
*Group 1: Estimate the area and depth of the puddle*

Calculation of the area. You can measure this by tracing with threads and stakes.

Method 1: If the puddle is relatively circular.



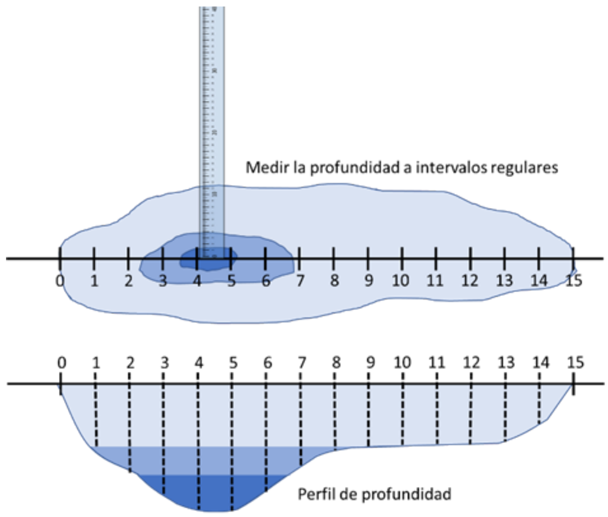

Method 2: If the puddle doesn't resemble any geometric shape




$$\acute{A}rea = Largo\ (Promedio)\ x\ Ancho\ (Promedio)$$

Note: If the puddle is small, take a picture of the puddle above using a selfie stick. Then, overlay a transparent gridded sheet over the photo.

Depth:




Sketch the depth profile of the puddle.

*Group 2: Measure water quality.*

Use pH strips to record the pH of the water. (If you have soil test kits, you can measure dissolved oxygen in water, alkalinity, conductivity, transparency of water, etc.)

Measure the pH of all nearby puddles and compare.

*Group 3: Organisms in the Puddle*

Observe and record the organisms you find. Bathing birds, aquatic insects, eggs, mosquito larvae, tadpole larvae, copepods, etc...

Gather the groups and ask them to share their observations about puddles, similarities, and differences. Did the puddle sizes vary? What happened to the quality of the water and the organisms they found?

You can return the following week, repeat the observations, and compare them with previous ones to detect changes.

- **Closing**

Students can make a poster about life in puddles, the adaptations of organisms to live in a temporary habitat, and the environmental conditions that intervene for a puddle to disappear quickly or remain longer.

Note: Activity based on Puddle Wonders! Aquatic Project Wild.

***Suggested Resources***

To learn more, the following resources are suggested:

Global map of total rainfall (Period: June 2000 to April 2023)
https://earthobservatory.nasa.gov/global-maps/GPM_3IMERGM

Map of current rainfall: https://gpm.nasa.gov/data/visualization/global-viewer

***Bibliography***

Cawdrey, K. (2023) *Warming leads to more frequent and intense droughts and extreme precipitation*. NASA Science https://bit.ly/3QL3bMg *Warming Makes Droughts, Extreme Wet Events More Frequent, Intense*. NASA Science. https://bit.ly/3CGCpgJ

Fischer, S., Gleiser, R. M., & Campos, R. E. (2016). Mosquitoes that breed in temporary bodies of water. *Mosquito Research in Argentina*, 105-118. http://server.ege.fcen.uba.ar/gem/pdf/Fischer%202016%20Libro.pdf

García, M., Vera, A., Benetti, C. J., & Blanco, L. (2016). Identification and classification of freshwater microhabitats. *Acta zológica mexicana*, *32*(1), 12-31. https://www.scielo.org.mx/pdf/azm/v32n1/0065-1737-azm-32-01-00012.pdf

Gutierrez, M. E. (2017). Tiny and fundamental freshwater zooplankton. *Ecofronteras*, 5-6. https://bit.ly/3r2th3l

Hanson, P., Springer, M., & Ramirez, A. (2010). Chapter 1: Introduction to aquatic macroinvertebrate groups. *Journal of Tropical Biology*, *58*, 3-37. https://www.scielo.sa.cr/pdf/rbt/v58s4/a01v58s4.pdf

Illarze, M., Grandal, E. O., Rodriguez-Tricot, L., Pinelli, V., Piñeiro-Guerra, J. M., Sosa-Panzera, L., Zarucki, M., Hernández, D., Ziegler, L., Berazategui, M., Borthagaray, A.I., Loureiro, M., Laufer, G. & Arim, M. (2021). La diversidad escondida: invertebrados de charcos temporales en barra grande Uruguay. *Boletín de la Sociedad Zoológica del Uruguay*, *30*(2), e30.2.5. https://bit.ly/43Zivto

Mechaly, A. S., & Cervellini, P. M. (2005). Condiciones físicas del salitral de la vidriera y su relación con el zooplancton. *Geoacta*, *30*. https://bit.ly/3WHaVTm

NASA Earth Observatory (2022) *Lake Evaporation on the Rise*. https://earthobservatory.nasa.gov/images/150067/lake-evaporation-on-the-rise

NASA Earth Observatory (2023) *GLOBAL Map: Total rainfall.* https://earthobservatory.nasa.gov/global-maps/GPM_3IMERGM

NASA-GPM (2023) *GPM IMERG Global Viewer*. https://gpm.nasa.gov/data/visualization/global-viewer

Pratt, S. E. (2022) *Aumenta la evaporación de los lagos*. NASA Ciencia https://ciencia.nasa.gov/ciencias-terrestres/aumenta-la-evaporacion-de-los-lagos/

What are the best dates to compare satellite images? The Landsat and Sentinel satellites pass over a certain site on some days, not all. For a better view of the Earth's surface, you should choose images with few clouds and compare the same month in different years.

Tutorial EO Browser

***Suggested Resources for Further Information***

As an extension of this activity, you can compare the images with temperature and precipitation data for the analyzed site, significant reduction events due to water hyacinth management (by manual, chemical, biological extraction methods).

To learn more about this phenomenon, we suggest reading one of the articles:

Harun, I., Pushiri, H., Amirul-Aiman, A. J., & Zulkeflee, Z. (2021). Invasive water hyacinth: ecology, impacts and prospects for the rural economy. *Plants*, *10*(8), 1613. https://www.mdpi.com/2223-7747/10/8/1613 [in English]

Rodríguez-Lara, J. W., Cervantes-Ortiz, F., Arámbula-Villa, G., Mariscal-Amaro, L. A., Aguirre-Mancilla, C. L., & Andrio-Enríquez, E. (2022). Lirio acuático (Eichhornia crassipes): una revisión. *Agronomía Mesoamericana*, *33*(1). https://dialnet.unirioja.es/descarga/articulo/8218098.pdf [In Spanish]

***Bibliography***

Kleinschroth, F., Winton, R. S., Calamita, E., Niggemann, F., Botter, M., Wehrli, B., & Ghazoul, J. (2021). Living with floating vegetation invasions. *Ambio*, *50*(1), 125-137. https://link.springer.com/article/10.1007/s13280-020-01360-6

Kriticos, D. J., & Brunel, S. (2016). Assessing and managing the current and future pest risk from water hyacinth, (Eichhornia crassipes), an invasive aquatic plant threatening the environment and water security. *PloS one*, *11*(8), e0120054. https://bit.ly/3R0nJ1z

Lowe S., Browne M., Boudjelas S., De Poorter M. (2000) *100 of the World's Worst Invasive Alien Species A selection from the Global Invasive Species Database.* The Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN), Auckland. https://bit.ly/3jvmxai

Wright, C. (28 June 2022). Remote Sensing Tracks Down "Plastic Plants" in Rivers. Researchers are using remote sensing to track floating mats of plastic trapped in water hyacinth plants. *EOS. AGU*. https://bit.ly/3PCrx7y