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The Place of Nature in Preserving Cultural Heritage and Reconnecting Citizens with their Environment: A Microscopic Approach

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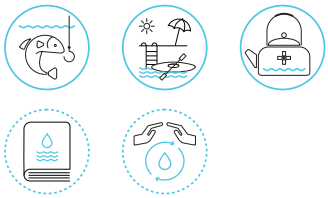
Abstract

Because of their historical and architectural richness, since 1991 the banks of the Seine in Paris have been listed as a UNESCO World Heritage Site. According to UNESCO, the definition of the historic urban landscape (HUL) emphasizes the interdependence between cultural heritage, the natural environment, and the evolution of urban life. However, underwater, the Seine River abounds of microscopic life constituted by phytoplankton organisms that are essential to aquatic ecosystems. Revealing this invisible life can help raise public awareness of the importance of the living as a natural heritage – similar to cultural heritage. The HUL approach should recognize the value of these autotrophic (self-feeding) microorganisms and the ecosystem services they provide. Several activities within a citizen science project offer the possibility to raise public awareness through plankton observation workshops. This approach also engages citizens in the protection of natural heritage for future generations.

KEYWORDS

Seine River
natural heritage
phytoplankton
biodiversity
citizen science

WATER ICONS



Policy Recommendations

- Integrating phytoplankton into the HUL approach is key to respond to current environmental challenges. The invisible biodiversity of the Seine provides an emblematic case study, positioning Paris as a living HUL laboratory where heritage and ecological dynamics overlap.
- A multidisciplinary framework, supported by reliable institutional resources and appropriate infrastructure, is essential for effectively engaging stakeholders and citizens in participatory aquatic biodiversity projects. Strategic investment and funding support are crucial to generate valuable conservation data, enhance scientific impact, and strengthen the resilience of both natural and urban ecosystems.

< Fig. 1 Moss-covered masonry along the Canal St Martin (Source: Carola Hein, 2025).

Introduction

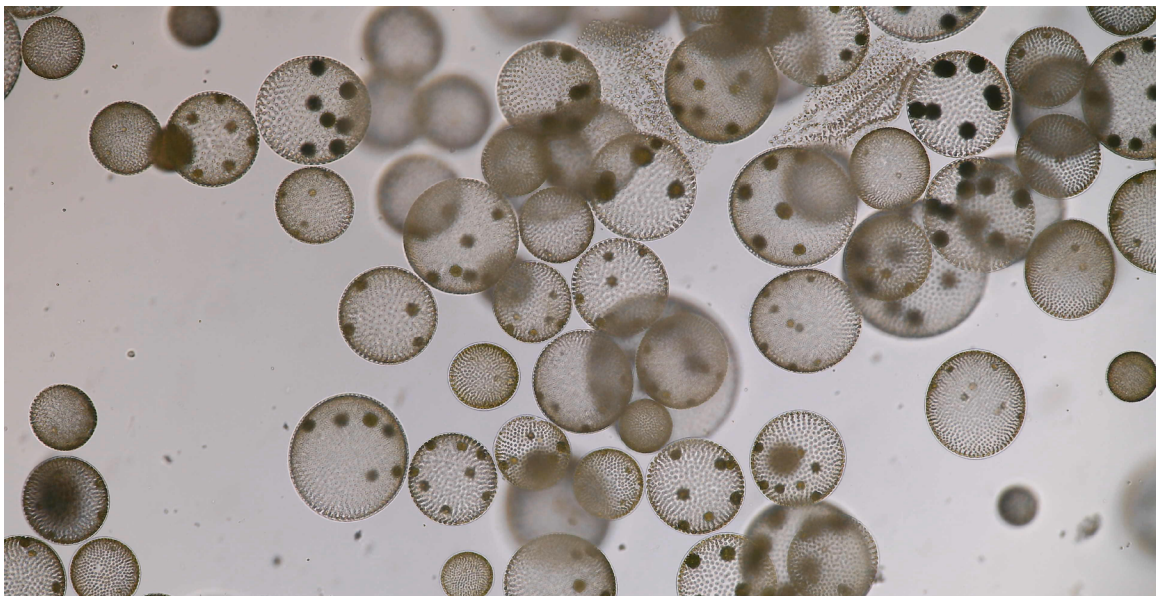
The heritage urban landscape (HUL) is a holistic approach to the management and conservation of historic urban landscapes, integrating cultural, natural and social values (UNESCO 2011). Especially in "water cities," HUL provides crucial support to cope with the consequences of human activities, including pollution, habitat modification and climate change. These environmental pressures have a considerable impact on biodiversity and must encourage citizens to reconnect with their environment and rethink their relationship with urban heritage (Hein et al. 2020). In this way, it is essential to reveal the value of ecosystems and the services they provide to society (Bull et al. 2016; Ferreira et al. 2023), raising citizen awareness about the need for protection.

Due to their historical and architectural richness, since 1991 UNESCO has classified the banks of the Seine as World Heritage. Yet, in addition to the beauty of the landscape that encompasses the Seine, the river is home to many interacting organisms that range from macroscopic to microscopic. Within this last group, photosynthetic microorganisms represented by the phytoplankton provide essential ecosystem services (e.g., base of the food web, oxygen producer, water quality bioindicator) and contribute significantly to the aquatic biodiversity (Naselli-Flores and Padisák 2023). Besides its ecological importance, the phytoplankton is also beautiful – and this beauty can evoke an emotional response that enhances awareness of our connection to our environment, both urban or natural.

Several authors have developed an experiential and affective approach (approche sensible) to environmental education programs (Planche 2018; Tavormina and Jackiewicz 2023), recognizing the potential of emotions to give meaning to action. This approach may be especially helpful when dealing with visible biodiversity. When dealing with biodiversity that is not visible to the naked eye, we can use tools to apprehend it and allow participants to feel immersed in what would otherwise be an invisible world.
Through the citizen science project "Planktonautes d'Île-de-France" (PiF), we are implementing the Plankton Planet program (De Vargas et al. 2020, 2022) in collaboration with the French National Museum of Natural History in Paris. This program, initially designed to study marine plankton, consists in the use of simple tools and protocols to train citizens to collect, observe and identify plankton. We use the same methodology in the PiF project to inventory freshwater plankton in Île-de-France, the region of France that contains Paris.

Before launching the PiF project described above, the first step is to raise public awareness of invisible biodiversity through plankton observation workshops. Through a sensory and experiential approach, citizens discover the invisible life they encounter every day. Gaining knowledge of biodiversity can help citizens reconnect with their environment, eliciting a strong sense of belonging and connection with nature, as well as changing behavior and attitudes (Booij and Shearer 2025). Thanks to the innovative and easy-to-handle Curiosity microscope (SeaLabX®, Plankton Planet), we can introduce plankton to audiences in diverse locations. In addition, following the observations, the workshop concludes with art-based activities to make tangible the connection between participants and the microscopic world.

The phytoplankton of the Seine offers an important opportunity to reconnect local communities to their environment through citizen science and to promote the role of nature in the



^ Fig. 2 Green freshwater microalgae *Volvox* collected from an outdoor pond at the Tropical Aquarium of the Palais de la Porte Dorée in Paris. *Volvox* colonies mesure 170-850 µm. Image taken with the Curiosity microscope, SeaLabX® (Source: Sahima Hamlaoui and Maria Cellamare, 2025).

HUL approach. Here we present various actions we have taken to raise public awareness during the preliminary stage of the PiF project. We also propose a framework integrating phytoplankton as a connecting element within the HUL context.

Methodology

The PiF project sets up plankton observation techniques using easy-to-use tools: plankton nets and the Curiosity microscope (SeaLabX®, Plankton Planet). The Curiosity is an ultra-compact and highly intuitive digital microscope. It was developed by the French company SeaLabX® for Plankton Planet program and Tara Ocean expeditions (de Vargas et al. 2020). It is specifically designed for citizens sciences and is very easily accessible to the general public. Its small size and ease of use make it a practical tool for observations during outdoor excursions. Plankton samples can be observed on the screen using the camera app on the connected device. The average cost of a kit is €1,500 (ex. VAT), though multiple configuration options are available.[1]

In our plankton workshops, field trips are proposed to the public to collect plankton and make microscopic observations (fig. 2). The observations are uploaded on the website iNaturalist that allows the sharing of data and contributes to knowledge of biodiversity (Mason et al. 2025).

Know-how transmission

Thanks to easy-to-use tools and the simplification of scientific concepts and knowledge

1. Visit for details: https://curiositymicroscope.org/en/get-a-quote/.

is possible to make them accessible to participants and audiences who are unfamiliar with science. Thus, during the workshops we use the following approaches to raise public awareness about the importance of phytoplankton in ecosystems:

- Phytoplankton produces more than 50 per cent of the oxygen we breathe (the rest is produced by terrestrial plants, macroalgae, etc.) through photosynthesis (Field et al. 1998; Mondal et al. 2022). This means that one of every two breaths is possible thanks to these microscopic organisms. Taking a breath in and out is a simple gesture that helps participants understand the importance of phytoplankton in everyday life.
- Phytoplankton organisms, known as primary producers, are the basis of food webs. With a brief role play performed by three groups from the audience representing each of the different biological compartments (phytoplankton, zooplankton, fishes), we explain how important phytoplankton is in aquatic ecosystems and how the slightest change in its structure has repercussions on the dynamics of the upper levels (zooplankton, benthic fauna, fish, birds) (Hulot et al. 2000).
- Phytoplankton is also an excellent bioindicator as it reacts rapidly to changes in the environment. Due to its short generation time, this element is among the first to respond to water quality changes (Cellamare et al. 2011). Given that some species show preferences for clean or polluted environments, our observations during the workshop can provide information about a site's water quality.
- Participants also have the opportunity



^ Fig. 3 Phytoplankton sampling in the Seine, below the IEA at Quai d'Anjou (a), microscopic observation (b, c) and screen-printing workshop (d). (Source: Sahima Hamlaoui and Maria Cellamare, 2025).

to handle the Curiosity microscope. This gives them confidence and the ability to use the tool independently.

These workshop exercises allow participants to understand that life on earth depends essentially on organisms invisible to the naked eye – even if many participants have never heard about phytoplankton before the workshop. After the microscopic observations, we offer a variety of art-based activities, including screen printing using ancient plates, drawing, origami, vegetal compositions and plays.

We have been able to vary our methods to fit different occasions and audiences, including specialists, schoolchildren and general public:

1. Following the conference (Re)Connecting River and City – The Seine in Paris and Île-de-France, held in March 2025, we proposed a plankton workshop to the organizer, Carola Hein (fig. 3). This involved taking a water sample from the Seine, below the Institute for Advanced Study (IEA, Paris) and observing the phytoplankton using the Curiosity microscope. This experience was a trigger in our reflection about the importance of living organisms such as phytoplankton in the HUL approach. To mark the occasion, we offered a screen-printing workshop with a plate used on a publication on cyanobacteria from the Seine (Couté 1979) – a little nod to the beauty and artistic potential of phytoplankton (fig. 4).
2. As part of the environmental awareness and education component of the PiF project, in May 2025, we offered a presentation on plankton's essential role on the planet for schoolchildren at a school near the Seine. Then, using the Curiosity microscope, students were able to discover the plankton that we collected from the river near to the Eiffel tower (fig. 5a, b). They took turns handling the microscope and taking a closer look at the microscopic life that thrives in the Seine and performed a role play about the aquatic food web.
3. In the context of the 47th Session of the UNESCO World Heritage Committee in July 2025, we gave a presentation entitled "The Place of Nature for Preserving Cultural Heritage: A Microscopic Approach" to a multidisciplinary audience constituted by historical heritage specialists such as architects, urban planners, archivists, among others (fig. 6a, b). Our contribution dealt with the ecosystem's services provided by photosynthetic microorganisms (MEA 2003, 2005) including phytoplankton (in the water column) and phytobenthos



^ Fig. 4 Screen-printing made with the original plates used on the article (Source: Alain Couté, 1979).



^ Fig. 5 Phytoplankton sampling in the Seine near to the Eiffel tower at Port Debilly (a) and plankton workshop for primary school students (b) (Source: Sahima Hamlaoui and Maria Cellamare, 2025).

(associated with the substrate). After the working session, participants were invited to collect plankton in the Seine and observe the microscopic life of the river (fig. 6c, d).

4. At the Goethe-Institut France in Paris, we organized in September 2025 an event for the general public (employees or members of the institute and retirees) entitled "Living with Water: Heritage, Biodiversity, and Nature-Based Solutions." It consisted of a guided walk along the Seine (fig. 7a, b), followed by a discussion with Carola Hein. We, in turn, made a presentation to the participants about the importance of life in the river, particularly plankton. We collected plankton and observed it during a discovery workshop at the Goethe-Institut (fig. 7c, d).

Discovering the Seine's Invisible Biodiversity and Investigating Water Quality

Previous studies have showed that the phytoplankton in the Seine River is highly diversified (at least 209 species) and dominated by green (Chlorophyta) and blue-green algae (Cyanobacteria) (Lefèvre 1943; Tuffery 1971; Cardinal 1979; Couté 1979). In the workshops we observed samples from three stations in the river. Generally, phytoplankton diversity was high and dominated by the diatoms *Melosira varians*, *Nitzschia sigmoidea* and *Aulacoseira ambigua* (fig. 8). Most of the species observed in the Seine are common in nutrient-rich environments. Long-term sampling and several stations along the river are needed to better describe the system's water quality.



^ Fig. 6 UNESCO meeting as part of the 47th Session of the UNESCO World Heritage Committee Session (a, b) and plankton workshop at Port de la Bourdonnais (c, d) (Source: Sahima Hamlaoui and Maria Cellamare, 2025).

From Citizen Science to the Protection of Heritage Urban Landscapes (HUL)

The various activities we have conducted have allowed us to share scientific knowledge with participants and help them appreciate the Seine's invisible biodiversity. In this first phase of the PiF project, by integrating "sensitive" and microscopic approaches, we were able to capture the public's attention and connect them with nature.

The Curiosity microscope, with its user-friendly and ergonomic design, allows participants not only to discover the microscopic world, but also to feel confident using the tool. This gives them a sense of belonging and allows them to become fully involved in the action. Changing scale through the microscopic approach helps people change their perspectives, better understand invisible biodiversity and become more aware of the need for protection.

Citizen engagement to protect biodiversity

The PiF project seeks to engage and train students and teachers at Paris schools located near the river, developing their knowledge of freshwater plankton. Our plan is to label the schools participating in the PiF project as "École Sentinelle de la Seine" (Seine Sentinel School). The young "Parisian planktonauts" will participate in the ecological monitoring of the river and will be able to act as guardians of their heritage. This initiative will contribute to the ongoing process of rehabilitating the Seine that



^ Fig. 7 Event at Goethe-Institut France in Paris, which included a guided walk and plankton sampling along the Seine at Port de la Bourdonnais (a, b) and workshop at the institute (c, d) (Source: Sahima Hamlaoui and Maria Cellamare, 2025).

was initiated before the 2024 Olympic Games. That rehabilitation process and the subsequent opening of public bathing sites along the Seine have created a swell of interest in public health and river water quality. We hope to build on this momentum and develop greater interest in river ecology.

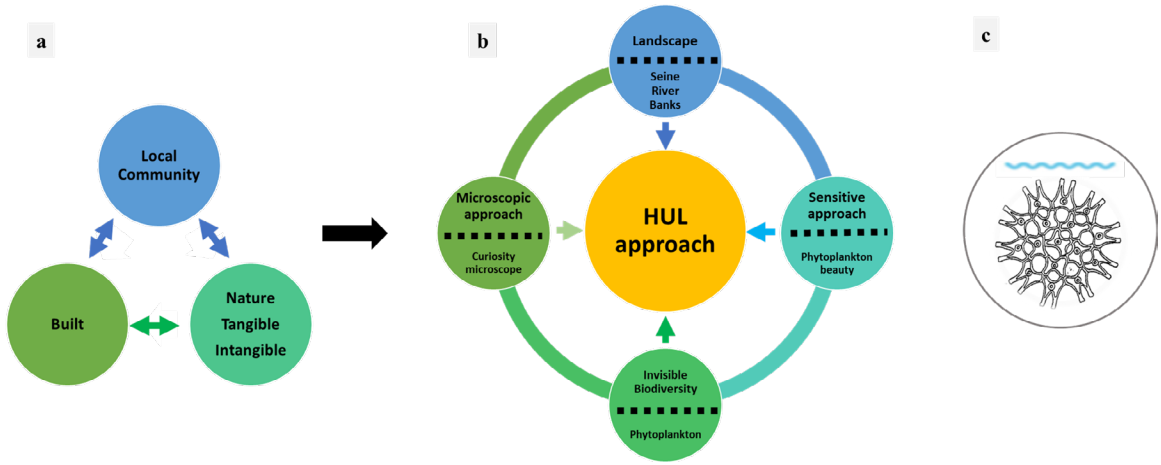
Enlarging the HUL approach

According to the recommendation on the HUL approach (UNESCO 2011), the conservation of historic urban landscapes should take into account the interactions between the built environment, the natural environment, and the local community (Hosagrahar 2021) (fig. 9a). This recommendation marked a shift away from exclusive attention to preserving the physical environment and emphasized the importance of the entire human environment with all of its tangible and intangible qualities (UNESCO 2011). Phytoplankton can be considered intangible because it is invisible to the naked eye.

Tools such as a microscope are needed to see it. As long as we cannot see it, it does not exist. In fact, most people are unaware of its existence. Given the ecosystem services phytoplankton provides to society, as an intangible element, it offers an opportunity to enlarge the HUL approach. Our experience has enabled us to highlight plankton's potential to reconnect



^ Fig. 8 Most representative phytoplankton taxa of the Seine River, sampled on July 12, 2025 at Port de la Bourdonnais: *Nitzschia* (a, f), *Desmodesmus* (b), *Amphora* (c), *Closterium* (d), *Gyrosigma* (e), *Surirella* (g, y), *Staurastrum* (h), *Micractinium* (i), *Actinocyclus* (j), *Phacus* (k), *Pandorina* (l), *Ulnaria* (m), *Cymbella* (n), *Cocconeis* (o), *Aulacoseira* (p, u), *Eudorina* (q), *Monactinus* (r), *Fragilaria* (s), *Tetradesmus* (t), *Oscillatoria* (v), *Melosira* (w) and *Iconella* (x) (size between 5 µm and 500 µm) (Source: Sahima Hamlaoui and Maria Cellamare, 2025).



^ Fig. 9 HUL diagram according to Hosagrahar (2021) (a), proposal including the phytoplankton in the HUL approach (b) and icon representing the phytoplankton (c) (Source: Sahima Hamlaoui and Maria Cellamare, 2025).

citizens with nature. In our view, taking invisible biodiversity into account makes the intangible aspect concrete and contributes to the development of a more holistic HUL approach (fig. 9b, c).

It is difficult to imagine Paris without the Seine, or the Seine without all the monuments that line its banks. In the same way, it would be reductive to consider Paris and the Seine as just a collection of buildings and a channel of water in the heart of the city. The built environment, monuments and the natural ecosystems they contain constitute a model in constant evolution. This heritage must be transmitted to future generations, not as museum relics but as living, changing models of adaptability (Hosagrahar et al. 2016). This idea echoes that of Booij and Shearer (2025), who describe cultural heritage as a process rather than a finished, unmoving product. This is how we can better respond to the Sustainable Development Goals for 2030 (Hosagrahar et al. 2016), which aim to make cities more resilient and sustainable by enhancing efforts to preserve and protect our common cultural and natural heritage.

Ecology, Architecture, and History

Through an in-and-out perspective, the microscopic approach reveals an analogy between the urban heritage of Paris and the living natural heritage of the Seine. While the urban heritage, through architecture, displays successive and superposed layers of history, photosynthetic microorganisms constitute a living heritage in perpetual motion. Phytoplankton, because of its dynamic nature, provides information on the current ecological state of the river as well as on conditions encountered along its course. In addition, the built environment (facades, foundations, statues) is often colonized by biofilms (phytobenthos) that develop on damp surfaces (Hoffmann 1989). Owing to its fixed nature, this other photosynthetic group records layers of local biodiversity over time. For example, benthic diatoms play a key role in paleolimnology (Dixit et al. 1992; Stoermer and Smol 1999; Griffiths et al. 2022), as they allow the study of the historical local evolution of aquatic ecosystems, including ecological status assessment and the effects of climate change. Together, these two ecological compartments – the mobile phytoplankton and the surface-attached phytobenthos – constitute veritable living archives and can also serve as predictive models for studying the evolution of aquatic ecosystems. This invisible biodiversity of the Seine River is a common good and a heritage that must be protected for future generations.

Conclusion

While the world of water is mainly associated with science, engineering, and management, urban heritage is directly linked to culture, preservation, and architecture. An interdisciplinary approach is needed to address contemporary challenges. It is essential to integrate these disciplines in order to better coexist with nature and urban heritage (Hein et al. 2020).

More than ever, scientists and civil society must work together through citizen science to protect and conserve the natural heritage of the Seine River. We need interdisciplinary efforts (involving architects, artists, historians, philosophers, politicians, economists, etc.) with the support of institutions to recognize the importance of ecosystems and the services they provide. Awareness-raising projects like the “Planktonautes d’Île-de-France” deserve the support of foundations, research institutes, public organizations, and non-governmental organizations.

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Partnership & Useful Links

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https://planktonplanet.org/
https://planktonplanet.org/2025/06/29/pif/
https://curiositymicroscope.org/

Planktonautes d'Île-de-France (PiF) · iNaturalist:
https://www.inaturalist.org/projects/planktonautes-d-ile-de-france-pif

PHABB project: https://mcam.mnhn.fr/fr/node/6680



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