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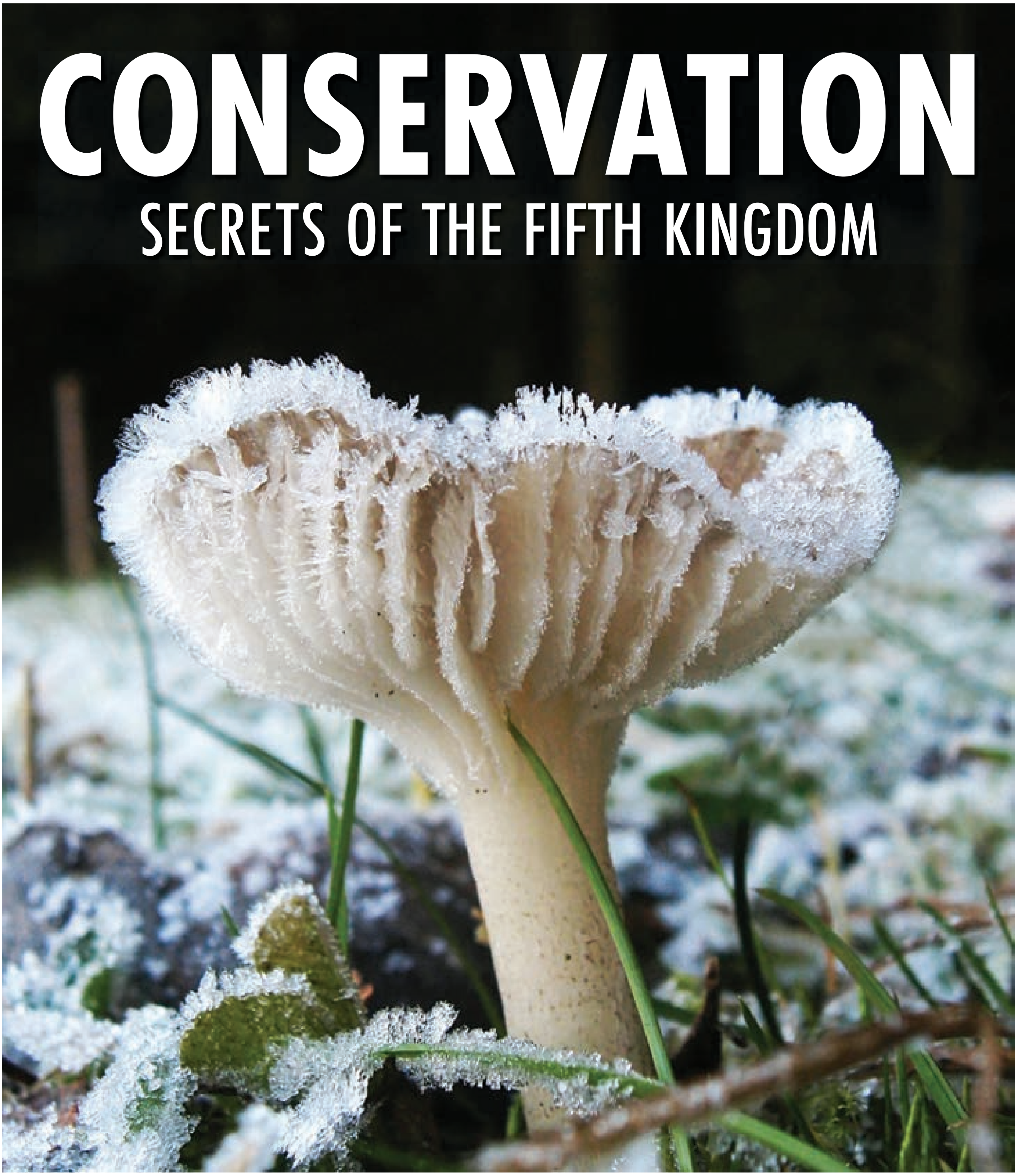


TAPPING FUNGI'S SECRET NETWORKS TO CLEAN OUR WATER

Could humble fungi treat our water and improve our cities? **Michael Green** explores the brave new world of mycofiltration

We have long understood how green engineering can enhance our towns and cities. Sustainable drainage systems (SuDS) mimic natural forms and processes, capturing and storing rain close to where it falls, reducing the risk of flooding and creating spaces where people and wildlife can thrive.

Green infrastructure – rain gardens, swales and constructed wetlands – also clean polluted water by filtering pollutants through soil. But can the fungal kingdom add a new dimension to SuDS?

Mycofiltration is an innovative approach that uses fungi as a biological filter, tapping their white infrastructure – the hidden network of microscopic fibres – to digest and remove persistent contaminants from water and soil.

When it rains, storm water runoff mobilises pollutants on roads, as well as sediments and agricultural waste from greenfield sites. Traditional grey engineered drainage systems – impermeable surfaces, gullies and underground pipes – move the problem of surface water elsewhere.

But out of sight does not stay out of mind. Whether they are flushed down sewers or flow overland, the pollutants find their way into watercourses, lakes and groundwater, putting the health of ecosystems and drinking water at risk. But how can fungi help?

DIFFUSE POLLUTION

Mycofilter is a fancy term for woodchip or straw inoculated with fungi. This can be used to fill depressions, stuffed into hessian sacks, or used in place of conventional mulches.

The technique was pioneered at the Dungeness catchment in Washington State, where diffuse pollution was entering the river and estuary, threatening both local wildlife and the local shellfish-harvesting industry.

In the 1980s, mycologist Paul Stamets initiated trials to address faecal coliform pollution from local livestock farming. He installed a 50 x 200 ft bed of woodchip in a natural depression and inoculated it with Stropharia rugosa annulate, a fungus used to cultivate Garden Giants, an edible mushroom that grows up to 20 cm high. Mr Stamets reported a 100-fold reduction in faecal coliform levels in water flowing through the woodchip-fungus bed.

His findings were investigated in formal field experiments for the US Environmental Protection Agency. Two rain gardens were excavated and lined with gravel, overlaid with soil, woodchip and planted with native vegetation.

In one rain garden, the woodchip was inoculated with Garden Giant mycelium and two species of oyster mushroom, Pleurotus ostreatus and P. ulmarius. Plants were also inoculated with mycorrhizal fungi, which have a symbiotic relationship with the roots of plants. Water samples taken over six months found that faecal coliform levels were reduced by 90 per cent at the fungal-enhanced rain garden, compared to 60 per cent for the control.

A subsequent laboratory study by Washington State University and Stamets' Fungi Perfecti company demonstrated a reduction of approximately 20 per cent in Escherichia coli bacteria in water filtered through Garden Giant mycofilters compared to woodchip control filters, although the results were less equivocal when straw was added.

MYCOREMEDIATION

Although these findings are promising, mycofiltration is a young science: commercial applications are relatively scarce. However, the potential of mycelium for treating water is supported by an established evidence base for mycoremediation – the use of fungi to clean polluted land.

Since the 1980s, scientists have observed how fungi break down and remove persistent pollutants in soil and other substrates, including petrochemicals, heavy metals and pesticides. White-rot fungi are among the few organisms that can digest lignin, the complex chemical that creates the tough woody material found in trees and some plants.

Look closely at a felled tree in your local park and you'll probably see the aftermath of a fungal feast: hollowed out trunks marbled with white mycelium, or bracket mushrooms pushing through the bark. It is this capability to digest lignin that also enables fungi to break down pollutants.

One such fungus is Pleurotus ostreatus, which many of us recognise as oyster mushrooms, cultivated for food and found growing wild across the UK. Laboratory tests have demonstrated the ability of Pleurotus mycelium to break down hydrocarbons in oil by up to 98 per cent. Volunteers used it to clean up an oil spill in San Francisco bay in 2007.

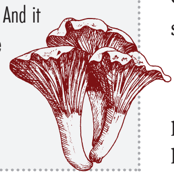
University of Helsinki scientists found that the presence of fungi removed 70-84 per cent of polycyclic aromatic hydrocarbons (PAH) – compounds

WHAT IS MYCELIUM?

MOST PEOPLE associate fungi with mushrooms. These are the reproductive apparatus – or fruitbody – of a fungus. But mushrooms are just a small part of the larger fungal organism, like an apple is to a tree.

If you kick up the leaf litter in a forest, or take a closer look at the roots of unwanted plants in your garden, you'll notice a layer of white fuzz under the surface or in the soil. This is mycelium, the dense network of one-cell thick fibres that make up the body of a fungus.

Some species produce mushrooms that last from a few days to several months. But the mycelium is there all year round, working hard to break down organic matter to convert to food. And it is this invisible white infrastructure of the mycelium that holds its power for cleaning water and healing degraded ecosystems.



SEVEN WAYS TO USE MYCOFILTRATION

1 SUDS AND URBAN STORMWATER MANAGEMENT

2 WATER FRAMEWORK DIRECTIVE TARGETS

3 CATCHMENT RESTORATION

4 WORKING WITH NATURAL PROCESSES AND NATURAL FLOOD MANAGEMENT

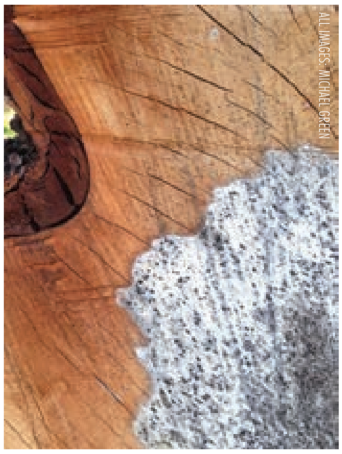
5 INDUSTRIAL AND AGRICULTURAL WASTE

6 GREYWATER RECYCLING

7 DRINKING-WATER TREATMENT


Mycelium works hard all year round, breaking down organic matter to convert to food


Some fungi, including oysters, can remove heavy metals from soil and water, bioaccumulating these in mushrooms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Fungi break down and remove persistent pollutants in soil and other substrates, including petrochemicals, heavy metals and pesticides

released by burning organic matter such as fossil fuels –from contaminated soil, compared to 29-43 per cent using naturally occurring soil microorganisms.

S. rugosa annulata, the Garden Giant, was the most effective at degrading PAHs, although strains of oyster mycelium also performed strongly.

Some fungi, including oysters, can remove heavy metals from soil and water which they bioaccumulate in mushrooms. Numerous mycoremediation studies indicate potential for mycelium to treat urban stormwater, where pollution from vehicles and industrial activity threaten precious water resources.

MYCOTECHNOLOGY

The UK piloted one of its first mycofiltration projects at the River Wandle in south London. In 2014, the Wandle Trust installed instream mycofiltration sacks at outfalls discharging polluted surface water into the river.

During storms, the sacks were overtopped by heavy flows from outfall pipes, supporting research that indicates that mycofilters are best suited to environments with shallow, low-energy flows, such as upstream rain gardens that intercept the first flush of pollutants during storms. They can also enhance downstream SuDS storage components such as wetlands and bioretention basins.

> There is huge potential to use fungi to clean polluted surface water and rivers in the UK. A major advantage of mycofiltration is its low capital and maintenance costs

Past projects and research indicate huge potential to use fungi to clean polluted surface water and rivers in the UK. A major advantage of mycofiltration is its low capital and maintenance costs. Volunteers built the River Wandle mycofilters from locally sourced, low-tech materials; hessian sacks stuffed with straw, woodchip and mycelium.

Maintenance consists largely of topping up mulch, which can be obtained from local parks or tree surgeons, and combined with spent mycelium substrate from mushroom farms, helping to reduce waste. I would like to see the day when mycelium is embedded in the SuDS management train alongside soil, vegetation and surface water features.

As well as surface water management, mycofilters can provide solutions for other contexts, from achieving Water Framework Directive (WFD) targets, to the Environment Agency's Working with Natural Processes strategy and natural flood management, such as myco-bunds that filter and slow down runoff.

Humans have invested vast resources attempting to subdue nature. But the paradigm of smothering the earth with asphalt and building walls and pipes for protection is coming to an end. In the long run, engineering that adapts to our surroundings – working with land, plants and fungi – will improve our resilience for an unpredictable future.

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