



Plant power: how can phytoremediation help tackle pollution?

Dr Naira Ibrahim

Nerium oleander plants established at a field research site in Mississippi to investigate their potential for phytoremediation of heavy metal-contaminated soil.

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For decades, industrial activity has been polluting our soils, waters and air with toxic metals. This threatens wildlife, contaminates food supplies and puts human health at risk, but a potential solution has been growing around us all along. **Dr Naira Ibrahim** from **Jackson State University** in the US is investigating the power of plants to absorb toxic metals from contaminated environments. Through her research, Naira has discovered that some remarkable plants may not only be able to help restore damaged ecosystems, but could also play a role in human medicine.



Dr Naira Ibrahim

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Fields of research

Environmental science; phytoremediation

Research project

Studying the genetic basis of
phytoremediation in *Nerium oleander* and
exploring its potential health benefits

Funders

US National Science Foundation (NSF)

doi: 10.33424/FUTURUM728

From industrial waste and oil spills to mining and agriculture, human activities release a wide range of pollutants into the environment, including toxic metals such as cadmium (Cd), lead (Pb) and zinc (Zn). These can linger for decades, contaminating food crops and drinking water and increasing the risk of serious health problems, including damage to the brain, kidneys and nervous system. So how can we clean up these stubborn pollutants without causing even more harm?

“Phytoremediation is a sustainable, nature-based technology that uses plants to remove, stabilise or detoxify pollutants from soil, water and even air,”

Talk like an ...

environmental scientist

Genetic sequencing

— a method used to read the order of DNA building blocks to understand genetic information

Heavy metals — metals that can be harmful to living things when present in high amounts, such as lead, cadmium and zinc

Ornamental plants — plants grown mainly for their

appearance, such as for gardens, landscaping or decoration

Phytoremediation — the use of plants to remove, reduce or control pollutants in soils, water or air

Enhanced weathering

— a method of speeding up natural rock breakdown so that they absorb more carbon dioxide from the atmosphere

says Dr Naira Ibrahim from Jackson State University. “Certain plants have the remarkable ability to absorb contaminants such as heavy metals through their roots and either store them safely within their tissues or transform them into less harmful forms.”

Nerium oleander

Naira is investigating the phytoremediation potential of ornamental plants. “Some plants act like natural filters, extracting pollutants such as toxic metals from contaminated environments while continuing to grow and improve soil quality,” says Naira. “Compared to conventional methods such as excavation or chemical treatment, phytoremediation is more

affordable, environmentally friendly and sustainable. It requires less energy, produces minimal waste, preserves soil structure, enhances biodiversity and creates green spaces instead of disturbing ecosystems. It also provides long-term environmental benefits while reducing clean-up costs for communities.”

Naira’s research is focussed on *Nerium oleander*, an evergreen shrub with pink, red or white sweetly-scented flowers. This plant has specialised transport proteins which enable it to absorb toxic metals through its roots. “Once inside the plant, these materials are transported into different tissues – including roots, stems and leaves – where they are safely stored within



Naira and a student researcher plant *Nerium oleander* as part of a field study investigating plant-based approaches for remediating contaminated soil.

cellular compartments, minimising damage to the plant itself,” says Naira. “Our research has shown that *N. oleander* is highly tolerant of contaminated environments because it possesses natural defence systems that protect it from heavy-metal toxicity.”

Enhanced weathering

Naira is interested in how phytoremediation can be boosted when combined with enhanced weathering, an innovative climate-change mitigation strategy that accelerates a natural geological process. “Finely crushed silicate rocks, such as basalt, are applied to agricultural or contaminated soils where they react with rainwater and atmospheric carbon dioxide (CO₂),” explains Naira. “This reaction permanently stores carbon in stable mineral forms, removing it from the atmosphere and improving soil fertility.”

Beyond capturing carbon, enhanced weathering can improve soil health by releasing essential nutrients for plant growth and helping trap toxic metals, reducing their movement into groundwater. Combining this with phytoremediation could offer a powerful strategy for restoring polluted land. “When grown in soils treated with enhanced weathering minerals, *N. oleander* benefits from improved soil fertility and healthier growing conditions,” says Naira. “Meanwhile, the rock amendments help reduce heavy-metal mobility while the plant actively extracts contaminants.”

The genetics behind *N. oleander*

To understand what makes *N. oleander* such an effective natural clean-up tool, Naira is investigating the genes that allow the plant to absorb, transport and safely store

toxic metals. The research combines plant biology, environmental science, genomics, microbiology and bioinformatics to uncover how the plant responds when it encounters pollution.

Using genetic sequencing, Naira can identify which genes are activated when *N. oleander* grows in contaminated soils and which microbes improve the plant’s ability to enhance the soil. Additional techniques, including imaging methods such as X-ray fluorescence and analysing root-associated microbes, reveal how plants and microorganisms work together to enhance the soil.

“Combining these techniques allows us to identify which genes become active when plants are exposed to heavy metals and how microbes contribute to improving phytoremediation efficiency,” says Naira.

Plant power – environmental and medical applications

Early findings show that when *N. oleander* is planted in contaminated soils, it switches on a range of genes that help transport toxic metals, defend against damage and protect its own cells in stressful conditions. Naira’s research also highlights the importance of interactions between plant genes and beneficial soil microorganisms.

“In the future, this knowledge could help scientists develop improved phytoremediation plants through selective breeding or biotechnology, leading to faster, safer and more efficient cleanup of contaminated land and water,” says Naira. “Ultimately, this research has applications in environmental restoration, sustainable agriculture, climate

resilience, public health and even future space agriculture.”

The research has also revealed exciting hidden potential beyond environmental cleanup. “*N. oleander* produces several bioactive compounds with antimicrobial, antioxidant and anticancer properties,” says Naira. “Our current research is investigating whether extracts from this plant can inhibit the growth of colorectal cancer cells.”

Community engagement

In Mississippi, where decades of intensive industrial activity have contributed to environmental contamination, Naira is working with communities to explore sustainable solutions. “We are collaborating with local stakeholders, students and environmental partners to evaluate contaminated sites, monitor soil and water quality, and identify sustainable remediation strategies,” says Naira. “We are aiming to reduce environmental pollution, improve ecosystem health, support community resilience and provide scientific data that can guide future environmental management and policy decisions.”

Looking ahead, Naira is exploring how genetics and microbes can make phytoremediation even more effective. “One of my long-term goals is to develop environmentally sustainable technologies that simultaneously clean contaminated soil and water, improve agricultural productivity, reduce greenhouse gas emissions, and protect public health,” she says. “I also hope to continue mentoring students from diverse backgrounds and preparing the next generation of scientists to solve complex environmental challenges through interdisciplinary research.”

About *environmental science*

The choices we make and the actions we take shape the future of our planet, and if you are curious about how to make positive changes to our environment, then environmental science may be the career for you. Environmental science explores how land, water, air, plants, animals and people are all connected, and what happens when those connections are disrupted.

“Environmental science allows us to solve global challenges including pollution, climate change, biodiversity loss and water quality,” says Naira. “It offers exciting careers in research, government, industry, conservation, biotechnology and environmental consulting.” Opportunities in the field are as varied as the many different environments on our planet, including

specialising in wildlife conservation or marine biology, developing renewable energy sources or sustainable agricultural methods, or tackling pollution using plants, like Naira.

Within those areas, roles can also be incredibly varied. For Naira, “A typical day includes teaching, supervising laboratory research, analysing environmental and genomic data, writing grant proposals, publishing research and collaborating with scientists.” An important part of her work is mentoring students from diverse backgrounds and creating opportunities for them such as supporting her work with communities in Mississippi.

Naira is keen to emphasise the interdisciplinary nature of

environmental science and how it brings together knowledge and expertise from many different fields. She says, “Environmental science combines plant biology, genetics, microbiology and environmental chemistry to develop sustainable solutions for pollution, climate resilience and healthier communities.”

Environmental science is evolving quickly, and newer developments in the field involve the use of artificial intelligence, satellites and drones. Future environmental scientists may even get to play an important role in space exploration by creating sustainable ecosystems for space agriculture using tools such as phytoremediation that have been discovered here on Earth.

Pathway from school to *environmental science*

“Students should study biology, chemistry, environmental science, mathematics, physics, computer science, data analysis and statistics,” says Naira. “Environmental problems are interdisciplinary and require teamwork, persistence, critical thinking and strong analytical skills.”

Naira encourages students to seek out internships or work experience opportunities, or volunteer to support research projects.

Explore careers in *environmental science*

Explore the American Society of Plant Biologists (aspb.org), the Institution of Environmental Sciences (the-ies.org) or the American Geophysical Union (agu.org) for useful resources, career advice and opportunities to attend events and meet professionals in the field. You could even consider joining as a student member.

You can learn more about the work of Naira and her colleagues in the Department of Biology at Jackson State University here: jsu.edu/biology



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Naira presenting her research at the Future Energy Summit, highlighting sustainable approaches to environmental remediation and energy-related environmental challenges.



Meet Naira

As a teenager, I was fascinated by plants and nature. Learning how plants interact with the environment inspired me to pursue environmental science and phytoremediation research.

I enjoy discovering new knowledge while mentoring students and helping them become independent scientists.

I am motivated by developing sustainable solutions that improve environmental and human health while inspiring the next generation of scientists.

Key to my success have been persistence, curiosity, collaboration, continuous learning and mentoring.

To unwind from work, I enjoy spending time with my family, gardening, reading scientific literature and spending time outdoors.

Naira's top tips

Never stop asking questions. Work hard, seek mentors, stay curious and remember that every scientist begins by learning one step at a time.

Environmental science

with Dr Naira Ibrahim

Talking points

Knowledge and Comprehension

1. What is phytoremediation and how can it help to clean up pollution?
2. What is enhanced weathering and how can it support phytoremediation?

Application

3. Where would pollution-removing plants be most useful, and why? How could this research be adapted to help communities in different parts of the world?
4. If you were studying the phytoremediation properties of plants, what research questions would you want to investigate?
5. A typical day for Naira could include carrying out research in a laboratory, teaching, mentoring students, engaging with communities, analysing data, writing research papers and collaborating with other scientists. What skills do you have already that would support you in any of these tasks?

Analysis

6. What challenges might scientists face when using phytoremediation on a large scale?
7. Naira says, "Community engagement is an essential part of my research philosophy. I believe scientific discoveries should directly benefit the communities facing environmental challenges." To what extent do you agree with Naira? What do you think might be the challenges of engaging with communities? What would be the benefits?

Evaluation

8. How should we balance the need for industrial activity with the need to protect the environment?

Activity

Naira believes in the importance of community engagement and is currently collaborating with communities in Mississippi to tackle toxic metal contamination.

In a small group, think about how you would introduce phytoremediation and enhanced weathering to a community. Design a communication campaign that tells local people about the science behind the techniques, the benefits they could bring and how community members could get involved.

Choose a format of communication that you think will work best for reaching people from a wide range of backgrounds. For example, you could create an educational leaflet, a local radio show, a short video on social media, or even plan an in-person question-and-answer session. Think carefully about how to appeal to everyone in your audience, as their levels of scientific understanding or educational backgrounds may vary widely.

Share your work with your fellow students and ask for their feedback. Consider the following questions:

- To what extent did you explain the science clearly, accurately and in an engaging way?
- Having shared your work with your fellow students, what would you change before sharing it with community members?
- What did you find easy about the task and why? What did you find difficult?

More resources

- Listen to the Costing the Earth podcast (bbc.co.uk/programmes/b006r4wn/episodes/downloads) and the Ask MIT Climate podcast (climate.mit.edu/ask-mit-climate-podcast) to learn about a range of environmental topics.
- Watch this series of TED Talks to explore different ideas and research on the topic of environment: ted.com/topics/environment
- Watch this YouTube video which explains more about phytoremediation: youtube.com/watch?v=Oyu5HiilpeQ

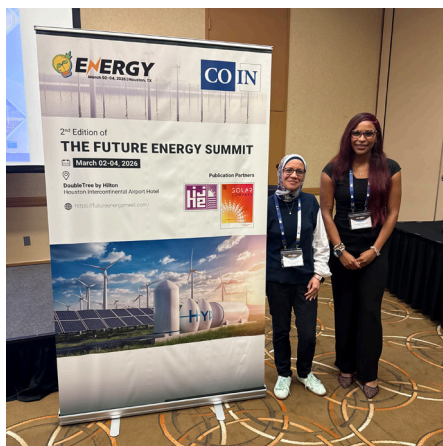


Photo montage

Top: Naira and a student researcher planting *Nerium oleander* during a field phytoremediation study in Mississippi.

Middle row: Left: Naira with a fellow participant at the Future Energy Summit.

Centre: *Nerium oleander* plants prepared for a field experiment investigating their ability to tolerate and remove contaminants from soil.

Right: Naira with a fellow participant at the Future Energy Summit.

Bottom: Experimental *Nerium oleander* plants growing under controlled conditions for studies of heavy-metal stress, plant responses and phytoremediation.

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