HOW A GIRL WHO LOVED LEARNING BECAME A TOP SOIL SCIENTIST

When Asmeret Asefaw Berhe was growing up in Eritrea, a nation in Northern Africa, her dad had a pet name for her.

In a large family that placed a high value on education, Berhe was the one who always had her nose in a book. Her parents expected her to go far. Her dad even took to calling her "the Professor."

"That had a huge impact on who I became," Berhe said. "In my head I always was going to have a science career one way or another."

Berhe endured conflict in her native country before making her way to the U.S. and building a career that fulfilled her father's prophecy. She is an associate professor of soil biogeochemistry at the University of California, Merced. Her work has been recognized with honors including a National Science Foundation Early Career Award.

Berhe's research focuses on how soil stores carbon and other elements. Earth's soil holds a huge amount of carbon. Berhe looks at how damage from erosion, fires, or drought can disrupt that storage.

Her work tracing carbon in soil is crucial for finding ways to manage our soil sustainably and also for helping us understand how soil regulates Earth's climate system. When we burn fossil fuels to power cars, factories, and appliances, we send carbon dioxide into the air. Carbon dioxide is a greenhouse gas, so adding more of it to the air warms our planet. If Earth's soil releases more carbon, our world could grow even warmer.

EDUCATION COMES FIRST

Berhe's father was a lawyer and her mother is a businesswoman in Asmara, Eritrea's capital. Berhe is the fifth of their six children. "I was kind of nerdy," she remembered. "I asked a lot of questions. I was that kid who read not just her own textbook but those of her older siblings. I loved learning new things."

Her parents did everything they could to nurture that a love of learning. "My biggest cheerleaders and mentors were my mom and dad," Berhe said "They encouraged us to read. They made it their mission to provide books for us."

While Berhe was growing up, Eritrea was racked by conflict. Neighboring Ethiopia had annexed Eritrea in

1961, triggering a guerrilla war for independence that lasted 30 years. The Eritrean People's Liberation Front finally defeated Ethiopian forces in 1991.

Members of Berhe's family were involved in the independence struggle. Her father was arrested twice. While Berhe was in high school, he had to flee the country for a time. Yet despite the turmoil, the children managed to continue their schooling. "Our family did everything in their power to make sure our education wasn't interrupted," she said.

Until third grade, Berhe went to an all-girls Catholic school. Then the government shut down the private schools, so she continued her education in coed public schools.

THE AMAZING WORLD OF SOIL

In high school, Berhe had many interests, including world news and geography. But her favorite subject was chemistry. "I loved science overall, and I loved learning about how different reactions worked and what things are made of," she said.

She finished high school and started at the University of Asmara in 1991. "I actually thought I wanted to study chemistry as a pre-med undergraduate major, until I took a class in soil," she said. "I realized there was an amazing world that I knew nothing about. As soon as I learned about soil, I was hooked."

The newly independent Eritrea faced a severe teacher shortage, so college students were recruited to teach. After her second year at the university, Berhe returned to her old high school and taught freshman English. Then she went back to Asmara University to resume her studies.

It was unusual for a woman to study soil science. Of 55 undergraduates in Berhe's department, only three were women. But her instructors were supportive, and she excelled at her studies.

For her honors thesis, Berhe did lab trials to see how well different crops prevented soil erosion. "It was fun doing the research, fun writing it up, and fun presenting it," she remembered. She received her bachelor's degree in soil and water conservation in 1996.

A NEW LIFE IN A NEW LAND

When it was time for graduate school, Berhe traveled to the U.S., to Michigan State University. She had relatives in Michigan, and Michigan State had a Resource Development program that interested her. Berhe investigated how landmines left over from wars affect land use.

Even after a war ends, landmines remain, she noted, and they keep people from using the land for years to come. "My research was global in focus," she explained. "But obviously I started thinking about this because of growing up in a war-torn country." She received her master's degree in political ecology in 2000.

To pursue a Ph.D., Berhe headed to the University of California, Berkeley. Her research looked at how erosion affects the exchange of carbon between air and land. She and her fellow researchers made a surprising discovery—erosion can actually cause soil to store more carbon.

Here's how it works: Growing plants take in carbon dioxide from the air to use in photosynthesis. When plants

die, some of that carbon goes into the soil. Microbes in the soil gradually digest the decaying plant matter and send carbon dioxide back into the air. But when soil washes away and gets buried under sediment, the carbon is trapped.

“This is not to say erosion is a good thing,” Berhe noted. In her paper reporting the discovery, she emphasized that erosion “is not a sensible management strategy for carbon sequestration.” But she added that it’s important to understand fully how changes in soil affect circulation and storage of carbon.

CAREER AND FAMILY

While she was at Berkeley, Berhe reconnected with Teamrat Ghezzehei, a young soil physicist she had known in Eritrea. They eventually married. One day after she submitted her Ph.D. thesis, Berhe gave birth to their first child, a boy.

She received her Ph.D. in Biogeochemistry in 2006. Then, when her son was just 3 months old, she started postdoctoral studies. Berhe did postdoctoral work at both UC Berkeley and UC Davis.

In 2009, Berhe and her husband both accepted positions at UC Merced, the newest campus in the University of California system.

The couple soon welcomed a second child, a girl. Juggling academic careers and childcare has been a challenge. “I’m lucky I’m in a job where I can rearrange my schedule,” Berhe said. “I also happen to be married to another scientist who understands exactly what I need to do. It’s also just a matter of sometimes sacrificing a lot.”

Their son is now 10 and their daughter is 6. The children often accompany their parents into the field for research or on trips to conferences. “They both love science, and they both want to be scientists,” Berhe said. “They love the idea of learning new things, and they understand the importance of soil.”

Berhe’s research at UC Merced includes studies on how drought and wildfires affect soil, particularly its ability to store carbon. Her fieldwork sometimes takes her to the scenic vistas of nearby Yosemite National Park.

Her fascination with soil—and her sense of the importance of sustaining soil systems—has deepened over the years. “Along with all the existential threats we’re facing—climate change, overpopulation—soil degradation needs to be up there,” she said. “If the quality of soil is diminishing going forward, we are going to be facing even more severe issues with food and nutritional security, as well as climate and water regulation.”

See **SECRETS IN THE SOIL** (below) for more on Asmeret Asefaw Berhe’s research.

STEM FOR EVERYONE

Even while balancing research, teaching, and family life, Berhe finds time for a cause close to her heart—encouraging women and minority students to stick with science and pursue STEM careers.

She is involved with the Earth Science Women’s Network, an international organization that supports women in geosciences. The group has more than 2,500 members in 50 countries.

Berhe also recently joined other female faculty members at UC Merced to start WSTEM—Women in Science, Technology, Engineering, and Mathematics. The support group sponsors events and promotes mentoring to help women at Merced succeed in STEM studies.

“It was very clear that there was a need for this,” Berhe said. “There are many factors that discourage women in science. We need to make women feel like they belong.”

Berhe also works to help both male and female students from underrepresented minority groups succeed in STEM fields. This effort is especially crucial at UC Merced, where a high percentage of students are the first in their families to go to college.

“It’s important to me that our scientific community reflects society,” Berhe said. “The more diversity you have in science, the better the quality of the science, and the more relevant science becomes to society.”

Listen to Asmeret Asefaw Berhe discussing her research: https://aaberhe.com/2015/07/22/asmeret-discusses-soil-and-human-security-on-down-on-the-farm-with-tom-willey-on-kfcf-88-1-fm/

SECRETS IN THE SOIL

Asked what natural resources are essential for life on Earth, many people would list air and water. But Asmeret Asefaw Berhe points out that there’s another resource we can’t live without—soil.

“Overall, society doesn’t have a good understanding of the importance of soil,” said Behre, an associate professor of soil biogeochemistry at UC Merced. “The quality of our soil dictates what we have to eat, what nutrients are available to us, and what kinds of structures we can build.”

Soil is essential not just for humans, but for life overall, she added. “Soil hosts the largest diversity of living things we know. A teaspoon of soil can hold upward of a billion microbes from more than 10,000 species.”

Behre has studied soil systems from a variety of angles, including how landmines in war-torn countries disrupt land use. These days she investigates how environmental changes—including fires, erosion, and drought—affect soil processes.

FOLLOW THE CARBON

Berhe hopes her research will help people find sustainable ways to manage this crucial resource. She also wants to shed light on how soil affects climate change.

Soil is a huge carbon “sink”—it stores a tremendous amount of carbon. The carbon in soil comes from decaying plants and other organisms, along with small amounts from inorganic sources—weathered rocks.

In its natural state, soil maintains a balance between gains and losses of carbon and nutrients. But thousands of years ago, when people started farming, they began to upset the soil’s natural balance. Most agriculture strips off native plants and changes soil’s composition. Farming can also leave soil vulnerable to erosion by water or wind.

As the human population grew, so did the damage to Earth’s thin mantle of soil. Around the world, cultivated

soil has lost much of the carbon it once held. A lot of that carbon has escaped into the air as carbon dioxide.

Carbon dioxide is a greenhouse gas—it holds heat in Earth's atmosphere. Our planet is warming mainly because people are adding more carbon dioxide to the air when they burn fossil fuels like coal and gasoline. But the cycling of carbon through Earth's air, water, and land is complicated. Understanding the role of carbon from soil systems fills in a key part of the climate-change picture.

A LAB WITH A VIEW

UC Merced, in Central California, is a perfect setting for Berhe's research. Merced is sometimes called the "Gateway to Yosemite." Berhe and her students collect soil samples in the famed national park and other parts of California's Sierra Nevada range to investigate soil processes and the damage caused by disturbances such as fire, drought, and erosion.

For instance, they collected soil from the burn area of the 2013 Rim Fire near Yosemite. Then they compared those samples with soil from a site that burned a decade earlier. This allowed them to see how storage of carbon and other elements in scorched soil changed over time.

When Behre and her students identify a spot they want to study, they go into the field and dig soil pits, typically about 1 meter square and up to 2.5 meters deep. They carefully collect samples at different depths. They also install sensors and collectors in the soil pits and on slopes and basins to monitor erosion.

Soil samples in hand, the team heads back to the university. "A lot of the work that we do happens in the lab," Berhe said. The researchers analyze soil through spectroscopy—using different colors of light to reveal what materials are made of. They also use magnetic resonance, a technology similar to MRIs used in medicine, to decipher the soil's chemical composition.

The work is fulfilling for Berhe and her students. "We love being able to ask questions that we think are interesting and important, and then to make new discoveries," she said. "I love interacting with students and researchers and talking about what excites us."

She believes their work is paying off, as more people come to appreciate how important it is to protect Earth's soil.

An article Berhe co-authored in the journal Science summed up what is at stake: "Ultimately, the way in which we directly and indirectly manage our planet's soil will be interwoven within our future success as a species."

In August of 2016, Sally Ride Science posted Asmeret Asefaw Berhe's story, in which she mentioned her involvement with ESWN. Asmeret has been a member of ESWN since 2007, and was featured in an ESWN spotlight in 2015. She recently became a member of ESWN's Leadership Board! Sally Ride Science at UC San Diego works to help educators build students' STEM literacy.