Los Angeles Times

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Turning data to sound in name of science

Researchers gain insights into matters as small as DNA and as vast as the galaxies.

By Sumeet Kulkarni

Biochemist Martin Gruebele regularly dons a pair of headphones in his lab at the University of Illinois. But instead of music, he listens to a cacophony of clinking, jarring noises — as if a group of robots were having a loud argument.

The payoff for this pain? These sounds help Gruebele understand how proteins in our body interact with water.

Protein molecules fold like shape-shifting transformers to carry out vital cellular functions in our body. When things go wrong, misfolded proteins can form plaques in the brain, a process that is thought to be the cause of neurodegenerative diseases such as Alzheimer's.

Gruebele has devised computer simulations to understand protein folding, which occurs primarily in the water inside our cells. But the interactions between a protein and trillions of water molecules are too complex — and happen too fast — for him to see them in his simulations.

So he listens for them instead.

"You have to think of that sound in the same way that you think about a graph as opposed to a painting," Gruebele said.

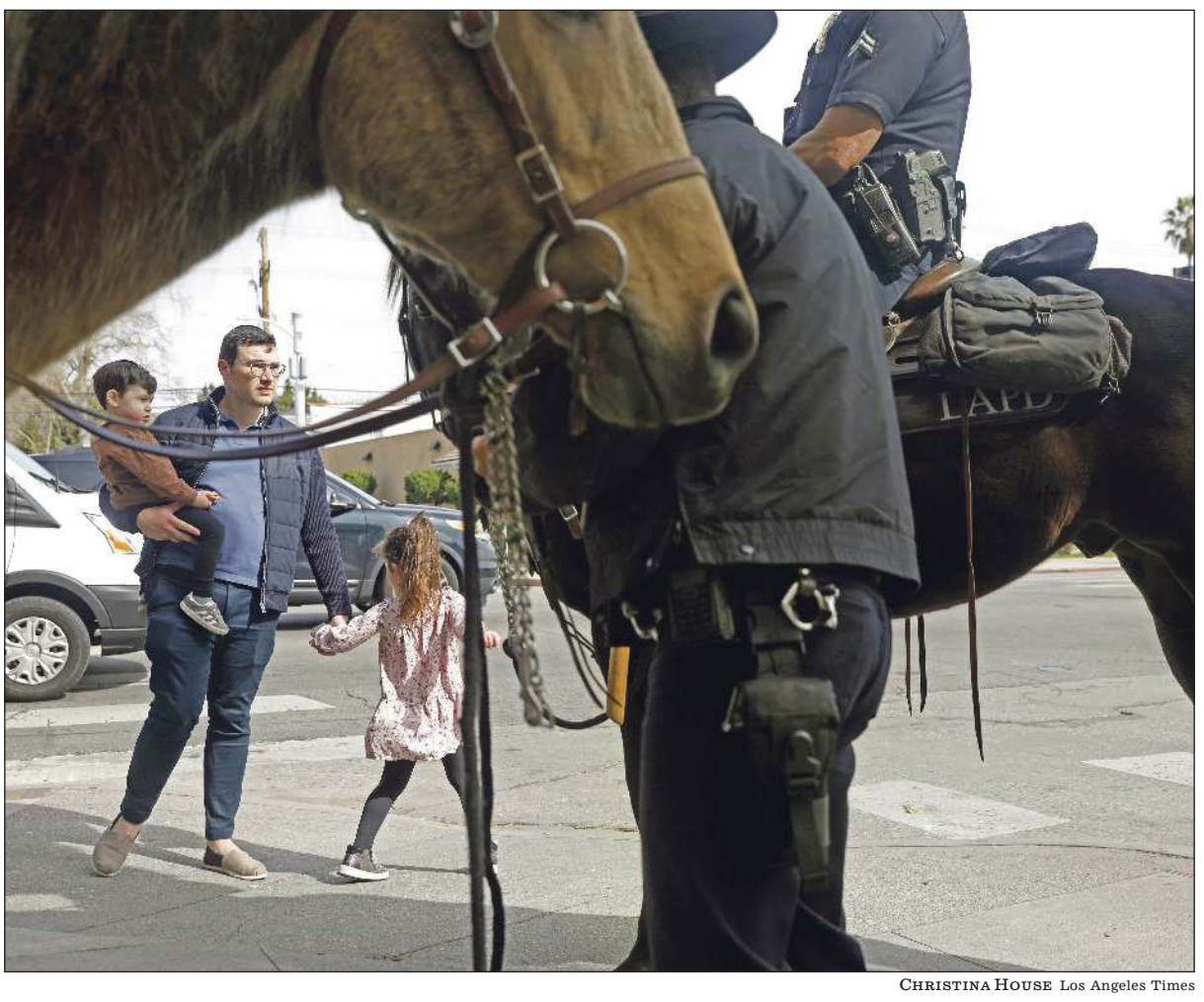
He uses a software program called Kyma to add a specific sound to each of the numerous bonds that occur as the protein folds. When played back, the sound brings order to the chaos by highlighting which particular interactions dominate.

"I can close my eyes and tell you, 'Aha, there's a protein-to-water hydrogen bond that just formed,' " he said as the track played out. "Once I've heard it, I can actually go back to the simulation and zoom in on that one specific water molecule and figure out which one it was and where it was making the bond."

Gruebele is part of a growing community of researchers using sound to convey scientific phenomena. It's the auditory equivalent of data visualization, and its adherents call it "data sonification."

The concept isn't entirely new. One of the earliest examples of using sound to represent data is the Geiger counter. This instrument was designed in 1928 to indicate the amount of

[See **Sounds,** A12]



Christina House Los Angeles Times

IZIK GOLDSTEIN, with Akiva, 3, and Tali, 5, passes LAPD officers stationed Friday in Pico-Robertson.

L.A. Jews 'always worried'

The suspect arrested in connection with two shootings this week has a history of making antisemitic statements, prosecutors say

By Noah Goldberg, Sonja Sharp, Terry Castleman and Richard Winton

Stephane Sultan, who owns a kosher restaurant on Pico Boulevard, knew his neighbors and customers were on edge because they kept confiding the same message.

They were carrying guns.

Sultan said they were arming themselves after the shooting Wednesday of a man leaving a synagogue in Pico-Robertson.

"We have to protect ourselves," Sultan said.

On Thursday morning, he was standing outside his restaurant, Trattoria Natalie, when he heard three pops. After watching police en route to the scene a few blocks away, he learned that another Jewish man had been shot after leaving worship services.

"Of course they were scared yesterday," said Sultan, who is Jewish and emigrated from France. "Everybody at the restaurant, at the market was talking about it."

Although both men who were shot survived their wounds, the violence has left the Jewish community on edge.

The arrest Thursday evening of a suspect confirmed fears that the attacks were targeted.

Jaime Tran — who authorities say has a history of making antisemitic statements, often specifically about Persian Jews — was taken into custody in connection with the shootings.

Tran, 28, was charged Friday with federal hate crimes. He admitted to police that he searched for a kosher

[See **Shootings,** A8]

Officials study overhauling dam

Lake Powell's low level imperils the ability to generate power, release water.

By Ian James

The desiccation of the Colorado River has left Lake Powell, the country's second-largest reservoir, at just 23% of capacity, its lowest level since it was filled in the 1960s.

With the reservoir now just 32 feet away from "minimum power pool" — the point at which Glen Canyon Dam would no longer generate power for six states — federal officials are studying the possibility of overhauling the dam so that it can continue to generate electricity and release water at

[See **Glen Canyon,** A8]

Carolyn Cole Los Angeles Times

JOHN WEISHEIT, an activist who has advocated for removing Glen Canyon Dam, is pleased that federal officials are discussing retooling the structure.

EPA is asked to help in lead cleanup

California lawmakers make request after Times inquiry into Exide project lapses.

By Jessica Garrison

Amid California's long struggle to hold an industrial polluter accountable and remove lead contamination from neighborhoods southeast of downtown Los Angeles, members of Congress are now calling on the federal Environmental Protection Agency to assist in the troubled cleanup of areas surrounding the closed Exide battery recycling plant — the largest and most costly effort in California history.

"It is clear that only the federal government has the capacity to resolve this crisis," wrote Rep. Robert Garcia (D-Long Beach) and California Sens. Dianne Feinstein and Alex Padilla in a letter Thursday to EPA Administrator Michael S. Regan. The letter cited a Los Angeles Times investigation published last week that found that numerous properties remediated at great cost to state taxpayers have been left with concentrations of lead in their yards in excess of state health standards.

"We believe the severity of the crisis, the failure of past remediation efforts to create healthy communities, and the risk to public health requires assistance from the EPA and the resources available under the Superfund program," the lawmakers wrote.

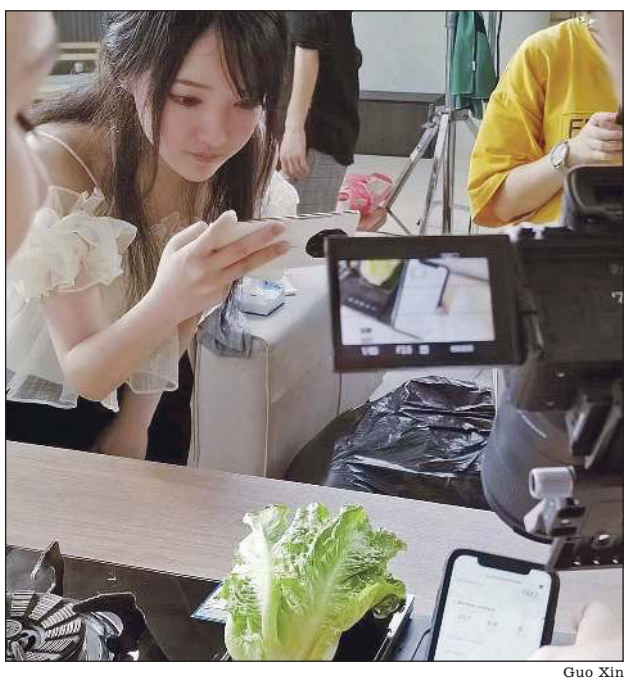
Officials with the state Department of Toxic Substances Control, which is overseeing the $750-million remediation effort, did not respond to a request for comment but have supported the idea of federal assistance in the past. They had hoped Exide would be responsible for the cleanup, but the company was allowed to walk away from much of the financial obligation after filing for bankruptcy.

Gov. Gavin Newsom welcomed the EPA's help, a spokesperson said Thursday night.

"Since the bankruptcy courts let Exide off the hook, the Newsom administration has worked closely with the Legislature to fund and implement this massive cleanup," said Anthony York. "We appreciate this support for the state's request to designate the Exide facility and surrounding community as a Superfund site, which will result in even more funding to support cleanup. The

[See **Lead,** A12]

Chinese factories hope for their own global brand



Guo Xin

THE CHINESE startup 4T7 makes a "smart" cutting board featuring a built-in scale and related app.

As manufacturing jobs exit China, companies see Alibaba, Tencent as models for survival.

By Stephanie Yang

TAIPEI, Taiwan — For nearly two decades, Bowen Tsui's family business in China has made garments to order for foreign clients to sell overseas under their own labels. Now, he believes the company's survival depends on whether it can design, brand and distribute clothing by itself.

About a year ago, the company began using two of its factory's assembly lines to make men's trousers, T-shirts and yoga pants stamped with its own name, Goodways Group. It purchased a new facility to use as a design studio, as well as a 30% stake in a Cambodian factory to manufacture men's and women's activewear. To sell his goods in China and Europe, Tsui hired livestream hosts to showcase products in the way of QVC and U.S. shopping channels, and he's looking for online merchants to reach American consumers.

The transition from simply manufacturing goods to conceptualizing and branding them is a result of China's changing economic landscape. Although the country maintains its status as the world's factory floor, accounting for more than a quarter of global manufacturing, lower costs in places such as Vietnam and India are steadily luring operations away. At the same time, improved product quality and e-commerce channels have given manufacturers greater access to shoppers at home and overseas.

For Tsui and a majority of his friends in manufacturing, the hot topic these days is how to launch their own brands, whether for socks or pet toys or camping gear.

"All the factories are experiencing tough times," said Tsui, 28. "This is the sun setting on our traditional business."

As financial pressures from rent, labor and environmental regulation have increased, Tsui and his family have adopted cost-saving strategies such as opening factories in Cambodia and integrating robotics into their facilities in China's Jiangsu province. In 2020, when the pandemic bankrupted several of the company's foreign clients and halted orders, Tsui decided

[See **Brands,** A4]

Weather
Partly sunny.
L.A. Basin: 70/49. **B8**

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‘Data sonification’ resonates across the universe

[**Sounds,** from A1]
radioactivity in a given place with clicking sounds. The faster the pace of the clicks, the more dangerous the environment. It’s a no-nonsense way to signal danger in a place that’s literally trying to kill you.

The Geiger counter was a mechanical device. But today, with digital audio, any piece of data can be mapped into sound.

Kyma was developed by Carla Scaletti, a composer and sound engineer based in Illinois. Its original purpose was all Hollywood — it was used in three Star Wars movies and the animated flick “Wall-E.” Its user interface allows individual sounds to be wired together like components in an electrical circuit. The result is a versatile tool that can produce endless audio combinations, even a soundtrack of human biology.

Scaletti believes sonification should be driven by the data alone.

“You have to be able to listen and analyze what you’re hearing and not just sit back and let it wash over you emotionally,” she said.

But for others such as ocean chemist and saxophonist Noah Germolus, the sounds of science ring closer to the sound of music.

Germolus, a PhD student studying ocean chemistry, collects water samples from the Atlantic and the Caribbean and brings them back to his lab at the Woods Hole Oceanographic Institution in Falmouth, Mass. There, he passes the samples through a series of chemical analysis tools that measure the abundance of nutrients essential for marine life, including carbon, nitrogen and phosphorus.

The data are recorded on his computer, then recast on a music staff.

“I take the intensity [of chemicals] and translate that to notes on a staff,” Germolus said. Data corresponding to low concentrations of chemicals are lower notes, and high concentrations are higher notes.

The resulting score echoes the diversity of undersea environments. There are deserts and oases based on the richness of nutrients and the marine life they attract.

All of it is reflected in Germolus’ music. His favorite soundtrack is of the barren deep ocean.

“I think it sounds a little bit melancholy,” he said. “The expression that it’s supposed to convey is ... you’re a microbe floating around, the water itself isn’t moving very much, you’re not moving very much, your metabolism is slow.”

Germolus had recorded the amount of dissolved organic carbon, the signature ingredient of life. He knew it would be scarce more than a mile beneath the surface, so the desolate tone wasn’t a surprise.

But surprises are welcome. Germolus recalled listening to data from the ocean surface and hearing a high G among a bunch of low notes, making him wonder, “What’s that? What’s going on here?”

SCOTT GELBER For The Times

A GROWING community of researchers is using sound to convey scientific phenomena, the auditory equivalent of data visualization.

> ‘What the human eye can see is just a tiny, tiny sliver of what is out there in the universe. It’s like the middle C, and a couple of keys on either side of it on a piano keyboard.’
>
> KIMBERLY ARCAND,
> data visualization expert with NASA’s Chandra X-ray Observatory

The sudden transition might be a marker of aromatic compounds, he said. “That kind of stuff is interesting and important, especially as it relates to both pollutants and as it relates to organic compounds.”

While Germolus makes a sort of jazz out of ocean nutrients, Jon Bellona uses data sonification to help us listen to the oceans breathe.

Working with ocean data collected in 2017, Bellona uses software to track the movement of carbon dioxide in and out of the water. When cold winter waters suck in carbon dioxide from the atmosphere, he hears low rumbling sounds. When the warmer oceans exhale the gas in the summer, he hears a scrunchy sound resembling waves crashing into the shore.

“Sonification can help researchers do day-to-day work,” said Bellona, a sound artist at the University of Oregon. It’s good for “discovering new patterns that we cannot see, and at the same time, in being inclusive.”

Amy Bower, an oceanographer at the Woods Hole Oceanographic Institution, said she was blown away by Bellona’s ocean track.

Bower is legally blind. While in graduate school, she was diagnosed with retinitis pigmentosa, a condition that causes vision to deteriorate slowly over time.

“For years, I’ve been investigating what’s available to me when it comes to accessing graphics and data,” Bower said. But without much success — the fact that science relies so heavily on plots and charts is a huge hurdle for visually impaired researchers like her.

Data sonification changes that. By listening to Bellona’s audio, “I could actually piece it together the way I used to when I would look at a graph,” she said.

Kimberly Arcand, a data visualization expert with NASA’s Chandra X-ray Observatory, views sonification as just another way of translating data from one form into another. It’s something astronomers already do all the time to enhance their understanding of light that’s outside the narrow band of wavelengths our eyes can detect.

“What the human eye can see is just a tiny, tiny sliver of what is out there in the universe,” Arcand said. “It’s like the middle C, and a couple of keys on either side of it on a piano keyboard.”

Many pictures of space, including the infrared images recently released by the James Webb Space Telescope, have been translated into visible light that humans can perceive, she pointed out, “so why not do the same with sound?”

For one thing, it makes astronomy accessible to those unable to see.

Consider an image of the center of the Milky Way galaxy created with data from the Hubble (which captures visible light), Spitzer (which sees the longer wavelengths of infrared light) and Chandra (which captures shorter-wavelength X-rays) space telescopes. Arcand assigns distinct sounds to different wavelengths of light, which users can hear as a cursor scans from left to right.

The sprinkling of stars is conveyed by the tinkling of wind chimes, while the widespread interstellar gas and dust draw out sustained stringed notes. Places with high-energy X-ray emissions strike deep piano notes. The whole symphony combines in a crescendo at the very center of the galaxy, where a supermassive black hole is shrouded by extremely dense cosmic matter.

Visually impaired people have described Arcand’s aural translation using words such as “spooky,” “scary,” “lovely,” “gorgeous” and “awe-inspiring,” she said. But what gratified her most was making sighted audiences aware that “there are people who can’t see the universe like they’re seeing right now.”

Bower said there are two schools of thought about taking liberties with sounds.

“If the purpose is just to get the public excited about science, then I’m all for making it as much an art,” the oceanographer said. “But if it’s for science, you gotta be faithful to the data.”

Mark Temple, a molecular biologist at Western Sydney University, sonifies data with both goals in mind.

“I’ve got a scientific motivation, and I’ve got sort of a musical motivation. I keep them independent,” said Temple, who used to be a drummer for the Australian indie pop band the Hummingbirds.

Today he can be described as the “DNA DJ.” He assigns a distinct note to each of the four bases of the DNA molecule — A, C, G and T.

By listening to a long string of genetic code, “you can easily distinguish repetitive DNA sequences from more complex DNA sequences,” Temple said.

For instance, people with Huntington’s disease have a three-letter segment of a particular gene that repeats significantly more often than it does in people who don’t have the disease. In Temple’s sonification of this gene, the telltale sign of Huntington’s sounds like a broken record.

Temple’s DNA discography has evolved in musical style. His newer tracks bring in more variation, such as unique sounds marking the start and the end of a gene, additional notes for active parts of DNA and background harmonies for the inactive sequences in between. A recent composition based on the gene for the coronavirus spike protein, which has 4,000 chemical letters, takes about four minutes to get through.

Temple has also created a web app that lets anyone plug and play their own DNA that’s been sequenced by a company such as 23andMe or Ancestry.com.

“If you have a genetic disease, and you’ve got something that you want to try and understand, I think playing the difference between a healthy individual and a diseased individual — so that the differences stand out — would be interesting to people.”

When it comes to sonification, every creator has different goals, uses and audiences. They also have their own ways of making sounds, from Scaletti’s sound design software and Temple’s DNA-coding algorithms to Germolus’ sheets of music.

But they all agree that no single tool can achieve it all.

“If you want to create things, you need to have the tools to do it. And they need to be easy and intuitive to use,” Gruebele said. (This is also true for visual graphics, a field for which plenty of software exists that everyone can use.)

Bower and Bellona are working to develop universal sonification methods, which will be the focus of a forthcoming project called Accessible Oceans.

They hope more researchers understand the value of using sound to present and analyze data. For a discipline that strives to make sense of the world we live in, Bellona said, sonification represented “a really exciting” shift in how scientists can utilize other senses toward communicating information.

Scaletti agreed that sound has the power to convey a lot of meaning.

“People know that because of language,” she said, “but they think everything else is music.” That’s why she’s carving a new niche in the human soundscape for science.

Scan this code with your phone to experience the sounds of this story online.

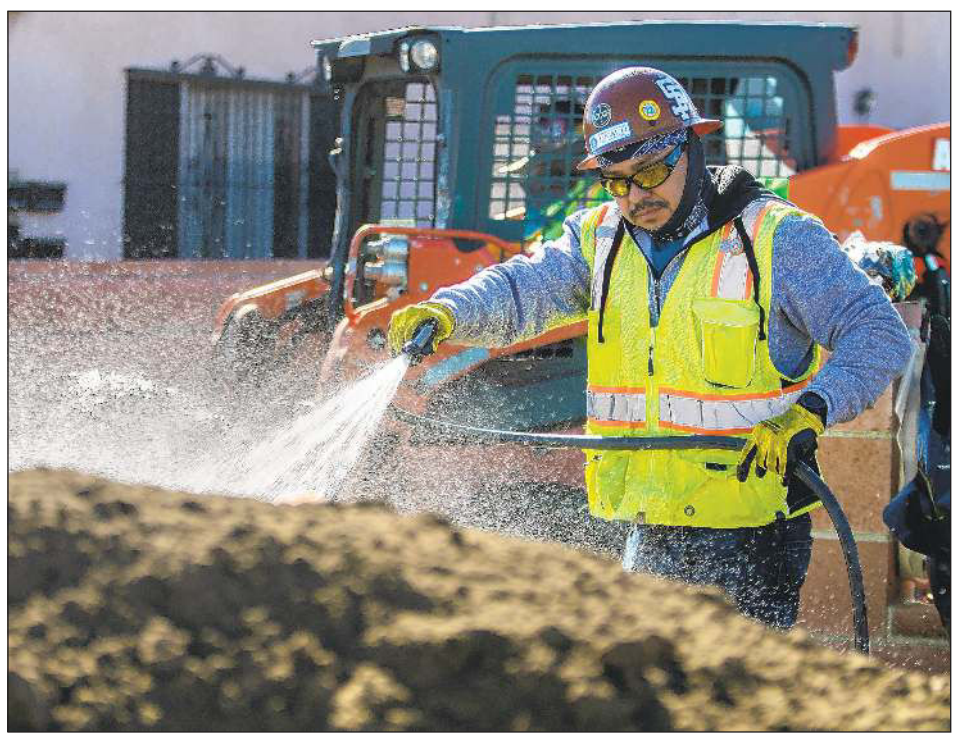
State lawmakers want EPA action on troubled cleanup

[**Lead,** from A1]
state will continue to pursue all avenues to advance these efforts and protect public health.”

Last year, the California Environmental Protection Agency had formally requested that the federal government put the plant and its surrounding neighborhoods onto a Superfund listing, saying it would “help protect people and workers in the environmental justice communities surrounding the facility by bringing in federal resources and expertise to help address toxic levels of lead in their environment.”

For nearly a century, the battery recycling plant operated near the banks of the Los Angeles River in the city of Vernon, belching poisons such as lead and arsenic into the air. Exide Technologies acquired the plant in 2000 and continued the plant’s history of violating environmental laws. According to state officials, it also contaminated thousands of nearby homes “with lead and dangerous chemicals.”

Exide, which has argued in the past that it was not responsible for lead contamination in the surrounding neighborhoods, filed for bankruptcy in 2020. The Trump administration, according to state officials, allowed Exide to walk away from southeast Los Angeles “without investigating the full extent of its contamination,” let alone clean it up.



FRANCINE ORR Los Angeles Times

A WORKER sprays water on a pile of contaminated soil in November as part of a lead remediation project near the former Exide battery recycling plant in Vernon.

After the plant’s closure in 2015, state officials determined that as many as 10,000 nearby properties could have been affected by Exide’s pollution, based on soil testing.

State leaders eventually committed to removing and replacing toxic soil, framing the massive cleanup as a measure of redress for neighborhoods subjected to decades of environmental degradation and government negligence. Many in the community were furious that the state had allowed the plant to operate for so long despite its history of illegal air pollution and hazardous waste violations.

So far, the state has spent more than $336 million and overseen the remediation of nearly 4,400 properties.

But the Times investigation identified numerous issues with the project.

Researchers at USC and Occidental College reported that they had tested surface soil from the yards of 93 remediated homes and found that 73 had at least one sample with lead concentrations over the California health threshold of 80 parts per million. They also found that 22 of the homes had at least one sample that tested over 400 parts per million, the federal limit.

“It raises a lot of questions about how systematic the cleanup is in these homes,” said Jill Johnston, an associate professor of environmental health at USC.

The Times also found that contractors working for the state have failed to meet state targets in more than 500 of 3,370 cleaned properties near the closed Vernon plant. Guidelines call for contractors to remove soil until the lead concentration is below 80 parts per million, or to dig down to a depth of 18 inches, before putting clean soil on top.

State officials said those failures pose no direct health risks because a covering of clean topsoil meant residents would not be exposed to lead unless the buried soil was unearthed. They also said that tree roots, pipes, cisterns or other buried objects made it impossible in some cases to dig down 18 inches.

Cleanup lapses go beyond residents’ yards. Six years in, the state still has no plan for removing some of the most contaminated soil in the neighborhoods — the strips of land between sidewalks and the street known as parkways.

The danger was highlighted in 2018, when county health officials traced a child’s poisoning to a dog tracking leaded soil from a nearby parkway into the house.

In a statement, Padilla said it was “time for the EPA to step up” and “take action to finally provide justice and guarantee a healthy environment for our communities.” He added that there has been “misstep after misstep by just about everyone involved following Exide’s crimes that forced communities in southeast Los Angeles to live with toxic pollution that continues to poison their families.”

The newly elected Garcia, who represents the area, said the importance of the issue was brought home to him during his campaign, when resident after resident in Commerce, Maywood and other communities around Exide told him that they had concerns about how the cleanup was going and felt left behind.

“This is a working-class community and they deserve to have a complete cleanup,” Garcia said.

In addition to the petition to the EPA, Garcia said he plans to raise the issue with President Biden. He also pledged that if a Superfund designation were approved for the site — a process that could take several months — federal officials would abide by California’s health standard for lead, which at 80 parts per million is more restrictive than the federal limit of 400 parts per million.

“This is an environmental disaster,” he said. “We need to do more.”