Analyzing environmental DNA from the area around a mine site can be faster and more accurate than traditional biodiversity surveys.

The power of DNA

Surveys that collect environmental DNA are allowing mining companies to monitor biodiversity over large areas more quickly and cost effectively

By Lynn Greiner

To manage the impact mines have on the environment throughout their life cycle, mining companies need to understand their impact on nature. To do this, they need to understand what lives and grows in the area around a mine site, and how it will be affected before, during and after a mine is in operation.

This is a global concern. In January, ICMM released a nature position statement in which it pledged to contribute to a nature positive future in five areas: direct operations, the value chain,

landscapes surrounding operations, systems transformation and governance and transparency. The statement described specific actions that ICMM's members should take in each area.

Canadian government guidelines lay out the rules under which the mining industry must act in the country, requiring baseline studies, risk assessments, management and monitoring, as well as detailed plans for restoring the site once the mine is shut down. The list of considerations is extensive, but one thing the rules do not do is tell miners how to do the work.

Biodiversity is often the difficult part of environmental analysis, noted Mehrdad Hajibabaei, associate professor in the department of integrative biology at the University of Guelph, and founder and chief scientific officer of Newfoundland-based environmental genomics company eDNAtec.

"When you want to get chemical or physical data, you have sensors [and] automated systems, but when it comes to biodiversity, it often turns into a black box," he pointed out. "That's the nightmare for an environmental manager, to be able to generate timely and comprehensive biodiversity data, and because of that, regulatory regimes have also not been as comprehensive when it comes to biodiversity."

Within mining operations, there are several areas where biodiversity data becomes critical, Hajibabaei said. During the initial baseline assessment, mining companies need to understand how their operations will affect general biodiversity: the number of species present, and whether any are endangered or under pressure, and thus need to be protected. Those operations do not just include the actual mine; aspects such as building roads to the site, running powerlines or other activities that alter the state of the environment must also be taken into consideration.

Then, when the mine is being decommissioned, restoration activities need to ensure that the site is returned to its initial natural state. "Rather than [just] putting grass on it so it looks green, we want to actually ensure that it has the diversity of organisms that it used to have there," said Hajibabaei.

Increased scale

While manual assessments, in which field workers perform an in-person audit of the environment to record the flora and fauna, are useful, they are inefficient—labour-intensive, time-consuming, expensive and require expert ecologists to be in the field for extended periods of time.

"What's more, the low availability of taxonomic experts to perform this work—as demand outstrips supply—limits the collection of data at the speed and scale that is necessary within the mining industry," explained Rachel Mador-House, head of scientific affairs for North America at nature intelligence technology company NatureMetrics, which has worked with mining companies such as Anglo American, Teck Resources, Rio Tinto and Glencore.

But thanks to a relatively new approach, an environmental assessment can be performed more quickly and accurately by analyzing environmental DNA (eDNA).

"DNA surveys allow us to detect species without seeing or hearing them, but through the collection of trace amounts of DNA, or 'eDNA,' that organisms leave throughout the environment," explained Joshua Newton, a PhD candidate at the Trace and Environmental DNA Laboratory (TrEnD) at Australia's Curtin University. "We're now able to harness this DNA by collecting a non-invasive sample from water, flowers or swabbing of plant material, removing the DNA from the sample, amplifying and analyzing this DNA, and then mapping it back to a reference database, which will give us a list of species whose DNA is present in that sample."

The DNA can come from any number of sources: the organisms themselves, shed cells, reproductive material such as seeds or spores from larger organisms, or even scat. DNA may also be retrieved from places like insect traps, samples netted in streams or the water itself. Newton is also working on new ways of retrieving samples, such as gathering the DNA of pollinators

Courtesy of eDNAtec

An eDNAtec ecologist collecting a sediment sample from a river for eDNA analysis.

from flowers, and is looking into the ability of spiderwebs to capture the DNA of vertebrates.

In comparison to conventional observation methods, Mador-House said, eDNA sampling is highly scalable, can track multiple species at once, and can be used to monitor large areas and more diverse environments, which can provide more expansive and accurate datasets. "Crucially, it is much easier to deploy in the field, requiring less specialist support on the ground, which means it is quicker and cheaper to deploy," she explained. "It is designed to be easily repeatable, and because the data is standardized, it provides an incredibly accurate picture of how an ecosystem is changing over time, to allow companies to make more informed and impactful decisions for nature."

Adam Cross, principal biodiversity at Australian mining company Mineral Resources (MinRes), which has previously partnered with Curtin University on eDNA research, noted that eDNA surveys "often require less taxonomic expertise than traditional flora and fauna surveys to provide something akin to a genetic fingerprint for which species from different groups of organisms are present in an area."

He added that eDNA surveys likely represent a powerful supplement to traditional biodiversity monitoring techniques. "They may be a cheaper and more rapid way of capturing a holistic picture of the biodiversity in an area and can more reliably detect organisms that might be difficult to identify or hard to distinguish from other similar organisms visually—for example, different subspecies or plants that are only easily distinguished from each other when in flower," he explained. "These surveys can also help detect organisms not commonly considered in traditional surveys, such as fungi, mosses and microbiota [microorganisms]."

The eDNA surveys can also discover small, hard-to-detect species, according to Matt Brekke, senior wildlife biologist at Stantec. "Since some species are endangered, it's very important to be accurate when conducting presence/absence surveys," he noted.

Those surveys do not always need to be conducted in isolation. There are ways to efficiently collect samples at a low cost during other monitoring activities, said Joe Huddart, biodiversity solutions engineer and mining sector expert at NatureMetrics. "Water is often the gateway for eDNA monitoring at a mine site. Routine testing of water to screen for pollution and contamination provides a perfect opportunity to collect eDNA samples," he said. "By collecting eDNA alongside physicochemical data, mines can add a layer of comprehensive biodiversity data at very little additional logistical effort."

In addition, said Huddart, soil sampling can be useful for identifying soil contamination and tracking revegetation success. "The soil microbiome ultimately dictates what plants grow above the ground, so by characterizing soil communities, it is possible to identify which species are vital for healthy functioning soils and how these respond to restoration and reclamation activities," he explained.

Limitations

However, eDNA surveying will not entirely replace traditional environmental surveys. It has two limitations: it can detect only the presence (or absence) of an organism, not necessarily its quantity, and it can only identify species whose DNA is already in a reference database.

"When it comes to quantification, we cannot count individual organisms because we're not capturing them. But we can provide other measures to address this shortcoming," Hajibabaei said. "We can use prevalence data to provide quantitative measures; for example, if we get 10 samples, and find DNA of a certain species in five of them, that shows that in that region, you have relatively 50 per cent of prevalence of that species. Whereas [at] another site, it may be 80 per cent. So we can provide some quantitative measures, but we cannot count the number of fish or the number of birds."

He pointed out that there are not DNA reference libraries for every species. "In order to be able to put a name on a DNA sample that we get from the environment, we need to compare it against the reference DNA," he said. "In certain taxonomic groups—at least in some contexts, like the large mammals—we do have references for them. But if you go, for example, to a marine setting, or to a remote site, we still see the DNA and say, 'there is an amphibian here, there is a fish here,' but we cannot necessarily put names to all the species."

That is why organizations performing eDNA testing are calling for the development of more comprehensive DNA reference libraries.

The International eDNA Standardization Task Force (iESTF) was founded by Hajibabaei in 2023 to address such challenges. Its global membership is working to develop international eDNA standards and encourage their adoption, as well as helping to set quality requirements for standardized procedures while "allowing room for growth and optimization in this rapidly advancing field," according to its website. The iESTF is also involved with ISO working groups on the effective development of standards for applications, engages with multiple stakeholders and acts as a "point of contact for information, resources and educational material."

Given its current limitations, Mador-House thinks that eDNA testing will not replace traditional biodiversity surveys in the near future, but it is a valuable complement to them. "There will always be a need for conventional species monitoring, using transects and highly skilled individuals in the field," she said. "However, the number of these ecologists and taxonomists is not sufficient to meet demand and a bottleneck has emerged; eDNA can help relieve this, while complementing and supporting field teams."

Huddart offered one further benefit of eDNA testing, "The simplification of nature's complexities into easily comprehensible metrics means that site-level data can be translated up to the boardroom and everyone in between, transparently reporting on the impact and progress being made towards organizational commitments to nature." CIM

A wildfire in the Côte-Nord region of Quebec on June 5, 2024.

Improved climate resilience

As extreme weather events become more frequent, weather forecasting technology can help mining companies mitigate climate-related risks

By Trish Saywell

Wildfires, lightning strikes, tropical storms, droughts, flooding and other extreme weather events are accelerating in frequency and intensity due to climate change.

Last year marked the warmest year on record since global temperature records began. In Canada, which is warming twice as fast as the global average due to its significant landmass in the north, and which has more than a quarter of the world's boreal forests, unprecedented wildfires ripped across parts of the country in 2023, devouring 16.5 million hectares and forcing some mining companies to suspend operations. While year-to-date statistics show that the 2024 wildfire season in Canada is less severe than last year's, it is too early to tell what the total impact will be; multiple mining operations across the country have already been impacted by wildfires (see p. 14).

"The wildfires are the first Canadian wake-up call," said Toronto-based Theo Yameogo, EY Americas and Canada mining and metals leader. "Climate change is real, but mining companies are at different maturity levels depending on their experience or exposure to it."

Larger companies with global operations are more in tune with the variety and extent of climate risks across continents, he said. And as costs rise to tackle climate-related risks, smaller companies may find taking preventive measures to be capital intensive. "Even with a small problem, a lot of money is required," noted Yameogo. "Some will have to

reduce profitability, and the cost becomes a discussion with shareholders and investors."

An EY survey of 150 mining executives last year ranked climate change as the fourth-biggest threat to the mining industry after environmental, social and governance (ESG) issues, capital and licence to operate. In the same survey the previous year, climate change ranked as the third-biggest threat to mining.

"Companies need to make sure they are baking risk into their business decisions," said Eric Jones, Texas-based global manager of business risk consulting for mutual insurance company FM, formerly known as FM Global.

"Where are they vulnerable? If there is a risk of wildfires, how will that impact them? If they're relying on a supplier for a key piece of equipment and it's located in a 100-year flood zone, how willing are they to accept that risk? You need to understand the physical threats. If you're building a production facility, make sure it's away from flooding and wildfire risk," he advised.

Risk reduction

One mitigation approach mining companies can incorporate into their business plans is the use of technology that can detect and forecast extreme weather.

For wildfire risk management, Vancouver-based SenseNet offers technology that integrates satellite imagery, advanced gas sensors, smoke detection cameras, artificial intelligence (AI) algorithms and real-time data analysis to provide early alerts for wildfires.

The company collects environmental data in real time from sensors that detect temperature, humidity, air quality, volatile organic compounds, carbon dioxide and monoxide, methane, nitrogen oxides and particulate matter.

The sensors last up to eight years and can detect fires in the smouldering stage, even in dense forests. They continuously collect data and upload it to the cloud, where it is processed by specialized AI algorithms. If there are irregularities or spikes in the air composition, these can be detected.

When the sensors pick up anomalies, cameras then zoom in for a better view. By capturing real-time images from wildfire zones, SenseNet's algorithm can then detect fire behaviour, danger levels and air quality. The company also tracks fire weather index and other datasets to understand weather patterns and predict potential fire outbreaks by lightning strikes.

That is important because the warming climate is creating drier and windier summers and more frequent lightning strikes; according to the Canadian Climate Institute, 93 per cent of the land burned in Canada in 2023 was due to wildfires started by lightning strikes. What is more, fire season is starting earlier and lasting longer. Some fires—called "zombie fires"—are now even burning through the winter months, kept alive by a combination of peat moss and dense snow.

"The first challenge is getting the messaging out," said Alex Pourian, SenseNet's director of strategic partnerships. "But we've seen some significant growth. Mining is a newish vertical for us and we've seen a fair bit of traction in the last six months."

U.S.-based AEM is another company that aggregates, analyzes and alerts on data from advanced technologies including lightning detection, surface observations, AI smoke detection and hydrological data for worker safety and environmental regulatory reporting. AEM also offers round-the-clock custom weather forecasting through its team of meteorologists. Through an automated alerting engine, AEM utilizes multiple data sources and allows users to customize location-based threshold alerts and deliver notifications via SMS, email, in-app alerts and through siren/strobe hardware.

AEM owns its own lightning and weather station networks, which mining companies use to understand surface conditions as well as where, when and how severe the lightning is. Timely alerts manage when workers need to take shelter and when they can return to work. The deployed remote weather stations collect data for simplified regulatory reporting and are also used to alert on conditions such as high winds and heat stress.

"We work with one of the largest domestic mining companies in the U.S. and we have put equipment out at most of their mines and processing sites," said Stuart Hershon, a mining solutions specialist at AEM. "Mining companies don't want to be in the weather business. They do not want to devote resources to maintain weather equipment and data. They would prefer a managed approach."

Hershon, who has worked at AEM for nearly 20 years, noted that it was only a few years ago that the mining sector began to understand the availability of comprehensive weather solutions for safety and environmental applications.

"A lot of mining operations cobble together their weather picture from a variety of sources, including free public apps and/or sensors that are old and uncalibrated," he said. "A technology solution that not only provides everything in one, real-time system, but ensures data quality, is an easy decision."

Challenges do arise when working in remote locations, where communications are not always as simple as a hardwired or cellular connection. At one site, the company was unable to connect to any of the local cellular networks, but AEM was able to provide satellite communications for near real-time data collection.

"They are seeing much less data loss, and even C-suite folks can log in to the software and get a clear picture of conditions at any site, globally," Hershon said. "It is monsoon season in Arizona right now and they're able to see lightning activity, precipitation data, heat stress and flash flooding information all in one common operating platform, which can also send notifications."

AEM works directly or in strategic partnerships with clients in Canada, North and South America, Australia, Africa and Southeast Asia. "We are seeing far more inquiries, both domestically and internationally, on new and reconstituted mine sites capitalizing on the increased demand from EV [electric vehicle] and solar battery proliferation," he added.

"More attention is being paid to climate change, and I believe that mining companies have a responsibility to focus on getting the best available data for safety and mitigation, especially as it pertains to water resources and wildfires."

Finland's Vaisala, a global leader in measurement instruments and intelligence for climate action, has a variety of tools including light detection and ranging (LiDAR) scanners for dust blooms, air quality sensors that can measure particulate matter down to 0.3 microns, and cloud-connected weather stations with multi-weather sensors. It also has water height sensors that can measure the level of a tailings dam using radar technology, and precipitation sensors that can detect freezing rain and freezing fog.

"The technology exists to mitigate extreme weather events, and the technology exists to save lives," said Frank DeFina, Vaisala's New York-based business development manager.

The Canadian National Lightning Detection Network, which is owned by Environment and Climate Change Canada, uses Vaisala

technology. "We can detect cloud-to-ground flashes with a location accuracy better than 100 metres," DeFina said. "At many of these open pits there's nothing much around them and your vehicle is the tallest thing at the site, [so] knowing where the lightning is, how much time you have to shut down, is pretty paramount."

DeFina confirmed that attention to climate change is growing in the mining sector. "There have been mining conferences where I talked about climate change and there were only a handful of people attending," he said. "But I think now a lot of the big CEOs are starting to understand the impacts of extreme weather events more and more. We've always had business from mines, but the dollar value of what's happening as a result of climate change-related weather impacts is growing, and they know they have to be stewards of the environment."

Financial impact

In Canada, insured damage for severe weather events and natural catastrophes in 2023 reached $3.1 billion, according to the Insurance Bureau of Canada. Insured damage from two wildfires in the Okanagan and Shuswap areas of British Columbia alone during August and September 2023 totalled $720 million.

While mining companies can talk about climate risk and qualitative impacts, they typically respond best when they know the financial cost of inaction, according to Jones of FM.

"You need to know what can go wrong—whether it's wildfire, climate risk or a train derailment—whatever can shut you down, and you need to understand the financial ramifications that can result," he said.

It is not just the cost of the actual disruption that should be of concern, Jones added. Disruptive events can have "long tails of financial impact," including opportunity costs, lost customers and diminished market share.

"All those things dilute cash flow going out in the future," he said. "When your cash flow is diluted and investors and the community see there's more risk associated with your operation, or you're not managing your risks properly, your cost of capital can increase, which can decrease the enterprise value of your business." **CIM**

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Noise control

Soft dB's Pierre-Claude Ostiguy discusses how mining projects can help maintain noise and vibration compliance while keeping operations running smoothly

By Mehanaz Yakub

Pierre-Claude Ostiguy is the director of the acoustics and vibration monitoring division at Soft dB, the largest private engineering firm in Canada that specializes in acoustics and vibration. With a doctorate in vibration, his expertise encompasses turning complex technical insights around acoustics and vibrations into practical solutions. Over the past five years, he has led his team in the development of tools, products and services designed to address the increasing need for effective noise and vibration monitoring at mining projects.

CIM Magazine spoke with Ostiguy to learn more about the importance of noise and vibration monitoring, the challenges it presents and the solutions that mines can adopt to ensure that their noise and vibrations are under control.

CIM: Why is noise and vibration monitoring and management crucial for mining projects?

Ostiguy: There are two main reasons. The first involves regulatory compliance. In Canada, mining operations are mandated to comply with federal, provincial and local noise regulations and standards. With certain noise or vibratory guidelines set in place, the noise contribution of a mine must not be in exceedance of these specific levels during daytime or nighttime

hours. As such, if a blast were to occur, it is critical that emissions do not surpass certain vibration or overpressure values.

There are studies that can be conducted in the design phase to ensure that a mine will operate within regulatory compliance once production is under way, but it is important to understand that there are many variables that can have an effect on noise climate—whether it's wind direction or thermal inversion. If there is a constant noise source, the noise level heard at a distance may actually change from day to day, even though the sound generated by the source remains unchanged. Having monitoring stations strategically in place allows for the ability to verify that operations are maintaining regulatory compliance, while also being able to address any variations in noise levels, should it become necessary.

The second reason is that community engagement becomes increasingly more important over the course of the entire mining process, starting from the exploration phase to the completion, or decommissioning, of the mine. Utilizing noise and vibration monitoring is an effective strategy, particularly with regard to community relations and social acceptance.

With the addition of new activities to the existing environment, such as exploration drilling, open-pit mining or the use of ventilation fans for underground mines, these changes can

cause a dramatic effect on the acoustic climate of the area. Therefore, when neighbouring communities are impacted by such change, this can often result in social acceptance challenges, especially when noise and vibration is not properly taken into account.

While there are some methods that can be used to reduce noise at source, effective noise and vibration monitoring has the advantage of being able to quickly address any complaints being raised by neighbouring communities. Continuous audio recording gives you the ability to verify the precise noise levels at the time of the complaint, assess whether the levels were in compliance and identify the exact source of the noise causing the disturbance.

An important aspect of community engagement is also understanding that it's not necessarily the loudest noise over a certain period that generates complaints—it could be a specific sound. For example, a fan that is continuously running might blend into the background over time, but a back-up alarm on a truck at 2 a.m. is more likely to lead to complaints. Despite being louder and shorter in duration, if we were to look at the average noise level over an hour, the noise contribution of the back-up alarm is marginal.

By having an effective real-time monitoring solution with continuous audio recordings, you can literally go back in time, listen to the noise and then assist the mine in identifying the noise needing mitigation. Finding resolution efficiently and effectively is particularly helpful if the mine is aiming to improve community acceptance for its operations.

CIM: What are some challenges when it comes to managing noise and vibration at mine sites?

Ostiguy: The main challenge has been finding a way to isolate and provide only relevant information to the mine, while still being able to measure everything in the process. This becomes particularly important in cases where there has been a complaint or compliance assessment is needed, so that the mine has access to all the necessary information required.

Noise and/or vibration monitors run 24/7, which means that the volume of data being collected is quite high. The goal of any type of monitoring system is to have the ability to avoid false positives. An example of a false positive would be if a bird chirps next to the microphones and causes an exceedance of noise thresholds, thus causing an alert. Given that this noise is not associated with the mine's operations, finding a way to prevent the mine from being notified is a success that Soft dB has been able to achieve.

Soft dB has developed a patented artificial intelligence (AI) filtering tool, specifically designed for the mining sector, that has the ability to remove/filter any unrelated noises from the mining activities, such as cars, airplanes, trains, birds, frogs—anything unrelated to the mine. Therefore, only relevant noise specific to mining operations, and approaching the threshold of exceedance, will send a notification.

It's the same concept with vibration monitoring. To prevent sending false positives for vibration, we've also developed a patented system for seismic and blast monitoring called the Master Trigger, where all the vibration monitoring stations can communicate with each other. If there is an increase in vibration at one point, the server connected to the stations will ask all the other stations if the particular vibration was measured. If the answer is yes, a report is generated and sent to the mine, but if the answer is no, the mine will not be notified, as it is deemed to be irrelevant.

CIM: What should be considered when implementing a noise and vibration monitoring system?

Ostiguy: There are a few aspects for mines to consider. It is important to have a solid background in noise and vibration, or to be supported by a company with strong expertise specifically in mining noise and vibration. Understanding mining operations, knowing precisely what is needed and what options are available, allows for the best outcomes when implementing and operating an effective monitoring system.

Monitoring solutions need to be capable of providing all the information necessary for a comprehensive understanding of the noise and vibration climate at all times. Monitoring isn't just about measuring a certain level, at a particular time—noise and vibration is far more complex. Having information on the amplitude and frequency of noise and continuous audio files is optimal.

Additionally, having a monitoring system that can reduce the overall time spent in the field, thereby increasing its efficiency. Monitoring solutions also need to be able to send data online in real time. If the system allows for this, then the mine can also receive notifications in real time, and is thus able to adjust accordingly.

There are also more advanced features, like automated calibration verification of microphones or vibration sensors, as well. These systems can perform daily self-checks, so that the mine won't need to send someone into the field every week to verify the sensors—it's all done automatically. Essentially, if something goes wrong, the client gets notified.

CIM: Do you have any successful case studies you can share with us?

Ostiguy: Soft dB is currently monitoring the noise and vibration at several mines across North America.

We have been providing monitoring services at Agnico Eagle's Canadian Malartic mine in Quebec for more than 10 years. It is one of the largest open-pit mines in Canada and its operations are located in close proximity to a community. Soft dB developed a system that informs the mine only when it is at risk of noise exceedance, while taking into consideration weather conditions, topography and the location of the trucks in real time. It calculates the mine's actual noise contribution in the community, which allows the company to be proactive at ensuring compliance. By utilizing the various tools that Soft dB has developed, the mine has been in total regulatory compliance for noise since 2018.

Soft dB was recognized for its excellence in environmental noise monitoring for the Canadian Malartic mine, in addition to being awarded a 2020 Québec Consulting Engineering Award (Grands Prix du génie-conseil québécois) acknowledging Soft dB for its mining activity monitoring program.

As part of its monitoring division, Soft dB actively participates in a variety of community initiatives. This includes meetings and presentations to provide its knowledge and expertise in noise and vibration, regarding the process of monitoring, how it works and how it can help [communities] to gain a better understanding of environmental noise, thus improving community acceptance.

Soft dB also provides noise and vibration monitoring services to Eldorado Gold Québec and its mining operations located in

Val-d'Or in northern Quebec. At the beginning of May, our specialists were invited to take part in a community meeting to offer an informational session about monitoring. This opportunity allowed our team to present our monitoring solutions, showcase our monitoring equipment being used for the mine, provide further explanation of what we are measuring (and how), as well as address any questions or concerns raised by the community members. Offering such opportunities to connect with communities, and provide transparency to noise and vibration solutions, has been shown to greatly increase social acceptance, thus contributing to the overall success of the mine.

CIM: What trends do you see in the future of noise and vibration monitoring for the mining sector?

Ostiguy: I believe that the future of noise and vibration monitoring in mining is having fully automated systems where there is no longer a need for someone to manage them or analyze the data and reports. The systems will provide all the relevant information effectively and independently on their own.

Getting to that point will require a lot of innovation, and this is precisely the direction where Soft dB is aiming to go—developing the next generation of noise and vibration monitors and web-based monitoring platforms. **CIM**