Luminous BioSolutions

*Tailings Ponds Naphthenic Acid Management*

One of the most pressing Oil Sands Tailings Ponds environmental challenges is Naphthenic Acids. We believe science, collaboration, and transparency are key to developing a sustainable solution that addresses this challenge.

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The Challenge

The scale of Northern Alberta Tailings Ponds is enormous. According to the Alberta government, as of 2022, there were 1.39 billion m3 of fluid tailings (water + fine solids), and 417 million m3 of oil sands mining water. For continued oil sand mining, there is a constant need for fresh or recycled water, which will contribute to increasing volumes of wastewater generated from the mining process. .

Among the organic compounds present in the OSPW, nne of the most challenging environmental and regulatory issues the industry is faced with is Naphthenic Acids (NAs). NAs are the most abundant and toxic chemicals of concern, harming aquatic, wildlife, and human life which is raising concerns for surrounding communities.

For decades, the inability for Oil Sands operators to safely release tailings water has:

* Delayed land reclamation
* Increased Operators financial liabilities, and
* Intensified public scrutiny
* Increased Environmental Risk

Industry leaders understand the significance of this challenge, but current NA monitoring and remediation methods are expensive, slow, and still under development for the scale required.

Regulators, communities, and investors are demanding solutions that is safe, scientifically sound, transparent and sustainable.

**Naphthenic Acids**

* NAs are toxic, harming wetlands, wildlife, and human health.
* NAs are persistent in tailings ponds for decades, affecting aquatic life and ecosystems.

**Water release regulations are coming soon**

* Water quality targets will be tough to meet given the sheer scale and complexity of tailings ponds and local stakeholder concern.
* Traditional monitoring methods are slow, expensive, and impractical for frequent testing across large volumes of water.
* Industry must act now to prepare for compliance.

**Comprehensive and long-term naphthenic acid monitoring is required now**

* A baseline of current state of NA concentration prior to remediation proves remediation effectiveness.
* Ongoing NA testing will provide transparency, credibility, and trust to community stakeholders

**Delayed NA reclamation planning amplifies the problem**

* Increased scrutiny from regulators and the public.
* Increased liability reputation risk.
* Increased risk of environmental or human health crisis

Our Solutions

Luminous BioSolutions is a Canadian Environmental Technology Company who has developed an innovative approach to detecting and breaking down Naphthenic Acids in Alberta Oil Sands Tailings Ponds.

Our bioluminescent bacterial biosensors provide a **fast, simple, cost-effective, and highly scalable** method for monitoring NA levels and offering real-time insights that existing techniques cannot match.

**How it works**

* **Rapid Detection:** Our engineered bacteria detect naphthenic acids within minutes and emit light in the presence of NAs, providing an immediate, easy-to-read signal of contamination.
* **Quantitative.** The biosensors produce light in direct proportion to the concentration of NA in a sample.
* **Specific and Sensitive:** Our panel of NA biosensors detect key NA compounds within the complex NA mixtures that represent the major clasess of NA compounds.The NA biosensors can detect the NA at the concentrations present in most tailings ponds (10 -120 mg/L).
* **Scalable & Cost-Effective:** Unlike expensive analytical chemistry methods that require weeks of processing, our biosensors allow high-throughput screening at a fraction of the cost.

Why this Matters

Current NA monitoring methods (i.e. Mass Spectrometry) are accurate but suffer from prohibitive costs, slow turnaround times, and limited sampling frequency. This results in low-resolution data, leaving industry and regulators blind to real-time changes.

**Luminous biosensors solution allows Oil Sands operators to**:

* **Increase testing frequency** across more locations throughout the water cycle, providing a higher-resolution map of NA concentrations.
* **Track changes in near real-time**, allowing for proactive management rather than reactive mitigation.
* **Reduce environmental risk** due to confident and comprehensive NA monitoring data.

For regulators and local communities, this means greater transparency and trust with clear, consistent data that ensures environmental safety.

Beyond Detection: NA Remediation

Remediation of NAs in Tailings Ponds is a daunting challenge, as NAs are toxic and persistent for decades.

Luminous BioSolutions are developing our bacterial solutions to accelerate remediation efforts by identifying naturally occurring bacteria that can efficiently break down NAs.

**How this helps Oil Sands water reclamation:**

* **Constructed Wetlands:** Our biosensors help identify and select microbial communities that can be used in wetlands to accelerate NA degradation.
* **Bioaugmentation Strategies:** We can scale up production of the most effective bacteria and introduce them into treatment sites, dramatically improving NA breakdown rates.
* **Continuous Monitoring:** Unlike conventional approaches, which rely on infrequent lab tests, biosensors can provide ongoing feedback on remediation progress, ensuring treatment success.

This is game-changing for oil sands operators seeking **cost-effective, scientifically sound reclamation strategies** that align with evolving environmental regulations.

Data-Driven Environmental Management

It is impossible to make any informed decisions without an accurate monitoring process of NA concentrations in the tailings ponds and a method to track their removal.  We have developed an NA monitoring and analytics platform that compiles NA test results in a data hub to provide:

* **Real-time tracking of NA levels** across multiple sites and throughout the water cycle.
* **AI-powered trend analysis** to predict problem areas before they escalate.
* **Regulatory compliance support** ensuring all monitoring data is easily visualized and accessible for audits and public transparency, if required.

Combining biosensor screening with remediation and data analytics, operators, regulators, and stakeholders are empowered with actionable intelligence for better environmental management.

A Holistic Approach

**The cost of inaction - both financial and reputational - is too high.**

Our biosensors, remediation technologies and data analytics are new, innovative, practical, cost-effective, and scalable.

Adopting our strategies enables oil sands operators to improve their environmental performance, rebuild public trust, and accelerate responsible reclamation efforts.

We invite oil sands operators, regulators, and Indigenous, local communities, environmental stakeholders and environmental engineering organizations to collaborate with us.

Contact us today to explore pilot projects and implementation opportunities.

[Conta​ct Us](https://www.luminousbiosolutions.com/contact-us)

About us

Luminous is a startup, but our BioSensors have been in development for over a decade, reflecting years of research and optimization.

The founding team brings decades of experience in bioscience and information technology. This deep well of experience means we are hitting the ground running with proven science and a sharp vision.

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Bacterial Biosensors for Detecting Naphthenic Acids (NA's)

Research Summary

[NA's](https://www.luminousbiosolutions.com/solutions#table_of_content_heading_1_6)[Environmental Impact](https://www.luminousbiosolutions.com/solutions#table_of_content_heading_1_7)[Technology Opportunities](https://www.luminousbiosolutions.com/solutions#table_of_content_heading_1_2)[Regulatory Concerns](https://www.luminousbiosolutions.com/solutions#table_of_content_heading_1_3)[Economic Viability](https://www.luminousbiosolutions.com/solutions#table_of_content_heading_1_4)[Business Opportunity](https://www.luminousbiosolutions.com/solutions#table_of_content_heading_1_5)

NA's -NOTHING HERE BUT I COULD ADD SOME NA CHEMISTRY DETAIOLS

Environmental Impact

Naphthenic acids (NAs) in oil sands tailings ponds are recognized as a major source of toxicity to the environment.

They are the primary contributors to the toxicity of Oil Sands Processed Water (OSPW) and have demonstrated harmful effects on a wide range of organisms, including plants, fish, amphibians, birds, and mammals.

Many NA compounds are persistent; complex multi-ring structures resist biodegradation and can remain in water for prolonged periods.  As a result, tailings ponds containing OSPW pose a long-term threat to nearby aquatic life, wildlife and humans if contaminants seep or are released into rivers and wetlands.

The scale of the issue is enormous – over 1.4 trillion litres of total find tailings have accumulated in Alberta’s tailings ponds. There is constant need for fresh water for continued , despite efforts to reuse water for mining.

Current remediation options are limited with no established, cost-effective methods to rapidly detoxify or efficiently break down NAs.  Industry practice has been to store OSPW in large ponds indefinitely, until water treatment methods have been firmly established.

An aerial view of a land

AI-generated content may be incorrect.

CITE PROPERLY

Monitoring NA levels and toxicity in such ponds is also challenging.  Companies rely on sophisticated laboratory analyses (e.g. GC-MS, LC-QTOF-MS high-resolution orbitrap mass spectrometry) to measure naphthenic acids.  These methods can detect NAs at very low concentrations (down to ~0.01 mg/L) but require laborious sample preparation (such as solvent extraction) and specialized equipment and personnel. Other quick and dirty methods are available (FTIR) but they lack specificity.

Such traditional monitoring is time-consuming and costly, making it difficult implement for continuous, long-term monitoring at scale, at multiple sites, and throughout the water cycle.

The combination of toxic environmental impact, massive scale, and cumbersome monitoring/remediation techniques has created an urgent need for alternative solutions to detect and manage naphthenic acid contamination in oil sands regions.

BiosensorTechnology

Developing a bacterial biosensor for NAs involves considerable scientific complexity and innovation.  Our researchers first identified specific bacterial strains were recovered and are therefore adapted to the conditions within from tailings ponds water. These bacteria are abundant in tailings ponds and are well known to degrade numerous organic compounds.

Step 1. Naphthenic acids are detected inside the bacterial cell. Bacteria are highly responsive and adapt to the presence of novel organic compounds.

Step 2. Using genomic methods, we identified genes that are induced when bacteria are exposed to naphthenic acids. These include numerous genes required to degrade NA as a nutrient, but also to protect itself from the toxic NA compounds, both of which are present in the complex mixtures of NA in a tailings pond.

Step 3. Using state of the art synthetic biology and DNA printing techniques, the NA-triggered promoters were then engineered into whole-cell biosensors. The target promoters drive the expression of luminescence reporter genes (luxCDABE) in response to NA exposure.

Step 4. The biosensor produces bioluminescence in direct proportion to the amount of NA present in a water sample, which is easily measured as an indicator of NA presence.

A diagram of a molecule

AI-generated content may be incorrect.

**The result was a panel of engineered bacteria, each expressing different promoters and finely tuned to light up in response to specific and unique naphthenic acid structures.**

In laboratory tests, the biosensors demonstrated promising sensitivity, specificity, and reliability for NA detection.  Our NA biosensors can detect individual NAs, as well as complex mixtures of NA from commercial sources, or that are purified from oil sands tailings ponds.

The detection limits achieved for NA biosensors were as low as 1.5 mg/L, which is sufficiently sensitive to detect NA in raw OSPW water.   NA can also be concentrated from OSPW samples, to allow for detection in samples with low NA concentrations.

Overall, compared to conventional analytical chemistry analysis, the biosensor technology offers a **simple, real-time detection method**. Biosensors compromise with lower sensitivity, in exchange for rapid, specific reliability, exploiting the nutrient sensing capacities of bacteria. Biosensors can be adapted for in field usage, if required.

This level of sensitivity and specificity, achieved through careful genetic engineering, underscores the significant scientific effort behind the NA biosensor development. We can now easily detect naphthenic acids in water samples. In the images below, the left is an image of petri dish growing the biosensor, and naphthenic acids were spotted onto paper disks. The image on the right is the bioluminescence produced by the biosensor, directly surrounding the paper disks.

A close-up of a light

AI-generated content may be incorrect.

For more details on the construction and validation of this NA biosensor technology, see our preprint publication in [BioRxiv](https://www.biorxiv.org/content/10.1101/2024.04.05.588297v1), and the peer-reviewed publication in the journal [ACS Synthetic Biology](https://pubs.acs.org/doi/abs/10.1021/acssynbio.4c00260).

Regulatory Concerns

Introducing a new biosensor for environmental monitoring must align with regulatory frameworks in Canada, especially given the sensitive context of oil sands pollution.

Currently, **naphthenic acids are not yet explicitly regulated by defined provincial or national standards.**  There are no official guidelines specifying allowable NA levels in water.  The federal and provincial governments must tackle water pollution from the oil sands, and regulators are increasingly scrutinizing NAs because of their toxicity.

**In 2024, the Canadian government agreed to assess listing naphthenic acids as “toxic” under the Canadian Environmental Protection Act, a step that could lead to stricter regulations on tailings water management**.

This regulatory momentum means that oil sands operators will likely face enforceable limits or treatment requirements for NAs in the near future.  Even under existing law (e.g. the Fisheries Act), companies are obligated to prevent discharges of deleterious substances into fish-bearing waters.

The NA biosensor technology could help industry and regulators meet these obligations by providing a tool to verify that NA concentrations,and therefore toxicity, remain below harmful thresholds before any water is released.

Gaining regulatory approval and acceptance for a biosensor-based method may have challenges.  Environmental authorities will require validation that the biosensor detection are accurate and reproducible when compared to established analytical chemistry tests.  The new method will need to be standardized and calibrated so that its luminescence output can be reliably translated into NA concentrations that satisfy regulatory criteria.  All biosensor testing is done in a microbiology lab, and no biosensor bacteria are released into the environment.  Ongoing collaborative research with the oil sands industry, as wel as academic and government experts, will likely examine the technology’s performance in pilot OSPW water treatment programs. Integration with existing monitoring frameworks is key.  The biosensor could be used alongside conventional water sampling,, to support and build confidence in the implementation ofthis new environmental monitoring technology by the oil sand industry and regulatory practices.

Economic Viability

From an economic perspective, bacterial biosensors promise a more cost-effective approach for monitoring naphthenic acids compared to traditional methods.  Current analytical techniques like mass spectrometry and chromatography not only require expensive instruments and highly trained personnel but also involve lengthy sample preparation and processing.

In oil sands operations, sending water samples to off-site labs for detailed NA analysis is a costly process.  The equipment (e.g. high-resolution MS systems) can cost hundreds of thousands of dollars, and each analysis can take many hours.  The research paper notes that these chemical analyses are time-consuming and costly, partly due to the multiple steps (extraction, concentration, etc.) needed to handle oily water samples.

In contrast, a biosensor assay could be conducted on-site with minimal equipment: essentially a bioreactor or test kit containing the engineered bacteria and a simple luminometer to measure light output.

Once developed, biosensor tests can be produced at a large scale, growing bacteria is cheap, and assays could be packaged in bulk (for example, freeze-dried cells or single-use cartridges).  This dramatically lowers the per-sample cost.  Instead of paying for specialized lab analysis of each water sample, operators could deploy the biosensor repeatedly on many samples or even continuously monitor water in real time, at a fraction of the cost.

Scalability is a significant advantage of the biosensor technology.  It can be adapted to high-throughput formats (e.g. 96-well plates or portable devices) to screen numerous samples quickly.  This means an entire tailings pond’s worth of monitoring points could be checked frequently without prohibitive expense, something not feasible with constant mass spectrometry analyses.

Additionally, results are obtained rapidly (within the same day), allowing companies to respond faster to any NA spikes or leaks.  In terms of implementation, the biosensor is fairly feasible to deploy means even as oil sands operations grow or regulations demand more frequent testing, the biosensor approach can meet those needs without a proportional increase in cost. This makes widespread implementation across oil sands sites plausible, as the technology matures.

Business Opportunity

There is clear business potential in commercializing the NA biosensor technology for stakeholders in the oil sands sector.  Oil sands operators themselves are prime customers: companies could integrate these biosensors into their environmental monitoring programs to ensure tailings water management is proactive and compliant.

By adopting such tools, firms can enhance their corporate environmental responsibility profile by demonstrating to regulators, investors, and the public that they are using innovative technology to safeguard local ecosystems.  Quick detection of rising NA levels or leaks would enable operators to take early action, potentially avoiding costly environmental incidents and regulatory fines.

The technology could also help optimize treatment processes (for instance, informing when tailings water has been cleaned enough to be recycled or released), thereby reducing operational costs overall.  In an era where ESG (Environmental, Social, and Governance) performance is scrutinized, a relatively low-cost, high-visibility solution like a biosensor shows a commitment to innovation in pollution control, which is marketable from a public relations standpoint.

Regulatory agencies and environmental monitoring programs represent another market opportunity.  Government bodies in Canada (such as Environment Canada or Alberta Environment) could use the biosensors for independent verification of water quality around oil sands projects.  Instead of relying solely on industry-supplied data or expensive lab work, regulators could deploy portable biosensor units for spot checks in the field, getting instant readings on naphthenic acid levels.  This would support compliance enforcement and environmental surveillance in a cost-efficient way.

Likewise, local stakeholders like Indigenous communities and environmental groups concerned about oil sands impacts have a vested interest in water quality tools.  There is an opportunity to provide community monitoring kits that leverage the biosensor, empowering these groups to conduct their own measurements of tailings pond outflows or nearby waterways.  Making the technology accessible to local stakeholders can increase transparency and trust, as everyone can directly observe whether NA pollution is under control.

To capitalize on these opportunities, effective market adoption strategies will be important.  One approach is to partner with oil sands companies for pilot projects, demonstrating the biosensor’s value on-site at an operational tailings pond.  Successful pilot results (showing that the biosensor correlates well with lab measurements and perhaps catches subtle changes faster) would build industry confidence and create early adopters who can champion the technology.  Another strategy is obtaining endorsements or certifications for instance, if a regulatory agency or a reputable third-party research organization validates the biosensor method, it would assure potential customers of its credibility.  Packaging and ease-of-use are also key to marketability: the biosensor could be sold as a user-friendly kit or device, with clear instructions and minimal maintenance, so that it integrates seamlessly into existing water monitoring workflows.  Addressing any challenges, such as the shelf-life of the bacterial sensor or the need to occasionally recalibrate the response, will be part of making the product reliable in real-world conditions.

Potential challenges in the market include overcoming the inertia of established methods.  Some operators may be hesitant to trust a new biological tool over tried-and-true lab assays.  To mitigate this, the biosensor might first be marketed as a complementary tool (for rapid screening or continuous monitoring), rather than an immediate full replacement for chemical analysis.

Cost savings and performance data will speak loudly here; as companies see the reduction in laboratory expenditures and the added insight from continuous data, they will be more inclined to invest in the biosensor solution.  Ensuring technical support and training for users will further ease adoption.

In summary, the biosensor for naphthenic acids presents a compelling business opportunity in the oil sands industry.  It addresses a critical need (efficient NA monitoring) created by environmental and regulatory pressures, offers economic benefits, and aligns with the increasing demand for sustainable and responsible operational practices.  With strategic implementation, it could become a standard tool across oil sands operations, benefiting operators, regulators, and communities alike by improving environmental oversight and reducing costs in managing oil sands tailings water.

How can we help?

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BIO

I have developed research programs in microbiology, antibiotic discovery and in bacterial biosensors for diverse applications. We use synthetic biology to engineer bacterial biosensors that detect naphthenic acids, the primary chemicals of concern in oil sands tailings ponds. These NA biosensors are being commercialized as novel tools for environmental monitoring of NA in water, and they also facilitate identifying microbes that degrade naphthenic acids. Our goal is to identify minimal bacterial communities that can efficiently degrade naphthenic acids in water treatment strategies.

Our Purpose

Everything we do is driven by a clear purpose: to solve a complex environmental challenge through innovation. We're committed to creating solutions that help address the NA problem in Oil Sands Tailings Ponds.

We hold ourselves to a high standard with core values that guide our work:

* **Transparency:** We share our process and data openly, building trust with partners and communities.
* **Sustainability:** We prioritize environmental responsibility, ensuring our work benefits the environment.
* **Collaboration:** We believe in the power of working together and welcome diverse perspectives to strengthen our solutions.

We’re not just building a product; we’re building relationships and a brighter future.