calix

Innovating for the Earth

Calix News

Issue 35

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Because there's only one Earth – Mars is for Quitters.

Welcome to Issue 35 of the Calix Newsletter

Phil Hodgson
CEO

In our second Newsletter for 2020, we feature the commencement of the LEILAC-2 project – the scale-up of our Low Emissions Intensity Lime and Cement technology – to enable efficient CO_2 capture in the lime and cement industries. With the acceleration of commitments to Net Zero CO_2 by 2050 by many countries, and now also major multinational companies, we have noticed significant additional interest in our technology, alongside our longer-term partners in its development such as HeidelbergCement, Cemex, Lhoist and Solvay.

We also feature several customer stories from our water treatment business in the United States, where we recently acquired IER and have started the process combining the strengths of both companies to chase our growth aspirations. The use of magnesium hydroxide in treating food processing wastewater for improved safety, waste solids management and cost efficiency as a replacement for dangerous caustic soda is a key marketing and sales strength of our IER business.

We also feature an introduction to our latest Sustainability Series magazine "Feeding a Growing Human Population" – outlining the challenges and Calix's unique solutions for more sustainable, safe and cost-efficient aquaculture and agriculture.

The last few months have presented unprecedented challenges for us all as we deal with the impacts of COVID-19 on our businesses, our communities and our families. Calix has thankfully remained relatively unscathed with respect to its business, its projects and its technology development, however we remain cautious and are preparing as best as possible to manage risks moving forward while the full effects of COVID-19 play out, especially in our global businesses in Europe, Asia and the US. As always, we would like to thank our shareholders and stakeholders for their support, and hope you all stay safe and healthy as we navigate through this new global societal paradigm.

REDUCING CO_2 EMISSIONS

Leilac

Project LEILAC update

The success of the The Low Emissions Intensity Lime and Cement (LEILAC) project, to separate and capture CO_2 from the cement production process, has enabled our scale-up "LEILAC-2" project to start.

Calix has announced that final project agreements have been executed for the scale-up of its Low Emissions Intensity Lime and Cement (LEILAC) technology for capturing unavoidable CO_2 process emissions during the production of lime and cement. Calix has also appointed Emma Bowring, project management executive, to lead LEILAC-2.

The LEILAC-2 demonstration plant will be a four-fold scale-up of the LEILAC-1 pilot plant, currently undergoing operational testing at HeidelbergCement's Lixhe cement production facility in Belgium. Early results from the pilot have proven the technology concept, and work continues on the gradual increase in operational throughputs, temperatures and durability testing in a program that will run until the end of 2020.

All intellectual property, both existing and developed as part of LEILAC-2, associated with Calix's core direct CO_2 separation technology, will continue to be owned by Calix.

LEILAC-2 was officially launched on April 7, 2020 and will run to the end of March 2025. It will involve the design, construction and operational testing of a 100 kilotonne per annum (ktpa) CO_2 capture facility at a working cement plant in Europe. The LEILAC-2 consortium consists of industrial partners such as Heidelberg Cement, Cimpor, Engie, IKN and Lhoist, universities, research institutes and various statutory organisations, and will be led by Calix, co-ordinated through its Calix-Europe subsidiary in France.

More CO_2 is emitted from cement production than any other industry. Many countries, regions, and companies are now pledging net-zero CO_2 emissions by 2050, increasing the need to accelerate the deployment of CO_2 mitigation technologies such as LEILAC. In May 2019, HeidelbergCement also committed to net zero CO_2 emissions by 2050, the first cement company to do so.

Jan Theulen, Director Alternative Resources, HeidelbergCement, said, *"As we need techno-economical improvements in carbon capture technologies to enable the path towards carbon neutrality by 2050, which we as HeidelbergCement are committed to, projects such as LEILAC are mandatory to make this happen. Therefore, we are keen to take our part of the responsibility in the LEILAC consortium to bring LEILAC-2 to a success."*

Phil Hodgson, CEO Calix, said, *"The last two years have seen CO_2 emissions move from a vague potential liability into a significant real liability, as CO_2 mitigation moves from a nice-to-have to a must-have business strategy, and the owners and stakeholders of businesses demand appropriate risk management of CO_2 by those businesses."*

Calix's commercialisation strategy for its LEILAC technology involves proof of demonstration at the LEILAC-2 scale by 2025, after which licence or royalty arrangements will be sought from those wishing to use the technology, delivered via engineering and technology partners. If fully proven at demonstration scale, LEILAC should have significant cost and operating advantages over competing technologies such as amine CO_2 capture (currently being proven at a similar scale to LEILAC-1) and oxyfuel (has not yet been piloted).

Innovation in Carbon Capture Conference, January 2020

LEILAC partners include: HeidelbergCement, Lhoist, Cemex, Calix, PSE, Carbon Trust, TNO, Tarmac (CRH), Quantis, Solvay, Imperial College London and the European Union's Horizon 2020 research innovation programme.

LEILAC is an EU Horizon 2020 research & innovation project.

After very good results from the first phase of Project LEILAC, further development and scale-up of the Calix technology has started.

The first LEILAC installation was completed at HeidelbergCement's 1.5 million tonnes per annum (mtpa) integrated Lixhe plant in Belgium and inaugurated mid 2019. Led by Emma Bowring, the new 100,000 tonnes per annum (tpa) process emissions capture facility will be operational by late 2024.

Calix has appointed project management executive, Emma Bowring, to also lead LEILAC-2 as part of the Calix executive management team.

Emma has 15 years experience in project management and business development with Sinclair Knight Merz/Jacobs Engineering Group, having worked across a number of industries including international development, infrastructure, oil and gas, health, justice and commercial sectors.

Originally from Australia, Emma has lived and worked around Australia, the Pacific Islands, Asia, Russia and now the United Kingdom. Notably, as project manager, Emma successfully delivered a complex AUD50m engineering, procurement, and construction management (EPCM) project involving construction and capacity building programs in the Solomon Islands. We look forward to seeing what she will bring to LEILAC-2.

Emma Bowring, LEILAC Project Leader
"I love working on projects that make a difference and contribute socially and environmentally. This, combined with the challenge of managing remote teams and complex international projects, is what brought me to Calix."

Press highlights

BBC NEWS

Project LEILAC appeared in a EuroNews TV documentary on the latest European research to reduce CO_2 emissions in cement manufacturing.

The report was a co-production between EuroNews and the European Commission, and was part of a programme called Futuris, on European science, research and innovation.

https://www.project-leilac.eu/projectleilac-in-euronews

Project LEILAC was also recently featured in the Carbon Capture Journal

Carbon Capture Journal

CCUS in EMEA

Aker Solutions' CCUS tech certified by DNV GL for cement plant

Converting CO2 into a valuable solid carbon resource

LEILAC project scales up fourfold for Phase 2

LEILAC project moves to Phase 2

After very good results from the first phase of the project, HeidelbergCement is starting the further development and scale-up of the LEILAC technology (Low Emissions Intensity Lime And Cement) together with the Australian technology company Calix and a European consortium.

The patented LEILAC process makes it possible to capture high-purity CO2 from cement production via a separate exhaust gas stream, ready for storage or utilization. Two-thirds of the CO2 emissions of a cement plant are process-related emissions generated during the heating of limestone and are therefore unavoidable.

The LEILAC-2 demonstration plant will be a four-fold scale-up of the LEILAC-1 pilot plant, currently undergoing operational testing at HeidelbergCement's Lixhe cement production facility in Belgium. Early results from the pilot have proven the technology's potential for significant energy and cost savings, increase in operational throughputs, temperatures and durability testing in a test program that will run until the end of 2020.

Central aspects of the LEILAC-2 project are the further scale-up of the technology to an industrial level, the full-process integration into an existing cement plant, and the heat supply of the plant from renewable energies for maximum reduction of CO2 emissions. The plant will be officially launched on April 7, 2020, and will run to the end of 2024 at a working HeidelbergCement cement plant in Europe.

Like its predecessor LEILAC 1, the LEILAC-2 project is based on Calix's innovative calcination technology and is supported with 36 million euros from the EU research funding programme Horizon 2020. As part of LEILAC-2, Calix will design and build a plant with a capacity of 25,000 tonnes per year to be constructed at the HeidelbergCement plant in Lixhe, Belgium.

Calix's commercialization strategy for its LEILAC technology involves proof of demonstration at the LEILAC-2 scale by 2025, after which licence or royalty arrangements will be sought from those willing to build LEILAC plants through engineering and technology partners. If fully proven at demonstration scale, LEILAC should have significant cost and operating advantages over competing technologies such as amine CO2 capture and sorbed.

Key objectives of LEILAC-2 are:

• Construction of a demonstration plant that will aim to capture around 20 per cent of a full-scale cement plant's process CO2 emissions (100,000 TPA of CO2), equivalent to 100 per cent of a large lime kiln's process emissions, for minimal energy penalty other than compressing the CO2.

• Successful demonstration of up to a four-times scale-up of the technology for around twice the capital cost of the LEILAC-1 facility, confirming cost-efficient CO2 capture for the lime and cement industries.

• Prove the effective retrofit and full integration of the technology into a cement plant's operations.

• Demonstrate the efficiency and stability of the complete cement-kiln process and high-quality clinker output when integrating Calix's CO2 separation technology.

• Showcase a modular, replicable, retrofit design for accelerated commercial deployment that delivers flexible scalability for varying operation size and configurations, agility to adopt the technology and decrease emissions progressively, and a broad range of options for captured CO2 utilisation and sequestration. These factors can eliminate the need for large capital expenditure and significant asset write-downs.

• Demonstrate the operation of direct separation kilns for lime and cement using renewable sources of energy such biomass and renewable sources of electricity, bringing the running of the plant to net zero CO2 emissions and enabling a move away from high carbon-emitting gas or coal-fired plants.

• Enable lime and cement kiln processing plants with a cost-efficient solution to effectively use intermittent renewable energy sources, with rapid ramp up/down rates leveraging electricity and load balancing techniques for grid stability.

More information
www.project-leilac.eu

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9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

13 CLIMATE ACTION

Project LEILAC - phase 1 - milestones

From the start of the construction of the pilot plant, to its inauguration.

Aug 2018

Sept 2018

Oct 2018

Apr 2019

May 2019

FOOD MANUFACTURING

An innovative mixed-metal hydroxide

for pH control and wastewater microorganism activity

AMALGAM-55

A customer story from Calix's US business: IER

A local Spokane meat processing facility and adjacent tannery generate over 2.5 million gallons per day (mgd) of high strength organic wastewater. The wastewater treatment facility has a National Pollutant Discharge Elimination System (NPDES) permit for discharge to a river. When a low-rate anaerobic digester was installed about 10 years ago, magnesium hydroxide (60% $Mg(OH)_2$) slurry was selected for pH and alkalinity control based on its strong but gentle buffering ability.

Though the magnesium hydroxide treatment was working well for pH and alkalinity control, the facility was continually struggling to develop a diverse microorganism population for improving the overall activity of the sludge. Based on consulting advice to add more calcium to the system, they switched to the use of hydrated lime ($Ca(OH)_2$).

The application of lime lasted only a couple of months, as they were astounded at the increase in the inert solids loading in the anaerobic system. This was measured as the ratio of Volatile Solids (VS) to Total Solids (TS).

Working with plant management to determine a minimum amount of calcium required as a feed supplement into the system, a proprietary blended product called AMALGAM-55 was formulated to contain predominantly magnesium hydroxide, with a minor component of calcium hydroxide.

CHALLENGES

- The plant was struggling with inadequate nitrogen removal and poor biogas production – related to poor microorganism activity.
- Based on consulting advice to add calcium, they switched to hydrated lime ($Ca(OH)_2$), which resulted in plugging problems and a dramatic increase in inert solids in their system.
- They switched back to magnesium hydroxide, but with the manual addition of bags of lime, which was expensive and time consuming.

SOLUTION

- IER worked with the plant operators to determine the minimum amount of calcium required for the system.
- IER provided the R&D to develop a proprietary blended product of magnesium hydroxide with a minor component of calcium hydroxide, called AMALGAM-55.
- AMALGAM-55 provided a reliable, one-drum product to address the customer's needs.

BENEFITS

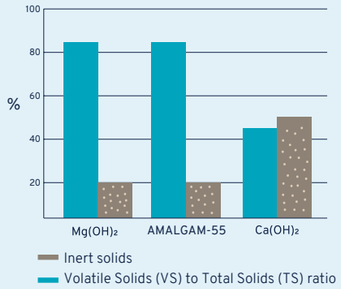
- The $Ca(OH)_2$ in AMALGAM-55 was formulated at a level sufficient for improved microorganism activity, but not enough to cause an increase in “inert” mineral solids.
- AMALGAM-55 gave pH control performance at a dose comparable to the use of magnesium hydroxide on its own.
- Because AMALGAM-55 is less expensive than magnesium hydroxide, the customer enjoyed a 15% chemical cost reduction, along with improved microorganism performance.

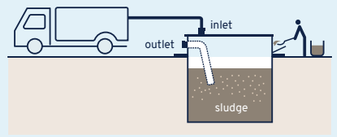
RESULTS

The feed of AMALGAM-55 resulted in improved microorganism activity while not impacting the ratio of Volatile Solids to Total Solids. The plant has been using AMALGAM-55 for the past 12 years while maintaining the percentage of Volatile Solids in the range of 75-85%, identical to that observed with the use of straight magnesium hydroxide.

IER provided the plant with substantial savings in operational costs, whilst maintaining compliance with the Environmental Protection Agency (EPA).

Hydrated lime ($Ca(OH)_2$) can increase operation and maintenance costs related to formation of scale and accumulated solids/sludge.

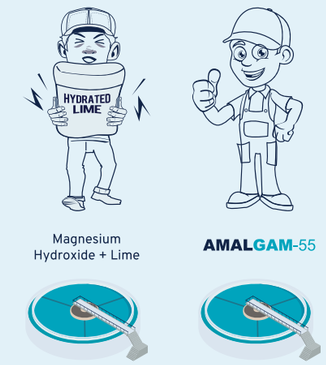




Increased inert solids => extra sludge disposal costs*

Sludge is an expensive and problematic byproduct of the wastewater treatment process.

**Sludge disposal costs = pumping + energy use + hauling*



The value of magnesium hydroxide as a substitute for caustic soda and lime

Magnesium hydroxide is the least expensive and most powerful alkaline chemical treatment available on the market for pH control applications. At the same time, it is by far the safest and most gentle to use.
By replacing the sodium in caustic soda or soda ash with the magnesium ion, the treated wastewater is transformed from having to deal with a detrimental form of salinity (Na^+) to the benefit of a macronutrient (Mg^{2+}). Mg^{2+} is the core element in chlorophyll that drives photosynthesis.

Controlling the pH of industrial wastewater is important to prevent harm to the wastewater collection/transmittance infrastructure by minimising the corrosive effect of gaseous acidic contaminants (such as H_2S) or, if applied to farm land, to prevent harm to the irrigated crops. Once the wastewater enters a treatment plant, the control pf pH is essential to optimise aerobic and anaerobic microorganism activity. In this article, we explore three ways magnesium hydroxide has cost-effectively replaced caustic soda and lime in different wastewater treatment applications.

1

Safety is the driver

Caustic soda and lime are historically the two most industrially available choices for wastewater pH control, however, both have significant limitations. Caustic freezes at 15ºC to plug feed lines and is extremely hazardous to handle, causing severe chemical burns.

Caustic burn

Lime is even better known for the plugging of feed lines, as well as wastewater transport lines due to the formation of calcium mineral scale, and over-exposure can also result in severe burns to operators' hands.

A customer story from Calix's US business: IER

Food processing plant

Challenges
- Low pH wastewater requiring alkaline adjustment
- Discharge compliance issues
- Safety issues in using caustic soda
- Limited physical and financial support

Solution
IER provided AMALGAM-60 (60% $Mg(OH)_2$ or concentrated milk of magnesia) as a replacement for 50% NaOH, employing an IER trial storage and feed system. This allowed the customer to compare the dosing and performance of the two chemicals prior to committing to the capital cost of making a permanent transition of chemicals.

Benefits
The customer's operators were very pleased with the reliability of AMALGAM-60 feed and overall treatment performance. However, they were most pleased with the safety of handling – when it spilled on their hands, they simply clapped it off like talcum powder!

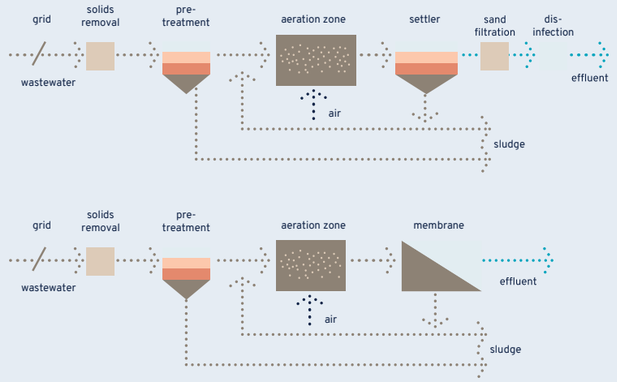
In addition to the performance and safety benefits, they experienced a 40% usage rate reduction that resulted in dramatic savings in their chemical costs.

The operator in charge of wastewater was thrilled with the safe nature of the product, the environmental manager was lauded for his vision, and the plant's CFO was thrilled with the reduced chemical budget.

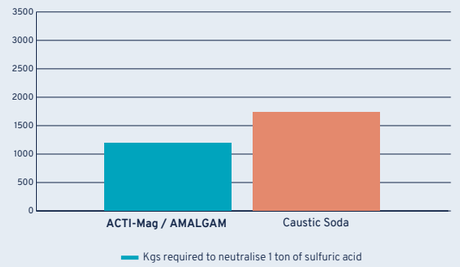
2

Replacing caustic soda in a membrane bioreactor system

The membrane bioreactor (MBR) process allows for a much smaller footprint as compared to conventional wastewater treatment, due to the replacement of large clarifier basins with membranes. Recent innovations in membrane technology have reduced the cost of MBR systems, making them a more attractive choice in the market.



As the MBR process is microbiologically driven, the control of pH is critical, and there is no alkaline additive that is safer both for operators and microorganisms than magnesium hydroxide.



A customer story from Calix's US business: IER

Municipal wastewater treatment facility in Pacific Northwest, USA

Challenges
- Population growth required addition of new treatment plant with small footprint
- Engineering recommended a MBR system with caustic soda for nitrification pH control
- Cold temperatures during winter months adversely affect membrane performance

Solution
- Benchtop testing was performed to demonstrate the expected usage rate reduction. A dose of 0.3 mL of AMALGAM-60 provided the same pH increase as 1.0 mL of 25% NaOH (used due to cold temperature conditions).
- For the on-line trial, IER provided two 1000 gallon storage tanks joined to a single metering pump for the AMALGAM-60 feed. A usage rate of ~1400 gallons per day (gpd) of 25% NaOH was replaced with ~450 gpd of AMALGAM-60, reproducing the replacement ratio as seen on the benchtop.
- Optimal pH and alkalinity control were maintained throughout the 90-day trial, despite the 67% reduction in chemical usage. Additionally, there was ~45% reduction in the daily tons of solids produced, resulting in a dramatic reduction in sludge hauling costs. This is consistent with the coagulation properties of magnesium hydroxide not offered by sodium hydroxide.

3

Improved solids settling

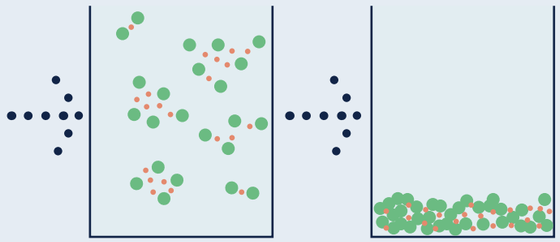
The wastewater stream for many industrial processes can be quite unpredictable and inconsistent. Dramatic changes in pH can have adverse effects on the settleability of suspended solids. To stabilise the pH, the wastewater is commonly neutralised with alkalis. The nature of the alkali selected can have a dramatic impact on the ability to settle suspended solids. Caustic soda typically provides no settling benefit and often results in gelatinous sludge that does not dewater easily. With lime ($Ca(OH)_2$) there is typically a significant increase in sludge volume due to the formation of calcium minerals, like calcium carbonate ($CaCO_3$).

In contrast, magnesium hydroxide assists with solids settling, providing a more compact sludge with a boost in alkaline pH to improve subsequent secondary treatment and anaerobic digestion performance.

ACTI-Mag™ | AMALGAM

trapping impurities

settle to bottom



ACTI-Mag and AMALGAM are cost-effective alkalies that help with solid settling and sludge compaction, resulting in drier dewatered cakes (which can then be used for animal feed or as a fertiliser).

A customer story from Calix's US business: IER

Specialty potato plant in the Pacific Northwest, USA

Challenges

- The plant generates ~2 mgd of high-strength wastewater
- Wastewater passes through a primary clarifier before being discharged to an anaerobic digestion process
- Due to rapid acidification of the suspended solids (potato waste) the pH in the clarifiers drop from 6.8 to 4.5 with no treatment

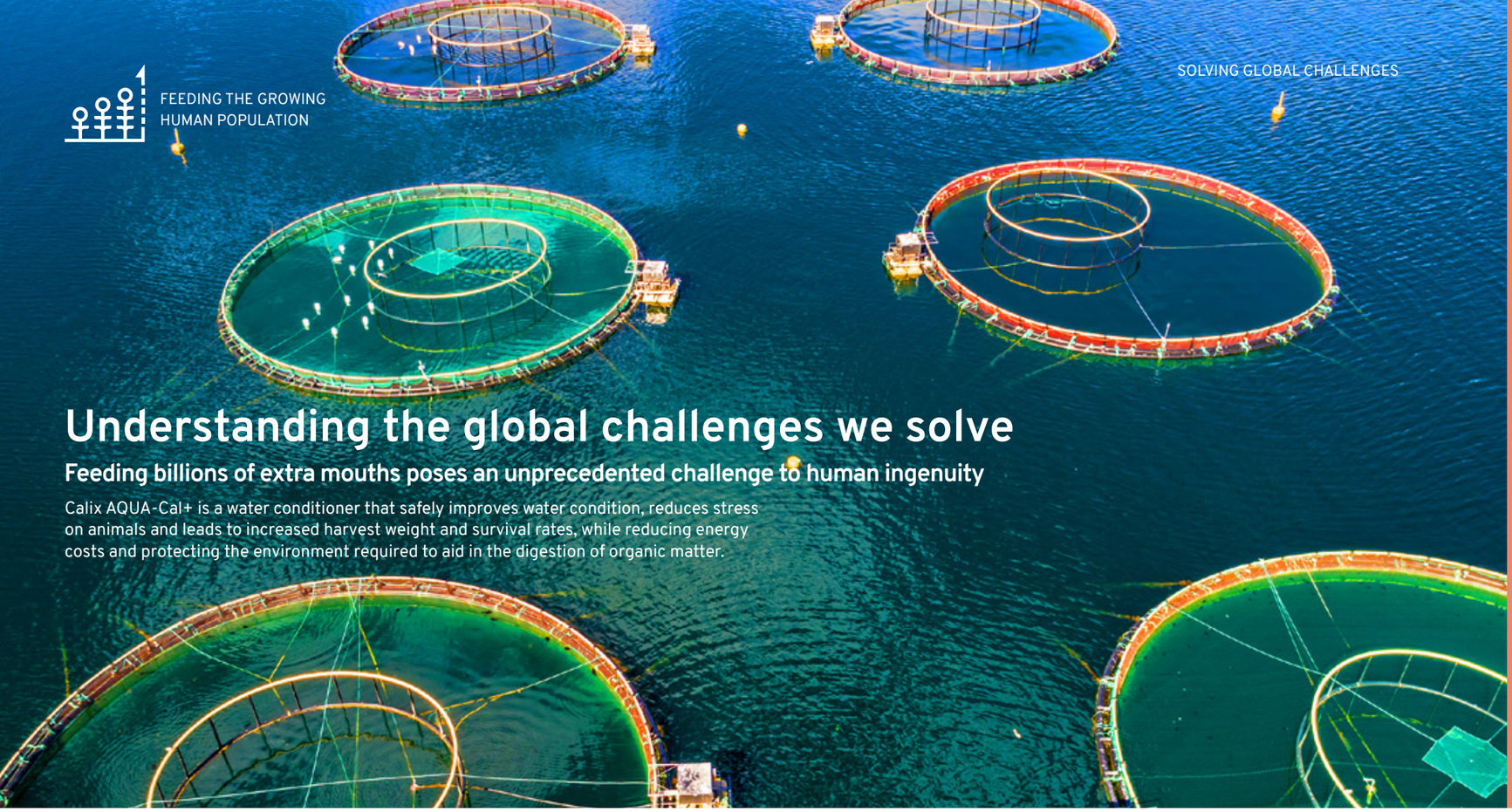
Solution

After trialling sodium hydroxide (NaOH), $Ca(OH)_2$, and $Mg(OH)_2$, magnesium hydroxide was selected as the alkali of choice for the following reasons:

- Greatest hydroxide concentration per pound of product → lowest dose
- Improved solids settling in the clarifier

Benefits

Magnesium hydroxide was the least expensive alkali and provided the greatest solids settling and sludge compaction, resulting in a drier dewatered cake (preferred for animal feed). Operators enjoyed the inherent safety benefit as compared to the other alkaline products tested.



Understanding the global challenges we solve

Feeding billions of extra mouths poses an unprecedented challenge to human ingenuity

Calix AQUA-Cal+ is a water conditioner that safely improves water condition, reduces stress on animals and leads to increased harvest weight and survival rates, while reducing energy costs and protecting the environment required to aid in the digestion of organic matter.

Read more about how Calix contributes to

"FEEDING A GROWING HUMAN POPULATION"

READ MORE

The world's population is expected to grow by over a third, or 2.3 billion people, between 2009 and 2050. This will not only give rise to an increased demand for food, as a result of more mouths to feed, but will also create other challenges. Increased incomes, economic development of emerging nations and urbanisation will result in changes in consumption patterns and a slow revolution of our food value chain.

9.7 BILLION

World population by 2050

70%

Population living in urban areas by 2050

1.7

Planets needed to support humanity's demand on earth's ecosystems

+70%

Increasing food demand by 2050

Responding to a rise in demand for proteins

It is now recognised that farming of aquatic species (i.e. aquaculture) will provide an increasingly significant response to the global animal-derived protein demand.

Seafood consumption is increasing in many parts of the world, and by 2030 it is predicted that aquaculture will be the prime source of fish due firstly to demands from consumers, and secondly due to depletion of wild capture fisheries.

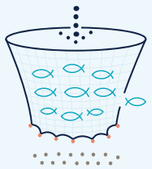
Although aquaculture has already become the fastest growing food-producing sector, productivity is already highly stressed by excessive fishing pressure, growing organic pollution, toxic contamination, and climate change.

Most commonly, farming occurs in net pens or cages anchored to the ocean floor near the coast. However, closed systems of tanks or ponds, either on land or floating in water, are also used.

Although aquaculture has the potential to relieve pressure on ocean fisheries, it can also threaten marine ecosystems and wild fish populations through the introduction of exotic species and pathogens, effluent discharge, the use of wild fish to feed farmed fish, and habitat destruction. If the aquaculture industry does not shift to a more sustainable path soon, the environmental pressures faced by intensive crop and livestock production on land will be faced by aquaculture.

Environmental risks of marine aqualculture

Introduction of non-native species
+
Drugs (antibiotics, hormones, anaesthetics, pigments, vitamins)
+
Herbicides - controls algae growth on netpens



- Incubation of local diseases caused by a high concentration of fish
- New diseases and parasites introduced by seed stock
- Genetically modified organisms
- Escape of non-native species
- Fish sewage - contains uneaten food, waste products, disease and pathogens

Because there is only one Earth... Mars is for quitters.

AQUA-Cal+™

Despite lockdowns in many countries due to COVID-19, AQUA-Cal+ continues to gain ground in shrimp culture.

In Malaysia, customers usage has not dropped since the start of the pandemic, with customers like QQ and Manjong continuing to order and increase application to a larger number of ponds. We are anticipating small increases in the coming months as restaurants open again.

Although China was severely affected by COVID-19, we are starting to observe a slow recovery with sales starting again as the industry recovers from a downturn over the first quarter.

In Vietnam, our trials in shrimp nursery culture are looking promising while new trials on white leg shrimp have also started in Taiwan.

We need to rethink the way we are producing food.

https://www.youtube.com/watch?v=E6o7T8Tt9pY

Spraying chemical pesticides remains the main approach to combating pest attacks in many crops.

But their future use is under scrutiny because of many concerns, not least their effects on human health and beneficial insects.

Watch Andrew Okely talk about BOOSTER-Mag, an easy-to-apply foliar spray that acts as both fertiliser and stimulates a plant's natural ability to fight disease and pests.

Introducing Sajeewani Fernando

Materials Scientist

Sajeewani joined Calix Limited as a Material Scientist in 2012, to assist the Research and Development team on various projects such as the development of new recipes for MgO based products, slurries, and to carry out tests on various other product developments.

Over the years, she assisted the development and improvement of several Calix products such as ACTI-Mag, PROTECTA-Mag, BOOSTER-Mag and AQUA-Cal+.

Before joining Calix, Sajeewani worked as a forensic analyst at the Government Analyst Department of Sri Lanka for eight years. She also worked as a chemist at Heychem Pty Limited, a pesticide manufacturing company. Sajeewani completed a Bachelor of Science and MSc in analytical chemistry at the University of Preradeniya, Sri Lanka.

In her free time, she enjoys spending time with her family – her husband Nilantha, 12-year-old son Lesandu and 2-year-old daughter Thinuli. Outside of her work, she loves books and travelling.

"I am excited to be a part of the Calix Research Team, and to contribute to a greater purpose, by innovating in environmentally friendly products."

Stop Press

Calix-led consortium executes final project agreements for "LEILAC-2" CO_2 capture facility

http://www.ecovoice.com.au/calix-led-consortium-executes-final-project-agreements-for-leilac-2-co2-capture-facility/

Calix gets green light for cement industry CO_2 capture

https://www.aumanufacturing.com.au/calix-gets-green-light-for-cement-industry-co2-cepture

A global need for better batteries

https://www.ecogeneration.com.au/a-global-need-for-better-batteries-calix/

Calix mentioned as a case study in the NSW Government's Net Zero Plan

https://stockhead.com.au/news/governments-are-backing-companies-with-good-concrete-tech-these-small-caps-are-on-the-radar/

http://www.ecovoice.com.au/calix-mentioned-as-a-case-study-in-the-nsw-governments-net-zero-plan/

Capturing CO_2: How to reduce carbon dioxide emissions from the cement industry

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