Number 519

March | April 2024

www.fertilizerinternational.com

Fertilizer INTERNATIONAL

Welcome to our iPad version of Fertilizer International Issue 518

Please either swipe through or use the contents link at the bottom of the page to navigate your way around this PDF.

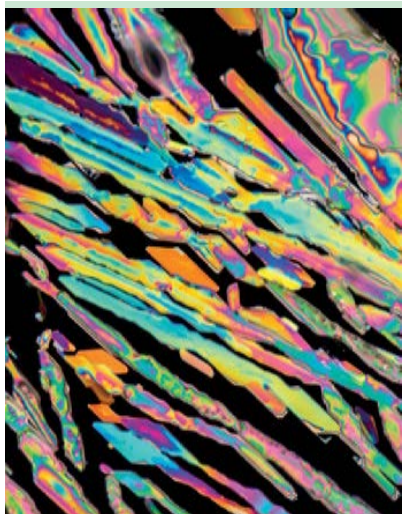
To use the full interactivity of this PDF on iPad we suggest that you open it within the free app iBooks.

New AG International Annual, Berlin

Biostimulant developments

Specialty market report

Phosphorus recovery update



Cover: Microscopic shot of potassium nitrate crystals in polarized light. iStockphoto.com/prill

Biostimulants go mainstream

Potash processing review

Read this issue online at: www.fertilizerinternational.com

Published by:

CRU

Fertilizer INTERNATIONAL

www.fertilizerinternational.com

NUMBER 519 **MARCH | APRIL 2024**

CONTENTS

PHOSPHATES AND POTASH INSIGHT

REGULARS

Editorial

Warsaw diary

2024 is my tenth year as editor of *Fertilizer International* magazine. But, having joined CRU in January, it's also a fresh start.

This simultaneous feeling of familiarity and change was something I reflected on during a return flight to London at the end of February, after attending CRU Phosphates 2024 in Warsaw. This is an event *Fertilizer International* has been supporting since its inception – and a conference I've been attending since 2015.

But this year was special. I enjoyed the event more and felt it was CRU's – our – most successful Phosphates conference yet.

This was partly because I was attending for the first time as part of the team responsible for its organisation. I can't really claim any credit for the event's crowd-pleasing programme, its smooth running and high standards of friendly professionalism. That was all my colleagues doing, not mine.

But I certainly wasn't alone in my favourable impression. On the last afternoon, other CRU Phosphates attendees told me – unprompted – they'd had a successful conference too. So, why was that?

Well, for every conference organiser, the most frequently asked question is: "How many delegates this year?" – as if that's the only indicator of success. Sure, attendance is a clear measure of industry interest and absolutely vital for the bottom line.

But, for our sponsors, exhibitors, delegates and speakers, events are, first and foremost, an experience. For those attending, it's their overall conference experience – good, bad or indifferent – that determines its success. It's about quality, not quantity.

I can therefore confidently say CRU *did* deliver one of the best phosphate conferences of the last decade in Warsaw. The personal feedback I've received suggests it was good for content, good for business, good for networking. And enjoyable too. My key CRU Phosphates takeaway? Overall, it was a happy event with happy attendees.

The programme definitely helped. That was clear from the first afternoon of the opening day when I couldn't find a seat for the technical showcase. That was as true at 5 pm as it was at 1 pm.

That enthusiasm continued into the second day. I'm not always a fan of the 'fireside chat' format. But, under the skilful moderation of ICL's Anthony Zanelli and with the right mix of panellists, it was a definite winner in Warsaw. The discussion of how the industry can continue to deliver on food security – while meeting its energy transition goals – was balanced, engaging and grounded. Judging from the endless questions, the audience thought so too.

For me, one highlight of the conference was the presentation on the future of farming by Karl Wyant, Nutrien's director of agronomy. This was full of insights and original observations. Yet Karl, a natural presenter, was so adept at keeping us amused we somehow forgot we were learning at the same time.

We were also fortunate that two key industry players, JESA Technologies and Prayon Technologies, chose CRU Phosphates 2024 to launch newly patented processes on the market. JESA's James Byrd presented the SWIFT process for valorising fluorine, turning this from a nuisance pollutant into a valuable co-product. We hope to report on SWIFT fully in *Fertilizer International* later this year.

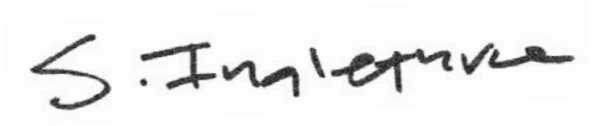
Kevin De Bois of Prayon, meanwhile, gave delegates a clear explanation of Prayon's new magnesium removal process for phosphate rock, as highlighted in our January/February magazine (*Fertilizer International* 518, p38). This new approach has real potential to transform both phosphate resource efficiency and resource availability.

It was a pleasure to moderate this technical session and see both James and Kevin present to a packed and receptive industry audience. It was standing room only too, with extra chairs needing to be brought in throughout.

And that's only a brief snapshot of CRU Phosphates 2024. As usual, we will be carrying a full write-up in our forthcoming May/June issue. This will allow us to also cover the LFP battery market (*Fertilizer International* 517, p46), one of the conference's other major themes and an area with huge growth potential.

Summing up, Warsaw has definitely set a high bar. I left CRU Phosphates 2024 enthused, better informed and with valuable new contacts. I hope other attendees found it similarly worthwhile and will be returning for next year's event in Orlando.

Please do join use there for CRU Phosphates 2025 – and help us build a global community for the phosphates industry.

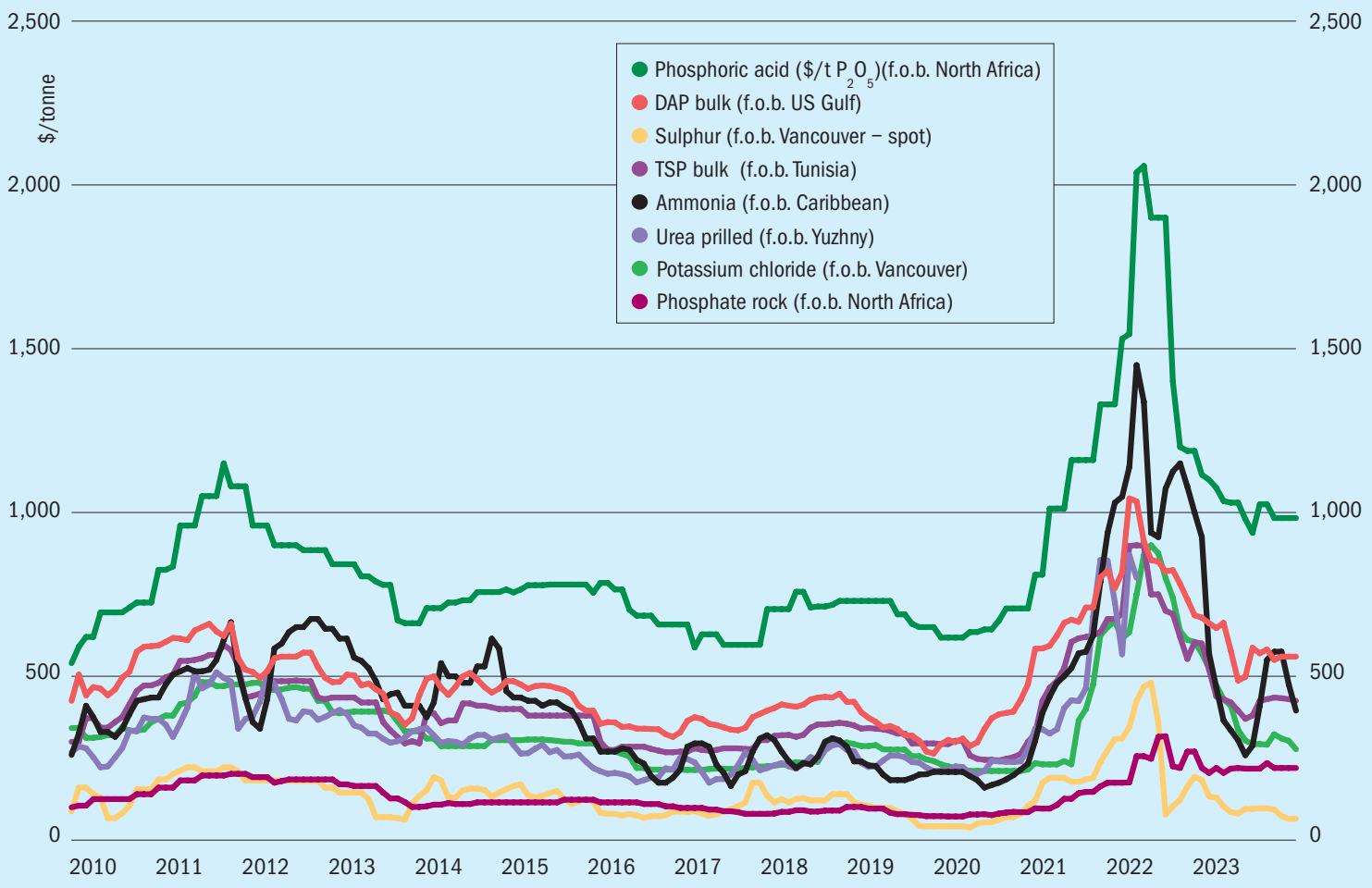


Simon Inglethorpe, Editor

"We were also fortunate that two key industry players, JESA Technologies and Prayon Technologies, chose CRU Phosphates 2024 to launch newly patented processes on the market."

Market Insight

Historical price trends $/tonne



Source: CRU

PRICE TRENDS

Urea. As February ended, urea prices found support in the US and Brazil while Europe remained subdued and Egypt struggled to find buyers. New Orleans was the one bright spot in the urea market – with NOLA prices benefitting from the meeting of suppliers and buyers at the TFI's domestic conference. With positive sentiment all round, prices moved up $30/st, peaking at $390/st f.o.b. for March.

Participants gathering at the AFA conference in Cairo were not boosted by the same sentiment as their US counterparts. Egyptian producers remain optimistic, however, despite the lack of market interest and prices edging below $400/t f.o.b. Some buying interest is expected to re-emerge in Europe, although the wet weather continues to cause disruption. Egyptian and Black Sea suppliers are unlikely to find relief in Turkey either, as demand there is soft due to poor farm interest.

Unlike phosphates, there is currently no clear indication when Chinese urea exports will resume.

Ammonia: Price benchmarks in the east remained stable-to-soft at the end of February, while prices in North America experienced some support in an otherwise lengthy market. Regional ammonia sentiment is trending towards the downside currently despite the rollover in the Tampa contract price.

There was little to shout about in the Middle East either. The region's producers continue to focus on contractual obligations, with Ma'aden reporting reduced netbacks on its latest term shipments around the $295/t f.o.b. mark. Import demand from India may be stimulated in the coming weeks following a 38 percent increase in the nutrient-based subsidy (NBS) rates for phosphate fertilizers. The news of fresh phosphate export quotas in China is also likely to boost ammonia producer sentiment.

Phosphates: China's publication of its 2024 DAP/MAP export quota and India raising its nutrient based subsidy (NBS) rates by 38 percent for phosphate fertilizers were the two main market developments at the end of February.

After weeks of market speculation, China announced a new phosphate export quota for 2024 of around five million tonnes for DAP and two million tonnes for MAP, with export inspections set to begin on 15th March 2024. These volumes are in line with CRU's previous expectations.

Most prices remained largely unchanged, however, despite these announcements, with the exception of the US market. US DAP prices rose to $600-610/st f.o.b. NOLA, with MAP barges holding stable at $610-625/st f.o.b. NOLA. Prolonged market tightness was reflected by a narrowing in the spread between DAP and MAP prices.

Potash: Potash price direction has been mixed. Prices in Brazil firmed for a second week in a row at the end of February while other spot prices outside the US declined. Brazilian potash prices recovered to an average price of $290/t cfr, their highest

Market price summary $/tonne – 19th February 2024

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	395	388**	f.o.b. E. Europe 238	f.o.b. US Gulf	560	-	-
f.o.b. Yuzhny	Port closed	Port closed	-	f.o.b. N. Africa	580	425	983
f.o.b. Middle East	310	352**	-	cfr India	593	-	968*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	278	-	cfr US Gulf	88	f.o.b. Vancouver	68	-
cfr India	319	-	-	-	f.o.b. Arab Gulf	75	-
f.o.b. Western Europe	-	627	-	-	cfr China	80	-
f.o.b. Baltic	215	-	-	-	cfr India	100+	-

Prices are on a bulk, spot basis, unless otherwise stated. (= contract ** = granular). Phosphoric acid is in terms of $/t P_2O_5 for merchant-grade (54% P_2O_5) product. Sulphur prices are for dry material. (+ Quotes for product ex-Arab Gulf). n.a. = not available.*

price level in four weeks, although still down $25/t on the start of the year.

Indian potash contract negotiations remain a mystery. Although some expect prices to fall to $280/t cfr, neither Indian importers nor suppliers have commented. India's NBS announcement left the potash subsidy unchanged for the upcoming Kharif season. The maximum retail price for potash was also unchanged at INR 1,670 per bag.

Sulphur: Prices ended February relatively stable following previous gains. While the price trend is seemingly still upwards, bullish sentiment is being limited by a few concerns.

The Middle East spot sulphur price – while still down 59 percent on early December 2022 – was assessed at $73-78/t f.o.b., having climbed 12 percent in the past two weeks. The benchmark rallied by 47 percent last year, between the end of July and mid-October, to reach $110/t f.o.b. before declining once again.

Steep increases in Chinese port stock levels, meanwhile, are a market issue. Although concerns over this are being countered by expectations of better demand, good affordability and likely increases in phosphate production linked to resumed export allowances.

OUTLOOK

Urea: Buying in the northern hemisphere is offering price support. Following warnings of spring season urea shortages from US producers and importers, this has finally translated into a price rally in the NOLA barge market. US prices are expected to strengthen during March and April before declining post season.

While Egyptian prices plateaued in February, after a strong start to the year, another rally is expected in March. This might prove to be a price peak as Europe moves out of season subsequently.

Ammonia: The outlook is looking less negative with slightly more support than previously envisaged. While good availability and limited spot interest continues to add length to the Asian market, suppliers are hopeful that a ramp-up in Chinese demand, in support of downstream urea and phosphate production, will add temporary support to prices through the spring.

> **"China's publication of its 2024 DAP/MAP export quota and India raising its nutrient based subsidy (NBS) rates by 38 percent for phosphate fertilizers were the two main market developments at the end of February."**

Similarly, in the Middle East, expectations of renewed import appetite from the Far East – and potentially India – should limit the price declines envisaged previously. In the US, the Tampa benchmark should hold relatively stable in the short term, in CRU's view, although it will most likely bottom out at some point during the third quarter.

Phosphates: Global DAP/MAP prices are expected to drift gradually lower over the short term, although the downside is expected to be limited until around May-June, given the persistence of tight supply.

Following China's announcement of a new 2024 phosphate export quota, some small DAP/MAP volumes may be exported in coming weeks. But CRU is not expecting bulk exports from China until well into second quarter. In the meantime, global prices look set to be supported by limited availability.

Global DAP/MAP demand remains relatively poor currently. Yet, with inventories across many key global markets quite low, demand is expected to rebound as buyers seek to replenish stocks.

Potash: Market oversupply should apply downward pressure on prices over the next six months, with spot and contract prices expected to fall below $300/t by May. Prices could even fall lower than expected if supply continues to rise.

Globally, supply continues to outweigh demand, with many potash markets reporting record 2023 imports. In Brazil, MOP prices are expected to rise to a peak in April/May before falling back. Southeast Asian standard MOP prices are expected to decrease steadily throughout the forecast period.

Sulphur: Prices are forecast to increase out to August due to good affordability and slightly improved demand, though any upside is likely to be limited by good availability.

Overall, the recent growth in sulphur production, in addition to stock drawdown and high Chinese inventories, is expected to limit upwards potential for prices in the short term and keep sulphur prices low relative to phosphates. However, affordability continues to support raw materials purchasing and leaves room for price increases, especially if downstream production picks up as expected and sulphur stock drawdown slows.

Fertilizer Industry News

INDIA

Paradeep Phosphates and Mangalore Chemicals announce merger

PHOTO: PARADEEP PHOSPHATES

Paradeep Phosphates plant at night.

Paradeep Phosphates Limited (PPL) and Mangalore Chemicals & Fertilizers Limited (MCFL) have agreed to merge.

If approved, the consolidated company will become one of India's largest integrated private fertilizer producers with a production capacity of around 3.6 million t/a.

The announcement on 7th February followed board-level approval by the directors of both companies. Under the agreed proposals, MCFL shareholders will get 187 shares in PPL for every 100 of their shares. These new PPL shares will be listed on India's National Stock Exchange (NSE) and the Bombay Stock Exchange (BSE).

PPL is a major domestic phosphate producer. Its assets include the flagship Paradeep plant in Odisha and the newly acquired Zuarinagar plant in Goa – these having an NPK/DAP production capacity of 1.8 million t/a and 0.8 million t/a, respectively.

MCFL is a smaller scale fertilizer producer based in Karnakata in the south of India. It operates a 380,000 t/a capacity urea plant and a 260,000 t/a capacity diammonium phosphate (DAP) plant. the DAP plant can also produce NP+S (20-20-0+13S) and NP (16-20-00) grades, while the urea plant was revamped in 2002 and uses Stamicarbon technology.

"MCFL has a presence in the southern regions of India while PPL has a presence in the northern, central and eastern parts of India, making the proposed combined entity a pan-Indian fertiliser company," the companies said in a joint statement.

"This move aims to enhance customer engagement, improve large deal capabilities, use manufacturing capabilities of both entities, reap benefits of economies of scale, optimise supply chain and thus create a more compelling value proposition for all stakeholders," they added.

MCFL and PPL have formed an implementation committee to oversee the merger process and liaise with regulators, employees, vendors, customers and other stakeholders.

Suresh Krishnan, PPL's managing director & CEO, said: "Consolidation of PPL and MCFL will mark a significant leap forward in our growth strategy and the resultant entity will be able to cater to the diverse soil needs of the country. We will be able to reap the benefits of economies of scale, optimize product mix, enhance distribution reach and supply chain capabilities and leverage on each other potent synergies. This will result in unlocking tremendous value and drive sustainable growth for our shareholders, employees, and partners."

MCFL director Nitin Kantak said: "The proposed merger will enable us to become a larger player and will help us to serve our market in a more diversified manner and will result in enhanced value creation for all the stakeholders."

The proposed merger will require the approval of shareholders, creditors and the Competition Commission of India. ■

$2.95 billion P&K subsidy for Kharif season

The Indian government has allocated subsidies worth INR 244 billion ($2.95 billion) to phosphate and potash fertilizers for the upcoming six-month Kharif season (1st April to 30th September).

The expenditure, which is set under the country's nutrient-based subsidy (NBS) scheme, is down INR 135.8 billion from the 2023 Kharif season.

"The subsidy on P&K fertilizers will be provided based on approved rates for Kharif 2024 to ensure smooth availability of these fertilizers to the farmers at affordable prices," the government said in a 29th February statement.

The NBS scheme will also include three new fertilizer grades, it added, without naming these.

Some NBS subsidy rates have risen while others have remained the same. The newly announced 2024 Kharif season subsidy for phosphate fertilizers is INR 28.72/kg, for example, up 38 percent from the 2023 Rabi season subsidy of INR 20.82/kg.

The 2024 Kharif season nitrogen, potash and sulphur subsidies, meanwhile, are unchanged from the 2023 Rabi season at INR 47.02/kg. INR 2.38/kg and INR 1.89/kg, respectively.

The government-set maximum retail price (MRP) for DAP and potash, at INR 1,350 and INR 1,670 per 50 kg bag, respectively, is also unchanged for the Kharif season.

YEMEN

Houthi missile hits fertilizer cargo vessel

The crew of the Handysize bulk carrier Rubymar abandoned ship off the coast of Yemen after it was hit by a missile fired by Houthi militants on 18th February.

The Belize-registered but British-owned vessel was said to be carrying a cargo of Saudi fertilizer.

The Rubymar was approaching the Gulf of Aden near the Bab el-Mandeb strait when it was hit by at least one missile, according to US Central Command, while another missed the vessel. The crew were safely evacuated and taken to the port of Djibouti, after a coalition warship and a merchant ship answered a distress call from the damaged vessel.

The UK Maritime Trade Operations (UKMTO) also reported the attack. It said the vessel was at anchor 40 miles (about

64.4 km) south of Mokha, Yemen, and had been abandoned.

The fertilizer-laden Rubymar left the Saudi Arabian port of Ras al-Khair on 8th February and was destined for the Black Sea port of Varna, Bulgaria, where it was due to arrive on 27th February.

Vessel-tracking data confirm the 30,000-tonne capacity vessel was carrying an unspecified cargo of fertilizers. Bulgaria has imported NP grades from Saudi Arabia previously, according to reports.

CANADA

Mosaic curtails Colonsay production again

PHOTO: MOSAIC

Mosaic is curtailing production at its Colonsay potash mine, Saskatchewan, Canada

Mosaic is curtailing production at its Colonsay potash mine Saskatchewan "in response to current market conditions", the company announced on 21st February.

Production only resumed at Colonsay in August last year after the previous December 2022 curtailment. The mine had been operating with an annual run rate of 1.3 million tonnes – with plans to expand this to 1.8-2.0 million tonnes later this year by restarting Colonsay's second mill.

The curtailment was announced as part of Mosaic's 2023 full year and fourth quarter results. The company's potash earnings (adjusted EBITDA) totalled $1.5 billion in 2023, down from $3.1 billion in 2022.

PORTUGAL

Tecnimont secures green ammonia plant contract

MadoquaPower2X has awarded Maire Group subsidiary Tecnimont a front-end engineering design (FEED) contract for an integrated green hydrogen and green ammonia plant at Sines, Portugal.

MadoquaPower2x is a project development consortium formed by Madoqua Renewables, Power2X and Copenhagen Infrastructure Partners (CIP).

The proposed plant will generate green hydrogen using alkaline-water electrolyser technology and use this to produce green ammonia via the Haber-Bosch process. Green ammonia will then be transported by pipeline to the Port of Sines where it will be loaded for export and/or used as maritime fuel.

Tecnimont's engineering design work covers the integration of the electrolysers, an air separation unit for nitrogen production, the ammonia production plant, as well as storage and ship loading. Tecnimont has also been asked to submit an engineering, procurement and construction (EPC) proposal to build the integrated green hydrogen and green ammonia plant.

The award of the FEED contract follows a pre-FEED study carried out by NextChem Tech, another Maire Group subsidiary.

MadoquaPower2X plans to capture renewable energy generated by under-development solar and wind assets in Portugal. This will be used to power as much as 500 MW of electrolysis capacity to produce up to 1,200 t/d of green ammonia. It will be the first project in Sines, the largest industrial and logistics hub in the Iberian peninsula, to produce ammonia from clean energy at industrial scale. The venture is part of a wider plan to set-up a value chain for green ammonia between the Port of Sines and a proposed Northwestern European Hub.

SWEDEN

€2bn green fertilizer plant announced

Fertiberia, Lantmännen, and Nordion Energi have joined forces to develop Sweden's first fossil-free fertiliser production plant.

The three partners have formed the joint venture Power2Earth to deliver the €2 billion project – said to be the largest of its kind in the Nordic region – with production scheduled to start in 2028. The project will be located in Luleå, Sweden, and produce one million tonnes of 'green' fertilizers per annum.

The partners have securing land for the production plant at Luleå and completed several feasibility studies since the project began in 2021. An environmental permit application for the project is due be submitted in the second quarter of this year.

The Luleå plant will be based on the generation of green hydrogen via water electrolysis and renewable energy. It builds on technology previously developed by Fertiberia in Spain.

Green fertilizer production at the plant has the potential to reduce carbon dioxide emissions by around 1.6 million tonnes, according to Power2Earth, this corresponding to roughly 25 percent of Sweden's agricultural emissions.

Javier Goñi, CEO of Fertiberia, said: "Fertiberia brings its industrial experience of more than five decades in the production, operation and logistics of ammonia, as well as its leadership in driving green hydrogen to decarbonise the agriculture sector with state-of-the-art fertilisers. We are also proud to contribute to the achievement of Sweden's ambitious CO_2 emission reduction targets while providing regional growth and building a more resilient food supply with reduced dependence on imports."

Lantmännen is an agriculture cooperative owned by 18,000 Swedish farmers and is a leading player in Northern European agriculture, machinery, bioenergy and food products.

Per Arfvidsson, Lantmännen's deputy CEO and CTO, said: "Power2Earth is revolutionary for the Swedish agricultural and food industry as fossil-free mineral fertiliser is crucial for creating a sustainable, efficient and future-proof food chain. Domestic production of mineral fertiliser reduces Sweden's overall dependence on fertiliser imports and is essential for developing a robust food preparedness.

Nordion Energi specialises in energy infrastructure and is the transmission systems operator (TSO) for the Swedish gas network.

Hans Kreisel, CEO of Nordion Energi, said: "Power2Earth is the first step on the Nordic Hydrogen Route, a 1000-kilometer-long underground hydrogen pipeline connecting Sweden and Finland. We are proud to contribute to regional green transition, economic development, and Swedish self-sufficiency together with Fertiberia and Lantmännen."

OMAN

Yara secures green ammonia supply deal

Yara has secured a long-term supply agreement for green ammonia produced in Oman.

The Norwegian-headquartered fertilizer giant signed a binding offtake agreement with Acme Cleantech subsidiary GHC SAOC on 1st March. This covers the supply of 100 000 t/a of green ammonia.

The ammonia will be supplied by Acme from the first phase of its green hydrogen and ammonia project in Duqm, Oman. The project, which successfully raised

$488 million in funding last July, is expected to start-up production in 2027. Acme plans to develop the project in phases to reach an ultimate green ammonia capacity of 900,000 t/a.

Favourable conditions for renewable energy generation, a strategic location, plus the government's proactive approach, combine to make Oman attractive as a green ammonia hub, according to Yara. The low-carbon ammonia supplied by Acme will comply with EU regulations such as the Renewable Energy Directive and renewable fuels of non-biological origin (RFBNO) requirements, it said.

Acme is one of India's largest independent renewable power producers with a project portfolio of more than 8.5 GWp of renewable capacity. These projects are either in operation or at the implementation stage. The company also built one of the world's first green ammonia plants at Bikaner, Rajasthan, in 2021.

CHINA

Stamicarbon wins another ultra low energy plant contract

Stamicarbon has secured licensing and equipment supply contracts from Jiangsu Huachang Chemical Company for a urea melt plant in Zhangjiagang, Jiangsu province, China.

The 1,860 t/d capacity urea plant will use Stamicarbon's Ultra-Low Energy design and incorporate a highly efficient pool reactor. It will replace an outdated melt plant of similar capacity that is currently operating but keep the existing prilling unit.

Stamicarbon's contract covers technology licensing and the supply of proprietary equipment, including high-pressure items made of super duplex stainless steel, and associated professional services.

Stamicarbon's Ultra-Low Energy design improves heat recovery, compared to the conventional CO_2 stripping process, by using high-pressure steam three times instead of the normal two. This reduces steam consumption by 35 percent and cuts cooling water use by 16 percent. This energy efficient design is currently in operation at two urea plants.

EGYPT

Stamicarbon to supply urea melt and granulation plant

El-Nasr Company for Intermediate Chemicals (NCIC) has awarded NextChem, via its nitrogen technology licensor Stamicarbon, a licensing and equipment supply contract for a urea melt and granulation plant.

The state-of-the-art 1,050 t/d capacity plant will be located 100 kilometres southeast of Cairo. NCIC selected Stamicarbon technology based on process optimisation, operational safety, enhanced yields, low energy consumption and superior product quality.

NextChem and Stamicarbon are both part of Maire Group.

thyssenkrupp Uhde to recommission Delta ammonia plant

thyssenkrupp Uhde, via its Egyptian subsidiary, has signed a front-end-engineering design (FEED) contract with the Delta Company for Fertilizer and Chemical Industries (Delta Fertilizers) to revamp and restart an ammonia plant at Dakahlia, Talkha, Egypt.

thyssenkrupp Uhde will recommission the ammonia plant after a three-year shutdown, while at the same time increasing its capacity from 1,275 t/d ammonia to 1,400 t/d. Additionally, its contract covers the restoration of offsite and central utility units. The German engineering company will also supply Delta Fertilizers with state-of-the-art technology for the production of ammonia and urea at the Dakahlia complex.

People

Leo Alders, the CEO of LAT Nitrogen, is the new president of Fertilizers Europe. He was elected with immediate effect at an extraordinary general assembly on 5th December last year.

Antoine Hoxha, Fertilizers Europe's director general, said: "I am very pleased to welcome Leo Alders as our new President. Given the challenges of high and volatile energy prices, the transition to low-carbon economy and the upcoming EU elections, the fertilizer industry needs a strong and experienced leader like Leo Alders. His deep belief in cooperation and outreach will help Fertilizers Europe strengthen the ties among all Plant Nutrition actors to become a key dialogue partner with the European institutions on the future of agri-food systems in Europe".

In reply, Leo Alders said: "I am grateful to Fertilizers Europe members for entrusting me to guide the European fertilizer industry in these challenging times. We are at a turning point in history, with many challenges ahead. With high and volatile energy prices and a challenging market outlook, my focus will be on restoring the industry's competitiveness to unlock our decarbonisation potential and secure sustainable food systems in Europe. A close cooperation with EU institutions and Members States is needed to safeguard our industrial base in Europe to ensure Europe's strategic autonomy in food and fertilizer".

Christopher Bohn became executive vice president (EVP) and chief operating officer (COO) of CF Industries on the 1st February. He was also elected to the company's board of directors.

In this role, Mr Bohn will lead for CF on global manufacturing, distribution, sales and supply chain, and clean energy projects. His responsibilities also include operational excellence with a focus on safety, productivity and long-term growth.

Christopher joined CF Industries in September 2009. He was formerly the company's EVP and chief financial officer (CFO) with responsibility for strategic planning, business development and investor relations. Mr Bohn will continue to serve as CFO until a permanent replacement has been found. CF confirmed that an external search is currently underway.

"Chris has experience leading most areas of our business and has been instrumental in developing and growing our clean energy strategy. He will continue to drive operational excellence across the organization while managing a range of complex growth initiatives," said Tony Will, president and CEO, CF Industries Holdings, Inc. "This promotion and his election to the Board recognize his strong leadership and future contributions to CF Industries."

Mr Bohn has more than 14 years of experience in the nitrogen fertilizer sector. He previously served CF Industries as: senior vice president (SVP), manufacturing and distribution; vice president (VP), supply chain; and VP, corporate planning.

Gordon Dunn became the new COO of Compass Minerals on 21st February. He will have executive management responsibility for all global operations within the company's salt and plant nutrition businesses. Mr Dunn has managed Compass Minerals' UK operations since January 2012, having joined the company in October 2007.

"In addition to Gordon's extensive experience leading safe and responsible operations, his technical expertise will serve us well as we focus on operational efficiencies and cost reduction initiatives across our operating footprint. His deep familiarity with our salt mining assets will be particularly important," said Edward Dowling Jr, president and CEO. "I'm confident his steady leadership will further bolster the strong performance culture we are building, which we expect will ultimately translate to improved returns for shareholders."

Gordon Dunn, the new COO of Compass Minerals.

PHOTO: COMPASS MINERALS

Mr Dunn brings more than 40 years of mining experience to his new role. Prior to joining Compass Minerals, Dunn held positions of increasing responsibility at: Air Liquide UK Limited, a gas, equipment and services company; Linde Gas, a global multinational chemical company; and UK Coal, the UK's largest coal mining business.

Mr Dunn Holds an MBA from the University of Hull and a BSc in mining and mining engineering from Nottingham Trent University. He succeeds George Schuller Jr who has left Compass Minerals, having been its COO since September 2019. ■

Calendar 2024/25

APRIL

9-11

New Ag International Annual,
BERLIN, Germany
Contact: Informa Connect
Email: info@newaginternational.com
Tel: +44 (0)20 8052 2011

15-17

Nitrogen+Syngas Conference USA,
OKLAHOMA, USA
Contact: Michelle Bingham, CRU
Tel: +44 (0) 20 7903 2159
Email: michelle.bingham@crugroup.com

MAY

20-22

IFA Annual Conference, SINGAPORE
Contact: IFA Conference Service
Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

JUNE

7-8

47th Annual International Phosphate Fertilizer & Sulfuric Acid Technology Conference, CLEARWATER, Florida
Contact: Edin Veladic, convention chair
Email: vicechair@aiche-cf.org

OCTOBER

2-3

TFI World Fertilizer Conference,
WASHINGTON DC, USA
Contact: Valerie Sutton
Tel: +1 202 962 0490
Email: vsutton@tfi.org

JANUARY 2025

26-29

CRU/Argus Fertilizer Latino Americano,
RIO DE JANEIRO, Brazil
Contact: CRU Events
Tel: +44 (0)20 7903 2159
Email: conferences@crugroup.com

New AG Annual welcomes you to Berlin!

PHOTO: ESTREL

The 22nd New AG International Annual event is taking place at the Estrel Congress Centre, Berlin, Germany, 9-11 April 2024. *Fertilizer International* is delighted to be supporting the conference as media partner for the first time.

Estrel Congress Centre, Berlin

This year's New AG International Annual event is being convened in Berlin, Germany, in mid-April. The city's modern, spacious and well-equipped Estrel Congress Centre provides an ideal venue for the fertilizer industry's leading specialty conference.

The New AG Annual is renowned as the premier international event that brings together the specialty fertilizer sector. This must-attend global gathering celebrates knowledge and innovation in the field of plant nutrition, offering a unique forum that joins up cutting-edge research with commercial applications.

Fertilizer International is delighted to have been invited to be media partner by conference organisers Informa/New Ag International and will be attending and exhibiting in Berlin, as well as moderating a conference session.

Network, learn, socialise

For more than two decades now, New AG Annual has been the place where scientists, agronomists and industry professionals gather for a yearly catch-up and learn the latest on:

- **Fertilizers & innovative technology for food**: strategic insights that plant nutrition companies can implement now.
- **Enhanced efficiency fertilizers (EEFs)**: promising new agronomic evidence & advances in product technology.
- **Value-added fertilizers**: plant nutrition tech that improves nitrogen & phosphorus use efficiency.
- **Water-soluble fertilizers (WSFs), specialty fertilizers & biostimulants**: critical insights plus up-to-date market analysis, reports, trends & forecasts.
- **Biostimulants – new products, technologies and agronomic results**: the latest on innovations hitting the market.
- **Plant nutrition, sustainability & the circular economy**: discover how secondary nutrient sources are being recovered and turned into valuable plant nutrition products.

Informative, innovative, inspiring

Join us in Berlin in April to be part of an international event that, uniquely, provides all of the following under one roof over several days:

- **300+ plant nutrition experts** – with backgrounds including scientists, R&D, marketing, business development and regulatory affairs.
- **An international audience** – our events are truly global with attendees from Asia, North America, Latin America, Europe and Australia.
- **Connect with local distributors** – we are dedicated to bringing you more meetings with local distributors than ever before.
- **Unrivalled content** – including the latest updates about the EU's Fertilising Products Regulation (FPR) and insights from notified bodies.
- **NEW workshops for 2024** –an exclusive seminar on the Geopolitics of Agriculture will provide you with critical guidance on how to manage and navigate your business in uncertain times. And lots more!

Expert speakers with cutting edge insights

With a packed agenda spanning two full days, invited speakers at New AG International Annual are leading experts working across plant nutrition on specialty fertilizers, slow-, controlled-release & stabilised fertilizers (SCRSFs) and biostimulants. Strengthen your knowledge with insightful and informative presentations from:

- **Ismail Cakmak**, Professor at Sabanci Unlversity
- **Marko Petek**, Associate Professor, Division for Agroecology, Department of Plant Nutrition, Faculty of Agriculture at University of Zagreb
- **Setareh Jamali-Jaghdani**, Product Development, R&D Agriculture at K+S
- **Sarah Reiter**, Business Development at BioConsortia
- **Vatren Jurin**, Vice President, Product Development at Dunham Trimmer
- **Philipp Theuring**, Market Developer at Easymining
- **Maria Trinidad Garcia Sanchez**, Deputy Director at Alfarin Quimica
- **Michael Tanchum**, CEO at Nexus Foresight
- **Raza Soomar**, Managing Director at RNZ Group
- **Thomas Mannheim**, Global Head of Agronomy at Fertiglobe
- **Hany Abdo**, Laboratory Manager at Toopi Organics
- **Yanora Asia**, Director at Yanora Sdn Bhd
- **Yasser Dergham**, Agronomic Engineer at Humintech

And many others…

See you in Berlin!

Be a part of the future of plant nutrition and join the rest of the global specialty fertilizer community at New AG International Annual this spring. To qualify for your EXCLUSIVE 10% DISCOUNT go to p55 or use the VIP code NAIANN24FI when registering.

Fertilizer International and *New AG International* magazines look forward to welcoming you at the Estrel Congress Centre in Berlin, 9-11 April 2024, for what is always a lively, informative and sociable event. ■

State of the specialty market

PHOTO: BUCCANEERSHIP/STOCKPHOTO.COM

Specialty fertilizer products represent a small volume, high value segment of the overall fertilizer market that's been growing at around four percent per annum in recent years. Economic, environmental, regulatory and agronomic imperatives are driving up their adoption – and an overall shift from volume to value in the fertilizer market.

Microscopic potassium nitrate (NOP) crystal. NOP is a major type of water-soluble fertilizer.

The fertilizer market, fundamentally, remains a commodity market. The three major crop nutrients N, P and K, more often than not, are supplied through four main products: urea, diammonium phosphate (DAP), monoammonium phosphate (MAP) and potassium chloride (MOP). Combined world production of these long-standing, globally-traded commodities is north of 300 million tonnes annually.

Despite the continuing dominance of commodity fertilizers, the shift from volume to value in the market – also known as de-commoditisation – is a recognisable trend. This shift was highlighted by Amit Roy, the former president and CEO of the International Fertilizer Development Center (IFDC), almost a decade ago in his 2015 Francis New Lecture (*Fertilizer International* 467, p18).

From volume to value

For decades now, urea, DAP/MAP and MOP have been manufactured and internationally traded as standardised products. Their pricing reflects raw material/production/shipping costs – as well as the relative balance of supply and demand – rather than their quality, which is already priced in. Value is not generally added and consequently each commodity fertilizer sells at broadly the same price, regardless of the producer, with little, if any, attempt at product differentiation.

That paints a very stable and unchanging pictures of the fertilizer market. Yet something fundamental has changed in the last decade.

Yes, commodity fertilizer production remains the mainstay for most leading manufacturers. But looking at production scale and output in isolation can be deceptive.

Instead, as with any business, you need to follow the money. And when it comes to price premiums, higher margins and market growth, fertilizer producers are increasingly fixated on value-added products.

The Mosaic Company, North America's largest phosphate producer makes a useful case study. Going back more than a decade, Mosaic was a classic commodity fertilizer producer with a largely traditional product offering based on DAP/MAP and MOP.

Since then, it has ramped-up production of its MicroEssentials premium product, a sulphur- and zinc-enriched specialty phosphate fertilizer. Similarly, Mosaic also signalled its shift away from commodity MOP by launching Aspire, a boron-enriched premium potash product, on the market in 2014.

The success of MicroEssentials is a textbook example of de-commoditisation and product differentiation. Mosaic has taken MAP, a standard commodity product and, by adding value, transformed it into a higher margin product with functional properties that confer a competitive advantage.

Mosaic has also overturned the assumption that specialty products are niche and small volume. Production of MicroEssentials has tripled since it first broke through the one million tonne threshold in 2013. MicroEssentials contributed around 2.8 million tonnes to Mosaic's total phosphate sales volumes of 6.6 million tonnes in 2022 – a share of more than 40 percent – delivering a gross margin $33/t higher than its standard commodity sales.

Crucially, MicroEssentials has shown that specialty products can enter the mainstream and displace conventional commodity fertilizers in broad acre agriculture. Indeed, the product is now so ubiquitous it is applied to one in every 10 acres of cropland in the US.

This is a sign that the era of the 'bulk speciality' has arrived – and is no longer a contradiction in terms. It's a term that Anglo American are using for their polyhalite product POLY4, for example, which the mining giant is planning to produce from its Woodsmith mine in the UK at scale of 13 million tonnes annually.

The shift away from commodities at Mosaic is mirrored by rival fertilizer producers. Increasing its capacity to produce and sell premium products is an integral part of Yara International's future growth strategy, for example. Premium products able to deliver high margins – including compound NPKs, calcium nitrate, fertigation and micronutrient products – feature strongly in Yara's fertilizer portfolio, being responsible for around two-fifths of its global sales volumes.

There is a clear financial imperative driving this. Premium products (NPKs and nitrates) generated a total premium of $1.8 billion for Yara in 2022 – versus the commodity alternatives – according to the company's calculations.

The specialty fertilizer market is being keenly embraced by technology providers too. Companies such as Veolia and GEA (water-soluble fertilizers), Stamicarbon (controlled-release fertilizers), Shell Sulphur Solutions, thyssenkrupp and IPCO (sulphur-enhanced fertilizers) are helping fertilizer producers add premium products to their portfolios.

Drivers and imperatives

As well as generating higher margins and premiums, there are also environmental, agronomic and regulatory factors driving greater adoption of specialty products.

The poor nutrient use efficiency (NUE) of commodity fertilizers is spurring change, especially as farmers are currently paying the fertilizer industry for nutrients that never end up in their crops. Amit Roy, in his 2015 Francis New lecture, quoted an IFDC estimate of $116 billion annually for the total economic cost of lost/unused NPK nutrients applied in agriculture (*Fertilizer International* 467, p18).

N, P and K nutrient use efficiency (NUE) can range from 20-80 percent. Even under well-managed systems, NUE rarely exceeds 50 percent. These losses, we know, also have serious and damaging environmental consequences.

On climate, what we also know, from the recent Systemiq report commissioned by the International Fertilizer Society (IFA), is that improvements to NUE will need to do a lot of the heavy lifting in cutting agricultural N_2O emissions out to 2050 – with much greater use of enhanced efficiency fertilizers, such as inhibited or coated products, also being necessary[1].

"If these technologies were implemented with half of all mineral nitrogen fertilizer applied, it could cut greenhouse gas emissions by 100–200 Mt CO_2e in 2050, relative to a business-as-usual scenario," reports Systemiq.

Then there is the agronomic necessity. To quote Amit Roy again:

"It is imperative that new, economically viable products are developed with nutrient-release properties that match crop requirements and contain essential plant-available secondary and micronutrients," he said.

Roy argued that the known shortcomings of standard commodities, and the better agronomic performance and higher margins of specialty fertilizers, should makes it increasingly attractive for fertilizer producers to develop new product lines (*Fertilizer International* 467, p18).

"They are changing their business model from selling large quantities of the same product to one selling small quantities of new products that are more effective in terms of plant uptake and profitable for the company and the farmers," Roy concluded.

Regulatory push

In Europe, policymakers are also having a significant impact on the balance of commodity versus specialty product use. Some are even asking whether clean air policies – namely the EU's 2013 Clean Air Programme and the UK's 2019 Clean Air Strategy – could eventually spell the end for standard commodity urea within Europe.

"There is no doubt among agronomists and fertilizer producers that enhanced urea fertilizers and urease additives will play a bigger role in arable farming because of the need to reduce ammonia losses under Europe's clean air goals. But not every market observer is convinced," commented Julia Meehan, managing editor for fertilizers at ICIS in 2020.

Germany has led the way. Despite consuming 2.2 million tonnes of urea in 2019, the EU's powerhouse economy introduced a new fertilizer ordinance (Düngeverordnung) outlawing its straight use from 2020. This stipulates that:

"Urea as a fertiliser may, from 1 February 2020, only be spread insofar as a urease inhibitor is added to it or is worked in without delay or at the latest within four hours of spreading."

The UK has followed Germany's lead, albeit with a voluntary, industry-led approach.

After consulting with the farming industry on reducing ammonia emissions from urea, The UK's environment department Defra is asking British farmers to use urea treated with an inhibitor for nine months of the year. Untreated or unprotected urea can only be applied to crops from 15th January to 31st March each year when cold and damp conditions prevail.

The new restrictions, while not having legal force, do apply to British farmers participating in the widely-adopted Red Tractor farm assurance scheme. This covers around 95 percent of urea use in the UK

Definitions and range of products

Rams & Co in its 2019 assessment of the global specialty fertilizer market for the International Fertilizer Association (IFA) covered the following product categories:

- **Controlled-release fertilizers (CRFs)**
- **Slow-release fertilizers (SRFs)**, including both urea-reaction products and sulphur-coated urea (SCU)
- **Stabilised fertilizers (SFs)**, usually urea, treated with an urease inhibitor (UI) and/or nitrification inhibitor (NI)
- **Water-soluble fertilizers (WSFs)** for hydroponics, fertigation systems or foliar application
- **Liquid fertilizers** for fertigation or soil and foliar application
- **Micronutrient products** (Zn, B, Mn, Cu, Fe, Mo, etc.), typically sulphates/oxides or chelates (for improved soil mobility and plant availability).

The first three categories are grouped together as slow- and controlled-release and stabilised fertilizers (SCRSFs). Slightly confusingly, these three product types are also known as enhanced efficiency fertilizers (EEFs).

EEFs are defined by the Association of American Plant Food Control Officials (AAFPCO) as: "Fertilizer products with characteristics that allow increased plant nutrient availability and reduce potential of nutrient losses to the environment when compared to an appropriate reference product."

EEFs offer farmers distinct cost advantages over conventional commodity fertilizers. They achieve this by delivering significant savings in inputs, labour, energy and time, alongside potential yield improvements. Beneficially, they can also increase both nutrient and water use efficiency, and reduce the environmental impacts of applying fertilizers to land.

EEFs benefit crops by avoiding excess and potentially toxic levels of soil nutrients that occur when fertilizers dissolve too rapidly. They also moderate the environmental effects of fertilizer use by reducing nutrient losses, preventing nitrate leaching and NOx emissions, and curbing the volatilisation of ammonia.

To obtain the desired properties, such as slower or regulated nutrient release, the fertilizer content of EEF products is either modified chemically or physically encapsulated within a coating (*Fertilizer International* 480, p30)

How big is the specialty market?

In its 2018 assessment for the International Fertilizer Association (IFA), Rams & Co estimated that specialty products were a 20.4 million tonne market that generated around $11 billion in wholesale revenues and about $5 billion in added-value (Figure 1)[2]. At the time, it characterised the speciality segment as:

1. Being a **small volume, high value market** with limited volumes (five percent share of applied nutrients) compared to other global fertilizers but significant value (around 10 percent of global wholesale revenues).
2. **Having significant historical growth** of between six percent p.a. (WSFs) to more than 16 percent p.a. (CRFs) over the preceding decade – and positive fundamentals for growth ahead.
3. **With good growth enablers** including: the rising demand for high quality crops; environmental benefits such as better water quality, lower greenhouse gas (GHG) emissions and reduced air pollution; improved nutrient use efficiency; regulatory changes – although these could either promote or depress market growth.
4. And the potential to **enter the mass market** as a result of fertilizer market de-commoditisation.

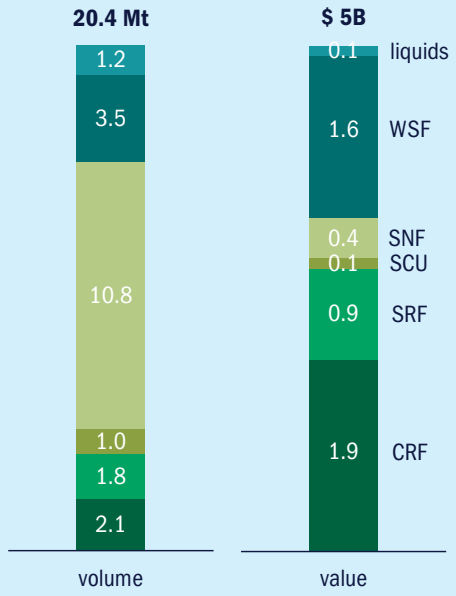
As of 2018, and excluding micronutrients, the specialty market had grown by 3.2 million tonnes in volume since the initial 2016 assessment by Rams & Co[3]. Looking ahead, this positive growth should be maintained in the medium/long term, suggested Rams & Co, supported by production cost reductions and technological advances[2].

IFA subsequently updated the 2016 and 2018 assessments by Rams & Co in 2022 with its own in-house assessment[4]. This provided a complete 2016-2021 annual dataset for three product categories (CRFs, SFs and WSFs). Coverage was less comprehensive than the earlier Rams & Co assessments as it did not report market information for SRFs, micronutrient products and liquid fertilizers.

The headline findings (ex. China) from IFA's latest specialty market assessment are as follows:

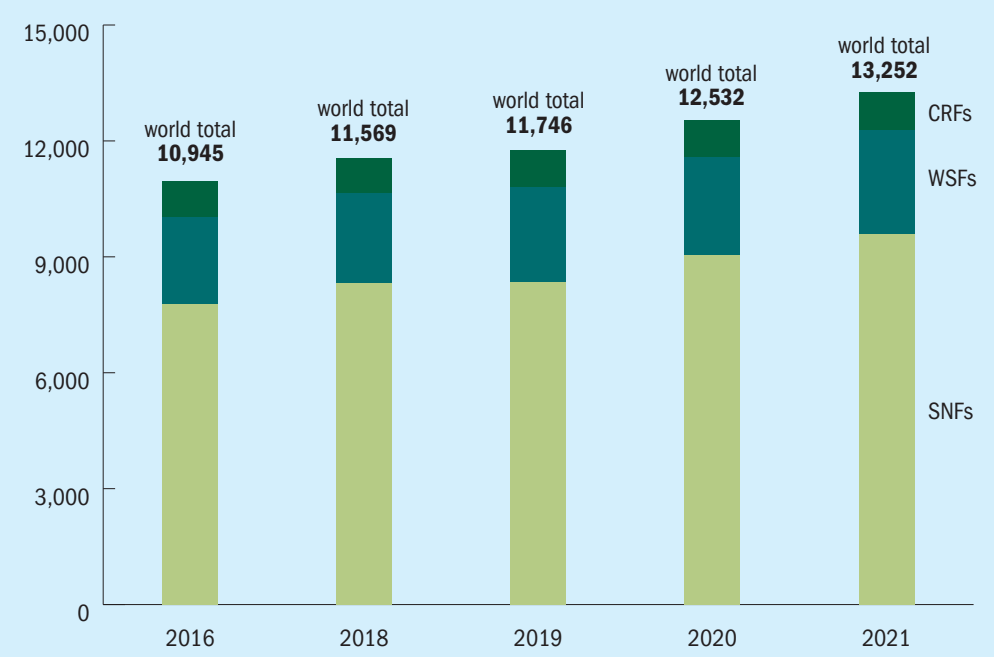
- Global demand for CRFs, SFs and WSFs increased from 10.9 million tonnes in 2016 to 13.5 million tonnes in 2021, a cumulative growth rate of 3.9 percent p.a. (Figure 2).
- SFs are the largest and strongest growing market segment. Global demand for these increased from 7.8 million tonnes in 2016 to 9.6 million tonnes in 2021, a cumulative growth rate of 4.3 percent p.a.
- WSFs are the next biggest specialty market segment. Their global demand increased from 2.2 million tonnes in 2016 to 2.7 million tonnes in 2021, a cumulative growth rate of 3.7 percent p.a.
- CRFs were both the smallest and slowest growing market segment. Their demand increased from 932,000 tonnes in 2016 to 969,0000 tonnes in 2021, a cumulative growth rate of just 0.8 percent p.a.

Fig 1: **Special products, world consumption (left) and added value (right), 2018***



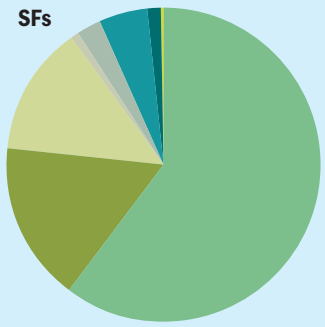
**The speciality market generated around $11 billion in wholesale revenues in 2018.*
Source: Rams & Co (2019)

Fig 2: **2021 Annual global consumption of CRFs, SFs & WSFs (ex. China), 2016-2021, '000 t**

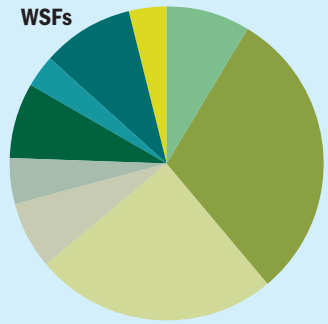


Source: Chilande (2022)

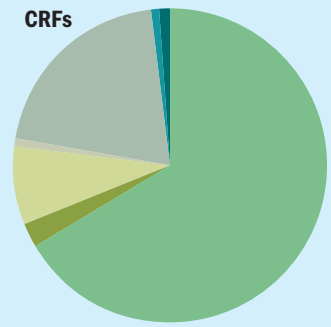
Fig 3: **Consumption of SFs (left), WSFs (centre) and CRFs (right) by region (ex. China), 2021, '000 t**



North America	5,801
Lat. Am. & The Car.	1,562
WCE	1,295
West Asia	85
East Asia (ex. China)	235
Oceania	467
Africa	139
EECA	17
World total	**9,600**



North America	235
Lat. Am. & The Car.	809
WCE	669
West Asia	192
East Asia (ex. China)	128
South Asia	204
Oceania	89
Africa	255
EECA	100
World total	**2,682**



North America	645
Lat. Am. & The Car.	25
WCE	79
West Asia	6
East Asia (ex. China)	198
Oceania	7
Africa	10
World total	**969**

Source: Chilande (2022)

IFA's latest assessment also provides a breakdown of specialty product consumption (ex.China) in 2021 by region (Figure 3). This shows that SFs have a particular strong presence in the Americas and European countries, while regional markets in Latin America and Europe domiate WSF consumption. North America and East Asia, meanwhile, are two key markets for CRFs.

IFA separately reported that the Chinese specialty market grew from 3.1 million tonnes to 3.6 million tonnes between 2016 and 2021, an annual growth rate of 1.7 percent[4]. This 3.6 million tonne market estimate for China, because it was arrived at using a different methodology, is not included in the 2021 world total of 13.5 million tonnes.

WSFs are the dominant specialty product category in China with consumption of 2.0 million tonnes in 2021. Monoammonium phosphate (MAP) and Potassium nitrate (NOP) together account for 60 percent of WSF usage, with the remaining 40 percent evenly distributed between calcium nitrate (CN), monopotassium phosphate (MKP) and potassium sulphate (SOP).

Measuring the market

Establishing the size of the specialty fertilizer market is prone to pitfalls – mainly due to a lack of data, poor data quality and differences in methodology – as others have pointed out[5].

The most obvious problem is the range and variety of product types – some solid, some liquid, while others such as inhibitors and micronutrients are minor product additives. To complicate matters further, the use of SCRSFs also extends to (non-agricultural) turf and ornamental markets.

Trade data is equally problematic. The six- or 10-digit HS codes generally ascribed to globally traded products are not designed to distinguish between specialty and commodity fertilizers. The code 3102100090, for example, covers both technical urea for the diesel exhaust fluid (DEF) market and sulphur-coated urea for agriculture. The HS code 31052000, meanwhile, can refer to standard or coated NPK fertilizers[5].

For these and other reasons, does it even make sense to assess the specialty market on global level?

Some are sceptical. *New Ag International* editor, Luke Hutson, collating and comparing specialty market data from several sources in 2020, including IFA's assessments, commented that[5]:

"Quantifying the market is difficult – very precise numbers may not be a realistic objective, particularly on a global scale … Global figures for SCRSFs probably don't make much sense. Regional numbers might be attainable on a frequent basis … for particular product types."

However, by combining together production capacity assessments and market studies, Hutson concluded that it was possible to set boundaries for the size of the slow-and controlled-release fertilizer market globally – which he estimated to be within a 'landing zone' of 3.9-4.9 million tonnes for 2018[5].

Based on an estimate of global production capacity (5.3 million tonnes), and assuming three percent p.a. demand growth, Hutson expected growing consumption to spur a new investment cycle in slow- and controlled-release fertilizer production between 2022-2024[5]. ■

References

1. Systemiq, 2022. *Reducing Emissions from Fertilizer Use*. Systemiq/International Fertilizer Association (IFA), September 2022.
2. Rams & Co, 2019. *Assessment of the global market for special products*. Prepared for the International Fertilizer Association (IFA) by Rams & Co, June 2019.
3. Rams & Co, 2017. *Assessment of the global market for slow and controlled release, stabilized and water soluble fertilizers*. Prepared for the International Fertilizer Association (IFA) by Rams & Co, November 2017.
4. Chilande, G., 2022. *Assessment of the global demand for special products*. IFA Market Intelligence, December 2022.
5. Hutson, L., 2020. Market overview for SCRSFs – the difficulties in quantifying this market. In: *SCRSFs – the next generation of fertilizers and beyond*. New AG International e-book series.

Fertilizer Latino Americano 2024

The 'Noche blanca' evening reception was sponsored by FertiStream.

PHOTO: ARGUS

More than 900 delegates from 400 companies and 56 countries gathered at the Hilton Downtown Hotel, Miami, Florida, 5-7 February, for the 2024 Fertilizer Latino Americano (FLA) conference. The event was jointly convened by Argus and CRU. We present selected highlights from this year's three-day conference.

Fertilizer Latino American returned to Miami, that most Latin of US cities, having last been held in the Sunshine State in 2022 (*Fertilizer International* 508, p24). The event has drawn record numbers in recent years (*Fertilizer International* 513, p20) as the industry has returned to in-person events post-Covid.

Delegates arrived on Sunday 4th February in the middle of a tornado warning. This extreme weather event was apt, given that sustainability was the focus of the event's opening day on Monday. This remains an overarching theme for the fertilizer industry which, as highlighted at last year's IFA conference in Prague (*Fertilizer International* 516, p36), continues to define itself as the place where energy and food markets intersect.

All things sustainable

Unshaken by Sunday's extreme weather, the conference opened on time on Monday. The opening sustainability forum focused on decarbonisation, EU emissions trading, green ammonia, next generation fertilizer technologies, biostimulants, micronutrients and AgTech.

Sustainability is very far away from being something people are willing to pay for, according to **Hunter Swisher**, the CEO of Phospholutions, because there is still a need for sustainability to demonstrate value.

"Profitability still drives farmer decisions, not sustainability. A product that is less cost effective but more sustainable is simply not a viable product," he said. The yawning gap between farmer and industry perceptions of sustainability therefore need to be bridged, in his view.

USDA research shows that since 1961 global agricultural productivity grew at 2-3 percent annually, according to **Chris Ferreira**, Verdesian's managing director, LatAm & Spain. Previously, these gains have largely been driven by land expansion, increases in irrigation and a greater use of inputs.

But an increasingly important driver has been total factor productivity (TFP). This measures improvements in farmer productivity from innovations in technology, labour and efficient farm practices.

From 1961-1970, TFP contributed a miniscule 0.05 percent to improvements in agricultural productivity. Its contribution to productivity has, however, increased rapidly in subsequent years, rising to 1.14 percent in the decade 2011-2020.

PHOTO: ARGUS

Hunter Swisher, the CEO of Phospholutions, told delegates there was still a need for sustainability to demonstrate value.

In recent years, therefore, ag innovation and greater resource efficiency are contributing more to feeding the planet, relative to other factors. In short: TFP is delivering more food from fewer resources.

Ferreira highlighted the role of fertilizer product innovation in delivering these agricultural productivity gains, now and in future.

Summing up Monday's session, **Tim Cheyne**, head of agriculture and fertilizers at Argus, said: "It's really interesting to see how sustainability is becoming a mainstream issue. Something that the main producers, consumers and farmers are increasingly needing to think about.

"We really dug into some of the key initiatives and technologies which are showing a lot of promise, in terms of improving nutrient use efficiency, [including] biostimulants and biologicals."

Unprecedented volatility and regional risks

Global fertilizer markets, Latin America's role in global food security, Brazil's new agricultural strategy and its ambitious new National Fertilizer Plan were the focus of Tuesday's keynote presentations. Market volatility and supply risks were highlighted throughout. Markets in Argentina, Uruguay and Paraguay also came under the spotlight.

Although recovery has been uneven internationally, Nutrien continues to see demand rising in its key markets, particularly North America, according to **Jason Newton**, the company's chief economist. He opened the main conference with a keynote address that placed the fertilizer

market in regional settings and its wider global context.

Unprecedented commodity market volatility was a key theme of Newton's presentation.

"We are, in the last 2-3 years, in an environment globally that is more volatile than certainly at any point in my lifetime – and probably in the lifetimes of most of you in this room," he told delegates.

Newton flagged up three disruptive geopolitical events, namely:

- **Russia-Ukraine**. Currently, Ukrainian grain production and exports remain around 30 percent down from 2021/22 levels, while fertilizer exports from Russia have returned to near/above pre-war levels, with the exception of ammonia.
- **The emerging Middle East conflict**. This is a cause for concern given the region's significance as a key maritime hub for global crude oil and LNG shipments. There are signs of increased shipping costs and transit times as vessels divert from the Red Sea. A widening conflict could impact on production and trade in the region, as well as wider global trade flows.
- **China's urea and phosphate export restrictions**. These have tightened the global supply/demand balance. China has traditionally been a key destination for imports of soybeans, corn, wheat, barley and rice. But the country's increasing focus on domestic crop production and sufficiency is prioritising internal fertilizer supply.

Collectively, all of the above have the potential to affect fertilizer, crop and energy markets and freight rates. Yet, at the time of the conference, fertilizers were not really seeing a risk premium from any of these three events, Newton said.

Summing up, Newton highlighted four key macroeconomic drivers to watch out for in 2024:

- El Nino-related weather volatility and its impact on Brazil's corn and soybean harvest
- Geopolitical unrest
- Macroeconomic uncertainty
- Supply chain risks.

These were all important market influences, suggested Newton, because, although supply and demand have re-balanced, macroeconomic drivers could be highly volatile in the year ahead.

PHOTO: ARGUS

Left to right: Tim Cheyne, head of agriculture and fertilizers at Argus, in discussion with Alzbeta Klein, IFA's DG/CEO, Marcelo Altieri, Yara's SVP for Latin America, Eduardo Monteiro, Mosaic Fertilizantes' supply chain director, and Ruy Cunha, Lavoro's CEO.

Navigating a chopping and changing market

The need to build more secure and responsive supply chains in Latin America was a key talking point among the panel in the next keynote. This explored global food security and how best to navigate a constantly changing fertilizer market.

Ruy Cunha, Lavoro's CEO, said we're in a more volatile world than before with strong but shifting fertilizer demand patterns. In Brazil, for example, last minute buying decisions were proving to be particularly problematic in his view.

Marcelo Altieri, Yara's SVP for Latin America, agreed. He said last minute buying behaviour not only placed stress on supply chains, it also ended up with farmers paying more for their product.

The lesson of recent years for the industry, policymakers and others was a simple one, said **Alzbeta Klein**, the DG/CEO of the International Fertilizer Association (IFA): "Food is energy." Whatever happens in energy markets is subsequently reflected in food baskets, she said.

Eduardo Monteiro, Mosaic Fertilizantes' supply chain director, said "innovation must be part of the fertilizer industry's DNA" if it was to continue to thrive. Summing up, Marcelo Altieri called on the whole of the agricultural supply chain to take a systemic approach and share the costs, the risks and the rewards of making food production 'nature positive'.

Latin American supply risks

The themes of supply risks and freight costs were centre stage on Wednesday, the last day of the conference.

Chris Lawson, CRU's head of fertilizers, gave an informative review of the supply risks facing Central and South America. Chris's general take was that, while not expecting an immediate price surge, there was no room for complacency. "I don't see the fertilizer market going to the moon again any time soon," he said.

Nonetheless, a range of medium-to-low risks to Latin American fertilizer supply were highlighted. The drought afflicted Panama Canal, for example, looks set to affect vessel supply and movement for the next few years, although the hit to freight rates has now largely been priced in.

Houthi attacks in the Red Sea were also on Chris's radar. Increases in Red Sea bulk freight rates have been modest to date at around +$10/t.

Producers in Egypt, Israel and Jordan are most exposed to Red Sea risks, in Lawson's view. While Gulf producers are also at risk, they have more viable alternative shipping routes available to them.

Chris Lawson, CRU's head of fertilizers, gave delegates the lowdown on global supply risks.

PHOTO: ARGUS

It is the scale of fertilizer trading out of the Middle East, however, which makes the prospect of deepening regional conflict worrisome. The global trade share of Middle Eastern urea, sulphur and phosphate rock is around 40 percent for each commodity, while ammonia from the region has a 30 percent share of global trade.

Consequently, urea supply to Latin America from the Middle East is at medium risk of disruption, in CRU's view. Brazil is particularly reliant on urea supply from Qatar, Oman and other Gulf producers, for example.

Lawson also gave a round up of risks to the supply of potash from Belarus and Russia, and briefed delegates on the status of urea and phosphate exports from China. Macroeconomic risks and European ammonia production economics were also covered.

Carolina Tascon, commercial executive director, VLI Logistica, gave a detailed presentation on the cost structure of fertilizer logistics in Brazil. Around 85 percent of fertilizer transport in Brazil is by road, not rail. This is less efficient and more expensive due to the sensitivity of truck transport to fuel cost rises.

Tascon was optimistic about the scope for reducing Brazil's fertilizer freight costs by optimising port logistics and shifting fertilizers from road to rail. When combined with new rail and waterway infrastructure projects, there is potential to cut fertilizer freight costs to Mato Grosso state from BRL 217/t to BRL 175/t, Carolina concluded.

Carolina Tascon, VLI Logistica's commercial executive director, took a deep dive into Brazil's fertilizer logistics.

PHOTO: ARGUS

Parting thoughts

Following a sociable, insightful and highly informative conference, delegates departing Miami were left with plenty of follow up questions, such as:

- Firstly, does Argentina's depressed fertilizer consumption of 4.6 million tonnes in 2023 represent the floor? The country's trade association seems to think so and is anticipating a potential recovery in domestic consumption to between 4.7-7.0 million tonnes by 2030.
- Secondly, will Brazil deliver on its ambitious national fertilizer production plan? The region's agricultural powerhouse is aiming to supply 50 percent of its fertilizer demand domestically by 2050. The fortunes of Brazil Potash's 2.2 million tonne capacity Autazes project is one bellwether.
- Finally, will the arrival of blue ammonia capacity be hypothecated to emerging energy/fuel markets or end up competing with grey ammonia instead. Future price trajectories for the ammonia market may partly depend on this.

Fertilizer International will be looking to inform its readers about these and other critical issues as 2024 unfolds.

Save the date!

Next year's Fertilizer Latino Americano conference is returning to Rio de Janeiro, Brazil, 26-29 January 2025. Please visit the event's website for the latest information on registration, sponsorship, the exhibition and agenda:

events.crugroup.com/fertilizerlatinoamericano

Author's note

Market information and commentaries should be interpreted with caution as these date from the time of the conference in early February and may no longer be accurate. ■

The conference exhibition attracted great delegate interest and proved popular for networking.

PHOTO: ARGUS

SOURCE: YARA

Biostimulant crop application, Greece.

New biostimulant developments

Biostimulants are emerging as mainstream products with major fertilizer producers – including Yara, Mosaic, Fertiberia and ICL – launching their own biostimulant lines and expanding production capabilities. Smaller innovative companies, meanwhile, such as Azotic and Fyteko, remain the mainstays of the sector and are continuing to being new products to market. Other players such as Den Nouden/GrowSolutions are targeting the expansion of organic fertilizers.

MARKET COMMENTARY

Biostimulants enter the mainstream

Biostimulants cover a diverse range of products designed to improve nutrient use efficiency and protect crops from abiotic stress. Growers generally purchase biostimulant products to improve crop yields and/or crop quality.

The main types of biostimulant include:

- Seaweed and other plant extracts
- Humic and fulvic acids
- Inorganic salts such as phosphites
- Chitin and chitosan
- Anti-transpirants
- Amino acids and peptides.

The global market for biostimulants (including microbial biofertilizers) was estimated at $2.56 billion in 2021, according to a report by S&P Global. This compares to a market size of $2.32 billion in 2020 and $2.1 billion in 2019. The market is currently growing at around 10 percent per annum (*Fertilizer International* 515, p20).

There is increasing acceptance and integration of biostimulants into the wider fertilizer and agricultural markets. This is illustrated by rocketing sales, the spate of new product launches, and merger and acquisition (M&A) activity.

A selection of leading biostimulant companies is shown in Figure 1. New entrants

Fig. 1: **Leading biostimulant companies**

to the sector, including incumbent crop nutrient companies, have generally built up their biostimulant portfolios through M&A and/or partnerships with start-ups and smaller market players.

Arguably, the last 12 months has been a breakthrough period for the emergence of biostimulants as mainstream products, with major fertilizer producers – including Yara, Mosaic, Fertiberia and ICL – launching their own biostimulant lines and expanding production capabilities.

Yara takes a leading position

Yara International launched YaraAmplix™, its new biostimulants product line, on the market in December last year. The range was unveiled to great fanfare at the Biostimulant World Congress in Milan, Italy. The launch was in response to increasing demand for products that can protect crops against climate change and optimise nutrient use efficiency, the company said.

"Climate change is putting many of the world's most popular foods such as maize, tomato and wheat at risk of reduced crops. With the average global temperature on earth having already increased by over one degree celsius in the last 100 years, agriculture is now experiencing more extreme weather than ever before," Yara said in a statement.

Yara has developed a comprehensive portfolio of biostimulants over the last five years – with year-on-year sales of these growing at more than 50 percent since 2018. These biostimulants will now become part of a new brand family, YaraAmplix, with several new products in the pipeline for 2024.

Yara's biostimulant range is mostly formulated from natural ingredients, including seaweed and plant extracts, with individual products designed to deliver targeted effects such as better resistance to abiotic stress, higher nutrient use efficiency, and crop yield and quality improvements.

"Extreme weather is destroying crops all over the world with drought, flooding and frost. Biostimulants helps farmers make their crops stronger, and more resilient to stress from climate change. Farmers are the first line of defence against food insecurity, and we are adapting to their needs with solutions that allow them to prosper when the environment is not always on their side," said Svein Tore Holsether, Yara's CEO.

Yara is a vocal backer of regenerative farming and what it calls a "nature-positive food future". The company expects YaraAmplix to become a key offering for farmers in the future by complementing its standard fertilizer portfolio as part of a more holistic crop nutrition package.

Yara's biostimulant products are backed by independent scientific trials. These are being carried out in all regions to evaluate and validate their effects for different crops under various conditions. To date, results have shown that biostimulants deliver an average yield increase of 7.5 percent over control treatments, with a 'win rate' of 74 percent, based on a 359 point dataset collected between 2018 and 2020.

The launch of YaraAmplix, by increasing the company's focus on regenerative agriculture, is why Yara is taking a leading position on biostimulants, says Rejane Souza, Yara's SVP for global innovation.

"Popular foods we all rely on, such as tomato, maize, soybean, and citrus to name a few, are at increased risk of yields loss due to extreme weather, so lowering greenhouse gas emissions to avoid a worsening scenario is key. As part of the solution, biostimulants are an essential tool to help reduce loss of food due to climatic stresses while improving nutrient use efficiency, a critical lever when it comes to enabling farmers to keep their business profitable and sustainable.," she said.

The YaraAmplix range is currently available in China, Brazil and France and will be gradually rolled out globally during 2024.

In May last year, Yara also announced that it was building a major new speciality fertilizer and biostimulant production plant near York in the UK (*Fertilizer International* 515, p7). Virtually all the plant's output will be exported to international markets when it is completed next year.

"Sales of YaraVita specialty crop nutrition products and biostimulants have grown fivefold in the last 20 years. These products are formulated to meet the specific needs of crops throughout the growing season and to help them increase their resilience to climate change," Yara said in a statement.

Bringing bio-inhibitors to markets

Spain's Grupo Fertiberia made its first major foray into the biostimulants market two years ago with the acquisition of Trichodex, a Seville-based biotech company founded in 1991.

Trichodex develops, manufactures and markets a range of functional agricultural products, including biostimulants and biofertilizers, based on patented biological processes. These 'bioactive' compounds protect crops against disease, pests and abiotic stress and boost profitability by improving yields. The company currently markets its biotech products in a dozen countries in Europe and Latin America.

The purchase of Trichodex is part of Fertiberia's strategy to offer high added-value biofertilizers and biostimulants as part its product portfolio. "The combination of Trichodex biotechnology with the development of innovative products from Grupo Fertiberia will provide farmers with cutting edge sustainable tools to improve their crops," commented Javier Goñi, president of Grupo Fertiberia.

In a market first, Fertiberia launched the bio-inhibitor NSAFE in December last year. NSAFE is designed to prevent nitrogen losses, protect soil biodiversity and increases yields.

The product acts as a nitrification inhibitor and prevents losses from soil (leaching)

Testing new fertilizer technologies at Pocklington near York in the UK. Yara plans to build a new speciality fertilizer and biostimulant production plant at the site.

PHOTO: YARA

PHOTO: FERTIBERIA

Fertiberia's NSAFE bio-inhibitor took more than six years to develop.

and to air (volatilisation). Consequently, nitrogen remains active in the soil for longer, allowing greater uptake by the crop.

NSAFE is the first biological product on the market with a nitrification inhibiting effect, according to the company. "This technology allows fertilisers to enrich the soil through their microbial nature, thus offering a more efficient and environmentally friendly alternative to traditional chemically synthesised inhibitors," Fertiberia said in a statement.

NSAFE took more than six years to develop and has been launched in Spain prior to other international markets. It is being incorporated into Fertiberia's Nergetic DZ+ fertilizer, a nitrogen top dressing, before being rolled out to the rest of the company's Nergetic product line.

NSAFE is more efficient than chemical inhibitors, according to Fertiberia, as it acts on nitrate nitrogen (NO_3^-) – not ammonium nitrogen (NH_4^+) as synthetic inhibitors do – absorbing this in protein form, before releasing it as organic nitrogen at the end of its life cycle.

"This pioneering technology protects nitrogen and prolongs its activity, remaining active in the soil for a longer amount of time and allowing plants to absorb it more slowly," said Alfredo Segura, Fertiberia's commercial director. "And it does so with a twist: respecting microbial life and without having an impact on microorganisms present in the soil".

Mosaic launches biological product platform

The Mosaic Company launched Mosaic Biosciences, a new global platform for its biological crop products, in August 2023. The move is designed to help Mosaic introduce new biostimulants and biofertilizers that complement and enhance the performance of traditional crop nutrient products.

"The technologies from Mosaic Biosciences enhance crop health and support the natural biology in plants and soil, ultimately maximizing the yield potential of every field… Mosaic continues to invest in biological technologies to bring best-in-class technology to growers.," Mosaic said in a statement.

The platform will market and sell Mosaic's growing portfolio of biological products. Quoting analysts, the company says the market for agricultural biologicals could reach nearly $30 billion by 2029.

"Mosaic Biosciences is a natural extension of our strong crop nutrition portfolio," said Floris Bielders, Mosaic's VP for strategy and new business platforms. "Rooted in science and proven in the field, our portfolio of biological technologies supports the existing biology in plants and soil to deliver healthier, stronger crops."

The Mosaic Biosciences portfolio includes the biofertilizers PowerCoat® and BioPath®. Both products incorporate proven strains of plant growth promoting rhizobacteria (PGPR) and are designed to improve nutrient use efficiency and enhance plant growth and vigour. Other products within the portfolio help mitigate abiotic stress from drought, heat and salinity.

Mosaic is using its new platform to "actively build a pipeline of new biologic products to drive improvements in plant health, stress management, nutrient uptake, and crop yield", the company said.

"Our portfolio of nutrient use enhancement technologies is just the start for Mosaic Biosciences," said Bielders. "In the coming months and years, we expect to bring additional biological products to the market – all of which will be backed by science and in-field experience. Biologicals are crucial in the evolution of crop nutrition and will elevate the potential in every field."

One of these new products is PRB9™, a liquid biostimulant (0-3-3) designed to combat abiotic stress. This 'next-generation' biological product contains an osmolyte compound which is naturally produced by plants as a coping mechanism when they are under abiotic stress.

Plants divert energy away from growing to protect their health in response to stressors such as heat, drought and even high-salinity irrigation water, says Mosaic. By adding PRB9™, either before or at the first signs of stress, hydration within the plant's cellular structure is maintained. This helps to balance the osmotic pressure inside each cell, thereby mitigating the leaf curling and wilting caused by abiotic stresses such as heat, drought or salinity.

PRB9™ is tank-mix compatible with most standard crop protectants and liquid fertilizer solutions, and can be incorporated into foliar sprays, fertigation solutions or pre-blended with liquid fertilizers. By supporting water and nutrient transport during stress events, the product helps improve crop yields by maintaining plant growth and vigour.

Capturing RNAi technology

Fertilizer producer ICL and biotech company PlantArcBio have successfully collaborated on the development of a novel biostimulant. The new product uses RNAi technology to maximise the natural yield increasing mechanisms of plants. It has been shown to successfully improve crop yields while having a minimal impact on the environment.

This novel biostimulant has significantly increased seed weight per hectare for canola crops in early-stage field trials. ICL and PlantArcBio are planning larger-scale field trials that will test the new technology using both commercial sprayers and standard farming practices.

Greenhouse trials for soybeans and rice are already in progress, with early results showing good potential. ICL and PlantArcBio have already filed a joint patent for their new RNAi biostimulant covering its application on multiple crops.

"The use of novel biostimulants based on RNAi technology helps promote sustainability, by reducing the use of chemicals in agriculture," said Hadar Sutovsky, ICL's VP for external innovation and the general manager of ICL Planet. "[it] does its work, then rapidly disappears from both the plants and the environment, lasting no more than a few days, as it is highly biodegradable and also leaves no residual footprint."

"The positive canola field trial results constitute another milestone in strengthening PlantArcBio's capabilities in the development of RNAi-based products," said Dror Shalitin, the founder and CEO of PlantArcBio. "ICL, a market leader in crop nutrition products, is a great strategic partner for us to commercialize this sustainable technology worldwide." ■

FYTEKO

Can biostimulants protect crops from climate change?

Guillaume Wegria

PHOTO: FYTEKO

Guillaume Wegria, one of Fyteko's co-founders.

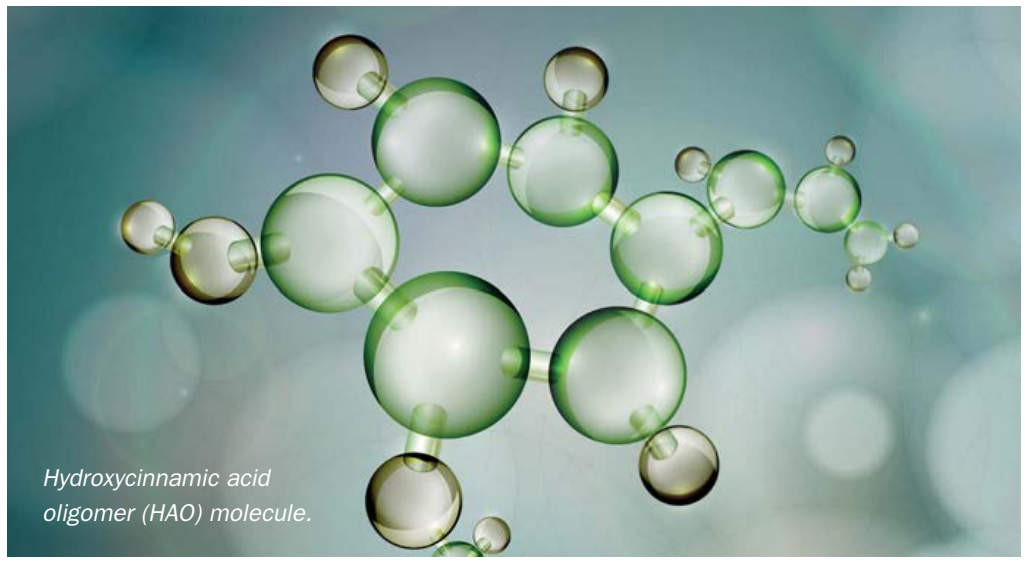


PHOTO: FYTEKO

Hydroxycinnamic acid oligomer (HAO) molecule.

A Belgian start-up is determined to help farmers through the climate crisis with its first product, a 'drought-proofing' biomolecule.

More likely than not: that's the probability that world mean temperatures will pass the 1.5 degrees global warming threshold before 2027, according to the World Meteorological Organisation's latest assessment.

A sobering verdict. But for the Brussels-based pioneering biomolecular manufacturer, Fyteko, those four words were a vindication that the route it chose as a business nine years earlier was the correct one.

It was 2014 when Fyteko's co-founders, Guillaume Wegria and Dr Juan-Carlos Cabrera, discovered the hidden properties of a hitherto neglected molecule, hydroxycinnamic acid oligomers (HAO), found in the cell walls of plants.

In fact, HAO turned out to be a remarkably powerful 'signal' molecule. When applied as a foliar or seed treatment, it 'primes' the growing crop against future abiotic stresses, enabling it to endure drought, extreme temperatures and other weather events, all of which are expected to become more common and more severe, if the WMO is proved correct.

The two bio-entrepreneurs acted quickly to patent their discovery and commercialise the use of HAO by establishing Fyteko as a vehicle to successfully synthesise this biomolecule at scale.

"The WMO report is sobering, but the truth is we just don't know how serious climate change will be for agriculture," comments Guillaume Wegria. "What we do know is that it's not going to be easy – growing crops is going to become more difficult.

"And one of the most significant climate-induced challenges for the world's farmers will be dealing with crop stress. Crops respond to stress by slowing growth and development, leading to depressed yields and loss of quality," he adds.

A 'climate-smart' biostimulant

Wegria calls the HAO biostimulant 'climate-smart': "Essentially, it's a 'drought-proofer'. By allowing cells to co-ordinate their activities in response to external stimuli and internal processes, HAO ensures the plant doesn't overreact when it encounters stress."

Wegria and Cabrera were thrilled to discover that even in the absence of recorded stress events, HAO can influence treated crops to the extent of a 14 percent yield increase.

"This phenomenon suggests crops can experience sub-clinical stress events, asymptomatically, that go unnoticed. HAO appears to limit the effect of those minor events," says Wegria.

This specific effect relies on a very simple mode of action. HAO, by bringing about a change in gene transcription, triggers a 'remapping' of metabolic processes, pathways and cell functions – these being identical to the biochemical responses observed in crops subjected to stress.

So, just as a vaccine primes human immune systems, HAO primes the plant. When incidences of abiotic stress occur later, these are recognised by the plant, triggering the same biochemical response. Plants primed in this way are better able to withstand stress events and, equally valuably, have a better recovery rate post-stress.

"The effects of seed treatment are most interesting," says Wegria. "HAO seems to accelerate germination and early seedling establishment. We know the importance of early establishment in optimising a crop's yield potential, but the signal molecule takes this further, offering additional protection against subsequent abiotic stress."

In experiments where plant seeds were treated with HAO, it triggered a faster response to stress from the internal defence mechanisms of young plants. Osmo-protection increased, for example, as did antioxidant synthesis.

Strong field results

A range of maize field trials were conducted using Fyteko's HAO product NURSEED®HC between 2017 and 2022. These were carried out for three different production levels: a lower inputs system (yield below 65 dt/ha), a medium level system (yield 65-100 dt/ha), and an intensive system (yield above 100 dt/ha).

The highest yield increase (12 percent) was observed in the low production plots. Medium production saw yield increases of 5.3 percent, while the intensive system reported a 3.9 percent yield increase (Figure 1).

NURSEED®HC delivered a high return of investment for the farmers. On average, they gained between $120 to $140 per hectare, depending on the production level.

Commercial interest

These results and ongoing positive findings have allowed Fyteko to establish successful partnerships with key players in the European seed market.

Technisem, a French company engaged in marketing quality seeds in West Africa – a tropical area vulnerable to abiotic stress – was quick to see the potential of the technology, and NURSEED®MAX soon featured on hundreds of tonnes of Technisem seeds.

Next in line was a partnership with Limagrain, a major player in European field seeds. This saw NURSEED®HC included within the company's maize seed portfolio. The product was included in Limagrain's European maize offer in 2023, before its roll out to other regions and more crops.

Interest in Fyteko's unique biomolecules has continued to grow, with French seed technology specialist Cerience becoming the latest collaborator. This new agreement introduces NURSEED®HC to the forage seed market.

Most recently, Fyteko agreed a distribution contract with Janssen PMP, a division of Janssen Pharmaceutica, in September 2023. This development extends Fyteko's European reach, as well as bringing farmers in Africa, Australasia and the Americas – including 12 US states – on board with this drought-proofing product.

The European Patent Office's recognition of HAO in 2023, by granting Fyteko's first European biostimulant patent, was another boost for the company.

Avoiding unpredictable cocktails

"Biostimulants are the fastest-growing category in plant protection worldwide. But the vast majority of commercial biostimulants are a cocktail of different molecules," notes Wegria.

"This can create problems in a like-for-like comparison against conventional agrochemicals because it's difficult to generate consistent results from multi-compound formulation for analysis and product refinement."

A major problem with multi-compound biostimulants is how to integrate them successfully with other products, bio-based or conventional.

"Something that looks good in the lab may perform very badly in the field, because you must understand the other interactions," explains Wegria.

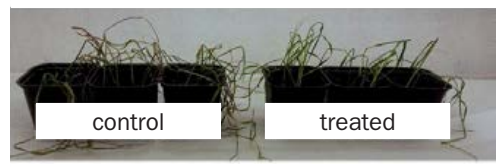
"Furthermore, that kind of experience can be a hindrance in boosting farmers' adoption of biostimulants. There have been many 'bio' products that have over-promised and underdelivered.

"Our biomolecule is a single compound, applied at low rates. We know how it will behave, and in assessing its performance in existing seed treatment processes it displays excellent compatibility."

Fyteko's strategy of engineering biostimulant formulations for specific uses, coupled with its focus on natural and novel signal molecules, is a cost-effective and efficient approach, says Wegria:

"We're one of very few companies developing biostimulants based on single, identifiable active ingredients that have a specific effect on the crop. We can tailor development to meet the unique requirements of each farming segment. That's going to be the hallmark of the next generation of bioproducts."

After seven days under drought stress



SOURCE: FYTEKO

One day after re-watering

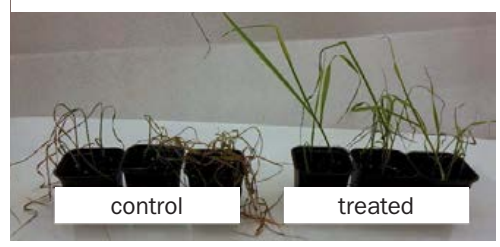
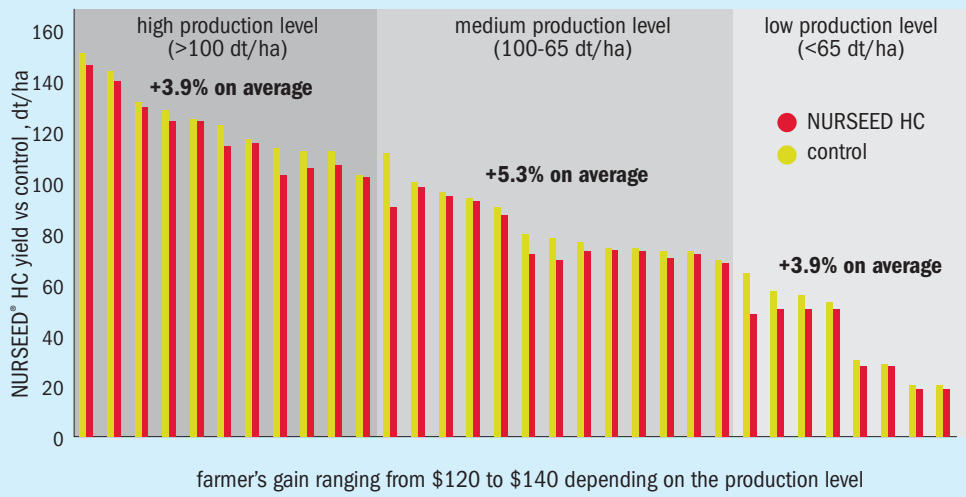


Fig. 2: Enhanced tolerance of wheat plants to simulated drought stress. These were grown from seeds treated with the HAO signal molecule developed by Fyteko.

Fig 1: **Yield response of maize after seed treatment with the biostimulant NURSEED®HC for three different levels of production intensity: high, medium and low (left to right)**



Source: Fyteko

Next in the pipeline

Fyteko's biomolecule development pipeline – its 'bio-based technology discovery platform' – already has biostimulants, herbicide bioenhancers and biocontrol products underway. These are creating what is effectively six different 'patent families' as part of Fyteko's intellectual property (IP) strategy.

The whole of this portfolio has potential for increasing and optimising crop yields, according to Fyteko.

"Agri-biomolecules are a brave new world. It's what we need to see in tomorrow's agriculture – if we're to maintain productivity and improve our sustainability," sums up Wegria. ■

Acknowledgement

Reporting and interview by Adrian Bell, Agromavens.

AZOTIC TECHNOLOGIES

Got nitrogen?

Tom Tregunno

Can biological nitrogen fixation help farmers become more resource-efficient and change their relationship with synthetic fertilizers – by enabling crops to draw down their own nitrogen from the atmosphere?

In answering this question, it was the puzzle of Brazil's sugar cane, grown to supply the country's nascent fuel-ethanol industry, that caught the attention of researchers in the 1980s. Why were crops in less productive areas of the country thriving despite receiving little or no nitrogen fertilizers?

The answer finally emerged in 1988 when scientists isolated a new species of bacteria – *Gluconocetobacter diazotrophicus* (Gd) – from sugar cane samples. This was found to provide the sugar cane with significant amounts of nitrogen.

The discovery of Gd, a type of bacteria that lives inside the plant cell (an endophyte), would be the first step in a thirty-year project to harness the power of these types of bacteria – and in doing so change the perception of farmers around the world about how to deliver nitrogen to their crops.

Nitrogen-fixing bacteria are not new to agriculture. Soybeans, peas, beans and alfalfa – all members of the legume family – have been exploiting the fertility these impart to soils for thousands of years.

Yet only in 1838 was it established that these types of crops had the ability to fix nitrogen. It then took another 50 years to work out that another class of microbes, rhizobacteria, were responsible. These enjoy a symbiotic relationship with legume crops by taking up residence in characteristic root nodules.

Going back to endophytes, these are now known to be hosted by around 300,000 plant species. Researchers have established that they promote plant growth, counter stress conditions and improve micronutrient uptake. Some even release chemical inhibitors to prevent competing plants from growing too close to their host!

Agricultural researchers now consider endophytes to be a new, broad class of biological crop inputs, based on these valuable characteristics. Indeed, several are already in commercial use.

But Gd's unique behaviour, like those of rhizobacteria, is of more fundamental interest. As a diazotroph, it can capture inert nitrogen from the atmosphere and turn it into a plant-accessible form, thanks to the presence of nitrogenase enzymes.

"Legumes are a great crop to have in any rotation," says Tom Tregunno, global business development manager for Azotic Technologies, the British company that is now commercialising the Gd research. "Not only can they fix their own nitrogen, but they leave residual nitrogen available in the soil for use by the following crop.

"It's not surprising, then, that the Holy Grail for plant scientists has been to try to replicate the mechanism we see in legumes in other crops such as cereals. But such is the specificity of rhizobacteria – each legume favours its own species of bacteria – that it's not been a simple task."

This highlights the appeal of Gd: it's a naturally occurring bacteria that scientists don't need to modify in any way. Unlike rhizobacteria, it's not plant specific. On the contrary, there's a growing body of research and trials showing how it works across a spectrum of crops, according to Tregunno.

In-cell nitrogen

Azotic's efforts to bring the product to market – it's sold as Envita in North America, and Encera across Europe – builds on the decades of research conducted by the University of Nottingham in the UK.

Gd is applied to crops either as a foliar treatment or in-furrow at planting. Either way, the bacteria quickly colonise the whole plant, using enzymes to enter the cells. There, it establishes a 'vesicle', and reproduces as the plant grows, to spread throughout the plant.

"The vesicle is Gd's equivalent of the root nodule we see in legumes – except it's not limited to the root," says Tregunno. That vesicle is a miniature nitrogen-production factory, where atmospheric nitrogen is turned into ammonia, NH_3.

PHOTO: AZOTIC

Tom Tregunno, global business development manager, Azotic Technologies.

"As well as being species and crop-agnostic, Gd also has the edge over rhizobacteria because it's producing nitrogen exactly where the crop needs it – in the leaves, where photosynthesis takes place. Here, growth and yield are ultimately determined.

"With Gd pumping out nitrogen, it gives the crop accessible nitrogen where and when it's needed."

That season-long supply of in-crop nitrogen holds much appeal. While it is possible to supply crops with small amounts of nitrogen frequently, little and often, this is not generally feasible or practical. Instead, to be cost effective, farmers make fewer but larger applications of nitrogen – effectively 'banking' it in the soil to be used by the crop later.

Not all that nitrogen reserve makes it to the crop, though. While conservative estimates put the lost nitrogen at around 50 percent, as much as two-thirds of the soil-applied nitrogen won't make it into the crop. These large-scale losses are due to run-off, volatilisation to the atmosphere or consumption by soil bacteria.

On-farm use

Azotic's research has now demonstrated Gd's compatibility with commonly grown field crops, including cereals, potatoes, maize, sugar beet, cotton, rice, soybeans

and alfalfa, as well as protected crops like tomatoes.

Azotic doesn't claim Gd is a complete substitute for conventional nitrogen fertilizer, as Tregunno is keen to stress:

"Crops treated with Gd will either reduce their demand for synthetic nitrogen by between one-fifth and one-quarter while maintaining yield, or they'll increase yield within a standard fertilizer programme.

"However, that's only the 'basic' offering. Depending on the crop, we've observed a slew of extra effects."

What is common across all crops is Gd's ability to provide nitrogen when it's most needed – during times of abiotic stress, such as excess heat and drought.

When temperatures rise, plants react by reducing transpiration, explains Tregunno, with this, in turn, limiting the ability to take up soil nitrogen. The same effect is observed when soils dry out, as plants can only take up nitrogen when there is sufficient soil moisture.

"When treated with Gd, there is a considerable and valuable effect on late-season N management in any crop," says Tregunno. "Gd provides plants with nitrogen even under adverse conditions, the result being that the crop stays green and keeps photosynthesising for longer."

In US silage maize, for example, independent trials have shown an average yield increase of around 1.8 t/ha when Gd is used across different nitrogen regimes. Crop quality was also found to have increased, specifically crude protein and essential amino acids, when treated maize was tested at Penn State University. Farmers also reported improved plant vigour in addition to the yield increase.

PHOTO: AZOTIC

Envita treated maize, (left), versus untreated control (right) for a trial in Seymour, Wisconsin.

"Maize is a crop that is often in the spotlight as a 'troublesome' crop when it comes to nitrate management," notes Tregunno. "So, to offer growers the ability to reduce nitrogen applications without reducing yield is pretty compelling."

PHOTO: AZOTIC

Three maize cobs grown from Envita treated maize (left) versus three from untreated control (right) for a trial in Logan, Iowa.

Sacks more potatoes

Potatoes are another crop requiring careful nitrogen management. As nitrogen is the key macronutrient influencing tuber size, application timing is everything.

"Early nitrogen goes into leaf production and a vigorous canopy; late nitrogen maintains that canopy and increases tuber size," Tregunno explains.

"Because Gd helps ameliorate any nitrogen shortages, it prevents the plants from entering a stress phase that will cause them to lose part of their set. When this happens repeatedly – and it need only be for the few hours in between irrigation events – the grower ends up with the wrong size tubers that won't make the grade for the intended usage, be it chipping, processing, maincrop or salad."

Trials have revealed Gd's positive effects. In one instance, Envita-treated potatoes returned an average of 39 sacks more 'Grade A' tubers, and a yield increase of 4.4 t/ha.

Understanding the science

While Gd works by providing an in-cell source of nitrogen throughout the season, it owes its effects on vigour and quality to the type of nitrogen it produces.

"Crops' reliance on the nitrate form of nitrogen favours vegetative growth," Tregunno points out. "Gd, however, produces nitrogen as ammonium.

"That acts to promote root growth, bringing benefits that include better drought resistance and improved overall nitrogen uptake. It also increases reproductive growth so, in flowering crops such as oilseeds and cotton, that means more flowers."

Thoughtful launch strategy

Azotic has also put a lot of effort into researching how Gd performs in tank mix. "Growers want to minimise the number of times they have to go into the field to make an application," acknowledges Tregunno.

"Biologicals, biostimulants, biomolecules – these are unfamiliar product classes. Farmers are well-versed in using agrochemicals and other conventional crop inputs – many practise their own agronomy too – but anything 'bio' is still unfamiliar."

While Azotic's launch strategy – the product was first available in North America in 2019, before going on sale in the UK and four EU countries in 2022 – focused on how Gd interacts with agrochemicals in tank-mix, it was also backed by extensive trials and demonstrations. These took the company's product beyond the usual confines of small plots and out onto field-scale crops.

"You only get one chance to make a first impression, as Ag biologicals have consistently overpromised and underdelivered," says Tregunno. "Yes, sometimes the fault lies with the product itself, but it's also true that some manufacturers have not recognised that biologicals need a different approach.

"More variables come into play – soil type, the soil's state of health, previous crops, varietal differences, timings, and so on. We're extending our own trials, and also offering growers a performance guarantee as a way to allow growers a risk-free way to start working with Encera and Envita out on farm.

"We're helping growers devise ways to make it work in their farming system. And we're also conducting an enormous, 'large area trial' from which to understand how it works in different farming systems and how those variables affect its performance.

"Data analysis will clarify its potential to change farmers' relationship with synthetic nitrogen. With a product like this that can work in every crop, we have a rare chance to transform agriculture – improving food security, reducing nitrogen fertilizer pollution from GHGs and nitrate runoff into our waterways, all the while helping to drive higher production and increased profits at the farm gate," sums up Tregunno. ■

Acknowledgement

Reporting and interview by Adrian Bell, Agromavens.

DEN NOUDEN / GROWSOLUTIONS

Why organic fertilizers?

Sander Selten

Previously, you were unlikely to read many articles about organic fertilizers in *Fertilizer International* magazine. But times have changed and there is now growing consciousness about the vital importance of soil health all around the world. To the extent that the organic fertilizer industry is currently growing at more than 11 percent per annum and is on track to generate global revenues of $27 billion by 2030, according to Kings Research.

Natural organic fertilizers are a key input – one that is helping transform standard farming practices and improve agricultural sustainability in our view. They have clear potential to add value to soils in numerous ways by, for example, improving organic matter levels, creating better water retention, lowering carbon footprints and, of course, optimising long-term crop yields.

Battle of the soil: inorganic vs organic fertilizers

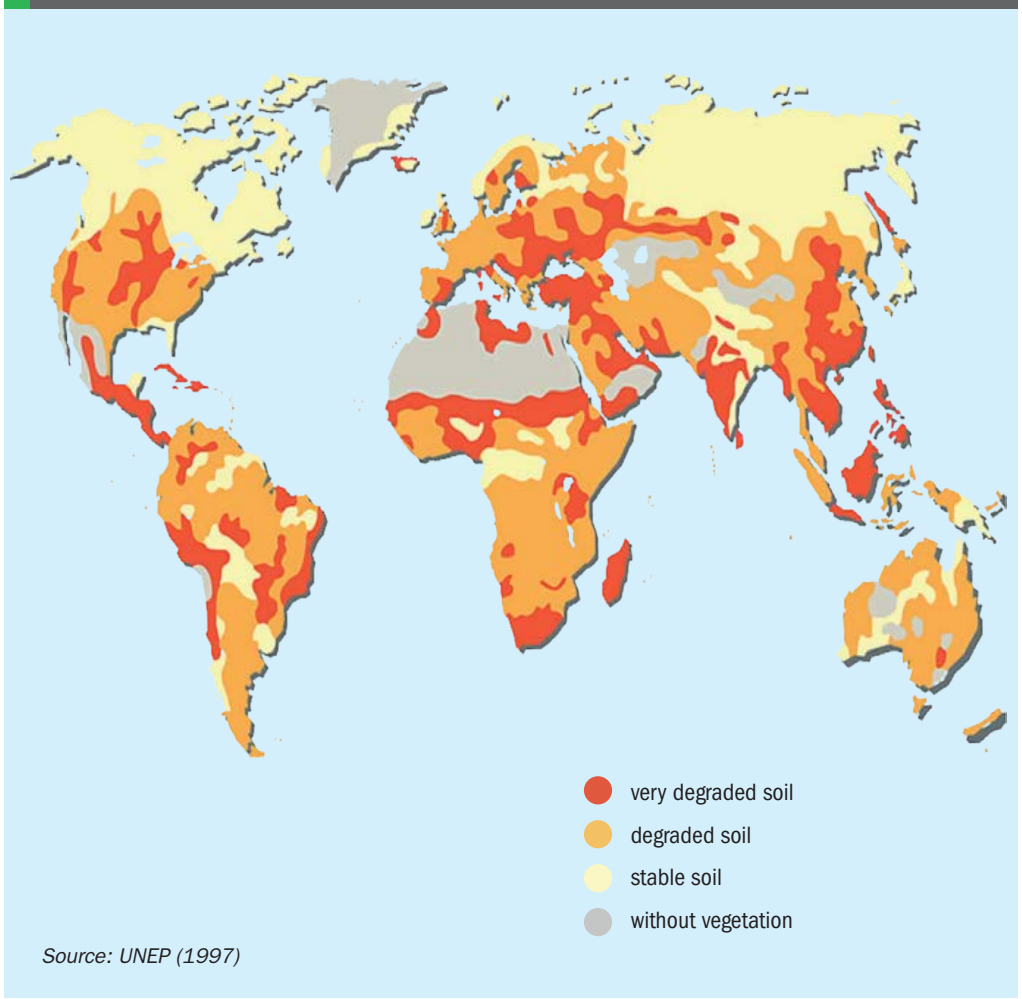
Plants – just like humans – need certain minerals for proper growth. While soils normally already have these nutrients, plant growth is negatively impacted when they are lacking. Fertilizers are therefore essential in making sure soils have the right balance of nutrients for healthy plant growth.

The main component of inorganic (mineral) fertilizers are soluble salts derived from non-renewable resources. Plant roots can quickly and beneficially absorb these salts. Yet, sadly, earthworms and soil-based microbes do not benefit when these nutrients are present in surplus. Indeed, excessive use of inorganic fertilizers has detrimental effects on the environment. These notably include the pollution of underground and surface waters from soil leaching, soil acidification, and the gradual depletion of soil micro-organisms. As a result, soils become degraded and their structure deteriorates along with their capacity to retain water – ultimately hindering plant growth.

The most productive agricultural soils generally contain between 3-6 percent organic matter. This is exepected, given the linear correlation between soil organic matter and crop yield. Unfortunately, almost half of the European soils have low organic matter content, principally in southern Europe, but also areas of France, the United Kingdom and Germany (Figure 1).

Much of the planet's biodiversity resides in the soil. For each farm acre (0.4 hectare), for example, the underlying soil can contain around 400 kilos of earthworms, 1.1 tonnes of fungi, 700 kilos of bacteria, 60 kilos of protozoa, along with 400 kilos of arthropods and algae, according to some estimates, as well as small mammals. On a numerical basis, a single gram of soil can hold one billion bacteria, with only five percent of these being known and discovered types currently.

Fig 1: **Map showing the global distribution of degraded soils**



Source: UNEP (1997)

GrowSolutions from Den Ouden

"GrowSolutions, now part of the 75-year-old Dutch family company Den Ouden, has more than 25 years of experience in organic fertilizers. Our concept focuses on the idea that a healthy soil is the foundation for healthy, growing plants," says Sander Selten, the company's commercial manager. "For us, soil improvers like bacteria, mycorrhiza, compost, organic fertilizers and biostimulants are the way for growers worldwide to transform standard growers practice into an agriculture with less dependency on chemical fertilizers and pesticides and finally growing more resilient crops".

GrowSolutions is a new company formed in 2023 from the merger of Ferm O Feed and Plant Health Cure (PHC), so bringing together two established product lines under one banner. Ferm O Feed is renowned as a specialist in organic fertilizers and biostimulants with a history stretching back more than 30 years – plus a global distribution network spanning 75 countries – while PHC is a leader in mycorrhiza technology and soil biology.

Fig 2: **The GrowSolutions product range is divided into five categories reflecting the different components of soil and plant health**

Source: GrowSolutions/Den Nouden

By combining these capabilities, GrowSolutions can offer a comprehensive and integrated package of premium products and services to growers worldwide. Valuably, this enhanced offering includes a production plant at Helmond in the Netherlands. This manufactures a range of soil enhancers, solid and liquid organic fertilizers and biostimulants, all designed to meet the diverse needs of modern agriculture.

Five pillars

The new GrowSolutions concept – and its product offering to the market (Figure 2) – is built on the following five pillars, these reflecting the different components of soil and plant health:

- **Soil health**: fungi and bacteria products
- **Root zone optimisation**: mycorrhizal fungi, trichoderma fungi, bacteria
- **Nutrient management**: granular and liquid organic fertilizer both plant as animal based
- **Efficient uptake**: natural fulvic acid
- **Plant resilience**: biostimulants based on harpine and various amino, humic, fulvic acids

GrowSolutions believes this will resonate with growers worldwide – being an easy concept to grasp and understand. ■

PHOTO: CF INDUSTRIES

Worldwide trends in urea process technologies

Mark Brouwer and **Jo Eijkenboom** of ureaknowhow.com examine the major shifts in global urea production. They also discuss the future of the urea industry and, in particular, how the sector is being affected by the increasing focus on low-carbon ammonia production.

CF Industries Donaldsonville site in Louisiana is the world's largest nitrogen complex.

Introduction

Urea production on an industrial scale can trace its origins back to the first half of the 20th Century. Because it is a mature technology, plant operators typically have high expectations when it comes to the performance of modern plants and urea process design. To meet those expectations, technology licensors generally need to offer a urea process concept that combines: high feedstock conversion, low energy consumption, low environmental footprint, low initial investment, high operating reliability and high product quality.

In this article, we examine the market share of the main global urea process licensors (Stamicarbon, Saipem, TEC, Casale, NIIC and Chinese design institutes) over the last three decades, and predict how their market share is likely to change in the near future.

Worldwide trends in urea process technologies are also summarised – including recent Chinese innovations.

Finally, the future of the urea industry is discussed, at a time when low low-carbon ammonia generation is becoming an investment and sustainability priority.

The article reviews and updates our original International Fertiliser Society paper with the same title published nearly a decade ago in 2015[2].

Urea process technologies

The popularity of the different urea process technologies offered by the four major urea licensors over the last 30 years is illustrated by Figure 1. This shows the number of urea plants (177 in total globally, excluding China) constructed annually using Casale, NIIK, Saipem, Stamicarbon and TEC process technologies between 1993 and 2023.

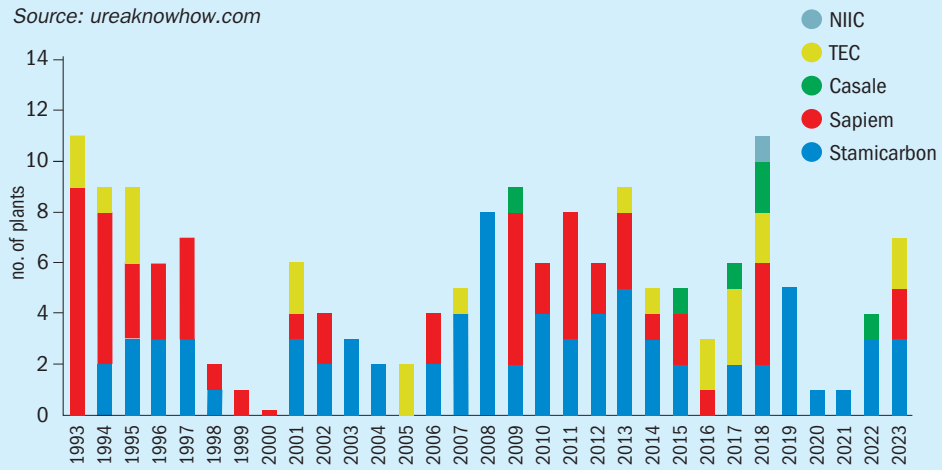
All of the urea plants constructed over this period, with the exception of one NIIC reference, are based on either CO_2 or NH_3 stripping technology. The urea plant breakdown by technology licensor is as follows:

- 42 percent Stamicarbon
- 37 percent Saipem
- 16 percent TEC
- 3 percent Casale
- 1 percent NIIC.

These percentages are based on the number of urea production lines.

From Figure 1, it is apparent that Casale, NIIC and TEC have all improved their market share in recent decades – a trend of growing

Fig 1: **Worldwide popularity of the major urea process technologies, during the last 30 years*, breakdown by company**



** Total of 177 plants constructed globally between 1993-2023, excluding China.*

popularity that is set to continue in our view.

NIIC's market share is likely to grow due to the geopolitical situation affecting its home market in Russia and the growth in domestic demand for urea.

TEC and Casale, meanwhile, are benefitting from the introduction to the market of their innovative ACES21-LP (Low Pressure) process and Green Granulation technology (*Fertilizer international* 517, p36), respectively. Casale has also expanded its technological portfolio to cover almost every nitrogen fertilizer production process.

In future, we predict that the relative market shares of the two dominant urea licensors, Stamicarbon and Saipem, will remain at a similar ratio in the near term, while TEC, Casale, NIIC and the Chinese design institutes will all grow their market shares.

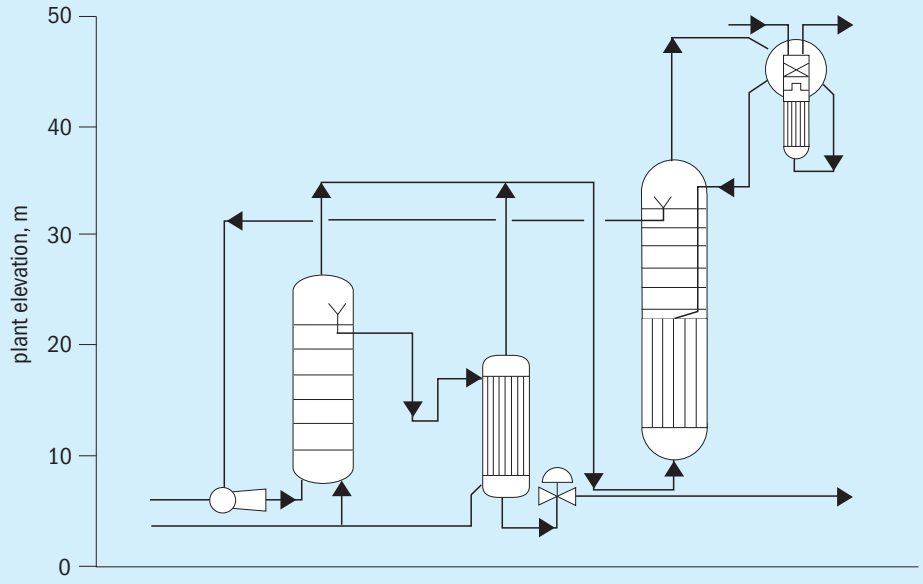
Chinese innovation

Historically, Chinese CO_2 stripping plants have typically been based on a falling film, high-pressure carbamate condenser design. Domestic Chinese companies can engineer, procure and construct these 'Stamicarbon-type' plants at a very competitive cost. Indeed, Chinese CO_2 stripping plants can be built for 25 percent of the investment cost of similar plants in other parts of the world, according to some estimates[1].

Nowadays, China is also increasingly active in developing its own proprietary technologies. The 'Technology of High Efficiency Synthesis and Energy Saving' (THESES) process developed by the Wuhan Engineering Corporation is one example of the country's urea process innovation[1]. The synthesis section of THESES plants combines a vertical submerged condenser and reactor with a low-elevation layout using a high-pressure ejector (Figure 2). The technology has been demonstrated since January 2014 by the operation of the 500 tonnes per day (t/d) urea plant at Meifeng, Sichuan.

Another example of Chinese process innovation is the JX Urea Technology developed by Chengdu-based company JX. This new technology reduces the steam, cooling water and power consumption of conventional 'total recycle' urea plants. The energy consumption of JX Urea Technology is comparable to urea stripping technologies yet can be delivered at a substantially lower investment cost. This technology has been proven by the operation of a 1,000 t/d capacity plant since January 2009. There are also plant references at 1,500 and 2,000 t/d capacity.

Fig 2: **Layout of the synthesis section of THESES urea plant developed by China's Wuhan Engineering Corporation**



Source: Wuhan Engineering Corporation

Worldwide trends in urea process technologies

Globally, the main trends in urea production plants and technology include:

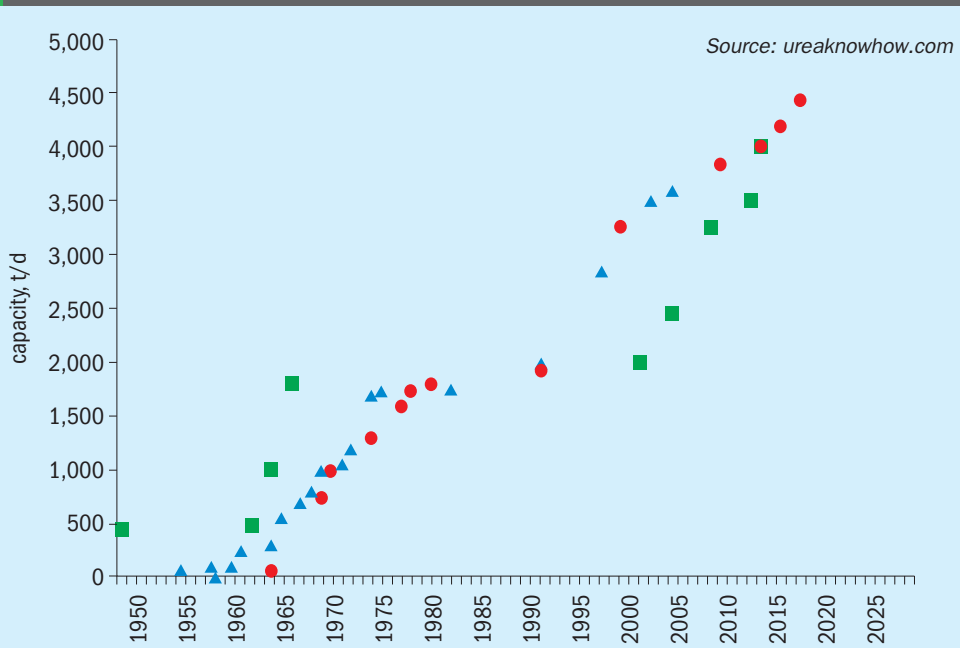
- Ever larger plant capacities
- Higher safety and reliability standards
- Lower energy consumption figures
- Lower emissions
- Submerged condensation in the synthesis section
- The use of high alloy construction materials
- Product innovation.

These trends are discussed below.

Ever larger plant capacities

The production capacities of urea plants have been on the increase since the mid-1950s, a long-term trend driven by economies of scale, cost reductions and innovations in process technology, materials and plant design. Mega urea plants – defined here as those of 3,000+ t/d capacity – have become increasingly popular since their emergence in the late 1990s.

Fig 3: **The increase in the maximum design capacity of licensed urea plants over time, 1948-2022**



The increase in the production capacity of urea plants over the last 70 years is shown in Figure 3. This covers technology licenses awarded annually, by company, dating back to 1948. These include plants designed by Stamicarbon (triangle symbol), Saipem (diamond symbol) and TEC (square symbol).

The rise in the design capacity of urea plants over time – for all the major licensors – is a clear and consistent trend. Currently, Saipem, Stamicarbon and TEC all have urea plants in operation with a capacity above 4,000 t/d.

The trend for increasing design capacity looks set to continue. Due to economies of scale, we expect the first 5,000+ t/d capacity urea plant to be built within the next decade. If Stamicarbon applied its 'medium-pressure add-on' option as a debottlenecking technology to one of its current 3,500+ t/d urea plants, for example, this would increase urea production capacity to more than 5,000 t/d.

Revamp projects deploying de-bottlenecking technologies at existing urea plants have also enabled licensors to significantly exceed original plant design capacities. Examples include:

- Yara Canada, a 2,000 t/d Stamicarbon-licensed plant now running at 3,300 t/d
- Profertil, a 3,250 t/d Saipem-licensed plant de-bottlenecked to 4,200 t/d but operating at around 3,950 t/d
- Erdos, a twin 1,000 t/d Stamicarbon-licensed plant de-bottlenecked to 3,520 t/d single train capacity
- Sichuan Chemical Works, a TEC-licensed plant de-bottlenecked to 2,460 t/d using ACES21 technology.

The shift in industry focus in recent years away from large-scale urea plants to large-scale low-carbon ammonia projects is another noteworthy change (see discussion below).

Higher safety and reliability standards

The trend for increasing production capacities, noted above, has been delivered through better operational safety, exacting reliability standards and higher on-stream times at urea plants. These improvements have been achieved by introducing:

- High pressure piping and valves
- Proper leak detection systems
- More instrumentation
- Digital tools such as operator training simulators
- Digital twins of operating plants.

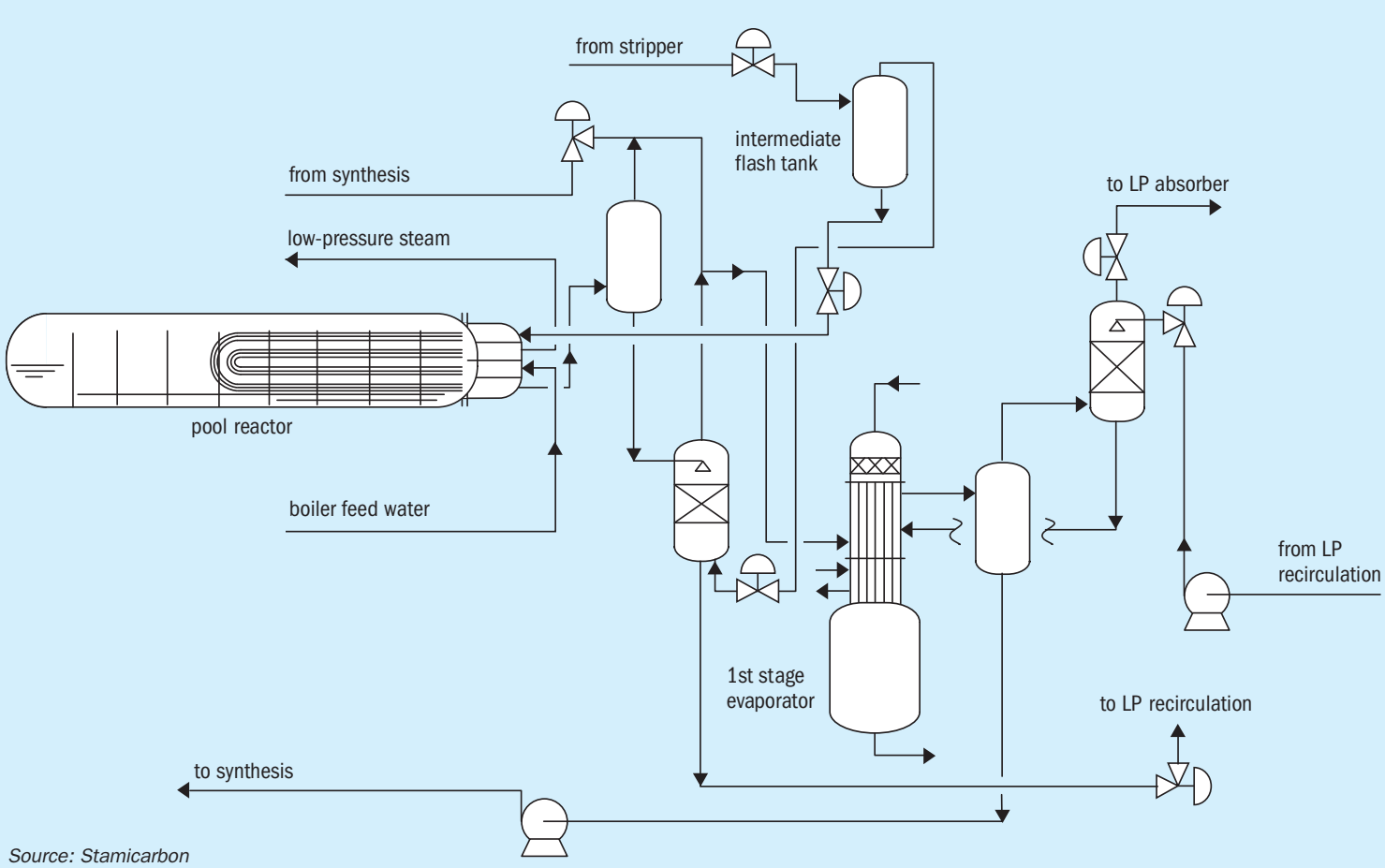
Lower energy consumption

Energy consumption of urea plants improved markedly following the introduction of CO_2 stripping in the late 1960s, falling from around 1,200-1,400 kg/t to 900 kg/t. In general, the efficiency of urea plants has been more or less constant in recent decades, with no significant differences between the various process technologies[1].

However, Stamicarbon has recently been able to reduce urea plant energy consumption to less than 600 kg/t with its Ultra Low Energy (ULE) design (*Fertilizer International* 516, p21). This new design (Figure 4) achieves a remarkably low steam consumption by introducing:

- A medium-pressure recirculation step
- A heat exchanger between the submerged high-pressure carbamate condenser and the liquid outlet of the CO_2 stripper
- A heat exchanger between the medium-pressure carbamate condenser and the evaporation heater.

Fig. 4: **Schematic of an Ultra-Low Energy urea plant. This incudes a medium-pressure recirculation system**



Source: Stamicarbon

Stamicarbon's ULE technology has proven very successful to date. The company has already signed contracts for seven ULE urea plants, the largest of these having a nameplate capacity of 3,850 t/d (*Fertilizer International* 514, p10).

Stamicarbon has been able to reduce steam consumption to less than 800 kg/t by configuring the medium-pressure recirculation section in creative ways – for example, as a medium-pressure flash vessel arranged in series downstream of the CO_2 stripper. Stamicarbon has also used this installation set up as a powerful tool for increasing urea plant capacity by as much 50 percent.

Currently, nearly all urea licensors incorporate a medium-pressure recirculation section in their process designs. The successful drive to improve ammonia and carbon dioxide consumption at urea plants also means this is now approaching theoretical limits.

Nonetheless, there is still scope for efficiency improvements in other sections of the urea plant – by introducing integrally geared CO_2 compressors, for example, or adopting Casale's Green Granulation fluidised bed granulation technology.

Lower emissions

Urea plants operating globally need to comply with increasingly strict emissions requirements. Environmental permits for new plants in the USA are particularly stringent (<10 ppm NH_3 and urea dust limits plus requirements for plume opacity). Urea plants operating in Saudi Arabia also need to implement acid washing to minimise NH_3 emissions from prilling towers and granulation plants.

These regulatory developments, and the growing capacity of urea plants, have spurred efforts to reduce finishing plant emissions. IPCO's Rotoform granulation technology, for example, has helped eliminate emissions from plants manufacturing specialty products such as technical urea, AdBlue and urea + ammonium sulphate.

The Grandperspective Scanfeld gas detector is a potential emissions gamechanger for the urea industry in our view. This automated, early-warning gas leak detection system can identify more than 400 chemicals at a distance using remote sensing.

A separate emissions and health concern is the use of formaldehyde to condition the final urea product. Formaldehyde is commonly used as an anti-caking agent and as a granulation agent in fluid bed granulation.

Although typically applied in the form of urea-formaldehyde solution, it is difficult to completely eliminate exposure to free formaldehyde. Consequently, leading companies are engaged in finding formaldehyde alternatives. Stamicarbon has been developing an alternative coating system for prills, for example, while both tkIS and Casale have developed alternatives for formaldehyde in fluid bed granulators.

Submerged condensation in the synthesis section

Submerged condensation in the synthesis section has been another important process development. This technological innovation was first introduced by Stamicarbon's PoolCondenser in 1996. TEC then followed suit with the Vertical Submerged Carbamate Condenser (VSCC). Casale also introduced the Full Condenser as a 'submerged' revamp option for falling film high-pressure carbamate condensers. Using a submerged condenser in the synthesis section has a number of benefits[1,2]:

- More efficient condensation as the heat transfer coefficient is around 40 percent higher than that of falling film condensation.
- This makes it possible to either reduce the heat-exchanging surface, cutting initial investment costs, and/or reduce energy consumption by raising LP (low-pressure) steam pressure.
- Ammonium carbamate is also retained in the condenser long enough for a significant proportion to convert to urea and water.
- This allows the condenser to be operated at a higher process temperature, enabling further reductions in the heat-exchanging surface and/or increases in LP steam pressure.
- Easier and more stable operation as the submerged condenser moderates fluctuations in NH_3/CO_2 ratio.

High alloy construction materials

Another marked trend in urea process technologies is the development of high alloy super-duplex stainless steels with improved corrosion resistance. These materials are less sensitive to chloride stress corrosion cracking. They also offer other benefits as an engineering material, such as higher strength and thinner wall thickness. Importantly, construction using high alloy materials improves plant operational reliability and safety. This means urea plants can remain on-stream for longer periods, raising output and increasing their profitability.

Stamicarbon and TEC have both pioneered the use of super duplex stainless steel in high-pressure synthesis sections. Stamicarbon, for example, offers Safurex, a duplex (austenitic/ferritic) stainless steel, as the standard construction material for its urea plant synthesis sections. Tens of Stamicarbon urea plants with a Safurex synthesis section are currently in operation.

Safurex, developed in collaboration with Sandvik Materials Technology, possesses superior mechanical properties and is highly corrosion resistant at low oxygen concentrations, allowing for much lower air dosing in urea plants.

Similarly, many TEC plants use high pressure equipment made with DP28W™, a duplex stainless steel. DP28W™ provides improved corrosion resistance in comparison to conventional duplex steel and shows excellent passivation behaviour in urea carbamate solutions[2].

A successful collaboration between Casale and Tubacex, meanwhile, created the super duplex Uremium29.

Saipem has developed OmegaBond tubes for its thermal stripping process. These combine a protective zirconium inner layer and a titanium outer tube[2]. For its other high pressure equipment items, Saipem currently prefers 25-22-2 austenitic steel. The company is also developing a super duplex with Tubacex for its NH_3 stripper.

Product innovation

Improving nitrogen use efficiency (NUE) and developing multi-nutrient fertilizers have been two of the main trends in urea product innovation. Combining urea with sulphur is a particular area of interest as this nutrient mixture can improve NUE. The range of available sulphur-enriched urea products includes urea + sulphur, urea + ammonium sulphate and urea + magnesium sulphate.

Other producers have focussed their efforts on developing inhibited or coated urea products – these being specifically

designed to deliver nitrogen to crops more efficiently. Inhibitors reduce nitrogen losses by delaying the hydrolysis of urea and preventing ammonia volatilisation, while coatings regulate the release of nitrogen over the growing season.

The use of inhibited urea products has now become mandatory in certain European countries such as Germany. The EU is also specifying the use of biodegradable coatings in controlled-release fertilizers (CRFs) in future.

The use of NEEM-coated urea in India has helped to improve NUE on the subcontinent. India is also targeting enhanced nutrient efficiency by launching nano urea on the market.

Looking ahead, the rise of carbon farming and demand from food retailers and manufacturers for more efficient and low-carbon fertilizers is only likely to strengthen the current trend towards more efficient and sustainable urea products.

Discussion – the future of urea production

The 2015 Paris Agreement, by driving the global expansion in renewable energy capacity, is now leading to greater green hydrogen and green ammonia generation. This, in turn, is impacting the fertiliser industry, with leading ammonia producers (CF Industries, Fertiberia, Nutrien, Yara etc.) already investing in and expanding their production assets to enter the low-carbon ammonia market. Incumbent energy producers and new entrants have also launched large-scale projects to supply the emerging power generation and shipping fuel markets for low-carbon ammonia, e.g. NEOM in Saudi Arabia.

In future, based on the generation of green ammonia from renewable energy, we expect to see a worldwide trend for locating nitrogen fertilizer projects much closer to centres of agricultural demand. Typically, these new nitrogen fertilizer plants – which are mainly at the feasibility stage currently – will be much smaller in scale compared to the modern mega plants of today. However, the reverse is true of low-carbon ammonia projects serving the energy/fuel market, as generally these are being planned at a very large scale.

The increasing availability of low carbon ammonia, a consequence of the energy transition, provides the perfect stepping stone for the production of 'green fertilizers'. These are typically ammonium nitrate-based fertilizers with a low carbon footprint.

Ammonium nitrate production does, however, come with limitations. Products, because they are potentially explosive, are tightly controlled due to safety risks and regulatory concerns over their misuse. Relative to urea, ammonium nitrate can also incur higher transportation, storage and application costs for producers, traders, retailers and farmers (on a per tonne of nutrient basis) due to its lower nitrogen content.

It is now possible to produce low-carbon urea using processes which consume carbon dioxide feedstocks generated by other sources. For smaller scale projects, however, production schemes for 'value added' low-carbon fertilizer products – such as urea ammonium nitrate (UAN), urea ammonium sulphate (UAS) and urea-based NPKs – are likely to be more feasible/profitable than straight urea production.

Large-scale investment will be required to make the transition from conventional nitrogen fertilizers produced from fossil fuel feedstocks (natural gas and coal) to their low carbon alternatives. Long transition times will be necessary too, given that nitrogen production complexes typically have a 40-50 year life. Natural gas-rich regions are also expected to remain big exporters of urea with investments continuing to favour the creation of higher margin downstream products using low-cost natural gas feedstocks.

As is well known, fertilizers make a major contribution globally to securing the supply of abundant and high-quality food. However, the environmental impacts associated with fertilizer use are now shifting the focus towards lower application rates and greater nutrient use efficiency (NUE). Delivering improvements in NUE will require a combination of:

- Innovative technologies that enhance fertilizer efficiency
- New regulations by policymakers that restrict the use of conventional 'straight' urea
- Improved farming practices
- Changes in consumer behaviour.

Such large-scale transformations take time and, while first steps are being taken, much more needs to be done to respect the world's planetary boundaries. In particular, the fertilizer industry will need to shift production away from standard bulk commodities to specialty products – to support farmers as they seek to increase crop yields while at the same time avoid damaging environmental impacts.

When it comes to reducing agricultural greenhouse gas emissions, urea is generally seen as the least-sustainable type of nitrogen fertilizer. One of the main reasons for this is that every molecule of urea applied on farmland releases one molecule of carbon dioxide. Additionally, urea applications are also associated with the release of ammonia and nitrous oxide emissions.

A combination of better farming practices, and the use of urea granules treated with inhibitors or coatings, can reduce the carbon footprint of nitrogen fertilizers. Yet the adoption of such techniques and technologies in small-scale farming will always be a challenge.

Consequently, urea will remain a valuable source of nitrogen in agriculture for the foreseeable future, despite a greater focus on improving NUE and reducing the GHG emissions associated with its use. In our view, urea will continue to be an especially vital fertilizer when it comes to providing food security in developing countries where it will retain links to important cropping systems such as rice cultivation.

Summary

We conclude that the main future trends in urea process technologies will be:

- Urea plants with ever larger nameplate capacities
- Lower energy consumption
- Emissions reduction
- Submerged condensation in the synthesis section
- The use of high alloys in equipment construction
- A shift to the manufacture of multi-nutrient urea products, as well as coated and inhibited urea products with higher use efficiency. ■

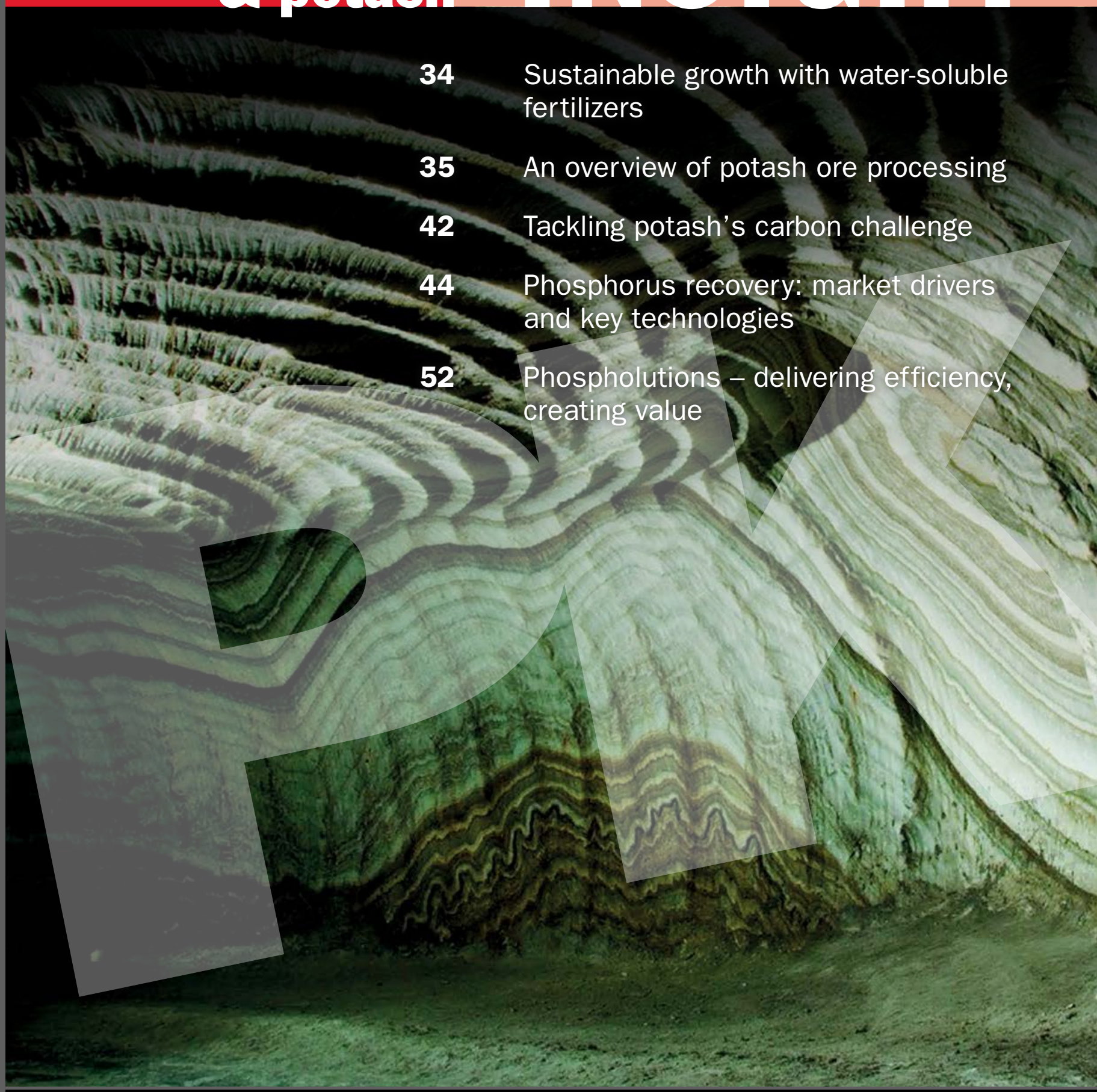
References

1. Eijkenboom, J. & Brouwer, M., 2015. Worldwide trends in urea process technologies. *International Fertiliser Society Proceedings*, 770.

2, Meessen, J., 2014. Urea synthesis. *Chemie Ingenieur Technik*, 86 (12), 2180-2189.

March-April 2024

phosphates & potash INSIGHT



■ Contents

ISSUE 519

FERTILIZER INTERNATIONAL
MARCH/APRIL 2024

CRU

AQUIFERT

Sustainable growth with water-soluble fertilizers

Fertilizer International spoke to **Matt O'Leary**, the MD of Aquifert, about the state of the water-soluble fertilizer (WSF) market at the 2024 Fertilizer Latino Americano Conference in Miami in February.

Above: Matt O'Leary, Aquifert's MD.

Opaque and misunderstood?

"Aquifert is a company specialising in the trading and distribution of water-soluble and speciality fertilizer. We look simply to solve the problem of getting quality products from quality sources at competitive prices to provide much need certainty – in what's still an under developed, opaque and misunderstood emerging sector of the global fertilizer economy.

"The global water-soluble fertilizer market has moved on from its niche origins. It is dominated by China and occupying a pivotal role in sustainable agriculture."

The sustainability debate

"As a commercial input alone, WSF adoption makes sense as it's one answer to … the ever-increasing global debate about climate, food security and regenerative agriculture. We see our products as a hat tip to the anti-fertilizer movement. Whilst a worthy cause, that's impractical for food production, should we wish to feed everyone. Aquifert's conviction is the market will demand better practices and we are at the forefront.

"Adopting WSFs is a substantial stride to addressing overuse, actual plant requirements, reductions in the physical amount of fertilizer and a more simplified way to track fertilizer use in general. From a micro level on the farmer ledger, through to a macro benchmark on national consumption levels. In essence, there is significantly more output, for every metric, from the use of these products – which are fast approaching 'conventional' status."

Big hitters and the rest

"Making up 80-90 percent by volume, the WSF carthorses are water-soluble NPK, technical MAP 12-61, monopotassium phosphate (MKP) 0-52-34, calcium nitrate, sulphate of potassium or SOP, potassium nitrate (NOP) 13-0-46 plus several forms of soluble magnesium sulphates and nitrates. Outside of these big hitters are the immature cousins. This group is made up of zinc, chelates, micronutrients, and others – think polyhalite, biostimulants, organics, liquids, and many other variants.

"The ability to apply [WSFs] in nearly all circumstances – to control for variables, such as weather, soil and application method – provides a channel to place management back into farming. [Harvard professor] Michael Porter would be pleased!

"Better feedback improves results and more space on the balance sheet for marketing, harvesting and enhancing other areas of any farming enterprise. We believe this will assist in lightening the bureaucratic loads now common in modern farming."

China leading a global expansion

"China has a total market of 100 million tonnes of domestic fertilizer use, and is at the forefront in the production of the new wave of WSF and speciality fertilizers. Aquifert are positioned as experts in this market with over 20 years combined experience working in China.

"The considerable industrial resource within China's borders has expanded its production from six million tonnes of WSFs in 2018 to an estimated 16 million tonnes by the end of 2024. This expansion in China, as the world largest food production business, demonstrates the shift that's now underway – in an industry accustomed to vessels loaded with tens of thousands of tonnes of major nutrient products, but unfamiliar with containerised, small quantity trading.

"Fundamentally, Aquifert take the view on an expanding market. There is definitely a sense we could see developing markets and countries with low fertilizer use make the technological jump into more sophisticated fertilizers.

"According to the World Bank there are various countries with less the 3 kg per acre of fertilizer consumption. When this is backed up against an advanced economy, such as the UK where fertilizer per acre is over 200 kg, we see a significant opportunity for more sustainable practice and growth of the market."

Chance to go green

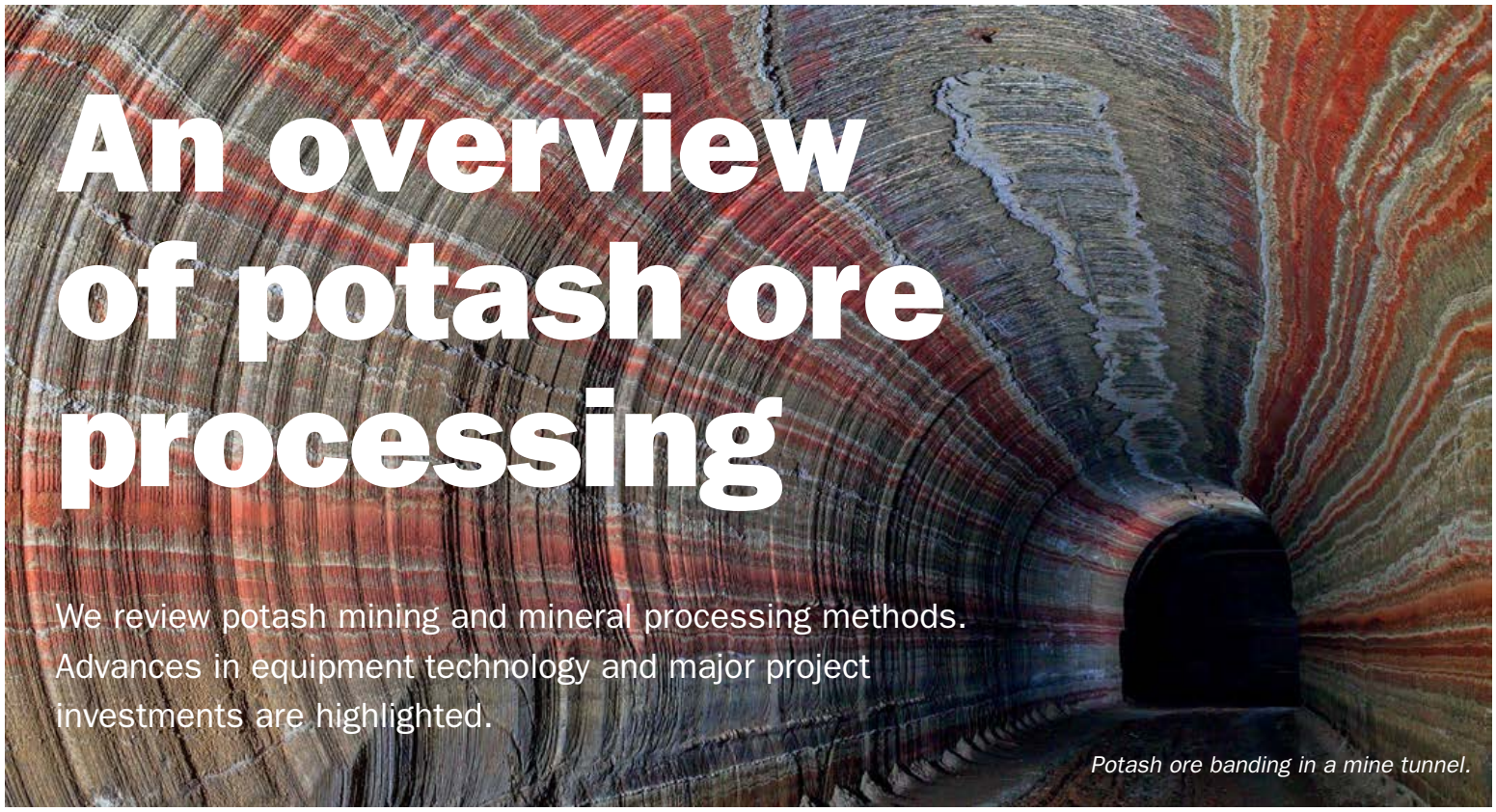
"In relation to manufacturing, we do see a significant scope to adopt green procedures. Speciality fertilizers present an opportunity to experiment and lay the foundations as a testing field for green production. There are already some significant bets being laid by major EU speciality producers for green production.

"Farmers are the key operators. They're the players in the supply chain most impacted by all these unfolding complexities. Aquifert is keenly aware of this and applies it as a fundamental thought process. The farmers' point of view underpins the directions of the business and what projects we take on. How will this affect the farmer is the question we revert back to on a daily basis.

"Aquifert is working on developing and growing the business over an extended time horizon. The future of the industry as a major contributor to people's wellbeing, the current willingness to adapt and change in response to pressures, the substantial opportunities being created and the speed of technological change – all of these make it a very exciting time to be operating in the fertilizer industry!" ■

PHOTO: SERGEJUS MICHALENKO/SHUTTERSTOCK.COM

An overview of potash ore processing



We review potash mining and mineral processing methods. Advances in equipment technology and major project investments are highlighted.

Potash ore banding in a mine tunnel.

Potash is the collective name given to the ores, minerals and products which contain the element potassium in water-soluble form. The term dates from the 1800s and originally referred to potassium carbonate and potassium hydroxide obtained from the ashes of wood and leaves. These were recovered as washings and concentrated by boiling in iron pots.

Potash was mined in Ethiopia's Danakil Depression as far back as the fourteenth Century. In the west, Germany was the first country to discover substantial geological reserves in the Zechstein Basin in the 1850s.

Turning potash ore into agricultural and industrial products became possible when a purification process to remove sodium and magnesium chloride from carnallite deposits was developed in Stassfurt, Germany, in 1859. This enabled potash ore to be mined, processed and applied as potassium chloride to crops.

Main mined ores

Sylvite (KCl), carnallite ($KCl.MgCl_2.6H_2O$), kainite ($4KCl.MgSO_4.3H_2O$), and langbeinite ($K_2SO_4.2MgSO_4$) have all been extracted as commercial sources of potash (Table 1). Of these, sylvite and carnallite occur more commonly geologically, with sylvite being the most economically important.

Sylvite is generally the industry's preferred potash ore mineral due to its relatively low processing costs. Langbeinite is also mined commercially on a relatively large-scale in Carlsbad, New Mexico. Kainite has been mined in the past, most notably in Sicily and Poland, and mixed langbeinite-kainite deposits also occur in the Carpathian region of west Ukraine.

Although carnallite was mined, beneficiated and processed in Germany for 130 years – and was the original target ore in the 1860s – potash production in the country now concentrates on lower cost sylvinite ore mining. In fact, carnallite ores are not generally targeted by conventional ore mining for the following reasons[1]:

- Carnallite ores are lower grade with a 17 percent K_2O content compared to 63 percent for sylvite
- Carnallite has unfavourable mechanical properties making it more difficult to mine in comparison to sylvite
- Its deliquescent nature makes it unsuitable for direct use as fertilizer and makes the conversion to sylvite necessary
- The dissolution and recrystallisation methods used to process carnallite ores are energy intensive and expensive
- The conversion of carnallite to sylvite during processing produces large volumes of $MgCl_2$ which need to be either utilised or disposed of as waste.

The highest-grade, naturally-occurring potash ore is sylvinite, a mixture of sylvite (typically 35 percent), halite (around 60 percent) and insoluble minerals such as clay (roughly five percent). Carnallite is generally classed as an unwanted contaminant when present in sylvinite deposits.

Agricultural importance

Potash covers a wide range of commercially manufactured end-products (Table 1) such as potassium chloride (KCl, muriate of potash, MOP), potassium sulphate (K_2SO_4, sulphate of potash, SOP) and potassium magnesium sulphate ($K_2SO_4.2MgSO_4$, sulphate of potash magnesia, SOPM).

MOP accounts for around 95 percent of world potash production and has a minimum K_2O content of 60 percent. SOP and SOPM are usually applied to chloride-sensitive fruit and vegetables, and together make up make up much of the remaining five percent of potash fertilizer usage.

Potash fertilizers are widely used in the production of fruit and vegetables (17%), maize (15%), wheat (15 %), rice (14%), sugar (4 %), cotton (4%), soybeans (4%) and palm oil (2%). Potassium is a valued major plant nutrient that:

- Increases plant resistance to drought, disease and pests
- Is essential for root systems

- Promotes nitrogen fixation in leguminous crops
- Improves the size, colour and sugar content of fruits and other crops.

Mining

Generally, the underground mining of potash is only economic for an ore grade of at least 14 percent K_2O and a bed thickness of 1.2 metres or more. Historically, potash plant and mills have typically needed a capacity of at least 300,000 tonnes (K_2O) to compete in an industry where most plants operated in the million-tonne (K_2O) production range. Ore reserves also needs to be sufficient for a minimum of 20 years of potash production, for a new mine of a given size[2].

Potash mining (Figure 1) is typically a highly mechanised, continuous process employing boring machines, drum miners, longwall miners and road headers. Boring machines with two or four cutting arms are an effective mining method for relatively flat and uniform potash beds. In mines where potash beds gently slope, undulate or thin and thicken, continuous miners with drum cutters mounted on moveable arms are most effective.

Froth flotation

The processing of sylvinite and other potash ores is a comparatively simple, standardised process performed in a similar same way at many potash plants[3]. The four basic beneficiation techniques used to process potash ore are:

- Froth flotation
- Heavy media separation
- Electrostatic separation
- Dissolution-crystallisation (hot leaching).

In conventional potash processing, the ore if firstly ground to a size where the potash is liberated from halite, deslimed to remove insoluble fines, then separated into a coarse and fine feed and beneficiated by froth flotation (Figure 2).

The potash industry first adopted flotation for processing sylvinite at Carlsbad, New Mexico, in the early 1930s, and the technology later spread to France, England, Germany, the CIS countries and Israel. In Saskatchewan, around 90 percent of fertilizer-grade MOP is produced by froth flotation, sometimes supplemented by heavy media separation.

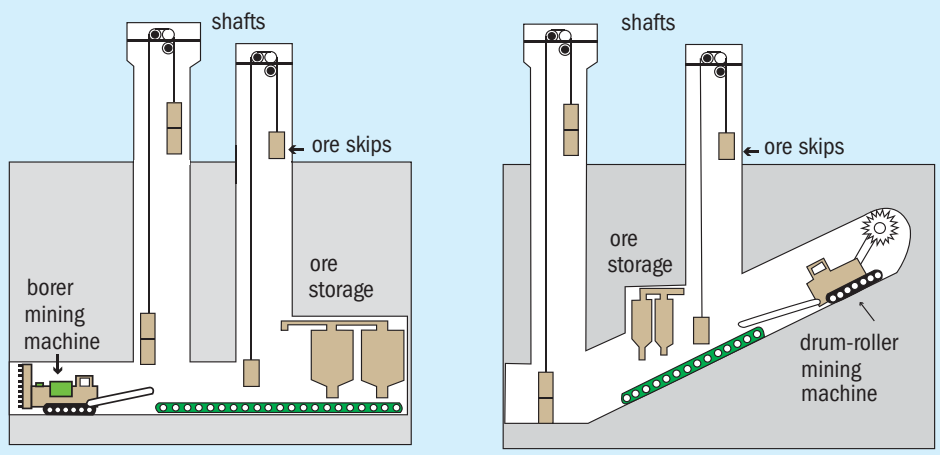
In sylvinite ore processing, froth flotation is used to separate sylvite from halite using

Table 1: **Potash minerals and major ore types**

Potash minerals	Chemical Formula	K_2O content (%)	Comments
Sylvite	KCl	63.17	Principal ore mineral
Carnallite	$KCl•MgCl_2•6H_2O$	16.95	Ore mineral and contaminant
Kainite	$4(KCl•MgSO_4)•H_2O$	19.26	Important ore mineral
Langbeinite	$K_2SO_4•2MgSO_4$	22.69	Important ore mineral
Contaminants	**Chemical Formula**	**K_2O content (%)**	**Comments**
Halite	NaCl		Principal ore contaminant
Polyhalite	$K_2Ca_2Mg(SO_4)_4•2H_2O$	15.62	Ore contaminant
Kieserite	$MgSO_4•H_2O$		Common ore contaminant
Anhydrite 0	$CaSO_4$		Common ore contaminant
Leonite	$K_2SO_4•MgSO_4•4H_2O$	25.68	Ore contaminant
Ores	**Mineralogy**	**K_2O content (%)**	**Occurrence**
Sylvinite	Sylvite, halite	10–35	Canada, USA, Russia, Brazil, Congo, Thailand
Langbeinitite	Langbeinite, halite	7–12	USA, Russia
Kainitite	Kainite, halite	13–18	Italy, Ethiopia, Belarus
Carnallitite	Carnallite, halite	10–16	Germany, Spain, Thailand
Hartsalz	Sylvite, halite, anhydrite, kieserite	10–20	Germany
Mischsalz	Sylvite, carnallite, halite, anhydrite, kieserite	8–20	Germany

Source: Prud'homme & Krukowski (2006)

Fig 1: **Potash ore mining – conventional extraction**



Source: Warren (2015)

a cationic collector[4]. Insoluble slimes such as clay and hematite are firstly removed using hydrocyclones, hydroseparators or fluidised-bed separators. Insoluble slimes can also be removed from the ore by two-stage flotation, although reagent costs can be high. The deslimed froth flotation feed is then usually processed separately as coarse and fine fractions.

A suspension of crushed ore in saturated brine, known as the pulp, is typically conditioned with a long-chain amine collector (50g/t) and a frother such as pine oil before it passes to an agitation cell. Inexpensive depressants such as guar gum and dextrin can also be added. This stops the flotation of clay and other unwanted gangue minerals not removed during desliming. An extender oil may also be added to coarse-size flotation pulps.

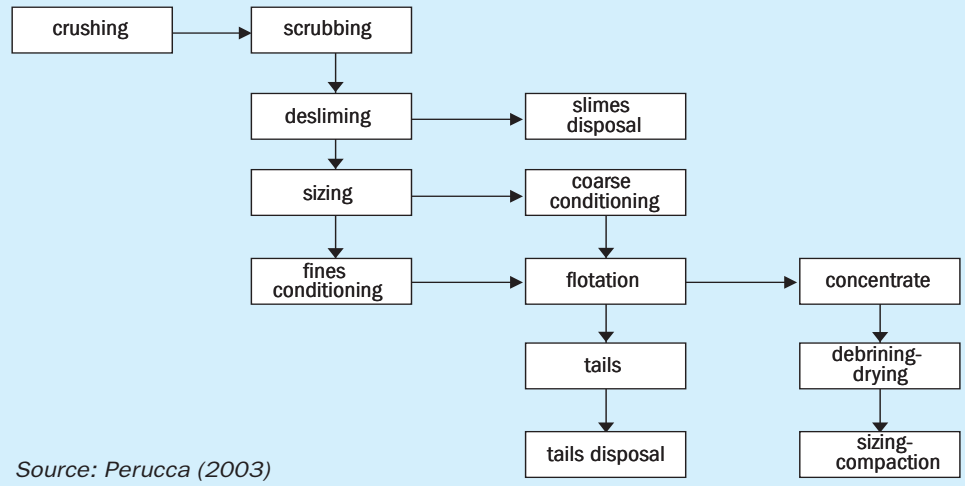
During flotation, a froth of bubbles is produced by compressed air at the bottom of the agitator cell. These entrain potash particles and carry them to the surface where they are mechanically recovered from the flotation cell. If present, sulphate minerals such as kieserite or kainite can be floated from potash ore using a fatty acid collector[4].

In Saskatchewan, the standard approach has been to process coarse and fine potash pulp using Denver DR-type froth flotation cells, ranging from 100-300 ft^3 in size, in a three-stage rougher, cleaner and re-cleaner flotation process[5]. Rougher concentrates (less than 0.84 mm size) usually become the final premium product after cleaner and re-cleaner flotation stages remove entrapped fine salt. The rougher tailings (above 1.41 mm) are generally re-crushed and floated in either a conventional or column flotation cell as a scavenger stage.

Belaruskali uses froth flotation to process potash ore from the Elets horizon of the Pripyat Basin in Belarus. This sylvite-halite ore contains minor carnallite, anhydrite, silicates and carbonate and is processed as follows:

- Ore crushing and pre-screening
- Ore milling and pre-sizing
- Mechanical and flotation desliming of ore
- Sylvite flotation
- NaCl leaching from the floatation concentrate
- Hydro-thickening and dehydration of tailings
- Hydro-sizing and dehydration of concentrate
- Concentrate drying.

Fig 2: **Conventional potash ore processing**



Source: Perucca (2003)

This process is used to manufacture Belaruskali's standard reddish-pink granular MOP fertilizer. Flotation produces a concentrate of 95-96 percent KCl grade at 85.5-87.2 percent recovery, according to Belaruskali.

Dissolution-recrystallisation

The dissolution–recrystallisation method for potash manufacture was developed by the French in the early 1910s and was widely adopted as an ore beneficiation method in the early days of the industry. Potassium chloride is crystallised from a clarified brine obtained from a hot leach of the ore. The method leaves behind insoluble material and undissolved salt (halite). Hot leaching is still used to recover potash processing fines and waste liquors and for the treatment of complex ores.

The hot leaching process developed by the German potash industry typically proceeds as follows:

- The ore is firstly ground to less than four millimetres and treated with hot brine
- Potassium Chloride dissolves while kieserite and halite remain undissolved
- The hot KCl-enriched brine is separated from kieserite and halite residue
- Potassium Chloride is obtained by vacuum crystallisation and washed, dewatered and dried using centrifuges and a gas-fired drum drier
- Solid-liquid separation and crystal washing yields a 96 percent KCl concentrate
- Froth flotation of the residue from hot leaching (<1 mm) is used to separate and recover a kieserite concentrate from halite.

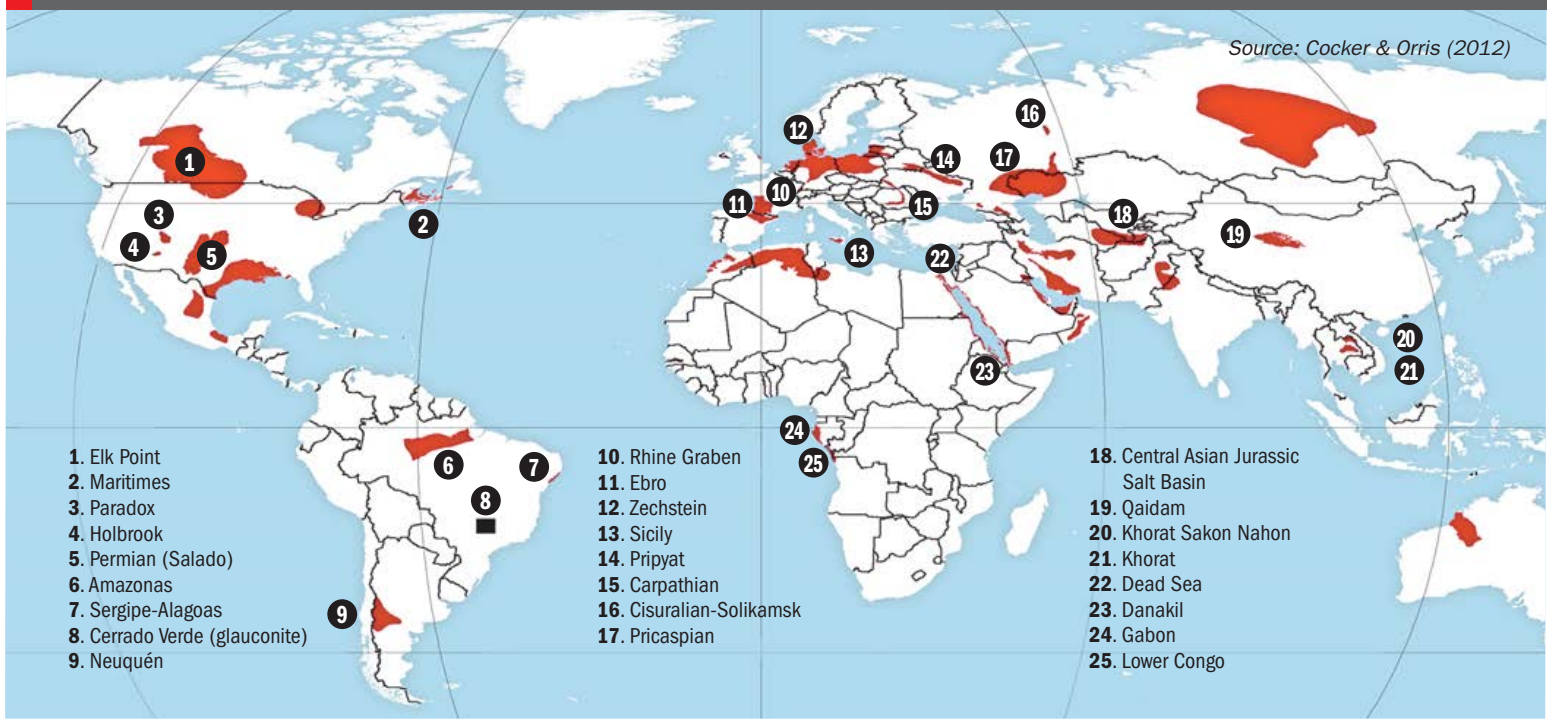
Belaruskali also uses hot leaching to produce a white, finely-crystalline granular product with 96-99 percent KCl grade at 88-89 percent recovery.

Electrostatic separation

Electrostatic separation of potash was originally investigated at Carlsbad in the US in the 1940s and later commercialised in Germany. For certain ore types, electrostatic separation is a fast and efficient processing method with low energy, maintenance, operating and capital costs[3]. This route also generates a dry waste product and therefore eliminates brine disposal problems.

The ESTA electrostatic separation process developed by K+S in Germany involves heating and then coating the ore with reagents at a carefully controlled humidity. A first electrostatic run is used to separate halite from crushed ore (<1.2 mm) by conditioning with 75 ppm salicylic acid and heating to 50°C in fluidised bed. The fluidised bed uses friction to impart a 'triboelectric' charge on ore particles, the size of the charge depending on their mineral composition. The ore is then introduced to a 10-metre-high free-fall chamber. This is lined with charged electrodes (10,000 volts DC). Relative humidity within the chamber is regulated at 10-15 percent. Further electrostatic passes – at a relative humidity of five percent with a fatty acid conditioning agent – are then used to separate potash minerals from kieserite. Middling fractions often need to be reground and reprocessed to achieve high yields and purity.

Fig 3: **Major world potash basins**



Heavy media separation

Heavy media separation has been a very successful processing method for coarse-grained Esterhazy potash ore in Sakatchewan, as well as langbeinite ore from Carlsbad. This beneficiation method exploits the density (specific gravity, SG) difference between minerals to achieve a separation. Mosaic, for example, uses heavy media separation at its Saskatchewan plants to separate halite (SG 2.16) from sylvite (SG 1.99). Halite will sink and sylvite will float during separation if the brine slurry density is adjusted to an intermediate SG value such as 2.07.

The potash ore is crushed to less than one millimetre in size, leached to remove carnallite and deslimed to remove clay. Deslimed feed is then screened at 10 mesh (2 mm) and the oversize sent to the heavy media separation circuit where finely-ground magnetite (<200 mesh, 0.074 mm) is added to the ore slurry.

Sylvite is then concentrated by two rougher and cleaner cyclone processing stages[3]. This yields a concentrate, middlings and tailings fraction. Middlings are usually reground and, together with the fines from initial crushing, processed by froth flotation[5]. Compared to a conventional froth flotation plant, heavy media separation has lower reagent costs although maintenance costs are higher because of the abrasive properties of the magnetite used.

Carnallite

Carnallite processing generally involves dissolving an ore concentrate and the recrystallisation of KCl with the generation of a halite-rich solid waste and saline liquid effluent. Hot leaching and cold leaching are the two main processing options for potash production from carnallite.

Traditionally, for carnallite from the Hattorf and Wintershall mines in Germany, the ore is ground to less than four millimetres in size and leached at around 90°C to yield a brine. Any halite and kieserite impurities remain as solids allowing them to be separated from the brine by filtration. Sylvite is subsequently recovered by precipitation by allowing the brine to cool to 30°C in vacuum crystallisers. A 60 percent grade KCl product is ultimately obtained by this route after centrifuging.

Langbeinite

The Mosaic Company and Intrepid Potash extract and process langbeinite ore from underground deposits at Carlsbad, New Mexico, to produce the commercial products K-Mag and Trio, respectively. The ore is mined from a 10 ft bed at a depth of 800-1,000 ft using continuous miners. Langbeinite can be separated from sylvite and halite by heavy media separation or froth flotation.

Mosaic produce K-Mag from langbeinite ore using a combination of attrition scrubbing, wash screening and heavy media separation. The SG of the ore slurry is adjusted by adding a dense, finely-divided, easily recoverable solid such as ferro-silicon or magnetite. Langbeinite (SG 2.83) is denser than minerals such sylvite (1.99) or halite (2.16) and so 'sinks' and discharges with the hydrocyclone underflow.

Changing geography

The geography of world potash production – now largely concentrated in Canada, Russia, Belarus, Israel, Jordan and Laos – has changed over the last 70 years. Several potash basins which were important producers after the Second World War, such as the kainite ore of the Sicilian Basin, kainite-langbeinite ore of the Carpathian Basin and the carnallite-sylvite ore of the Rhine Graben in France, have since become depleted or closed due to economic and environmental pressures (Figure 3).

In the United States, MOP production in the Salado Basin (Carlsbad) of New Mexico ceased around a decade ago due to resource depletion although SOPM production continues. The higher grade ore (sylvinite) is largely mined-out and the remaining lower grade ore (mixed langbeinite, kieserite and sylvite) is more expensive to process than potash from Saskatchewan[6]. This is not an isolated problem. Mines in Europe's Zechstein Basin, their production long since eclipsed by that of Canada, Russia and Belarus, are also facing depletion within the next 30 years as well as being burdened by higher production costs.

INVESTMENT IN NEW ASSETS, MODERNISATION AND EXPANSION

PHOTO: MOSAIC

The Mosaic Company's flagship Esterhazy mine.

Next Generation Potash

Nutrien's is modernising its massive potash mining operations through the Next Generation Potash investment programme. This has a focus on autonomous mining and predictive maintenance that monitors critical assets and identifies failures before they happen.

The programme will enhance safety and strengthen Nutrien's competitive position, according to the company, by reducing production costs and helping offset inflationary pressures. Nutrien extracted more than six million tonnes of potash ore tonnes by automated mining in 2022, an increase of around 50 percent on the previous year.

The world's largest potash mine

Mosaic finally completed it massive, decade-long K3 potash expansion project at Esterhazy, Saskatchewan, in October 2023. Esterhazy is now officially the world's largest potash complex, says Mosaic, after its 7.8 million t/a of production capacity was externally verified.

The K3 expansion has transformed Esterhazy into one of the world's largest and most efficient mines (*Fertilizer International* 502, p26). Mosaic added 13 automated rotary mining machines to its underground fleet as part of the $2.9 billion mega project. These automated miners are controlled by professional operators working from Esterhazy's new Integrated Operations Centre (IOC). The IOC uses advanced camera and sensor technology to monitor and operate mining machines and the conveyor system. The centre remotely controls the extraction and movement of potash ore to the surface – and its onward transport to two surface mills for processing via 11 kilometres of enclosed conveyors.

Jansen mega project

BHP recently approved an investment of $4.9 billion (CAD 6.4 billion) in stage two of its Jansen potash project in Saskatchewan, Canada. The investment, announced in October 2023, is expected to transform Jansen into the world's largest potash mines, doubling production capacity to approximately 8.5 million t/a (*Fertilizer International* 517, p8).

This latest tranche of investment follows BHP's final investment decision in Jansen in August 2021 alongside the approval of $5.7 billion (CAD 7.5 billion) for the project's first stage. This will deliver 4.35 million t/a of potash capacity initially with production starting towards the end of 2026 (*Fertilizer International* 504, p8). Prior to this, BHP had invested a preliminary $4.5 billion (CAD 4.9 billion) in developing the project.

In June 2022, Sandvik Mining and Rock Solutions secured a major order for 10 battery-electric vehicles (BEVs) from BHP, along with one electric tethered loader, for the Jansen potash project's first phase (*Fertilizer International* 513, p38).

This latest order follows a SEK 2 billion ($216 million) mining systems contract for the Jansen project won by Sandvik in February 2022. This commits Sandvik to supplying a fleet of electric, cable-connected MF460 borer miners between the third-quarter of 2023 and 2026. These borers have been specially developed for the project following several years of Sandvik-BHP collaboration.

These investments in electric mining equipment will help Jansen deliver the lowest per tonne carbon emissions of any Saskatchewan potash mine, according to BHP.

Kainite crystallisation flotation (KCF) unit

Werra, K+S Group's biggest potash production centre, is a large-scale complex spread across four sites in two German states: Hattorf and Wintershall in Hesse, and Unterbreizbach and Merkers in Thuringia. Werra produce fertilizers alongside numerous technical and industrial products.

K+S has invested heavily in new production technology at Werra in recent years. In particular, the commissioning of the kainite crystallization flotation (KCF) unit at the Hattorf site in 2018 has allowed the company to dramatically cut the volume of wastewater discharged into nearby rivers,

The €180 million KCF unit recycles saline solutions generated by ore processing operations at the Hattorf and Unterbreizbach sites using technology developed in-house by K+S. Valuably, the unit has improved operational efficiency of the Werra complex by extracting more saleable product from process water (*Fertilizer International* 501, p10).

Going electric

EuroChem has invested heavily in the latest generation of electric mining machines at its $2.1 billion Usolskiy potash mine in Russia's Perm region and its sister $2.9 billion VolgaKaliy mine in the Volgograd region. The same potash mining equipment is being installed at both mines (*Fertilizer International* 495, p37).

Ural-20R mining machines, transfer hoppers and shuttle cars installed at the two mines excavate and transport potash ore to the main underground conveyor systems. The Ural-20R units, manufactured by Kopeysk Machine Building in Russia's Chelyabinsk region, can cut an arched roof 3.1 metres high and 5.1 metres wide. These crawler-mounted and electrically-powered machines are approximately 12 metres long, weigh 100 tonnes and have an annual capacity of around 600,000 tonnes each. ■

Rising costs are a particular issue for established potash producers. Maintenance and mining costs generally increase as potash operations age due to decline in ore reserves and grades and factors such as longer mining distances and thinning seams.

Many production plants have also kept to their original design, undergoing only limited modernisation and mining and processing improvements. Consequently, the economics of individual mining operations usually reflect the age of the asset and the particular characteristics of the local ore body.

Potash mining is governed by hard economics. This means that investments in technological development, cost reductions and efficiency improvements are only justified if the mine's remaining life, its profitability and external market conditions allow.

Nonetheless, huge investments in greenfield projects and brownfield expansions are being made by the industry. Mosaic and Nutrien and new entrants such as EuroChem and BHP are modernising and growing the potash industry by investing billions in automation, digitalisation and electrification (see box). ■

ADVANCES IN EQUIPMENT AND TECHNOLOGY

Continuous mining

Continuous miners are a mainstay of potash, gypsum and salt mining (*Fertilizer International* 475, p54) and their productivity has more than tripled in the last decade. Increases in their size, weight and power now allow these mining machines to operate at more economic production rates than traditional drill and blast methods.

Joy Global, the US mine machinery manufacturer, has sold over 6,000 continuous miners globally. The company was purchased by its Japanese rival Komatsu for $3.7 billion in 2016.

Potash producers have placed more than 70 orders for Joy continuous miners, flexible conveyor train (FCT) systems and other equipment. The firm's continuous miners are used by US producer Intrepid Potash at its New Mexico mine and by ICL at its Boulby mine in the UK.

Komatsu's Joy 12HM46 electrically-powered continuous mining machine, released in 2016, is specifically designed for excavating salt, potash, gypsum and trona. It incorporates design upgrades that increase service life, reduce total cost of ownership, and raise output by up to 20 percent versus earlier models. The new machine has a production rate of up to 1,000 tonnes per hour and should deliver ore outputs above 8,000 tonnes per day, suggests Komatsu, when used in combination with continuous haulage systems (*Fertilizer International* 501, p10).

Grinding

TerraSource is the owner of major equipment brands Gundlach, Pennsylvania Crusher and Jeffrey Rader. Collectively, these brands have supplied many of the impact crushers, cage mills and roll crushers employed by the global potash industry. The company has installed crushing equipment for all the major potash producers in North America, for example, as well as having a significant presence at potash operations in Russia and the Middle East (*Fertilizer International* 503, p44).

Gundlach, which has been an equipment supplier to the North American potash industry since 1967, offers both wet and dry crushing equipment. Notable potash industry models include the:

- 4000 Series roll crusher for raw potash ore
- 2000 Series roll crusher for breaking flake from the compactor
- Cage-Paktor cage mill for polishing oversize material from screens
- Nanosiz-R roll mill used for sizing oversize potash material discharged from screens.

Compaction-granulation

Köppern, a family-run business founded in Hattingen, Germany, has been supplying compaction and granulation equipment to the fertilizer industry for more than 70 years. Its sales include several hundred roller presses in over 60 countries.

Granular potash is produced almost exclusively by a compaction-granulation process. Fine-grained potash feed is generally compacted on roller presses to produce flakes with a density close to that of natural potash. These flakes are then crushed and screened to produce a closely-sized granular product.

Multiple compactors are often installed within one potash plant. These roller presses have a maximum flake throughput of approximately 140 t/h and a gross granular potash capacity of 40-50 t/h. After compaction takes place, impact and roller mills, working in a closed-loop cycle with multi-deck screens, crush the flakes into a granulate with an approximate density of 1.90-1.95 g/cm^3.

Since the 1990s, the preferred flake capacity of potash compactors has increased to 110-130 t/h. Köppern has introduced a number of innovations and design changes to ensure compactors of this size are safe, reliable to operate and deliver excellent flake quality. This has involved the modification of various sub-assemblies, including the frame, feeder, roll design, roll drive and the hydraulic systems (*Fertilizer International* 501, p10).

Liquid/solid separation

Andritz is a market-leading supplier of liquid/solid separation equipment to the potash industry. The company's equipment has been adopted by many large-scale potash producers globally, including conical screen bowl decanters, large-diameter disc filters and proprietary fluidised bed systems.

Andritz has a total of around 600 potash references around the world. In recent years, large-diameter Andritz disc filters have been adopted by potash operators in Belarus, Russia and South America, while its innovative conical screen bowl decanters have entered operation in North America.

The installation of a high-capacity, energy-saving Andritz dewatering system in Belarus, for example, has delivered major operational improvements at Belaruskali's Plant No 1. These included a 10 percent increase in production capacity, 15 percent lower energy costs and a 30 percent reduction in residual product moisture (*Fertilizer International* 484, p64). ▶

Froth flotation

Nouryon has a broad portfolio of flotation agents for the potash industry. The company has designed and developed several collectors for different potassium-bearing minerals and flotation conditions (*Fertilizer International* 506, p41). Its Armoflote® 619 collector is unique – according to the company – as it enables the successful reverse flotation of halite from carnallite and other double salts such as schoenite.

Fine clay particles – also known as slimes – negatively affect potash flotation due to their high charge and high surface area. Nouryon's Ethomeen® HT/40 and Berol® non-ionic collectors, and its Phospholan® PE65 anionic collector, enable selective reverse flotation of these slimes. This improves potash recovery by avoiding the loss of fine potash particles associated with mechanical desliming.

Several equipment innovations from Eriez are helping to improve froth flotation efficiency and reduce potash production costs (*Fertilizer International* 513, p38).

Inefficient size separation, for example, can negatively affect final product grades and recoveries in potash flotation. The Eriez CrossFlow® separator, which replaces vibrating screens and cyclones in potash processing, counters this problem by improving sizing efficiency and preventing fines by-pass.

The company's CavTube® column flotation cells have been shown to improve the flotation of fine potash – by increasing bubble surface area, developing a deep froth, and using counter-current washing to remove impurities.

Eriez's air-assisted HydroFloat® separator, meanwhile, can be used in combination with froth flotation to enhance the recovery of coarse particles (up to 4 mm in size) from the froth concentrate. It has been shown to achieve potash recoveries of more than 95 percent during coarse particle flotation, while maintaining a concentrate grade of more than 90 percent. ■

References

1. Warren, J., 2015. *Evaporites: A Geological Compendium*. Springer.
2. Prud'homme, M., & Krukowski, S., 2006. Potash. In: Kogel, J. et al. (eds.) *Industrial Minerals and Rocks, 7th Edition*. SME.
3. Garrett, D., 2012. *Potash: Deposits, Processing, Properties*. Springer.
4. UNIDO,1998. *The Fertilizer Manual, 3rd Edition*. Springer.
5. Perucca, C., 2003. *Potash Processing in Saskatchewan – A Review of Process Technologies*. CIM Bulletin.
6. Cocker, M., & Orris, G., 2012. *World Potash Developments*. Arizona Geological Survey Special Paper 9.

Tackling potash's carbon challenge

Waste heat recovery in the potash industry is now possible thanks to the availability or robust and reliable heat pipe heat exchangers (HPHEs). **Igor Makarenko**, Solex Thermal Science, explains how HPHE technology can help potash producers reduce their primary energy consumption and cut their CO_2 emissions.

Air pre-heater. HPHEs can be used to recover thermal energy from particle-laden air discharged from direct-fired rotary and fluidised bed dryers.

PHOTO: ECONOTHERM (UK) LTD

Potash producers globally are facing mounting pressure to decarbonise their operations. Driven by environmental concerns, regulatory pressures, stakeholder expectations and market demand, the industry at large is being called upon to improve its energy profile and reduce greenhouse gas (GHG) emissions.

Some producers have already made significant inroads. The International Fertilizer Association (IFA), for example, recently recognised the success of a new sustainable mining management system at ICL Iberia's potash mining operation in Suria, Spain. This notably includes an aggressive GHG emissions management plan.

BHP, meanwhile, has announced an additional CAD 7.5-billion investment in its under-construction Jansen potash mine in Saskatchewan, Canada (*Fertilizer International* 517, p8). The extra finance will double planned production capacity while producing up to 50 percent less GHG emissions per tonne of product, in comparison to the emissions average for potash mines in the province.

Still, industry bodies such as Fertilizer Canada are urging all potash producers to make a step change in their carbon reduction efforts. Proposed solutions have ranged from energy co-generation, complete mine electrification, to carbon capture and storage.

Yet these efforts face significant barriers – including high capital costs, regulatory approvals and long implementation timelines – while the potash industry needs access right now to low-cost carbon reduction measures with a high return on investment (ROI). This is particularly true for natural gas combustion, which is the single largest source of GHG emissions in traditional potash mining.

The combustion of natural gas generates nearly one-third of potash mining emissions, according to a recent University of Alberta study. In solution mining, there are typically two sources of emissions:

- Firstly, those from gas-fired boilers used to heat water before its pumped through ore body to dissolve the potash.
- Secondly, those generated during later drying stages at processing plants.

Similarly, in conventional mining, large scale emissions are also generated by the combustion of natural gas that provides the massive amount of heat required at the drying stage.

Heat pipe heat exchangers (HPHEs)

The adoption of heat pipe heat exchangers (HPHEs) has great potential in the potash industry (Figure 1). HPHEs have the ability to reclaim energy from process streams – that otherwise is typically wasted – offering the dual benefit of lower primary energy consumption and reduced GHG emissions.

While heat pipes have been around in some form or another since the 1830s, their use in heat exchangers first became commonplace during the mid 1940s. Today, HPHEs are generally used as industrial air-to-air heat recovery devices, with a variety of different designs available. They are typically found in industrial applications where plentiful (and otherwise wasted) heat can be recovered from exhaust gases.

The heat pipe itself is a hermetically-sealed hollow chamber containing a small amount of a functional fluid. The hollow chamber acts as a void and allows a process based on a change of phase to occur in the pipe.

HPHEs recover thermal energy as follows:

- The latent heat of vaporisation of a functional fluid present in a series of pipes – as it changes phase from a liquid to a gas – is used to absorb the heat contained in hot exhaust gases or liquid.
- The vapour generated rises to the top of the pipes where they come into contact with cold air or a water coolant.
- This causes the vapour to condense and release its heat.
- This heat is then absorbed by the cold air or water.

In the potash industry, HPHEs can be used to recover thermal energy from particle-laden air that is discharged from direct-fired rotary and fluidised bed dryers. They achieve this by capturing heat from this so-called 'one-pass air' and then uses this to pre-heat ambient air re-entering the dryers. A beneficial consequence of heat recovery is that it allows potash producers to curb their natural gas consumption during the drying of finished products. By lowering the temperature of the air entering scrubbers, the installation of HPHEs can also reduce scrubbing capacity requirements at potash operations

Valuably, in solution mining, the energy recovered from exhaust streams by HPHEs during the drying stage can be used to pre-heat process water. This is pumped underground and through the ore body to dissolve the potash – generating the brine that goes on to supply the above-ground processing plant.

Benefits

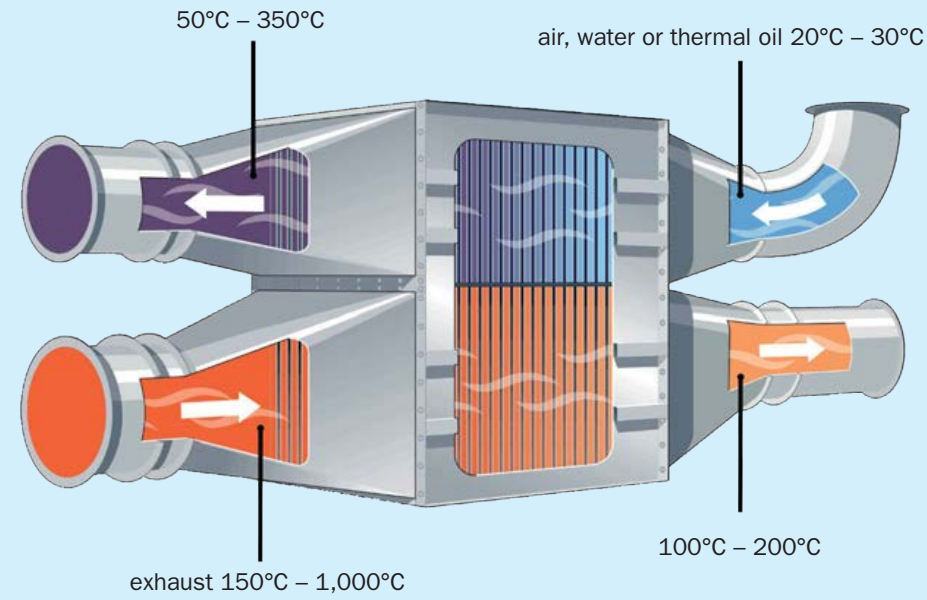
HPHEs are well suited to waste heat recovery applications. In fact, their key advantages highlight the very reasons why other technologies have been less successful.

Potash processing generates exhaust gas as a by-product, as is common in most industries that processes raw materials. The hot, corrosive and highly contaminated nature of these exhaust gases has made the use of traditional equipment such as shell and tube heat exchangers difficult.

In fact, many shell and tube heat exchangers fail within just six months, as noted in a recently published book[1]. Common types of failure include:

- Thermal stress cracking due to the differential expansion between the surface and casing
- Corrosion due to cold-spot-induce condensation
- Thin metal surfaces that lead to erosion and corrosion.

Fig 1: **HPHE schematic. HPHEs operate by extracting heat from 'one-pass air' at the potash drying stage. This can be used subsequently to pre-heat ambient air re-entering the dryers – or, in solution mining, pre-heat process water that is pumped through the ore body to dissolve the potash.**



Source: Solex

The risk of failure from contamination is also high in shell and tube heat exchangers, which can further disrupt manufacturing schedules.

The advantages of HPHE technology, in contrast, allow them to excel in industries where current heat exchangers are failing[1]. These include:

- The use of simple, robust industrial-grade equipment with built-in multiple redundancies.
- The pipes in HPHEs are free to expand and contract without applying stress on the casing.
- Isothermal operation, meanwhile, eliminates cold spots and condensation.
- The risk of cross contamination is also eliminated due to the separation between the exhaust flow and heat sink.
- The use of thicker walls (typically 2.5-3.5 millimetres) – because heat transfer is not affected by wall thickness – provides higher corrosion tolerance.

Furthermore, in the unlikely event that one heat pipe does fail, this doesn't significantly affect the overall performance of the HPHE unit and can be easily replaced in the next maintenance cycle[1].

"The development of the HPHE technology eliminates the drawbacks observed with traditional technologies with a higher degree of flexibility and reliability," the book's authors conclude[1].

Conclusion

Potash production plays a pivotal and growing role in feeding the planet. Global food production will need to double by 2050, according to some projections, to properly feed an estimated population of 10 billion people.

The key challenge for the potash industry is how to become more sustainable while meeting growing demand for its products. Indeed, there is an increasing expectation that the whole of the fertilizer industry will need to adopt low-carbon technologies and processes, as the IFA urged in its recent 2023 *Sustainability Report*.

The recovery of waste heat is an attractive option for the potash industry, as it provides the opportunity to decrease primary energy consumption, while also reducing GHG emissions. Although highly challenging previously, reclaiming thermal energy from waste heat sources is now possible thanks to the availability of robust and reliable equipment such as HPHEs.

With decades of proven effectiveness and widespread use across various industries worldwide, HPHEs present a highly compelling approach to bolstering the decarbonisation efforts of the potash industry.■

References

1. Malinauskaite, J., & Jouhara, H., 2023. *Sustainable Energy Technology, Business Models, and Policies*. Elsevier.

Phosphorus recovery: market drivers and key technologies

We look at current progress towards the greater use of recovered phosphorus, and whether there are lessons to learn from the success of the fast-growing carbon capture industry. We also highlight two pioneering European companies, EasyMining and Glatt, who are racing to bringing recovered phosphorus products to market.

MARKTRACK

Phosphorus recovery – learning lessons from carbon capture?

Catherine Thise

In an era defined by persistent economic pressures, climate challenges, and geopolitical volatility, it might have been assumed that the Covid-19 pandemic and conflicts in various parts of the world would convulse and reshape the fundamentals of the global fertilizer industry. Yet, against all odds, world production of phosphate rock and its derivatives has remained intact with strong demand growth across most global regions in 2023.

PHOTO: OSTARA

Ostara Nutrient Technologies recovers phosphorus from wastewaters globally to produce the struvite fertilizer Cystal Green.

The phosphorus recovery challenge

In numerous countries, efforts to promote phosphorus recycling in various forms are escalating, and the state of research is continuously advancing. However, critical questions remain:

- What can we say about the real impact and significance of investments in these technologies and the alternatives?
- What economic, ecological, and political advances, initiatives, directives, and decisions will enable us to progress toward a more sustainable global phosphates industry?
- Finally, how do we transform this industry so it is capable of addressing global demographic challenges and food security issues without depleting planetary resources or exacerbating climate change?

This article aims to provide fresh insights into phosphorus recovery – in light of human, environmental, and geopolitical challenges. It also provides a critical view on whether incumbent producers will change their production processes and investment objectives – and embrace technological advances in phosphorus recovery and the new operations dedicated to recycling and valorising phosphorus from secondary sources.

A geopolitical perspective on phosphate production and trade will also be provided, especially Europe's particular needs and priorities within the global economy.

Clearly, ecological concerns and sustainable development goals should encourage the phosphates industry to grow towards a greener future. With this in mind, an analysis of the development of the carbon capture industry in Europe and the United States is provided – to help understand how economic factors, legislative measures, and centralised support for technologies can influence a sector that has, until now, been unprofitable.

Cabon capture is currently experiencing tremendous growth, with significant advances within the United States. We therefore examine what lessons we can learn from the development of the carbon capture industry, how it is overcoming challenges, and the implications of these for the future of phosphorus recovery.

Geopolitics of phosphate recovery

Over the past 15 years, European states such as Switzerland, Germany, the Netherlands, and Sweden have been working to mandate the recovery of phosphorus from wastewater and sewage sludge. This legislative and political momentum is a response to recognised issues of pollution, overconsumption, and resource depletion.

Since 2014, phosphate rock has been included on the European list of critical raw materials, a status reaffirmed in 2020. The European Commission periodically conducts a criticality assessment across a broad spectrum of non-energy and non-agricultural raw materials. The 2020 criticality assessment covered 66 materials, compared to 41 in 2011, 54 in 2014, and 78 in 2017.

The two main parameters used by the Commission to determine a material's criticality include:

- **Economic importance**: This provides an overview of a material's significance to the economy in terms of application areas and the added value to the European Union's manufacturing sectors. Economic importance is also adjusted using a substitution index. This assesses the technical performance of substitutes and their costs for individual applications.
- **Supply risk**: This determines the risk of supply interruption to the EU. This is based on the concentration of primary supply in raw material-producing countries, their governance and trade aspects. Substitution and recycling are seen as risk reduction measures.

Phosphate rock's inclusion on this list is due to import dependency, its non-renewable nature and irreplaceability, and the geopolitical risks posed by the concentration of resources. Indeed, The EU imports 90 percent of its phosphate needs. Since 2017, white phosphorus (P4) has also been listed, being crucial for numerous industries, including electronics, batteries, and pharmaceuticals.

The designation of phosphate as a critical material, by underscoring the importance of waste recovery and more efficient use, should act as an incentive for the development of recycling technologies.

Legislation has spurred the development of new technologies (Table 1) and led to the creation of units that recover and transform secondary phosphorus into saleable end products. Yet the scope and utilisation of these technologies, and especially the commercialisation of end products, remain marginal when compared to the scale of the primary global industry. Especially given that phosphate rock mining has grown by nearly nine percent since 2020.

The real challenge associated with the development of phosphorus recovery technologies is not their technical feasibility or availability, but rather various economic and cultural factors within the industry.

Firstly, bringing these unconventional products to market is difficult, if their costs are higher, and when their quality and characteristics are not well understood by farmers. This contrasts with the very low cost of mining phosphate resources in countries where labour is relatively cheap and environmental policies may not be as rigorously enforced as they are in Europe. These existing market dynamics certainly do not make life easy for producers of alternative phosphates!

This market situation and the influence of low primary resource prices can make the business case for phosphorus recovery unattractive to investors over the medium term. It also highlights the complex dynamics at play in shifting towards more sustainable phosphate production.

Table 1: **Existing phosphorus technologies**

Sludge / process water	Sewage sludge	Fly ashes from sewage sludge
Around 40 identified technologies	Around 25 existing technologies	Around 20 existing technologies
First patent back in 1970	Products: fertilizers / struvite	Products: all types of phosphates

Source: Marktrack

Carbon capture – a case study

These considerations resonate with another high stakes emerging industry that has experienced a surge in recent years: the global carbon capture industry.

While the first complete carbon capture facilities date back to 1972, the technology has only really taken off in the last few years. The worldwide capacity for carbon capture, utilisation, and storage (CCUS) has been expanding at a compound annual growth rate (CAGR) of 10 percent over the past five decades, largely due to its application in enhanced oil recovery (EOR) within the United States. Despite this growth, the technology currently sequesters just 0.1 percent of global carbon emissions.

Nevertheless, the sector is on the brink of revitalisation. A surge in project announcement has occurred in the last two years – an uptick largely attributed to supportive policies and the pursuit of corporate net-zero objectives.

Projections based on recent project declarations suggest that CCUS capacity is expected to rise by a staggering 740 percent, reaching 420 million tonnes p.a. by 2035. This expansion corresponds to a CAGR of 18 percent between 2022 and 2035.

The United States, United Kingdom, and Canada are emerging as leading nations in the CCUS sector, based on currently declared project capacity. These three countries are solidifying their positions by adopting innovative policies and growing their in-country technological know-how.

Lessons to be learned from carbon capture

Three key lessons can be drawn from the growth of the carbon capture industry – and should serve as an inspiration in our quest for a more sustainable phosphate industry:

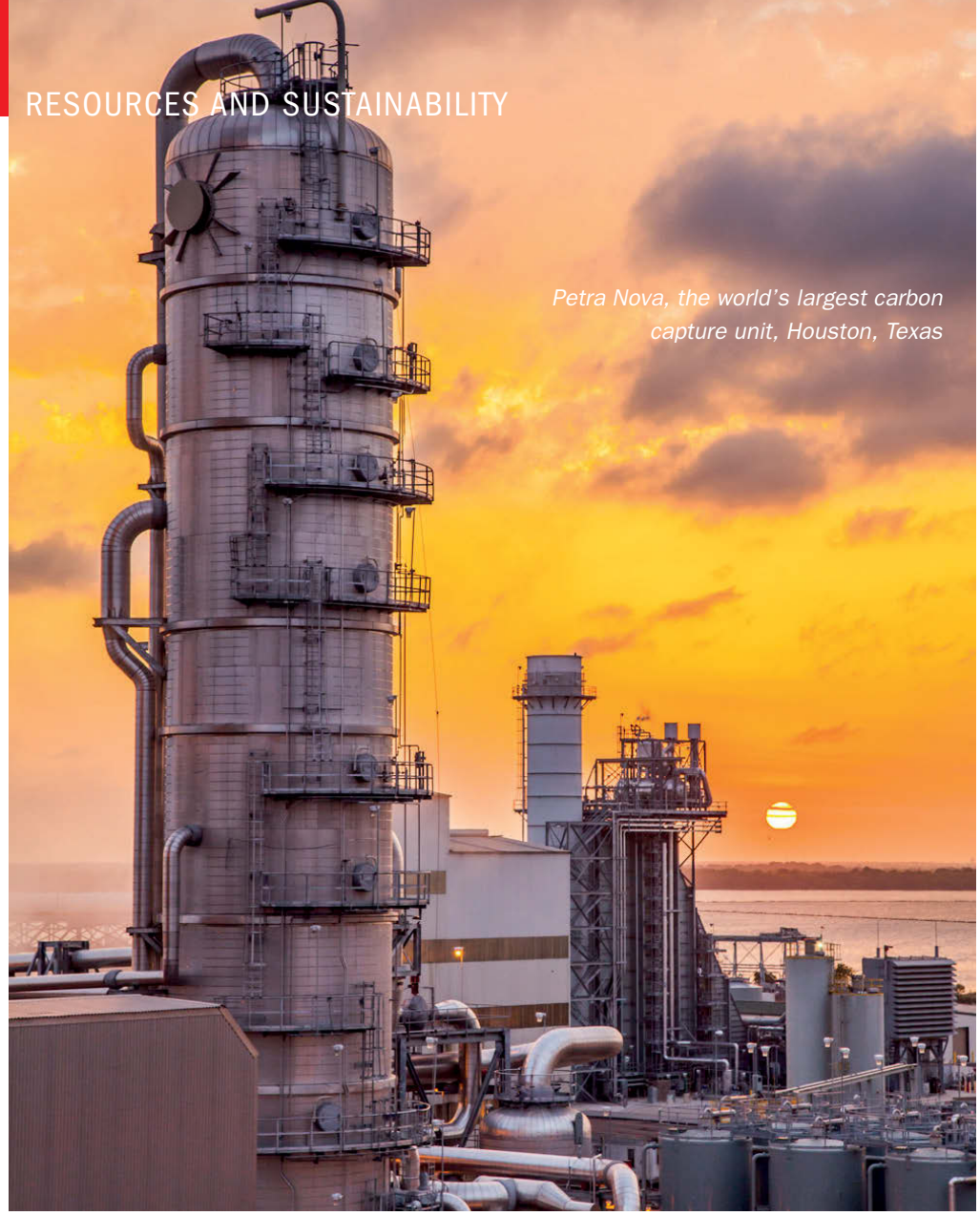


PHOTO NATIONAL ENERGY TECHNOLOGY LAB

Petra Nova, the world's largest carbon capture unit, Houston, Texas

The first lesson has been the significant challenge in finding uses for the captured CO_2. This has seen storage, not use, accounting for the majority (85%) of its fate. Why is this the case? Simply put, storage is the most economically viable solution in the short term.

In both the carbon capture industry, as well as in phosphate recovery from wastewater and secondary sources, there is no shortage of technologies; they are diverse and numerous across the globe (Table 1). Instead, the real issue is what to do with the output of these processes. The notable difference, versus CO_2, is that phosphate is a critical element for human life – this, hopefully, will drive the discovery of viable and beneficial products, uses and end markets.

The second and even more crucial lesson concerns financial incentives and legislation. These have genuinely propelled the development of carbon capture technologies.

A close look at the trajectory of the carbon capture industry reveals that a low carbon price, even when it occasionally hits $100/t, is not enough to justify substantial technological investments worldwide. Instead, data analysis shows that the markets where carbon capture technology is expanding are those where the state has implemented financial incentives, with or without legal capture obligations, to stimulate corporate investment.

In the United States, for instance, the Inflation Reduction Act (IRA) has been a real trigger for investment in these technologies. Europe, in contrast, has lagged behind in terms of investment, despite strong political will to combat climate change. The upshot? Policies that accelerate and support investment are what truly act as catalysts for new installations.

Finally, an interesting observation from the emergence of carbon capture technologies has been the establishment of systems of cooperation and hubs. This has seen companies that capture, convert, transport, store, or use captured CO_2 join together to form clusters – linking up for reasons of economic logic and the better use of global technological capabilities.

These clusters allow each player in the CCUS value chain to focus on their core competencies and leverage the strengths of others around them. The establishment of these industrial 'ecosystems' is what truly enables cutting-edge technologies to meet the major challenge of carbon capture – and do so without having to worry (too much) about being present across the entire value chain.

A parallel to this situation could be greater cooperation between specialists in wastewater treatment, sewage sludge processing, phosphate recovery, on the one hand, and those specialising in the transformation, valorisation, and marketing of phosphate-based products on the other. In my view, setting up such partnerships is a prerequisite for the success of the nascent phosphorus recovery industry.

Summing up – lessons and reflections

As I stated in my 2022 presentation to CRU's phosphate conference in Tampa[1], improved cooperation between stakeholders across the value chain, coupled with sound economic principles, are essential for the emergence and dissemination of disruptive technologies and their fight against climate change.

Unlike CO_2, which is considered a cost to industry, phosphate is an essential component of life. Our relationship with this critical raw material is mixed. Negative perceptions of the industry, and the unchecked ramp-up of phosphate rock extraction, reflect poorly on fertilizers and phosphates and their positive contribution to everyday lives. At a time when all efforts are directed towards using and valorising planetary resources sustainably, while minimising our carbon footprint, we should hope that companies, countries and international institutions can draw inspiration from the carbon capture industry and take lessons from the incentives that have enabled it to flourish.

To end on a personal and light-hearted note, I look forward to the day when I can proudly tell my friends "I am a phosphate analyst" without feeling embarrassed about the ecological impact our profession has on the world.

Instead, I hope phosphorus will be recognised as essential to life. I am convinced this remains the driving force behind countless individuals involved in phosphorus recovery initiatives around the globe: the pursuit of a better, more sustainable world where humanity and its environment co-exist in harmony. ■

References

1. Thise, C., 2022. Phosphate recovery from sewage sludge – market developments. *CRU Phosphates 2022 Conference & Exhibition*, 7–9 March, Tampa, Florida.

EASYMINING

Ash2®Phos – quality matters, volume matters, reliability matters!

Christian Kabbe and Philipp Theuring

Fig. 1: The inauguration of the world`s first full-scale Ash2Salt plant in Högbytorp, Sweden, in spring 2023

PHOTO: CHRISTIAN KABBE

EasyMining believes that, if we are serious about creating a sustainable society, we have to start using the materials we already have – for as long and as often as possible – without compromising public health and the environment. To put it simply, quality matters!

There are currently four EasyMining processes in various stages of development and implementation.

The **Ash2Salt** process extracts commercial grade salts (KCl, NaCl, $CaCl_2$) out of fly ashes from municipal solid waste incinerators. The first full-scale plant (Figure 1) commissioned in 2023 has the capacity to process 135,000 t/a of fly ash and recover several thousand tonnes each of the above three salts. The process has the potential to domestically capture what is a gigantic secondary source of potassium, given the huge volumes of these type of ashes, and use this in fertilizers.

Aqua2N is a patented innovation for the efficient removal and recovery of ammonium from aqueous flows. It has been successfully piloted in the past few years and is now entering the implementation phase in sewage treatment. The process also has potential in digestate and manure processing.

Our **CleanMAP** technology, meanwhile, extracts ammonium phosphate from mining waste or other mineral sources.

Last, but certainly not least, **Ash2Phos** technology recovers several valuable materials from ashes, including incinerated sewage sludge, or other P-rich feedstocks. This article provides an update on the full-scale implementation of Ash2Phos.

Ash2Phos update

As previously highlighted by this magazine, the Ash2Phos process is designed to recover more than 90 percent of phosphorus contained in P-rich ashes, such as those from sewage sludge incineration, and convert this into a high-grade calcium phosphate product, branded as RevoCap® (*Fertilizer International* 509, p58).

In our view, the only way of guaranteeing that the materials recovered from sewage sludge ash are of uniformly high quality is, firstly, by extracting these from the highly variable and heterogeneous ash matrix and, secondly, efficiently separating off heavy metals and other contaminants.

As well as recovering phosphorus, the Ash2Phos process also generates well-defined co-products, such as commercial-grade ferric chloride and sodium aluminate, while leaving a sand fraction that is suitable for use as a construction material. The heavy metal fraction, separated by Ash2Phos as filter cake, also has potential as an ore material for metallurgy.

Other recycling methods which – unlike the above approach – leave phosphorus within the ash matrix, together with various amounts of iron, aluminium and other metals, are not 'true' phosphorus recovery processes, in our view. Ash2Phos, in contrast, is a true circular economy process, as it splits 100 percent of the ash into valuable products and co-products, thereby closing several material cycles instead of only one.

In phosphorus recovery, the ability of a process to generate final products which are safe and of homogeneous quality, independent of the heterogeneous quality of the input material, is critically important. This point is underlined when you compare ash composition data to the limit values for contaminants set by the EU Fertilising Products Regulation (Table 1).

Unprocessed ashes do not make good P fertilizers. This can be seen from the values for ash 'matrix elements' in the upper part of Table 1. In particular, fertilizing efficiency is poor when the iron and aluminium content (Fe+Al) of the ash is much higher than its phosphorus (P) content (i.e., (Fe+Al)/P >>1). The key point here is that just offering P content, while leaving the matrix elements in place, means the end-product will not function as an effective nutrient provider in agriculture!

The heavy metal data in the lower part of Table 1 reveal the legal status of materials intended for fertilizer use. It can be seen that there is a high risk of sewage sludge ashes being prevented from usage in the fertilizer market as the limits for all the regulated heavy metals are generally exceeded.

Currently, it is rare for sewage sludge ashes to meet regulatory requirements on heavy metals. And compliance is expected to vanish completely in future, as more demanding sewage treatment discharge consents are introduced alongside stricter contaminant limits for fertilizers, as legislators and regulators act to protect public health and the environment.

Phosphorus recovery from sewage sludge will become obligatory in Germany in stages between 2029-2032. Objectives such as cutting fertilizer import dependency, reducing soil contamination and improving phosphorus use efficiency

Table 1: **Typical elemental values for municipal sewage sludge ashes in central Europe**

Element	Average concentration (%)	(mg/kg)	Concentration range low (%)	high (%)	
P	9,4	94,000	5,9	13,1	
Fe	10,8	108,000	1,8	20,3	
Ca	10,1	101,000	7,1	16,2	
Al	5,5	5,000	2	20,2	
K	1	10,000	0,3	1,7	
Mg	1,3	13,000	0,3	2,5	
Na	0,6	6,000	0,2	1,1	
Ti	0,4	4,000	0,1	0,6	
Si	11,6	11,000	5	17,5	**Regulatory limits**
Heavy Metals	**Average concentration** (%)	(mg/kg)	**Concentration range low** (mg/kg)	**high** (mg/kg)	**EU FPR** (mg/kg)	**DÜMV** (mg/kg)
Cu	0,10	1,015	522	2,477	600	900
Zn	0,29	2,862	1,882	4,930	1,500	5,000
Cr	0,02	213	79	1,088	2	2
Mn	0,17	1,713	435	4,932		
Ni	0,007	73	39	191	100	80
Pb	0,01	139	63	363	120	150
As	0,002	187	44	124	40	40
Cd	0,0003	26	1	57	60	1,5 / 50
Hg	0,0001	7	1	21	1	1

Source: EasyMining

were behind the country's introduction of a new sewage sludge ordinance. To meet this deadline, building up ash processing capacity clearly needs to start now.

EasyMining has joined forces with Gelsenwasser to implement and roll-out Ash2Phos in the German market. In 2021, the two companies formed the joint venture Phosphorgewinnung Schkopau GmbH to build and operate the first full-scale Ash2Phos plant in the Schkopau chemical industry park (Figure2). This will have a capacity to process 30,000 t/a of ash, yielding 15,000 t/a of high-grade RevoCaP®.

SOURCE: EASYMINING

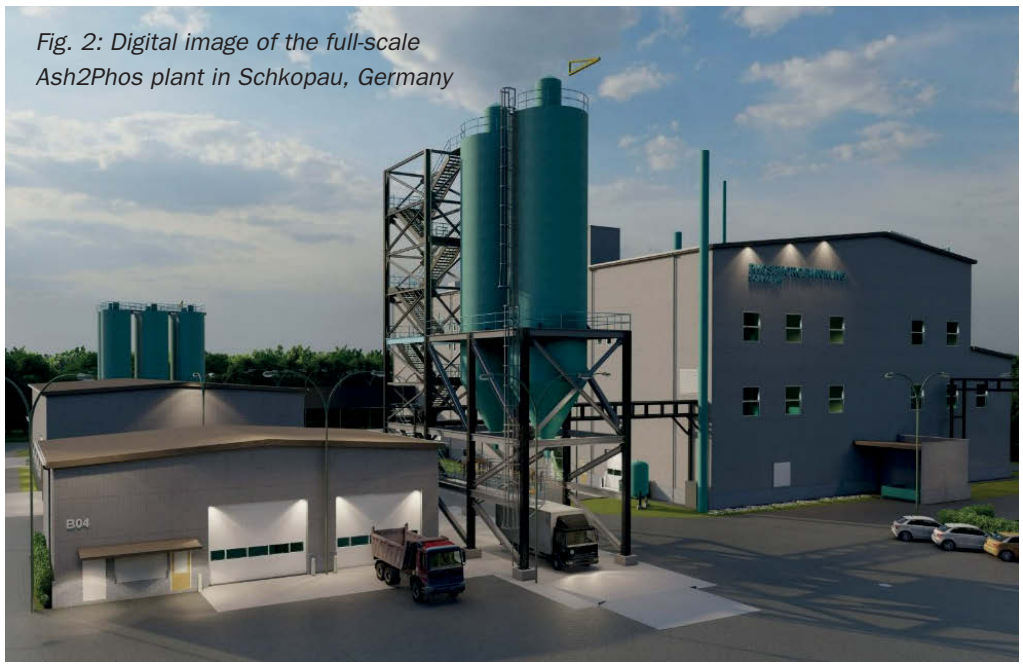


Fig. 2: Digital image of the full-scale Ash2Phos plant in Schkopau, Germany

In collaboration with Gelsenwasser, the roll-out of up to four more Ash2Phos plants is expected by 2035, providing a total capacity of 300,000 t/a for sewage sludge ash in the German market and yielding a volume of 150,000 tonnes of RevoCaP® annually. Further roll-out in neighbouring countries, as well as in Germany, is already a strong prospect.

Construction of the Schkopau plant is scheduled to start in the second quarter of this year with start-up expected in late 2026. The plant should be operating at full capacity in 2027 if all goes to plan.

The second Ash2Phos plant, at Helsingborg, Sweden, will have the same capacity as the Schkopau unit. It is currently in the permit application phase, with construction likely to follow the inaugural German plant after a gap of 1-2 years.

Supply risks, emerging markets and the circular economy

Supply chain disruptions in the aftermath of the Covid-19 pandemic, and the energy and commodity market shocks of 2022, have made one thing crystal clear: for Europe, external dependency on raw materials from other regions, together with reliance on extended supply chains, is increasingly risky for – and even a threat to – its economy, society and citizens. This makes access to resources a major pillar of continuing economic success and social survival.

Full control and access to resources are only possible when these are available within Europe's borders. Consequently, it is likely that the domestic recovery and recycling of secondary resources will become essential from now on. Conversely, the wasteful use of resources and downcycling are no longer affordable. This is especially true for Europe, a region of high resource consumption that is relatively poor in primary raw material deposits.

Interestingly, while the European Commission has placed phosphorus on the EU Critical Raw Materials (CRM) list, alongside so-called tech metals, the element is absent from its Strategic Raw Materials (SRM) list. This suggest that the importance of phosphorus to the European economy has yet to be fully recognised.

Greater recognition may come, however, with the emergence of phosphorus as a key enabler of the energy transition in the transport sector.

This is linked to the growing use of lithium iron phosphate (LFP) batteries in electric vehicles (*Fertilizer International* 517, p53). This emerging market is in addition to the essential role of phosphorus as an irreplaceable nutrient in agriculture. LFP batteries currently require 350 g P per kWh and their use in vehicles is just starting to ramp up.

Such fast growing non-food applications for phosphorus could place pressure on primary resources and increase the prices of phosphate products in future. The key question here is this: which markets will recovered phosphorus supply in future – and will lower value agricultural markets be able to compete with demand from vehicle and battery makers if this provides higher margins and returns. Looking ahead, therefore, it cannot be assumed that the traditional agricultural route to market for phosphorus recovered from sewage sludge will remain unchallenged.

It is useful to compare the potential scale of recovered phosphorus production in Europe with global demand from LFP batteries:

- The theoretical P potential in German sewage sludge ashes, for example, is about 50,000 tonnes annually.
- Production at this scale would be enough to equip about two million electric vehicles with LFP batteries (based on the world's current highest selling model).
- Theoretically, at European level, about 100,000 tonnes of P could be made available for LFP batteries by 2035, potentially equipping four million vehicles with a power source.

Demand for P from the electric vehicle sector is forecast to grow and be sustained. Since car batteries are designed to last 8-12 years, battery recycling is unlikely to be able to fulfil the LFP battery requirements from new vehicle production before 2040, in our view.

Summary

Agricultural and industrial demand for phosphorus will change how secondary resources are viewed and managed in Europe. Discarded materials that were once considered just waste and a disposal problem must now be used as efficiently as possible for the benefit of the economy, society and the environment.

EasyMining, given our production plans and the high quality and versatility of our RevoCap® calcium phosphate product, is well positioned to contribute to the food security needs of a growing global population – and substantially increase supply security for other industries.

About EasyMining

EasyMining is the innovation company of the Ragn-Sells Group, a Swedish resource management and recycling company with a history dating back to 1881. At EasyMining, we're developing and implementing innovative large-scale processes that recover valuable resources. This includes the commercial capture of the major crop nutrients N, P and K from material flows at industrial scale. Our technologies enable the recovery of highly uniform and high-quality raw materials and products from highly variable secondary sources, such as ashes or process waters. ■

GLATT

Phosphorus recovery: delivering better yields and less waste

Dr Johannes Buckhheim

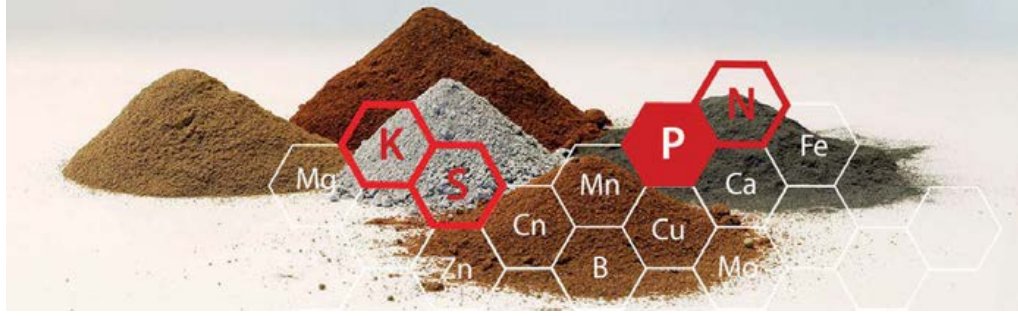
In this article, we set out how the legal and environmental requirements to recover phosphorus more effectively from sewage sludge ash – while removing heavy metal contaminants – has prompted the wider adoption of Glatt's PHOS4green process.

Introduction

Phosphorus, as an essential plant macronutrient, is a key component of many fertilizers. Furthermore, its classification as a critical raw material has made phosphorus recovery – from sewage sludge, for example – a legal requirement in the European Union and Germany.

The patented PHOS4green process, developed by Glatt Ingenieurtechnik GmbH (Glatt) in Weimar, Germany, is an attractive and viable option for recovering economically-valuable phosphorus and other essential macro and micronutrients present in sewage sludge ash (Figure 1).

Fig. 1: Sewage sludge ash is an attractive source material for fertilizer production as it contains phosphorus and many essential macro and micronutrients.



SOURCE: GLATT

The sewage sludge ash generated in urban centres frequently contains high levels of heavy metals alongside phosphorus. In Germany, the removal of these heavy metals during the phosphorus recovery process is now mandatory to prevent the environmental contamination of agricultural land.

Encouragingly, Glatt technology has been shown to be effective at eliminating heavy metals from sewage sludge ash during recent trials carried out in the Rhine-Main metropolitan region of Germany under the RePhoRM research project.

A two-stage process

Developing PHOS4green as an advanced commercial technology has been a particular priority for Glatt in recent years (Figure 2). The two-stage process extracts

phosphorus from sewage sludge ash and then incorporates it within fertilizer granules. These have a precise chemical composition and specific physical properties.

PHOS4green granules are an effective soil fertilizer as they contain high levels of plant-available nutrients. Granules of sufficient hardness and density can be easily manufactured with an adjustable particle-size distribution (2–3 mm).

The manufacturing method is based on the processing of liquid suspensions using fluidised bed and spouted bed equipment. The use of spray granulation is a major innovation that allows the continuous production of fertilizer granules (instead of batch production).

Eliminating ash contaminants

Heavy metals (copper, zinc, nickel, lead etc.) enter urban wastewaters via various pathways. These are typically concentrated in sewage sludge during mechanical and biological treatment at wastewater treatment plants – and subsequently end up in sewage sludge ash following thermal treatment.

The degree of heavy metal contamination can vary significantly as input levels into wastewater depend on factors such as industrial activity within the municipality.

The composition of recovered phosphorus derived from waste streams – including the P generated by Glatt's PHOS4green process – must comply with clear regulatory limits (set by German Düngemittelverordnung [DüMV] and EU Regulation No. 2019/1009) when incorporated into fertilizers.

Heavy metal removal is not necessary when sewage sludge ashes comply with these fertilizer ordinances. But how can municipal regions guarantee compliance with these stipulations – if the heavy metal content of their sewage sludge ashes exceeds regulatory limits?

The RePhoRM project

To address this question, Glatt is participating in RePhoRM (Regional Phosphorus recycling in the Rhine-Main region), a collaborative project funded by the German Federal Ministry of Education and Research (Grant No 02WPR1545A-G). The project is now fully underway after a successful trial phase.

RePhoRM was set up to jointly develop and implement technology for large scale phosphorus recycling in the Frankfurt Rhine-Main metropolitan region in Hesse State, Germany. The project sources ash from local mono sewage sludge incineration plants for use as a feedstock.

The project's aims, as set out in the Hessian resource protection strategy, are to close the nutrient cycle within the region by using recycled phosphorus to create granular fertilizers for agriculture. The project is 'closing the loop' by establishing a practical and viable phosphorus recovery process for Frankfurt Rhine Main and creating a regional phosphorus recycling network.

The most challenging project objective, from a technical point of view, is designing a method that effectively and efficiently remove heavy metals from sewage sludge ash prior to phosphorus recovery.

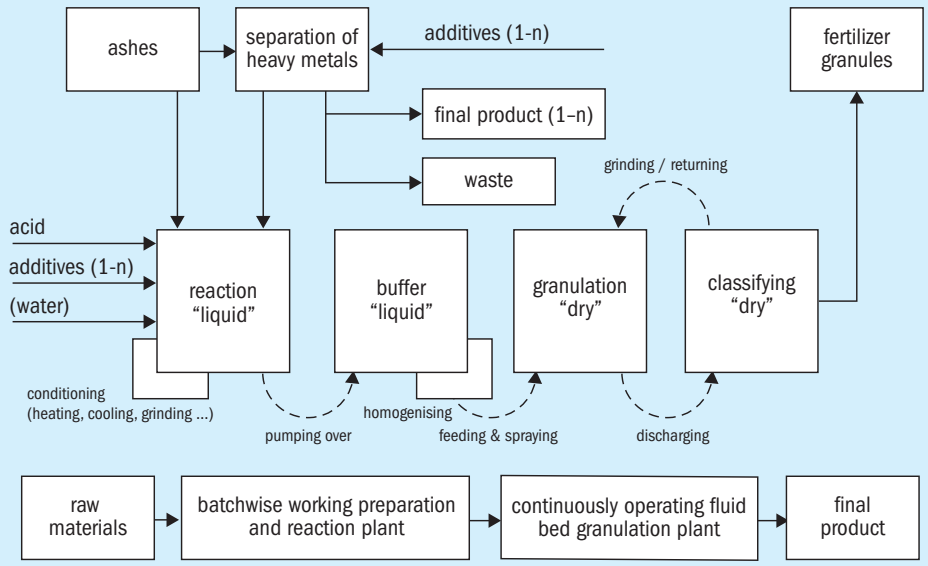
The role of Glatt in the project, and the main challenge for the PHOS4green process, is to produce fertilizer granules by:

- Firstly, removing heavy metals from sewage sludge ash (the input material)
- Developing and implementing the phosphorus process industrially on a large scale.

Glatt is also contributing its expertise to the following two sub-projects:

- The planning and construction of a container plant at Industriepark Höchst
- Spray granulation studies on purified secondary phosphorus recovered from sewage sludge ash.

Fig 2: **Glatt offers various heavy metal removal options as part of its modified PHOS4green process.**



Source: Glatt

The overall objectives of the RePhoRM project are to:

- Develop a joint approach to phosphorus recycling in the Frankfurt Rhine Main metropolitan region that meets the needs of the region's major wastewater treatment and mono sewage sludge incineration plant operators
- Establish a large-scale phosphorus recovery unit for sewage sludge ash at Industriepark Höchst using PHOS-4green technology
- Optimise the spray granulation process under various conditions
- Ensure the regulatory conformity of the granular fertilizer, especially its agricultural acceptance as a recycled product
- Carry out accompanying lifecycle assessments for heavy metal removal and phosphorus recycling
- Develop a legal and organisational framework for a phosphorus recycling network
- Provide an economic analysis of the project's integrated approach to phosphorus recovery and prepare a business case.

Project partners

- Technical University of Darmstadt
- TVM – Thermische Verwertung Mainz GmbH
- City of Frankfurt – Stadtentwässerung Frankfurt am Main (SEF)
- Becker Büttner Held – BBH
- Glatt Ingenieurtechnik GmbH
- Association for sewage treatment Langen/Egelsbach/Erzhausen.

Table 1: **Option 1: phosphorus extraction by washing is recommended for ashes highly contaminated with heavy metals, especially cadmium, lead and arsenic.**

Option 1	**Extraction of phosphorus – P extraction objective: P-release rate > 80%**
Pros	• Application for ashes with low P content • Application for ashes with high load of heavy metals • Removal rates of 20-80%
Cons	• High amounts of waste • Loss of essential elements
Products	• Depleted phosphoric acid • NPS, NPK, …

Source: Glatt

Table 2: **Option 2: the selective removal of heavy metals, in contrast to phosphorus, extraction, is the main priority.**

Option 2	**Extraction of heavy metals – HM extraction objective: low P re-dissolution, high re-dissolution rate of heavy metals**
Pros	• Low waste stream • Over 95% of the P content of the ashes is utilised
Cons	• Lower depletion rates depending on extraction agent and ash matrix • Removal rates of 10 – 50%
Products	• P-38, P-46, NPS, NPK

Source: Glatt

Three process options

The project identified three process options for PHOS4green, depending on the quality of the ash input and the product output required:

- **Option 1**. This is the basic level process for phosphorus extraction (Table 1). Spray granulation with PHOS4green technology is used to produce fertilizer granules from sewage sludge ash. This enables customisation of their chemical composition and physical properties. The priority is establishing local supply chains and strengthening the circular economy.
- **Option 2**. This focuses on a newly developed selective process for removing heavy metals using specific acids (Table 2). The objective is to utilise as much of the ash as possible and minimise waste generation. This approach is ideally suited to ashes with low heavy metal concentrations.
- **Option 3**. This is a 'double-extraction' process that combines a basic process for phosphorus recovery and heavy metal removal in two steps. Step two is designed to be particularly effective at removing heavy metals such as nickel and zinc.

The heavy metal and phosphorus content of fertilizer granules (P-38) produced using the Option 2 process are shown in Table 3.

Next steps

The project's findings should enable the implementation of an integrated approach to phosphorus recovery by determining both the quantitative and qualitative characteristics of sewage sludge ash flows.

Initially, heavy metal inputs into the sewage system and wastewater treatment plants in the city of Frankfurt am Main were recorded. This baseline data, by determining the accumulation of heavy metals from different sources, allowed mitigation options to be developed. Following on from this, the dissolution and separation of heavy metals from sewage sludge ash at both laboratory and demonstration-plant scale was investigated.

Developing an economic method for heavy metal removal allows more sewage sludge ash to be used for phosphorus recovery. Implementing a modified PHOS-4green process that includes heavy metal removal offers dual benefits, as it should compensate for fluctuating ash loads in the future and meet stricter regulatory limits, if and when these are introduced.

The ability to remove heavy metals from incoming raw materials eliminates the need for 'lot-by-lot' selection and allows the use of all the available sewage sludge ash instead. This helps to make the process viable as a long-term option by simplifying sewage sludge treatment, within regions and between urban areas, by reducing the influence of both the origin and quality of ash on phosphorus recovery and fertilizer production. This contributes to sustainable sewage sludge use by helping guarantee a secure long-term disposal route.

Glatt aims to provide an efficient recycling process option that offers fertilizer manufacturers high-quality products while minimising their environmental impacts. The company's innovative technologies are contributing to a more sustainable circular economy by helping to overcome the challenges of recycling phosphorus from sewage sludge ash. ■

Table 3: **Heavy metal content of fertilizer granules (P-38) produced using the heavy metal extraction process (Option 2).**

Element mg/kg	Raw material ash mixture mg/kg	P-38 granules mg/kg	Limit due to EU-V 2019/1009 mg/kg	Limit due to DüMV annex 2 mg/kg
arsenic	28	17.7 ± 2.27	40	40
cadmium	7.7 (GW 10 mg/kg)	2.33 ± 0.21	60 mg/kg P_2O_5	50 mg/kg P_2O_5
copper	987	476 ± 34	600	900
nickel	86	70 ± 5.0	100	80
lead	142	69 ± 4.61	120	150
zinc	2,700	1,389 ± 102	1,500	5,000
P_2O_5 (ges)%	20	42.4 ± 2.65	–	–
P_2O_5 (H_2O)%	<1	29.4	–	–

Source: Glatt

Phospholutions – delivering efficiency, creating value

PHOTO: IFA

African AgTech Start-Up winner Hunter Swisher, CEO of Phospholutions.

Phospholutions, Inc., a sustainable fertilizer company headquartered in the United States, recently launched its flagship technology, RhizoSorb®, to improve phosphorus fertilizer efficiency.

RhizoSorb is a patented and proprietary fertilizer additive. The core technology originated from The Pennsylvania State University and was discovered by Hunter Swisher, an undergraduate majoring in plant sciences.

In 2016, Swisher established Phospholutions to commercialise this technology. Recently recognised as a Forbes 30 under 30 awardee in social impact, Swisher continues to spearhead and lead the company – which has raised nearly $30 million in venture capital since its inception.

Doubling efficiency

RhizoSorb is embedded directly into fertilizer granules during conventional upstream production. The product, backed by data from more than 500 replicated small plots and field trials, has been proven to double phosphate efficiency, allowing farmers to reduce application rates and achieve the same yield.

Phospholutions has attracted financial backing from leading investors and global agricultural companies, including Keytrade Ag, Continental Grain Company, Tekfen Ventures, Bunge, UPL, and The Andersons. It was recently announced that industry veteran Bert Frost, currently EVP of Sales, Market Development, and Supply Chain for CF Industries, will join as the company's Board Chair.

Phospholutions was the first agricultural start-up to become a member of the International Fertilizer Association (IFA) and most recently won the IFA/UM6P African AgTech Start-up Challenge (see main photo).

Sharing value

Phospholutions business model involves partnering with phosphate manufacturers to produce and co-market RhizoSorb-based fertilizers.

RhizoSorb 8-39-0, a formulation derived from monoammonium phosphate (MAP), was recently launched in the North American market (via two-step distribution) as a lower-cost replacement for conventional phosphate fertilizers in row crops. The product delivers more value per unit of applied phosphorus to farmers, saving 15 percent per acre on average, while achieving the same or greater yield.

PHOTO: PHOSPHOLUTIONS

Granular RhizoSorb 8-39-0 phosphate fertilizer.

Phospholutions is also expanding internationally in Europe, Central, and South American markets.

RhizoSorb's active ingredient is a mined and processed material that is incorporated

as a powder directly into phosphoric acid granulation. This reduces production costs per tonne by decreasing phosphoric acid and ammonia use while increasing production throughput. The technology has the potential to significantly extend mine life and generate more value per unit of phosphorus.

RhizoSorb is currently the only technology on the market that allows phosphate producers to share in the value created by better efficiency – offering phosphate producers the opportunity to make more margin per P_2O_5 tonne. RhizoSorb 8-39-0, being sold at a premium and when applied across 35 percent more acres per tonne, should allow producers to gain more market share without increasing rock consumption.

Supplying phosphorus as needed

Conventional chemical fertilizers are highly soluble and nutrient release does not necessarily align with plant needs. Consequently, as little as 10 percent of applied phosphates are available to the crop in the year of application.

Phosphate is soluble in the soil and is highly reactive, fixing to soil particles, organic matter, and metal ions such as calcium, iron, and aluminum. Once fixed in the soil, phosphate can take years to decades to release – and can even be locked up indefinitely, never to be available for plant uptake.

Current on-farm management strategies can result in phosphorus overapplication to compensate for this inefficiency and to ensure yields are not compromised by poor availability to the crop. Some growers also excessively overapply phosphate in low P soils to ensure they build soil phosphorus over time. This overapplication, due to run-off and nutrient leaching, contributes to devastating impacts on aquatic ecosystems.

The technology behind RhizoSorb works by pre-loading phosphorus onto the surface of RhizoSorb during phosphoric acid granulation. It represents a new and novel approach to controlling the release of nutrients.

Phosphorus adsorbed onto RhizoSorb during production is later released into the soil solution based on a chemical concentration gradient. This allows the crop to remove plant-available phosphorus as it is needed. As phosphorus within the soil solution is depleted, RhizoSorb releases more P to replenish what is removed. Its unique release behaviour can significantly reduce the amount of applied phosphorus that is tied up, making more phosphorus available for plant uptake throughout the entire growing season.

Sustainable phosphorus use

RhizoSorb technology could be a breakthrough in promoting more sustainable phosphorus use in future. Phospholutions has released a third-party life cycle analysis showing RhizoSorb 8-39-0 reduces carbon emissions per acre by more than 45 percent compared to MAP. Additionally, a study funded by the fertilizer industry at the New Zealand Plant and Food Research Center showed RhizoSorb 8-39-0 reduces run-off potential by up to 78 percent versus MAP.

Coming to market with RhizoSorb technology, Phospholutions offers fertilizer producers and growers the ability to capture additional value by decreasing environmental impacts and making conventional fertilizers more sustainable without requiring large capital expenditures. ■

Advertisers' Index

Advertiser	Page	Website
CRU/Argus Fertilizer Latino Americano 2025	53	fla-conference.com
CRU Sulphur+Sulphuric Acid 2024	OBC	sulphurconference.com
Eirich	9	eirichusa.com eirich.com
EMT	27	emt.tech
New AG International Annual	IBC	informaconnect.com/newagconference
Prayon (Profile)	41	prayon.com
Prayon Technologies	IFC	technologies.prayon.com

Next issue: May/June 2024

Distribution:
IFA Annual Conference, Singapore, 20-22 May

- Fertilizer financial scorecard
- Low carbon ammonia projects – overcoming headwinds
- The enhanced efficiency fertilizer market
- Spotlight on sulphuric acid technologies
- Fluoride removal: nuisance pollutant to valued by-product
- The crop benefits of polyhalite

Closing date for advertisement space booking is 17 April 2024
For further information and to book advertisement space contact:
Marlene Vaz, Advertisement Manager
Email: marlene.vaz@crugroup.com Tel: +44 (0)20 7903 2177

Editor:
SIMON INGLETHORPE
simon.inglethorpe@crugroup.com

Managing Editor & Publisher:
LISA CONNOCK
lisa.connock@crugroup.com

CEO Communities:
NICOLA COSLETT
nicola.coslett@crugroup.com

Subscription rates:
GBP 300; USD 550; EUR 450

Subscription claims:
Claims for non receipt of issue must be made within 3 months of the issue publication date.

Sales/Marketing/Subscriptions:
MARLENE VAZ
marlene.vaz@crugroup.com
Tel: +44 (0)20 7903 2177

Advertising enquiries:
MARLENE VAZ
marlene.vaz@crugroup.com
Tel: +44 (0)20 7903 2177

Previous articles from *Fertilizer International* and *PK Insight* from 1997 to the present are available digitally in PDF format. To make a purchase, or for a list of available articles, please see:
www.bcinsight.com

ISSN: 0015-0304

Design and production:
TIM STEPHENS

Mixed Sources
Product group from well-managed forests and other controlled sources
www.fsc.org Cert no. SA-COC-001904
© 1996 Forest Stewardship Council

Printed in England by:
Buxton Press Ltd
Palace Road, Buxton, Derbyshire, SK17 6AE

Published by: CRU Publishing Ltd
1st Floor, MidCity Place
71 High Holborn
London WC1V 6EA
Tel: +44 (0)20 7903 2000
Web:www.bcinsight.com
www.bcinsightsearch.com

40th

Oil | Gas | Fertilizers | Metallurgy | Industrial

CRU Sulphur + Sulphuric Acid 2024 Conference & Exhibition

4-6 November 2024 • Hyatt Regency, Barcelona, Spain

CO-LOCATED WITH REFCOMM EUROPE

Technical excellence and operational improvement for the sulphur and sulphuric acid industries

Call for Papers Open

JOIN THE DISCUSSIONS IN BARCELONA

Now in it's 40th year, the event continues to be an essential annual forum for the global sulphur and acid community to learn, connect and do business.

You can expect an expanded market outlooks agenda, including expert insights from CRU's analysis teams on major supply and demand markets, including sulphur, sulphuric acid and phosphates, plus additional industry updates from key players from across the supply chain.

> "This event was a great opportunity to meet world wide industrial professionals in sulfuric industry, goods & service providers as well as operationals, in the same time and in the same place."
>
> **Ismaili Abdessamad**, OCP, Operations Senior Manager Sulphur + Sulphuric Acid attendee

For more information or to book your place, please visit:
www.sulphurconference.com