

2nd International Workshop on Alternative Potash

15 June 2017



Prof. David Manning is a trained geologist in geochemistry and mineralogy, bringing skills from that area to the field of soil science whilst maintaining activity in mineral raw materials, energy and waste management. His goal is to develop a detailed understanding of the reactions that take place in soils to provide benefits that help sustain human populations. His work focuses on (a) carbon capture - through the artificially-influenced precipitation of carbonate minerals and through use of poorly-reactive carbons such as biochar, and (b) on novel methods to build soil fertility - exploiting the weathering of minerals.



Prof. Antoine Allanore's research applies to sustainable materials extraction and manufacturing processes. He joined MIT in 2010, after several years of service within one of the world's largest iron and steel R&D centres. As a Faculty Professor in the Department of Materials Science & Engineering, he has developed numerous alternative approaches to metals and minerals extraction and processing; for example a waste-free process to produce a potassium fertilizer from earth-abundant raw materials. Prof. Allanore was awarded the TMS DeNora Prize in 2012, recognizing outstanding contribution to the reduction of environmental impacts, especially focused on extractive processing, as well as the Early Career Faculty award also from TMS.



Dr. Natalia Yakovleva joined Newcastle University London as a Senior Lecturer in International Business Strategy in September 2015. She has a PhD in Environmental Studies (2002) and a Bachelor Degree in Economics (1998). Natalia has held academic positions at Cardiff University, University of Surrey and University of Winchester. She is a programme director for BSc International Business Management (London campus) and an active researcher in the field of sustainable business and corporate social responsibility. She is on the editorial boards for The Extractive Industries and Society (Elsevier journal) and Resources (MDPI Journal).



Dr. Mbette Mshindo Msolla holds a PhD in Agriculture (majoring in Soil Science from Sokoine University of Agriculture). He has worked with Ministry of Agriculture, where he put into place the Fertilizer Act of 2009 and its Regulations of 2011 which culminated to the formation of Tanzania Fertilizer Regulatory Authority (TFRA) mandated on issues related to fertilizer trade and quality and he is the Chairman of the Board of TFRA. He is also a football coach with elite clubs and has been the Tanzania National Football coach for five years.



Dr Eder Martins is a Researcher at EMBRAPA, and is based at EMBRAPA Cerrado in Brasilia, Brazil's agricultural research centre. He is a geologist by background, with degrees from the University of Brasilia. He has specialized in the application of geochemistry and mineralogy to address problems in agriculture, and is one of the most prominent members of Brazil's Soil Remineralizing movement, which helps identify rock types suitable for crop nutrition. He has played a major role in defining federal regulations in Brazil that enable milled rocks as soil remineralizers to be used for this purpose.



Annock Chiwona is a Malawian PhD student at Newcastle University. Against the background of high K fertilizer costs, he endeavors to identify novel alternative silicate potash sources. His research combines geophysical gamma ray and remote sensing data to identify nepheline syenites in Malawi's East African rift system section. He argues that nepheline-bearing rocks could be suitable as an alternative K silicate fertilizer because of the highest dissolution rate of nepheline.



Dr Marcelo Oliveira is currently Chief Mineral Sciences Officer at Advanced Potash Technologies and he has a visiting Scientist position within the Department of Materials Science and Engineering at the MIT. He earned his PhD in geochemistry and petrology from the University of Pará. In 2010, he was a Postdoctoral Researcher (Experimental Petrology and Mineralogy) in the Université d'Orléans (France) and a BA in Geology from the University of Pará.



Ingo Wender is the Founder and President of Advanced Potash Technologies. Ingo is an entrepreneur and founded ATP's Potash Project in 2011. Prior to APT, Ingo founded and led the development of an iron ore Project in Minas Gerais, Brazil. The project was ultimately sold in 2011 to a group of international investors. Before being active in the mining/commodities world, Ingo was involved in the import and export of equipment for the oil & gas and paper & pulp industries in Brazil. Ingo earned a Bachelor in Mechanical Engineering from FEI (Faculdade de Engenharia Industrial), Brazil.



Dr Rafael Curimbaba graduated in Business at FAAP in São Paulo, Brazil, in 1998 and in Electrical Engineering in 2014 at UNIUBE in Uberaba, Brazil. He has a Master in Business (MBA) at Rice University in 2002 and Master in Project Management at Keller Graduate School of Management in 2004, both in Houston, USA. He completed a PhD in Business at USP in São Paulo, Brazil, in 2008. His professional background started as Stock Market Analyst in 1998 at Finasa Investment Banking in São Paulo, Brazil, and in 1999 he started to work for Curimbaba Group as the CFO at Sintex Minerals in Houston TX until 2005 when he moved to Brazil to hold a corporate position of Business Development Vice President for the 14 companies of Curimbaba Group.



Robert Meakin is an agricultural biochemist. He ran an analytical laboratory for four years, and then spent 10 years as a commercial intensive vegetable farm manager in various locations, ran his own agronomy consultancy for 15 years and is a FACTS examiner and AP crop protocol author. Currently, he manages the global agronomy programme at Sirius Minerals that consists of over 200 trials on 27 crops in 17 countries.



Dr Huig Bergsma has been working as a geochemical engineer since 1995 for Geochem Research and Arcadis. Since 2014 he has worked as a freelancer under the name of BodemBergsma. Starting out as an all-round geochemist, focus has shifted during the years via mineral carbon sequestration to soil mineral fertility. Lately BodemBergsma is involved in mineral soil restoration in nature reserves, asbestos weathering experiments and rock dust fertilization in Sub Saharan Africa.



Dr Oliver Heidrich has worked since 1992 with national and international companies, local authorities and Universities in waste, recycling, environmental, life cycle assessment, and stakeholder and corporate management. He was on the Board of Directors with Econoplas, a plastic manufacturing business and an associate director of SEQM, a consultancy and training business. Now in research, he develops and applies environmental engineering and management principles to gain detailed understanding of the inter-relationships between resource use within and outside cities, in relation to climate change, the built environment, and the associated resource requirements and supplies.



2nd International Workshop on Alternative Potash (IWAP) - London

15th June 2017; 9:30 – 18:00

The Geological Society, Burlington House, London

Programme

Please note the schedule may be subject to change

Time	Speaker	Title
09:00	Registration	
Why do we need alternatives to Potash?		
09:30	Prof. David Manning (Newcastle University)	Introduction: why do we need alternative potash?
09:50	Dr. Natalia Yakovleva (Newcastle University, London)	Potassium fertilisers and development: review of major approaches to improve supply
10:10	Dr. Andrew Msolla (African Fertilizer and Agribusiness Partnership (AFAP))	Potassium deficiency in Tanzanian soils: an emerging problem
10:30	Dr. Eder Martins (EMBRAPA)	Regional agrominerals as support to Evergreen Revolution
10:50	Break	
Silicate products		
11:10	Annock Chiwona (Newcastle University)	Nepheline syenite's potential as alternative potash source for Malawi
11:30	Marcelo Oliveira (Advanced Potash Technologies)	Ultrapotassic syenites: an alternative K-source worldwide
11:50	Prof. Antoine Allanore (MIT)	Hydrothermal alteration of ultrapotassic syenite as affordable option to potash supplies in the tropics
12:10	Ingo Wender (Advanced Potash Technologies)	HydroPotash- a disruptive technological development
12:30	Lunch	
Experiences from using alternatives to Potash		
13:30	Rafael Curimbaba (Grupo Curimbaba)	Phonolite as source of potash with results comparable to high water soluble potash
13:50	Robert Meakin (Sirius Minerals)	Polyhalite as an alternative potash source in Brazil
14:10	Robert Meakin (Sirius Minerals)	Polyhalite effectiveness as an alternative potash source in Tanzania
14:30	Huig Bergsma (BodemBergsma)	K-minerals: the backbone of acid neutralization in Dutch nature reserves
14:50	Break	
Discussions and ways forward		
15:10	Panel	Open discussion
16:20	Mike Armitage (SRK Consulting)	Wrap-up
16:30	Drinks Reception until 18:00 at the Society of Antiquaries of London, Burlington House	
	Dr Oliver Heidrich (Newcastle University)	Urban areas and the global flow of potassium (Poster)

IWAP brings together industry, policy makers, academics and aid agencies to share perspectives on finding affordable and sustainable alternatives to potash. The Geological Society, London, is conveniently located for the head offices of global mining and finance houses as well as other international organisations and those involved in policy.

<http://conferences.ncl.ac.uk/alternativepotash-iwap/>

Introduction: Why do we need alternative potash?

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Abstract

Potash, conventionally sourced from evaporite deposits, is the product of a well-established industry that has matured since the Second World War. Global production is about 39 million tonnes annually, 99.9% of this from 12 countries and 75% from Canada, Russia, Belarus and China (Jasinski 2016). Potash use varies greatly, with consumption focused on the developed world. Nutrient audits suggest that K is removed from soil with every crop to such an extent that world potash production would have to double to maintain soil K contents (Sheldrick et al., 2002). Africa, with 16% of the world's population, consumes just 1.6% of world potash production (FAO; 2016), indicating failure to access the global potash market.

Given the global need for more K fertilizer, and the difficulties faced by poor farmers in accessing conventional potash, it is necessary to consider alternatives that supplement existing sources. These include polyhalite, a K-Mg-Ca sulfate, and K-bearing silicate minerals and rocks. Polyhalite has potential for global trade and if derived from deep mines its production requires high capital investment; it provides a range of crop nutrients in addition to K. Silicate minerals and rocks can be produced from surface mines, at lower cost than deep mining, but in temperate soils generally are very slow to release their low K contents. However, in tropical soils such materials are more rapidly weathered, enabling them to act as effective sources of K.

This meeting brings together speakers with experience in the development and agronomic testing of polyhalite and silicate rocks. It focuses on the needs of Africa and Brazil, and demonstrates the value of using silicate rocks in Europe to meet specific goals.

References

- Food and Agriculture Organization of the United Nations (2016). *World fertilizer trends and outlook to 2019*. Available at: <http://www.fao.org/documents/card/en/c/7d56821a-49ed-4e96-9420-d381fc33da22/> [Accessed 17 May 2017].
- Jasinski, S.M. (2016). *Potash*. United States Geological Survey Minerals Yearbook. Available at: <http://minerals.usgs.gov/minerals/pubs/commodity/potash> [Accessed 10 May 2017].
- Sheldrick, W.F., Syers, J.K. and Lingard, J. (2002). A conceptual model for conducting nutrient audits at national, regional and global scales. *Nutrient Cycling in Agroecosystems* 62, pp. 61-67.

Potassium fertilisers and development: review of major approaches to improve supply

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Abstract

The paper aims to review major approaches to improving potassium fertilizer supply in developing countries and discusses the constraints of the two dominant food system paradigms, industrialized and closed system production, in securing fertilizer supply.

The paper describes the current global supply of potassium fertilizers and approaches to improving the supply based on the review of existing literature and industry reports. In order to outline the approaches to supply of potassium, the paper utilizes both supply chain perspective (Marsden et al, 2000; Sonnino and Marsden, 2006) and global production network view (Coe et al, 2008; Bridge, 2008; Dicken, 2011; Santos et al, 2015).

The paper discusses how two food systems, industrialized and closed system production, experience difficulties in combating structural limitations of producing organic and inorganic potassium fertilizers for food production. It suggests developing a hybrid system, where capabilities of private actors to supply potassium fertilizers can be utilized for serving the needs of large-scale and small-scale food production.

References

- Bridge, G. (2008). Global production networks and the extractive sector: governing resource based development. *Journal of Economic Geography*, 8, pp. 389–419.
- Coe, N.M., Dicken, P. and Hess, N. (2008). Global production networks: realizing the potential. *Journal of Economic Geography*, 8: 271–295.
- Dicken, P. (2011). *Global Shift: Mapping the Changing Contours of the World Economy*, 6th edition, Sage Publications: London.
- Marsden, T., Banks, J. and Bristow, G. (2000) Food supply chain approaches: Exploring their role in rural development. *Sociologia Ruralis*, 40(4), pp. 424-438.
- Santos, R.S.P. and Milanez, B. (2015). The Global Production Network for iron ore: materiality, corporate strategies, and social contestation in Brazil. *The Extractive Industries and Society*, 2, pp. 756-765.
- Sonnino, R. and Marsden, T. (2006) Beyond the divide: rethinking relationship between alternative and conventional food networks in Europe. *Journal of Economic Geography*, 6(2), pp. 181-199.

Potassium deficiency in Tanzanian soils: an emerging problem

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Abstract

The United Republic of Tanzania with a total population of 44,928,923 persons (National Census, 2012) has a total land area of 944,800 square km (94.5 million hectares) of which 44.5 million hectares of the land is classified as arable land and 50 million hectares as range land. Only 24.5% of the arable land is under cultivation (whereby 91% of agriculture land in use is driven by smallholder farmers and 9% is commercially used) and 48% of range land utilized. The average food crop production is 1.7 tons per ha whereas under good management and appropriate fertilizer use should result in yields of 3.5-4.0 tons per ha. Tanzania's main economic pillar is embedded in the agricultural sector, as it employs 75% of the total population and contributes up to 100% of food availability in years with good distribution of rains in 2014, the sector contributed 28.9% of the Growth Domestic Product - GDP whereby the crop sub-sector alone contributed 16.2%. Approximately 85% of the cultivated land is dominated by small-scale farmers who operate between 0.9 and 3.0 hectares.

Despite the importance of agriculture in Tanzania, the sector is faced by many constraints and challenges with main being low productivity of land, labour and production inputs. Unfortunately, this is happening even to farmers who are using recommended P and N rates. Through various soil analyses, it has been determined that K is limiting in almost all major soils in Tanzania currently in agricultural production. The major soils in Tanzania include the following: Cambisols (35.64%), Acrisols (8.03%), Luvisols (7.26%), Ferrasols (6.32%), Vertisols (5.02%) and Fluvisols (2.7%), although the extent of K deficiency varies depending on their geological background and how intensively they have been practised in a soil type without K replenishment (experiencing continued nutrient mining). Experiments carried out by different institutions have proved beyond doubt that K deficiency does immensely contribute to the lower yields farmers are experiencing now.

The Government has also realized that and has taken the following initiatives;

- Encouraged a public-private initiative to carry out detailed soil mapping and this is expected to be completed in less than the coming two years.
- Where soil fertility statuses have been established beyond doubt, fertilizer blends that will provide balanced nutrients are encouraged to be used.
- The new fertilizer regulations of 2017 have lessened earlier impediments in issues related to registration and validation.
- More players are encouraged to continue promoting the use of K through demand creation activities through demonstration plots using the missing nutrient approach.

However, more efforts need to be made to ensure that K deficient soils are supplied with K through proper fertilizer blending.

Regional agrominerals as support to Evergreen Revolution

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Abstract

Evergreen revolution is defined as a proposal from the southern hemisphere to ensure the sustainability of tropical agriculture. The objective of this approach is to allow the expression of the soil and plant microbiome to reduce the need for the application of pesticides. In addition to allowing cleaner agricultural production, this process lowers costs and ensures permanent soil cover on a permanent basis.

Excessive use of NPK derived mainly from northern hemisphere sources increases external dependence on nutrients and intensive use of fossil energy. The new regional agrominerals being studied in the tropics allow an efficient use of nutrients in production systems without causing biological imbalances in soils. On the other hand, these new agrominerals promote soil changes in the long term. A significant change of soil properties can be predicted with the continuous application of these agrominerals. The main changes in soils are related to the increase of the permanent cation exchange capacity (CEC) of mineral origin, which are generally low in tropical soils.

The agrominerals that are intensively studied in the tropical regions are of silicate origin. Soil remineralizers and K fertilizer produced by hydrothermal processes (hydropotash, HYP) are the main examples.

The remineralizers allow soil conditioning and still provide essential nutrients. HYP are high-efficiency regional potassium fertilizers, and provide silicon and CEC. Agronomic research has demonstrated the generation of emergent properties in soils: increased capacity to sequester carbon; increased water retention; generation of permanent CEC.

The research of these new agrominerals depends on a regional study of agricultural soils and the need for nutrients and conditioners for the production systems. The methodological set is being called Agrogeological Zoning.

The potential of nepheline syenite as an alternative potash source for Malawi

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Abstract

Malawi faces severe fertilizer challenges for her agricultural sector growth and food crop production. The Government's farm input fertilizer subsidy program (FISP), intended to benefit the most vulnerable households, has helped to increase household food production, especially between 2005-2011. Between 2006-2015, the price per tonne of subsidized fertilizer with about 72%N, 18%P, 10%K, has been 95% below the commercial prices (Fuentes, 2013), from around MK 950 (US \$2.88) to MK 500 (US \$1.52) and then MK 1050 (US \$2.36) in 2015-2016 farming year. Despite these efforts, between 2003-2012 average annual fertilizer imports were at 290,000 tonnes with less than 10% of this being potassium (K) fertilizers (Fuentes, 2013). In 2013, the supply was 297,000 tonnes which is still far below the 600,000 tonnes annual demand if the country were to achieve its agricultural sector growth goals by 2016. While 96% of the arable land is occupied by small-holder farmers, their average cereal production is 1.9 tonnes/ha, compared to large estate farmers whose cereal yield is about 3.2 tonnes/ha (Fuentes, 2013). This shows that small-holder farmers are much more affected by soil nutrient deficiency (Chirwa et al., 2011). The country's use of a blanket fertilizer recommendation of 92 kg N ha⁻¹ and 40 kg P₂O₅ ha⁻¹ is ineffective because it assumes a specific crop instead of considering the variable needs of different soils (Chilimba et al. 1999; Lakudzala 2013). Over 60% of Malawi's land area has been reported to be K-deficient (Chilimba and Liwimbi, 2008; Lakudzala, 2013).

High fertilizer costs and uncertainty over the sustainability of the FISP create a need for alternative potash sources. In this study, we use recently acquired countrywide airborne geophysical gamma ray data (Bates & Mechennef, 2013) to identify nepheline syenites and related alkaline rocks in Malawi's part of the East African Rift System (EARS). Nepheline has the highest dissolution rate of the potassium silicate minerals (Palandri & Kharaka 2004), which means that nepheline-bearing rocks should be considered as an alternative K-silicate fertiliser for Malawi, despite lower total K contents. Results are compared with X-ray fluorescence (XRF) geochemical analyses of samples collected from fieldwork in selected areas of Malawi to assess their potential as potash sources.

References

- Bates, M. and Mechennef, F. (2013). Data Acquisition Report, Sander Geophysics Limited 1, pp. 1-294.
- Chilimba A.D.C. and Liwimbi L. (2008). Evaluation of nitrophosphate fertilizer for maize production in Malawi. Annual Report of the Soil and Agricultural Engineering Commodity Group. In: *Department of Agricultural Research Annual Planning Meeting, Mangochi*, 14 - 19th September 2008, pp. 63-75.
- Chilimba, A.D.C., et. al (1999). Mehlich 3 or modified Olsen for soil testing in Malawi. *Commun. Soil Sci. Plant Anal*, 30(7-8), pp.1231-1250.
- Chirwa E., et. al (2011). Factors Influencing Access to Agricultural Input Subsidy Coupons in Malawi. *Future Agricultures Working Paper 027*.
- Fuentes, P. (2013). Malawi Fertilizer Assessment. Alabama, USA: IFDC 1(1), pp. 1-60.
- Lakudzala, D.D. (2013). Potassium response in some Malawi soils. *International Letters of Chemistry, Physics and Astronomy*, 8(2), pp. 175-181.
- Palandri, J.L. and Kharaka, Y.K. (2004). A compilation of rate parameters of water-mineral interaction kinetics for application to geochemical modeling. *U.S. Geological Survey Open file Report*, 2004-1068, p.71.

Ultrapotassic syenites: an alternative K-source worldwide

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Abstract

Tropical soils, such as the Brazilian Cerrado, are poor in macro and micronutrients. Despite many tropical countries being part of the top ones in agribusiness, they have few producing potash mines so that most needs to be imported. This very uncomfortable dependence also has a significant impact on the country's trade balances. Due to actual low potash market prices, it is unlikely that any significant new production capacity will be developed in these countries from the local potash salt deposits.

Embrapa is the leading Brazilian research institute for agriculture and to change, specifically, the Brazilian dependence on imported potash, strongly supported the amendment 12,890 (2013) to the Brazilian Fertilizer Law 6,894 (1980), thus defining officially rock powder with proven agronomic efficiency as soil remineralizer and alternative potash fertilizer.

Having this in mind, Advanced Potash Technologies (APT) screened locations close to agricultural regions from the Cerrado and with favourable geology and logistics, for syenitic rocks with up to 14.5% potash content and other macronutrients. These rocks are uncommon, but APT was able to locate them in key areas by using modern geological tools including development of petrogenetic models, DTM patterns, and radiometric signatures.

The exploration model is low cost and based on petrology, geomorphology and geophysics, saving time and money, as geology teams go to the field with very well defined targets and priorities. With this model validated, APT were enabled to find syenites around the world and already has several ultrapotassic syenite projects in different regions of Brazil, USA, and Australia.

At the same time, a five year research program from APT with the MIT/USA developed Hydropotash (Ciceri et al. 2014, 2017), a second generation low cost high efficiency potash fertilizer produced from syenites, without by-products, with controlled accelerated release of potash and also other benefits for agriculture.

References

Ciceri, D., Skorina, T., Gadois, C., Li, K. and Allamore, A. (2014). Processing of potassium silicates for K-release. In: *16th World Fertilizer Congress of CIEC*. City: Rio de Janeiro, Brazil.

Ciceri, D., de Oliveira, M., Stokes, R.M., Skorina, T. and Allamore, A. (2017). Characterization of potassium agrominerals: Correlations between petrographic features, comminution and leaching of ultrapotassic syenites. *Minerals Engineering* 102, pp. 42-57.

Hydrothermal alteration of ultrapotassic syenite as affordable option to potash supplies in the tropics

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Abstract

Tropical countries are currently depending on imports of potassium fertilizers (KCl) from northern hemisphere countries, particularly Canada and Russia. Ultrapotassic syenites are a promising and affordable alternative source of potassium for tropical countries. They are resources with an exceptional potassium grade (≈ 14 wt% K_2O), and are distributed throughout the world. This presentation will provide an overview of ongoing research work on ultrapotassic syenites carried out by the Allanore Research Group at the Massachusetts Institute of Technology. The methods of the research involve:

- i) petrographic and mineralogical description of the feedstock material to forecast comminution behaviour
- ii) assessment of chemical reactivity with traditional (leaching tests) and advanced (microfluidic) techniques
- iii) engineering of a processing methodology to enhance nutrient availability.

The latter approach has shown that alkaline hydrothermal alteration of ultrapotassic syenites in presence of CaO yields a processed material with potassium availability two orders of magnitude higher than in the raw material. Mineralogical and reactivity properties of the processed material coupled with green-chemistry considerations highlight a novel opportunity for affordable local supplies of potash fertilizers in tropical countries.

HydroPotash - a disruptive technological development

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Abstract

Eight of the top 10 agricultural nations import approximately 95% of their consumed Potash fertilizer, mostly from Canada, Russia and Belarus. Though the real demand is actually much higher than is currently being imported, high prices, inland transportation costs, and product inefficiency hinder many farmers access to it. In addition, the high concentration of chlorine contained in the MOP (Muriate of Potash) also has significant negative impact on soil and prohibits the application for organic crops. Our aim at Advanced Potash Technologies (APT) was therefore to create an efficient but also affordable Potash fertilizer which could be sourced locally by all farmers, including those focused on organic crops. This talk will detail some of our progress to-date.

The raw materials used in our process are selected potassium-rich rocks which exist in many countries of the world. These rocks, in the vast majority of cases, cannot be used as a fertilizer alone as the release of the contained potassium is extremely slow. We therefore turned to the Allnore research group at MIT, who developed a disruptive low-cost Hydrothermal process to make the potassium in these rocks available for the crops. The resulting fertilizer can be directly applied and contains other important nutrients for the plants (such as silica and clay components).

The patented process generates no by-products or waste and has a much lower carbon footprint than the established industry players. In addition to experimental work at MIT and process scaling at École Polytechnique de Montréal, APT has also recruited the support of EMBRAPA, a Brazilian agricultural research corporation, to conduct extensive third-party agronomic tests. We are now preparing to present our product to Brazilian farmers, with the aim of globally commercializing in the near future.

Phonolite as source of potash with results comparable to high water soluble potash

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Abstract

Yoorin Fertilizantes (Yoorin) is a fertilizer company in Brazil with more than 50 years of operation focused on thermophosphate products. Since 2012, Yoorin added to its portfolio a milled potash silicate rock with high potash solubility called phonolite, Yoorin named it Ekosil as the commercial brand.

Based on prior studies at UNESP, Ekosil showed excellent results for the same amount of K_2O in comparison with KCl. Considering the recommended dosage of K_2O per hectare, Ekosil showed an incremental yield of 10%, 9.7%, 7.2%, and 8.3% for corn, soy bean, coffee, and sugar cane respectively. As a result, Yoorin decided to launch this product in Brazil. For sugar cane, Ekosil also increased BRIX (quantity of sugar in the sugar cane) results in comparison to KCl.

Since Ekosil became a commercial product, sales in Brazil have increased every year, reaching more than 34,000 metric tons in 2016 coming from zero in 2012. The primary reason for Ekosil sales performance is due to its efficiency. After more than 200 experiments and based on Yoorin database, 95% of these experiments had better results using Ekosil in comparison with KCl. In average, yields increased by 10% for soy bean, 22% for coffee, and 4% for corn.

Another advantage that was observed with Ekosil is related to black sigatoka disease in banana crops. According to banana farmers who used Ekosil, the product drastically reduced this disease. We believe the soluble silica content on Ekosil would be the cause of this event; however, this assumption should be investigated.

In conclusion, Ekosil is a reliable source of potash with results proven better than KCl. Ekosil may also bring some extra benefits such as the BRIX for sugar cane or disease control.

Polyhalite as an alternative potash source in Brazil

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Abstract

Polyhalite ($K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot 2H_2O$) offers an alternative potash source for Brazilian farmers as an organic multi-nutrient fertilizer. Comprising potassium (14% K_2O), magnesium (6% MgO), calcium (17% CaO) and sulphur (19% S), polyhalite, commercially known as POLY4, might be effective in tropical environments where gypsum is used to condition the soil prior to fertilization. Sirius Minerals and Kemp *et al.* (2016) identified over 2.5 billion tonnes of polyhalite in the UK with an estimated supply of over 50 years. Polyhalite research in tropical environments is inadequate; therefore, research trials are required to determine the effects of polyhalite on a range of broadacre and high value crops.

Field trials in Mato Grosso, Bahia, Minas Gerais and São Paulo states have been established demonstrating polyhalite's effectiveness on corn, soybeans, potatoes, sugarcane and tomatoes. Using local NPK fertilizer recommendations, polyhalite fertilizer plans were evaluated against standard practices. Corn and soybean trials assessed local NPK blends compared to polyhalite NPK blends. Tomato and potato trials were designed as a K rate response study with fixed N and P local recommendations. A sugarcane trial using a liquid start fertilizer compared 1t of gypsum to 0.75t of polyhalite to assess yield, soil conditioning and nutrient retention.

Corn and soybean trials have shown similar yield responses using polyhalite NPK blends. In some situations, results indicate that farmers might be able to apply less polyhalite NPK blend and achieve the same yield as local NPK blends. For tomato and potato trials, results highlight the benefit of using a multi-nutrient fertilizer plan with calcium and magnesium being important inclusions for tomatoes and potato respectively. Sugarcane yields were improved by 9% where polyhalite was used. Increases in soil residues post-harvest were observed for Ca, S, K and Mg highlighting the added value of polyhalite over gypsum in soil conditioning.

References

Kemp, S. J., Smith, F. W., Wagner, D., Mounteney, I., Bell, C. P., Milne, C. J., Gowing, C. J. B. and Pottas, T. L. (2016) 'An Improved Approach to Characterize Potash-Bearing Evaporite Deposits, Evidenced in North Yorkshire, United Kingdom', *Economic Geology*, 111(3), pp. 719–742. doi: 10.2113/econgeo.111.3.719.

Polyhalite effectiveness as an alternative potash source in Tanzania

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Abstract

Polyhalite, commercially known as POLY4, comprises potassium (14% K₂O), magnesium (6% MgO), calcium (17% CaO) and sulphur (19% S) with the chemical formula (K₂SO₄.MgSO₄.2CaSO₄.2H₂O). As an organic multi-nutrient fertilizer, polyhalite is a suitable alternative potash source in support of sustainable agriculture. Exploration by Sirius Minerals and characterization work by Kemp et al. (2016) identified a resource of over 2.5 billion tonnes of polyhalite in the UK with an estimated supply for over 50 years. Contemporary research, particularly in tropical environments, on polyhalite is limited; hence a requirement to conduct research trials to determine polyhalite fertilizer potential.

In the Southern Highlands of Tanzania, six trial sites growing corn (*Zea mays* L.) were established to assess potassium supply from polyhalite against potassium chloride (MOP) using micro-dosing to apply 20 kg K₂O ha⁻¹. Measured treatments were: 1) Control in which no fertilizer was applied; 2) Recommended practice of 120-60-0 (NP treatment, 120-60-0); 3) NP treatment + Muriate of Potash (MOP); 4) NP treatment + Polyhalite (POLY4); and 5) NP treatment + MOP + Kieserite (MOP + Kieserite).

Results from Tanzania indicated that all treatments outperformed control to demonstrate the need for potassium. Furthermore, the importance of sulphur was identified by yield improvements for both POLY4 and MOP+Kieserite treatments over MOP across all six sites (Pavuluri et al., 2017). POLY4 and MOP+Kieserite treatments offered similar yields indicating no response to magnesium in either treatment.

Research trials continue across Tanzania to validate polyhalite as an alternative potash source on a wider range of crops and soil environments.

References

Kemp, S. J., Smith, F. W., Wagner, D., Mountney, I., Bell, C. P., Milne, C. J., Gowing, C. J. B. and Pottas, T. L. (2016) 'An Improved Approach to Characterize Potash-Bearing Evaporite Deposits, Evidenced in North Yorkshire, United Kingdom', *Economic Geology*, 111(3), pp. 719–742. doi: 10.2113/econgeo.111.3.719.

Pavuluri, K., Malley, Z., Mzimhiri, M. K., Lewis, T. D. and Meakin, R. (2017) 'Evaluation of polyhalite in comparison to muriate of potash for corn grain yield in the Southern Highlands of Tanzania', *African Journal of Agronomy*, 5(3), pp. 325–332.

K-minerals: the backbone of acid neutralization in Dutch nature reserves

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Abstract

Increased acid deposition since the industrial revolution has induced severe soil degradation in Dutch nature reserves. Consequently, plant and animal species have disappeared or are declining at an alarming rate, being replaced by a few species best adapted to low soil pH and high ammonium and aluminium concentrations (Vogels et al., *In press*, Bobbink & Hettelingh 2011). Until recently, soil pH and base saturation were the primary parameters to monitor the effect of acidification on ecological quality. To mitigate effects of acidification, limestone has been applied to increase pH and base saturation (Dorland et al., 2004). However, for several reasons, liming is not always favourable. In inherently carbonate free sandy soils it may lead to undesired changes in soil ecological functioning (Frostegård et al., 1993). We expect this can be prevented by using silicate minerals instead as they more closely resemble the original soil minerals.

In order to understand mineral weathering in relation to soil chemistry, detailed weathering studies were conducted in soils of varying age. Soil cores were taken and weathering profiles were constructed using portable XRF data. Detailed mineralogical analysis of A/E-horizon and C-horizon was performed with QEMSCAN. Mineral depletion was both determined with the classical depletion method (Olsson and Melkerud, 2000) and a novel K/Ti based method.

Results indicate that soil weathering rates during the last century have increased 50-100 times. In some cases soil mineral stocks are significantly reduced, with K-bearing minerals accounting for 40-65% of this loss. Last century the weathering rates of K-minerals even seem to have increased relative to Ca/Mg-minerals.

We believe that anthropogenically enhanced soil mineral weathering is and has been greatly adding to the current acidification problem. Soil mineral restoration is imperative for complete ecological recovery and K-minerals play a key role in this.

References

Bobbink, R. and Hettelingh, J.P. (eds)(2011). *Review and revision of empirical critical loads and dose-response relationships*. Bilthoven, the Netherlands: Coordination Centre for Effects, National Institute for Public Health and the Environment (RIVM), RIVM report 680359002/2011 (244 pp).

Dorland, E., van den Berg, L.J.L., van de Berg, A.J., Vermeer, M.L., Roelofs, J.G.M. and R. Bobbink (2004). The effects of sod cutting and additional liming on potential net nitrification in heathland soils. *Plant and Soil* 265, pp. 267-277.

Frostegård, Å., Bååth, E. and Tunlio, A. (1993). Shifts in the structure of soil microbial communities in limed forests as revealed by phospholipid fatty acid analysis. *Soil Biology and Biochemistry* 25(6), pp. 723-730.

Olsson, M. and Melkerud, P.-A. (2000). Weathering in three podzolized pedons on glacial deposits in northern Sweden and central Finland. *Geoderma* 94, pp. 149-161.

Vogels, J.J., Verberk, W.C.E.P., Lamers, L.P.M. and Siepel, H. (In press). Can changes in soil biochemistry and plant stoichiometry explain loss of animal diversity of heathlands? *Biological conservation*. <http://dx.doi.org/10.1016/j.biocon.2016.08.039>. Available online 16 September 2016.

Urban areas and the global flow of potassium

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Abstract

In 2016, planning permission was granted to Sirius Minerals Ltd to mine potassium (K) from the mineral polyhalite in North Yorkshire National Park, UK. We show the impacts of such local decision on a global scale by illustrating the supply risks of K fertilizer considering the global and urban metabolism of potassium. More than 90% of all potassium mined is used as fertilizer but there is no sink of potassium other than the sea (Manning, 2015). K is of key importance to global and local policy, but interactions are constrained by separate policies. Supplies of potassium have been raised of highest concern especially in Africa and material flow accounting can help to identify the scale of the problem and the potential solutions (Fernández et al., 2015; Sheldrick and Lingard, 2004).

We developed a database that quantifies and illustrates the global and urban flow of potassium that is needed to feed the city. The poster presentation shows the supply and consumer chain of K from 'mine to mouth' using material flow and life cycle assessment principles. Using food composition data we calculate the human potassium intake, based on average daily food intake, diet and census data for the North East of England and the city of Newcastle. We link this back to the global potassium production using COMTRADE database to quantify the demands. Despite supposedly available potassium, we identify potential bottlenecks of supplies for Western cities and discuss problems of nutrient loss and soil conditioning for the cities in the Southern Hemisphere. We make recommendations to address the problems by improving policy, use of non-renewable resources for food production and the supply, consumption and recycling of potassium.

References

- Fernández, J.E., Musango, J.K., Currie, P., Dudek, P., Kim, J., Lay-Sleeper, E., Norford, E. (2015). A Typology of African Urban Resource Consumption. Clift, R., Druckman, A., Lee, J. (Eds.), *International Society of Industrial Ecology-Taking Stock*. International Society of Industrial Ecology, Surrey, UK.
- Manning, D.A.C. (2015). How will minerals feed the world in 2050? *Proceedings of the Geologists' Association* 126, 14-17.
- Sheldrick, W.F., Lingard, J. (2004). The use of nutrient audits to determine nutrient balances. *Africa. Food Policy* 29, 61-98

Notes

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