INNOVATION TO DRIVE TOMORROW'S SUSTAINABLE AGRICULTURE

ABSTRACT COLLECTION

SYMPHOS 2017

4th International Symposium on Innovation and Technology in the Phosphate Industry.

May 8th - 10th, 2017

Mohammed VI Polytechnic University,
Mohammed VI Green City, Benguerir - Morocco

WWW.SYMPHOS.COM

OCP

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SYMPHOS 2017

SUMMARY

EDITO

The International Phosphates Industry Innovation and Technology Symposium (SYMPHOS) is a biennial world-class gathering, bringing together all actors of the phosphates and derivatives industry. This predominantly technological and scientific event showcases the progress of Research & Development in such fields as phosphates and derivatives, technical, scientific, and technological innovation, new agricultural applications, and sustainable development and renewable energy.

SYMPHOS 2017 will build on the advances achieved during its three previous editions (May 2011, May 2013, and May 2015) and will focus on R&D with the aim of strengthening and entrenching a sustainable form of agriculture, driven by innovation, new technology, and next-generation fertilisers.

In light of the success of the last three editions, and in recognition of the ever-growing SYMPHOS community and its need to deliberate over new technology and cutting-edge innovations, we are organising the 4th edition of SYMPHOS from May 8 to 10, 2017, at the polytechnic Mohammed VI University Convention Centre in Benguerir.

ABOUT OCP GROUP

OCP is proud to play an important role in feeding a growing global population, by providing essential elements for soil fertility and plants growth.

With almost a century of experience, OCP Group is a leader in the phosphate rock and derivate markets. OCP provides a wide range of well-adapted fertilizer products to enhance soil, increase agricultural yields, and help feeding the planet in a sustainable and affordable way.

Headquartered in Morocco, OCP works in a close partnership with more than 160 customers over five continents.

For more information visit: www.ocpgroup.ma

OFFICIAL PROGRAM

SUNDAY, MAY 7TH 2017

4:00pm - 7:00pm	**REGISTRATION**

MONDAY, MAY 8TH 2017

8:00am - 10:00am	**RECEPTION AND REGISTRATION**
10:00am - 10:30am	**OPENING CEREMONY**
10:30am - 11:15am	**PLENARY 1 /** *AFRICA AUDITORIUM*: **Innovation for Sustainability,** Seeram Ramakrishna, Professor of Mechanical Engineering and Bioengineering, Center for Nano Fiber and Nano Technology, the National University of Singapore(NUS), Singapore
11:15am - 12:00pm	**EXHIBITION INAUGURATION**
12:00pm - 1:15pm	**LUNCH**
1:15pm - 1:55pm	**PLENARY 2 /** *AFRICA AUDITORIUM*: **Using Biotechnology to Make Phosphate Fertilizer More Sustainable,** Bruce E. Rittmann, Director, Biodesign Swette Center for Environmental Biotechnology, Regents' Professor of Environmental neering, Arizona State University, USA

SLURRY PIPE / *GREEN CITY ROOM*

1:55pm -2:20pm	CO1: **Adaptation of the Jorf Lasfar phosphoric acid plants for using the slurry phosphate instead of dry phosphate,** Salaheddine Fakher El Abiari, OCP S.A, Morocco
2:20pm - 2:45pm	CO2: **How Slurry Properties Impact on Slurry Pipeline Transport,** Julian Rusconi, Paterson & Cooke, South Africa
2:45pm - 3:10pm	CO3: **Intelligent Internal coatings for pipe spools in phosphate and other slurries,** Michael Magerstädt, ROSEN IPS, Switzerland
3:10pm - 3:30pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

MINING / *GREEN CITY ROOM*

3:30pm - 3:50pm	CO1: **Mine Digital Intelligence – From Data to Business Decisions,** Javier Orellena, Schneider Electric, Australia

3:50pm - 4:10pm	CO2: **Automation and innovation in surface mining equipment driving efficiency, precision and production. Experience in hard rock,** René Albert, Vermeer EMEA, Netherlands
4:10pm - 4:30pm	CO3: **Rock Hawg, innovative way to Surface Mining,** Flavio Villa, Tesmec S.p.A., Italy
4:30pm - 4:50pm	CO4: **Why Automate a BlastHole Drilling rig for your mining operation?**, Andrew Voll, AtlasCopCo, USA
4:50pm - 5:10pm	CO5: **Sustainability of Phosphate and Potash Reserves in Jordan,** Khalid Al-Tarawneh, Al Hussein Bin talal University, Jordan

AGRICULTURE / *AFRICA AUDITORIUM*

1:55pm - 2:20pm	CO1: **Fertilizer Use and Food Security Challenges in Morocco,** Lhoussaine Moughli, Hassan II Agronomy and Veterinary Institute, Morocco
2:20pm - 2:45pm	CO2: **A comparative assessment of phosphorus use efficiency in the crop production system of different countries: a substance flow analysis perspective,** Xin Zhang, University of Maryland, USA
2:45pm - 3:10pm	CO3: **Novel rapeseed germplasm and alternative oilseed crops to cope with climate change and enhance edible oil's food security in Morocco**, Abdelghani Nabloussi, National Institute of Agronomic Research, INRA, Morocco
3:10pm - 3:30pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**
3:30pm - 3:50pm	CO4: **Nutrient Management for Sustainable Agriculture Development: use of reactive Moroccan Rock Phosphate,** Rudy Husnain, Indonesian Agency for Agricultural Research and Development, Indonesia
3:50pm - 4:10pm	CO5: **Enhancing efficiency of traditional P fertilizers**, Elena Bocharnikova, Institute of Physial-Chemical and Biological Problems in Soil Scienes RAS, Russia
4:10pm - 4:30pm	CO6: **Soil fertility mapping and fertilizer recommendation in cocoa belt of Cote d'Ivoire,** Koffi Emmanuel Kassin, CNRA Cacao program, Cote d'Ivoire
4:30pm - 4:50pm	CO7: **Contributing to solutions for malnutrition through fertilizers,** Samuel Gameda, International Maize and Wheat Improvement Center (CIMMYT), Ethiopia

P-SUSTAINABILITY / *GANTOUR ROOM*

1:55pm - 2:20pm	CO1: **Circular Economy – Challenges and Opportunities for Phosphorus Recovery & Recycling from Wastes in Europe,** Christian Kabbe, Berlin Centre of Competence for Water, Germany
2:20pm - 2:45pm	CO2: **Industry Initiatives Enhancing Phosphorus Sustainability,** Tom Bruulsema, International Plant Nutrition Institute, Canada

2:45pm - 3:10pm	CO3: **Mining, Processing and Using Phosphates in a Circular Economy,** Ludwig Hermann, Outotec GmbH & Co KG, Germany
3:10pm - 3:30pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

ENERGY / *GANTOUR ROOM*

3:30pm - 3:50pm	CO1: **Progress and trends in the utilization of phosphate-based materials in energy and environmental fields**, Ange Nzihou, Toulouse University - International Mines Albi Graduate school of Engineering, France
3:50pm - 4:10pm	CO2: **Solar sludge drying demonstration plant**, Lars Amsbeck, DLR Institute of Solar Research, Germany
4:10pm - 4:30pm	CO3: **New conceptual design of an energy storage and recovery unit,** Chakib Bouallou, MINES ParisTech PSL Research University, France
4:30pm - 4:50pm	CO4: **Thermal energy storage using lithium, sodium and potassium polyphosphates,** Doan Pham Minh, Toulouse University - International Mines Albi Graduate school of Engineering, France

BIOTECHNOLOGY / *KHOURIBGA ROOM*

3:30pm - 3:50pm	CO1: **Bioformulation of Microbial Fertilizer based on Clay and Alginate Encapluation,** Issam Meftah Kadmiri, MAScIR, Morocco
3:50pm - 4:10pm	CO2: **Legume-rhizobia Symbiosis Enhances Phosphorus Fertilizers Use Efficiency in Soil Under Field Conditions,** Cherki Ghoulam, Faculty of Sciences and Techniques Marrakesh, Morocco
4:10pm - 4:30pm	CO3: **Microalgae as biostimulant of plant tolerance to salt stress,** Hicham El Arroussi, MAScIR, Morocco
4:10pm - 4:30pm	CO4: **Mycorrhizal and Trichoderma harzanium Inoculation Enhance Bean Growth and Protection against Phaeoisariopsis griseola in Southern Cameroonian Soil,** Martin Jemo, OCP S.A, Morocco

WORKSHOP 1: INDUSTRIAL MAINTENANCE / *SAFI ROOM*

1:55pm - 2:20pm	WS1: **How smarter can be maintenance and production control?,** Luca Colombo, Trelleborg Fluid Handling Solutions, France
2:20pm - 2:45pm	WS2: **From asset maintenance toward asset lifecycle management,** Abdenour JBILI, OCP S.A & Jacobs Engineering S.A, Morocco
2:45pm - 3:10pm	WS3: **Key Factors in Implementing Successful Maintenance Improvement Projects,** Malcolm Werner, Jacobs, Morocco
3:10pm - 3:30pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

3:30pm - 3:50pm	WS4: **A Technical In-Depth Look at Predictive Maintenance and Other Related Inspection Methods,** James Parker, AMERAPEX CORPORATION, USA
3:50pm - 4:10pm	WS5: WS6: **How could you manage critical assets from anywhere? Wake up your sensors with the Wi-Care**, Pierre Colon, I-Care sprl, France
4:10pm - 4:30pm	**Discussion**

WORKSHOP 2: SULFURIC ACID / *JORF LASFAR ROOM*

1:55pm - 2:20pm	WS1: **Debottlenecking of Sulphuric Acid Plants,** Abdelbaki Khamsine, Outotec GmbH & Co.KG, Germany
2:20pm - 2:45pm	WS2: **Improve your sulphuric acid plant energy efficiency by making Clean Water,** Rene Dijkstra, Jacobs Engineering, USA
2:45pm - 3:10pm	WS3: **In-situ DSC as a Tool for New Cs Sulfuric Acid Catalyst Development,** Tom Brouwers, MECS Europe/Africa, Belgium
3:10pm - 3:30pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**
3:30pm - 3:50pm	WS4: **Fundamentals of reliable sulphuric acid plant design,** Michael Fenton, Jacobs Engineering, USA
3:50pm - 4:10pm	WS5: **Innovation In Sulphur Handling,** Raiz Basheeruddin, Furnace Fabrica Ltd., India
4:10pm - 4:30pm	WS6: **Emissions Reduction in Sulphuric Acid Plants,** Jan Albrecht, Outotec GmbH & Co.KG, Germany
4:30pm - 4:50pm	**Discussion**

TUESDAY, MAY 9TH 2017

9:30am - 10:10am	**PLENARY 3 /** *AFRICA AUDITORIUM*: **High Energy & high power electrodes for automotive battery applications,** Amine Khalil, Argonne National Laboratory, USA
10:10am - 10:50am	**PLENARY 4 /** *AFRICA AUDITORIUM*: **Exploiting the potential role of fertilizers in increasing food production in developing countries amidst worsening food insecurity and climate change,** Prof. Tekalign Mamo, Director, Center for Soil and Fertilizer Research in Africa, Mohammed VI Polytechnic University of Benguerir, Morocco
10:50am - 11:20am	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

PHOSPHORIC ACID / *AFRICA AUDITORIUM*	
11:20am - 11:45am	CO1: **Phosphate Slurry Neutralization Experience Under Different Conditions,** Haseeb Hayat, Fatima Fertilizer Company Limited, Pakistan
11:45am - 12:10pm	CO2: **Role of additives in improving extraction efficiency of Phosphoric acid manufacture**, G M Patel, CIFC P Ltd, India
12:10pm - 12:35pm	CO3: **DH Phosphoric Acid Plants Revamp Options**, Peter Stockhoff, Thyssenkrupp Industrial Solutions, Germany
12:35pm - 1:50pm	**LUNCH**
1:50pm - 2:30pm	**PLENARY 5 /** *AFRICA AUDITORIUM*: **Replacement and Maintenance Strategy,** Pascal Du Bois D'enghien, Project Manager MECS Europe/ Africa BVBA, Belgium
2:30pm - 2:50pm	CO4: **Hemi versus Dihydrate, Why Hemi Is Often the Better Choice for Phos Acid,** John Wing, Phosacid, USA
2:50pm - 3:10pm	CO5: **Research and development of cleaner wet process for phosphoric acid production without waste gas discharge,** Jiahua Zhu, Sichuan University, China
3:10pm - 3:30pm	CO6: **Green acid purification with a solvent extraction process,** Hannu Laitala, Outotec Oy, Finland
3:30pm - 3:50pm	CO7: **A Phosphoric Acid Process Simulator for Knowledge Transfer,** Sergio Joao, SNC-Lavalin, Canada and Alexandre DURAND, Prayon, Belgium
3:50pm - 4:10pm	CO8: **Phosphoric Acid Purification Technology,** Viviana Diaz, KBR Ecoplanning Oy, Finland
4:10pm - 4:30pm	CO9: **Sizing factors for phosphoric acid plant design,** Paul Anthony Smith, P Smith & Associates, Brazil
4:30pm - 4:55pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

BENEFICIATION / *GREEN CITY ROOM*	
11:20am - 11:45am	CO1: **The Importance of Phosphate Process Optimization from Mine to Market,** Todd Parker, ArrMaz, USA
11:45am - 12:10pm	CO2: **Improved selective flotation reagents for phosphate ore upgrade,** Alexej Michailovski, BASF SE, Germany
12:10pm - 12:35pm	CO3: **Increasing Flotation Efficiency in Reverse Flotation – Exploring the Benefits of a New Flotation Reagent,** Paul Wiatr, Nalco Water, USA
12:35pm - 1:50pm	**LUNCH**

1:50pm - 2:30pm	**PLENARY 5 /** *AFRICA AUDITORIUM*: **Replacement and Maintenance Strategy,** Pascal Du Bois D'enghien, Project Manager MECS Europe/ Africa BVBA , Belgium
2:30pm - 2:50pm	CO4: **Major environmental projects launched in OCP's mining sites,** Noureddine AJIM, OCP Group, Morocco
2:50pm - 3:10pm	CO5: **The mechanism of apatite/carbonates separation in acidic flotation process of calceours phosphate ores,** Lev O. Filippov, University of Lorraine, France
3:10pm - 3:30pm	CO6: **Basic recommendations for the sustainable use of primary and secondary sources of phosphorus in Poland** , Marzena Smol, Polish Academy of Sciences, Poland
3:30pm - 3:50pm	CO7: **Processing Phosphate Rock from North Africa with ArrMaz Carbonate Collectors,** Guoxin Wang, ArrMaz, USA
3:50pm - 4:10pm	CO8: **Latest Developments and Experiences on the Beneficiation of Rock Phosphates using X-Ray Sorting Machines,** Jens-Michael Bergmann, TOMRA Sorting GmbH, Germany
4:10pm - 4:30pm	CO9: **Development and testing of the nextSTEP(Tm) technology, an energy-efficient flotation rotor designed from a fundamental approach,** Liam Mac Namara, FLSmidth Minerals, USA
4:30pm - 4:55pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

VALUABLE TRACE ELEMENTS / *SAFI ROOM*

11:20am - 11:45am	CO1: **Recovery of Administratium from Phosphates,** Vaughn Astley, Dr. Phosphate Inc., USA
11:45am - 12:10pm	CO2: **A comparison between REE extraction from phosphate rock before and after phosphoric acid production,** Salah Althyabat, Al-Hussein Bin Talal University, Jordan
12:10pm - 12:35pm	CO3: **The Algerian Glauconite-bearing Phosphorites: REE Variation and Insights on the Depositional Environment,** Rabah Kechiched, Ouargla University, Algeria
12:35pm - 1:50pm	**LUNCH**
1:50pm - 2:30pm	**PLENARY 5 /** *AFRICA AUDITORIUM*: **Replacement and Maintenance Strategy,** Pascal Du Bois D'enghien, Project Manager MECS Europe/ Africa BVBA , Belgium
2:30pm - 2:50pm	CO4 : **Rare Earths Recovery and Separation from Wet Process Phosphoric Acid,** Tom Baroody, K-Technologies, Inc. USA
2:50pm - 3:10pm	CO5: **Economical comparison of Hydrofluoric Acid Production from Fluorosilicic acid and Fluorspar,** Olivier Ruffiner, Buss ChemTech AG, Switzerland

3:10pm - 3:30pm	CO6: **Fluorine Recovery and Utilization from a Phosphoric Acid Plant,** Curtis Griffin, PegasusTSI, USA
3:30pm - 3:50pm	CO7: **A new process for producing a high grade synthetic calcium fluoride from fluosilicic Acid,** Kamal Samrane, OCP S.A, Morocco
3:50pm - 4:10pm	CO8: **Ammonium sulfate production from by-products of the wet phosphoric acid process - fluosilicic acid and phosphogypsum,** Maksim Tcikin, The research Institute for Fertilizers and Insectofungicides, Russia
4:10pm - 4:30pm	CO9: **Improvement of the Fluorine Recovery Process in a Phosphoric Acid Concentration Unit,** Hadrien Leruth, Prayon, Belgium
4:30pm - 4:55pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

MATERIAL / CORROSION / *GANTOUR ROOM*

11:20am - 11:45am	CO1: **The use of phosphate pigments in anti-corrosion coatings,** Mark Powell, Colorado L.C., Morocco
11:45am - 12:10pm	CO2: **Critical Equipment Monitoring & Protection System,** Amine Ghali Benna, SKF France, Morocco
12:10pm - 12:35pm	CO3: **ZEB-REVO, a digital 3D mapping tool in a closed environment,** Ahmed Hosni, BRGM / DRP, France
12:35pm - 1:50pm	**LUNCH**

INDUSTRIAL MAINTENANCE / *GANTOUR ROOM*

1:50pm - 2:30pm	**PLENARY 5 /** *AFRICA AUDITORIUM*: **Replacement and Maintenance Strategy,** Pascal Du Bois D'enghien, Project Manager MECS Europe/ Africa BVBA , Belgium
2:30pm - 2:50pm	CO1: **Two case studies of simulation-based engineering: Compass Minerals SOP Project and Optimizing Process and Control of a Tilting Pan Filter**, Monserrat Amezcua, ANDRITZ Separation Inc., USA
2:50pm - 3:10pm	CO2 : **Case Studies of Major Mining and Petrochemical Incidents involving Industrial Maintenance: Use of TRIPOD Beta Methodology in Understanding the Causes,** M'hamed Cherqaoui, Vivo Energy Maroc, Morocco
3:10pm - 3:30pm	CO3: **Factors impacting successful implementation of Lean production in process industry: An investigation of Moroccan phosphates industry,** Amine Belhadi, OCP S.A, Morocco
3:30pm - 3:50pm	CO4: **Outotec HEROS™ Update - journey through operational experience,** Michael Kemmerich, Outotec GmbH & Co.KG, Germany

3:50pm - 4:10pm	CO5: **A Reliable Condition Monitoring Approach Related to a Steam Turbine Major Overhaul**, Omar Kenfaoui, Prüftechnik, France
4:10pm - 4:30pm	CO6: **Optimized Spare Parts Management – An Investment in Asset Availability & Reliability,** André Wötzel, Thyssenkrupp Industrial Solutions AG, Germany
4:30pm - 4:55pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

INDUSTRIAL TECHNOLOGY / *JORF LASFAR ROOM*

11:20am - 11:45am	CO1: **Eco-friendly bulk handling equipment in the fertilizer industry,** Pietro de Michieli, Bedeschi Spa, Italy
11:45am - 12:10pm	CO2: **Hydrocycloning technology in phosphate beneficiation with polyurethane based material, "TWIN-type" and "FLAT-bottom" geometries,** Thomas Baumann, AKW Apparate & Verfahren GmbH, Germany
12:10pm - 12:35pm	CO3: **Energy Efficiency of Pumping Systems in the Fertilizer Industry through Optimized Pump Selection,** Merja Pärssinen, Sulzer Pumps, Finland
12:35pm - 1:50pm	**LUNCH**
1:50pm - 2:30pm	**PLENARY 5 /** *AFRICA AUDITORIUM*: **Replacement and Maintenance Strategy,** Pascal Du Bois D'enghien, Project Manager MECS Europe/ Africa BVBA , Belgium
2:30pm - 2:50pm	CO4: **Screening Technologies in Phosphate Production,** Günter Schrön, RHEWUM GmbH, Germany
2:50pm - 3:10pm	CO5 : **Phosphorite beneficiation using a STEINERT mobile XRT sorter,** Kai Bartram, Steinert Elektromagnetbau GmbH, Germany
3:10pm - 3:30pm	CO6: **MAX3™ - Maximized Value for Capex, Opex and Emission,** Matthew Viergutz, Dupont Solutions SAS, France
3:30pm - 3:50pm	CO7: **Dry Sulphur Material Handling Systems, Sulphur Prilling, and New Melter Technology,** Mark L Gilbreath, Matriix PDM Engineering, USA
3:50pm - 4:10pm	CO8: **Re-introducing solid bowl decanter centrifuges for dewatering in the mining industry,** Bent Madsen, Alfa Laval Copenhagen A/S, Denmark
4:10pm - 4:30pm	CO9: **Optical sieve analysis for Online quality control and real time monitoring of the granulation process,** Robert Waggeling, Microtrac GmbH, Germany
4:30pm - 4:55pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

NEW PHOSPHATED MATERIALS / *KHOURIBGA ROOM*

1:50pm - 2:30pm	**PLENARY 5 /** *AFRICA AUDITORIUM*: **Replacement and Maintenance Strategy,** Pascal Du Bois D'enghien, Project Manager MECS Europe/ Africa BVBA , Belgium
2:30pm - 2:50pm	CO1: **Antibacterial biomimetic apatite-based bone cements,** Christele Combes, University of Toulouse, France
2:50pm - 3:10pm	CO2: **Electrode materials based on phosphates for low cost sodium ion batteries,** Ismael Saadoune, UM6P, Morocco
3:10pm - 3:30pm	CO3: **Phosphorus-containing materials for heat storage,** Abdoul Razac Sane, Toulouse University - International Mines Albi Graduate school of Engineering, France
3:30pm - 3:50pm	CO4: **The Use of FRP (Fiberglass-reinforced Plastic) in Phosphate Fertilizer and Sulfuric Acid Processes**, Olivia Woerth, Ashland Technologies, Germany
3:50pm - 4:10pm	CO5: **Apatite Calcium Phosphates for Medical Applications: The Example of Drug Delivery Systems,** Allal Barroug, Cadi Ayyad University, Morocco
4:30pm - 4:55pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

NOVELTY SHOW «DIGITAL MINE» WORKSHOP BY VIST GROUP AND BELAZ / *BOUCRAA ROOM*

11:20am - 11:45am	**Welcoming speech:** 1) Dmitry Vladimirov - General Director of VIST Group company. 2) BELAZ representative NS1**: Digitalization of mining operation. Trends and challenges.**
11:45am - 12:10pm	NS2: **VG Karier Implementation on OCP S.A. Merah mine. Case Study.** OCP representative.
12:10pm - 12:35pm	NS3: **BELAZ presentation. New trends of digital mining vehicles - smart on-board solutions.**
12:35pm - 1:50pm	**LUNCH**
1:50pm - 2:30pm	**PLENARY 5 /** *AFRICA AUDITORIUM*: **Replacement and Maintenance Strategy,** Pascal Du Bois D'enghien, Project Manager MECS Europe/ Africa BVBA , Belgium
2:30pm - 2:50pm	NS4: **Autonomous and tele-operated mining vehicles. New possibilities of efficiency and safety in mining.**
2:50pm - 3:10pm	NS5: **BELAZ presentation. New models of trucks, case studies of efficient usage of dump trucks in phosphate, gold, coal mining companies.** Robotized trucks

3:10pm - 3:30pm	NS6: **Industrial health and safety management system – case study of risk management in mining**
3:30pm - 3:50pm	NS7: **Predictive maintenance and predictive production - new "blue ocean" in efficiency. Case study of processing plant.**
3:50pm - 4:10pm	NS8:**Optimizing drilling and blasting using high precision guidance, fragmentation analysis and predictions.**
4:10pm - 4:30pm	NS9: **Driver assistance systems for reliable statistics and safety.**
4:30pm - 4:55pm	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**
8:00pm	**GALA DINNER**

WEDNESDAY, MAY 10TH 2017

9:30am - 10:10am	**PLENARY 6 /** *AFRICA AUDITORIUM*: **Reach legislation and how it affects fertilizer products innovation,** Gilles Barreto, Responsable Research and Development Tensioactifs, Research Center Rhône-Alpes ARKEMA (CRRA), France
10:10am - 10:50am	**PLENARY 7 /** *AFRICA AUDITORIUM*: **Leveraging the combined powers of science and entrepreneurship in African Agriculture transformation,** Débísí Àràbà, Director, Africa Region, International Center for Tropical Agriculture (CIAT), Kenya
10:50am - 11:20am	**COFFEE BREAK / NETWORKING & POSTERS PRESENTATION**

FERTILIZERS / FEEDS / *AFRICA AUDITORIUM*

11:20am - 11:45am	CO1: **The Production of NPK Fertilizers,** David Ivell, Jacobs Engineering, USA
11:45am - 12:10pm	CO2: **Feed grade calcium phosphates,** Vasil Statev, B.C.Consult LTD, Bulgaria
12:10pm - 12:35pm	CO3: **Impact of Process Entrance on the MDCP Quality,** Hassna El Idrissi, OCP S.A, Morocco
12:35pm - 1:50pm	**LUNCH**
1:50pm - 2:15pm	CO4: **Optimization of Fertilizer Bulk Blending Equipment in Africa,** Karl Ibadulla, PegasusTSI, USA
2:15pm - 2:40pm	CO5: **Novel Technologies to Convert Low-Grade Phosphate Rock into Slow Release Fertilizers,** Zhenli He, University of Florida-IFAS, USA
2:40pm - 3:05pm	CO6: **Application of units, combining the granulation and drying, for development of flexible processes of phosphorous-containing fertilizers production,** Andrei Norov, The Research Institute for Fertilizers and Insectofungicides, Russia

3:05pm - 3:30pm	CO7: **Casale integrated Technologies and Services for New Fertilizer Plants,** James Montanaro, Casale SA, Switzerland
3:30pm - 3:55pm	CO8: **Electron microscopy analysis as a tool to improve granular fertilizers,** J. A. González-León, Research Center Rhône-Alpes ARKEMA (CRRA), France

BY PRODUCTS / *GREEN CITY ROOM*

11:20am - 11:45am	CO1: **The Occurrence of Serendipity During 50 Years of Phosphate Research....Crystals Galore!!**, Vaughn Astley, Dr. Phosphate Inc., USA
11:45am - 12:10pm	CO2: **Phosphorus Recovery from Sewage Sludge Ash by a Wet-chemical Process,** Carsten Dittrich, MEAB Chemie Technik GmbH, Germany
12:10pm - 12:35pm	CO3: **Characterization and valorization of Tunisian phosphogypsum in pressed unfired bricks and autoclaved bricks,** Wissem Gallala, University of Sousse, Tunisia
12:35pm - 1:50pm	**LUNCH**
1:50pm - 2:15pm	CO4: **New Approach And Case Study to Mitigate Environmental Impacts From Phosphogypsum Stacking,** Vincent Dardenne, AQUALE SARL, Belgium
2:15pm - 2:40pm	CO5: **Pilot Tests for the Use of Afitex Geocomposites in Sludge Basins of MEA Processing Units,** Abdesselam Tair, Afitex, France
2:40pm - 3:05pm	CO6: **Dewatering of Phosphatic slimes by carbonate based particles,** Mehmet Sabri Çelik, Istanbul Technical University, Turkey

INDUSTRIAL TECHNOLOGY / *SAFI ROOM*

11:20am - 11:45am	CO1: **ECOSTOCK: Towards energy and waste valorization,** Antoine Meffre, Eco-Tech Ceram, France
11:45am - 12:10pm	CO2: **New Developments and Experience with Multi-Stage High Pressure Pumping Using Centrifugal Slurry Pumps,** Kenny Don, FLSmidth Krebs, USA
12:10pm - 12:35pm	CO3: **Recent Developments in FLSmidth Dewatering Technology,** Todd Wisdom, FLSmidth Salt Lake City, USA
12:35pm - 1:50pm	**LUNCH**
1:50pm - 2:15pm	CO4: **Phosflow® Technology for Effective Heat Exchanger Scale Inhibition in Phosphoric Acid Plants Utilizing North African Phosphate Rock,** Ravi Rajshekar Hiremath, Solvay, USA
2:15pm - 2:40pm	CO5: **SmartCyclone delivers new opportunities for process optimization,** Josh Klein, FLSmidth Krebs, USA

2:40pm - 3:05pm	CO6: **Next generation polymer dewatering of clay dominant tailings systems,** Lewis Utting, BASF Australia Ltd, Australia
3:05pm - 3:30pm	CO7: **Improving Gas Cleaning Equipment Operations Through Reduction of Blockage by Solids,** Graeme Cousland, Begg Cousland Envirotec Ltd., United Kingdom
3:30pm - 3:55pm	CO8: **"Barracuda® - a Revolutionary New Mining Concept",** Bergbau Ullrich Mentges, Thyssenkrupp Industrial Solutions AG, Germany

WATER / *GANTOUR ROOM*

11:20am - 11:45am	CO1: **The water footprint - the optimization of the resource,** Emmanuel Lenain, SUEZ International, France
11:45am - 12:10pm	CO2: **From Seawater to Drinking Water: How CAP Holdings' NexGenDesal™ System Makes It Happen,** Gregory Pasiuk, CAP Holdings Co. LLC, USA
12:10pm - 12:35pm	CO3: **Groundwater Salinity Mapping of Foum El Oued – Laayoune Agricultural Perimeter and Proposed Management,** Shabbir A Shahid, International Center for Biosaline Agriculture, United Arab Emirates
12:35pm - 1:50pm	**LUNCH**

SOILS MANAGEMENT / *GANTOUR ROOM*

1:50pm - 2:15pm	CO1: **Practicing Compost and Biofertilizer to Enhance Phosphorus and Nitrogen Availability to Quinoa Crop Productivity and Improving Health of Sandy Soil,** Shagufta Gill, International Center for Biosaline Agriculture, United Arab Emirates
2:15pm - 2:40pm	CO2: **Forage Production System on Salt-Affected Farms in Foum El Oued – Laayoune,** Redouane Choukr-Allah, International Center for Biosaline Agriculture, United Arab Emirates
2:40pm - 3:05pm	CO3: **Innovation and technology for soil fertility assessment and fertilizer recommendation,** Babasola Ajiboye, OCP Africa, Morocco
3:05pm - 3:30pm	CO4: **Recent developments in sustainable P management strategies/technologies in the crop production system: A systematic review,** Rubel Biswas Chowdhury, University of Maryland, USA

WORKSHOP 3: CADMIUM / *JORF LASFAR ROOM*

11:20am - 11:45am	WS1: **Decadmiation: A 'healthy' challenge for the phosphate industry,** Rajesh Raitani, Solvay Group, USA
11:45am - 12:10pm	WS2: **Cadmium Removal from Phosphate Rock,** Tanja Schaaf, Outotec GmbH & Co. KG, Germany
12:10pm - 12:35pm	WS3: **Technology for deactivation of Cd and other heavy metals in phosphate rock,** Vladimir Matichenkov, Institute of Basic Biological Problems RAS, Russia

12:35pm - 1:50pm	**LUNCH**
	WORKSHOP 4: INDUSTRIAL MANAGEMENT / *JORF LASFAR ROOM*
1:50pm - 2:15pm	WS1: **From mineral characterization to plant implementation: an integrated methodology to promote success in the mining industry,** Simon B. Blancher, ERAMET Research, France
2:15pm - 2:40pm	WS2: **Simplified SO2 emissions control with side benefits,** Devin Shaw, Shell Cansolv, Canada
2:40pm - 3:05pm	WS3: **Moving to The 20th Century!!!** APC, Vaughn Astley, Dr. Phosphate, Inc., USA
3:05pm - 3:30pm	WS4: **Application of Modern Seam Modelling, Margin Ranking and Open Pit Design Techniques in Phosphate Mining,** Sabine Anderson, SRK Consulting Limited, United Kingdom
3:30pm - 3:55pm	WS5: **Advanced Conveyor Supervision: Case Study,** Yassine Elyassami, OCP S.A., Morocco
3:55pm - 4:25pm	**CLOSING CEREMONY**

B-TO-B MEETINGS	
Monday, May 8th	1:55pm › 5:10pm
Tuesday, May 9th	11:20am › 4:30pm
Wednesday, May 10th	11:20a › 3:55pm

EXHIBITION VISITS	
Monday, May 8th	1:55pm › 5:10pm
Tuesday, May 9th	11:20am › 4:30pm
Wednesday, May 10th	11:20am › 3:55pm

POSTERS PRESENTATION	
Monday, May 8th	1:55pm › 5:10pm
Tuesday, May 9th	11:20am › 4:30pm
Wednesday, May 10th	11:20am › 3:55pm

POSTERS LIST

Poster 1	**Towards revegetation of the cover made with phosphate mine wastes in order to control the AMD generated at Kettara pyrrhotine closed mine,** Hamza Zine, Faculty of Sciences Semlalia Marrakech, Morocco
Poster 2	**Tailored blending definition as a source of flexibility in controlling mine production,** Ahlam Azzamouri, Mohammed VI Polytechnic University, Benguerir, Morrocco
Poster 3	**Application of geophysics for the detection of derangements of phosphate layers in Oulad Abdoun basin,** Essaid Zerouali, OCP Group, Morocco
Poster 4	**Geological and geo-electrical characterization of the aquifer system of the transition zone between the phosphate plateau and the Tadla plain,** Fadwa Radouani, OCP Group, Morocco
Poster 5	**Phosphate flotation cells study and simulation using the CFD approach,** Asmaa Hadane, Mohammed 6th Polytechnic University, Benguerir, Morocco
Poster 6	**Modeling and Optimization of water recovery the sludge from beneficiation process of phosphate ore using Experimental Design Methodology,** Asmae El Agri, Faculty of technical science Fès, Morocco
Poster 7	**Criblage des paramètres d'un procédé de consolidation des boues issues d'un procédé d'enrichissement d'un minerai phosphaté par les plans d'expériences,** Asmae El Agri, Faculté des Sciences et Techniques Fès, Morocco
Poster 8	**Malladrite form of hexafluorosilicate salts in wet phosphoric acid processes: solubility and characterisation in acidic aqueous solutions at T= 80°C,** ELYamani Yaktine, Hassan II University Casablanca, Morocco
Poster 9	**Etude d'impact de magnésium dans la fabrication de l'acide phosphorique (ACP) et son effet sur le comportement rhéologique de l'ACP,** Aziz Boukhsib, Research and developpement business unit OCP Group JorfLasfar, Morocco
Poster 10	**Désulfatation de l'acide phosphorique 29% en P2O5 : Amélioration de la performance de l'unité de concentration,** Abderrahmane Aboulhassane, University Chouaïb Doukkali, El Jadida, Morocco
Poster 11	**Systèmes de pompage photovoltaiques : Etat de l'Art et Perspective d'adoption pour la micro irrigation,** Assia Harkani, University Hassan 1st, Settat, Morocco
Poster 12	**Conception of Phosphorus Fertilizers Coated by Biopolymers: Efficiency and Impact on the Chemical and Biological Soil Quality,** Saloua FERTAHI, Mohammed VI Polytechnic University, Benguerir, Morocco
Poster 13	**Valorization of Wastes and production of Energy and Biofertilizers,** Saida TAYIBI, Mohammed VI Polytechnic University, Benguerir, Morocco
Poster 14	**Synthesis of carbonated apatite by ion exchange,** Marwa Mbarki, Faculty of Sciences of Sfax, Tunisia

Poster 15	**Statistical study and modeling of the effect of phosphoric acid impurities on the physical quality of ammonium phosphate determined from the production data,** Nacira Lebbar, Faculty Of Science, El Jadida, Morocco
Poster 16	**Potential of Sentinel-1 and 2 constellations for predicting soil salinity with high spatial resolution at regional scale,** Khalid Omari, Mohamed-V University, Rabat, Morocco
Poster 17	**A simplified method for laboratory soil analyses,** Nora Chaouqi, University Hassan 1st, Settat, Morocco
Poster 18	**Assessing of inorganic phosphate biosolubilisation by bacterial strains isolated from "EL Halassa" Khouribga phosphate mine,** Mohammed Mouradi, University Hassan 1st Settat, Morocco
Poster 19	**Sequestration of CO2 by adsorption on phosphogypsum,** Adil Lachehab, Research and developpement business unit OCP Group, Morocco
Poster 20	**Study of organic matter in phosphogypsum: Another parameter of pollution indicator,** Mohamed Khaddor, Université Abdelmalek Essaâdi, Tanger-Tétouan, Morocco
Poster 21	**Innovative scalable process for the fabrication of an Energetic Phosphate electrode material for Lithium ion batteries,** Hasna Aziam, Mohammed VI Polytechnic University, Benguerir, Morocco
Poster 22	**Phosphates de type NASICON comme matériaux d'électrode pour batteries sodium-ion à haute densité d'énergie,** Siham Difi, Cadi Ayyad University, Marrakech, Morocco
Poster 23	**Challenge for the energy storage via phospho-olivine cathode materials in Li-ion batteries,** Ilham Bezza, University Cadi Ayyad, Marrakech, Morocco
Poster 24	**Electrochemical features of Fe0.5TiOPO4 as anode material for lithium-ion batteries,** Karima Lasri, University of Central Florida Orlando, USA
Poster 25	**Optimization of the thermal phosphate treatment by using petroleum coke in calcination process,** Ikbal Bouatba, Cadi Ayyad University, Marrakech, Morocco
Poster 26	**Bio-inspiration in nanomaterials design: green synthesis method of nano-structured oxides,** Loubna Hdidou, Mohammed VI Polytechnic University, Benguerir, Morocco
Poster 27	**Analysis and comparison of SWGH desalinated water producible in different Moroccan locations,** Oumaima Choukai, ENSA, Ibn Tofail University, Morocco
Poster 28	**Etude de la décomposition des phosphogypses en présence des schistes bitumineux marocains,** Mohamed Ait Darham, Cadi Ayyad University, Marrakech, Morocco
Poster 29	**The use of modern characterization techniques for cadmium speciation in phosphate ores,** Abdessamad Khalil, National Graduate Engineering School - Mines Rabat, Rabat, Morocco

Poster 30	**Modeling and optimization of the extraction of cadmium from industrial phosphoric acid,** Kaoutar Berkalou, High School of technology, Morocco
Poster 31	**Recovery and characterization of REE-bearing phosphates,** Edahbi Mohamed, University of Quebec in Abitibi, Canada
Poster 32	**Assessement of the transfer of metals trace elements to spontaneous plants: potential application for phytostabilization of phosphate limestone wastes,** Meryem El Berkaoui, Mohamed-V University, Rabat, Morocco
Poster 33	**Etude de la lixiviation chlorhydrique du minerai phosphate Marocain,** Marouane Amine, University Cadi Ayyad, Marrakech, Morocco
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Poster 36	**Removal of dyes from wastewater using natural phosphate doped by TiO2 (NP-TiO2),** Meriem Joudi, University Chouaib Doukkali El Jadida, Morocco
Poster 37	**Removal of disperse blue 165 from wastewater using Moroccan natural phosphate as an adsorbent: equilibrium, kinetics, and thermodynamics,** Jihane Mouldar, University Chouaib Doukkali, El Jadida, Morocco
Poster 38	**Strength and workability of concretes manufactured with phosphate waste rocks,** Argane Rabei, University Cadi Ayyad, Marrakech, Morocco
Poster 39	**Is hydroxyapatite a potential matrix for the safe waste disposal ?**, Saliha Boudia, Tizi-Ouzou University, Algeria
Poster 40	**Removal of Polar Compounds from waste Water by Emulsion Liquid Membrane Stabilized by the Combination of Surfactant and Ionic Liquid,** Sawsan A. M. Mohammed, University of Baghdad, Iraq
Poster 41	**An innovative and simplified treatment scheme for urban wastewater treatment and reuse in sustainable irrigation based on activated sludge process,** Tawfik El Moussaoui, University Cadi Ayyad, Marrakech, Morocco
Poster 42	**Multi Soil Layering (MSL) technology: an eco-efficiency and sustainable alternative for phosphorous removal from wastewater,** Lahbib Latrach, Cadi Ayyad University, Marrakech, Morocco
Poster 43	**Natural nanomaterial engineering for water treatment: A new process to improve solar disinfection,** Faissal Aziz, University Cadi Ayyad, Safi, Morocco
Poster 44	**Phosphate sludge based ceramic membranes: thermal behaviour and microstructure,** Mohamed Loutou, Cadi Ayyad University, Marrakech, Morocco

Poster 45	**Elaboration Of Ceramic Filters From Moroccan Natural Phosphate And Clay To Remove organic Dyes From Industrial wastewater,** Badreddine Hatimi, University Chouaib Doukkali, El Jadida, Morocco
Poster 46	**Effect of Sodium Hydroxide on Fly Ash and Phosphogypsum Geopolymer Bricks,** M. Mohammed Vadel Bebana**,** University Abdelmalek Essaâdi, Tanger-Tétouan, Morocco
Poster 47	**Potential reuse of phosphate sludges as raw material for building materials using geopolymerization**, Samira Moukannaa, Mohammed VI Polytechnic University, Benguerir, Morocco
Poster 48	**Physico-chemical characterization of calcium phosphates, Synthesized by the microwave method,** Zahra Gandou, High School of technology, Rabat, Morocco
Poster 49	**A chaotic opposition-based crow search algorithm for solving the unit commitment scheduling problem,** Rachid Habachi, University Hassan 1st, Settat, Morocco
Poster 50	**Prototype of a Decision Support System for Scheduling Fertilizer Production,** Ahlam Azzamouri, University Mohammed VI Polytechnique, Benguerir, Morocco
Poster 51	**Using Multi-Layer Perceptron neural networks for predicting remaining useful life of rolling bearing: Case of OCP,** Abdelhak Elidrissi, Mohammadia engineering school, Morocco
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Poster 53	**The Synthesis and Characterization of anhydrous Proton Conducting Membranes based on Sulfonated Poly(vinyl alcohol), Poly(vinyl pyrrolidone) and Silicotungstic acid with or without Silica,** Said Maarouf, Moulay Ismail University, Meknès, Morocco
Poster 54	**Management of Norm Residues: Phosphogypsum Case: Challenges and Solutions,** Asmae Ettoufi, El Hassan Sayouty Hassan II University, Laboratory of High Energy Physics and Condensed Matter, Faculty of Science Ain chock, Casablanca 5366, Morocco

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CONFERENCES SPEAKERS' BIOGRAPHY

M. SEERAM RAMAKRISHNA
PL1: May 8th 10:30am - 11:15am

Presentation Title:
Innovation for Sustainability

Position:
Director of Center for Nanofibers and Nanotechnology, Singapore

Professor Seeram Ramakrishna, FREng is the Director of Center for Nanofibers and Nanotechnology at the National University of Singapore (NUS).

NUS is ranked among the top 20 universities in the world. He received PhD from the University of Cambridge, UK, and the General Management Training from the Harvard University, USA. His research led to 5 books; ~ 1,000 papers with 63,000 citations and ~120 H-index; and 5 start-up companies. He advices corporates, governments and universities around the world.

Thomson Reuters identified him among the World's Most Influential Scientific Minds. He served as the University Vice-President (Research Strategy); Dean of Faculty of Engineering; and Director of NUS Enterprise. He founded a successful international organization called the Global Engineering Deans Council. He is an elected Fellow of major academies and professional societies of Singapore, USA, India, and UK.
He authored the book: The Changing Face of Innovation.

M. BRUCE E. RITTMANN
PL2: May 8th 1:15pm - 1:55pm

Presentation Title:
Using Biotechnology to Make Phosphate Fertilizer More Sustainable

Position:
Regents' Professor of Environmental Engineering and Director of the Biodesign Swette Center for Environmental Biotechnology at Arizona State University, USA.

His research focuses on the science and engineering needed to "manage microbial communities to provide services to society." Services include generating renewable energy, cleaning water and soil, and improving human health.

Dr. Rittmann is a member of the National Academy of Engineering; a Fellow of AAAS, WEF, IWA, and NAI; and a Distinguished Member of ASCE.

Dr. Rittmann was awarded the first Clarke Prize for Outstanding Achievements in Water Science and Technology from the NWRI, the Walter Huber Research Prize and the Simon Freese Award from ASCE, the G.M. Fair Award from AAEES, and the Perry L. McCarty/AEESP Founders Award.

Dr. Rittmann has published over 610 journal articles, books, and book chapters, and he has 16 patents. With Dr. Perry McCarty, Dr. Rittmann co-authored the textbook Environmental Biotechnology: Principles and Applications (McGraw-Hill Book Co.).

M. AMINE KHALIL

PL3: May 9th 9:30am - 10:10am

Presentation Title:
High Energy & high power electrodes for automotive battery applications.

Position:
Senior Materials Scientist, Chemical Sciences and Engineering, Laboratoire national d'Agronne, USA.

Dr. Khalil Amine is an Argonne Distinguished Fellow and the director of the Advanced Battery Technology team at Argonne National Laboratory, where he is responsible for directing the research and development of advanced materials and battery systems for HEV, PHEV, EV, satellite, military and medical applications. Dr. Amine currently serves a committee member of the U.S.

National Research Consul, US Academy of Sciences on battery related technologies. He is an adjunct distinguished professor at Stanford University, Hong Kong University of science & Technology, Peking University, Beijing Institute of Technology and Nanjing science & technology University.

Among his many awards, Dr. Khalil is a 2003 recipient of Scientific America's Top Worldwide 50 Researcher Award, a 2008 University of Chicago distinguished scientist award, a 2009 recipient of the US Federal Laboratory Award for Excellence in Technology Transfer, 2013 DOE Vehicle technologies office award and is the five-time recipient of the R&D 100 Award, which is considered as the Oscar of technology and innovation. In addition, he was recently awarded the ECS battery technology award and the international battery association award.

Dr. Amine holds over 176 patents and patent applications and has over 439 publications with a google h-index of 88. From 1998-2008, Dr. Amine was the most cited scientist in the world in the field of battery technology.

He serves as the president of IMLB. He is also the chairmen of the international automotive lithium battery association and associate editor of the journal of Nano-Energy.

M. TEKALIGN MAMO
PL4: May 9th 10:10am - 10:50am

Presentation Title:
Exploiting the potential role of fertilizers in increasing food production in developing countries amidst worsening food insecurity and climate change.

Position:
Head of Center for Soil and Fertilizer Research in Africa, Adviser to the Minister of Agriculture, Ethiopia

Prof. Tekalign Mamo is a professor of Soil Science and currently Director of Center for Soil and Fertilizer Research in Africa, a newly launched program at Mohamed VI polytechnic University in Benguerir, Morocco. Before this, he was a Senior Director at the Ethiopian Agricultural Transformation Agency where he launched and led the Ethiopia Digital Soil Fertility Mapping and Fertilizer Blending Projects, thus for the first time customizing chemical fertilizers for Ethiopian farmers.

He served as State Minister of Agriculture; Vice President of Haramaya University; and Senior Researcher and Director of Research. He is the founder and first Editor-in-Chief of the Ethiopian Journal of Natural Resources and Founding Fellow of the Ethiopian Academy of Sciences (EAS). He is the recipient of the 2014 African Green Revolution Laureate Award, 2015 UN FAO International Global Ambassador for Soils and the 2016 International Norman Borlaug Laureate Prize given by International Fertilizer Industry Association (IFA).

He also has many recognitions including Recognition by the International Potash Institute, (IPI) , Certificate of Recognition and Gold Medal Award for Meritorious Achievements in Ethiopian Agricultural Research; Swiss Trans-disciplinarily Award; and Recognition by the International Potash Institute (IPI). He has supervised many graduate students, published extensively and serves in several international scientific committees.

M. PASCAL DU BOIS D'ENGHIEN
PL5: May 8th 1:50pm - 2:30pm

Presentation Title:
Replacement and Maintenance Strategy

Position:
Project Manager, Specialist in Alloy Equipment

Pascal DU BOIS D'ENGHIEN joined DuPont Clean Technologies as from MECS acquisition in 2011. He has been working as MECS Project engineer and Project manager since 2005.

From 2012 to 2015, he has been relocated in Morocco to follow MECS projects in OCP and be the primary technical contact person between OCP and MECS.

He returned back to Belgium end of 2015. Recognized as a specialist in Alloy Equipment Manufacturing, Installation and Operation, is working in the DuPont MECS Alloy Department. He has over 10 years of experience in this domain.

Pascal holds a Master in Mechanical Engineering from UCL in Belgium.

M. GILLES BARRETTO
PL6: May 10th 9:30am - 10:10am

Presentation Title:
REACH legislation and how it affects fertilizer products innovation

Position:
R&D Director Surfactants & Polyols, Arkema, France

M. Barreto is a graduate from the engineering school of Paris ESPCI and received a master 2 of theoretical physics of liquids from Paris UPMC in 1995.

In 1996, he joined Arkema and worked on several fields for speciality chemicals as an innovation and technical assistance manager : bitumen emulsions and adhesion surfactants for road maintenance and construction, processing surfactants for road construction, fertilizer coatings.

Since 2006, he is the R&D Director for surfactants, polyols and oil and gas production chemicals at Arkema. He was R&D Director for Supramolecular Chemistry between 2007 and 2009.
He is recipient of the Potier Prize from the French Ministry of Industry in 2007 in the field of chemistry for the sake of the environment, the International Road Federation Innovation Prize in 2008 and the ICIS prize for the best innovation and the best product in 2009 for renewable energy savings aids in the road industry. He is the assignee of 23 patents.

Main expertise is in chemical physics, colloïds, surfactants and polymers, rheology and organo-mineral interfacial phenomena. Main fields of activity are performance and sustainability for the Fertilizer, Mining, Oil and Gas, Coatings, Adhesives industries.

M. DEBISI ARABA
PL7: May 10th 10:10am - 10:50am

Presentation Title:
Leveraging the combined powers of science and entrepreneurship in African Agriculture transformation

Position:
Director of the International Center for Tropical Agriculture (CIAT) – Regioinal Office for African Kenya.

Debisi Araba is an environmental policy and strategy specialist. He is the Regional Director for Africa at the CGIAR's International Center for Tropical Agriculture (CIAT). He was a Louis Bacon Environmental Leadership Fellow in the mid-career Master of Public Administration Program at the Harvard University Kennedy School of Government. He was previously the Technical Adviser on Environmental Policy to the Honorable Minister of Agriculture and Rural Development in Nigeria.

He was also the Team Leader of the Environment and Climate Change Unit in the Ministry. His present focus is on agricultural resilience and he recently co-authored Nigeria's National Agricultural Resilience Framework. He additionally leads the development of climate smart strategies for the agriculture sector.

Dr. Araba began his professional career with the Newcastle City Council in the United Kingdom, where he worked as a consultant and Project Manager on waste recycling and environmental policy. He also worked at the African Development Bank with the Gender, Climate Change and Sustainability Unit where he provided policy advice and designed Technical Assistance Programs on carbon financing.

Dr. Araba is a respected and published academic who has presented his work at various conferences worldwide. He is a Fellow of the Royal Geographic Society and a member of the Nigerian Society of Engineers, International Solid Wastes Association and the Collaborative Working Group on Solid Waste Management in Low and Middle Income Countries.

Dr. Araba holds a Bachelor of Science (BSc) degree in Physical Geography, a Master of Science (MSc) degree in Clean Technology from the University of Newcastle Upon Tyne, and a Doctorate degree (with best thesis) from the Centre for Environmental Policy, Imperial College London, UK, where his research focused on designing frameworks for incorporating evidence-based research into environmental policy in developing countries.

PLENARY LECTURE

INNOVATION FOR SUSTAINABILITY

PR. SEERAM RAMAKRISHNA
Center for Nanofibers and Nanotechnology, the National University of Singapore (NUS), 119077 Singapore

Since the industrial revolution, innovation has been the stronghold of a few corporations. In the emerging post-globalised world, the face of innovation is changing. Certain national governments around the world are investing over a trillion dollars to build innovation capabilities and capacities to enable sustainable development and growth.

Moreover, technology is accelerating the pace of innovation, and the corporations are embracing open source innovation models to deliver sustainable products and services to the local markets.

Sustainability or the concern for our environment is on the agenda of common people, governments and corporations. Earth Day is now celebrated by more than 1 billion people, making it the largest civic observance in the world. Recently at the United Nations Climate Change Conference in Paris, a climate protection treaty was adopted by consensus of the 195 nations.

This lecture will delve into the nexus of innovation, sustainability and economic opportunities in manufacturing, energy, water, materials, transportation, mining, agriculture and food packaging sectors.

How emerging zero waste manufacturing, remanufacturing, life cycle engineering, resources efficiency, materials informatics, additive manufacturing, clean energy, smart manufacturing, big data analytics, internet of things, cloud computing, and smart sensors are gearing to enhance productivity, cost savings, and sustainability will be deliberated?

USING BIOTECHNOLOGY TO MAKE PHOSPHATE FERTILIZER MORE SUSTAINABLE

BRUCE E. RITTMANN
Biodesign Swette Center for Environmental Biotechnology Regents' Professor of Environmental Engineering Arizona State University

Sustainable phosphorus (P) means optimizing P use so that abundant, nutritious food coexists with healthy aquatic ecosystems. The concept of sustainable P has been gaining traction in recent years, and Arizona State University is leading the Sustainable Phosphorus Alliance (SPA) to bring together industry, academic, and government actors who wish to work together to promote sustainable P. Only a small fraction of mined P ends up in human food; most of it is lost to run-off from fields and to animal wastes.

While animal operations can reap strong economic benefits from P recovery in concert with energy recovery, capturing lost P from run-off is technologically and economically difficult. Therefore, producing phosphate fertilizer that is more available to plants and less likely to be lost as run-off is the best way toward more sustainable P.

This talk will describe two promising approaches based on microbial biotechnology. Both rely on preventing the precipitation of phosphate into mineral forms that are poorly available to plants.

The first takes advantage of the ability of microalgae to rapidly adsorb large amounts of phosphate, which is then readily available for plant use. The second involves fortifying the fertilizer with nitrifying bacteria, whose metabolism naturally produces acids that lower pH and minimize precipitation of mineral solids.

In both cases, making the P more available lowers the application rate and the risk of P loss to run-off.

HIGH ENERGY & HIGH POWER ELECTRODES FOR AUTOMOTIVE BATTERY APPLICATIONS

KHALIL AMINE
Argonne National Laboratory, 9700 South Cass Av., Argonne, IL
Materials Science & Nanoengineering/MSN
University Mohammed VI Polytechnic

In other to enable 40 miles PHEVs and long electric drive range EVs, there is a need of developing advanced battery systems that offer at least 250 to 300 wh/kg energy density. The most significant technical barrier to developing commercially viable Plug-in Hybrid Electric Vehicles (PHEV) is the energy storage system.

The challenge is to develop batteries that are able to perform the requirements imposed by a PHEV system and yet meet market expectations in terms of cost and life.
In this case, the PHEV battery will experience both deep discharge, like an electric vehicle, and shallow cycling necessary to maintain the battery for power assist in charge sustaining HEV mode.

Conventional lithium-ion batteries based on metal oxides and graphite have made significant progress in recent years for HEV applications, however, durability with the PHEV duty cycle and the ultimate cost and safety of the technology remain key challenges.
To achieve a very high all electric drive range, a new battery system with advanced high capacity cathode materials and stabilized high capacity anode is needed.

In this talk, we will disclose several strategies to increase the energy density of LiFePO4 and LiMn1-xFexPO4 cathode without compromising their power capabilities. We will also disclose a novel full gradient cathode material that offers 230mAh/g capacity with very high loading density. These cathodes can be coupled with high voltage non-flammable electrolyte to improve the safety of lithium ion battery.

Finally, we will describe some new approach of improving the cycle life of Si/carbon composite anode by impregnating nano-silicon particles within graphene sheets.

EXPLOITING THE POTENTIAL ROLE OF FERTILIZERS IN INCREASING FOOD PRODUCTION IN DEVELOPING COUNTRIES AMIDST WORSENING FOOD INSECURITY AND CLIMATE CHANGE

PR. TEKALIGN MAMO
Center for Soil and Fertilizer Research in Africa (CESFRA) Mohammed VI Polytechnic University, 43150 Benguerir, Morocco

Although there is a gradual and continuous decrease in the extent of global food insecurity, this is not the case in sub Saharan Africa (SSA) and western Asia where it is rather increasing. These are also among the regions that use the least quantity of fertilizers and at the same time, the soil nutrient balance is negative.

More, by 205o, SSA needs to produce multiple fold from its current production level (by far the highest required surplus compared to other regions) to feed its growing population. Last year alone, no less than 20 million people were affected by the impacts of climate change and subjected to hunger.
Since Africa possesses 60% of the uncultivated land in the world, there is a big opportunity for the fertilizer industry to invest in developing countries such as SSA. By assisting them in unlocking the gap in their knowledge about nutrient deficiencies in their agricultural soils and demonstrating to them that customized fertilizers will for sure help them increase their crop productivity by many folds, no farmer will hesitate to switch to customized fertilizers and increase his/her fertilizer consumption as we witnessed in Ethiopia.

Going with this is also the issue of raising fertilizer use efficiency to avoid wastage and impacts on greenhouse gas emissions. Here at UM6P, we have launched a Center that has prioritized to work in Africa to help farmers customize their fertilizers.
We thus need your cooperation in our endeavors as it is not that easy to clap with one hand only.

This approach will also be more successful effort for the fertilizer industry in playing their role to help reduce poverty in developing countries; at the same time, they can expand their market reach.

REPLACEMENT AND MAINTENANCE STRATEGY

PASCAL DU BOIS D'ENGHIEN,
Project Manager MECS Europe/Africa BVBA , 1560 Hoeilaart, Belgium
YOUSSEF RIAHI,
Project Manager MECS Europe/Africa BVBA , 1560 Hoeilaart, Belgium

Sulphuric acid producers are no strangers to the struggle with corrosion. Prevention and maintenance are key to avoiding frequent maintenance issues, costly equipment failure and unplanned shutdowns, all of which have a significant impact on productivity, reliability and the bottom line. Key elements of an advanced strategy of maintenance for Sulphuric Acid Plants are around the combination of a robust evaluation process and a first class and optimized replacement approach.

MECS developed a family of austenitic stainless steel alloys with a high silicone content called ZeCor®. Designed specifically for strong sulphuric acid applications, ZeCor® has become one of the most widely used alloys in the industry. MECS high performance equipment is continuously improved by the Research and Development team and provides high quality fabrication, installation and commissioning standards, including safety.

Thought case studies, this paper will consider all important factors in plant optimization during the replacement phase and the ways of extending the life of the plant and individual pieces of Equipment and will mainly cover the Alloy Towers (Drying and Absorbing), Heat Exchangers (Gas/Gas and Acid Coolers), Converters and Steaming Equipment (Waste Heat Boiler, Economizer, Superheater).

Richard.Martinez@dupont.com

Topic : Material, Corrosion and protection systems

REACH LEGISLATION AND HOW IT AFFECTS FERTILIZER PRODUCTS INNOVATION

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There is no doubt that in the recent years there has been a growing concern about the impact of chemical products to the human being and its environment. Every single chemical industry is concerned, including the mining and fertilizer industry.

In Europe, there has been an important step forward to improve the use of chemical products as the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) has been established in 2007.

In this work, an analysis of what REACH means for the chemicals products producers, traders and consumers is made.
A brief review of how it drives the generation and communication of experimental data to increase the knowledge of chemical products in the market is also presented.

REACH legislation has a strong impact on the innovation of new chemical products. The role of this new legislation into the development of new chemical products, in particular from the fertilizer coatings and additives perspective, is also discussed.

LEVERAGING THE COMBINED POWERS OF SCIENCE AND ENTREPRENEURSHIP IN AFRICAN AGRICULTURE TRANSFORMATION OR UNLOCKING THE POWER OF PRIVATE ENTREPRENEURSHIP IN ADDRESSING SOIL HEALTH AND CROP PRODUCTIVITY

DEBISI ARABA
International Center for Tropical Agriculture (CIAT) – Regional office for Africa, Nairobi, Kenya

The thesis of the address will discuss existing knowledge and identify gaps, in the context of opportunities in increasing yield and restoring degraded land in a sector constrained by environmental challenges.

The fundamental role of soils in providing healthy and nutritious food is often overlooked. However, one-third of global soils are currently facing moderate to severe degradation caused by soil erosion, nutrient depletion, salinity, sealing and contamination. Nutrient impoverished soils contribute to systemic food and nutritional security issues.

Scientists thus assess the potential for enhancing and sustaining the productivity of specific farming systems through more efficient use of inputs and natural resources, helping to identify improved management practices for specific conditions, with the aim of curbing soil degradation.

To achieve the scale and impact required to usher in the African Green Revolution, there needs to be renewed cooperation between research institutions and private entrepreneurs, at all levels, from the boardrooms and laboratories, to the agrodealer stalls and farms.

This address will conclude by providing pathways for leveraging scientific evidence and combing market insights to position soil health at the forefront of agricultural transformation in Africa.

4 areas - from OCP strategy and engagement in Africa - which will be included in the address

I. Profiling soil fertility
II. Digital soil mapping in key countries
III. Fertilizer recommendations and on-farm field trials
IV. Capacity building

Thematic areas to be discussed:

1) SOIL ANALYSIS AND RESEARCH FOR A BALANCED FERTILIZATION

- High resolution digital soil mapping of nutrient constraints to guide decision making towards vulnerable areas
- Rapid assessment using mid-infrared spectroscopy or soil doctor
- Soil fertility profiles to identify constraints including nutrient and micro-nutrient deficiencies, low soil carbon, soil pH and aluminum toxicity
- System health analysis and nutrient leaching testing
- Market analysis to determine input availability and potential for demand
- Improving policy context for soil fertility availability on local markets
- Tapping financing opportunities for soil fertility management
- Outlook and synthesis of soil profiles professionally produced with infographics similar to the CSA Profiles: https://ccafs.cgiar.org/publications/csa-country- profiles

2) FERTILIZER BEST MANAGEMENT PRACTICES

- Fertilizer recommendations tested in multiple long-term agricultural field trials that provide opportunities to test different fertilizer blends
- Best-bet solutions and application training in the 4Rs
- Private sector engagement to test crop response to fertilizer products and promote their use through our growing farmer network
- Testing better fertilizer blends and modern fertilizer types - controlled release
- High interest soil fertility interventions to address fertilizer or input needs; ISFM; deep application urea; liming.
- Building institutional capacity: in public, private, NGO, PPP sectors to deliver improved soil fertility for example through Muhammed VI Polytechnic University.

3) PRECISION AGRICULTURE

- Decision support tools for farmers for on site; crop; soil; climate-specific fertilizer recommendations, for improved whole farm management
- Big Data analytics to maximize returns on inputs while preserving resources

4) SOIL CARBON SEQUESTRATION POTENTIAL

- Options for reduced N-emission intensities boosting on-farm resilience
- Landscape mapping to guide limited investment in whole ecosystem restoration

WORKSHOPS

WORKSHOP 1. INDUSTRIAL MAINTENANCE

HOW SMARTER CAN BE MAINTENANCE AND PRODUCTION CONTROL ?

LUCA COLOMBO, SERGE TEYSSIER
Trelleborg Industrie, Clermont Ferrand, 63050 France

Everyone would like to know when it will be the right time to change a component in an industrial environment.
How it's possible to know when it will be the right time to change an equipment ? We believe that we found the right way, by installing a chip and a QR code in our hoses and expansion joints.
The maintenance manager will be able to map all its rubber products, by date of manufacturing, installation, last revision with a simple and clever application.

With every smartphone the maintenance can add a new component and delete the old ones from the installation, by having a full information and alerts with an app that you can control either by your phone and by your computer, in a cloud environment in total security.

The second stage is to provide our equipment with a clever system able to advise the maintenance that a single rubber unit need to be changed in the next six months, helping to shorten the supply chain for spare parts.

We can supply this new technology without any price increase for our products and also giving the possibility to use it also to map competition products with a little fee.

Save time, money and check your rubber spare parts at the same time, this is INNOVATION

FROM ASSET MAINTENANCE TOWARD ASSET LIFECYCLE MANAGEMENT

JIBILI ABDENOUR (METHODS MANAGER), MICHAEL DAWSON (ASSET MANAGEMENT DIRECTOR), EL BAHLAOUI ABDELLAH (MECHANICAL ENGINEER)
OCP Group, Safi site , Morocco; Jacobs Engineering S. A.

World Class companies and especially their C-Suite Executives recognize the value of proactive, risk based maintenance. The impact to the bottom line can't be underestimated with improved production and lower per unit costs - two strategic objectives which define OCP's financial performance, global competitiveness, and ability to weather market variations.
OCP and JESA have launched a new initiative to install a "best practices" based asset management and maintenance program for the SAFI, Maroc Chimie, and Triple Super Phosphate (TSP) / Mono Calcium Phosphate (MCP) perimeter.
The program will transfer knowledge from Jacobs' extensive global maintenance experience and integrate it with OCP's strong maintenance background to achieve a new standard of professional maintenance for OCP.
While the first year is establishing the program and beginning of execution, we are laying the groundwork to enable performance based contracts by measuring Key Performance Indicators such as availability, cost, and asset condition. This new approach will incentivize alignment, reduce costs, and increase production.
In addition, this partnership will involve advancing to new horizons in Moroccan ecosystem through workforce development, knowledge transfer, maintenance activities, and procedures.

The main objectives are:

- ISO55000 certification for Asset Management which will enable OCP to realize the maximum value from their asset rich portfolio:
- Creating REM (Reliability Engineering for Maintenance) leading toward criticality based equipment strategies for effective maintenance;
- Improving WorkExecution of Maintenance (WEM) by focusing on practical implementation of best practices and by putting theory into practice;
- Improving the impact of Predictive Maintenance by using and integrating technologies that guide maintenance actions from a proactive perspective;
- Developing third party certified training programs adapted to the local craft;
- Supporting the culture of change with adapted soft skills training and programs to sustain all these improvement.

Our presentation will share our path, progress, and evolution beginning from the initial situation before 2006, through internal improvement with OCP maintenance craft, and finally toward OCP / JACOBS new JESA platform to create a new adapted model which fits with Moroccan and African environment specific features

KEY FACTORS IN IMPLEMENTING SUCCESSFUL MAINTENANCE IMPROVEMENT PROJECTS

MALCOLM WERNER, TARIK NASSIF
Jacobs Engineering S. A., Zénith Millenium, Lotissement Attoufik – Sidi Maarouf, 20190 Casablanca, Maroc

As OCP moves to advance maintenance skills and performance, it's key to note that globally, more than 50% of all maintenance and reliability improvement projects fail within the first two years. While there is no guarantee for certain success, there are key factors that make success more likely. JESA in collaboration with Jacobs Engineering provides a unique perspective on this topic. Learn these key factors based experience with both successes and failures.
Key points:

1. Most maintenance and reliability improvement projects fail. Human nature is biased towards reactive rather than proactive responses.
2. Engineers prefer to address technical issues but people and work place culture are the real challenges.
3. There are key factors that must be addressed to be successful. These factors will be explained.
4. Some examples will be provided to emphasize the key factors.

In our experience, very few asset management programs have been successfully sustained for more than two to three years. It is observed that most asset management programs, especially improvement programs in brownfield applications, fail. They either fail during implementation, during transition to owner control, or over time (3 to 5 years) when champions and knowledgeable leaders move.
Technical problems easier to solve than influencing human behaviour and changing site culture. Most, if not all, unsuccessful attempts to resolve asset problems are due to people resisting the change.
Reactive maintenance is the natural chaotic state for all industrial facilities. The Law of Entropy applies to asset management; without external input all systems decline into disorder. People appear to prefer combat with assets than to proactively preventing failures. People seem to prefer to demonstrate super human heroic capabilities to repair machines than to exert their intellectual capacity to prevent machinery breakdowns.

There is a "formula" for success. However, the simplicity of the process does not imply simplicity in the implementation.

1. Owner Champion(s)
2. Experience Facilitator(s)
3. Transformational Leaders
4. Continuous Conversations
5. Enrollment
6. Dealing with Resistance and Barriers Tracking Results

We will provide a perspective based on the views of a senior US maintenance and reliability manager who has spent significant time supporting OCP projects over the last three years and from a Moroccan Maintenance Manager with in depth knowledge of the local environment. The discussion should be lively and interesting.

A TECHNICAL IN-DEPTH LOOK AT PREDICTIVE MAINTEANCE AND OTHER RELATED INSPECTION METHODS

JAMES PARKER
Director Of Business Development NDT Services, AMERAPEX CORPORATION, 2950 North Loop West, Suite 1100 Houston, Texas,USA

Constant changes are always occurring in the non-destructive testing and inspection environments.
Within the last few years, an arsenal of new “advanced” technologies are now available to address most existing as well as new concerns applicable to all types of process plants.

A technical in-depth description of these issues will be presented emphasizing the following: Corrosion Under Insulation (CUI), MsS Guide Wave, Positive Material Identification (PMI), Eddy Current, Computer Radiography and all aspect of storage tank inspection including the use of Electro Magnetic Acoustic Transducer (EMAT) technology.

The application of these Advanced NonDestructive Testing (ANDT) techniques reduces unplanned shutdowns and forms the core of a predictive maintenance program and a complete Mechanical Integrity (MI) program.

HOW COULD YOU MANAGE CRITICAL ASSETS FROM ANYWHERE? WAKE UP YOUR SENSORS WITH THE WI-CARE

PIERRE COLON
I-Care sprl, Rue René Descartes 1 - 70000, Belgique

In any industrial plant keeping an eye on your critical assets at any moment is the key of the process reliability for many years. Indeed if you have to face an unplanned breakdown on one of these units the costs to repair it will be important and the loss of production has to be avoided. Then if you could manage the reliability at any moment and furthermore from anywhere it should be really profitable for your company.

That's the reason why I-Care as one of the major actor in the condition monitoring and reliability world has developed internally some efficient tools and technics to manage this reliability as Wireless vibration sensor with remote analysis to know the health of your equipment at any place and any time : the Wi-Care. This tool could help to implement the reliability excellence program for any assets.

With more than 1.000.000 of bearings analyzed last year and a team of more than 150 engineers through the world I-Care decided to use this field experiment to create a new wireless sensor to check the health of your assets. It doesn't matter if this equipment is in a hazardous area, too far, moving, etc. The Wi-Care sensor is made for these situations and has a lifetime battery of 5 years.

As this solution is completely flexible you could adapt it to any existing sensors to optimize the installation and the costs! Our remote engineers are able to provide you a further analyze remotely to help your maintenance team to take the right action for each equipment. Then you have an expert advice without any displacement and within a few hours.

To have a complete solution, our web-based software was created to offer a new multi-technology platform with information available for all the levels of the hierarchy. All the reports, informations and actions can be implemented in this portal additionally to the wireless datas.

The goal of this new solution is to offer an intuitive plug-and-play tool to all the actors in the maintenance world whatever the environment or the process. This technology is a real innovation and is now patented which can prove the innovation aspect. It is also ATEX zone 0 certified and can be installed even in really wet or hot environment.

DEBOTTLENECKING OF SULPHURIC ACID PLANTS

JAN ALBRECHT, DR HANNES STORCH
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During the lifetime of plants it is very common that the production requirements change and increased throughput or production is required.

This paper will elaborate on the possibilities and influencing factors for debottlenecking projects for sulphuric acid plants. It will provide examples of executed debottlenecking projects of the recent past. Main drivers and influencing factors to develop and execute debottlenecking project will be discussed as well as the common measures to achieve increased plant performance.

The paper will also line out what can and needs to be done during normal operation campaigns to achieve and insure steady and reliable production at nameplate or increased rates.

OUTOTEC will present its portfolio of possible services to assist the successful development and implementation of debottlenecking projects.

IMPROVE YOUR SULPHURIC ACID PLANT ENERGY EFFICIENCY BY MAKING CLEAN WATER

MOUMEN CHAGRAOUI
Managing Director, SOFRETIM, France

Extracting more of the energy released during the production of sulphuric acid is increasingly important to create additional revenue for plant operators.
Many plant operators only recover the sulfur oxidation energy in the form of high pressure steam whereas recovery of the absorption energy in the form of LP steam is viewed as a risk to plant reliability and availability due to the narrow safe operating window of this LP steam production system.
LP steam production systems are therefore typically only considered for sites with multiple sulfuric acid plants.

In order to achieve up to 100% energy recovery from the sulfuric acid process Chemetics has developed a family of process add-on systems that recover additional energy without causing a reduction in plant availability.

In this paper Chemetics will provide an overview of these process systems and how each is designed as an independent system from the main process. Special attention is given to the CES-DSW™ process which provides safe and reliable production of desalinated water.

IN-SITU DSC AS A TOOL FOR NEW CS SULFURIC ACID CATALYST DEVELOPMENT

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A new in-situ Differential Scanning Calorimetry (DSC) method has been developed to probe the thermal effects associated with sulphuric acid oxidation catalysts. Heat flow curves indicate the melting point of catalyst species under reaction conditions.

DSC information was also used to rank catalyst activity and to obtain kinetic parameters, such as activation energy and the Break Point Temperature (TB). Catalyst activity, measured separately in a laboratory differential reactor, was found to increase with decreasing TB.

A high activity Cs catalyst was scaled up to commercial production and its performance was evaluated in a pilot plant reactor. The data indicated that the catalyst is significantly more active than the base case.

This paper discusses how the higher-activity Cs catalyst can help customers meet their performance targets in new and existing plants.

FUNDAMENTALS OF RELIABLE SULPHURIC ACID PLANT DESIGN

MOUMEN CHAGRAOUI
Managing Director, SOFRETIM, France

In the world of large fertilizer projects many decisions are made by the project team at an early phase that have the potential to affect the reliability, efficiency and maintenance cost of the sulfuric acid plant for the life time of the plant.

Many of these issues can result from a lack of detail in the request for proposal allowing acid plant contractors to select marginally lower cost designs/materials to be the low-cost bidder that results in higher operating cost for the operator during the plant life.

This paper provides information that can be used to improve the plant design at an early stage without a major increase in the overall project cost.
Increased reliability, plant availability and energy efficiency that result from these improvements can significantly improve the life cycle cost of the complex.

INNOVATION IN SULPHUR HANDLING

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RAIZ BASHEERUDDIN, ALTAF BANKOTKAR
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In 2015, Furnace Fabrica India Ltd. (FFIL) successfully commissioned a Lumpsum Turnkey EPC contract constituting of basic engineering validation, complete detailed engineering of a 6000 TPD sulphur melting and filtration unit with supply & installation of all equipment including civil works and commissioning at JORF Lasfar, Morocco.

The scope of works consisted of Fabrication/Erection of Technological Equipment, steel structure, associated piping, Civil works, complete electrical works including MV cabling from the off plot substation, Building/Road works, Testing Trial & Commissioning of.

Since FFIL's scope included detail engineering, it invested more than 100,000 engineering manhours including process design. The process plant comprises of three main sections namely, solid sulphur handling and storage, sulphur melting & pumping and sulphur filtration & pumping.

Incorporating a melting tank above the ground, equipped with heating coils and agitators, the improved design of conical bottom tank with careful corrosion & fire hazard control, sulphur melting is carried out at specific parameters.
To achieve sulphur quality with ash content 7-5 ppm as per basic requirement of the client, the Filtration Plant is designed with Leaf filters and Cartridge filters operating in tandem for each cycle of filtration. The cartridge filter is considered with ceramic candles which can be flushed and cleaned with low pressure steam. The cartridge filter acts as a security to hold back any ash slip that occurs from leaf filter during filtration.

The whole process is collectively supported by various utility systems. In addition to technologies used in this project, this paper attempts to focus on innovative methods used for sulphur handling solutions.

EMISSION REDUCTION IN SULPHURIC ACID PLANTS

JAN ALBRECHT, DR. HANNES STORCH
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During the lifetime of plants it is very common that the emission requirements change and reduction in plant emissions is required.

This paper will elaborate on the possibilities and influencing factors for projects to reduce emissions for sulphuric acid plants.
It will provide examples of executed revamp and modernization projects of the recent past. Main drivers and influencing factors to develop and execute emission reduction project will be discussed as well as the common measures to achieve reduced plant emission.
Special focus will be on the various tail gas treatment systems which can be installed downstream of the final absorption.

The paper will also line out what can and needs to be done during normal operation campaigns to achieve and insure steady and reliable production within the allowed emission range.

DECADMIATION: A 'HEALTHY' CHALLENGE FOR THE PHOSPHATE INDUSTRY

RAJESH RAITANI, JOHN LAMPARIELLO
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An increase in global population is the key driver for growth in phosphate products demand. The majority of the phosphate products find their use in fertilizers for agriculture to improve yields from farms.

However, these fertilizers are made from phosphate rocks which often contain trace amounts of cadmium, which is believed to be toxic and mutagenic to humans at low exposure levels. Tightening regulations on permissible cadmium in fertilizer and food products have pressed fertilizer producers look for cost-effective options to reduce cadmium levels (decadmiation) in phosphoric acid.

Increased regulatory restrictions, shrinking margins on fertilizer products and high decadmiation costs from traditional methods, offer immense opportunity for innovation in decadmiation techniques.

This article provides a review of various decadmiation techniques available, discusses the need for an efficient and cost-effective solution for cadmium and other heavy metals removal from the fertilizer products, and introduces Solvay's ACCOPHOS® reagents for decadmiation of phosphoric acid.

CADMIUM REMOVAL FROM PHOSPHATE ROCK

TANJA SCHAAF, LUDWIG HERMANN, ROBERT PARDEMANN, JOCHEN GRÜNIG, KHATARINA FÖRSTER, ANDREAS ORTH
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Phosphate rock is used for the production of phosphate fertilizers, phosphoric acids and a variety of chemical products, frequently based on white phosphorous. Apatite is the predominant constituent of phosphate rock, albeit with small but relevant substitutions, such as carbonates.

Non-nutritive metals, in particular cadmium, are natural contaminants of phosphate rock and are a health and an environmental concern in Europe. Cadmium (Cd) is toxic and mutagenic. Cd can be accumulated in the food chain, because it can be easily absorbed from the soil by plants. Considering degrading phosphate rock qualities and tightening legislation for the Cd levels in P based fertilizers, Outotec has derived a concept for thermal beneficiation of contaminated phosphate rocks and other solids.

Outotec, as one of the globally leading companies in minerals and metals processing technologies, has close to 400 calcination, roasting, combustion and gasification reference plants in operation, all based on proprietary fluidized-bed processes.
Based on the experience from thermal treatment of a large variety of ores, a process has been developed, adapted and tested on different rock phosphates. Experiments were performed at Outotec's Frankfurt Research Centre applying two experimental facilities, a small-scale batch reactor (100 g sample) and a continuous bench-scale facility (10 – 30 kg/h feed rate).

The presented results show that Cd can be removed from phosphate rock at relatively modest temperatures without sacrificing too much the reactive surface of the rock. In addition to that, carbon (in organic or carbonaceous phase), which can cause problems in efficient acidulation during fertilizer production, has been decomposed well below specification limits.

The presentation shows the basic concept for the thermal treatment of high impurity phosphate rocks with low energy consumption and high rate of heat recovery.

TECHNOLOGY FOR DEACTIVATION OF CD AND OTHER HEAVY METALS IN PHOSPHATE ROCK

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Institute of Physial-Chemical and Biological Problems in Soil Scienes RAS, Institutskaja street 2, Pushchino, 142290, Russia

Most sources of phosphate rock (PR) used as a fertilizer, which had little hazardous elements (As, Cd, Hg, Pb et al.), were depleted and today the environmental quality of extracted PR drops every year. The phosphate fertilizer manufacturing includes the process leading to activation of not only P, but contaminants as well.

PRs from Togolese Republic and Morocco were analysed on the total and mobile forms of As, Cd, and Pb. PR samples were treated with concentrated monosilicic acid or solid Si-rich substances having high solubility on Si and than analyzed for mobile forms of pollutants and different forms of P. Solid and liquid forms of Si sorb or precipitate pollutants with the formation of slightly soluble silicates.

The PR treatment by monosilicic acid resulted in converting Ca-phosphates into Ca-silicates and increasing P solubility by 2-3-fold. The thermodynamic calculations of this process were carried out. In greenhouse and field experiments conducted with treated, untreated PRs, and superphosphate on tomato, cucumber, cauliflower, barley, and corn, the P status in the soil-plant systems was determined.

The results evidence that Si substances remarkably reduced the mobility and plant-availability of the pollutants (by 50 to 90%). On the other hand, significant amount of plant-unavailable P was converted into plant-available form (30-50%). Under application of the Si-treated PR the productivity of such crops as tomato, cucumber, barley, and corn was increased up to the same level as under the same application rate of superphosphate. New technology for reducing mobility of hazardous elements and increasing the plant-availability of P was suggested.

FROM MINERAL CHARACTERIZATION TO PLANT IMPLEMENTATION: AN INTEGRATED METHODOLOGY TO PROMOTE SUCCESS IN THE MINING INDUSTRY

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GUILLAUME RAMEAU, VINCENT DIEUDONNÉ
ERAMET Ingenierie, 1 av Albert Einstein, 78190 Trappes, France

Process improvements in the mineral industry are often treated by element and metal recovery comparisons in physical and chemical experimentations. Even though this is essential as the final product price is strongly chemistry-linked, it must be noted that elements are hosted by minerals with varying chemical and physical properties.

In order to better understand and to improve yields and recoveries it is very useful to perform detailed mineralogical characterization studies addressing each step of mineral processing processes. A mineral characterization study should commence right at the beginning of mineral processing development.

Pertinent information includes the modal mineralogy, granulometric distribution of each mineral species, mineral associations and liberation potential of phases. By establishing the location of valuable elements within minerals of known physical and chemical properties, it is possible to predict process behaviors of these phases during mineral processing, and also to evaluate the efficiency of already applied process conditions.

Based on the obtained information a laboratory trial can be performed to test and improve process parameters. A continuous collaboration between laboratory mineralogists, mineral processing scientists who perform laboratory and pilot tests, and engineering teams, is essential to optimize processing results.

This joint approach allows to develop new mineral processing applications or to optimize existing applications, and is applicable throughout the various project development stages all the way to plant start-up.

Examples demonstrating the benefits of the efficient collaboration between ERAMET Research and ERAMET Ingénierie will be presented, among which the development of a beneficiation process for the Maboumine rare earths project.

SIMPLIFIED SO2 EMISSIONS CONTROL WITH SIDE BENEFITS

MARTIN LEBEL
Shell Cansolv, 400 Boulevard de Maisonneuve Ouest, Suite 200, Montréal, H3A 1L4, Canada

As legislations across the world have become more stringent for sulphur dioxide emissions, sulphuric acid plants are faced with increasingly expensive solutions to keep their license to operate. Most additions to aging acid plants over the years have included new catalytic beds with an absorption tower or tail gas scrubbers.

With reducing emission targets, additional revamps have become more difficult and expensive to install or more cost intensive in terms of operation. The addition of regenerable SO2 tail gas scrubbing like the Cansolv SO2 Scrubbing System to the portfolio of technologies offers plant managers a solution that can be easily tailored and added on to existing facilities while future proofing emissions at the same time.

The Cansolv SO2 Scrubbing System has been in operation on sulphuric acid plant tail gas in fertilizer application and has been proven to be a cost effective reliable solution with over 15 years commercialization worldwide in various applications. With performances exceeding expectations, plant operators have seen SO2 emissions drop to less than 10 ppmv or roughly 0.3 kg/ton of acid produced. The recovered SO2 is recycled into the acid plant to maximize the sulphuric acid production and considered a GREEN technology.

With the possibility to easily bolt-on the solution to existing acid plants, the Cansolv SO2 Scrubbing System can provide the answer to both current and future while emission specifications while simultaneously decoupling emissions from the upstream unit performance.

This paper looks at highlighting the advantages of applying regenerable tail gas solutions to existing acid plants, supported by operations data.

MOVING TO THE 20TH CENTURY! APC

DR. VAUGHN ASTLEY
Dr. Phosphate, Inc. Highland City, Florida 33846, USA

Remember when automobiles/cars had no computers?
Now we have up to 100 in a Mercedes S Class series.
All These Computers/Microprocessors result in Improved fuel economy, more power from smaller engines, less emissions, FASTER ACCELERATION!!!, MORE STABILITY, and going FASTER AROUND CORNERS, WOW!!

Why not use the enhanced process logic available with Advanced Process Computer Controls to improve Phosphoric acid production?
It is like Cruise Control for the Operators and Supervisors. These developments started around 1988 and were installed in standalone computers and subsequently within the DCS systems. The logic uses real time plant data, real time material balances, fuzzy logic, and adaptive controls, and self adjusts to changes within the process.

The APC programs were first placed in On-Line Control Mode in 1991, and continuously controlled free sulfate level, P2O5 Strength, Filter Feed Rate, and thus Operating Rate and Recovery. Significant Improvements in P2O5 recovery › 3% and production rate › 7% have been realized, but less would be expected in a very well-run plant.

While these original systems are still in operation, new control systems have been developed that provide even better control. The systems will be described as well as the cost of implementation and resultant performance.

APPLICATION OF MODERN SEAM MODELING, MARGIN RANKING AND OPEN PIT DESIGN TECHNIQUES IN PHOSPHATE MINING

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Modern techniques for seam modelling and margin ranking of phosphate deposits can provide rapid methods for assessment and optimization.
These techniques offer a range of visual and numerical outputs such as colour contouring for quickly identifying optimum locations for commencement of mining operations and the orderly progression of the mining sequence and schedule.

For multi-seam deposits in particular, this can be very useful in rapidly identifying mining targets for progressive terrace mining using conventional open pit techniques.
In combination with blending and stockpiling algorithms where quality control is imperative, such techniques prove particularly useful for mine design and scheduling to target optimum production rates and quality criteria.

This paper explores such techniques and provides a useful guide to general application.

ADVANCED CONVEYOR MONITORING: CASE STUDY

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Monitoring industrial plants is imperative. Acquisition, processing and analyzing data, collected from sensors and other intelligent instruments, are indispensable. Conveyors used in OCP for bulk handling of phosphates, fertilizers or other products are major components in the chain value of each production unit. However, their supervision is generally based on isolated indicators reflecting operations conditions and failures.

In this article, we try to present an advanced supervision design based on the combination of conveyor's operating parameters. In order to offer a decision-making scoreboard to industrial managers. Our approach is based on real-time monitoring of indicators such as: On / Off status, Product flow / tonnage, Energy consumption, vibration, faults / alarms.

Then we perform combination of those data in order to detect the vacuum steps, under-speed, specific consumption evolution, rotating equipment deterioration, predominant failures and the downtimes linked to various reasons.

In this case study of phosphate conveyors, we were able to design advanced monitoring that could provide a device for rational management of bulk handling chains.

Keywords: Advanced Monitoring, Conveyor, Bulk Handling.

THEMATIC SESSIONS

ADAPTATION OF THE JORF LASFAR PHOSPHORIC ACID PLANTS FOR USING THE SLURRY PHOSPHATE INSTEAD OF DRY PHOSPHATE

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In order to increase its production capacity of phosphoric acid and fertilizers at Jorf Lasfar site, OCP completed the pipeline project linking Khouribga and Jorf Lasfar sites. The transport capacity is 38 MT/year.
In parallel, since 2010, OCP has started the project for adapting the eight existing phosphoric acid units for the use of the slurry phosphate instead of dry phosphate, with 1,8 MMAD TIC.

The adaptation project consisted of regrouping the eight existing units (500 T.P2O5/day of capacity for each one) in two by two, to make four new lines with a capacity of 1350 T.P2O5/day per line. This project allows reaching an increased availability and other performances such as the reduction of fluorine emissions with a rate less than 5 mg/NM3 and improving the chemical efficiency around 95%.

Basic and detail engineering was carried out by SNC LAVALIN & PRAYON. SNC LAVALIN Engineering supervised construction with skilled team from Belgium and Morocco. To optimize the shutdown times, most of the equipment was built without interruption of the running plant. We could schedule shutdowns of respectively 10 months for the first adapted line and 6 months for the following lines.

The added new equipment are as follows: 4 reaction tanks equipped with agitators and circulating pumps of 17 000m3/h - 4 flash cooler - 4 Pulp thickening units - 8 tilting cell slurry filters - All the pumps and agitators - Electric switchgears and transformers - overhead and underground piping - Pumps.
The retrieved and adapted Equipment are: the reaction tanks with their main agitators - the existing maturation tanks - the scrubbers, the stacks and main blowers - the electric rooms - The filtration buildings after reinforcement, the DCS that has undergone an extension and additions of new technologies and features.

At the end of February 2017, the situation is as follows:
XY Line: start-up in September 2015. Cumulative production: 422 KT P2O5
CD Line: start-up in July 2016. Cumulative production: 70 KT P2O5
AB Line: Completion of adaptation work and start-up in April 2017.
ZU Line: Adaptation Shutdown planned after start-up of AB Line

HOW SLURRY PROPERTIES IMPACT ON SLURRY PIPELINE TRANSPORT

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Slurry transport pipelines offer a viable alternative to more traditional modes of bulk transport such as road and rail and they can be applied to a wide range of minerals including phosphate.

Slurry flow behavior and the pursuit of optimal and efficient pipeline operation is greatly influenced by the slurry properties, specifically the concept of transport of a "coarse" solids fraction in a conveying fluid formed by the mixture of water plus "fine" solids fraction.

This paper focusses on how changes in slurry properties (size of the coarse particles and viscous properties of the conveying fluid) impact on slurry pipeline system operation and it discusses the slurry property optimization process for long-distance slurry pipeline applications.

INTELLIGENT INTERNAL COATINGS FOR PIPE SPOOLS IN PHOSPHATE AND OTHER SLURRIES

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For 5 years now, RoCoat™ high performance polyurethane coating is protecting station piping at Daoui pump station of the Khouribga phosphate project from wear and erosion-corrosion.

Meanwhile, RoCoat has widely been applied in oil sands tailings and hydrotransport, limestone slurries, shotcrete, and dredging slurries, often extending useful life by a factor of 10. Whilst design life extension is an important feature of these coatings, cost savings and process safety can be improved even more if monitoring of coating wear from outside the pipe is possible. So-called "Instrumentation Spools" developed by ROSEN containing intelligent RoCoat are in service in Canadian oil sands since April 2015. Sensors integrated into the coating layer measure coating wear. Sensor data are transmitted to the outside of the steel pipe without need for a hole through the pipe wall. More exact maintenance scheduling based on these sensor data can save up to 25% or even more of maintenance cost according to operators.

Integrated wear monitoring opens a much wider range of application for RoCoat in pipes that hitherto were protected by metallic, ceramic, rubber, or other interior coatings.

A very similar sensor technology has now been integrated into other polyurethane wear protection products by ROSEN, e.g., hydrocyclones, rollers, and others.

MINE DIGITAL INTELLIGENCE – FROM DATA TO BUSINESS DECISIONS

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Mining operations are constantly tasked with identifying new ways to produce more, while using less. Mine effectiveness and reliability is the foundation of improving operational excellence.
Timely decisions need to be made in order to identify production waste. Intelligent data needs to be visualized in real-time. Operational events need to be captured with impacts quantified and root causes identified.

Unfortunately, complex information technology solutions often have a very poor success rate, with some reports suggesting 30 percent of complex projects are canceled before completion.

In most mining operations, the dilemma faced by miners is the excess of information.
A myriad of dissimilar and proprietary systems like process controls, laboratory, quality control, asset management, maintenance, dispatch systems, mining planning, mine scheduling, and energy management are delivering tons of data that can be useless if not treated, filtered and managed.

In addition, the largest untapped efficiency potential lies at the critical interface between enterprise and the operations at the mine - If not properly connected, these applications can generate an excess of isolated databases, data duplication, spreadsheets, and manual entries. Very often, custom software (middleware) is required to integrate applications.

The objective of this paper is to present technologies, best practices, tools and architectures that collect, integrate and manage data delivering real time optimization from simple process to the whole supply chain.

AUTOMATION AND INNOVATION IN SURFACE MINING EQUIPMENT DRIVING EFFICIENCY, PRECISION AND PRODUCTION, EXPERIENCE IN HARD ROCK

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Vast experience on using Vermeer surface mining equipment globally in various conditions and applications has confirmed and proven the need for automation.
Automation not just on control of general machine functions but also the interaction and communication with grade control systems and auto steering of the machine.

This paper highlights the importance of automation to achieve higher precision and higher production to positively impact every step in the process resulting in a more efficient operation.
The machines log performance metrics that are both available on the machine for the operator or supervisor to see as well as in the office through telemetric communication.
Building on these technologies Vermeer has developed an innovative new surface mining attachment that combines benefits from the current designs in a way that is new to the industry.

Keeping operator safety and comfort in high regard there are several enhancements to the T1255III tractor that have been adopted after proving their value from other machines in the product line.
Vermeer has realized that simply building a strong machine is only part of the process needed to successfully apply machines in applications.
An in house rock lab was developed to test rock samples from all over the world. Correlating results that are witnessed in the rock lab with real world production values has allowed them further understand both the machines but also the entire process.

In this paper we will explain a real world example from collecting the samples to cutting product in the field.

ROCK HAWG, INNOVATIVE WAY TO SURFACE MINING

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The Rock Hawg combines new technologies and working methodologies to excavate in a cost-effective way strong and unfractured rock substituting and avoiding the use of explosive.

The latest innovations introduced by Tesmec in the last two years allow the increase of productivity and the worksite efficiency according to customer's requirements.
This is due to the combination of two different cutting options, up cutting and down cutting, just in a single Rock Hawg solution.
Thanks to this innovation there is the possibility to leave the excavated material on the ground or to stockpile/load it on truck.

The working methodology "up-cutting version" is suitable for unfractured rock mass, tough (not fracturable) rock and from medium strong up to very strong rock.
This cutting methodology, which is the modification of the machine including the inversion of the drum rotation from its traditional sense and the addition of a transversal conveyor, leaves a clean and flat surface and the area can be immediately re-cut, without any preparation.

Another innovation is the significant reduction of teeth consumption thanks to the low cutting speed mode, developed to reduce the chain speed and increase the chain pull for digging very strong, even abrasive rocks.
This cost saving is also due to the development of high performance teeth which incorporate a poly-crystalline-diamond composite material, allowing more productivity thanks to the teeth's increased hardness and durability.

Furthermore, the Rock Haws has technological instruments aboard which allow:

- automatic digging and self-diagnostic to improve ease of use of the trencher, increase productivity and make it less dependent on operator skills;
- satellite automatic guidance, that automatically controls machine alignment and digging depth;
- remote monitoring and reporting activity to help improving each machine's bottom-line performance.

WHY AUTOMATE A BLASTHOLE DRILLING RIG FOR YOUR MINING OPERATION

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Reluctance and fear is a common reaction when discussing automating drilling operations that have predominantly always required human interaction.

So what are the reasons that large mining houses are opening up their minds to enabling drill automation?
We could summarize these reasons within three major aspects being a focus on Safety, a will to increase productivity, and finally be an actor in a major change in the way we do things in a very traditional industry.

We are going to take you through the journey of the features making Drilling Automation a reality around the world, but we will also see that we are only at the beginning of this journey given the tremendous opportunities automation offers.

SUSTAINABILITY OF PHOSPHATE AND POTASH RESERVES IN JORDAN

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The purpose of the paper is to estimate the level of necessary reinvestment 'user costs' needed to repay forthcoming generations for the depletion of phosphate and potash reserves in Jordan.

El Serafy equation technique has been used to estimate the user cost for both resources from 2002 to 2010.
On a discount rate of three percent, phosphate resources had a user cost of $US 0.99 million in 2002, $US 0.86 million in 2005 and $US 0.09 million in 2010.
Also on a discount rate of three percent, potash resources had a user cost of $US 10.13 million in 2002, $US 41.39 million in 2005 and $US 92.07 million in 2010.

The Sustainable Budget Index (SBI), used to measure whether the user cost was reinvested or used for public consumption, surpassed 1.0 from 2002 to 2010 which indicated that mineral revenues have been used for public consumption rather than for investment purposes.

Key words: Jordan, phosphate, potash, sustainable, user cost, discount rate, investment.

FERTILIZER USE AND FOOD SECURITY CHALLENGES IN MOROCCO

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Fertilizer use rates in Morocco are low with about 52 kg (N+P2O5+K2O).ha-1. This leads to limited crop yields, especially for wheat which is the main consumed commodity in Morocco and large quantities are imported.
This causes also a continuous soil fertility depletion resulting from nutrients removed by crops being above the nutrients rates applied by farmers.

The present work shows that there is a potential wheat yield increase from the current 1.3 T.ha-1 to 3.2 T.ha-1 if crop best management practices are adopted by the farmers, which include an increase of crop nutrients rates from the current 50.5 kg (N+P2O5+K2O).ha-1to 145.5 kg (N+P2O5+K2O).ha-1.

The main reasons behind the current limited fertilizer use in Morocco are the high fertilizer costs compared to crop price, inefficient extension services, and low use of soil testing for accurate fertilizer recommendations despite the 50% soil testing subsidy offered by the Ministry of Agriculture and Fisheries to the farmers.

In order to increase fertilizer use rates, measures are being taken. This paper presents these measures and how they are implemented. They include more efficient crop best management practices extension activities, soil testing extension, production and extension of new regional fertilizer formulations more adapted to soil fertility status and climate conditions, and weather-indexed insurance incentives in order to reduce the risk of weather-induced production variability and foster fertilizer use by farmers.

A COMPARATIVE ASSESSMENT OF PHOSPHORUS USE EFFICIENCY IN THE CROP PRODUCTION SYSTEM OF DIFFERENT COUNTRIES: A SUBSTANCE FLOW ANALYSIS PERSPECTIVE

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Sustainable management of phosphorus (P) is crucial for global food security and the environment. In order to formulate effective policy and strategic decisions for sustainable global P management, it is critical to understand the nature and magnitude of P flow in various systems at different geographical scales.
A number of substance flow analyses (SFAs) of P have been performed in many countries in recent years. Although available SFAs generally consider various systems of P flow associated with the P cycle, the initial review of these analyses revealed that the majority of P flow in a country is associated with the crop production system and therefore, this system requires special emphasis in terms of securing global P sustainability.
Thus far, we are unaware of any comparative assessment of phosphorus use efficiency (PUE) in the crop production system of different countries, however, such understanding is essential for making effective decisions towards the sustainable management of the global P resource.
Based on a systematic review of 18 recent national scale SFAs of P, this study presents a comparative picture of PUE (the fraction total P input that is harvested in crop products) in the crop production system of different countries.
The review indicates that nearly 90% of the annual total P inflow in the crop production system occurs through mineral fertilizers and animal manure, where mineral fertilizers accounted for nearly 60-90% of the total inflow in 10 out of 18 analyses; while animal manure accounted for around 50-80% in the remaining studies.
The review also reveals that the majority of the total P outflow in the crop production systems occurs as crop/plant products that accounted for more than 80% of the total outflow in nearly 90% of the reviewed studies, while a substantial proportion of the total P outflow also occurs as erosion, runoff, and/or leaching.
In case of more than half of the reviewed studies, less than 30% of the annual total P inflow was eventually stored in soils. The assessment of the PUE in the crop production systems of different countries indicates that in 12 out of 18 studies, PUE ranged from 56-84% (of which six studies showed around 80% PUE), while in the remaining studies, PUE was less than 50%. Of all countries around the world, a high PUE (approximately 70-80%) was observed in case of nearly all of the European countries, interestingly, P input as animal manure was found substantially higher than P input as mineral fertilizers for these countries. Given that the European countries lacking domestic phosphate rock reserves, probably, more emphasis has been given on the sustainable management of P in these countries. This study concludes that there is still significant scope for improving PUE in the crop production systems of many countries, and appropriate policy and management interventions for sustainable P management are required for countries particularly those have been identified with low PUE in this review.

NOVEL RAPESEED GERMPLASM AND ALTERNATIVE OILSEED CROPS TO COPE WITH CLIMATE CHANGE AND IMPROVE EDIBLE OIL'S FOOD SECURITY IN MOROCCO

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Morocco is suffering a food security problem in edible oils. The overall national production, including olive and oilseed crops, does not exceed 20% of the needs. The gap is covered by importation which has negative repercussion on the national economy and food security. Oilseed crops yield will further decrease in the future as was demonstrated by a Worldbank study on effect of climate change on agricultural production in Morocco.
Nowadays, there is a political will to promote and develop oilseed crops to improve the farmers' income and to ensure edible oil food security by increasing national oilseed production. The government and the oilseed interprofessional federation co-signed in 2013 a program contract to develop this sector as envisaged by the Moroccan agricultural strategy 'Green Morocco Plan'.
In this context, The INRA, as public research institution, is committed to play a role through adaptive and prospective research strategy, including genetic approach. Actually, agriculture constraints, mainly climate change occurring in Morocco, will aggravate drought and heat stress in the future. Therefore, farmers need to cultivate adapted sunflower and rapeseed varieties as well as alternative crops that are more resistant/tolerant to these abiotic stresses. Diversification and development of adapted and resilient oilseed crops and the adoption of a wide range of cultivars are of paramount importance to cope with climate change and to enhance food security.
Regarding the crops already cultivated in Morocco, foreign germplasm introductions as well as mutagenesis breeding program were carried out for rapeseed to broaden the existing genetic variability. As a result, novel promising germplasms were obtained and selected. These showed a significant genetic gain, compared to the existing varieties, under contrasted environmental conditions, mainly for phenological and agronomic traits, i.e. flowering earliness and seed yield.
Besides, other crops such as safflower, Indian mustard and Ethiopian mustard were introduced as alternative oilseed crops being more drought and heat tolerant than sunflower and rapeseed. They will be useful and beneficial in environments cropping system where cereals are generally grown in monoculture or in rotation with fallow, mainly in semiarid areas. The first field trials showed their good adaptation to our local environmental conditions.
The main results obtained for both strategies are presented and discussed.

NUTRIENT MANAGEMENT FOR SUSTAINABLE AGRICULTURE DEVELOPMENT: USE OF REACTIVE MOROCCAN ROCK PHOSPHATE

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Acid soil in tropics region is amounted to 1.7 billion hectares or about one third of the total
(Sanchez and Logan, 1992). Soil in tropics region is often affiliated with highly weathered soil due to its characteristics. Declining of soil pH, decreasing of nutrient supply to plant, at the same time transforming aluminium and few of micronutrient into more soluble and become toxic to the plant, these are the common problem that occurred in highly weathered soil. Upland tropical soil is dominated by Ultisols and Oxisols which are deficient in phosphorus, an essential macronutrient in all biological organism. Other problem in this type of soil is phosphorus availability, where precipitation and adsorption by aluminium (Al) and iron (Fe) oxides decrease the availability of phosphorus.
In the previous study, it was clearly shown that application of Moroccan reactive phosphate rock (RPR) combined with manure in acid soils improved maize yield and soil fertility. In order to evaluate the potential of direct application of Moroccan RPR for maize and oil palm growth, OCP S.A has conducted a long-run collaboration research with IAARD – Ministry of Agriculture- Indonesia. The maize trials are located in farmer field in Pleihari, South Kalimantan Provinces and at experimental station of IAARD in Taman Bogo, Lampung Provinces (Sumatra).
The on-farm trial site for oil palm are conducted at oil palm plantation in Pelalawan, Riau Province (Sumatra) and Tanah Laut, South Kalimantan Province.
The result showed that application of 0.75-1 ton/ha of RPR combined with 2 ton/ha of manure increased both maize yield in Taman Bogo and Pleihari .The average yield was 8-9 ton/ha
constantly for 5 planting season in Taman Bogo. While in Pleihari site, the yield ranged from 10-12 ton/ha constantly for 4 planting season.
The result indicated that residual effect of RPR can last for 4 to 5 planting season.
Application of RPR also increased yield of oil palm in Riau and South Kalimantan Province
sites. One time of RPR application which equal to Phosphorus fertilizer rate through broadcast system resulted in high yield as much as 32 ton/ha/year compared with other treatment. According to the response curve of yield on RPR application, the best recommendation rate of RPR is between 1.25 and 1.5 of times phosphorus fertilizer recommendation rate which is equal to 4.78-5.74 kg/tree/year for 8 years old oil palm in Riau site and 2.18-2.56 kg/tree/year for 2.5 years old oil palm in South Kalimantan site.
Recommendation of nutrient management to improve the productivity of upland acid soils
are liming, organic matter, applying Moroccan RPR, site specific recommendation of N and K
fertilizer, and also using the plant-tolerant variety. In this case, Moroccan RPR can be used tosubstitute other phosphate fertilizer commonly used.
The advantage of using RPR is its effect both in supplying P and long term residual effect that increases efficient use of this slow release P fertilizer.

ENHANCING EFFICIENCY OF TRADITIONAL P FERTILIZERS

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Application of the traditional P fertilizers relates to low efficiency and high risk of environmental pollution.
On sandy and loam-sandy soils, 60 to 80% of P applied can be leached into natural water resulting in negative impacts on farmer's economy and environmental quality.

In alkaline soils high in Ca, P fixation leads to reduced efficiency of P fertilization by 50 to 80%. The necessity of increased fertilizer application rates results in exacerbating environmental pollution.

A series of field tests with P fertilizers and Si-rich substances was conducted on various crops (banana, barley, corn, potatoes, sugarcane, rice and others) under different soil-climatic conditions (Australia, China, Russia, and USA).

The P status in the soil-plant system was evaluated, including leachable P in sandy soil, as influenced by the plant-available soil Si. The data obtained evidences that combined application of Si and P materials promotes reduced P leaching in sandy soils by 60 to 90% as compared with application of P alone.
The sorbed P was kept in the plant-available forms.
In the soils with a medium-to-strong P fixation capacity, Si-rich substances promoted converting plant-unavailable P (□a-P, Al-P and Fe-P forms) into plant-available forms.

The mechanisms of the Si-P interactions were assumed and investigated in different soils. Several active Si compound-based technologies for enhancing the P fertilizer use efficiency were elaborated and tested. These technologies can be adapted for different types of P fertilizers and soil-climatic conditions.

SOIL FERTILITY MAPPING AND FERTILIZER RECOMMENDATION IN COCOA BELT OF CÔTE D'IVOIRE

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Côte d'Ivoire has been the world's leading producer of cocoa since the 1970s, with an estimated production of 1796 000 t in the 2014/2015 campaign. This speculation is both political and strategic for Côte d'Ivoire. Cocoa provides 40% of total export earnings and contributes 15% to national GDP.

The most widely used cocoa growing system is an extensive and itinerant system on forest clearing, characterized by low fertilizer use. In this mode of cultivation, nutrients exported through harvesting are therefore not compensated by adequate fertilization. Today, due to the lack of availability of forest land, this mode of cultivation is no longer reproducible. In addition, soil fertility has declined.

However, due to the importance of the cocoa for the country, fertilization seems the only option to ensure its sustainability. To do this, a diagnostic soil was conducted as part of the fertilizer initiative to assess the current level of soil fertility in order to adapt fertilization. The study was carried out on the basis of soil units. Thus, 580 geo-referenced composite soil samples were taken from the main soil units throughout the cocoa belt in Côte d'Ivoire.
These samples were analyzed through a wet chemistry methods. The analyzes concerned pH, organic carbon content, nitrogen, available phosphorus, cation exchange capacity, base saturation rate and exchangeable bases.

The analytical results were compared with the thresholds and ratios defined for cocoa farming in order to assess the level of soil fertility. The data show that 82% of the soils are poor in N, 57% in C, 81% in P, 34% in K, 61% in Ca, 37% in Mg and 27 in the soils are acidic. Then the soil diagnostic tool was used to calculate the nutrient requirements to achieve a yield of one tonne of market cocoa and to correct soil mineral deficiencies.
From these needs and taking into account the pH of the soil, 6 hypothesis of fertilizer formulas were proposed by the research of which two contain nitrogen.

Finally, the GIS software (QGIS), was used to establish the fertilizer recommendations maps per soil unit. However, these formulas will have to be tested to confirm their effectiveness and evaluate their economic profitability.

Keywords: Soil fertility, recommendation of suitable fertilizers, Côte d'Ivoire.

CONTRIBUTING TO SOLUTIONS FOR MALNUTRITION THROUGH FERTILIZERS

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Malnutrition – also known as hidden hunger – is a major public health problem in many countries in Sub Saharan Africa. Interventions such as supplementation and food fortification have limited reach in rural populations.

Fertilizer use has broader reach in these areas and could serve as a vehicle for supplying micronutrients not just to crops but also to the human population that consumes them. This presentation highlights the research we have carried out in Ethiopia using zinc containing fertilizers on cereal crops to determine their impact on yield and grain zinc content.

Studies were conducted on maize in controlled settings on research stations, and on farmers' fields on wheat, barley and teff. All studies were conducted on zinc deficient soils. Findings to date indicate that fertilizers containing zinc increase grain zinc content by 15-30%.

Results suggest that it is possible to complement efforts to address human malnutrition through the use of micronutrient containing fertilizers. Effects of Zinc and boron applications on maize were investigated in Kenya an other countries and iron and Zn containing fertilizers applied to irrigated and lowland rice showed significant effects on rice yield effects of these micronutrients on grain content and possible human health are under investigation.fertilizer use efficiency were elaborated and tested. These technologies can be adapted for different types of P fertilizers and soil-climatic conditions.

CIRCULAR ECONOMY – CHALLENGES AND OPPORTUNITIES FOR PHOSPHORUS RECOVERY & RECYCLING FROM WASTES IN EUROPE

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Circular economy for nutrients! How to transfer buzz words into solid results?
So far the potential to recover and recycle phosphorus remains untapped or is just inefficiently used as in the case of sewage sludge, manure and food waste.

To provide alternatives to argued traditional nutrient recycling routes, various technical solutions have been developed in recent years (www.p-rex.eu). They allow recovery of phosphorus minerals suitable as raw material for industries like fertilizer production or even as ready-to-use renewable or next generation fertilizer.

This contribution provides an overview of promising and implemented technologies for phosphorus recovery from waste streams. It discusses aspects regarding their wide-spread application and limitations in the context of environmental but also economic impacts and the legal framework.

The current revision of the European fertilizer regulation within the European Commission's circular economy package provides a concrete example, what issues have to be coped with and what measures have to be taken to create a level playing field for both, primary and secondary based materials destined for fertilizer use.
Some EU Member States have started to enforce phosphorus recovery from relevant wastes, but are lagging behind in enabling recycling.

Still, the so-called technical nutrient recovery is missing a demand-side driven market pull for recovered (secondary) nutrients and the biggest challenge will be bridging the gap between supply (recovery) and demand (recycling).
Whereas in the past, the focus of nutrient recovery technologies was laid upon high recovery rates for single nutrients, now energy efficiency, synergies and cost become more and more important.

What about value chains? We have to look for easy to implement, rather integrative solutions instead of reinventing the wheel, creating fancy parallel (infra)-structures.
There is a lot of know-how already waiting to be shared with huge potential to be creatively transformed into innovation. Think forward, act circular!

INDUSTRY INITIATIVES ENHANCING PHOSPHORUS SUSTAINABILITY

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The last few years have witnessed widespread worldwide attention to issues associated with phosphorus. Both its impact on the environment and humanity's dependence on its finite sources are alarming many. Agricultural producers are now expected to manage phosphorus for both crops and environment.

In the Lake Erie watershed, a 4R Nutrient Stewardship program has been implemented to address a recent resurgence of re-eutrophication—an increasing trend in harmful algal blooms over the past 15 years, concomitant with an increasing trend in dissolved phosphorus loads and concentration in the tributaries draining productive agricultural cropland.

Though partnering of industry associations and collaborations beyond the fertilizer industry, the 4R approach has succeeded in gaining recognition of the industry's support for and adoption of best management practices, and in the formation of a strategy for research towards improving the industry's ability to report its sustainability performance through credible metrics.

This presentation will review the establishment of the Lake Erie 4R Certification program and the International Plant Nutrition Institute's current efforts to apply 4R Nutrient Stewardship to the management of phosphorus in agriculture globally.

MINING, PROCESSING AND USING PHOSPHATES IN A CIRCULAR ECONOMY

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The European Commission adopted an ambitious Circular Economy Package, which includes revised legislative proposals on waste to stimulate Europe's transition towards a circular economy. A boost for global competitiveness, sustainable economic growth and new jobs generation is expected as a result of the initiative. Among other factors, the Circular Economy is motivated by the overuse of natural resources: we have transgressed the safe operating space for biodiversity, nitrogen and phosphorus use and we are in a zone of uncertainty for land-system and climate change. Agriculture is a key influencing factor for virtually all of the anthropogenic activities considered as non-sustainable in the context of planetary boundaries. Accessibility to and use of fertilizers are a key influencing factor for crop yield and the ability to feed a global population expected to reach 9.7 million by 2050. According to FAO (2016), population growth and changing diets require 50% more proteins, 82% more dairy products and 100% more meat involving an increase of agricultural output hardly conceivable in a world threatened by soil degradation, soil sealing by Megacities and their infrastructure and climate change.

In the light of these challenges it is clear that we must decouple growth from material use, produce more with less and avoid waste. No wonder that the European Commission has set ambitious targets for municipal waste recycling – 65% by 2030 – and proposed a new fertilizer regulation stipulating new rules and equal footing for organic and waste based fertilizers. The European phosphate industry has started integrating recycled materials into their process chains and may gradually replace phosphate rock based supplies by – mainly inorganic – recycled materials such as struvite and selected ashes.

Apart from substituting virgin raw materials by recycled ones that may not be the best option for OCP and other non-European supplies, at least in the short term, material and energy use efficiency can be the target. It seems to be obvious and on the agenda for quite some time but evaluations of customers' practices show that efficiencies and waste management have large room for improvement. In particular in periods of low raw materials and energy prices, incentives for process assessment and monitoring are largely missing. However, precisely in times like these with possibly low use of assets and human resources, a review assessment of the process chain is highly recommended. Outotec's approach and tools for achieving a higher material efficiency, a lower environmental footprint and improved returns will be demonstrated in the SYMPHOS 2017 presentation.

PROGRESS AND TRENDS IN THE UTILIZATION OF PHOSPHATE-BASED MATERIALS IN ENERGY AND ENVIRONMENTAL FIELDS

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Among the update and current challenges, the clean production of energy is of concern. Regardless the feedstock used to produce energy (coal, biomass, wastes residues) it is admitted that an effort still need to be put on the removal of pollutants such as H2S, HCl, NH3 and heavy metals from various industrial gases, and in investigating their impact on environmental pollution and health.
This comes also with another challenging issue of the development of efficient materials acting as sorbent and catalyst for the removal of the targeted pollutants.

In this paper we will summarize 15 years of research in collaboration with leading universities worldwide and with major industrial players dealing with the use of phosphate materials for catalysis and sorption for polluted gas treatment [1, 2, 3].

The paper will also highlight the multiscale chemical, physical and thermal characterization approaches and techniques used to better understand the behavior of phosphate materials during their synthesis and processing.
New applications dealing with the development of phosphate-based materials for energy storage will also be presented.

[1] B. Rego de Vasconcelos, L. Zhao, P. Sharrock, A. Nzihou, D. Pham Minh, Catalytic transformation of carbon dioxide and methane into syngas over ruthenium and platinum supported hydroxyapatites, Applied Surface Science 390 (2016) 141–156.

[2] A. Nzihou, P. Sharrock. Role of Phosphate in the Remediation and Reuse of Heavy Metal Polluted Wastes and Sites. Waste and Biomass Valorization, 2010, 1, (1):163-174.

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SOLAR SLUDGE DRYING DEMONSTRATION PLANT

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Drying of phosphate sludge opens possibilities to use the sludge in the construction industry or at least to significantly reduce the land used for disposal through stacking. Commercial dryers normally use fuels like natural gas or light heating oil to achieve flue gas temperatures in the range of 750°C.

In sunny regions, solar tower systems can provide hot air in the same temperature range, in a cost-effective and environmentally benign way.
Several technology approaches will be presented. Details will be given for a modular solar tower system with particles as heat transfer medium.
The proposed demonstration plant is based on an existing 2.5MWth particle receiver.
A heliostat field with 519 heliostats à 8 m2 mirror area is used to reflect the sunlight to the receiver on a 45 m tower. Together with 15h of thermal storage and a particle-to-air heat exchanger the dryer can be provided with 800kWth for 24h/day.

With this energy 5t/h of sludge can be dried. Total investment costs for the demonstration plant are estimated as 5.6 M€.
To increase the capacity after a successful demonstration further modules compromising receiver, heliostats and tower can be added. If required, the hot particles can also be transported up to several km between the solar plant and the dryer unit.

NEW CONCEPTUAL DESIGN OF AN ENERGY STORAGE AND RECOVERY UNIT

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The intermittent nature of renewable energy sources is a key challenge to their integration into the electricity grid. The aim of this work is to introduce an advanced concept of Power-to-Gas (PtG) plant, which is designed to bring a closed-loop solution able to absorb electricity surplus and to restore it later, via the transient storage of energy carriers.

Thus, this unit introduces an innovative way for renewable energy uses.
This study proposes a steady state model used to assess process flowsheets as well as operating conditions of the industrial scale plant.
The unit consists of three main processes. Electricity surplus is firstly fed to a low temperature Proton Exchange Membrane Electrolyzer (PEM) to produce hydrogen and oxygen.
The produced hydrogen is then combined to CO2 in a methanation process using Sabatier reactors hence generating Substitute Natural Gas (SNG) and heat. Both oxygen and SNG are stored in underground caverns ready to be burned in the Oxycombustion process.

The modelling results indicate that during the storage phase, a 200 MW power supply from the electrolysis process leads to a corresponding 155 MW of SNG produced in the methanation process with an overall efficiency of 83%. A flow rate of 14400 Nm3/h of stored SNG is burned in pure oxygen during the recovery phase producing up to 480 MW electric power with an efficiency of 49% as well as CO2 rich flue gas easily captured and reused in SNG production.

Thus, this new concept, called EMO unit (Electrolysis-Methanation-Oxycombustion), addresses two major concerns of the usual PtG storage and recovery systems which are the CO2 massive supply requirement for methanation process and CO2 release into the atmosphere after SNG combustion in air.

THERMAL ENERGY STORAGE USING LITHIUM, SODIUM AND POTASSIUM POLYPHOSPHATES

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Up-to-date, molten salts (nitrate-based salts) are the main materials for sensible heat storage at industrial scale. The working temperature range of these materials is limited below 500 °C to avoid the thermal decomposition. There is not yet a solution for sensible heat storage at higher temperature.

This work aimed to investigate alkali polyphosphates ((MPO3)n, with M = Li, Na or K) as new promising materials for sensible heat storage at high temperature.
Alkali polyphosphates could be formed by dehydration of monoalkali dihydrogenphosphates (MH2PO4, with M = Li, Na or K), which took place below 400 °C.

Monoalkali polyphosphates resulted from this dehydration melted above 600°C.
All these liquids evaporated above 900 °C but no destruction of their chemical structure was recorded. Thus, sodium polyphosphate can be used as media for sensible heat storage at high temperatures.

Mixtures of two alkali metals (binary systems: Li-Na-PO3, Na-K-PO3, or Na-K-PO3) or three alkali metals (ternary system: Li-Na-K-PO3) were also studied.
The control of their composition was found to be efficient for reducing their melting point.

This work highlighted the potential application of alkali polyphosphates as new material for sensible heat storage at high temperature because of its large working temperature range.
The results obtained open new prospects for the development in the thermal energy storage field.

BIOFORMULATION OF MICROBIAL FERTILIZER BASED ON CLAY AND ALGINATE ENCAPLUATION

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The aim of this study was to develop new formulations of the microbial fertilizer Pseudomonas fluorescens Ms-01 and Azosprillum brasilense DSM1680 based on the Moroccan clay. two formulations were studied based on the Halloysite + Alginate and montmorillonite + Alginate material.
The two formulations were compared to the alginate taking as control and were applied to the bacterial strains to develop efficient slow-release biofertilizer.

The microcapsules produced were spherical in shape and were chemically and physically characterized and further analyzed for their Swelling ratios, soil Biodegradability, release kinetics of microbial cells and their survival stability over 3 months storage under different conditions (Ambient Temperature vs 4°C storage).
The effect of the microcapsules on the growth of wheat plants was also investigated.

Results showed that both formulations were able to preserve bacterial survival which reached 7,14 LogCFU.g-1 after 3 months storage in the Halloysite formulation.
The swelling ratios were ranged between 61,5±1,35 and 36,5±5% for the montmorillonite and the Halloysite formulations respectively.
The release kinetics revealed the slow release capacity of the microcapsules mainly with the Halloysite formulation which significantly released bacterial cells after 15j incubation in saline water (6,43 LogCFU.ml-1).
The application of the microcapsules in wheat plants increased significantly root and shoot biomasses and nitrogen content on the roots.

In conclusion, the formulation of microbial biofertilizer in clay and alginate increased their survival under long term storage and allow their slow release in soil which significantly improved plant growth.

Keywords: Biofertilizer, Halloysite, montmorillonite, Slow-release, plant growth

LEGUME-RHIZOBIA SYMBIOSIS ENHANCES PHOSPHORUS FERTILIZERS USE EFFICIENCY IN SOIL UNDER FIELD CONDITIONS

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Phosphorus (P) fertilizers were applied to soil for crops yield improvement.
Meanwhile, an important part of applied P to soil is quickly fixed as insoluble forms just after application and thus the fertilizers efficiency is reduced.
To remobilize phosphorus forms soil, plants develop processes to increase soil P availability.
The nitrogen fixing Legume-rhizobia symbiosis are able to cope with soil P deficiency by developing some efficient processes increasing soil P availability.
Since biological nitrogen fixation (BNF) by legume-rhizobia symbiosis needs more inorganic P, our investigations are focused on the study of P deficiency effects on this process, the identification of mechanisms involved for remobilization of soil fixed P and its absorption in order to select legume-rhizobia symbiosis with high ability to extract P from soil insoluble forms and its use for high nitrogen fixing performance.
Our studies were carried out on Common bean, Faba bean, alfalfa and chickpea. Our trials were performed in farmers 'fields and greenhouse conditions.
The rhizobia strains were isolated from legume growing areas as Haouz, Chaouia, Tadla and Doukkala. Our results showed that isolated rhizobia strains presented high variations in their abilities to solubilize insoluble P forms and we characterized some strains more performing for BNF and P solubilisation.
Under phosphorus deficiency, legume-rhizobia symbiosis developed biochemical processes to improve its P nutrition particularly those allowing solubilisation of P in the rhizosphere as medium acidification and excretion of phosphatases enzymes.
Beside these mechanisms serving itself, this symbiosis contributes to improve other crops nutrition, when associated in intercropping system.

Thus, we confirmed that growing the selected legume-rhizobia symbiosis could be an efficient tool to enhance phosphorus fertilizers use efficiency by avoiding their accumulation in soil. The more performing rhizobia strains could be involved in a new phosphorus fertilizer formulation to ensure its high use efficiency after fertilization.

MICROALGAE AS BIOSTIMULANT OF PLANT TOLERANCE TO SALT STRESS

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Plant growth and development are adversely affected by salinity, a major environmental stress that limits agricultural production.

The present study investigates the potential of halophilic microalga D. salina exopolysaccharides (EPs) to suppress the inhibition of plant growth caused by salt stress on Solanum lycopersicum cultured in both concentrations of NaCl (3g/L and 6g/L NaCl).

The studied parameters are: plant growth, osmotic adjustment substance, proteins content, lipids profile and ROS scavenging enzymes activities.
Results showed that the decrease of height and dry weight of shoots and roots systems, potassium (K+) and proteins content, caused by salt stress was mitigated after microalgae exopolysaccharides treatment.

On the other hand, the increase of proline, phenolic compounds, Na+ and the antioxidant enzymes (CAT, POD, SOD, APX) activities caused by salt stress was attenuated after exopolysaccharides treatment. GC-MS metabolic analysis showed that EPs treatment allowed the activation and / or inhibition of the various metabolic pathways involved in the pathways of plant tolerance to stresses such as jasmonic acid-dependent pathways and salicylic acid-dependent pathways.

Our study demonstrates that microalgae exopolysaccharides could help plants to tolerate salt stress.

MYCORRHIZAL AND TRICHODERMA HARZANIUM INOCULATION ENHANCE BEAN GROWTH AND PROTECTION AGAINST PHAEOISARIOPSIS GRISEOLA IN SOUTHERN CAMEROONIAN SOIL

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Arbuscular mycorrhizal fungi (AMF) and members of Trichoderma genus colonize and protect plant roots against pathogen infections via different induced defense mechanisms, among other the enhancement of biosynthesis of secondary metabolites and low molecular weight compounds.
We reported here the results from a field study on the influences of simultaneous inoculation of AMF and Trichoderma harzanium on common bean crop grown under the field condition of southern Cameroon. A disease-sensitive and a disease-resistant bean genotypes were sown and harvest at mid-flowering and at maturity stages and analyzed for biomass Dry matter production, root length colonized by AMF and the concentrations of P, N, amino acids and phenolic determined. The disease severity caused by Phaeoisariopsis griseola was further assessed.

The growth of the disease-resistant bean genotype was notably increased following AMF inoculation. The inoculation with co-inoculation with AMF and Trichoderma resulted in remarkably testing effects on plant biomass N and P concentrations, root length colonization by AMF, and the incidence of foliar diseases. The Trichoderma inoculation particularly resulted in increased root length colonization by AMF, N and P concentrations and the foliar diseases incidences.
Significant genotypic variation for the amino acid, proline, and phenol synthesis was noted and bean-resistant genotype resulted in higher concentrations of molecular weight compounds than the sensitive one. The interactions between the Trichoderma and AMF inoculation were noteworthy with regards to N and P accumulation and diseases incidences, respectively.

The overall plant induced mechanisms for the common bean crop to cope with diseases and achieve superior yields are discussed to support breeding program aiming at developing disease-resistant and high yield bean yield under stressing environmental conditions of small-scale farming production systems of Cameroon.

Keywords: Arbuscular mycorrhizal fungi (AMF) – tropical soils - Foliar fungal diseases- Low-phosphorus soils - Trichoderma harzarnium inoculation

PHOSPHATE SLURRY NEUTRALIZATION EXPERIENCE UNDER DIFFERENT CONDITIONS

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Fatima Group was established in 1936 with trading of commodities and gradually entered into the manufacturing of various products. The Group has a success story spread over seven decades, expanding its horizon from trading to manufacturing. Today, the Group is engaged in trading of commodities, manufacturing of fertilizers, textiles, sugar, mining and energy. Over 10,000 people are associated with Fatima Group, in various capacities.

Fatima Group, from its both Pakarab Fertilizers and Fatima Fertilizer plants, produces a wide variety of fertilizers, including urea, calcium ammonium nitrate (CAN), nitro phosphate (NP) to cater for the agronomy of the Country. The combined manufacturing capacity is 2.1 million metric tons per annum, with Urea 592,400MT, CAN 870,000MT and NP 664,500MT per annum.

The paper covers learning from multiple test runs, optimizations and efficiencies improvements carried out in neutralization section of Nitro phosphate plant. There is single stage neutralization in PFL NP plant of Fatima group and considering as the point of improvement three-stage phosphate neutralization was adopted during design phase of new NP plant at FFL complex.

In three-stage neutralization multiple issues were faced; After doing close comparison of operating conditions/parameters with other sister company, test runs of “Double Stage Neutralization” and “Single Stage Neutralization” were carried at new FFL plant as well. Ammonia spargers in these neutralizers were also optimized to improve the efficiencies detail of which is also covered in this paper.

It is expected that paper will be quite interesting and thought-provoking for manufacturers and designers of phosphate fertilizers.

ROLE OF ADDITIVES IN IMPROVING EXTRACTION EFFICIENCY OF PHOSPHORIC ACID MANUFACTURE

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The manufacture of phosphoric acid by the wet process is often characterized as a method devoted to producing the optimum size and shape phosphogypsum crystals.
Releases of large volumes of carbon dioxide and silicon tetra-fluoride gases generate foam that becomes entrained in the gypsum slurry.
Robust antifoams to control foam generated in the digestion of phosphate rock are critical to a safe and cost effective operation since the foam produced reduces the throughput of the process equipment.

Raw materials feed streams occasionally vary and in such cases, the phosphate rock can contain constituents that cause stable bubble formation, excess reactor fuming and entrained gases. Significant foam presence and/or gas entrainment decreases agitation and slurry circulation by lowering pumping efficiencies.

These factors combine to reduce reaction efficiency, capacity and chemical control stability. Additionally, foam overflows can lead to hazardous conditions due to the corrosive properties of phosphoric acid.
This may result in large quantities of incompletely reacted materials foaming into the vapour condensing systems or waste disposal system, causing costly repairs and yield losses.
Sulphate excursions due to poor circulation can impact citrate soluble and insoluble digester losses. Poor crystal formations will reduce filtration rates, thereby reducing operating rate and/or increasing water-soluble P205 losses.

The crystal characteristics determine the speed of filtration that defines the production rate for the plant and the cake-washing efficiency that is one of the more important components contributing to acceptable yields. Controlling and/or modifying the crystals have been a long-time goal of all phosphoric acid producers.

Organic crystals modifiers have also been investigated and while them have never been demonstrated to be cost-effective for the dihydrate process.
Scaling is probably the main problem in phosphoric acid evaporators.

While calcium sulphate has an inverted solubility in most neutral aqueous solutions, its solubility in phosphoric acid is of the normal type.
Therefore, scaling on the heat transfer surfaces does not occur because of inverted solubility, but because of high super saturation.

DH PHOSPHORIC ACID PLANTS REVAMP OPTIONS

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Operating phosphoric Acid plant is subject to revamp and upgrades due to deterioration of main static equipment, which could require a major overhaul or a complete replacement.
DH plants operators can have significant value after operating and optimizing their plants for many years, to upgrade their plants capacity and performance significantly by switching to HH process with the existing foot print. This can be a step change that can exceed 100% of the running capacity at the DH mode.

By allocating the overhaul investment towards upgrading the plant into the HH setup, much of the existing facilities can be utilized to achieve very high capacity increase together with no increase in utility consumption, or even a reduction. In addition to increase acid quality and concentration.

tkIS present its unique solution based on common objective setting with clients, full asset assessment, cost benefit analyses, and turnkey delivery of a revamp-upgrade solution, that will deliver low cost investment combined with high capacity gain at an attractive returns on investment..

HEMI VERSUS DIHYDRATE, WHY HEMI IS OFTEN THE BETTER CHOICE FOR PHOS ACID

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The Hemi process often gets short-changed because its biggest advantages are outside of the reaction and filtration sections. It is essential to consider all effects, including rock grinding, sulfuric acid requirement, evaporation, power co-generation, acid handling, cooling water, gypsum, and DAP. This presentation and paper share technology based on the author's decades of experience with Hemi, Dihydrate, & Hemi-Di phosphoric acid processes.
It is offered to the industry as a tool for:

- Selecting which phos acid process to use for a new venture
- Considering converting from Dihydrate to Hemi or Hemi-Di
- Considering Hemi conversion as a shortcut to expanding capacity of existing facilities

The Hemi process is well known for high product concentration, energy efficiency, and avoiding need to grind phosphate concentrate. This presentation and paper expand on these as well as other crucially important important aspects of the Hemi process. There are huge benefits before and after the reaction and filtrations sections.
Topics include:

- P2O5 recovery – as measured ex filter and downstream
- Sulfuric acid requirement
- Operating stability – in reaction and filtration
- Reduction of evaporation load
- Steam requirement
- Cooling water requirement
- Continuous recovery of P2O5 losses from wet gypsum stacks
- Utilization of gypsum as a co-product – with wet or dry gypsum stack
- By-product recovery – uranium, fluosilicic acid, & rare earths
- Guidelines relating to capital & operating cost predictions

Numerous keys to successful Hemi plant design, start-up and operation will be shared. The author helped many clients consider Hemi, Dihydrate, and Hemi-Di projects for new and modified plants. Dozens of studies ranged from brief evaluations to basic engineering. His first two hemi projects were conversions of Prayon dihydrate phosphoric acid plants to the Hemi process. They achieved guaranteed performance on day 19 and day 2 of their startups, respectively. One may be the world's easiest-to-run phos acid plant. The second consistently achieved 96% P2O5 recovery (ex-filter) – likely the best for any Hemi plant. The author consulted for IJC's Hemi plant in Jordan and managed process design for Ma'aden's large Hemi phos acid complex at Ras al Khair, Saudi Arabia.
The advanced Hemi-Di process will also be described. Guidelines will be presented for predicting capital & operating costs of Hemi projects.

RESEARCH AND DEVELOPMENT OF CLEANER WET PROCESS FOR PHOSPHORIC ACID PRODUCTION WITHOUT WASTE GAS DISCHARGE

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Wet process for phosphoric acid (WPA) has long been recognized effective and profitable in phosphate industry.
While the chemical contents transferred from phosphor ores into phosphoric acid is only near 30% (P2O5). The rest matters, accounting up to 70% of the ore, may bring much trouble to environment if discharged as wastes.
The essential meaning of sustainable resource exploitation must imply full utilizing the values of every element so that avoiding waste discharge consequently, which is the principle followed by our R&D of cleaner WPA without waste gas discharge.
Of the two fluoride-containing gas releasing steps in WPA, phosphor ore decomposition and phosphoric acid concentration, the former is much more critic in fluorine recovery since not only the complex component but also the diluted content as low as 100 ppmv in gas phase especially for dehydrate-WPA process with ambient air as medium for cooling of decomposition reactor.
A close loop, named Condensation plus Concentration Cycle (CCC), was proposed to deal with this challenge.

The innovations of CCC loop include:

1) heat removing from ore decomposition reactor and transferring to phosphoric acid evaporator through natural cycle boiling and condensation of a clean refrigerant working under 75~85°C;

2) full condensing of fluoride-containing vapor from reactor into hydrofluoric acid in a concentration equilibrium with phosphoric acid in the reactor, then partial evaporating through adiabatic flash-evaporation under 40~45°C for production of qualified hydrofluoric acid;

3) CO2 carbonating with phosphogypsum and ammonium to convert CO2 and Ca2+ released from the ore into CaCO3 (raw material for cement), and auxiliary material H2SO4/NH3into(NH4)2SO4(fertilizerforagriculture).

The key technics are being developed under the supporting from NSFC and MOST of China, some of them had been verified and put into commercial operation in a scale of 30 kt(P2O5)/a in the year 2016.

GREEN ACID PURIFICATION WITH A SOLVENT EXTRACTION PROCESS

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Phosphoric acid from leaching, green acid, contains higher level impurities than before because ore qualities are declining.

Impurities in the green acid contain elements like iron, aluminum, fluorine, arsenic and cadmium. To purify green acid from the impurities a solvent extraction process can be used.

In an example case solvent extraction process is connected to a phosphoric acid production process.
Target is to produce from the impure phosphoric acid feed technical grade concentrated acid.

Main process connection and unit processes of the production process are presented.
Feed to the solvent extraction process contains 50 % P2O5. Product acid from the concentrator contains 62 % P2O5. Impurities removed in the solvent extraction process are cadmium, lead, mercury, iron and calcium.

A PHOSPHORIC ACID PROCESS SIMULATOR FOR KNOWLEDGE TRANSFER

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The Phosphoric Acid process requires a high proficiency not only on chemical first principles but also in the understanding of complex phenomena impacting operations (phosphate impurities, foaming, reaction blockage, etc.).

A high-fidelity dynamic process simulator was developed to model process phenomena and their interactions over plant performances. This way, the simulator can be used as a training accelerator for knowledge transfer to operators.

This paper shows all the modeled phenomena and how the simulator is beneficial for operator training. This benefit for the operators leads to a potential improvement of the plant profitability thanks to their faster adaptation on the field and their enhanced skills to detect any process deviation.

PHOSPHORIC ACID PURIFICATION TECHNOLOGY

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KBR Ecoplanning brings unique expertise to Phosphoric Acid Purification (PAP), including the experience to optimize the configuration of the facility to minimize capital and operating expenses.

Purification of green phosphoric acid requires a series of steps determined by the impurities in the raw material and the specification requirements of the finished product. A typical configuration consists of

- Pretreatment (to remove excess sulphate, toxic metals such as arsenic, lead and cadmium, reduction of fluoride, removal of particulate contaminants and organic matter),
- Purification (extraction, scrubbing and stripping), and
- Concentration to specified strength (technical or food grade)

Selection of the right unit operations can have a significant impact on the design and operation of the facility. Proper sequence can also significantly reduce the ongoing operating costs associated with energy and reagent consumption, unit maintenance, and on-stream time.

KBR Ecoplanning Oy has a long, rich history of creating value for our clients, with more than 50 years of service in evaporation and crystallization processes and hundreds of satisfied clients.

Presentation subject is **Phosphoric Acid Purification Technology.**

SIZING FACTORS FOR PHOSPHORIC ACID PLANT DESIGN. IT SEEMS WE HAVE BEEN USING ERRONEOUS SPECIFIC VALUES FOR YEARS

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It has been common practice for years for specialists in phosphoric acid to use values of specific volume and specific filtration rate to define the performance of a phosphate source in terms of reaction and filtration rate.
Values based on these indices have been used to evaluate the comparative performance of phosphate raw materials developed from pilot-plant testing results.
In fact, due to variations in the ratios of various elements these formally used indices do not indicate a real comparison between two specific sources of raw material.
It is proposed that the present indices be maintained to compare future results with past values but that the new values proposed shall be used to interpret in a more rigorous way the effects of efficiency and quality of crystals formed for various phosphate sources.

THE IMPORTANCE OF PHOSPHATE PROCESS OPTIMIZATION FROM MINE TO MARKET

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Phosphate is a non-renewable resource and must be managed accordingly.

Understanding the phosphate industry from beginning to end is the key to unlocking the true potential of phosphate ore to produce superior quality fertilizer sustainably and cost-effectively.

Describing 10 key practices for better rock processing to improve grade and recovery thereby creating a more valuable rock and better feed stock for fertilizer plants, enabling them to produce higher value fertilizer.

Better quality fertilizer in turn delivers greater benefits to farmers, improving crop yields, livestock nutrition and food quality to meet the needs of a growing global population.

Mining chemicals and fertilizer process aids are essential to creating such value throughout the phosphate fertilizer supply chain.

IMPROVED SELECTIVE FLOTATION REAGENTS FOR PHOSPHATE ORE UPGRADE

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The global depletion of easily accessible high-grade phosphate deposits leads to a rising demand for beneficiation technologies in phosphate ore processing, often requiring one or several flotation stages.

Both direct apatite flotation (e.g. from igneous ores) and inverse carbonate flotation typically use fatty acid based collector systems modified with additives, typically anionic or nonionic surfactants, to improve selectivity and recovery.
Especially in inverse carbonate flotation, the effect of a secondary collector/modifier on flotation performance is critical due to the low solubility and limited self-emulsification ability of fatty acids at low pH – which in turn is required to achieve selectivity between carbonates and apatite.

A common class of high performance flotation additives for phosphate beneficiation are alkyl phenol ethoxylates (APEOs), powerful emulsifying additives with a hazardous environmental profile whose application is restricted or banned in many jurisdictions.
The hydrophilic-lipophilic balance (HLB) characterizing these additives has a massive impact on both the collector adsorption selectivity and on froth properties, ultimately affecting the flotation kinetics.

The following paper demonstrates how the precise control of the HLB value of the collector system using an environmentally friendly APEO-free additive system can lead to improved flotation plant performance in both igneous and sedimentary phosphate ores, combining enhanced metallurgical characteristics with a reduction in reagent cost.

INCREASING RECOVERY IN REVERSE FLOTATION – EXPLORING THE BENEFITS OF A NEW FLOTATION REAGENT

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The effects of a new reagent for the phosphate industry reverse flotation process were examined in the laboratory. Reagents including collectors and depressants have been widely studied for the flotation of gangue from phosphate containing minerals (apatite).
Nalco Water has studied the performance of a new reagent which helps to depress the apatite and improve the efficacy of flotation separation.

Laboratory test work was conducted in accord with statistical design of experiments to study the effects of phosphoric acid depressant and the new reagent on concentrate grade and recovery from reverse flotation. Experimental results indicate that the addition of this new reagent can increase phosphate recovery by as much as 3% with no decline in concentrate grade.
Additionally, application of this new reagent decreases the need for phosphoric acid, used as a depressant, by as much as 50%.

The relationships between the flotation reagents and how changes in dose ratio affect recovery and grade are detailed herein. These relationships were then used to create several business scenarios that highlight the potential benefits to the phosphate industry.
This Nalco Water reagent provides a new tool which can be used to maximize recovery and increase profitability.

MAJOR ENVIRONMENTAL PROJECTS LAUNCHED IN OCP'S MINING SITES

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The OCP Group's environmental policy is a key part of its DNA. In fact, we believe that in order to achieve our ambitious goal of being world leader in the phosphate industry through the three main pillars: Cost leadership, capacity boost and flexibility, we must above all adopt a strong and solid sustainable development strategy. That's what we've been doing and excelling in for the last few years. In this work, we will present the main environmental projects that OCP launched in its various mining sites.

Keywords: Environment, slurry pipeline, land reclamation, fuel consumption, electrical consumption, waste water reuse, solar energy, wind energy, waste management, track treatment,OCP.

THE MECHANISM OF APATITE/CARBONATES SEPARATION IN ACIDIC FLOTATION PROCESS OF CALCEOURS PHOSPHATE ORES

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The depletion of easy to benefeciate sedimentary siliceous phosphate ores attracts more attention to solve the problems associated to the rotation of calcareous phosphate ores which require further research work.
Beneficiation of carbonate phosphate ores is a world wide problem and unique adequate technology for processing all type of such ores on an industrial scale does not exist at presnet.

The difficulties encountered have been attributed to the similarities in the surface-chemical and electrokinetic properties of carbonate gangue (calcite, dolomite) and phosphate. Various processes have been developed in order to perform froth flotation on igneous phosphate ores but, according to some references, no viable solution has been found for the moment.
The acidic flotation process of carbonates at pH 4.5-5.0 followed by a direct phosphate flotation uses phosphoric acid as depressor of apatite during carbonate flotation.
The mechanism of apatite depression is rather hypothetical because of lack of data on the surface speciation in such a complex mineral suspension.

A real-time method for in-situ and ex-situ control of surface compounds on the minerals using a submerged Raman analyzer probe is proposed in this work to collect the data on the nature and kinetics of phase formed. The infrared spectroscopies, X-ray diffraction and scanning electron microscopy have been used to identify and monitor the species formed on apatite and calcite surfaces as a function of phosphoric acid contact time and concentration.

The stability of calcium phosphate compounds on the surface of calcite and apatite is dependent on the initial acid concentration and pH values. Preferential fatty acid collector adsorption on the carbonates is attributed to the differential kinetics of hydrophilic calcium phosphates formation on the mineral surfaces. An experimental flotation study showed the reverse anionic flotation as best efficient route to process the high carbonated phosphate.

BASIC RECOMMENDATIONS FOR THE SUSTAINABLE USE OF PRIMARY AND SECONDARY SOURCES OF PHOSPHORUS IN POLAND

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According to the European Union (EU) legislation, phosphorus (P) is indicated as a critical raw material (CRM). Due to the risks of a shortage of supply and its impact on the economy, which is greater than other raw materials, the proper management of phosphorus resources is required in order to achieve global P security.

In Poland, the risk of insufficient amounts of P is associated with the fact that there is currently no production of phosphates and the demand for phosphorus-bearing raw materials is met entirely from imports, consisting primarily of phosphate concentrates.
In order to reduce Poland's dependence on phosphate imports, the development and further implementation of a sustainable strategy and of method for recycling and conserving P used in society is required.

One of the potential secondary P resources is waste, eg. sewage sludge ash (SSA) generated in incineration plants (approx. 43,000 Mg/year). However, SSA disposal practices are unsatisfactory – mainly it is stored together with other waste. It is necessary to emphasise that only selectively stored SSA can be made available for the P-recovery.

Investment projects need to be considered which are designed to construct installations for the recovery of P from SSA, taking into account technological, environmental and economic considerations. It should be pointed out that Polish investors who decide to promote innovative projects for the proper management of SSA could receive financial support from the EU under the Research and Innovation Programme (Horizon 2020) and its instruments.

Moreover, the creation of database focused on collection and sharing the data about P amount recovered in Polish installations is indicated as a helpful tool in development of an efficient P management model for Poland.

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PROCESSING PHOSPHATE ROCK FROM NORTH AFRICA WITH ARRMAZ CARBONATE COLLECTORS

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It has been estimated that there is more phosphate reserves associated with carbonate minerals than with silica worldwide.
It is well known that separation of carbonate from phosphate is more difficult than separating phosphate from siliceous gangues because phosphate and carbonate contain same or similar earth cations which leads them to exhibit similar surface behavior in flotation process.

In recent years, ArrMaz has made great efforts in the development of carbonate flotation collectors with significant success.
A series of carbonate flotation collectors have been developed for carbonated phosphate ores.
Extensive studies have been conducted in processing carbonated phosphate ores from various origin such as Asia, North America, Middle East, Africa, etc.

This paper will present a few examples of using ArrMaz collectors to process carbonated phosphate ores from North Africa.

LATEST DEVELOPMENTS AND EXPERIENCES ON THE BENEFICIATION OF ROCK PHOSPHATES USING X-RAY SORTING MACHINES

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The phosphate world is looking at Ma'aden's Saudi Arabian phosphate project Wa'ad Al Shamal. These days it is put into operation. The whole beneficiation plant is designed for 13.5 million tons of raw material per year and built by Chinese HQC (Huanqiu Contracting & Engineering Corporation).

TOMRA Sorting Mining was awarded a key component of this beneficiation plant: the dry pre-processing of the run-of-mine (ROM) ore using XRT (X-ray transmission) technology.

The XRT-technology enables materials to be recognized and separated based on their average specific atomic density. This makes it possible to obtain a high purity level in sorted materials irrespectively of size, moisture or contamination.

Once at full operation the TOMRA Sorting machines will sort up to 70 per cent of the ROM material by removing the chert from the phosphate in order to reduce the silicon content considerably.
The removal of the unwanted chert waste allows it to reduce the downstream process significantly. TOMRA's early involvement in the plant's design stage allowed it to place the XRT systems in a way which delivers a smaller overall process design without compromising performance.

Since the XRT-technology is a dry process all water-related impacts, as for instance pumps, pipes, or the disposal of wet fine tailings, are not necessary for this step.

The paper covers the basics of the XRT-technology, the impacts on plant design and overall recovery and finally highlights the latest learnings and developments.

DEVELOPMENT AND TESTING OF THE NEXTSTEPTM TECHNOLOGY, AN ENERGY-EFFICIENT FLOTATION ROTOR DESIGNED FROM A FUNDAMENTAL APPROACH

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Mineral concentrators around the world are under pressure to reduce power consumption and operating costs while retaining metallurgical performance and process efficiency. To address this need, an academic-industrial research partnership has assessed the role of rotor/stator design in influencing energy dissipation and the resultant flotation kinetics.

Scale modeling, fluid velocity profiling, and other fundamental tools were used to identify the energy consuming sub-processes that occur in a conventional flotation cell. With this fundamental knowledge, CFD modeling was used to design a new rotor geometry that minimized wasteful energy consumption by creating a more uniform slurry velocity at the rotor tip.

The resultant rotor lowered power draw, reduced wear rates, and maintained metallurgical performance when compared to several alternatives. These findings have been verified across all operating scales from the laboratory to industrial installation.

This paper presents data from these studies to demonstrate the potential for improved flotation equipment performance and to demonstrate how basic research can lead to step changes in machine design.

RECOVERY OF ADMINISTRATIUM FROM PHOSPHATES

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It is well known that certain apatite minerals and specifically fluorapatite contain significant amounts of rare earth metals (0.5% to 1.0% as Ln2O3).
Some apatite deposits not only contain significant concentrations of rare earths but also contains a favourable distribution of the individual rare earth elements, which offers a significant advantage over most conventional ores.

The rare earths associated with the apatite follow the phosphate rock as feed to the wet-phosphoric acid production process.
About 50% of the rare earths report to the copious amounts of precipitated phosphogypsum formed and disposed of while the rest pass to the product acid.

The concentration of the rare earth administratium is relatively low (0.1% to 0.14%), but has very significant impacts upon any facility that attempts to recover this very entertaining element.

A COMPARISON BETWEEN REE EXTRACTION FROM PHOSPHATE ROCK BEFORE AND AFTER PHOSPHORIC ACID PRODUCTION

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Phosphate rock can be considered a secondary source of rare earth elements(REE), even though containing traces of these critical, as large tonnages are mined annually. During phosphate rock beneficiation, REE are distributed among beneficiation streams: phosphate concentrate, flotation tailings, and phosphate slime; moreover, and during the following fertilizers production, REE are distributed among downstream products: phosphoric acid, and phosphogypsum.

Most of the current research focuses on the extraction of REE from these streams, where phosphogypsum and phosphoric acid have been attracted the most attention. However, little attention has been given to the distribution of these REE in both beneficiation and fertilizers streams and its effect on the overall REE recovery.

In this work, a comparison has been conducted between the extraction of REE from each the above-mentioned streams and the in-line extraction of REE during phosphoric acid production; then the overall extraction of REE from phosphate rock was compared before and after the inline extraction of REE during fertilizer production.

THE ALGERIAN GLAUCONITE-BEARING PHOSPHORITES: REE VARIATION AND INSIGHTS ON THE DEPOSITIONAL ENVIRONMENT

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New data on rare earth element (REE) analyses are reported here on northeastern Algerian glauconite-bearing phosphorites. These rocks of Paleocene-Eocene age are located in the Eastern part of the Saharan Atlas, where two localities were investigated: the Djebel El Kouif in the north and the Kef Essenoun in the south.

The latter belongs to the world-class Djebel Onk mining deposit. Hand-picked glauconite grains and other phosphate particles (pellets, coprolites, enamel and dentine of marine fish teeth) were embedded in epoxy resin and polished.
They were imaged by SEM and major, trace and REE element contents were analyzed "in-situ" by Electron Microprobe and LA-ICP-MS techniques respectively. For comparison, bulk phosphorite samples were also analyzed by solution ICP-MS.

The results show that phosphorite from the main layer of the Kef Essenoun deposit has a significant abundance in glauconite grains, while their occurrence in the Djebel El Kouif is restricted to the basal levels.
These glauconite grains exhibit higher ∑REE contents than the co-existing particles (Kef Essenoun: min = 654 ppm, max = 1760, average = 1146 ppm; El Kouif: min = 543 ppm, max = 623 ppm, average = 584 ppm). The overall whole rock REE content also shows substantial differences between the two deposits.

Therefore, whole-rock REE enrichment in the Kef Essenoun main sub-layer can be linked to the abundance of glauconite grains. PAAS normalized-REE patterns of the glauconite grains display signatures similar to those of co-existing particles and whole-rocks in each locality indicating a similar origin for the REE. It is noteworthy that phosphorites grains from the northern deposit show a REE uptake source from oxic-modern seawater, while those from Kef Essenoun deposit exhibit bell-shaped patterns with weak Ce anomaly suggesting a different environment of deposition (i.e. more reduced conditions). These geochemical results along with previous petrographic studies, also confirm the allochthonous character of the main phosphorite sub-layer in Kef Essenoun, i.e., winnowed, moved and re-deposited phosphorites as proposed by some authors.

Keywords: Phosphorites; Glauconite; REE; Ce-anomaly; Algeria.

RARE EARTHS RECOVERY AND SEPARATION FROM WET PROCESS PHOSPHORIC ACID

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Rare earth elements (REEs) have long been essential strategic materials critical to various consumer, industrial, and military applications. It is well established that there are various REEs in phosphate deposits, and as such the phosphate industry offers the potential to be a supplier of these materials.

Work has been conducted over the years on the recovery of REEs from phos-acid, and more recent efforts have been directed towards the recovery of these materials from phosphogypsum. In all of these cases, the first actual "product" to be produced is a mixture of REE concentrates, which the producer often attempts to sell.

However, the value of the mixed concentrate material is relatively low compared with the individually separated REEs. Therefore a process to separate and purify the individual REEs is desirable. But separating the REEs from each other is an extremely difficult task. Over the years a number of methods have been utilized, and to date the major separation technique that has enjoyed the most success is solvent extraction. SX has been used in several of the larger-scale rare earths recovery operations where the REE concentrates are derived from conventionally mined ores such as monazite and bastnaesite.

While effective, the application of SX is a capital intensive process with some environmental drawbacks. K-Technologies, Inc. (K-Tech) has developed technology based on the application of continuous ion exchange (CIX) and continuous ion chromatography (CIC) that allows for more effective and economically attractive rare earth group and individual species separations and purification compared with SX.

This paper will discuss the results of recent K-Tech work, and illustrate how CIX/CIC techniques can be used to achieve more economic REEs recovery from phos-acid and subsequent separation into individual components.

ECONOMICAL COMPARISON OF HYDROFLUORIC ACID PRODUCTION FROM FLUOROSILICIC ACID AND FLUORSPAR

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This paper will present the details of a potential new source of revenue from your phosphate rock. The source is the fluoride present in virtually all phosphate rock and that is mostly currently disposed of.

The fluoride content in phosphate rock can reach levels up to 4 wt-% and is typically scrubbed as fluorosilicic acid (FSA). While small quantities of this FSA are used commercially, the vast majority is neutralized and disposed of resulting in a negative impact on the economics of fertilizer production.

Using the FSA as a feedstock for hydrofluoric acid (HF) production instead, can mean significant economic advantages: turning a waste product into a valuable revenue stream. In addition, the process has cost advantages over the traditional HF production method from fluorspar. And since less than 5% of the world's HF is produced via our new FSA route, there is plenty of opportunity.

This paper will compare the investment and operation costs of our new FSA-based processes with the traditional fluorspar process.

FLUORINE RECOVERY AND UTILIZATION FROM A PHOSPHORIC ACID PLANT

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The production of phosphoric acid (PA) requires phosphate rock as a raw material that typically contains 2.5 - 4.4 % fluorine.
During the evaporation or concentration step a significant amount of fluorine vapour is released. The evaporation concentration and silica concentration have a significant affect on the fluorine recovery chemistry.
An excess of silica can potentially cause precipitation. A deficiency of silica results in a higher percentage hydrogen fluoride (HF) in the final product, which is extremely corrosive. In some plants, silica is added to the phosphoric acid to keep the fluorine chemistry in balance.

The fluorine vapour is typically in the form of silicon tetra fluoride (STF) and (HF) and can be recovered as fluosilicic acid (FSA) co - product. The FSA can then be sold as a final product or converted into other products.
FSA can be used to make additional fluorine based products such as, HF, high and low density aluminium fluoride (ALF3), STF and numerous other fluorine based chemicals.

The production of FSA and converting the FSA to other products has the potential to generate additional revenue and increase profits.

The phosphoric acid plant can be easily converted to produce FSA, however the production of other fluorine based products can be challenging and complex.
The market conditions and demand for these products is also very complex and is critical to the decision to make fluorine based products.

This paper will discuss the process of making FSA, including process chemistry, equipment design and product quality.
The paper will also discuss the major fluorine based chemicals that can be produced from FSA, including advantages and disadvantages, impacts to the PA plant operations, market conditions and demands for each product.

A NEW PROCESS FOR PRODUCING A HIGH GRADE SYNTHETIC CALCIUM FLUORIDE FROM FLUOSILICIC ACID

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Phosphate rocks contain 2 to 4 percent fluorine. Part of the fluorine from the rock is precipitated with the gypsum, another part is leached out with the phosphoric acid product, and the remaining portion which represents about 70% of the total fluorine is vaporized in the reactor and evaporator.

As environmental regulations continue to restrict chemical processing emissions, a better environmental alternative is to use scrubbers to remove fluorides as fluosilicic acid prior to condensing the vapors in barometric condensers.
If a market cannot be found for the fluosilicic acid, it can then be neutralized with several calcium compounds such as phosphate rock, lime and limestone which are not profitable methods.

At the present time, the most important outlets of fluosilicic acid are fluoridation of drinking water, manufacturing of silicofluoride, hydrogen fluoride and the aluminium fluoride which is the most significant chemical use worldwide of fluosilicic acid.
In the past several years several processes have become known which make possible the valorization of fluosilicic acid into hydrogen fluoride or aluminium fluoride, however, none of these processes is being suitable to absorb the overall quantities of fluosilicic acid generated by the phosphate producers.

So, there exists, a definite need to expect other ways to convert the fluosilicic acid on more attracting fluorinated products such as synthetic calcium fluoride. This will substitute the fluorspar which is the most starting mineral for the all fluorine products chain, especially when considering its highest cost as results of the resources decreasing and its export limitation all over the world.

This work presents a new OCP process which has been recently patented, for producing high grade synthetic calcium fluoride and active silica crude from fluosilicic acid, obtained as by product from phosphate rock acidulation as results of the fluorinated gas treatment.

AMMONIUM SULFATE PRODUCTION FROM BY-PRODUCTS OF THE WET PHOSPHORIC ACID PROCESS – FLUOSILICIC ACID AND PHOSPHOGYPSUM

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At present time, many producers of phosphate fertilizers faced with the challenge of processing and recycling of fluosilicic acid (FSA). It is a pollutant with a primary concern and cannot be landfilled without treatment.

Existing best available techniques for processing FSA involves production of fluoride salts which market is very limited. As a result, the acid is neutralized with lime. This method of treatment ultimately increases the amount of solid waste sent for storage.
A better environmental alternative of this method is the use of technological solutions which can allow to process FSA with production of substances demanded by the chemical industry.

NIUIF has developed a new technique of co-processing by-products phosphogypsum and FSA with production of ammonium sulfate and fluoride containing precipitate. This process is based on neutralization of the FSA by ammonia in the presence of phosphogypsum.

Gypsum, the main component of phosphogypsum, is used for precipitation of F in form of calcium fluoride. After neutralization and precipitation the suspension is separated into solution of ammonium sulfate and mixture of calcium fluoride, gypsum and silica usable in the cement industry. Water solution of ammonium sulfate with low content of F and SiO2 can be used for production of NS, NP, NPS and NPK fertilizers.

IMPROVEMENT OF THE FLUORINE RECOVERY PROCESS IN A PHOSPHORIC ACID CONCENTRATION UNIT

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Nowadays, the environmental requirements are more and more stringent in the phosphoric acid industry. Liquid and gaseous effluents need to be reduced or even suppressed. In this view, the fluorine emission during concentration is a key component to be controlled.

Existing design of high efficiency implies the usage of droplet separators and double absorption towers. It offers good results but is often expensive and takes a lot of space. In its production plant of Engis, Prayon has decided to tackle this challenge.
Intensive investigation has been done, mainly focusing on the physicochemical process variables.

This study results in a major design improvement. The traditional design has been simplified. The absorption efficiency was greatly improved leading to a dramatic decrease of the fluorine rejects in surface water and optimizing the production of a valuable raw material.

THE USE OF PHOSPHATE PIGMENTS IN ANTI-CORROSION COATINGS

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Zinc Phosphate is widely used in the paint industry in Protective coatings systems, designed to protect metallic structures from corrosion over long periods of time, in all types of conditions.
The composition and physical properties of this pigment will be discussed. The salt spray laboratory test is used to validate different paint formulations and paint systems according to international standards.

This test and the international classification of the various Protective paint systems will be discussed. Increasingly, Calcium and Magnesium phosphates are being used due to their improved environmental profile.
Water-based coatings are also, increasingly being requested to replace the existing solvent-based products. These ecological trends are accelerating the development of new Phosphate based anticorrosion pigments.

CRITICAL EQUIPMENT MONITORING & PROTECTION SYSTEM

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Le Nouveau système de Rack SKF Multilog IMx-M et le logiciel SKF @ptitude observer permettent de mesurer et d'analyser les vibrations et les données dynamiques en temps réel des machines critiques et semi-critiques ; En cas de défaut ou une divergence par rapport à la consigne, le système permet un arrêt (action programmable) de la machine avec des temps de réponses très brefs selon la classe de protection API 670.

Bénéfices pour les équipementiers :

- Combine la protection et la surveillance des machines critiques dans un système compact et fiable.
- Protection et surveillance basées sur les exigences de la norme API 670.
- 64 entrées dynamiques par rack: plus de machines à surveiller avec moins de racks et d'armoires d'instrument
- Module de Protection et de surveillance générique: couvre toutes les applications, simplifie la spécification du système et la gestion de pièces de rechange et réduit les exigences en matière de pièces de rechange.
- Fonction Hot-swap : permet le changement d'un module tout en étant sous-alimentation pour avoir une protection continue et le suivi de tous les autres modules lors du remplacement du module défectueux.
- Format des racks en 19" peu profonds pour une mise à jour facile des systèmes existants.
- Fonction autodiagnostic avancée et vérification continue du bon fonctionnement, y compris l'alimentation et la température interne.
- Suivi des tendances des différents paramètres de la machine.
- Orbite / Shaft Centerline
- Diagramme polaire
- Analyse des signaux temporels
- Diagnostic automatisé
- Analyses avancées des engrenages
- Analyse vectorielle.
- Module Équilibrage
- Gestion des alarmes et les journaux des événements

ZEB-REVO, A DIGITAL 3D MAPPING TOOL IN A CLOSED ENVIRONMENT

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As part of its activities related to instabilities of underground cavities, in particular those of shallow mining, BRGM is required to map the geometry of the structures studied and to georeference them. This information is necessary in order to verify the presence of vulnerable buildings and infrastructure at the level of these cavities.

On the other hand, they make it possible to carry out a diagnosis of ascent of possible instabilities towards the surface (fontis).
Stability analysis methods are generally based on simple geometric parameters, often two-dimensional, to characterize mine work: width and height of the galleries, nature and thickness of the grounds of the covering and their proliferation, etc.

The real state of the gallery is generally observed in situ and integrated into the expertise.
The author of the stability diagnosis does not have a precise 3D survey of the gallery examined enabling him to visualize at any time the actual appearance of the work as it was at the time of the visit(Eg local flaking of the pillar, local fall of roof blocks).
Such a three-dimensional survey would be very expensive in time and money.

The BRGM has equipped itself with a so-called "ZEB-REVO" tool, a high-performance scanning tool, which allows fast, accurate and high-quality geometric data capture.
Its simultaneous location and mapping algorithm (SLAM) allows it to quickly map closed environments, freeing itself from a GPS. This tool has been successfully used by the BRGM to map shallow galleries in the central region of France.

ZEB-REVO could be used in a material transport duct to diagnose volumetric variations due to possible deposits (precipitation, sedimentation, etc.). With a high degree of precision, this tool could easily establish the visible variations on the internal wall of a duct with respect to an initial state; the latter being predefined by the initial shape of the duct.

Monitoring the walls of the Slurry pipeline could be a very good example of application of the ZEB-REVO tool in order to guard against a possible fouling phenomenon which could inevitably lead to a reduction in transport flows.
Thanks to its speed of execution, the robustness of its calculations and its maneuverability, this tool could prove very useful from the point of view of monitoring the transport structure.

TWO CASE STUDIES OF SIMULATION-BASED ENGINEERING: COMPASS MINERALS SOP PROJECT AND OPTIMIZING PROCESS AND CONTROL OF A TILTING PAN FILTER

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Simulation-based engineering unifies the design of process, the equipment and the control concepts into one integrated model. Engineers can now minimize design contingencies, saving capital cost and create designs that are more operable and automated.
This is accomplished by combining process information with equipment parameters allowing control concepts, which are identical to those that will operate the actual plant, to be designed and verified. This innovative concept enables successful startup and optimized operation for both green and brown field projects.

This paper describes a case on how the concept of simulation-based engineering was used by Compass Minerals to get their new SOP (Sulfate of Potash) plant in Ogden, Utah, production-ready and quickly ramp up to full production with minimal impact on the existing operations. Simulation-based engineering was used for process design validation, operator training, and development of process control and optimization for the SOP plant.

This paper further describes the application of simulation-based engineering of a Tilting Pan Filter (TPF) for a dihydrate phosphoric acid application. A steady-state simulation model was developed based on a combination of first principles, test work and existing plant data.

The model predicts the tilting pan filter's performance under different design and operating conditions. Furthermore, a high-fidelity dynamic simulation model will be developed for the TPF to create a virtual plant environment which provides enormous value for plant design and automation engineering during the entire project life cycle

CASE STUDIES OF MAJOR MINING AND PETROCHEMICAL INCIDENTS INVOLVING INDUSTRIAL MAINTENANCE: USE OF TRIPOD BETA METHODOLOGY IN UNDERSTANDING THE CAUSES

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One of the main objectives of incident investigation is to prevent re-occurrence by understanding how the incident has happened, its underlying causes and identifying specific recommendations.

This research focuses on the analysis of the main fire and explosion incidents, involving industrial maintenance, which occurred in the mining and petrochemical industry over the last 50 years. The selection of the case studies is based mainly on the extent of damage, in terms of casualties, environmental damage and asset loss, following the incidents.
The underlying causes are analysed using the TRIPOD Beta incident investigation methodology. This methodology, developed by Shell and the UK Energy Institute, provides a structured approach in identifying and classifying the root causes.

Conclusions were drawn from the results of the analysis with regard to incident preventions measures and recommendations.

FACTORS IMPACTING SUCCESSFUL IMPLEMENTATION OF LEAN PRODUCTION IN PROCESS INDUSTRY: AN INVESTIGATION OF MOROCCAN PHOSPHATES INDUSTRY

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Lean production sweeping the global industrial sector. Namely, this new improvement approach is believed to be one of the most powerful production systems of all. It combines various management concepts and practices that can be applied to identify immensely efficient and effective production systems that use fewer resources to create higher quality and generate more profits.

Due to its outstanding success in discrete manufacturing sector, lean production has had broader application to span new areas such as continuous process sector.
Unfortunately, research has demonstrated that a number of continuous process enterprises are still failing to successfully implement this improvement approach.
It has sometimes been explained by the fact that continuous process industry cannot just imitate, in total, implementation ways developed by the discrete manufacturing enterprises in other countries.
On the other hand, the academic literature still contains few studies of application of lean in this specific type of organizations.
This situation does not enable to gauge what are the real factors that affect successful implementation of lean in process industries.

In this view, the present paper puts forward initiatives of lean system implementation in OCP group, the Moroccan global leader in the phosphate and phosphate derivatives markets.
The main objective of this study is to outline the factors impacting the implementation of lean in such environment.
Lastly, this study has led to the elaboration of recommendations to promote the success of lean and the achievement of its relevant gains in the context of OCP group.
This will serve as basis to develop framework of lean implementation in continuous process industries.

Keywords: lean production, process industry, successful implementation, continuous process.

UPDATE – JOURNEY THROUGH OPERATIONAL EXPERIENCE

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In recent years the sulphuric acid industry demands to maximise recovery of process heat, develop ever more energy efficient processes and operations has been a key focus of the industry. Metallurgical acid plants are now expected to also produce high and/or low pressure steam for power generation in a safe and reliable way.
With the help of proven processes, like the Outotec LURECTM, HEROSTM and HIPROSTM technologies, this demand can be realised.

The paper will present a case study of one of the operating Outotec HEROSTM-Systems – integrated into an existing metallurgical plant. This industrial reference for producing LP-steam illustrates our experiences with the design in a retrofit environment, as well as our installation, commissioning and several years of operational data showing how operational experience mirrors the design considerations of this system.

The presentation will cover key aspects of integration of the heat recovery system into a complex industrial facility, analysis of control concept in combination with the selected level of instrumentation, analysis of material of construction, process critical areas of such a system as well as feedback from customer´s operation.

A further aspect of great interest to the industry as a whole – the internet of things (IOT) – will be present the potential for digitalisation by combining Outotec's process knowledge with actual operational plant data to assist the customer's operation.

A RELIABLE CONDITION MONITORING APPROACH RELATED TO A STEAM TURBINE MAJOR OVERHAUL

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Steam Turbines are almost the most critical machines in a plant.

This article is related to a field service and/or a troubleshooting procedure recommended for steam turbines major overhaul.

During this topic, Prüftechnik France will give in details the different steps that offers a reliable condition monitoring approach.

This approach is defined in three stages:

- Measurement procedure in operational conditions before Machines stops. The aim of this step is to get the machine behavior reference related to the process, the vibration signature and the alignment tolerances.
- Measurement procedure during the major overhaul related to bore and shaft alignment as well as geometrical control.
- Acceptance tests after the major overhaul to validate the new machine behavior related to the process and the vibration signature.

This approach can help any steam turbine user in case of a troubleshooting approach to avoid technical issues and get the more information and data about the machine before and after a major overhaul.

OPTIMIZED SPARE PARTS MANAGEMENT – AN INVERSTMENT IN ASSET AVAILABILITY & RELIABILITY

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Spare Parts Management has traditionally been viewed as a "cost producing factor".
Which company does not have the situation that the spare part inventory value increases frequently?

The reasons are mostly well-founded, but each production company has the potential to decrease the inventory value of spare parts. The range for this value of 1.0% to 1.5% of equipment replacement value (ERV) is regarded as normal (best-practice).

A holistic spare parts management approach includes analyzing, forecasting and procurement, considering the current asset life cycle.
The benefit of a well-organized and structured (holistic) spare parts management can reduce:

- Maintenance cost (direct and indirect),
- Downtime and
- Number of breakdowns.

The paper is about the approach to create value from increased asset availability and reliability by optimized spare parts management.

ECO-FRIENDLY BULK HANDLING EQUIPMENT IN THE FERTILIZER INDUSTRY

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While in the past, the environmental safeguard was not an issue, nowadays ports worldwide consider the prevention of pollution a first objective, especially with import/export of dry bulk cargo as fertilizers. In this case, the risk of spillage and dust production is very critical.

Problems can occur during the loading or discharge operation, but also if the material need to be stored in the port zone. To achieve a reduction of emissions the first step could be the use eco-friendly bulk handling equipment.

Bedeschi, thanks to its research and development in green technology, is able to design and produce machines, which incorporate sophisticated dust control measures, able to reach the highest environmental standards.

During the conference, we will present some successful case studies in the fertilizer industry showing solution to reach the main objective: guarantee both efficiency and green environmental conditions in the ports.

HYDROCYCLONING TECHNOLOGY IN PHOSPHATE BENEFICIATION WITH POLYURETHANE BASED MATERIAL, "TWIN-TYPE" AND "FLAT-BOTTOM" GEOMETRIES

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Capitalizing on more than 50 years of material development, AKW is offering a wide range of polyurethane hydrocyclones AKA-VORTEX.
With full ability to play on the hardness and specific resistance (to chemical, pressure and temperature) of the polyurethane, AKW adapts its formulations to the specific application requirement.
Combined with the unmatched characteristic of modularity of the polyurethane parts, it allows AKW to offer more than 3000 different modifications for its hydrocyclones. As such, it can serve almost all required process conditions.

Beside the proven advantages of polyurethane in the manufacturing and handling of hydrocyclones, such as an easy and accurate molding, the generation of very even and smooth inner surface ensuring accurate cut sizes, the easy handling on site due to light weight and modular assembly as well as a help to efficient preventive maintenance operations, AKW leveraged lately some additional benefits by developing the "TWIN hydrocyclone technology".
Through this unique technology, AKA-VORTEX hydrocyclones are helping customers to optimize the overall footprint and investment levels of the requested systems, by allowing strong reduction in the space requested as well as minimizing the need of critical and expensive functional parts. With the phosphate industry entering into a major growth phase while at the same time investment levels requiring tight monitoring, several brownfield/retrofitting projects have already selected the unique TWIN technology.
Lately, some of the actual developments in the phosphate industry that require coarse cut sizes, stable thickening rates and equalized product concentrations pushed AKW to introduce in the phosphate market the "FLAT-bottom hydrocyclone technology" that is already widely used in other industries.

ENERGY EFFICIENCY OF PUMPING SYSTEMS IN THE FERTILIZER INDUSTRY THROUGH OPTIMIZED PUMP SELECTION

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Industrial manufacturing faces an increasingly competitive environment. Companies are looking for opportunities to reduce production costs without impacting on their productivity or the quality of the end product.

One of the most effective methods is to concentrate on energy efficiency. This will also have additional benefits in terms of improving green credentials. Pumping systems account for more than 20% of the world's electrical energy demand, and in certain industrial plant operations they can be responsible for between 25% and 90% of the energy usage.

The most significant savings in the energy consumption of a pumping system can be achieved by selecting the most appropriate pump technology for an application with premium efficiency. This selection process starts with gaining a complete understanding of the application, fluid characteristics and flow demands.

SCREENING TECHNOLOGIES IN PHOSPHATE PRODUCTION

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Phosphate production uses different kinds of screening machines, because different screening tasks arise. The main application is the screening in defined product fractions which requires precisely working screening machines due to strict requirements of the branch. But starting processes can often be seen in wet screening in order to clean phosphate material from alien parts like stones after exploitation.

After product screening, high capacities are needed in scalping screens after extracting material from silo or before shipping and transportation of the product. Sometimes fine polishing is used in order to free the product from dust particles.

RHEWUM screening technologies for these purposes are a wide field following to many years of experience in phosphate screening. Applications are amongst others wet screening machines with huge screening surfaces and spraying systems following to customer's special requirements, big double frequency screening machines as scalping screens with capacities of 1.000 t/h and more, as well as very precisely working screens with direct excitation of the screens clothes and inclination in order to keep the strict requirements of the phosphate product screening.

This presentation will be introducing in RHEWUM screening machines and their special use in phosphates and fertilizer screening.

PHOSPHORITE BENEFICIATION USING A STEINERT MOBILE XRT SORTER

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In a phosphorite dolomite deposit in Kazakhstan a STEINERT XSS mobile sorter unit is used to upgrade the phosphorite. This case study shows the results, its benefits and the mechanical set-up of the sorting plant.

To create a high-quality phosphate the MgO content needs to be controlled and kept below a certain limit. The deposit has a natural concentration of magnesium oxide of approx. 6-12%. In analytical tests, it was discovered that the phosphorite contained a concentration of 1.6 to 1.8% MgO, which is well below the critical value, while the dolomite contained between 6 and 24% of MgO. So, to reduce the concentration of MgO the dolomite needs to be separated from the phosphorite.

The STEINERT XSS sorter is based on dual energy X-ray transmission (XRT), which can differentiate particles based on atomic densities. It works on the same basis as luggage scanners at airports. Since the x-rays penetrate the particles completely, it has the potential to identify atomic density differences hidden within the rock.
Therefore, the technology is very robust and does not require any material washing and can be realized in a completely dry process.

STEINERT has developed a completely mobile plant, consisting of an XRT sorter and the accessory equipment, including power generator, in 3 40' containers. It can be setup remotely, in very short time, as it is completely self-contained system. The plant can upgrade the phosphorite at the deposit to a product with less than 2% MgO and a masspull of 70%. The removed waste has a MgO content of more than 15%.

In the final paragraph, we will look at the operating costs of such a plant and how economic it is.

MAX3TM- MAXIMIZED VALUE FOR CAPEX, OPEX AND EMISSION

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For the sulfuric acid industry, compliance with emissions and effluent reduction targets - while balancing productivity and profitability - is becoming essential to survive these turbulent times. Previous approaches to simultaneously minimize capital expenditures (CAPEX), operating expenditures (OPEX), and emissions proved unsuccessful because of technology limitations.

Producers were forced to make choices, selecting one benefit while accepting a negative consequence, either financial or environmentally. But today, CAPEX, OPEX, and emissions cannot be dissociated because of an increasing global drive to minimize production costs and emissions together. These pervasive trends have heavily influenced research and development work at MECS over the past 6-8 years. MECS knew that a new approach was needed to solve these complicated problems, and started by reviewing all areas in a sulfuric acid plant that consume time, water and money, as well as all drivers of emissions, both liquid and gaseous. The MECS R&D team has developed a novel approach that eliminates or at least reduces high consumers of time, water and money while also recovering more energy – all at best in class emissions.

The result is MAX3TM - a proprietary sulfuric acid plant technology that simplifies the conventional sulfuric acid plant flow scheme by combining a single absorption HRSTM plant with MECS' SolvR® regenerative SO2 scrubbing technology. It eliminates equipment, cuts costs and increases efficiency. In a MAX3 TM plant, the use of SolvR® makes it possible to achieve close to zero SO2 emissions. SolvR® also improves operating flexibility, capital
and operating costs. It economically removes SO2 from gases with concentrations as low as 300 ppmv and as high as 50 vol%, reducing SO2 emissions below 30 ppmv. If even lower limits are required, additional regenerative steam can be used to reduce SO2 emissions below 10 ppmv.

This paper describes MECS's research and development journey to develop MAX3™, from lab concept, to proven technology.

DRY SULPHUR MATERIAL HANDLING SYSTEMS, SULPHUR PRILLING, AND NEW MELTER TECHNOLOGY

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Most current technology and lessons learned from major dry sulfur import facility, truck transportation system, conveyor belt and vertical conveyors designed and built for a major Sulphur melter in the USA is presented and explained.

Challenges involved with handling dry Sulphur that is imported from sources around the globe will be identified and solutions presented. The subject port facility has open storage and the melter facility utilizes a 6,000 Metric Ton concrete storage silo for dry Sulphur. Conditions the dry Sulphur is exposed to range from tropical rains and moisture to very dry and windy conditions during transitional seasons. Dust control and potential explosive situations are presented and explained.

A current update on high capacity, 1 Million MTPY, Sulphur melting facility operating and maintenance results will also be provided. This facility was designed and built under an EPC contract by Devco. Current Devco II Sulphur Prilling technology utilizing molten Sulphur droplets traveling through counter flow vertical water column will be explained along with the benefits of inherent moisture for dust management during storage and handling of wet formed Sulphur prills.

RE-INTRODUCING SOLID BOWL DECANTER CENTRIFUGES FOR DEWATERING IN THE MINING INDUSTRY

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Solid bowl decanter centrifuges were originally introduced for solids dewatering in the mining industry some 40 years ago.
The solids were typically quite coarse and drainage of liquid was the primary dewatering mechanism. Drainage of liquid from solids was further improved when screen bowl decanter centrifuges were introduced as the next solution.

Due to this development the use of solid bowl decanter centrifuges in mining only covered a short period. Over time the composition of solids material to be dewatered have changed to include more fines, where other technologies gradually have even replaced the use of the screen bowl decanters.

The original, solid bowl decanter centrifuge has developed a lot in other industries since its first use in the mining industry.
A significant difference for new, deep pond decanter centrifuges is the use of solids consolidation below the liquid surface instead of drainage.
This is particularly beneficial for feed streams with a high content of fines including streams, where flocculants must be used to capture the fines.

At present, many tailing streams show these characteristics and test work within different mining industries have shown that modern solid bowl decanter centrifuges can be adapted to match the solids dryness of the dominating dewatering technologies in mining industries today.

The accelerated dewatering with low hold-up volume and small footprint in a truly continuous operation can provide operational benefits in many processes. With fully automated operation it is expected that decanter centrifuges will be widely used for dewatering in many mining applications in the future.

OPTICAL SIEVE ANALYSIS FOR ONLINE QUALITY CONTROL AND REAL TIME MONITORING OF THE GRANULATION PROCESS

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The usual procedures for this are:

- Granulating
- Tableting
- Pelletizing
- Sintering
- Briquetting

The specifications of fertilizer with regard to the particle size distribution, place high demands on the manufacturer. The granulate is generally between 1 mm and 5 mm, with over 90 percent between 2 and 4 mm.
Currently, the final product which is fed into storage is only monitored with respect to particle size. The particle size distribution is only available to the operator every 4 to 8 hours! For a shop that runs 24 hours per day and 7 days per week, product may only be tested 3 times. In addition, since production runs 7 days per week but the laboratory is working only 5 days per week, product will go almost 3 days with no measurement.

Online Process control
To check the actual granulation, an online particle size measurement should be used after granulation. In this case, it must be taken into account that the product to be measured is free-flowing otherwise, the particles will stick together and cannot be measured accurately. The system operator gets the values in real time and can react immediately to process changes.
Online Quality control
The second important place, where size and shape should be measured, is after sieving. Here, "good product" is measured and monitoring of the screening step in the production process takes place.

The advantages are apparent:
The immediate recognition of changes in the process can be immediately acted upon. Granulation becomes uniform over all shifts with no unnecessary process adjustments being made by a multitude of operators. This increases efficiency. Product output is maximized for the plant delivering higher revenues to the business. Finally, with an ROI in less than 60 days, the PartAn 3D PRO is a smart investment.

ANTIBACTERIAL BIOMIMETIC APATITE-BASED BONE CEMENTS

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With the development of minimally invasive surgical techniques, there is a growing interest in the development of injectable bioactive bone cements especially for orthopedic applications.
Some important issues such as improvement of resorption capability and better protection against implant-associated infections are major challenges in this field.
Calcium phosphate cements have great potential as carriers for controlled release of drugs in bone tissue due to their composition close to bone mineral, excellent bioactivity and possible use as injectable and degradable grafting materials.

This presentation will focus on the two main strategies we implemented to confer antibacterial properties to apatitic bone cements as local drug delivery systems: the molecular route involving antibiotic molecules (fusidic acid or derivative) or the ion-doping route involving ions with known antibacterial properties (silver ions) added to the cement formulation.
In both cases, the antibacterial agent or their derivatives can either be introduced in the liquid or solid phase of the cement.
The effect of the presence of these antibacterial agents on paste and hardened calcium phosphate-calcium carbonate cement properties (setting time, injectability, antibiotic and ion release, antibacterial properties and biocompatibility...) has been thoroughly evaluated.

The possibility to control cement parameters and properties makes these antibacterial biomimetic cements promising candidates especially for the prevention of bone implant-associated infections.

ELECTRODE MATERIALS BASED ON PHOSPHATES FOR LOW COST SODIUM ION BATTERIES

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Lithium-ion batteries are the most common rechargeable batteries used in portable electronic devices and the technology of choice to power hybrid, plug-in, and electric vehicles. However, concerns have been raised about the availability and cost of Lithium in recent years.

Due to the high abundance and the low cost of sodium, as well as its suitable redox potential (E(Na+/Na) = -2.71 V vs. SHE), sodium-ion batteries are regarded as possible alternative for lithium-ion ones, especially for large-scale energy-storage applications where a large quantity of active materials were needed.

Thus, the electrochemical energy storage community has been devoting increased attention to designing new anode and cathode materials for sodium-ion batteries, making it a robust research area within rechargeable battery systems. Nasicon-type Phosphates, exhibiting open 3D structures, offer interesting features (low cost, structural and thermal stability..) to be considered as candidate for sodium ion batteries.
They also offer fascinating fundamental properties in relation with their energetic performance, in term of capacity, working potentials and the coulombic efficiency.

Two kinds of Nasicon-type phosphates, with the general formula MxMy'(PO4)3, will be presented here with the aim to show the relationship between the electrochemical performance and their physic-chemical properties.

Keywords: Energy Storage, Phosphate, Sodium ion batteries,

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PHOSPHORUS-CONTAINING MATERIALS FOR HEAT STORAGE

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Nowadays, climatic warming becomes one of the most serious environmental concerns worldwide, due to the consumption of fossil resources.
In addition, energy demand progressively increases because of world population increase and the development of new emerging countries.
The development of renewable energy resources such as solar, wind, biomass, and wastes is highly recommended for the 21th century. Among them, solar energy and waste heat from industrial sites are promising thanks to their abundance.
The recovery rate of waste heat is still low, even in developed countries [1].

According to the International Energy Agency (IEA) [2], by 2050, 9.6% of global electricity could be produced from solar power, especially from concentrating solar power plants (CSP). For both CSP and waste heat recovery, energy storage system is needed because of the intermittence property of these energy sources.
For CSP, it is estimated that more than 600 million of heat storage materials will be necessary by 2050. Up-to-date, molten salts (alkali nitrates and alkali nitrites) are the main heat storage media used in CSP.
However, they have several disadvantages including low thermal conductivity, low operational temperature range and corrosive property. In addition, their use may cause competition with agricultural activity.

This work aimed at developing new phosphorus-containing materials for sensible heat storage. Different mixtures were investigated. The materials developed in this work are demonstrated to be stable at high temperature. They have interesting thermal, mechanical and thermo-mechanical properties. The results have shown that these new materials are suitable for heat storage at large-scale application. The environmental evaluation of these heat storage media has also demonstrated their low environmental impact.

Reference

[1] Applied Energy 188 (2017) 586–594
[2] IEA, « Technology roadmap-concentrating solar power », 2010

THE USE OF FRP (FIBERGLASS-REINFORCED PLASTIC) IN PHOSPHATE FERTILIZER AND SULFURIC ACID PROCESSES

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The demand for corrosion resistant composite equipment increased significantly starting mid 2000 when nickel prices raised very rapidly. With a 50-year reputation for low maintenance and relatively stable cost, Fiberglass-reinforced Plastic (FRP) made with Epoxy Vinyl Ester Resins provides process engineers with a reliable, cost effective construction material that can be employed in numerous applications that are corrosive to stainless steel, and at a much lower cost than high alloy clad steel.
Although some other materials may be cost competitive with FRP, their use typically results in higher life cycle costs due to maintenance.

The purpose of this paper is to compare FRP made with Epoxy Vinyl Ester Resins with high nickel alloy in "wet process" phosphoric acid and sulfuric acid environments. Comparison of relative cost and corrosion data are presented to provide the information necessary for process engineers to facilitate future decisions concerning material of construction. Examples of equipment will be shown to demonstrate that it is an ideal product for the fertilizer industry.

Keywords: corrosion, epoxy vinyl ester resin, fertilizer, fiberglass-reinforced, high nickel alloy, plastic, phosphate, phosphoric acid, reinforced thermoset plastic, sulfuric, vinyl ester resin

APATITE CALCIUM PHOSPHATES FOR MEDICAL APPLICATIONS: THE EXAMPLE OF DRUG DELIVERY SYSTEMS

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Bone is a composite material of organic and inorganic phases. The mineral component which represents about 60–70% of the total dry bone weight, consists of an apatite calcium phosphate containing carbonates and small amount of other elements (sodium, magnesium...). The former part is comprised of organic material such as collagen.

Bone is made up of a framework rebuilding constantly itself through to the actions of cells. However, under abnormal conditions the bone density is not maintained and this results in damaged bone. Thus, the development of synthetic biomaterials to replace and repair bone tissue lost from injury or disease, has significantly increased over the last decades.

Among the different materials investigated, apatitic calcium phosphates have genered widespread consideration in advanced hard tissue engineering, due to the physicochemical and biological properties they possess. Another challenge in the conception of calcium phosphate biomaterials is to use them as carriers for local delivery of therapeutic agents, useful in treatments of different skeletal diseases. For this it is essential to understand the effect of the chemical and physical parameters of the system on the drug-carrier interactions and their influence onto the release process.

Since there are many aspects related to calcium phosphates surface properties that are unknown, there is a great need for further research to improve our understanding of the link between synthesis, properties and in vivo behaviour of these materials.
The present work reports on the interaction between biomimetic calcium phosphates nanoparticles and biological active molecules.

The physicochemical parameters of the substrates as well as the chemical properties of the solution were taken as experimental variables in order to determine the in vitro basic binding and release profiles and to control the main driving forces at the interface between the mineral and biological system. The information gained in this field may contribute to throw light on the in vivo behaviour of bone substitutes as well as to promote these materials for the purpose of skeletal drug delivery.

THE PRODUCTION OF NPK FERTILIZERS

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NPK fertilizers are growing in popularity. The market in Africa is dominated by NPK products and the African market is expected to grow significantly in the coming years.

There are several methods of producing NPK's with the main methodologies being:

Bulk Blending
Steam Granulation
Chemical Granulation

This paper discusses the advantages and disadvantages of each method as well as the relative CAPEX and OPEX.

NPK is a very broad term and covers a multitude of different formulations, each of which has their own processing characteristics. We will discuss the different types of products and their formulations and the challenges that are faced when designing plants to produce such grades.

Finally we will look at the technical challenges in modifying plants originally designed to produce DAP to enable a range of different NPK products to be produced.

FEED GRADE CALCIUM PHOSPHATES

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Brief overview of the main methods for production of commercial Feed phosphates /Calcium phosphates – DFP, DCP, MDCP, MCP/

- Thermal method;
- Sulfuric acid method;
- Hydrochloric acid method;
- Phosphoric acid method;

1. Block diagrams of the processes.
2. Specifics of the products and production possibilities by the different methods.
3. Specifics and critical parameters of the raw materials used in the different methods.
4. Environmental affect and by products/ wastes care by different methods.
5. Main advantages and shortages of the production methods.

IMPACT OF PROCESS ENTRANCE ON THE MDCP QUALITY

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Phosphorus is supplied to the animal from two sources, namely: organic feed sources (plant sources, animal sources), and inorganic sources (mainly calcium phosphates).

The main difference between organic feed ingredients and inorganic feed phosphates is the bioavailability or digestibility of phosphorus. Indeed the bioavailability of P in animal products is significantly lower than the Monocalcium phosphate, the difference varies from -10% for fish meal to -35% for bone meal.

It's widely recommended to use inorganic phosphate source rather other substitutes, actually the market demand of different feed phosphate such as MCP, MDCP, DCP, TCP... This requires a well-controlled manufacturing conditions and better quality of raw materials.

In feed industry, process have to guarantee a high digestibility: sure quality of raw materials, optimised reaction, efficient drying, etc. are critical steps to contrôle.

- Phosphorus

The treatment of phoshoric acid must observe, beyond the removal of fluorine and heavy metals, the impurities threatening the reaction.

- Calcium

Whatever the source of the calcium used, its purity and its reactivity guarantee very well the absence of indigestible agents in the product.

Consequently, the impact of process entrance on the feed quality must be taken for a serious concern, pure and stable the raw materials are, able will be the process to guarantee a high quality of feed.

OPTIMIZATION OF FERTILIZER BULK BLENDING EQUIMENT IN AFRICA

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In every region of the world, the increase of crop-based agriculture has been associated with a large increase in the use of chemical fertilizer.
Generally Africa has consumed low levels of fertilizer, fertilizer consumption must increase in Africa if the region is to meet its agricultural growth demands, poverty reduction goals, and food supply objectives.
One of the constraints to supplying fertilizer within Africa is the cost to distribute the fertilizer. Africa typically has higher fertilizer prices than many other regions.

Fertilizer prices are typically higher in Africa for a number of reasons:

1. Small and fragmented market size, Africa accounts for less than 1% of the global fertilizer market. More than one half of the countries in Africa consume less than 25,000 tons of product, the level at which fertilizer can be imported cost effectively.
2. Numerous types of fertilizer products, Africa's fertilizer markets tend to be not only small but also fragmented, and they require numerous fertilizer products. For example, more than 20 fertilizer products are typically available at any given time in Malawi, a small country in which annual fertilizer sales rarely reach 200,000 tons. There is no technical reason from a farming standpoint to have so many different fertilizer products. The number of different products makes it difficult to take advantage of economies of scale and get the Fertilizer at a reduced cost.
3. High transportation and handling costs from the port. Many countries in Africa are landlocked. They have no ocean port through which they can import fertilizer shipped by sea from distant manufacturing centers. Landlocked countries typically must absorb US$50–US$100 per metric ton in additional transport costs to have goods delivered from the nearest port to their own border and vice versa. Farmers in landlocked countries are affected by geography, because they not only end up paying higher prices for imported goods such as fertilizer but they also receive lower prices for exports, including agricultural commodities. In addition, poor roads add to transportation costs, which may constitute up to one third of the farm-level price of fertilizer in countries such as Zambia, compared with less than 5 percent in the United States. In addition, inadequate and inefficient port infrastructure adds to costs in African countries.

One way to potentially reduce costs is to provide efficient bulk blending within Africa, there are three options for bulk blending

1. Option 1: To have a portable blending facility at the port to bulk blend and bag as product is off loaded.
2. Option 2: To have a portable bulk blending facility within the country that can be brought to fertilizer storage locations and perform bulk blending.
3. Option 3. To have a portable bulk blending facility within the country that can be set up prior to truck delivery and bulk blend as trucks are delivering product.

The paper will discuss the challenges with fertilizer distribution in Africa and solutions to help reduce costs by providing portable bulk blending system options. The engineering technology and design for portable bulk blending systems will be discussed.

NOVEL TECHNOLOGIES TO CONVERT LOW-GRADE PHOSPHATE ROCK INTO SLOW RELEASE FERTILIZERS

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Phosphorus (P), one of the major nutrients for plant growth, animal production, and human health, is mainly mined from phosphate rock. Globally, 90% of the mined P is used for food production, as fertilizers and animal feed. The demand for P is increasing due to rapidly expanded world population.

However, phosphate reserves are limited, particularly those adequate for phosphoric acid production. Alternate technologies need to be sought for exploring the value of low-grade phosphate ores, which are left in the mining sites in large amounts.

In this study, we developed new technologies that can convert low grade phosphate rock (PR) into slow release fertilizers which are needed for mitigating environmental pollution with water soluble P in modern agriculture. Dolomite phosphate rock (DPR), one of the low grade PRs from central Florida, was tested with the newly developed technologies, in which DPR power is subjected to activation by reacting with pre-screened organic molecules under optimized conditions.

The results indicate that the activation process raised water soluble P in the DPR by more than 10 times. Moreover, the activated DPR is featured with slow release characteristics by continuously supplying P to crop plants according to their growth needs.

This slow release property may be attributed to relaxing of Ca-P and/or Mg-P bond due to interactions with organic molecules during the activation process. Compared to conventional P fertilizers, the activated DPR fertilizers can meet the nutritional requirement of crops for P while minimizing P loss into the environment. In addition, the activated P fertilizers have great potential for application in organic farming as they are not considered as chemicals.

APPLICATION OF UNITS, COMBINING THE GRANULATION AND DRYING, FOR DEVELOPMENT OF FLEXIBLE PROCESSES OF PHOSPHORUS-CONTAINING FERTILIZERS PRODUCTION

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Among units, combining the granulation and drying processes, the drum granulator-dryer (DGD), widely used at phosphorous-containing fertilizer production plants on the territories of former USSR Republics, may be highlighted. As opposed to similar units, called "spherodizer", DGD has more efficient internals.
The presence of internal reverse screw allows to return some amount of material (internal return material) to the DGD head section.
This, along with the superior internal lifting flight design, provides the creation of more dense material curtain and increases the number of granule formation centers.
Because of this, unit efficiency increases, amount of external return material decreases, thermal efficiency of the system increases.

Traditionally, there was an opinion that DGD units was applied for production of TSP, MAP and some grades of NP- and NPK-fertilizers, obtained by raw material decomposition by nitric acid.
Along with that, the capacity of one process line was from 10 up to 25 t/hour, depending on fertilizer type, moisture content in slurry and DGD unit diameter.

In addition, till certain time, there was an opinion that it was impossible to produce the fertilizers with high mole ratio NH3 : H3PO4 – DAP, NPS, NPK in DGD units.
Last years, the large scope of works, which allowed to change the idea about these units potential, was carried out in our Institute JSC "NIUIF".

The universal processes, developed by us and equipped by DGD, allow to produce various grades of fertilizers, namely: TSP; NP – DAP 18-46; MAP 12-52; NPS – 16-20-0-12(S), 20-20-0-14(S), 19-38-0-7(S) etc.; NPS+S with elemental sulphur 12-40-0-5+5,13-33-0-7,5+7,5; NPK 10-26-26, 15-15-15, 16-16-16, 5-15-30, 4-30-15 etc; NPKS 1-20-20-5(S) etc., and, also, granulated PK-fertilizers of grades 0-24-24, 0-20-30 etc., and PKS 0-20-20-5 (S) industrially produced for the first time.

At present, we have developed and patented the process AG-DGD, which is perspective and having no analogs in the world, and combining the advantages of both processes.
We believe that universal, compact and cost-effective processes with DGD, combining the granulation and drying processes in one unit, have good perspective and may be an alternative to traditional processes with AG-DD.

CASALE INTEGRATED TECHNOLOGIES AND SERVICES FOR NEW FERTILIZER PLANTS

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The world's population is projected to reach ten billion by 2050. Humankind is increasingly dependent for survival on cheap and plentiful fertilizer; such dependence is further accelerated by rising standards of living and reduction of arable land. Demand for ammonia for industrial use is increasing, too. Larger global nitrogen demand will inevitably call for new ammonia, urea plants, nitrates and phosphate plants.

Drivers for construction of new ammonia and urea plants are quite diverse, though.
The capacity of new facilities will range from a few hundred to several thousand tons per day. Smaller plants for standalone ammonia production will address local demand - for example to feed nitrate and phosphate facilities, or for industrial use.

Larger plants will produce urea fertilisers for regional consumption and for export to the global urea market. The profitability of these new plants will depend on the fitness of the process design for the capacity and purpose, and one process design will simply not suite them all. Casale has developed different plant design concepts, one for each capacity range optimised for these different applications.

This paper describes the new Casale technologies and process designs developed to maximize the benefits of new ammonia and urea plants of every size and purpose with an eye on unique advantages that Clients gain from services provided by Casale, being the only company in the world owning all the related technologies and know-how.

ELECTRON MICROSCOPY ANALYSIS AS A TOOL TO IMPROVE GRANULAR FERTILIZERS

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The structure of granulated fertilizers can be very complex as it depends on many factors, such as the raw materials used and the granulation process applied.
In addition, it may evolve over time as it is susceptible to environmental conditions such as temperature and air humidity.
An extremely useful tool to better understand the external an internal structure of fertilizer is the electron scanning microscopy.

In this paper, actual examples of the how this analytical technique can be used to better understand the structure of granulated fertilizers are shown. Sample preparation methods are described.
The versatility of the technique, as it not only used to image the structure but to identify chemical species and map them throughout the structure is also demonstrated.
Its application to better understand and solve granular fertilizer problems such as dust generation and caking is also shown.

THE OCCURRENCE OF SERENDIPITY DURING 50 YEARS OF PHOSPHATE RESEARCH... CRYSTALS GALORE!!

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The problems associated with voluminous sludges formed during shipment in Rail Cars and Ships of Merchant Grade 54% Florida derived phosphoric acid were expensive and messy. These rail car sludges could amount to several thousand Kgs of sludge in returning cars, and many tons in ships.

This led to the development of an acid that did not form sludges during shipping. The acid was evaporated at 58% P2O5 and was black in colour, rather than dark brown, and did not precipitate much if any solids during shipping, even over several months.
The acid was successfully used by Agrico and IMC for many years for shipment all over the USA for fluid fertilizer manufacture made by pipe reactors, and for suspension fertilizers.

On a very cold and crispy night in Iowa, I was called to investigate a rail car that was indeed frozen completely solid. There hangs a tale of two years of Research and Development of an intriguing process, that culminated in a 5 gpm pilot plant that crystallized phosphoric acid, and on re- crystallization produced a technical grade phosphoric acid.

No solvent nor any chemicals were needed!!! However the raffinate was so bad we could not dispose of it. We just required a better acid such as that produced by OCP, or other acids produced from rocks less contaminated with the usual iron, aluminium and magnesium impurities.

PHOSPHORUS RECOVERY FROM SEWAGE SLUDGE ASH BY A WET-CHEMICAL PROCESS

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By the end of this century phosphate deposits with low concentrations of hazardous substances, primary cadmium and uranium, will be totally exploited.
Phosphates cannot be substituted for plant nutrition by other substances. Thus, usage of secondary phosphate materials is becoming more and more important.

Recovering phosphorus from ash enable the recovery of 80 % of the inflow load to a municipal wastewater treatment plant (WWTP). The recovered phosphorus can be sold to the phosphate or fertilizer industry.

The PASH process (Phosphorus Recovery of from Ash) enables phosphorus recovery from sewage sludge ash or ashes from the incineration of meat and bone meal.
The recovery of the phosphorus content starts with leaching the ash with diluted hydrochloric acid in a stirred tank at ambient temperature.

Elevated temperature results in an increased iron concentration in the resulting leach solution and shall be avoided. The leach solution is filtered and the filter cake is washed with water and then carefully de-watered. The liquid filtrate (leach solution), containing phosphorus, calcium and metal compounds, is passed to a purification step for selective metal recovery followed by phosphate precipitation.

Keywords: leaching, solvent extraction, incineration; phosphorus recovery, sewage sludge

CHARACTERIZATION AND VALORIZATION OF TUNISIAN PHOSPHOGYPSUM IN PRESSED UNFIRED BRICKS AND AUTOCLAVED BRICKS

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In Tunisia, the production of one ton of phosphoric acid generates about 5 tons of phosphogypsum (PG). The object of this work was to explore the feasibility of unfired bricks made with phosphogypsum pressed uniaxially with the addition of sulfate resistant cement, lime and siliceous local sand.

After characterization of raw materials by XRD, XRF and grain size, formulations for the manufacture of specimens were carried out. The compressive and flexural strength, water absorption, volumic mass and ultrasonic pulse velocity were investigated after 3, 7 and 28 days of curing.

The results reveal that PG incorporation increased the volumic mass and mechanical strength values mainly when the cement ratio is equal or over 7%.
The compressive strength can overpass 25 N/mm² after 28 days of curing. On the other hand, water absorption oscillates between 3.42 % and 16.88%. Furthermore, the autoclave curing enhances these proprieties.

After leaching, the concentration values of heavy metals were below regulatory limits. The prepared brick can be considered non-hazardous materials.
This technique will consume a large quantity of PG, conserve raw materials and reduce waste materials effect on environment.

NEW APPROACH AND CASE STUDY TO MITIGATE ENVIRONMENTAL IMPACTS FROM PHOSPHOGYPSUM STACKING

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The process of producing phosphoric acid from the reaction of phosphate rock and sulphuric acid generates significant amounts of calcium sulphate, a by-product that is commonly referred to as « phosphogypsum ». Phosphogypsum can be used in a wide variety of applications, but from the large quantity produced annually worldwide, only a small part of it finds a commercial use. The majority of the rest has to be stored in large stacks or, in some cases, discharged into water bodies or used as backfilling material in open-pit mines.

On land, phosphogypsum can be stored by stacking in wet or dry forms. If not adequately designed, the disposal of phosphogypsum may become a significant source of environmental impacts such as highly acidic seepage water and leaks of impurities (including heavy metals, fluoride compounds and various naturally-occurring radioactive elements) into the subsurface and the groundwater. Potential release of carcinogenic radon gases may also occur. In addition, stability of the stacks has to be carefully studied and sometimes dust emissions from the stacks might also be a problem.

However, most of these potentially harmful issues could be mitigated, or avoided, by use of adequate environmental management tools.

The environmental impacts of phosphogypsum stacks depend on the hazard posed by the materials they contain and by the site-specific conditions. Thus, studying the specific characteristics of the phosphogypsum and the specific hydrogeological conditions present at the site leads to the development of powerful predictive models (contaminant dispersion model, dust dispersion model, stability model, etc), which can then be used for designing more efficient and environmentally effective stacking methods. When applied to existing stacks, these innovative methods may also help to define mitigation solutions.

These methods have been applied successfully to an existing dry stack of phosphogypsum in Belgium and to a future stack in Morocco, leading to cost-effective solutions and sustainable reductions of environmental issues.

PILOT TESTS FOR THE USE OF AFITEX GEOCOMPOSITES IN SLUDGE BASINS OF MEA PROCESSING UNITS

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The enrichment of the phosphate ore is currently carried out at the OCP plants by the washing, grinding and flotation process. This type of treatment generates fine and coarse rejections where the sludge fraction (100 to 110 g / L), usually composed of schlamms (‹ 40 µm) and flotation rejects (‹ 125/160 µm), is thickened in decanters to separate water.

About 80-83% of water is generally recovered at the decanter and then recycled to the treatment units. The rest is transferred to the dikes in the form of sludges having a solid concentration ranging from 300 to 350 g/l.

From the dikes, approximately 10 to 12% of water is recovered and then recycled to the treatment units. An important part of this water (about 6 to 8%) remains unrecovered and can be a water that:

- evaporates due to strong sunlight and high temperatures.
- seeps into the soil,
- remains trapped in the sludges.

In order to increase the recovery of the water contained in these sludges, this work was undertaken following the collaboration of the OIK, R&D and AFITEX teams. The main objective is to carry out pilot basin tests to develop and assess the good functioning of a range of drainage's geocomposites for a better recovery of the water from the dikes and a good stability of the walls of the basins.

The results of these tests highlighted several interests of the Draintube (geocomposite) compared to the traditional solution of the natural basin.

- Solid percentage less than 1% in the recovered filtrate. This makes it reusable at the treatment units,
- protection of dikes from erosion and instability at the basin slope;
- at the bottom of the basin:
  - optimized drainage;
  - recovery of 20% more filtrate than with the traditional basin;
  - limitation of surface evaporation of the basin;
  - drying up a large volume of sludge over a short period of time.
- Preservation of groundwater by limiting infiltration through ponds.

DEWATERING OF PHOSPHATIC SLIMES BY CARBONATE BASED PARTICLES

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Phosphatic slimes particularly those of sodium bentonite (montmorillonite) origin are well known for their resistance to sedimentation.
In this respect, bentonites especially have been a subject of various studies involving flocculation by polyacrylamide based polymers. However, polymer free systems have received less attention because phospahatic slimes are especially persistence in nature and thus present limited success to such remedies. A few studies available in literature involve addition of coarse calcite particles to accelerate settling of clay particles.

In this study, settling behavior of sodium bentonite in the presence of various carbonate-based solid is examined as a function of % solids, external particle loading, pH and modifications. Various pretreatments such as calcination were applied to modify the additive minerals such that their shape and surface roughness are made conducive to agglomeration.

In addition to these physical modifications, chemical modifications such as pH were made to induce electrostatic interactions. Improvements in settling and dewatering were gathered top explain the mechanism of acceleration in settling process. Zeta potential and turbidity measurements were performed to discuss the kinetics of aggregation process. DLVO calculations were made so as throw light into the theoretical calculations and see the possibility of coagulation.
The results are also compared with typical flocculation results using polyacrylamide type polymers in literature.

ECOSTOCK: TOWARDS ENERGY AND WASTE VALORIZATION

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Because of the increasing global population, the change of food habits and the reduction of the total agricultural area, the agricultural efficiency needs to be improved. To achieve this, the phosphate industry produces fertilizer which fabrication process needs both electricity and heat.

In 2014, the European Union spent near 185 GWh for its production which correspond to 28 000 k per year. [1] Nowadays, the heat is wasted at the end of the process and involves energy losses which are unfortunately not fully recovered due to a lack of competitive solutions. These losses could be reused to decrease the price of production, by preheating the oven or producing electricity.

Waste heat recovering is the challenge Eco-tech Ceram (ETC) has set itself by developing a rechargeable heat battery called ECOSTOCK. It will have the ability to collect, store and release the waste heat up to 1,000°C thanks to the development and use of refractory ceramics made from recycled inorganic and industrial secondary raw materials.

With ECOSTOCK, ETC has designed an innovative heat storage unit with two major competitive advantages:

- The design of the system: modular, transportable, and turnkey;

- The eco-efficient heat storage materials: ETC develops its own refractory ceramics made from industrial inorganics by-products.

These advantages can give the system a return on investment (ROI) time between 2 and 5 years. This new solution will obviously be useful for the phosphate industry and its associated waste. It's a combination of several innovations, leading to new energy usage and revalorisation with significant impacts on energy valorisation and thus on the environment.

[1] Société chimique de France, "ACIDE PHOSPHORIQUE, PHOSPHATE," 2015.

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NEW DEVELOPMENTS AND EXPERIENCE WITH MULTI-STAGE HIGH PRESSURE PUMPING USING CENTRIFUGAL SLURRY PUMPS

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This paper covers FLSmidth Krebs' development, over the last eight years, of an extensive range of high pressure centrifugal slurry pumps for multi-stage applications.

The primary objective has been to produce safe, economical, energy efficient and maintenance friendly centrifugal slurry pumps to fulfil the expanding requirements of the mineral processing industries in the long distance transportation of tailings and mineral slurries.

Two ranges of pumps have been developed, a double cased pump (based on the Krebs' rubber lined slurryMAX-XD pump) for fine slurries and an unlined white iron cased pump (based on the millMAX pump) for more aggressive slurries.

The logic behind the development of the two pump ranges will be explained in depth covering the design and first article production, getting it right.
The methodology of the hydraulic and structural criteria requirements that are considered during the pumps' design are integrated with the use of computational fluid dynamics and finite element analysis to ensure that the pumps perform safely, reliably and with maximum efficiency.

Application of the pumps to projected operating data is explained taking into consideration specific needs for flange and foundation loads, maintenance and condition monitoring.
Some of the typical existing installations will be described with the operational data and emphasis on operational and maintenance safety.
Consideration of slurry rheology and its implication on pumping performance is discussed.

RECENT DEVELOPMENTS IN FLSMIDTH DEWATERING TECHNOLOGY

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FLSmidth is one of the world leading suppliers of solid-liquid separation equipment and has been at the forefront of many product developments in thickening and filtration in over 135 years of existence.

As mineral reserves continue to deteriorate in quality as the better ones are consumed, miners are pushed to develop lower grade deposits in more difficult locations often with increased restrictions on the consumption and use of water.

The Phosphate industry consumes significant amounts of water in arid/semi arid areas and generates large volumes of tailings. Recovering water from these tailings and disposing of the solids are new challenges for this industry .

Consequently Techniques for dewatering large tonnages of tailings, with minimal power consumption and making use of economies of scale through larger equipment are continuously being sought.

This paper will present some of the recent developments by FLSmidth including plant data from the start up of the world largest filter press.

PHOSFLOW® TECHNOLOGY FOR EFFECTIVE HEAT EXCHANGER SCALE INHIBITION IN PHOSPHORIC ACID PLANTS UTILIZING NORTH AFRICAN PHOSPHATE ROCK

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Phosphate rock grade and composition varies from region to region, posing major challenges in their processing and use in phosphoric acid production.
These challenges are overcome generally through process design and operational changes, often at the cost of production capability.

Still, scaling in heat exchangers during the concentration of phosphoric acid continues to be a prevalent problem across the globe and is frequently the source of bottlenecks in fertilizer production.

The scale composition and morphology varies across the plants, and often scale removal is ineffective, risky and resource-exhaustive. In this scenario, an alternate approach of scale inhibition may offer desirable outcomes.

Successful scale inhibition in heat exchangers using Solvay's PHOSFLOW® technology was demonstrated at a fertilizer plant in India that utilizes a combination of North African phosphate rock and operates with multistage evaporation of phosphoric acid.

This paper discusses the key benefits resulting from PHOSFLOW® technology which includes increased unit production up to 15 %, production cycle extension from 14 days to 31 days and reduced cleaning time up to 70%.

SMARTCYCLONE DELIVERS NEW OPPORTUNITIES FOR PROCESS OPTIMIZATION

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This paper covers FLSmidth Krebs latest development of a unique combination of wireless and sensor technology which brings condition monitoring capabilities to traditional hydrocyclone processes.

SmartCyclone is a monitoring and control solution for reducing cyclone-related process perturbations, improving cyclone overflow particle size distribution, and predicting and controlling cyclone maintenance schedules.

The SmartCyclone™ System introduces electronic sensing and communications to FLS Krebs' hydrocyclone separator product line and the encompassing process creating an "island of optimization" for mineral processing and specialty markets.
With a SmartCyclone-equipped process, the cyclone sensors can report the functional state of the cyclone by monitoring the conditions of the slurry flow for each cyclone individually. The sensors can also report the wear status of the cyclone components, so that parts purchasing and maintenance operations can be planned in advance and with greater control.

Finally, the sensors can report when a cyclone, or the SmartCyclone system itself, is malfunctioning such as when an individual cyclone experiences a condition called "roping" or a break-down in the classification.

Utilizing SmartCyclone monitoring and control solutions, plants can achieve maximum process efficiencies through quick upset condition identification and automatic correction resulting in less process down-time, reduced variation in flotation feed resulting in improved mineral recovery, more systematic cyclone operation and continuous wear monitoring/management resulting in predictable cyclone circuit maintenance, and increased production capacity by limiting roping which allows the process to be operated closer to the limits of the cyclone manifold design.

Overall, the SmartCyclone system will help a closed-circuit grinding process to achieve a level of automation with process efficiencies previously not possible with conventional processing equipment alone.
Extended cyclone life and increased operational efficiency lead to the ideal outcome – improved comminution productivity, improved recovery and higher profitability.

NEXT GENERATION POLYMER DEWATERING OF CLAY DOMINANT TAILINGS SYSTEMS

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Observations show that mineral tailings containing high levels of clay often retain high amounts of water, which in some cases, occupies more than fifty percent of the tailings volume.
Whilst some of this water may eventually be lost to evaporation, these clay dominant systems still often require the tailings storage facilities to be built large enough to accommodate this additional volume. Should the additional water be suitable for reuse, expensive mechanical dewatering equipment is required in order to facilitate its removal from the tailings slurry and return it for reuse.

Typical of all clay dominant systems; settling, dewatering and consolidation performance is highly sensitive to pH and the ionic character of the water. Where it is not possible to have ideal water conditions, due to salinity, the prevailing water source and/or geology, the use of polymers to increase dewatering and subsequent rate of consolidation of these tailings in the storage facility is a technology of growing interest.

A number of conventional and next generation polymers were synthesized by BASF and testing was conducted across a number of clay dominant tailings. Response of each chemistry was observed with varying clay content, measuring the impact of mixing dynamics, water release, yield stress profiles and eventual consolidation of the polymer treated solids.

IMPROVING GAS CLEANING EQUIPMENT OPERATIONS THROUGH REDUCTION OF BLOCKAGE BY SOLIDS

GRAEME COUSLAND
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Process gases in Phosphoric Acid and DAP production (and in Sulphuric Acid plants) are usually contaminated by insoluble solids and sticky fumes, which then block the gas scrubbing or gas filtering equipment installed to prevent emission to atmosphere.

To improve operational performance and to minimize maintenance and cleaning, optimized packing materials are now available for cross-flow and vertical fume scrubbers, delivering longer life and better results. Granulator scrubbers are also an ideal application for these materials.
When used in a Separator, these materials will achieve high droplet removal efficiencies, with minimum loss of energy & capacity, which benefits a plant's water balance. Solids and fumes can also be handled without blocking using Begg Cousland Envirotec's "Becoflex" rotary brush technology, for example as a package system for phosphate materials handling.

Sulphuric Acid plant inlet air depends on it's cleanliness to avoid downstream problems of blockage by dust, which leads to plant capacity restrictions and frequent filter washing. Selection of reliable upstream filters, combining a balance of good efficiency and low pressure loss is required, and these too can be enhanced with new filtration media.
The paper will review and give examples of these issues, solutions and results.

“BARRACUDA® - A REVOLUTIONARY NEW MINING CONCEPT”

BERGBAU ULLRICH MENTGES
thyssenkrupp Industrial Solutions AG, thyssenkrupp Allee 1, 45143 Essen, Germany

For mining in hard materials with a compressive strength of up to 50 MPa, thyssenkrupp has developed the BARRACUDA® which is the next step in thyssenkrupp’s compact bucket wheel excavator program.

With an improved steel structure and innovative bucket wheel, the BARRACUDA® widens the field of application of bucket wheel excavators from digging only to cutting and digging. As a matter of fact thyssenkrupp introduces a mass cutting machine for harder materials with high throughput rates into the mining world.
It also substitutes drilling and blasting completely which eliminates a substantial cost factors in mining operations.

Furthermore the BARRACUDA® is designed to be highly flexible, with different systems to introduce it to the existing mine environment, adaptability in the block geometry and different options for the choice of power supply.

Therefore the BARRACUDA® can be adapted to the existing conditions and to be as cost-efficient as possible. It thus bears a huge potential for a step change and to reach considerable improvements in mining operations.

THE WATER FOOTPRINT – RESOURCE OPTIMIZATION

EMMANUEL LENAIN
SUEZ International – Africa Near East

The Water Lily Solution The Waterlily® solution was developed by SUEZ in order to complement the environmental and economic performance approach of the industrial sites (PerformEE) on the water component. Beyond a simple water balance, the water footprint is an indicator that reflects the potential environmental impacts of water use (on a given site, a given facility or for a commercialized product).

This measurement system takes into account (based on ISO 14046): The quantities and the quality of the direct and indirect waters involved in the processes studied; Temporal and geographic specificities (especially areas of high water stress); Different environmental impacts: ecotoxicity, eutrophication, etc.
The approach is deployed in 4 main stages:

1. Water balance: completion of the inventory of direct and indirect consumptions, effluents;
2. Assessment of the water footprint: translation of the water balance into impacts on health, resources and ecosystems;
3. Optimization of environmental and operational performance: analysis of the water balance and impact assessment in order to draw up an action plan (with identification of the associated environmental benefits) for operational solutions to be implemented;
4. Communication: valorization of implemented actions Benefits

The opportunity to MEASURE its performance while OPTIMIZING OPEX / CAPEX costs; A unique INDICATOR in accordance with the ISO 14046 standard to COMMUNICATE in a pertinent way on your commitment and your actions in the preservation and valorization of resources; EXHAUSTIVE CARTOGRAPHY of the flow of water in circulation in your process to KNOW the consumption and the evolution of the quality; An expert proposal force to consider SOLUTIONS improving your performance and contributing to the development of your WATER STRATEGY.

Case study SANOFI Our methodology has already been used to evaluate the environmental performance of several manufacturers. For example, it has enabled SANOFI, the leading pharmaceutical company in France, to optimize the management of its water cycle at its plant in Toronto, Canada.

A complete water balance of the site was realized and numerical optimization tracks were proposed enabling the site to reduce its water uses by almost 50% while optimizing their operational costs and minimizing investments.

FROM SEAWATER TO DRINKING WATER: HOW CAP HOLDINGS' NEXGENDESALTM SYSTEM MAKES IT HAPPEN

ROBERT L. CAMPBELL
CAP Holdings Co. LLC, 94102 San Francisco, California

The NexGenDesal™ System Achieves the Lowest Specific Power Consumption and Carbon Footprint in the Industry, Using Only Renewable Power, No Chemicals, No OnSite Operators, Remaining Environmentally Benign, at the Lowest Projected Total Cost of Ownership If you wonder how NexGenDesal achieves this, follow us through the steps from seawater to drinking water.

It begins with years of systems engineering refinement, achieving uniquely advanced performance attributes which demonstrate the whole system works greater than the sum of its parts. Approximately 80% of the highly engineered NexGenDesal™ System components are commercially available off the shelf (COTS), while the remainder are highly proprietary, the result of almost 20 years work alongside several U.S. National and foreign Laboratories.

Energy Source

- Renewable sources (such as solar, wind, sea kinetic, and waste to syngas) will run the plants independently from local electrical grids

- Intermittency of renewable sources will be solved by several new technologies including the production and storage of pressurized hydrogen, fed into a COTS fuel cell. CAP will produce both hydrogen and oxygen from water by electrolysis, using a proprietary technology unique to us, developed at former nuclear weapons institutes in the Ukraine under DoE Cooperative Research and Development contracts. The hydrogen process requires little power but importantly, produces the gases at high pressure. Pressurized hydrogen gas has the most potential as a renewable energy, which is why auto manufacturers are introducing hydrogen fuel cell cars.

- Renewable energy sources will be sized to produce the hydrogen and operate the plant

Pretreatment Stages

1. It starts with horizontal intake wells, employing below sea floor intakes that utilize highly permeable pipes. These sea wells will be accomplished by contracting with companies that have installed many worldwide, initially for aquariums, and now for desal plants. We will add technology, borrowed from the oil and gas drilling industry, to do the site surveys and lay the pipes properly.

2. Pump seawater, lifting it into the gallery to the Combined Effects Pretreatment stage (the most proprietary aspect of NexGenDesal, and replacing the need for chlorine, acid and anti-scaling polymers), a hyper-oxidation and cavitation approach which allows CHC to control scale and destroy pathogens to avert membrane fouling. Much ozone is produced in this stage.

There is an ozone contact period, creating oxidized materials to be used in the next stage.

3. Cake filtration stage, based on work pioneered at CAP and Oak Ridge National Lab (ORNL). We use a +/- 25-micron titanium screen, to catch the "cake" and use it as a filtration device, but which is self-cleaning (a very significant innovation). The pressure of the seawater is employed to create a vacuum which, in turn, periodically pulls the cake off the screen and sends it back into the brine without ever interrupting the flow the filtered seawater flow.
4. Depending upon the seawater temperature, the next step may be to heat the water in a compact, counter-flow titanium flat plate heat exchanger, also developed by CAP in conjunction with ORNL. This adjustment optimizes flux of the specific reverse osmosis membrane employed. By feeding the water around 35° C, flux increases, reducing the power required to pump seawater into the membranes, enabling the system to reach optimal efficiency at minimum power.

a. Heat may be generated by a combined solar electric/thermal system (little heat is required to reach 35° C, typically)
b. If using molten carbonate fuel cells, the system will use the heat from both air and hot water byproducts of the fuel cells.

5. When heated, water goes into a mass transfer column that converts any residual ozone back to oxygen, removing much of the CO2, thus protecting the membranes and reducing pumping energy demand. The seawater comes out hot, ozone free, and mostly gas free with suspended particles less than 5 microns.

Reverse Osmosis (RO) Stage

1. Hot water enters the RO stage, using very efficient positive displacement pumps, that employ reciprocal, multi-piston positive displacement pumps which not only are highly efficient, but reduce the acoustic signature over normal positive displacement pumps.
2. Water then enters conventional high pressure vessels, in which we employ an inter-stage design and distribution of membranes. The inter-stage design addresses the need to remove bromates and boron along with all other salts. We've certified two alternate membrane suppliers and continue to qualify others. High pressure brine is used for energy recovery, using a pressure exchanger which does not allow mixing of brine with the incoming treated seawater. This pressure exchanger contains and integral booster pump under separate speed control for process optimization.
3. NexGenDesal's normal 36% drinking water from seawater recovery rate achieves critical point optimization for the system, based on the physics of the pressure loop: the energy requirement is minimized, while maintaining the specific brine velocity that eliminates the problem of membrane fouling, while yielding lower concentrated brine at optimum discharge velocity for mixing into the sea. It has taken years of system engineering to achieve this critical point optimization.
4. Heat is removed from the permeate and brine by the heat exchanger.
5. Brine will be mixed into the sea using "duckbill diffusers," a proven, maintenance free technology, causing no measurable impact on the marine environment. Water will exit at a relatively low flow rate, with no chemicals and within 1-2 degrees of ambient water temperature.

Lights-Out Operation

- Plants will run automatically, requiring no on-site operators, and will be controlled remotely via a commercial Secure Supervisory Control and Data Acquisition (SCADA) system unique to CHC with a sensor set that has been tested over several years, in conjunction with the Department of Energy.
- Plant will be connected to CAP Monterey Bay Operation via selected satellite systems that do not employ ground stations, eliminating less-secure Internet and phone connections, utilizing a highly compressed, secure burst communications protocol, with most of the predictive diagnostics based on a wide range of sensor inputs including acoustic characteristics of the operating plant.

GROUNDWATER SALINITY MAPPING OF FOUM EL OUED – LAAYOUNE AGRICULTURAL PERIMETER AND PROPOSED MANAGEMENT

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Water scarcity in arid regions necessitates the use of saline groundwater for irrigated agriculture. This also applies to agricultural farms in Foum El Oued – Laayoune where in most of the farms alfalfa and maize are the major crops, which are moderately sensitive (MS) to salt tolerance, and do not match with the current groundwater salinity.

Farmers are of the views that both soil and water salinity are negatively impacting the forage production in Foum El Oued – Laayoune.
It is, therefore, essential to understand current groundwater quality (salinity and sodicity) for better management and use of this important resource for crop production.

In order to accomplish the groundwater salinity map, 67 water samples were collected from agricultural farms and their salinity and sodicity (sodium adsorption ratio) levels established in the laboratory.
GPS coordinates were also recorded to prepare groundwater salinity map using GIS tool and Inverse Distance Weighted (IDW) method.
The maps clearly reveal a heterogeneous nature of soil and groundwater salinity and most of the farms present salinity levels much higher than the salinity tolerance levels of both maize and alfalfa crops.

This requires regular monitoring of root zone salinity and careful management through leaching to assure soil salinity is below the threshold salinity levels.
However, this is not always possible due to higher water salinity levels and for salt-sensitive crops (such as maize and alfalfa), where fresh water is required to dilute water salinity through appropriate blending.
In the absence of fresh water, the other option is to adopt salt-tolerant crop production systems (biosaline agriculture).

In this paper we will present and share the latest status of soil and groundwater water salinity in the agricultural farms of Foum El Oued – Laayoune and discuss various options for their management. In addition, nutritional aspects with respect to soil pH of Foum El Oued agricultural farms will also be discussed and integrated nutrient management in the light of 4 Rs (Right source, Right Time, Right Place and Right rate) will be discussed to improve soil fertility of the Foum El Oued farming area.

Key words: Soil salinity, groundwater salinity, Foum El Oued, maize, alfalfa

PRACTICING COMPOST AND BIOFERTILIZER TO ENHANCE PHOSPHORUS AND NITROGEN AVAILABILITY TO QUINOA CROP PRODUCTIVITY AND IMPROVING HEALTH OF SANDY SOIL

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Sandy soils are commonly found in desert environment in most of the arid regions, such as GCC countries and Sahara deserts of Morocco. The sandy soils are inherently low in fertility. Sandy soils are prone to erosion losses and leaching of water and nutrients.
A plausible approach to make the sandy soils fertile and productive will be the addition of compost to improve soil tilth, and biofertilizers for slow and sustained release of nutrients, especially N and P in organic forms.

The researchers at the center are recycling green waste collected from farm to valuable compost at a pilot scale facility and using in different experiments. At ICBA a long term programme is underway to test the suitability of biofertilizer and compost as soil conditioner as well as a source of plant nutrients. Together with these amendments bio-based soil health enhancer (Bontera) is also used to facilitate nutrient release and improve metabolic activities of both soil microbes and plants.

The results from these long term experiments will be shared and discussed in the conference.
More specifically, the results include the release and plant uptake of nitrogen and phosphorous in soil amended with compost and Bontera as a source of biological active humates and effective microbes that include a battery of P solubilizers.

The experiment was conducted on Quinoa crop at two irrigation levels (50% & 100% ETc) using drip system. The results have shown that the Co-application of Bontera (biofertilizer) with other amendments has shown positive and promising effects on soil-plant system and crop productivity.

The results show irrigation equivalent to 50% ETc did not cause a significant reduction in biomass as compared to 100% ETc which is considered a significant observation in terms of water economy. In addition, a saving of 25% chemical fertilizer can be achieved through the application of Bontera when used @ 1-2 L/ha as foliar application.

The presentation will summarize the results from field experiments, as well as laboratory studies that showed substantial release of available N and P during incubation for 8 weeks and improvement in soil properties.

Key words: Compost, Biofertilizer, Bontera, Quinoa, Sandy soil,

FORAGE PRODUCTION SYSTEM ON SALT-AFFECTED FARMS IN FOUM EL OUED – LAAYOUNE

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Soil and groundwater salinity is emerging as significant factor in Foum El Oued agricultural perimeter for long term sustainability of maize and alfalfa production. Long term use of saline water for irrigation can accumulate salts in the soil and adversely affects crops production through physiological stress and ion toxicity.

The goals of this study, is centered on addressing the challenges in marginal environments like the irrigated area of Foum El Oued – Laayoune, to evaluate and introduce alternative salt-tolerant forages for sustainable production, and efficient use of saline water resources.

Alternative crops (sorghum, pearl millet, barley, cowpea, sesbania) were tested in Laayoune in a farmer field under saline irrigation (10 dS/m) in sandy soil. Drip system was used for irrigation. The alternative crops were planted in mid-October 2016 with 3 replications for each species. The monitoring included plant fresh and dry weight, grain yield, leaf nutrient analysis and forage quality.

This paper will discuss the feasibility of these alternatives crops on salt-affected farms in Foum El Oued – Laayoune conditions and the sustainability of this cropping system in terms of soil fertility and environment preservation.

Key words: Forage production, Foum El Oued, Alternative crops, cropping system, Foum El Oued

INNOVATION AND TECHNOLOGY FOR SOIL FERTILITY ASSESSMENT AND FERTILIZER RECOMMENDATION

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Lack of site-specific soil information, either on soil health or soil fertility, is one of the major problems faced by African smallholder farmers in increasing their productivity. Over the last decade, concerted effort has been devoted by various international stakeholders towards addressing soil fertility issues in Africa.

One of the laudable initiatives is the mapping of soil fertility, which took advantage of recent advances in digital soil mapping. However, there is a need to improve digital mapping of soil fertility at a scale that allows for site-specific fertilizer recommendation and nutrient management. This paper will highlight the challenges of site-specific fertilizer recommendation aimed at providing fertilizers that are well adapted to various crops and soil conditions in Africa, ranging from crop nutrient measurement to yield calibration and economic analysis.

In addition, the importance of partnerships and transdisciplinary research collaboration covering digital soil morphormetrics, advanced soil and plant analytical techniques, chemometrics, crop modelling, and agronomy will be discussed. We will continue to leverage on partnerships and transdisciplinary research collaboration to drive science-based sustainable intensification for resource-constrained African smallholder farmers.

RECENT DEVELOPMENTS IN SUSTAINABLE P MANAGEMENT STRATEGIES/TECHNOLOGIES IN THE CROP PRODUCTION SYSTEM: A SYSTEMATIC REVIEW

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The significance of sustainable management of phosphorus (P) in the crop production system for achieving global food security and environmental sustainability is well known. Considering this important fact, significant efforts are already underway globally to improve phosphorus use efficiency (PUE) in the crop production system, and numerous strategies and technologies have been reported over the recent years in this regard.

However, we are unaware of any systematic review of recent developments in sustainable P management strategies/technologies at various stages of the anthropogenic P flow (inflow, storage, outflow) through the crop production system.

Therefore, based on a systematic review of relevant published literature over recent years (2010-2017), this study presents an overview of the recent advancements in sustainable P management technologies associated with P inflow, storage and outflow in the crop production system. Input-side strategies/technologies are associated with appropriate forms of P fertilizer to enhance the bioavailability of P to plant roots, appropriate placement of fertilizer to enhance PUE by plants, appropriate dose or quantity of fertilizer, appropriate timing of P fertilizer application, appropriate crop combination and biotechnological development.

Storage-side strategies/technologies are associated with application of chemicals/amendments that help plant to utilize the soil residual P or help to release P that are adsorbed or bound to soil particles, improving chemical/ physical properties (i.e. pH, moisture, aeration, root-penetrability) of soils, and soil microbial inoculation. Output-side strategies/technologies are associated with minimizing runoff and soil erosion i.e. reducing tillage, creation of vegetation buffer zone, selection of appropriate crop types/ combination, and changing farming systems i.e. changing grazing patterns of livestock.

Based on this overview, this study prioritizes the key strategies/technologies that might be utilized to minimize unnecessary/excessive P inflow, storage and outflow to achieve sustainable P management in the crop production system.

POSTERS

TOWARDS REVEGETATION OF THE COVER MADE WITH PHOSPHATE MINE WASTES IN ORDRER TO CONTROL THE AMD GENERATED AT KETTARA PYRRHOTINE CLOSED MINE, MARRAKECH, MOROCCO

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In Morocco, many mining sites have been abandoned after their long exploitation without any post mining management. Tailings and residues are harmful to the environment by their negative impacts: soil and water pollution, horrific visual effects, impacts on flora and fauna and local population health.

The Kettara mine, located 30 km north-northwest of Marrakech, is an example of abandoned mining sites. Mining discharges were exposed to weathering factors giving an Acid Mine Drainage (AMD) affecting ground water and neighboring environment.
In order to minimize the AMD effect, the phosphate mining by-products were used as a cover to neutralize the soil acidity and to reduce water infiltration. One of the aspects investigated was the influence of vegetation cover.
In this study, the floristic diversity of vascular plants, found in the Kettara mine area, was examined. Promising quantitative and qualitative results were obtained from the study. The flora of the mine area is highly diversified: 182 species belonging to 139 genera and 44 families containing three strict endemic species of Morocco and seven species that are considered rare.
The life-form of harvested species indicates a predominance of hemicryptophytes (24.73%) and chamaephytes forms (9.34%). These kind of plants could play a very important role in the rehabilitation and reclamation of the Kettara mine as a tool to stabilize mine discharges and reduce the water infiltration, for the reclamation of an open-cast phosphate mine sites in Morocco.

Key words: Vegetation cover, floristic diversity, life-form, mining discharges, Acid Mine drainage, stabilisation, Kettara mine.

TAILORED BLENDING DEFINITION AS A SOURCE OF FLEXIBILITY IN CONTROLLING MINE PRODUCTION

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The phosphate extraction process of at the Ben Guerir deposit feeds 15 ore stocks of different chemical characteristics. The production decisions impact the replenishment of these stocks, which can be strongly delayed in time.

The ore demand to be met for the export or production of phosphoric acids does not concern these primary ores but blended ore grades matching certain chemical characteristics. The cost of this transformation is not very sensitive to required grade and many possible blending “recipes” lead to the same end product.

The structure of this grade demand fluctuates over time and orders are known only a few weeks in advance. The structure of ore stock replenishment also changes significantly over time.

This paper shows that degrees of freedom in blend structure, unfortunately often ignored, are available:

1) To meet demand while limiting recourse to emergency procedures to offset ore shortages;

2) To limit temporary storage of quantities of certain produced ores due to insufficient storage space in the blending zone. Mathematical programming can be used to define tailored blends based on available ores to meet demand within a few weeks, and so avoiding or limiting costs induced by use of a standard mix of primary ores. This is illustrated by a number of examples. The parameterization used in the formulation of the problem enables instantaneous adjustment to any change in thecharacteristicsoftheextractedoresandrequiredgrades.

APPLICATION OF GEOPHYSICS FOR THE DETECTION OF DERANGEMENTS OF PHOSPHATE LAYERS IN OULAD ABDOUN BASIN

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The phosphate series of the Oulad Abdoun basin begin in the Maastrichtian by phosphate deposits that are relatively very marly and end at the Lutetian by a limestone slab. Dérangement is any disruption of the usual succession of the phosphate series which disrupts the evolution of the kinematic chain, and thus leads to a reduction in both the production and profitability.

In this case, we have a partially disturbed series and the dérangement consists of a mixture of all the elements of the series (limestone, flint, marls and phosphate). This work has been carried out in two ways:

- The first which is purely geological consisted in identifying the different layers of the Oulad Abdoun basin in the El Halassa site and their continuity at the outcrop. These observations allowed us to conclude that the basin has two kinds of dérangement: a dérangement on the scale of the whole series, called major dérangement, and a second which affects only part of the series, called a minor or local dérangement.

- The other one which is geophysical. This involves the application of three geophysical methods: the electrical tomography, magnetism and seismic refraction. The correlation of these applications should result in the delimitation of the mineralized zone and the observation of all the elements that, in one way or another, affect this mineralization. These elements are designated by the word dérangement. Their identification by these geophysical methods during the prospecting would allow the definition of a precise basis for exploitation of the deposit in which the reserves estimation error may be minimal.

The combination of these methods allowed us to identify and map the dérangement zones in the El Halassa site. This study will be extended to other sites and the results may be compared and correlated in order to apprehend the extension and origin of these dérangement.

GEOLOGICAL AND GEO-ELECTRICAL CHARACTERIZATION OF THE AQUIFER SYSTEM OF THE TRANSITION ZONE BETWEEN THE PHOSPHATE PLATEAU AND TADLA PLAIN

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The present study is part of the geophysical studies undertaken in the northern zone of the Tadla plain on the edge of the Phosphate Plateau. This region actively participates in the national agricultural production, is faced with the rarity and the irregularity of superficial waters supplies. Tremendous efforts have been devoted to the exploration of underground aquifers.

These aquifers offer an annual regularization capacity which makes them valuable to ensure a steady supply in a safe and secure manner. Their reserves also make it possible to meet seasonal needs through temporary overexploitation insofar as reconstitution is possible. Based on these considerations, geological and geophysical reconnaissance of the aquifer system of the study area, which is part of the hinge zone between the phosphate plateau and the Tadla plain, could constitute an appreciable milestone that can help a better understanding of its structure and consequently its water potential.

The geological study illustrates the superposition of several distinct levels ranging from the Cenomanian to the Mio-Plio-Quaternary and showing an irregular dip from NE to SW. These levels form a large mono-synclinal depression.
This configuration was confirmed by data from the geophysical investigations of the prospected area. Indeed, the results of vertical electrical soundings and electric tomography show the superposition of several layers of contrasting electrical resistivities ranging from 2.5 to exceed 350 Ohm and thicknesses varying from 15 m to 300 m. These layers form a monoclinic structure that dips from the NE to the SW.

This structure is affected by a series of faults which are at the origin of the collapse of the compartments located to the south of the zone. The plateau-basin boundary is also marked by a series of ENE-WSW oriented flexures resulting in geoelectric discontinuities on the resistivity sections.

PHOSPHATE FLOTATION CELLS STUDY AND SIMULATION USING THE CFD APPROACH

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The agitation is a complex homogenization operation involving hydrodynamic, thermal, chemical and mechanical phenomena. When carried out industrially, it requires a rigorous investigation to ensure an optimal performance. This operation is widely used in the phosphate industry, during both ore beneficiation and chemical treatment.

In our case, the purpose of the study is to underline the key elements that intervene in the flotation cell and to analyze the hydrodynamic behaviors during this phosphate beneficiation process. For this purpose, the flotation cell is assimilated to a stirred tank with multiphase flow of phosphate pulp.

In this work, we are interested on the use of computational fluid dynamic (CFD) to study and to simulate agitated tank, in order to study the complexity of the flow of the phosphate pulp within the phosphate flotation cell.

The main aim of this work is to investigate the principal criteria that can afford optimal performance. Especially, the dissipated power, the pumping flow and the critical impeller speed. For these performance criteria, the results of CFD calculations agree well with those obtained experimentally.

Keywords
Phosphate; flotation; CFD; agitation; multiphase Flow.

MODELING AND OPTIMIZATION OF WATER RECOVERY THE SLUDGE FROM BENEFICIATION PROCESS OF PHOSPHATE ORE USING EXPERIMENTAL DESIGN METHODOLOGY

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Most industrial process consumes and throws out a lot of wastewater. Particularly during ore phosphate beneficiation (Washing and flotation units) the huge quantities of sludge is engendered. This sludge is disposed or stockpiled within mine site. It is deposed in basins over an area or several dozen hectares. This represents a significant management challenge for operator.

The sludge, which contains the huge quantities of water, should be dewatered and the water could be recycled for news uses. However, this operation costs expensively, because it must a long time for recovering water.
To minimize disposal costs, the sludge is often mechanical dewatered prior to disposal.
Due to high thin particles content and low speed of sedimentation, reuses water is not economically attractive option. In fact, there are many parameters that control the sedimentation process. Several works were carried out to study the effect for some parameters from the recovery rate sludge's water.
Traditionally, a scientist carries out experiments way by varying the parameters the ones after the others. This method gives results but is very expensive in time because it inevitably requires the realization of a great number of experiments.
This is why it is important to help the scientist to achieve his experiments with design of experiment (DOE).
By this mythology, the scientist knows how to plan experiments. The experimental step will help him structure his research in a different way, to valid his own assumptions, with better understanding of the study phenomena, and to solve the problems.
The objective of this work is to present modeling and optimization of water recovery the sludge from beneficiation process of phosphate ore using experimental design methodology. This sludge is produced from a process of beneficiation of a phosphate ore. By a screening design (Hadamard Matrix) we evaluated the effect of five parameters on this rate.
The data analyses of this screening design livered that only three parameters have an effect on this rate. By a Box-Behnken design we were able to find the values of these three parameters to achieve until 49% of water. This result has a great impact both economic and environmental.

Keywords: Phosphate, sludge, Design of Experiment, Screening design, Response surface design, Box-Behnken, Hadamrd Matrix.

CRIBLAGE DES PARAMETRES D'UN PROCEDE DE CONSOLIDATION DES BOUES ISSUES D'UN PROCEDE D'ENRICHISSEMENT D'UN MINERAI PHOSPHATE PAR LES PLANS D'EXPERIENCES

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Nombreux sont les procédés industriels qui utilisent et rejettent des eaux. Cependant les industries minières sont réputées de grandes consommatrices d'eau.
Par conséquent, ils génèrent beaucoup de rejet sous formes de boues. Ces dernières contiennent beaucoup d'eau et des fines particules. Ceci engendre des graves problèmes à la fois économique et environnementale.

Il faut de grandes étendues de terrains pour stocker ces boues et attendre beaucoup de temps pour que ces boues sédimentent et pouvoir récupérer de l'eau. Beaucoup de paramètres agissent sur le phénomène de sédimentation des boues et par la même occasion la récupération des eaux.

Plusieurs auteurs se sont intéressés au traitement de boues industrielles. Cependant dans le cas des boues issues des procédés d'enrichissement des minerais phosphatés il n'ya pas de références sur l'étude des paramètres de ce procédé.

Dans ce travail nous nous sommes intéressés à l'évaluation des effets de cinq (05) paramètres sur le taux de récupération d'eau des boues issues d'un procédé d'enrichissement des minerais phosphatés. A ce sujet notre choix s'est porté sur le plan de criblage. Nous avons utilisé la matrice d'Hadamard.
Après seulement huit (08) essai, nous avons pu, sans ambigüité, évaluer le poids de ces cinq paramètres sur le taux de récupération d'eau. Nous avons pu aussi conclure que seuls trois des cinq paramètres soumis à l'étude avaient un effet. Les deux autres sont jugés sans effet. Ceci va nous permettre dans une étude future d'optimiser ce procédé de sédimentation.

Keywords: Phosphate, boues, Plan d'expériences, Plan de criblage, Matrice d'Hadamard

MALLADRITE FORM OF HEXAFLUOROSILICATE SALTS IN WET PHOSPHORIC ACID PROCESSES: SOLUBILITY AND CHARACTERIZATION IN ACIDIC AQUEOUS SOLUTIONS AT T= 80°C

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During the process of manufacture of phosphoric acid by the sulfuric attack of phosphate, the fluorine is released with the gas stream in the form of HF and SiF4, as solid phases with the gypsum and remaining in the phosphoric acid produced.

The hexafluorosilicate salts are combined with other impurities in the acid phase produced, to give birth to other aqueous and solid chemical species, inducing the problem of fouling. Reactors, pumps, and pipes, are clogged by the solids which compromises the production chain. In practice, the scale will be deposited on the reactor walls, and cleaning is often needed.

The valuation and resolution of some problems (such as fouling) encountered in the industrial production of phosphoric acid are of great interest, and enable better production yields of phosphoric acid.

The knowledge of the physical-chemical properties of these compounds and their mixing in phosphate industry for which the literature indicates that significant deficiencies exist, allows a better understanding of the mechanisms governing such complex thermodynamic equilibria.

The solid phases obtained in the digestion stage were analyzed and characterized using different techniques, such as chemical analysis, X-ray diffraction, Fluorescence, Infrared spectrometric.
The solubility of hexafluorosilicate compounds was made in acidic aqueous solutions according to the nature and the concentration of acid at the temperature 80°C; the mineral solubilities were also examined and analyzed.
In another way, our previous measurements of the malladrite system were combined with reference pure water, Na2SiF6(s) solubility data to develop a chemical model that evaluates solute and solvent activities, and the thermodynamic characteristics, solubility products ( ) were also given.

ETUDE D'IMPACT DE MAGNESIUM DANS LA FABRICATION DE L'ACIDE PHOSPHORIQUE (ACP) ET SON EFFET SUR LE COMPORTEMENT RHEOLOGIQUE DE L'ACP

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La fabrication industrielle de l'acide phosphorique (ACP) se fait essentiellement à partir de la roche phosphatée. Elle s'opère dans la majorité des procédés industriels par voie humide.

Si l'avantage essentiel de ce type de procédés est d'être moins énergétique, ils présentent aussi l'inconvénient majeur de produire des acides phosphoriques bruts impurs contenants une grande variété d'impuretés dissoutes tel que le magnésium (MgO).

Cette dernière est l'une des impuretés indésirables pour les industries de transformation des phosphates minéraux par voie humide, d'une part, vu ses effets sur l'augmentation de la viscosité de l'acide phosphorique industriel et ses effets sur la section filtration.
D'autre part, le MgO contribue à la formation de phases minérales complexes insolubles telles que la Ralsonite ($MgAlF_6Na, 6H_2O$), $MgSO_4$ et $MgSiF_6$, qui pénalisent non seulement la qualité d'ACP, mais aussi toute la chaine de procédés de valorisation en aval.

Le présent travail a en effet une double vocation. D'une part, il consiste en une étude expérimentale dans laquelle on a déterminé l'impact de la teneur de magnésium sur le comportement rhéologique de l'acide phosphorique industriel 30%P_2O_5 sur un intervalle de température allant du 25°C à 80°C. D'autre part, sur la lumière des résultats obtenus, nous avons déterminé expérimentalement l'effet de l'augmentation de la teneur en magnésium sur la filtrabilité d'une bouillie phosphorique, issue d'un banc d'essai expérimental de production d'ACP 30% P_2O_5 par voie humide selon le procédé Dihydrate.

DESULFATATION DE L'ACIDE PHOSPHORIQUE 29% EN P2O5 : AMELIORATION DE LA PERFORMANCE DE L'UNITE DE CONCENTRATION

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La fabrication de l'acide phosphorique à partir du phosphate naturel par attaque acide sulfurique engendre inévitablement des impuretés telles que les sulfates, le fluor, la matière organique et les métaux lourds.
Les ions sulfates, en particulier, présentent un taux de l'ordre de 2%, affectent incontestablement l'efficacité de l'étape de concentration de l'acide phosphorique 29% en P2O5, suite à la formation du solide qui engendre l'encrassement prématuré de la chaine de production et par conséquent une diminution du rendement de 20% voire 30% si on tient compte des arrêts de lavage sans tenir compte de la dégradation des équipements suite à l'augmentation de la pression.

La caractérisation physico-chimique du solide, formé au niveau de l'unité de concentration, par la diffraction des rayons X et par ICP-ES a montrée qu'il se compose principalement du gypse et des fluorosilicates.

Dans l'objectif de minimiser la formation du solide et par conséquent l'amélioration du cycle de production de l'unité de concentration, deux matériaux (phosphate naturel et chlorure de baryum) ont été utilisés pour la désulfatation de l'acide phosphorique 29% en P2O5 en utilisant un protocole simple qui peut être inséré à l'échelle industrielle.

La méthodologie des plans d'expériences a permis la détermination des conditions optimales pour une réduction significative du solide formé pour chaque matériau. Les résultats encourageants obtenus au niveau du laboratoire seront présentés, comparés et discutés dans l'optique d'un éventuel passage à l'échelle semi-pilote.

"Recherche effectuée dans le cadre du Centre Universitaire de Recherche Chimie Appliquée et Développement Durable CUR CA2D de l'Université Chouaïb Doukkali »

SYSTEMES DE POMPAGE PHOTOVOLTAIQUES : ETAT DE L'ART ET PERSPECTIVE D'ADOPTION POUR LA MICRO IRRIGATION

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A l'échelle internationale l'usage de l'énergie photovoltaïque est devenu important.
La faisabilité technico-économique des installations photovoltaïques se justifie progressivement vu les chutes remarquables des prix en termes des coûts des watts crêtes installés (de l''ordre de 1$/Wc en 2010 à 0.5$/Wc en 2016).
Par ailleurs, les technologies photovoltaïques peuvent présenter une solution environnementale importante comme alternative aux solutions énergétiques basées sur les combustibles pour le pompage de l'eau en agriculture.
Au Maroc, un programme national de promotion du pompage solaire a été initié en 2013 visant à promouvoir les installations de pompage photovoltaïques pour les petites exploitations de moins de 5 hectares représentant un effectif de 90% et une superficie de 44%.
De point de vue technique plusieurs recherches ont été faites sur les différents types des systèmes de pompage photovoltaïque et leurs performances. On distingue trois types de systèmes de pompages solaires à savoir les systèmes basés sur le stockage de l'énergie dans des batteries ou des réservoirs d'eau surélevés et les systèmes fonctionnant en couplage direct sans source de stockage.
Les deux premiers systèmes sont bien adaptés pour l'irrigation dans les sites isolés. Cependant, ils sont coûteux vu les coûts des unités de stockage à installer.
Par ailleurs le troisième système de pompage basé sur le couplage direct peut présenter une solution fiable économiquement s'il est bien implémenté technologiquement pour une meilleure performance énergétique.
L'étude de l'état de l'art a montré qu'il y a une diversité technologique dans l'implémentation des systèmes de pompages photovoltaïques en l'occurrence les techniques de conversion de l'énergie et d'adaptation des systèmes hydrauliques (technologies des panneaux photovoltaïques, algorithmes MPPT, convertisseurs, onduleurs, type des pompes).

La technologie des systèmes de pompage photovoltaïques en couplage directe est prometteuse mais elle présente parfois une insuffisance pour répondre aux besoins en eau dans différentes conditions atmosphériques, due à la variation du débit tout au long de la journée et qui sera l'objectif qu'on vise à améliorer.

CONCEPTION OF PHOSPHORUS FERTILIZERS COATED BY BIOPOLYMERS: EFFICIENCY AND IMPACT ON THE CHEMICAL AND BIOLOGICAL SOIL QUALITY

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World population is growing and fertilizers are one of the most important elements for agriculture to insure global food security. Nitrogen (N), phosphorus (P) and potassium (K) are three major elements required for the growth of plants.
However, the latter consumes only a little part (30–60% N, 10–20% P, 30–50% K) and the rest is lost in the environment (volatilization, leaching or fixation) causing environmental and economic damages.

That's why researchers have paid great attention to develop eco-friendly fertilizers "Controlled release fertilizers".
The aim of our project is to improve the eco-efficiency of OCP fertilizers (NPK) using wastes and biomasses.

In the present work, we design a new generation of OCP fertilizers with controlled release, water adsorption and microorganisms' encapsulation, using biopolymers resulting from Moroccan wastes available in large quantities and at low costs.
We investigate the effect of coating technologies on biopolymers properties and determine the key parameters which influence nutritive elements release in soil, the seed germination yield and the plants growth.

Keywords: Controlled release fertilizer, Biopolymer, Biomass, Soil, Plant, Phosphorus, Nitrogen, Potassium

VALORIZATION OF WASTES AND PRODUCTION OF ENERGY AND BIOFERTILIZERS

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The management of organic wastes (organic solids and effluents) is one of the indispensable ways to ensure sustainable development for emerging and developing countries such as Morocco.

It represents real financial and environmental challenges, due to the increasing cost of wastes' treatment and the pollution risks of groundwater and soil, owing to their unstable states. Nevertheless, it is necessary to identify biomass/waste sources and to define the most efficient valorization processes based on their compositions and physicochemical properties.

Statistics show that the amount of organic wastes is continuously increasing as a result of population growth, changes in production, and consumption patterns.
At this stage, the recycling and energy recovery of abundant organic waste presents an effective solution to control the increasing energy consumption, while minimizing the environmental footprint (GHG, water and soil pollution, global warming, etc.) and providing not only new energy sources but also intermediate molecules. Those are derived from green chemistry and allow access to a range of already known biofertilizers.

The main objective of this work is to develop biotechnological itineraries via biological and thermal bioprocesses in order to better exploit Moroccan wastes (olive residues, fish wastes, tomato residues, industrial wastes, algal biomasses...) and wastewater to obtain new sources of energy and biofertilizers.

Keywords: Biomass/Waste, Bioprocess, Energy and Biofertilizer

SYNTHESIS OF CARBONATED APATITE BY ION EXCHANGE

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Pure hydroxyapatite never occurs in biological system but co-exists with its substituted forms. These are formed by partial replacement of calcium, orthophosphate or hydroxide groups. It is of current interest to find simple synthesis procedures that lead to carbonated hydroxyapatite (CAP) with controlled carbonate contents.

This paper reports a simple synthesis of (CAP) starting from hydroxyapatite powder and sodium bicarbonate. Previously synthesized stoichiometric HA from Prayon (Belgium) was used to successfully prepare CAP by ion-exchange reaction in pure distilled water. The products were characterized by X-ray diffraction (XRD), infrared (IR), Thermal analysis (TG-DSC).

The powders containing up to7% of carbonate were obtained as a function of the heating time of reaction. The contents in carbonate substitution (B type) also increased as a function on the concentration of dissolved carbonate ions. Such products may be used to analyse the irradiations accumulated in solids by their EPR spectrum related to carbonate radicals.

Keywords: Synthesis of carbonated apatite. Ion substation in hydroxylapatite

STATISTICAL STUDY AND MODELING OF THE EFFECT OF PHOSPHORIC ACID IMPURITIES ON THE PHYSICAL QUALITY OF AMMONIUM PHOSPHATE DETERMINED FROM THE PRODUCTION DATA

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Ammonium phosphate fertilizer is produced by simple reaction (neutralization) between ammonia and phosphoric acid resulting in the formation of the basic salt.
The knowledge of the physical properties of fertilizers presents a lot of interest at different level. All the problems dealing with the behavior of the particles (segregation, spreading, granulation, hardness...) need a better characterization of the fertilizers in order to understand and/or predict them.

Several works were carried out to define and control the effect of impurities from phosphoric acid on the physicochemical properties of ammonium phosphates fertilizers.
In the investigation of the influence of elements such as Fe, Al, MgO, F-, SiO2, Na2O, K2O and Cl- on fertilizer quality, we followed the production lines of Ammonium phosphate fertilizers for several months, even more than a year.

The aim of the current work is the statistical study and modeling the effect of phosphoric acid qualities on the physical quality of fertilizers such as granulation yield, grain size, and the average diameter of granules D50, based on the analysis of data from different production lines by applying the Principal Components Analysis (PCA). In addition models were constructed using Multiple Linear Regression (MLR) and Artificial Neural Network (ANN).

POTENTIAL OF SENTINEL-1 AND 2 CONSTELLATIONS FOR PREDICTING SOIL SALINITY WITH HIGH SPATIAL RESOLUTION AT REGIONAL SCALE

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Earth Observation (EO) technology provides extensive and repetitive coverage over large areas with valuable time series of geospatial and biological information.

The European Space Agency (ESA) has recently launched Sentinel-1 and 2 constellations to provide routine observations for operational services and data continuity for operational satellite systems. Sentinel-2 carries a super-spectral sensor with 13 bands in the Visible and Near Infra-Red and Short-Wave Infra-Red wavelength region. The Sentinel-1 mission provides data from a dual-polarization C-band Synthetic Aperture Radar instrument.

The large swaths and high spatial resolutions of these missions are suitable tool for surveying large areas at a high temporal and spatial interval. The high spectral resolution is especially needed for agricultural land use purposes such as soil tiling, livestock grazing and application of fertilizers.
The combination of Sentinel-1 and Sentinel-2 data for land cover monitoring in different agriculture scenarios, provides useful information on qualitative and quantitative crop changes.

This study aims to assess the complementarity and interoperability both instruments to assess soil salinity considered one of the major ecological factors limiting plant growth, particularly in arid and semi-arid regions.
The high evapotranspiration increases soil salinity and consequently decreases vegetation quality (decrease in water content, chlorophyll and mineral intake).
Results of Salinity Indices and backscattering models are evaluated against agricultural in-situ data collected in the Beni Mellal region, Morocco.

The development of these methods helps in assessing crop and soil conditions and deriving quantitatively important crop parameters. These parameters are required for a timely management intervention to allow precision management of soils and crops by optimizing fertilizer use and water management strategy in agricultural areas.

Finally, with the larger imaging capabilities of the 2 constellations, these results can be a precursor of regional to global scale mapping of the generated products.

A SIMPLIFIED METHOD FOR LABORATORY SOIL ANALYSES

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The research goal was to develop a simplified method for estimating the available phosphorus for routine analysis. This study compared the measured Soil-P using the ICP-NaHCO3 with the simplified extraction method (SM-P).

The correlation (r=0.99) and the regression(using xlstat-pro) were employed for comparing the data of available phosphorus content in soil samples for a variety of Moroccan soil types, with contrasted physicochemical characteristics: Ali Moumen, Oued Qibane, Ouled Said, Settat, Dower Lhfaya, and Had Ghoualem (are located using ArcGIS 10.1 and fertiMap).
SM-P is most suited for soils with pH →= 7 and CaCO3 content above 5%.

In this experiment, several parameters are modified, particle size, the type and degree of mechanical agitation, the color development solution (((NH4)6Mo7O24.4H2O) & (K(SbO), C4H4O6,5H2O)),1 %(w/v) (C6H8O6), and the adaptation of the reading at 860 nm, are improving the accuracy of P analysis, the high correlation of this method with ICP-NaHCO3 content can be an indication for it.

The results of this experiment showed that SM-P could be the best method for predicting the available phosphorus, simple, quick, and easy to execute.

Keywords: Fertilizer Phosphate, Extraction Methods, Available Phosphorus, Moroccan Soils

ASSESSING OF INORGANIC PHOSPHATE BIOSOLUBILISATION BY BACTERIAL STRAINS ISOLATED FROM "EL HALASSA" KHOURIBGA PHOSPHATE MINE

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Natural phosphate represents an important reserve of phosphorus (Pi), essential element for plant nutrition and development. However, direct application of phosphate fertilizers has been proved ineffective for the phosphorus deficit soils remediation due to its low solubility.

The aim of this study is to assess the ability of several bacteria species isolated from El Halassa, Khouribga deposit to solubilize inorganic phosphate. This ability has been tested and followed on NBRIP agar and broth medium with hydroxyapatite Ca5(PO4)3(OH) as sole phosphorus source.

The results showed that Serratia marcescens, Pseudomonas cepacia and Bordetella sp. presented larger solubilization halo zones on NBRIP agar, with values of 2.3, 2.6 and 2.3 cm respectively in comparison to the other bacteria. Meanwhile, Enterobacter sakazakii, Serratia marcescence and Pseudomonas cepacia showed the highest ability to release the liquid-soluble phosphate with concentrations of 1039.73 ± 1.3, 994.4 ± 8.4 and 1003, 6 ± 5.6 mg L-1 respectively in the presence of Ca5(PO4)3(OH) as sole phosphorus source.

Monitoring of the orthophosphates release in the medium for each strain, revealed that the amounts of orthophosphates progressively increase during first days of incubation and at the same time as the decreases of the pH in the media.
This can be explained by the secretion of organic acids and H+ protons by these microorganisms.

Key words: Khouribga mine, phosphate biosolubilization, NBRIP media, Hydroxyapatite, Enterobacteriacea.

SEQUESTRATION OF CO2 ADSORPTION ON PHOSPHOGYPSUM

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The problem of anthropogenic carbon dioxide (CO2) emissions as the main greenhouse gas constitutes a major component of environmental concerns at global level.
In order to reduce these CO2 emissions, various methods can be used, including mineral sequestration which is a promising approach to the problem of managing and capturing CO2 permanently and safely.

The aim of the present study is to evaluate the use of phosphogypsum (PG) as a Ca source for CO2 mineral sequestration. Our results demonstrate the high efficiency of portlandite (Ca(OH)2) and sodium sulfate (Na2SO4) by PG dissolution using an alkaline solutions. Carbonation experiments is obtained during a rapid kinetics performed at ambient pressure and temperature resulted in total conversion of the portlandite into calcite (CaCO3) with a purity levels exceed 93%.
These results show that this new methodology is especially attractive and ecologically clean, since it has the potential to reduce two environmental problems simultaneously: management of hazardous industrial by-product (PG); and greenhouse gasses emissions (CO2).
We believe that the procedure proposed here should be considered not only as a solution for problems related to the management of PG and CO2 emissions, but also for future phosphoric acid and other gypsum-producing industrial processes, resulting in more sustainable production.

STUDY OF ORGANIC MATTER IN PHOSPHOGYPSUM: ANOTHER PARAMETER OF POLLUTION INDICATOR

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The production of phosphogypsum is continuously increasing due to the need for phosphoric acid. In fact, the phosphogypsum is under product resulting from the manufacture of the phosphoric acid at the time of the sulphuric acid attack on the phosphatic sediment. The reaction of destruction of the ore releases the undesirable elements (organic matter, heavy metals ...) which in majority are trapped in phosphogypsum.

The purpose of our study will be, the knowledge of the transformation of the organic matter at the time of the acid attack. A comparative study will be undertaken between the organic compounds of origin in the phosphatic sediment and the compounds formed resulting from the acid attack. And consequently, define harmful organic materials in the environment. Moreover, the research of the organic compounds allows to make the follow-up of the contamination of environment marine.

The traditional extraction of the freeze-dried sample has enables to obtain lipids. The lipids are split by liquid chromatography in three principal parts: neutral part 28%, acid part 12% and polar part 27%. The thermal analysis, ATG/DSC shows that the content of organic matter in phosphogypsum is about 4% compared to the total mass.

The neutral part of the lipids was subjected to the second finer fractionation, by applying the same method of separation. The detailed analysis of this fraction is carried out by coupling CG-SM. It shows the presence of ramified hydrocarbons, of the linear monoacides. The N-alkanes are present of nC14 at nC29 with the concomitant presence of some doublets nCn:1/nCn:0. Another component like biomarker are present

This work can be used as a means of controlling the diffusion of new products in sea water, so help the environment service of OCP to take decision.

INNOVATIVE SCALABLE PROCESS FOR THE FABRICATION OF AN ENERGETIC PHOSPHATE ELECTRODE MATERIAL FOR LITHIUM ION BATTERIES

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In 1992, Lithium ion batteries were first commercialized by Sony and made a big hit in the market thanks to the combination of high power and high energy density, long cycle time and stability.

Currently, the Lithium ion battery technology uses LiCoO2 and graphite as positive and negative electrode materials, respectively. Nevertheless, Co has a limited abundance in nature, is toxic and very expensive.
Therefore, LiFePO4 is a good candidate to replace LiCoO2 especially in stationary applications and in electric vehicles. LiFePO4 was first reported by Goodenough et al. in 1997 as a positive electrode material for rechargeable Lithium ion batteries.
It shows a high theoretical capacity (170 mAh g-1), a high discharge potential (3.45 V Vs Li+/ Li), an excellent thermal stability, a low cost, and it is environmentally benign.

This study aims at developing an innovative scalable process for the fabrication of phosphate electrode material LiFePO4, starting from OCP's phosphoric acid with three different concentrations.
There are many parameters to control during synthesis, such as concentration, pH, reaction time and temperature, using additives or not, calcination time, temperature and atmosphere.

In the present paper, the control parameters will be analyzed and discussed and first results will be presented.

PHOSPHATES DE TYPE NASICON COMME MATERIAUX D'ELECTRODE POUR BATTERIES SODIUM-ION A HAUTE DENSITE D'ENERGIE

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Les systèmes électrochimiques de stockage de l'énergie sont essentiels pour le développement des véhicules électriques, de l'électronique portable ou des énergies renouvelables. Les batteries Li-ion offrent actuellement la plus forte densité d'énergie mais la demande croissante et la répartition géographique inégale des ressources en lithium risquent à terme de limiter la production industrielle.

Le sodium est plus abondant, mieux réparti et moins couteux. Il pourrait constituer une solution alternative intéressante, en particulier pour les systèmes stationnaires. Toutefois, le développement des batteries Na-ion nécessite la recherche de nouveaux matériaux d'électrode comme les NASICON (Na super ionic conductors) qui possèdent une forte conductivité ionique et peuvent, dans certains cas, être utilisés comme anode ou cathode.

Dans cet exposé, nous présentons une étude des performances et des mécanismes réactionnels de deux familles : Na1+xFexTi2-x(PO4)3/C et Na1+xFexSn2-x(PO4)3/C avec 0 ⩽ x ⩽ 1. Ces composites ont été synthétisés par voie solide suivie d'une pyrolyse avec le saccharose.
Ils sont constitués de particules ayant une porosité élevée et enrobées par du carbone conférant à l'électrode une bonne conductivité ionique et électronique. La structure cristalline des particules est basée sur un enchaînement d'octaèdres MO6 (M=Fe, Ti, Sn) et de tétraèdres PO4 et leurs propriétés électrochimiques sont fortement liées à la nature de M.

Les mécanismes réactionnels se produisant lors des cycles de charge-décharge ont été analysés en mode operando par diffraction des rayons X, spectroscopies Mössbauer du 57Fe et de 119Sn et spectroscopie d'absorption X. Pour les composites fer-titane, ces mécanismes sont essentiellement basés sur la diffusion des ions Na+ dans les canaux des phases cristallisées avec changements d'état d'oxydation des métaux.

Pour les composites fer-étain, les mécanismes sont plus complexes incluant insertion, conversion conduisant à la destruction des phases NASICON, puis formation d'alliages NaxSn.

CHALLENGE FOR THE ENERGY STORAGE VIA PHOSPHO-OLIVINE CATHODE MATERIALS IN LI-ION BATTERIES

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The strongest improvements in the field of Li-ion batteries might be achieved via the development of new cathode materials. Developing and improving such new cathode materials is important to provide a system for energy storage with high energy and power density. Batteries are by far the most common form of storing electrical energy and Li-ion Batteries are the mode of choice.
The phospho-olivine materials LiMPO4 (M=Fe, Mn) represent one major challenge for further improving commercial LIBs. The two elements Fe and Mn are used because they are environmentally benign and due to their high abundance in the earth's crust.
The main advantage of the LiFePO4 and LiMnPO4 materials are the low raw materials cost and their environmental friendliness.

The presence of covalent P-O bonds results in a high structural and thermal stability [1]. It provides protection against overdischarge and safety at high temperatures compared to the transition metal oxides [2].
Furthermore, LiFePO4 is considered as popular and efficient cathode materials for application in lithium ion batteries because of its high specific capacity (170 mAh/g) under normal operating conditions [3].
In this work we present the synthesis of LiFe1-yMnyPO4 via wet chemistry (sol-gel route). Pure phases were obtained with specific particle sizes. The electrochemical tests were performed using the coin cells technology. Several techniques were implemented to understand the mechanism of the electrochemical lithiation/delithiation process.

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ELECTROCHEMICAL FEATURES OF FE0.5TIOPO4 AS ANODE MATERIAL FOR LITHIUM-ION BATTERIES

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Energy storage is a broad and rapidly developing research domain that has become a primary focus of the scientific community. Batteries form a clean and appropriate method to store energy for a long-term use. Lithium ion batteries (LIB) have proven to be a widely-used power source for many commercial applications. The LIB show the best volumetric and gravimetric energy density, compared to the other various types of rechargeable batteries.

Thanks to these advantages, LIB devices can provide a reliable rechargeable system to meet the demand for clean and high-efficiency transportation.
However, there is still need to reduce costs and toxicity, increase safety, and further increase the specific energy stored in the battery materials. The electrode materials play a primordial role on the performance of lithium ion batteries. Fe0.5TiOPO4 oxyphosphate are promising candidates as anode in a lithium ion battery application, owing to their low cost and toxicity, natural abundance, high capacity and good cyclability. Furthermore, the crystal structure of Fe0.5TiOPO4 provides an open, flexible and highly stable 3D framework.

Here we report on the preparation of this functional material using a sol-gel method based on the phosphoric acid as phosphorus precursor. The first part of our presentation will focus on the crystal structure of Fe0.5TiOPO4, and its electrochemical performance. In a second part, we will provide insights into the atomic and electronic structures evolution during cycling. State of the art experimental techniques were used to carefully monitor the electrochemical reaction mechanisms involved at different lithium-ion insertion/extraction steps. This presentation will also include a computational study, which brings valuable information on the structural modifications upon lithium insertion as well as lithium-ion transport in the bulk of Fe0.5TiOPO4, using density functional theory (DFT).

OPTIMIZATION OF THE THERMAL PHOSPHATE TREATMENT BY USING PETROLEUM COKE IN CALCINATION PROCESS

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The basic technology for the heat treatment of phosphate ores is calcination, which aims to eliminate organic matter and elements considered to be particularly dangerous and toxic to ecosystems and to humans.

If the different aspects of conventional calcination have been widely studied, the calcining methods Realized and insured in the presence of petroleum coke have been studied very little. Similarly, the effects of combustion of petroleum coke in these processes on the quality of the thermo-phosphate products formed and on their use properties such as composition, particle size, density, porosity, surface area, hardness, heat capacity, thermal conductivity, etc. have never been determined.
It is precisely in this context that we are interested in studying all these aspects on the main properties of phosphate ore use in order to optimize its heat treatment.

In this work, the influences of the physico-chemical parameters studied are presented and three aspects were discussed:

I) The first part is devoted to the description of the mounting and the experimental procedures used to realize the calcination of the phosphate ore samples with and without petroleum coke.

II) The second part presents the experimental results obtained, based initially on the evolution, as a function of temperature, of the principal constituents of the ore, namely its organic matter (MO) measured as organic carbon Corg, Its mineral matter (MM) determined as carbon dioxide CO2, and its principal product apatite measured as P2O5 phosphorus pentoxide. In a second step, the thermo-physical properties of the product formed are presented.

III) In the third part, a comparison of conventional fuels with petroleum coke was carried out on the basis of a brief energy balance of the main reactions of the calcination, some of which are endothermic and others exothermic.

This empirical test could reveal the role and energy contribution of petroleum coke in the calcination process of phosphates over those conventionally used.

BIO-INSPIRATION IN NANOMATERIALS DESIGN: GREEN SYNTHESIS METHOD OF NANO-STRUCTURED OXIDES

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Nature inspires chemists and biologists to develop processes for producing molecules (enzymes ...), materials (apatite-based bones ...) and energy.
Nano-scale metal oxides nanoparticles show specific and advanced electric, magnetic, optical and catalytic properties, which make them critically important to be used in countless fields including catalysis, batteries, gas sensors, etc.

The chemical and physical properties of these nanoparticles are mainly influenced by their size, crystal phase, composition, morphology, and structure.
All of these characteristics can be controlled via synthesis methodssuch as hydrothermal, combustion, co-precipitation and sol-gel.

Recently an efficient green, energy saving and cost effective procedure has been developed, based on using biopolymers, such a biocompatible, biodegradable and non-toxic template controlling nanoparticles.

The aim of this study is to investigate gelling mechanism of biopolymers in the presence of metallic cations to produce metallic nano-oxides, which will be used in photocatalytic applications for water depollution and in energy storage.

ANALYSIS AND COMPARISON OF SWGH DESALINATED WATER PRODUCIBLE IN DIFFERENT MOROCCAN LOCATIONS

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This paper comes as a feasibility study part of an innovative desalination technology in Morocco, Country which is suffering from a serious hydric stress promising a thirsty future.

Luckily, the Moroccan government, aware of the impact weighty resulted of such crisis, has drawn up a strategy aimed at framing and strengthening the means of water production, as the seawater desalination processes.
Indeed, the international event COP22 held in Marrakech, was a good occasion to lunch a huge project of 1000 seawater desalination stations in Morocco and Africa, using a green production technology.

Always, in the same optic of water production with pollution reduction, we treat, in this work, a humidification-dehumidification desalination process, called SeaWater GreenHouse (SWGH), using an agricultural greenhouse with solar collectors as roof, combining irrigation and desalination functions by a distillation low temperature method. Thus, we will present and analyze the simulation results, provided by our SWGH Matlab Simulink modeling and made for different parameters and locations. In order to, estimate the outlet freshwater amount depending on the site choice.

As a conclusion, we will be able to draw a choice technique of the most benefic environmental, meteorological and geographic place of SWGH implementation, where a great producible is reachable

ETUDE DE LA DECOMPOSITION DES PHOSPHOGYPSES EN PRESENCE DES SCHISTES BITUMINEUX MAROCAINS

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Le phosphogypse est un sous produit des procédés de traitement des phosphates naturels et de production de l'acide phosphorique. Il constitue à la fois un déchet et une ressource en matériau dont la valorisation est devenue indispensable en raison des quantités élevées produites et des questions environnementales qui ont pris une importance majeure.
Comment donc faire passer ce sous produit du statut de déchet à celui de ressource ?

En effet, l'une des voies prometteuse de valorisation est sa transformation par grillage en présence d'un combustible solide pour produire du dioxyde de soufre SO2 et l'oxyde de calcium CaO qui constituent des ressources importantes respectivement dans la fabrication de l'acide sulfurique et la production du clinker.
De nombreux travaux de recherche ont donc permis de mettre en place des méthodes de caractérisation des phosphogypses et de comprendre certains phénomènes observés en usine (fins de prise très longues, corrosion rapide des fours, déshydratation, influences des ions monohydrogénophosphates et fluorophosphates sur la réactivité des phosphoplâtres,...). Cependant, les travaux de recherche sur la transformation du phosphogypse en présence d'un combustible solide tels que les schistes bitumineux ne sont à ce jour pas élucidés.

C'est dans ce contexte que se situe notre travail recherche afin de contribuer à la valorisation des deux ressources marocaines : Phosphogypses et Schistes bitumineux. La combustion de cette dernière ressource, dont le Maroc recèle des gisements importants, apportera non seulement l'atmosphère réductive requise mais également une partie de l'énergie nécessaire à la décomposition globale du phosphogypse tout en contribuant à la solution de la question environnementale.
Aujourd'hui, mener une stratégie de recherche & développement durable dans ce domaine, ne peut qu'augmenter productivité, rentabilité et profitabilité par l'utilisation des ces deux ressources.

Les études abordées sur cette décomposition avaient pour objectif initial d'élucider ses principales réactions ainsi que ses mécanismes réactionnels.
Elles portent sur ses aspects thermodynamique, cinétique et énergétique qui sont influencés par des paramètres importants : température, vitesse de chauffage, masse initiale de l'échantillon, masse intégrée des schistes,....
Les techniques d'analyses thermiques couplées ATD/ATG ont été utilisées pour déterminer ses influences. La liste de ces paramètres peut être étendue à d'autres et l'application de la méthodologie de la recherche expérimentale, qui tient compte des leurs interactions, permettra l'établissement et l'optimisation d'un model à partir des résultats expérimentaux afin de déterminer leurs effets sur le rendement et la qualité des produits formés.

THE USE OF MODERN CHARACTERIZATION TECHNIQUES FOR CADMIUM SPECIATION IN PHOSPHATE ORES

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Phosphate fertilisers are well known as a significant source of cadmium in soils.
In fact, Cd is a natural impurity occurring in phosphate ores and its final content in the fertiliser depends both on the type of raw material, as well as on the manufacturing process. Currently, stringent regulations are increasing the worldwide demand for low-Cd phosphate raw material.

On the other hand, Cd reducing technologies in mineral fertilisers are economically challenging and depend mainly on physical, chemical and mineralogical properties of raw material.

This paper approaches these issues by bringing novel insights on Cd speciation in phosphates rocks using modern characterization techniques such as SEM-based automated mineralogy combined to micro-fluorescence techniques.

The obtained results showed that phosphate concentration in all samples ranged from 20 to 38% and Cd concentration ranged from 58 to 306 mg kg–1. Automated SEM results showed various Cd distributions mainly related to carbonates.

MODELING AND OPTIMIZATION OF THE EXTRACTION OF CADMIUM FROM INDUSTRIAL PHOSPHORIC ACID

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Phosphoric acid is the second ranked chemical in the world production of acids after sulfuric acid. It is of great importance at the industrial level, especially in the manufacture of fertilizers (about 85%), surface treatment of metals, the pharmaceutical and fermentation industry, the treatment of wastewater, cleaning products, binders for refractories, mineral chemistry and the food industry.

Commercial phosphoric acid is mostly manufactured using thermal and wet processes. Being the method of interest in this study wet process leads to phosphoric acids of different concentrations containing impurities, which either were present in the starting ore or entrained by the reagents used in the preparation process.
Some can be recovered such as uranium, vanadium and rare earths, or penalizing substances such as arsenic, molybdenum and heavy metals (Cd, As, Se ...).

Cadmium, which is particularly toxic to the environment and to humans, follows the food chain and accumulates in the plants and in the calcified tissues of the vertebrae. Purification of phosphoric acid is a major problem.

Several methods were evaluated including precipitation, ion exchange, adsorption on activated carbon, membrane technologies such as electrodialysis (ED), reverse osmosis and liquid–liquid extraction which is the main interest of the present study.

The objective of our research work is to eliminate cadmium by the liquid-liquid extraction process during the manufacture of phosphoric acid.
The optimization and modeling of this extraction depends on different parameters that influence the extraction efficiency (choice of solvent, temperature, pH, physicochemical characterization of the products in solution, concentration, reactor type ...).

RECOVERY AND CHARACTERIZATION OF REE-BEARING PHOSPHATES

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Phosphate ores are the most important source of phosphorus, which is mainly used in industrial applications such as agriculture fertilizers and phosphoric acid production. The phosphate minerals are found within magmatic, metamorphic, and/or sedimentary deposits. They are mostly of sedimentary origin in Morocco and of magmatic origin in Canada. Phosphate ores are identified as potential sources of rare earth elements (REE).
Apatite (Ca5(PO4)3F) is the most common REE-bearing phosphorus mineral . The occurrence of REE in apatite is explained by the cationic exchange between Ca and REE, especially with light rare earth elements (LREE).
Metallurgical valorization of REE phosphate deposits is a challenge. The choice of the appropriate processing techniques depends mostly on: (i) the type of gangue minerals, (ii) the content of REE within apatite, and (iii) the degree of liberation of REE-apatite. In most cases, a combination of techniques is needed to produce the required grade.
The present study will focus on the characterization and preconcentration of REE from two types of deposits containing apatite, carbonates, and silicates. The mineralogical characteristics of the raw materials were investigated using different techniques (SEM-EDS, Qemscan, EPMA, and XRD).
After crushing and homogenization of the samples, a combination of flotation and gravimetric separation using dense liquor were used. Different flotation collectors were tested in order to selectively float phosphates (Aero702, Aero727), carbonates (S-9201), and silicates (fatty acids and Aero 845).

The mineralogical results show that:

(I) The studied apatite samples contain LREE (0.85-5.08%),
(II) 80% of the apatite is liberated in the samples, and
(III) The remaining 20% of apatite is associated mainly with carbonates (i.e. calcite, ankerite, and siderite).

The best apatite recovery scenario was obtained using Aero 702 and 845 promoters combined to a dense liquor separation.

ASSESSEMENT OF THE TRANSFER OF METALS TRACE ELEMENTS TO SPONTANEOUS PLANTS: POTENTIEL APPLICATION FOR PHYTOSTABILIZATION OF PHOSPHATE LIMESTONE WASTES

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The pyrrhotite abandoned Kettara mine, located 30 km northwest of Marrakech, is an example of area rich in metal trace elements (MTE). For the rehabilitation of the site, a hydrogeological cover system made of phosphate limestone wastes (waste rocks and phosphate sludge), was conducted to allow the reduction of the infiltration of water, and even the reduction of the production of acid mine drainage (AMD) which is a major problem of mine. To finalize the rehabilitation design, the influence of vegetation on the cover made with the phosphate mine wastes needs further investigation. In this projectthe spontaneous vegetation of the phosphate mine wastes and their vicinity are studied in order to select plants which would increase water release to the atmosphere via transpiration and control erosion and runoff in sloping areas of the cover.

The MTE: As, Ba, Cd, Co, Cu, Mn, Pb, Ti, V, Zn, are analyzed in the specimens and rhizospheric soils from six sites of phosphates mine wastes and their vicinity.

The results showed that the phosphates mine wastes contains high concentrations of Cr, Cu, Zn, Cd and V.The soilscontain higher level of heavy metals such as Cu, Zn, Pb, and V. The heavy metals of plants collectedfrom phosphates and soils showed that metal concentrations are generally lower in both roots and shoots parts than in soils and mine wastes, indicating that these plants tolerated heavy metals by the exclusion strategy. Aizoon hispanicum, Cleome brachycarpa, Anacyclus valentines, Festucaovina, Colocynthis vulgaris, Scolymus hispanicus, Herniaria cinerea, Asphodelus tenuifolius, Plantago afra, Eryngium ilicifolium, Aizoon canariense, and Sonchus sp., accumulated lower concentrations of heavy metals in shoots and roots than in their rhizospheric soils. Therefore, they are good candidates for phytostabilization of the cover made with phosphates mine wastes to control AMD at Kettara mine.

ETUDE DE LA LIXIVIATION CHLORHYDRIQUE DE MINERAI PHOSPHATE MAROCAIN

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Le Maroc est pourvu de la plus grande réserve du Phosphate au monde. Cette richesse est estimée à plus de 90 milliards de m3[1]. Les gisements se localisent dans un certain nombre de bassins situés dans quatre domaines géographiques différents [2, 3].

L'exploitation de la roche phosphatée pourrait faire l'objet d'innovations diverses [4].
L'objet de notre travail est particulièrement d'étudier l'influence des paramètres : concentration d'acide, rapport solide/liquide, durée de réaction, vitesse d'agitation et température sur le déroulement du processus de dissolution de la roche phosphatée dans le but d'en déterminer les paramètres optimaux.

Nos recherches se situent, en effet, dans la cadre de la valorisation de la roche phosphatée marocaine en matière de terres rares. Le phosphate que nous avons utilisé est issu du bassin du Gantour.
Les analyses menées sur la matrice minérale et sur les solutions d'attaque chlorhydrique ont montré l'existence de l'yttrium comme élément majoritaire.
Mots clés : Terres rares, Phosphate, Extraction

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VALORISATION OF CELLULOSIC WASTE BASIC CACTUS TO PREPARE ACTIVATED CARBON

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The cellulosic waste is the most abundant material in the earth. It is considered as renewable polymer of wood cell walls and plant cells. It is used in different field mainly as sustainable potential precursors and it is very interesting for the preparation of activated carbon.

The purpose of this study is the valorisation and production of activated carbon from cellulose waste, old cladodes of Ficus indica cactus optunia, and the residue of prickly pear seeds after oil extraction. Preparation and characterization of activated carbon (AC) from the two wastes by chemical treatment, phosphoric acid H3PO4 at a temperature of 450 °C, showed a very good adsorption of methylene blue and iodine.

This treatment illustrated a very important surface area of 820m2/g for waste seeds and more than 470m2/g for waste cactus cladodes. Analysis by infrared, pH point of zero charge showed a basic character for both carbons active developed.

WASTEWATER TREATMENT PLANT SLUDGE VALORIZATION IN CO-DIGESTION WITH BIOMASS WASTES TO PRODUCE BIOENERGY AND BIOCHARS AS FERTILIZERS

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Sludge from wastewater treatment plants is produced in high amounts, which required their management. Instead of landfilling, land-spreading and combustion, thermochemical and biological processes could be applied to sludge valorization, elimination, or extraction of valuable by-products.

These products are biogas biofuels and biochar, which could be used for wastewater detoxification, gaseous purification and adsorption (H2S, CO2…), as well as for soil amendment. Sludge will be digested alone and in a mixture with biomass wastes, mainly (tomatoes residues, olive pomace, algae wastes, fish wastes…).

In the present work, methanogen potential will be measured for different sludge and biomass wastes ratios, before and after different pretreatments, in order to investigate effect of operational conditions on bio-methane yield.

Furthermore, pyrolysis will be applied to the digestion residues called "digestate" to produce biochar, and determine the relationship between its physical/chemical properties and the sythesis temperature and other operating factors.

The purpose of this study is the design of an ecological process combining anaerobic digestion and pyrolysis to valorize wastes and to produce energy and biochars in a pilot scale.

Keywords: Sludge, Biomass wastes, pretreatments, anaerobic digestion, pyrolysis.

REMOVAL OF DYES FROM WASTEWATER USING NATURAL PHOSPHATE DOPED BY TIO2 (NP-TIO2)

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Natural phosphate is an important natural resource in Morocco which needs to be valorized. It can be used not only as fertilizers but also it has been successfully utilized as catalyst (either alone or conveniently-modified) in a wide range of organic reactions and as adsorbent to remove dyes from waste water.

The objective of this study was to prepare a new adsorbent based on Moroccan natural phosphate doped by TiO2 (NP–TiO2) and its application in the adsorption of dyes in aqueous solution. The adsorbent was characterized by X-ray diffraction (XRD), infrared spectroscopy (IR) and BET analysis. The adsorption of Disperse blue 79 (DB79), Disperse blue (DB 165) reactive yellow 145 (RY 145) and Reactive Red 141 (RR 141) was studied in a batch mode (dose of adsorbent, concentration of dye, pH and temperature).

The experimental results show that NP-TiO2 can totally remove DB79, RR 141 and DB 165 in 60 min, whereas 78% was removed in the case of RY 145 in 60 min. The adsorption rate data were analyzed using the pseudo-first order kinetics of Lagergren and the pseudo second order models to determine adsorption rate constants. The isotherms of adsorption data were analyzed by various adsorption isotherm models.

Keywords: Moroccan Natural Phosphate, TiO2, Disperse Blue 79, Disperse Blue 165, Reactive yellow 145, Removal, Adsorption kinetics, Adsorption isotherms.

REMOVAL OF DISPERSE BLUE 165 FROM WASTEWATER USING MOROCCAN NATURAL PHOSPHATE AS AN ADSORBENT: EQUILIBRIUM, KINETICS, AND THERMODYNAMICS

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This study investigates the capability of Disperse blue 165 dye adsorption onto Moroccan natural phosphate. The effects of pH, initial dye concentration, adsorbent dose and contact time have been evaluated.

Natural phosphate was characterized by Fourier transform infrared spectroscopy and X-ray diffraction. The isotherms such as Langmuir and Freundlich were examined. The experimental results showed that the dye removal yield achieved up to 99%. Dynamic adsorption was studied by pseudo first order and pseudo second order models.

The adsorption behavior was also tested using thermodynamic parameters. The results show that Moroccan natural phosphate could be used as adsorbents for the removal of disperse blue 165 dyes from textile effluents.

Kyewords: Disperse blue 165, adsorption, kinetics, natural phosphate, isotherm, Thermodynamic.

STRENGH AND WORKABILITY OF CONCRETES MANUFACTURED WITH PHOSPHATE WASTE ROCKS

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Phosphate exploitations generate important tonnage of waste rocks during the various steps of extraction.
These mineral by-products are generally deposited in surface piles, which constitute a weak sustainability approach that may generate significant ecological disruptions.

On the other hand, the reuse of mining waste rocks as construction material constitutes a promising management approach consistent with the principles of sustainable development.
Nevertheless, the implementation of this approach is still limited due principally to insufficient knowledge about the characteristics of these secondary resources and to unjustified presumptions related to their pollution potential.

This paper aims to address these issues by assessing the reuse potential of phosphate mining waste rocks as aggregates for mortars and concretes, through multidisciplinary characterization: physical (bulk density, specific gravity, water absorption, fine content), geotechnical (grain size distribution, flakiness index, soundness, resistance to wear and fragmentation), chemical (XRF and ICP-AES) and mineralogical (XRD and SEM).
In addition, workability, flexural and compressive strengths of various concrete mixtures using different substitution levels of natural aggregates by phosphate waste-rocks were then undertaken.

The results showed firstly that the waste-rocks studied contain low pollution potential (insignificant metal content) consisting essentially of carbonates (calcite, dolomite and ankerite) 68%, fluorapatite 27% and quartz 5%. Moreover, physical and geotechnical analyses showed weak performances especially for resistance to wear and fragmentation, which corresponded to 50.2% and 34.4%, respectively.
These results influenced significantly the properties of the resulting concretes, which presented good mechanical performances (15 MPa at 28 days, using 70% of phosphate waste-rocks) especially when coarse waste rocks above 20 mm and fine one below 80µm was removed.
These preliminary results indicate that phosphate waste rocks could be used for the manufacture of specific use materials, such as decorative concretes.

IS HYDROXYAPATITE A POTENTIAL MATRIX FOR THE SAFE WASTE DISPOSAL?

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The storage of radioactive and toxic wastes is today a major issue for our society and apatites are materials that can potentially be used as conditioning matrix. Natural apatites may in fact immobilize and trap Rare Earth Elements (REE) in their own structures and are assumed to be stable under geological weathering conditions.

We investigate the possibility of synthetic artificial enriched hydroxyapatites in REE and explore their stability under natural weathering conditions.
Our results shows that effectively, cerium can be hosted in apatite under solid-solution at low level (←3%), but forms isolated Ce-oxide at high level (between 3% and 15%).

The experimental weathering of this material reveals that rapidly a neogenic phase made of monetite (CaHPO4) is formed preserving this stability of the enriched apatite.
For all experiments carried out, the concentration of cerium released in solution is less than nanomoles/L.

REMOVAL OF POLAR COMPOUNDS FROM WASTE WATER BY EMULSION LIQUID MEMBRANE STABILIZED BY THE COMBINATION OF SURFACTANT AND IONIC LIQUID

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Phenol and its derivatives are hazardous materials that present in industrial waste water in concentration levels that can endanger human and animal life.
This study was conducted to reduce the polar compounds and phenols compounds are taken as an example to reduce their concentrations to meet the environmental regulatory limit.

Three phenols namely phenol, 2-chlorophenol, and 4-nitrophenol were extracted individually from their aqueous solutions using Emulsion liquid Membranes (ELMs) prepared using kerosene as the membrane phase, combination of (Span 80) surfactant and a hydrophobic ionic liquid 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide, [BMIM]+[NTf2]– , and NaOH as the stripping agent in the inner phase of the W/O emulsions.

Experiments were carried out to study the influence of three emulsion composition variables, namely the ionic liquid concentration, internal aqueous stripping phase to organic phase ratio (φ1), and NaOH concentration in the internal phase, as well as three process parameters, emulsion to external aqueous feed phase ratio (φ2), mixing speed of feed solution, and the initial solute concentration in the feed on the rates of extraction of phenols.

The amount extracted of 2-chlorophenol in the early stages of the experiments was much larger in comparison to phenol and 4-nitophenol under identical conditions. This behavior resulted from the fact that 2-chlorophenol has a very favorable distribution coefficient (m) towards kerosene over water.
However, at later stages, the degree of extraction of 4- nitrophenol was higher because of its larger acid dissociation constant, Ka. On the same lines it was observed that for phenol the distribution coefficient was smallest among all the solutes studied and the acid dissociation constant was also the smallest, this results in that phenol extraction curve displaying the smallest rate of extraction and also the smallest extent of extraction.

Keywords: Emulsion liquid membrane, polar compounds, waste water treatment, Ionic liquids.

AN INNOVATIVE AND SIMPLIFIED TREATMENT SCHEME FOR URBAN WASTEWATER TREATMENT AND REUSE IN SUSTAINABLE IRRIGATION BASED ON ACTIVATED SLUDGE PROCESS

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In arid and semi-arid regions, the demand for water is continuously increasing. These regions suffer from shortage in water supply for domestic, industrial and agricultural purposes. Therefore, the availability of water resources is a key factor in the development of the agricultural sector which one of important economical sectors.

In front of this situation, urban wastewater treatment and reuse is one of the alternatives that could be reliable and highly beneficial for irrigation and at the same time for agriculture. In fact, the wastewater can be an alternative to the use of clean water for agriculture, leaving fresh water used for other purposes including drinking water supply. Indeed, environmental and socio-economic advantages of this reuse can only be achieved if water through a wastewater treatment plant (WWTP) that will eliminate the components liable to harm the environment and public health.

The aim of this study is to define new methodologies and new wastewater treatment plant (WWTP) schemes for urban wastewater treatment and reuse for the sustainable irrigation. The new proposed biotechnology based on activated sludge biological process is characterized by simplified treatment schemes, is able to remove pathogens and dangerous components for the environment and able to release nutrients useful for the fertigation such as nitrogen, phosphorus and potassium.

The more important advancement is that the proposed plant has a significant operational flexibility, guaranteed by the possibility of gradually changing the plant configuration passing from the configuration of the irrigation period to that of the period without irrigation.

MULTI SOIL LAYERING (MSL) TECHNOLOGY: AN ECO-EFFICIENCY AND SUSTAINABLE ALTERNATIVE FOR PHOSPHOROUS REMOVAL FROM WASTEWATER

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Phosphorus (P) is one of the principal nutrient that is critically needed for the normal functioning of ecosystems. Nonetheless, excess P and nitrogen (N) is the main cause of eutrophication.

One of the main resource of P into nature occurs from wastewater especially in rural areas where it was usually discharged into the environment without any treatment. Multi-soil-layering (MSL) system is a new low cost and sustainable technology based on water filtration using local and available materials such as gravel, soil, sawdust, iron and charcoal. The removal of P is realized by adsorption on the Al and Fe hydroxides in the soil and precipitation with iron metal. MSL technology was recently introduced in Morocco and tested in Talat Merghen village (Al Haouz, Marrakech) which is the first wastewater treatment plant using MSL technology.
The present paper aims (1) to evaluate MSL technology in removing P from rural domestic wastewater during one year of operation, and (2) to identify critical factors influencing phosphorus removal in MSL system.

Three MSL pilot systems (height 65 cm, diameter 40 cm) were built and loaded by three different hydraulic loading rates (HLR) of 250, 500 and 1000 L m-2 day-1. The obtained results showed a good removal percentage of total P (74 to 90 %) depending on hydraulic regime. The retention and elimination of P in MSL systems is influenced by several factors. The higher removal of P were obtained under low HLR treatment. MSL system hydraulic regime has a direct effect on P removal mechanisms by decreasing hydraulic retention time. The efficiency of MSL systems to reduce P from wastewater is also strongly influenced by influent wastewater quality. The removal of P was positively correlated with their influent concentrations. Hydraulic regime and influent P levels are important factors affecting the removal of P in the MSL system that should be taken into consideration for the improvement of environmental quality in rural areas.

Keywords: wastewater treatment, Phosphorus, hydraulic loading rate, hydraulic retention time, multi-soil-layering system.

NATURAL NANOMATERIAL ENGINEERING FOR WATER TREATMENT: A NEW PROCESS TO IMPROVE SOLAR DISINFECTION

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Low-cost treatment methods to allow safe use of water can have important beneficial implications in the rural area.
Recently, the macromolecular organic pollutants have become a focus problem in the environmental remediation. As an effective advanced treatment technology, Heterogeneous phototcatalysis is a promising and innovative green purification technology.
Photocatlaysis technology based on iron oxide has provided an effective and promising means for remediation of environmental pollutants in air and water.
Iron oxides and iron oxyhydroxides have been studied extensively as photocatalysts, because of their visible-light responsiveness, low cost, nontoxic nature, and natural abundance.
Of the various such compounds investigated, natural goethite (α-FeOOH) is known to be a visible-light-responsive photocatalyst.
In this study, the photocatalytic degradation of dye (Mythelen Bleu) and bacteria innactivation using polyacrylonitrile (PAN) nanofibers containing natural geothite particles were investigated.
The fabricated composites nanofibers of PAN/Geothite were characterized with Scanning Electron Microscopy (SEM), Energy Dispersive X-ray (EDX), and Fourier Transform Infrared Spectroscopy (FTIR).
Chemical composition of the natural goethite nanoparticles were determined by X-ray Fluorescence spectrometry (XRF). Partially intercalated structures of PAN/Geothite composites nanofibers were confirmed by SEM and FTIR analysis.
So, the aim of this study is the fabrication and surface engineering of electrospun nanofiber/ goethite composites, and the photocatalytic activities examination of this nanocomposite on the decomposition of dye under visible-light irradiation.
The results show that the nanocomposites have highly enhanced photodegradation by their exfoliation using electrospinning technique, which decompose the dye (5 mg/l) much faster and more completed in less than 90 min.

Key words: Heterogeneous phototcatalysis, Dye, Natural Goethite, Nano-composite, visible-light irradiation.

PHOSPHATE SLUDGE BASED CERAMIC MEMBRANES: THERMAL BEHAVIOUR AND MICROSTRUCTURE

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During ore phosphate beneficiation, fluorapatite is separated from associated gangue minerals by a combination of successive mineral processing steps that involve crushing / screening, washing, and flotation.

These operations generate large volume of tailings (called phosphate sludge) that are deposited in tailing pounds over an area of several dozen hectares. This represents a significant management challenge for the operator.Generation of phosphate sludge in Morocco has emerged as an issue of major waste management in recent years.

In this study the potentialreuse of phosphate sludge as a ceramic membrane filters has been investigated. The phosphate sludge and two aluminosilicates rich clays have been studied using various analytical methods (ICP, XRD, SEM, DTA...etc).
Different formulations have been developed by mixing the sludge with the used clays.Porous ceramic pellets were prepared from this industrial waste based on these formulations via traditional method. The sintering process was carried out in the range [900-1200°C].

In this context, the influence of experimental parameters on the properties (density, firing shrinkage, water absorption and compressive strangth) and microstructure of the resulting materials was studied such as: clay content, sintering temperature and soaking time. Also, filtration test were carried out.

The results indicated that the neoformation process was mostly controlled by temperature and its increase had a positive impact on the physocal properties. The filtration tests proved that phosphate sludge based membranes with acceptable properties could be manufactured in specific conditions.

Keywords: Ceramic membrane; Phosphate sludge; Clay; Filtration.

ELABORATION OF CERAMIC FILTERS FROM MOROCCAN NATURAL PHOSPHATE AND CLAY TO REMOVE ORGANIC DYES FROM INDUSTRIAL WASTE WATER

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Ceramic filters were prepared from mixtures of Moroccan clay, natural Moroccan phosphate and starch.
These filters were potentially studied for the removal of days; Disperse Blue 79, Reactive Red 141, methylene blue from industrial waste water.

The influence of several parameters such as firing temperature, particle size and weight fraction of compounds on morphologic structure and the porosity of the filters were evaluated. Also the effect of filters weight and initial dye concentration were studied.

Clay and natural phosphate materials were characterized by X-ray diffraction spectroscopy, FTIR spectroscopy and fluorescence X-ray spectroscopy.
Scanning electron microscopy was used to visualize the surface morphology of the filter materials.

Results showed that the fraction of compounds have a great impact on the filtration rate, with high percentage of starch, the filtration flow rate was more important while dye removal capacity was found to be decreasing.

Keywords: Filter, Clay, Natural phosphate, Starch, Dye, Filtration.

EFFECT OF SODIUM HYDROXIDE ON FLY ASH AND PHOSPHOGYPSUM GEOPOLYMER BRICKS

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The processing of phosphate rock by the wet phosphoric acid process generate huge quantities of by-products, namely phosphogypsum (PG). Fly Ash (FA) is a by-product of the combustion of pulverized coal in electric power generation plants.

Recycling these wastes materials is one of the effective solutions of its disposal problem. Among the remediation solutions, their utilization as building materials to save the environment from degradation.

The present work aims the synthesis of geopolymer bricks based on Moroccan PG and FA. The geopolymer mortars were characterized using different techniques such as XRD, MEB, and FTIR. The effect of the concentration of the activator solution and curing time on compressive strength were studied. The results demonstrated the suitability of Moroccan phosphogypsum for the synthesis of geopolymer.

Keywords: Geopolymer brick; Phosphogypsum; Fly ash; Compressive strength.

POTENTIAL REUSE OF PHOSPHATE SLUDGES AS RAW MATERIAL FOR BUILDING MATERIALS USING GEOPOLYMERIZATION

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In Morocco, the mining sector is dominated roughly by phosphates production. The country possesses about two-thirds of the world's total phosphate reserves and remains the leading global exporter and the third largest producer.
However, this activity generates large volumes of sludge (very fine tailings) resulting from the processing of washing and flotation.

These mineral by-products are generally transported as slurry and deposited in situ in storage ponds, which leads to large land occupation and costly management approaches. Therefore, there is a pressing need to develop sustainable alternative methods for efficient management techniques of these phosphate by-products.

In this context, this research paper aims in investigating the potential reuse of phosphate sludge as raw material for the manufacture of construction materials using geo-polymerization. This technique consists of a chemical process that allows transforming aluminosilicates in alkaline media into very compact well-cemented amorphous materials called geo-polymers.

A wide variety of parameters such as activator type and concentration, curing temperature, type and composition of aluminosilicate source influences considerably the geo-polymerization performances and the final properties of geo-polymerized products.
Geopolymerization was realized on the mixtures of coal fly ashes and phosphate sludge The effect of sodium hydroxide (NaOH) concentration (5, 10, 12 and 15), temperature of curing (40°C and 60°C) and time of curing (24h and 48h) on the unconfined compressive strength (UCS) and density were studied.

Furthermore, the effect of phosphate sludge incorporation (10%, 20%, 30% and 40%) on mechanical properties were investigated. The results indicate that NaOH concentration and curing temperature are two key-parameters that influence the Geopolymer mechanical performances. At the highest temperature, the UCS increased with higher NaOH concentration up to 12 M and then decrease.
Also the addition of phosphate sludge have a negative impact in the UCS of the Geopolymer binder.

PHYSICO-CHEMICAL CHARACTERIZATION OF CALCIUM PHOSPHATES SYNTHESIZED BY THE MICROWAVE METHOD

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Valorisation of natural phosphates, Morocco's main wealth, is one of the major preoccupations of many teams of researchers and industrialists.
In this context, our work aims at the use of these phosphates as precursors for the manufacture of biomaterials in the medical field. Thus, we have been interested in using them for the preparation of materials containing a chemical composition close to that of the mineral phase of the calcified tissues. These materials can even be injected for the treatment and / or compensation of bone loss.

The wet synthesis of a pure microwave-assisted hydroxyapatite phase has been described in the literature by varying various parameters such as precursors, preexposure, ageing period, exposure time and input power. Several Ca and P precursors have been used. Nevertheless, the exposure time remains relatively long to obtain a particle size and a conformal degree of crystallinity.

In this work, hydroxyapatite (HAP) and tricalcium phosphate (TCP), widely used in orthopedics and medicine, have been prepared from lime and phosphoric acid using microwave technology. This non-polluting energy source has evolved over the last few years and now offers a promising energy source for the synthesis of different types of materials such as organic compounds, classical ceramics, polymers and composites.

X-ray diffraction examination and infrared absorption spectrometry and chemical analysis showed that the particle size and structure of the synthesized products depend on the time of the synthesis and the heat treatment after synthesis. The exposure time was optimized by studying the relationship between the various synthesis parameters.

A CHAOTIC OPPOSITION-BASED CROW SEARCH ALGORITHM FOR SOLVING THE UNIT COMMITMENT SCHEDULING PROBLEM

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In this paper, we propose a chaotic opposition-based crow search algorithm (COCSA)to solve one of best-knownpower system optimization problems as the UnitCommitment Problem (UCP).

The objective of UC problem is to finding an optimal electricity production plan over a short-term planning horizon subjugating to the forecasted demand and other system operating constraints to meet the load demand and spinning reserve for each interval.

CSA is a new population-based metaheuristic that mimics the intelligent behaviors of crows. The proposed method is implemented using MATLAB programming and tested on well-known test instances from the literature.

The numerical results reported the potential and effectiveness of the proposed algorithm compared to various metaheuristics such as Particle Swarm Optimization (PSO). Simulated Annealing (SA), Differential Evolution (DE), Genetic Algorithm (GA).

PROTOTYPE OF A DECISION SUPPORT SYSTEM FOR SCHEDULING FERTILIZER PRODUCTION

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This paper describes a prototype of a Decision Support System (DSS) which was created to help decision makers on finding an optimal schedule of orders in a fertilizer production plant.
It takes into account aspects that are usually not included simultaneously: heterogeneous parallel processors, due date windows, preventive maintenance, processors availability, processors and sequence - dependent setup time.

This DSS helps to define a feasible problem and examine the upstream and downstream implications –related to the availability of inputs and the fertilizers storage capacity constraints- of the proposed schedule on the supply chain in which the fertilizer production plant is integrated.

In this paper, we examine approaches used to solve the scheduling problem whose characteristics led us to integrate an optimization model in a DSS, and we give an example of use a DSS prototype under test.

Keywords: Decision support system, Optimization, Scheduling, fertilizer plant

USING MULTI-LAYER PERCEPTRON NEURAL NETWORKS FOR PREDICTING REMAINING USEFUL LIFE OF ROLLING BEARING: CASE OF OCP

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The implementation of an efficient maintenance system increases the availability of equipment as well as their performances, while reducing the costs of maintenance.
In this work, we are focused on the concept of prognosis which represents a key process of predictive maintenance.

The scientific literature has several different classifications of prognostic approaches, namely the prognosis based on models, the prognosis guided by data and the prognosis based on experience.
In this work we will focus on the prognosis guided by data mainly with machine learning methods (multi-layer perceptron neural network and multi-linear regression) to predict the remaining useful life of a strategic equipment (Grinding mill) of the Benguerir OCP's mine.

An exploration of prediction capabilities was conducted based primarily on operating conditions data (tonnage, phosphate layer, phosphate quality, hours of operation) to predict the remaining life of critical grinding mill components such as rolling bearing, in order to improve availability of the grinding mill and reduce downtime. In this work, we found that neural networks give better predictions of remaining useful life than multiple linear regressions, which will allow maintenance managers at the Benguerir OCP's mine to better plan maintenance actions and reduce the cost of stopping.

Keywords: Machine learning, Multi-Layer Perceptron, Neural Network, Multiple linear regression, Remaining Useful Life, Prognostic, OCP.

STUDY OF THERMODYNAMIC AND KINETIC ASPECTS OF THE COMBUSTION OF PETROLEUM COKE: THE MODELING OF A NATURAL PHOSPHATE CALCINATION PROCESS

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Indispensable operation in the enrichment of phosphate ore, calcination represents a considerable energy cost industrially and the behavior of the high temperature ore has a direct impact on the progress of the heat treatment process and consequently on the quality of the thermo-phosphated products formed and the overall yield.

It is in this context that the present research work on the energy optimization of the calcination of phosphate-rock ore in the presence of petroleum coke is a major asset for its choice as a solid fuel in many industrial processes.
The interest of the study of the combustion of petroleum coke is guided by two essential aspects of high temperature heat treatment:

(I) The contribution to energy needs of the calcination furnace in which involves the global heat generated by the reactions of its combustion.
(II) Direct conditioning of the quality of the products formed by the properties of calcined petroleum coke.

Therefore, optimization of the calcination process in the presence of petroleum coke first requires an understanding of the physico-chemical phenomena occurring during the combustion of its solid particles, namely those associated with their levitation and those Linked to the kinetic aspect of its overall combustion.

To achieve these objectives, experimental techniques have been coupled to a levitation reactor to determine key combustion parameters and to track their evolution as a function of particle size. In order to study the kinetics of coke combustion, the emphasis was placed on the thermal analyzes ATG and ATD, whose their coupling was an effective means.
The experimental results obtained on the thermodynamic and kinetic aspects of the combustion of petroleum coke, in an oxidizing medium and under non-isothermal conditions allow to :

(I) Analyze the physicochemical changes undergone by coke during Combustion in order to better control the quality of the finished products, in this case the desired thermo-phosphate products;
(II) To evaluate the heat contribution of said reactions to the energy balance of the calcining furnace;
(III) To determine the kinetics and the mechanisms of this transformation for better combustion modeling.

It appears that the combustion mechanisms involved are regulated by two types of processes: physico-chemical processes (release of volatile materials, combustion reactions of hydrogen, carbon, etc.) and transfer processes (diffusion, thermodiffusion, thermal transfer, reactive gas flow and products, etc.). The preheating and combustion times are related to these phenomena, which in turn depend on the thermo-physical properties of the petroleum coke.

THE SYNTHESIS AND CHARACTERIZATION OF ANHYDROUS PROTON CONDUCTING MEMBRANES BASES ON SULFONATED POLY(VINYL ALCOOL), POLY(VINYL PYRROLIDONE) AND SILICOTUNGSTIC ACID WITH OR WITHOUT SILICA

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A novel ionic polymer membranes of different thicknesses (50-450µm) based on polyvinylpyrolidone (PVP), polyvinyl alcohol (PVA), sulfosuccinic acid and silicotungstic acid (SiWA) with or without silica have been synthetized for polymer electrolyte membrane fuel cells (PEMFCs).

The chemical characterization of the membranes has been studied by Fourrier Transform Infrared Spectroscopy (FT-IR). The thermal stability of the membranes has been studied using the techniques of thermogravimetric analysis (TGA) and differential thermal analysis (DTA) between room temperature and 600°C.
The water uptake, ionic conductivity, ionic exchange capacity and fixed ion concentration of these membranes were determined.

Water uptake of these membranes ranged between 30% to 75%. The ionic conductivities of these membranes ranged between 1.02.10-3 S/cm to 7,3210-3 S/cm. The best water uptake and ionic conductivity were those of the membrane based on PVA, PVP, SSA, 10.30 wt. % of SiWA and 5,15 wt.% of Silica .
Whereas, the highest ion exchange capacity was 3.79 mmol/g .Therefore, it can be concluded
that the membrane was a potential condidate for application in PEMFC.

Keywords: Polymer electrolyte membranes, Polyvinylpyrrolidone, Polyvinyl alcohol, Sulfosuccinic acid, silicotungstic acid, Ionic conductivity, Fuel cell.

MANAGEMENT OF NORM RESIDUES: PHOSPHOGYPSUM CASE: CHALLENGES AND SOLUTIONS

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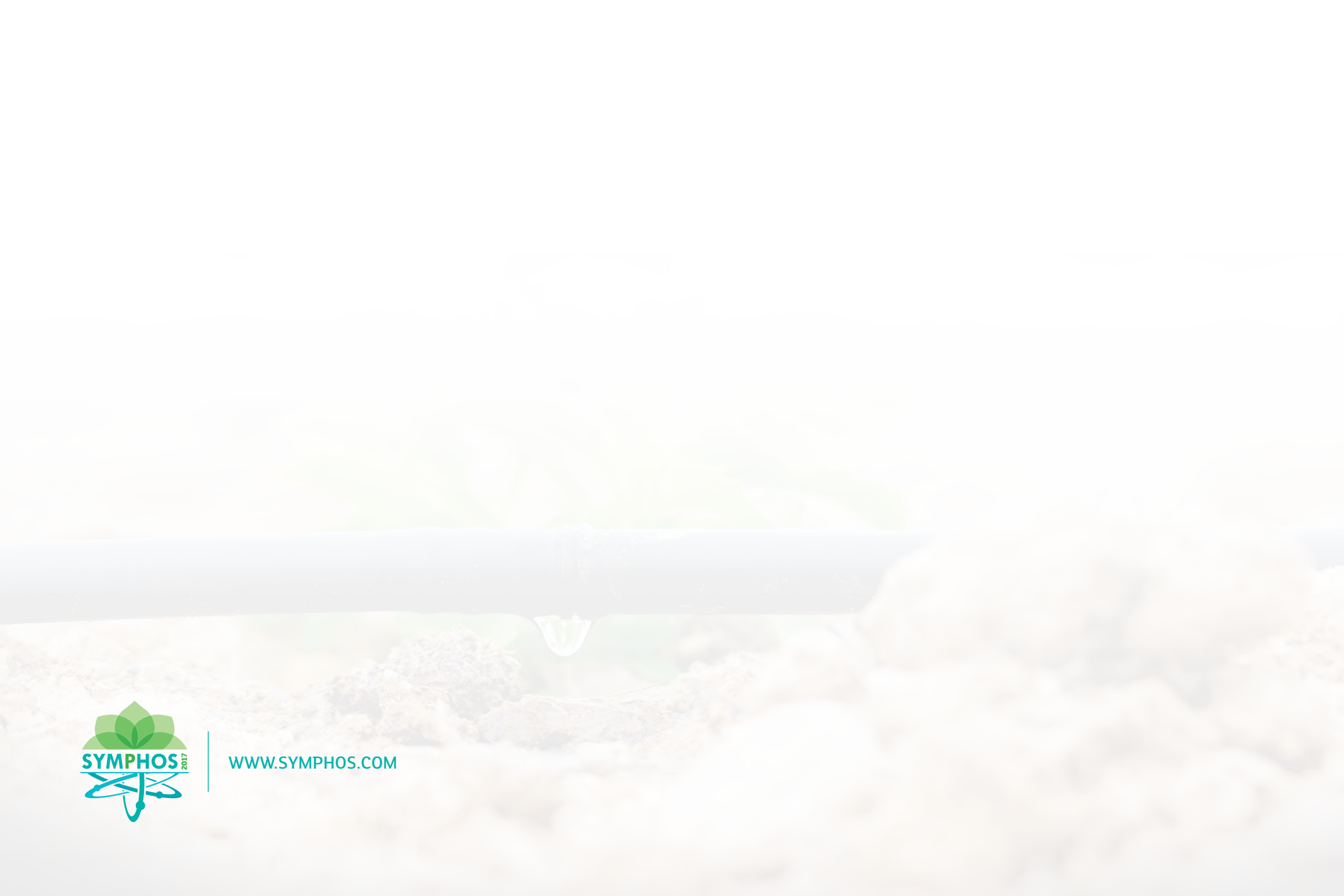
The term NORM stands for Naturally Occurring radioactive Material. It refers to materials found naturally in the environment (e.g. minerals) which contain naturally-occurring radioactive isotopes (e.g. isotopes of uranium and thorium and their radioactive decay products such as radon gas). Certain industries manipulate significant quantities of NORM (Naturally Occurring Radioactive Materials), which usually ends up in their waste streams (e.g. phosphate industry), or in the case of uranium mining.

In the phosphate industry, the immense volume of phosphogypsum (PG) produced annually in Morocco deserves to come to the attention of national and international environmental protection agencies and regulatory bodies.

One of the efficient solutions to minimize the environmental and public radiological impact of NORM residues is its recycling, or its use in other applications rather than disposing of it as waste, is the first consideration. There are many opportunities for recycling NORM residues back to the processes that generated them. Similarly, there are many opportunities for the safe use of NORM residues as by-products. NORM residues should therefore be regarded more as a resource than as waste

In this paper, we will try firstly to focus on the phosphate industry in Morocco as a manipulator of NORM, then we will highlighted the importance of the valorization of PG as a by-product generated in the industrial extraction process, we will also summarize the challenges implementing the regulations governing the phosphate industry through the new Moroccan law 142-12 related to Nuclear and radiological safety and security.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