



## **SESSION F:**

**Environmental microbiology:  
bioavailability, ecotoxicity, diversity  
and population dynamics.**



## SYSTEMS ECOTOXICOLOGY: FROM TRANSCRIPTOMICS, PROTEOMICS AND METABOLOMICS TO PHENOMICS

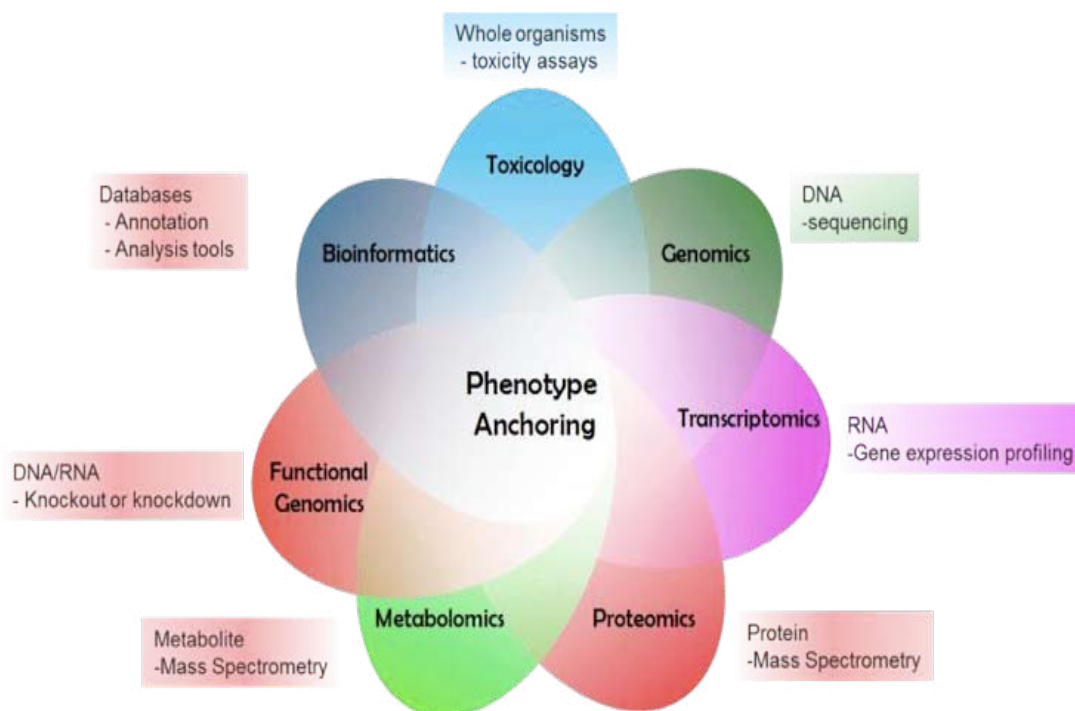
Pillai Smitha\*

\*Eawag (Swiss Federal Institute of Aquatic Research), Ueberlandstrasse 133, Duebendorf 8304, Switzerland

smitha.pillai@eawag.ch

Classic ecotoxicology has focused upon a bottom-up approach to understand stressor effects in which a few genes, proteins, or biochemical reactions are studied at a time. The invention of new technologies in the last decade has enabled the analysis of whole transcriptome (gene transcripts), proteome (proteins) and small cellular molecules (metabolite profiling) resulting in whole system approaches and the field of systems biology. By complementing the traditional approach with the system biology it is possible to define the genetic, protein, and biochemical reactions as integrated and interacting networks of an organism. The consequent integration of the molecular phenotype (transcriptome, proteome and metabolome) to the physical and biochemical traits of an organism (phenomics) provides a holistic understanding of the effects of and the response to a toxicant. Also, importantly, it allows prediction of linkage of mechanistic impacts at the molecular level to impacts at the individual, population or ecosystem level.

This talk will present some systems ecotoxicology studies, wherein the earlier mentioned techniques have been exploited, ranging from mammalian cells, non-model vertebrates and invertebrate, to algae exposed to various toxicants.



**ELECTROSTATIC INTERACTIONS BETWEEN NANOPARTICLES AND BACTERIA: HOW A SIMPLE MODIFICATION OF THE AMES TEST REVEALED MUTAGENICITY OF TiO<sub>2</sub> NANOPARTICLES?**Jomini S.<sup>1\*</sup>, Bauda P.<sup>1,2</sup> and Pagnout C.<sup>1,2</sup><sup>1</sup>. Université de Lorraine, Laboratoire des Interactions Ecotoxicologie, Biodiversité, Ecosystèmes, CNRS UMR 7146, rue du General Delestraint, Metz, 57070, France.<sup>2</sup>. International Consortium for the Environmental Implications of Nanotechnology, ICEINT, <http://www.i-ceint.org/>

stephane.jomini@umail.univ-metz.fr

Titanium dioxide has been used commercially since the early 1900s and is currently the most widely used white pigment in the world, with a total annual production of 4.5 million tons [1]. TiO<sub>2</sub> provides whiteness and opacity to many consumer products such as paints, plastics, inks, papers, coatings, ceramics, and textiles. To date, majority of the TiO<sub>2</sub> used industrially is micrometer sized. But, with the development of nanotechnology, TiO<sub>2</sub> nanoparticles (NP-TiO<sub>2</sub>) are more extensively produced and find wider applications due to their unique physicochemical properties compared to the bulk TiO<sub>2</sub>. The percentage of manufactured TiO<sub>2</sub> as nanoparticles has been estimated as 2.5% in 2009 and a completely converted industry by 2025 in USA [2].

The booming demand for NP-TiO<sub>2</sub> has spurred significant public alarm about its possible adverse effects especially genotoxicity. It was occurring in 2006, after the IARC reclassified TiO<sub>2</sub> from Group 3 to Group 2B carcinogen. NP-TiO<sub>2</sub> were recently listed by the OECD as one of the priority nanomaterial for immediate testing. Several studies have been done to determine the carcinogenic potential of NP-TiO<sub>2</sub>. However, these studies have given very controversy results. Some authors found that NP-TiO<sub>2</sub> are genotoxic, whereas some other, like Warheit et al [3] and Pan et al [4], which both used the classical Ames Mutagenicity test on *S. typhimurium*, found that these nanoparticles are not genotoxic.

In this study, we showed that the conventional Ames Mutagenicity test is not adapted to study the nanoparticle genotoxicity. The culture medium used in this test (rich medium - pH close to nanoparticle isoelectric point) promoting the nanoparticle aggregation and thereby minimizing the possible interactions between nanoparticles and test cells. Based on these considerations, the Ames test was modified and made more effective for the detection of the nanoparticle genotoxicity. Thus modified, the Ames test revealed genotoxicity of two manufactured NP-TiO<sub>2</sub> (Aeroxide P25 and Nanoamor) and a TiO<sub>2</sub>-based nanomaterial used in sunscreens.

[1] Gambogi, J. In Minerals Yearbook: Titanium; 2006, U.S. Geological Survey, Washington, DC.

[2] Pagnout C., Jomini S., Dadhwal M., Caillet C., Thomas F., Bauda P., Colloids and Surfaces B: Biointerfaces, 2012, 92, 315– 321.

[3] Warheit D.B., Hoke R.A., Finlay C., Donner E.M., Reed K.L., Sayes C.M., Toxicology Letters, 2007, 171, 99–110.

[4] Pan X., Redding J.E., Wiley P.A., Wen L., McConnell J.S. &amp; Zhang B., Chemosphere, 2010, 79, 113–116.



## NEW INSIGHTS INTO MICROBIAL MECHANISMS OF NITRIFICATION IN ACID SOILS

He J.Z.\* , Hu H.W., Zhang L.M.

State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China.

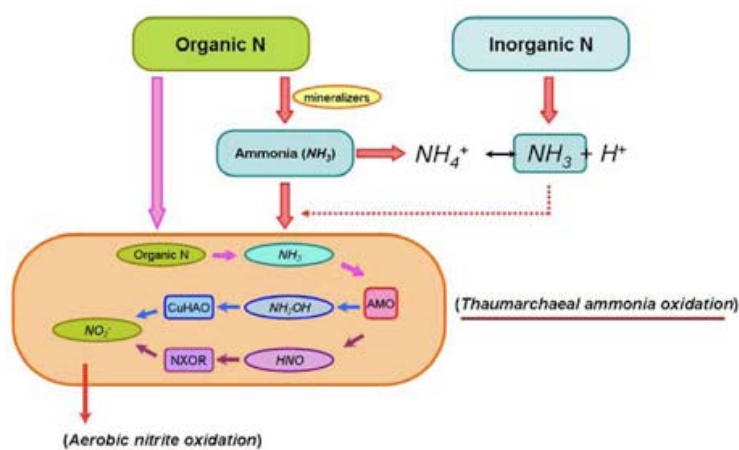
jzhe@rcees.ac.cn

Recent studies of ammonia-oxidizing archaea (AOA) suggested their significant contributions to global nitrogen cycling. AOA are widespread in terrestrial ecosystems with possibly unique mechanisms for nitrification, better adaptation to low-pH pressures, and strikingly lower ammonia requirements compared with ammonia-oxidizing bacteria (AOB). Previous perceptions that microbial ammonia oxidation in acidic soils was minimal and entirely mediated by autotrophic bacteria and occasionally by heterotrophic nitrifiers, have been dramatically challenged. Relative contributions of AOA and AOB to autotrophic ammonia oxidation have been reported to vary in different soils, but ammonia substrate availability, which was largely restricted under acidic conditions, seemed to be the key driver. Theoretically predicted ammonia concentrations in acidic soils below the substrate threshold of AOB and remarkably high ammonia affinity of AOA raised the supposition that AOA could represent the dominant ammonia-oxidizing group in ammonia-limited acidic environments. Recently, the functional dominance of AOA over its bacterial counterpart and autotrophic archaeal ammonia oxidation in acidic soils has been compellingly confirmed by DNA-stable isotope probing (SIP) experiments [1] and the cultivation of an obligate acidophilic thaumarchaeon, *Nitrosotalea devanattera* [2]. In this paper, we present the currently available knowledge concerning the history and progress in our understanding of the ammonia-oxidizing microorganisms and the mechanisms of nitrification in nutrient-depleted acidic soils, propose the possible mechanisms shaping the distinct niches

of AOA and AOB, and thus strengthen the assumption that AOA dominate over AOB in the ammonia oxidation of acidic soils.

Fig. 1. Possible ammonia sources for thaumarchaea and proposed pathways of thaumarchaeal ammonia oxidation based on genomic analysis of *N. maritimus* [3].

AMO: Ammonia monooxygenase; Cu-HAO: periplasmic multicopper oxidase; NXOR: nitroxyl oxidoreductase.



[1] L.M. Zhang, H.W. Hu, J.P. Shen, J.Z. He. The ISME Journal 2011. Doi:10.1038/ismej.2011.168.

[2] L.E. Lehtovirta-Morley et al. Proc Natl Acad Sci USA 2011, 108, 15892-15897.

[3] C.B. Walker et al. 2010. Proc Natl Acad Sci USA 2010, 107, 8818-8823.



## CONTROL OF THE ROUTES FOR MICROBIAL FORMATION OF THE HYDROXYCARBONATE FEII-FEIII (GREEN RUST) AND MAGNETITE BY IONIC AND NONIONIC POLYMERS

Jorand F.P.A.\*<sup>1</sup>, Zegeye A.<sup>1</sup>, Sergent A.-S.<sup>1</sup>, Remy P.-P.<sup>1</sup>, Bihannic I.<sup>2</sup>, Ghanbaja J.<sup>3</sup>, Hanna K.<sup>1,4</sup>

<sup>1</sup>Université de Lorraine LCPME UMR 7564 CNRS-UL, 405 rue de Vandoeuvre, 54600 Villers-lès-Nancy, France.

<sup>2</sup>CNRS LEM UMR 7569 CNRS-UL, 15 av. du Charmois, 54500 Vandoeuvre-lès-Nancy, France.

<sup>3</sup>Université de Lorraine SCMEM Bvd des Aiguillettes, 54506 Vandoeuvre-lès-Nancy, France.

<sup>4</sup>Present address: Sciences Chimiques de Rennes UMR CNRS 6226 (ENSR), Equipe CIP, Av. du Ga Leclerc, 35708 Rennes, France.

frederic.jorand@univ-lorraine.fr

It is well known that iron oxide reduction by *Shewanella spp.* bacteria promotes the formation of FeII bearing minerals, such as the mixed FeII-FeIII hydroxysalt green rusts (GRs), in anaerobic conditions. Although the formation of microbially promoted GRs is widely demonstrated, the mechanisms and factors governing the GR precipitation as the main (major) secondary iron mineral at the expense of other products in lab-scale investigations or environmental systems are largely unknown. As GR is an effective reductant for several contaminants the mechanism controlling its formation merit investigation, from both the environmental and engineering points of view. Several factors such as cellular material (i.e. autoclaved cells and/or bacterial polymers), synthetic anionic polymers or oxyanions have been identified to control GR mineralization as secondary mineral at the expense of other products such as magnetite. The arrangement mode of the heterogeneous aggregates resulting from the interactions between bacterial cells, iron oxide particles and polymers was suggested to influence the routes of formation of secondary iron minerals by limiting the diffusion of reactive species and thus creating favorable microenvironment for GR formation. In these aggregates, the electron transfer from cells to iron oxides is supported by organic electron shuttles. On the other hand, anionic polymers, colloidal and aqueous silicates were found to also influence the nature of the secondary iron minerals through the stabilization of the GR crystals. These results indicate clearly that the bacterial cells drive indirectly the nature of the secondary FeII-bearing mineral.

Moreover, they give new insights into the understanding of the mechanisms of « biogenic » mineral formation based on the electron transfers from bacteria towards iron oxides. Finally, this work contributes to our understanding of the processes leading to green rust formation in environmental systems, such as soils or aquatic systems biofilms (Fig. 1), in which a very high cell density can be found at a micro-scale level, associated to exo-cellular polymers and natural silica mineral composites.

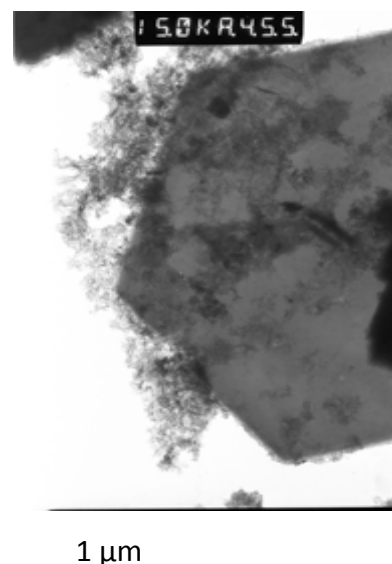


Fig. 1. Photography by transmission electronic microscopy of a crystal of green rust issued from a ferruginous biofilm material incubated in anaerobic conditions.

**SPATIAL DYNAMICS IN BIOFILMS ARCHITECTURES**

Briandet Romain

Micalis, INRA AgroParisTech.

briandet@jouy.inra.fr

Most of what makes microbial cells in a biofilm different from their planktonic counterparts is their multicellular spatial organization. Beyond the static description of the 3D structure, biofilm formation is a dynamic cyclic process including different steps from the initial attachment to surface to the dispersion of cells. Numerous studies have shown that this biological process involves a coordinated spatio-temporal expression of adhesion, motility, matrix or cell death genes in response to micro-environmental conditions and signaling molecules. As the understanding of biofilm complexity increases, simple descriptive architectural studies are being replaced by those in which the three-dimensional organization of the biofilm is related to other information, such as species composition, relationship with substrate or physiology. The analysis of such structure/function relationships has considerably evolved during the last decade, in line with technical advances in microscopy. The developments in confocal laser scanning microscopy (CLSM), coupled with the creation of new fluorescent molecules and protein reporters allowing the labelling of specific matrix components or cell states, have deepened our knowledge of biofilms. These new tools allow researchers to explore non-invasively the dynamic architectural and physiological evolution in the three-dimensional structure of biofilms.

**TREATMENT OF ARSENIC CONTAMINATED MINING WATER USING BIOFILMS**

Guezennec A.G.\*, Michel C., Joulian C., Dictor M.C., Battaglia-Brunet F.

BRGM, Environment & Process Division - 3, av. Claude Guillemin - 45060 Orléans cedex 02, France

a.guezennec@brgm.fr

Arsenic is a common trace-level constituent of gold-quartz vein deposits in mining regions. This toxic metalloid is often present in waste material, water and soil near gold mining areas. The discharge of mining drainage water containing arsenic contributes to its dispersion in the environment. The resulting contamination of surface waters, groundwater and sediments is a matter of great public concern due to the deleterious effects of arsenic on human health. In water, arsenic exists mostly as trivalent arsenite (As(III)) and pentavalent arsenate (As(V)), both forms being toxic to living organisms. Most of the existing treatment processes are effective only on As(V) which forms anionic complexes and is therefore more easily converted into solid waste, unlike As(III) which forms mobile neutral complexes. As a consequence, the removal of arsenic from water requires a preliminary oxidation step. The chemical oxidation of As(III) by O<sub>2</sub> is very slow (Jekel [1]), and the use of oxidant chemicals entails high operation costs (US-EPA [2]). This cost aspect could be overcome by using biological treatment with As(III)-oxidizing bacteria (Zouboulis and Katsoyiannis [3]). Arsenic oxidation capabilities of bacteria are known for a long time, since Green [4] isolated a bacteria belonging to *Achromobacter* in cattle dip in South Africa. Numerous studies reported isolation of heterotrophic and autotrophic bacteria able to oxidize arsenic (Philips and Taylor [5], Osborne and Ehrlich [6], Abdrashitova et al. [7], Battaglia-Brunet et al. [8]).

The present study deals with a mining water drainage resulting of the digging of an exploration gallery in a gold-arsenopyrite mineralization (cherts and quartz veins). Its flow-rate varies between 10 and 30 m<sup>3</sup> h<sup>-1</sup> and the arsenic concentration between 10 and 500 µg L<sup>-1</sup> for a pH close to 6.5. The water contains also high concentrations of iron (between 2 and 15 mg L<sup>-1</sup>). Both arsenic and iron concentrations are higher than the French quality standards (which are set to 100 µg L<sup>-1</sup> for arsenic and 3 mg L<sup>-1</sup> for iron in this kind of context), and thus, require a treatment to be removed from the effluent before discharging it in the environment. In the earlier part of the study, Battaglia-Brunet et al. [9] identified a biological As(III)-oxidizing activity in diverse micro-environments along the water stream, from the source to the discharge point. From those results, we investigated the possibilities of using this natural phenomenon for the removal of arsenic in a passive on-site treatment process based on three successive steps: (i) biological oxidation of As(III) by indigenous bacteria biofilm in a fixed-bed reactor filled with pozzolana, (ii) precipitation of iron in the form of hydroxides, (iii) adsorption of As(V) onto iron hydroxides (and/or co-precipitation of As(V) with iron).

Small-scale laboratory experiments showed that the indigenous bacterial population promoted As(III) and Fe(II) oxidation in conditions close to those of the site, i.e. temperature, water composition and oxygen availability. The immobilization of the bacteria on pozzolana by the development and the maintenance of a biofilm increased oxidation rates compared to natural conditions. These results were confirmed by long-term on site pilot-scale experiments. As and Fe removal was significant and their concentrations at the pilot outlet decreased under the discharge standards. The critical operation parameters determined in the study will be used to design a treatment unit based on the biological passive process described above.

- [1] M.R. Jekel, Arsenic in Environment, part I: Cycling and Characterization, Ed J.O. Nriagu, John Wiley & Sons 1994, 119. [2] U.S. Environmental Protection Agency. EPA/600/4-98/042 1998. [3] A.I. Zouboulis, I.A. Katsoyiannis, Environmental International 2005, 31, 213. [4] H.H. Green, South African Journal of Science 1918, 14, 465. [5] S.E. Philips, M.L. Taylor, Applied and Environmental Microbiology 1976, 32, 392 [6] F.H. Osborne, H.L. Ehrlich, Journal of Applied Bacteriology 1976, 41, 295 [7] S.A. Abdrashitova, B.N. Mynbaeva, A.N. Ilyaletdinov, Mikrobiologiya, 1981, 50, 41 [8] F. Battaglia-Brunet, C. Joulian, F. Garrido, M.C. Dictor, D. Morin, K. Coupland, D.B. Johnson, K.B. Hallberg, P. Baranger, Antony Van Leeuwenhoek International Journal 2006, 89 (1), 99. [9] F. Battaglia-Brunet, M.C. Dictor, F. Garrido, C. Crouzet, D. Morin, K. Dekeyser, M. Clarens, P. Baranger, Geomicrobiology Journal 2002, 23, 201.

**BACTERIAL OXIDATION OF ARSENIC IN POLLUTED SOILS: ROLE OF ORGANIC MATTERS**

Lescure T.<sup>1\*</sup>, Jouliau C.<sup>1</sup>, Bauda P.<sup>2</sup>, Hénault C.<sup>3</sup>, Battaglia-Brunet F.<sup>1</sup>

<sup>1</sup>BRGM, Environment & Process Division, Environmental Biogeochemistry Unit, 3 avenue Claude Guillemin, 45060 Orléans, France.

<sup>2</sup>CNRS UMR 7146, LIEBE, University of Lorraine, Bridoux Campus, rue du Général Delestraint, 57070 Metz, France.

<sup>3</sup>INRA, Research Center of Orléans, Soil Science Unit, 2163 Avenue de la Pomme de Pin, CS 40001 Ardon, 45075 Orléans, France.

t.lescur@brgm.fr

Microbes play a major role on the behavior of metals and metalloids in soils. Arsenic speciation, in particular, is related to the activity of bacteria able to oxidize, reduce or methylate this element, and determines mobility, bioavailability and toxicity of As. Arsenate (AsV) is less toxic and less mobile than arsenite (AsIII). Bacterial As(III)-oxidation tends therefore to reduce the toxicity of arsenic in soils and its risk of transfer toward underlying aquifers. It is well known that organic matter influences abiotically the speciation of arsenic and thus its mobility in soils. Previous results suggest an effect of organic matter on the kinetics or efficiency of bacterial As(III)-oxidation in presence of oxygen, thus in conventional physico-chemical conditions of a surface soil. The objective of the present project is to quantify the influence of organic matters on the bacterial speciation of arsenic in polluted soils. Moreover, the biogeochemical consequences of this phenomenon on the mobility and ecotoxicity of this metalloid will be studied. The first task of this program is the systematic investigation of the influence of different types and concentrations of organic matters on the activity of As(III)-oxidizing pure strains. Influence of simple substrates (aspartate, succinate) and complex substrate (yeast extract) on As(III)-oxidation kinetics has been studied. For each experiment, the bacterial growth and the expression of genes involved in the speciation of arsenic, *i.e.* *aio* and *ars* genes, has been monitored. A direct perspective of this work will be to perform experiments with humic and fulvic acids (complex organic matter commonly found in soils), and with water-extracted organic matter from polluted soils. Then the As(III)-oxidation activity of bacterial communities extracted from contaminated soils will be followed. These assays should allow the screening of conditions which will be applied in subsequent experiments with several real contaminated soils, including a former mining site, impacted industrial sites, and a forest soil heavily contaminated after arsenical ammunitions storage.

This work is co-funded by BRGM and ADEME (convention TEZ 11-16).





## CONTROL OF THE HYDROXYCARBONATED GREEN RUST STABILITY, A TRANSITORY PHASE FROM FE(II) OXIDATION BY AZOSPIRA ORYZAE

Etique M., \* Zegeye A., Ruby C., Jorand F.

Laboratoire de Chimie Physique et Microbiologie pour l'Environnement. LCPME, UMR 7564, CNRS-Univ. Lorraine. Institut Jean Barriol. 405 rue de Vandoeuvre, F-54600 Villers-lès-Nancy, France.

marjorie.etique@lcpme.cnrs-nancy.fr

One of the major constraints to remove nitrate from water by the organotrophic denitrification is the availability of the organic electron donor. Lithotrophic denitrifying bacteria could be an alternative as they gain electron from inorganic donors. Thus anaerobic iron-oxidizing nitrate-reducing bacteria are capable of coupling the oxidation of  $\text{Fe}^{2+}$  to dissimilatory reduction of  $\text{NO}_3^-$  to  $\text{N}_2$  [1]. Various secondary iron minerals can be produced during this process and the mechanisms of their formation are worth studying because they could influence the denitrification. Recently, green rust (GR) – a layered Fe(II)-Fe(III) double hydroxides – was identified as an intermediate compound during the oxidation of Fe(II) by the nitrate-reducing *Acidovorax* sp. strain BoFeN1 [2]. Our work was dedicated to investigate *Azospira oryzae* in different media containing ferrous iron, nitrate, and various cell densities. The results showed that a high cellular concentration led to hydroxycarbonated GR formation stable in time (Fig. 1), whatever the media.

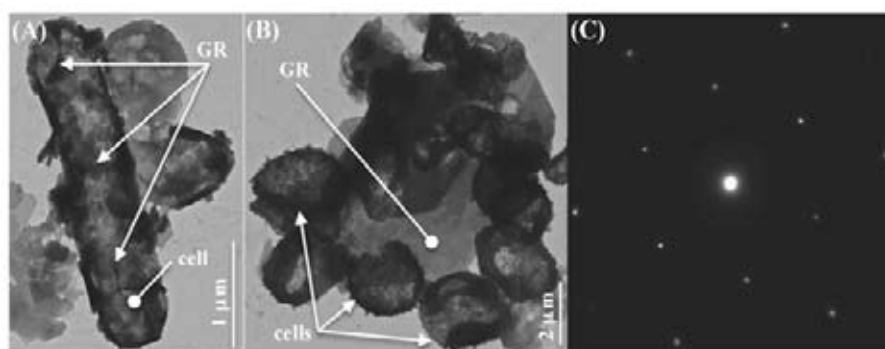


Figure 1. Transmission electron micrographs of GR produced by the anaerobic iron-oxidizing nitrate-reducing bacterium *Azospira oryzae*: (A) cells covered by GR crystals, (B) cells grouped around GR particles. The electron diffraction pattern (C) is composed of spots distributed on a hexagonal lattice. The cell parameters deduced from the diffraction pattern are  $a = b = 3.154 \text{ \AA}$  and  $c = 22.326 \text{ \AA}$  in agreement with the hydroxycarbonated GR structure [3].

However, this intermediate mineral is metastable at low cellular concentration, its fate depending on the chemistry of the medium and can be transformed to a more thermodynamically stable mineral: magnetite/goethite.

[1] K.L. Straub, M. Benz, B. Schink, F. Widdel, *Appl. Environ. Microbiol.* 1996, 62, 1458-1460.

[2] C. Pantke, M. Obst, K. Benzerara, G. Morin, G. Ona-Nguema, U. Dippon, A. Kappler, *Environ. Sci. & Technol.* 2012, 46 1439-1446.

[3] R. Aissa, M. Francois, C. Ruby, F. Fauth, G. Medjahdi, M. Abdelmoula, J.M. Genin, *J. Phys. Chem. Solid.* 2006, 67 1016-1019.

**GROWTH AND EXTRACELLULAR ENZYME PRODUCTION OF FUNGI ON CADMIUM, CHROMIUM, COBALT, LITHIUM AND MANGANESE CONTAINING CULTURE MEDIA**

Hartikainen E.S.\*, Hatakka A., Kähkönen M.A.

Department of Food and Environmental Sciences, P.O. Box 56 (Biocenter 1), FI-00014 University of Helsinki, Finland

samuel.hartikainen@helsinki.fi

Impacts of metals on the growth and enzyme production of fungi were tested with Cd- (0-10 mg kg<sup>-1</sup>), Co- (0-100 mg kg<sup>-1</sup>), Cr- (0-100 mg kg<sup>-1</sup>), Li- (0-100 mg kg<sup>-1</sup>) or Mn- (0-400 mg kg<sup>-1</sup>) containing culture media. ABTS [2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)] was used as an indicator of oxidative enzymes, mainly laccases and/or peroxidases, in culture media.

Fungi are important in the cycling of carbon and other nutrients in the well-balanced soil ecosystems [1]. Metals may decrease the ability of fungi to grow and produce extra- and intracellular enzymes, which are useful when degrading the xenobiotics from polluted soils e.g. for bioremediation purposes. Therefore it is important to understand the responses of fungi to different metals as pollutants. Cd, Cr, Co, Li and Mn are metals which are found as pollutants in the mining and industrial sites and their surroundings [2]. Little is known about impacts of Cd, Cr, Co, Li and Mn on the growth and oxidative enzyme production of different taxonomical groups of fungi.

All selected fungi, namely *ascomycetes Alternaria sp.*, *Chaetomium sp.*, *Epicoccum sp.*, *Fusarium sp.*, *Trichoderma harzianum* and *basidiomycetes Agrocybe praecox*, *Pleurotus pulmonarius*, *Phlebia radiata*, *Physisporinus rivulosus*, *Stropharia rugosoannulata*, were able to grow with all tested metals (Cd, Cr, Co, Li and Mn). The growth of *basidiomycete A. praecox* was tolerant to Mn, Cr and Li. The colour zone was formed with tested basidiomycetous fungi with all five metals indicating the unabated production of oxidative enzymes. The five tested ascomycetous fungi did not show any colour zone formation with Mn, Cd, Li and without metals. *Alternaria sp.*, *Chaetomium sp.*, *Epicoccum sp.* and *Trichoderma harzianum* showed colour zone formation with Co and Cr indicating enzyme production. Each of the tested fungus responded individually, which means that metal pollution may change the balance between different fungi in soil.

[1] A. Hatakka, K.E. Hammel, In: M. Hofrichter The Mycota, Industrial Applications, 2010, 10, 319-340.

[2] M.A. Palmer, E.S. Bernhardt, W.H. Schlesinger, K.N. Eshleman, E. Foufoula-Georgiou, M.S. Hendryx, A.D. Lemly, G.E. Likens, O.L. Loucks, M.E. Power, P.S. White, P.R. Wilcock Science 2010, 327, 148-149.



## MICROENVIRONMENT CHARACTERISTIC AND MICROBIAL COMMUNITY IN ACTIVATED SLUDGE FLOCS OF DIFFERENT PARTICLE SIZE

Han Yunping, Liu Junxin\*, Guo Xuesong, Li Lin

Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, 18 Shuangqing Road, Haidian District, Beijing 100085, P.R. China

jxliu@rcees.ac.cn

The activated sludge was comprised by many flocs with different particle size. Interdependent microorganisms in each floc are principal subjects during biodegradability of organic matter in wastewater treatment plant (WWTP).

Microenvironmental characteristics in floc of different particle size are closely related to the microbial community structure in corresponding floc. However, the complex interplay between microenvironment variation and microbial responses within activated sludge flocs is yet poorly understood due to the limitation of analyzing methods.

In this study, the internal microenvironment and microbial community in activated sludge flocs (ASF) were detected by microelectrodes technique and Fluorescence in situ hybridization (FISH) method. The aims of this study were to explore the characteristics of microenvironment and relationship between microenvironment and microbial structure in flocs with different particle size level. The flocs collected from a WWTP in Beijing were divided into five levels (< 61  $\mu\text{m}$  for L1, 61-96  $\mu\text{m}$  for L2, 96-160  $\mu\text{m}$  for L3, 160-250  $\mu\text{m}$  for L4, and >250  $\mu\text{m}$  for L5). Results showed that the concentrations of dissolved oxygen (DO),  $\text{NH}_4^+$  and  $\text{NO}_3^-$  were distinctly different in ASF with different particle size. The distribution of DO,  $\text{NH}_4^+$  and  $\text{NO}_3^-$  could penetrate the whole floc when the floc particle size was 50  $\mu\text{m}$ . The obvious variation was exhibited in floc with particle size of 250  $\mu\text{m}$ , and the decrement rates of DO,  $\text{NH}_4^+$  and  $\text{NO}_3^-$  concentration reached to 54.92%, 3.40% and 90.77%, respectively. The distribution and contents of ammonia-oxidizing bacteria and nitrite-oxidizing bacteria showed that their contents reduced gradually along the depth of bigger flora, whereas they distributed evenly from surface to core in the smaller flocs (Figure 1). The microenvironmental characteristics and microbial structure in different size sludge flocs presented relatively stable in a stable process of sewage treatment.

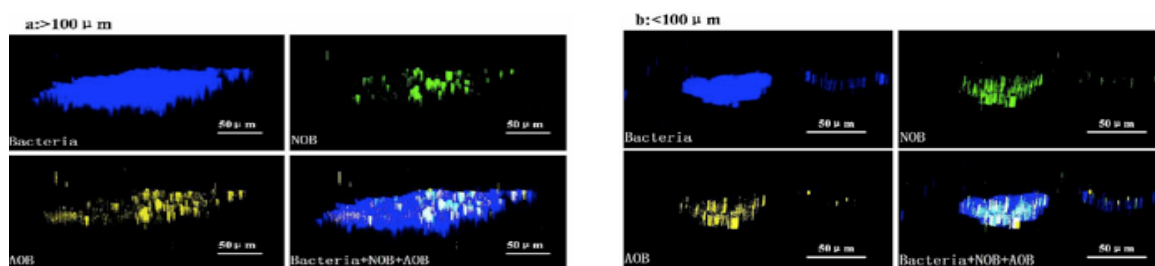


Figure 1 FISH images of functional bacteria in activated sludge. Bacteria that were dyed DAPI displayed blue, the green pixels in images represented NOB, and the yellow pixels represented AOB. The combination of images was 3D projects in LAS-AF soft. (a:>100  $\mu\text{m}$ , b:<100  $\mu\text{m}$ )



### SEM/EDX MONITORING THE BIOAEROSOL PARTICLES COLLECTED BY ANDERSEN SAMPLER IN A WASTEWATER TREATMENT PLANT

Li L., Liu J.X.\*

Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, 18 Shuangqing Road, Haidian District, Beijing 100085, P.R. China

jxliu@rcees.ac.cn

Within wastewater treatment plant, the sites that contain moving mechanical equipment for water aeration are the regions with the highest emission of bioaerosols which have become of increasing concern and research interest in recent years. The risks associated with exposure to aerosols may not only be related to microorganism species and concentration but also to the size of aerosolized particles. Small particles can be very easily carried by the wind to distances ranging from a few hundred meters to several kilometers. The structure characteristics and the chemical components in aerosols with different particle size caused by rotating brushes in an Orbal oxidation ditch were assessed by scanning electron microscope together with energy dispersive X-ray spectroscopy (SEM/EDX). Air samples were collected by an Andersen sampler at different distances from the rotating brushes and different heights above the water surface. The Andersen sampler can separate airborne particles by collecting them in stages with holes of different sizes, providing information about cell density and particle size. Cells, spores and a large amount of inorganic particles could be observed through SEM photos. Most of the particles presented in the stage with particle size of 2.1-3.3  $\mu\text{m}$ . The structure and chemical components in the aerosols presented site-related variability. The cells and spores often emerged at the sampling site closer to the water surface and near the rotating brushes, whereas most of the insoluble particles were detected from 40m downwind the rotating brushes.

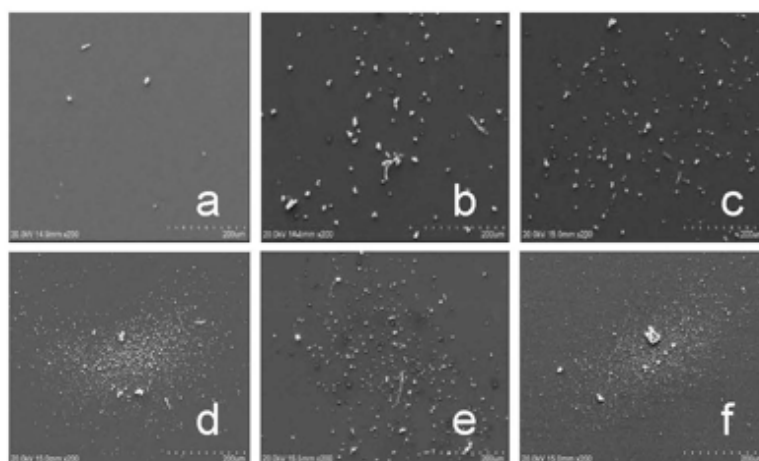


Figure The SEM photos of aerosols collected from the WWTP a: Stage 1 of Andersen sampler; b: Stage 2 of Andersen sampler; c: Stage 3 of Andersen sampler; d: Stage 4 of Andersen sampler; e: Stage 5 of Andersen sampler; f: Stage 6 of Andersen sampler.

# INDEX OF AUTHORS

## A

Abe Yumiko 160  
 Abollino O. 117  
 Adachi Y. 110, 133, 180  
 Addoun A. 148  
 Adouani N. 143  
 Aidarova S.B. 172  
 Ait-Idir A. 57  
 Akretche D.E 57  
 Albarran N. 169  
 Alessi D. 26  
 Alnnasouri M. 143  
 Alonso U. 139, 140, 169  
 Ammami M.T. 64  
 Ammar M. 89, 174, 175  
 Amrane A. 80  
 Ancia A. 81  
 Andrieu H. 108  
 Anglerot Didier 123  
 Ansanay-Alex Salomé 65  
 Aotani K. 147  
 Araïssi M. 35, 93  
 Arfaoui J. 126  
 Arra T. j 68  
 Avena M. 121  
 Ayed I. 35, 93  
 Azaroual M. 193  
 Azize A. 74

## B

Baik M. H. 134  
 Bárányi S. 109  
 Barczak M. 36, 72, 178  
 Bargar J.R. 26  
 Barnabas A 27  
 Barral M.T. 128  
 Barthélémy K. 125  
 Bartmiński P. 72  
 Bash Al-Malikey Salam J. 66  
 Basile-Doelsch I. 159  
 Battaglia-Brunet F. 201, 202  
 Bauda P. 197, 202  
 Bauer A. 170  
 Béchet B. 108  
 Becquer T. 28, 46  
 Bekturganova A.D. 69  
 Belaroui L.S. 67  
 Bellakhal N. 90  
 Belloni L. 130  
 Beloin Christophe 160  
 Benamar A. 64  
 Benbessi A. 87  
 Benedetti Marc F. 188  
 Benedetti M. F. 105  
 Benedetti M.F. 117, 132  
 Benedicto A. 138  
 Bengueddach A. 67

Ben Haj Amara A. 89, 174, 175  
 Ben Rhaïem H. 89, 174, 175  
 Bera S. 130  
 Bersillon J.L. 68  
 Bessho M. 37  
 Biache C. 42  
 Bian Z. Y. 150  
 Bieganowski A. 127  
 Biesheuvel P.M. 34  
 Bigalyev A.B. 69  
 Bigalyeva R.K. 69  
 Bihannic I. 23, 29, 199  
 Bildstein O. 145  
 Block Jean-Claude 160  
 Boland D. 24  
 Borowski P. 178  
 Bosch J. 56  
 Bosch Julian 161  
 Bottero J-Y. 159  
 Bottero J-Y. 184  
 Bouabdalaoui L. 70  
 Boudesocque S. 88  
 Boulakradache M.O. 57  
 Bovet N. 111  
 Bradford Scott A. 183  
 Braunschweig Juliane 161  
 Breda C.C. 97  
 Briandet Romain 200  
 Briois V. 27  
 Brulé Nelly 187  
 Budianta Wawan 120  
 Budzinski Hélène 65  
 Buès M. 44  
 Buron C.C. 85

## C

Cameselle C. 57  
 Campbell K. 26  
 Campredon B. 114  
 Carteret C. 125  
 Ceccato D. 140  
 Cecilia J. 116  
 Cecília J. 142  
 Cerrato J.M. 26  
 Chagneau A. 22  
 Chalhaf R. 174  
 Chang I-Wen 54  
 Charles M. N. 43  
 Chaurand P. 159  
 Chaussé A. 70, 90, 176  
 Chefetz B. 164  
 Chen C.W. 76  
 Chen Xiaoling 62  
 Chen Y. 190  
 Chéry Philippe 163  
 Choi J. W. 134  
 Cieśla J. 127

C. Jouliau C. 73  
 Claret F. 22  
 Clement L. 186  
 Clément L. 136  
 Clostre F. 98  
 Colette-Maatouk S. 119  
 Colla G. 84  
 Collins R.N. 24  
 Companys E. 189  
 Coq Bernard 123  
 Cordeiro A. L. 107  
 Corrêa J. 97  
 Cossu-Leguille Carole 187  
 Coulibaly L. 71  
 Coulibaly L. S. 71  
 Croué J.P. 105  
 Cruz-González S. 189  
 Cuello Gabriel 162

## D

Dąbrowski A. 36, 72  
 Daillant J. 130  
 Daoud Amina 187  
 Darbha G.K. 22  
 David C. 189  
 Davis J.A. 26  
 Davison W. 116  
 Delahay G. 126  
 Deluchat V. 73  
 Descantes Y. 76  
 Devesa-Rey R. 128  
 Díaz-Fierros F. 128  
 Dictor M.C. 73, 201  
 Dika C. 157, 166  
 Djafer A. 74  
 Djelal H. 80  
 Dobrowolski R. 36  
 Dobrzyńska J. 36  
 Doelsch E. 159  
 Douillard J.M. 145  
 Dou X.M. 129  
 Duarte Leandro Juliana 61  
 Duarte Leandro Uliana 96  
 Duc M. 76  
 Dupont L. 88  
 Duriez C. 30  
 Duval Jérôme F.L. 160  
 Duval J. F. L. 107, 157, 166, 168  
 Duval J.F.L. 130

## E

Echevarria G. 46  
 Echevarria G. 27, 68  
 El Hadri Hind 163  
 Elostá Fathi 77

Estrade N. 124  
 Eswayah A. 78  
 Etique M. 125, 203

## F

Falkenberg G. 30  
 Fan Mingde 75  
 Farinha J. P. S. 91  
 Farinha J. P. S. 168  
 Faure P. 79  
 Faure P. 42, 182  
 Favier L. 80  
 Felten Vincent 187  
 Fernandes P. 98  
 Fernández Espinosa A.J. 94, 146  
 Feron D. 70  
 Ferrage E. 29  
 Ferrari Roselyne 188  
 Filippova I. 82  
 Filippova I.V. 81  
 Filippov L. O. 82  
 Filippov L.O. 81, 92  
 Fokkink Remco 91  
 Fox P. 26  
 Francius Grégory 160  
 Fraysse F. 170  
 Fritsche A. 56, 156  
 Fritzsche Andreas 161  
 Furman O. 111

## G

Galceran J. 116, 142, 189  
 Gantzer C. 157, 166  
 Garaud Maël 187  
 García-Gutiérrez G. 139  
 García-Gutierrez M. 169  
 García-Gutiérrez M. 140  
 Gareil P. 119  
 Garnier J. 28, 117  
 Gelabert A 117  
 Gelabert A. 31  
 Ghanbaja J. 30, 170, 199  
 Ghigo Jean-Marc 160  
 Ghorbel A. 126  
 Giambérini Laure 187  
 Giammar D.E. 26  
 Gibert-Brunet E. 119  
 Giffaut E. 136  
 Gley R. 170  
 Golfier F. 44  
 Gooddy D.C. 192  
 Görner T. 84  
 Grandjean M. 82  
 Graouer-Bacart M. 122  
 Grégoire B. 125  
 Gregory John 104  
 Grivé M. 53  
 Groeber S 27  
 Guerrini I. A. 97  
 Guezennec A.G. 73, 141, 201

Guillet P. 182  
 Guillon E. 122  
 Guimaraes E. M. 28  
 Guo X.T. 151  
 Guo Xuesong 205  
 Guyot François 188

## H

Hajdú A. 191  
 Halajnia A. 83  
 Haldys V. 176  
 Hamard E. 76  
 Händel M. 156  
 Hanna K. 199  
 Hanna K. 46, 79, 124  
 Han Yunping 205  
 Hao Jiming 58  
 Hartikainen E.S. 204  
 Hassenboehler L. 84  
 Hatakka A. 204  
 Havenith M. 38  
 Hazotte A. 124  
 Hébrant M. 115  
 Heggen M. 183  
 He H. 118, 135, 185  
 He Hong 60  
 He Hongping 41, 75  
 He J.Z. 198  
 He L. 185  
 Hellmeister Pedrosa Ylara 61, 96  
 Hénault C. 202  
 Hirajima T. 113  
 Hirajima Tsuyoshi 52  
 Hiraki A. 171  
 Hofacker A. 25  
 Hoppe S. 137  
 Hosomomi Y. 113  
 Höss S. 56  
 Huang R. 111  
 Huber F. 22  
 Hubert F. 29  
 Hu Chun 40, 55  
 Hu C.Z. 51  
 Hu H.W. 198  
 Hulea Vasile 123  
 Hurel C 114  
 Hurel C. 141, 186  
 Hurel Charlotte 65  
 Hu Xuexiang 55

## I

Ida T. 37  
 Idou A. 74  
 Igoud S. 87  
 Iijima K. 149  
 Ikuma K. 111  
 Illés E 191

## J

Jacobsen C. 22

Jakobsen Rasmus J 48  
 Jannoyer M. 98  
 Janot N. 26, 105, 132  
 Jeong J. T. 134  
 Jiang C. 167  
 Johnson O. 43  
 Jomini S. 197  
 Jorand F. 203  
 Jorand F.P.A 199  
 Jorand F.P.A. 124  
 Jordan N. 186  
 Jouliau C 202  
 Jouliau C. 201  
 Jouvin D. 117  
 Jouvin D. 31  
 Józefaciuk G. 127

## K

Kaegi R. 25  
 Kähkönen M.A. 204  
 Kajino Mizuo 58  
 Kara Ali A. 68  
 Kasel Daniela 183  
 Kenzhyn Zh. 69  
 Khataee A.R. 83  
 Khelifi A. 148  
 Kjeldsen Peter 48  
 Klumpp E. 38, 167  
 Klumpp Erwin 183  
 Kobayashi M. 133, 180  
 Kondo Yutaka 58  
 Kone T. 44  
 Kononov O. 130  
 Koopal Luuk K. 102, 165  
 Kouadio O. 42  
 Kouadri Moustefai S. 74  
 Kozhakhmetov S. 86  
 Krapf Marie-Eve 160  
 Kretzschmar R. 25  
 Kristanti R.A. 47  
 Krüger J. 112  
 Kuriniawan A. 171

## L

Labille J. 184  
 Lafolie F. 182  
 Lakard B. 85  
 Lakard S. 85  
 Lakzian A. 83  
 Lamy E. 108  
 Lang F. 112  
 Lan H. C. 51  
 Lapworth D.J. 192  
 Lartiges Bruno 160  
 Lassabatere L. 108  
 Lata L. 72  
 Lau B.L.T. 111  
 Lead J.R. 192  
 Lebreton C. 31  
 Lee J. K. 134

- Legrand L. 70  
 Lei Di 50, 131  
 Leidi E.O 146  
 Leme Ednilse 61, 96  
 Lereau L. 73  
 Leroi Catherine 123  
 Leroy1 P. 193  
 Lescure T. 202  
 Lespes Gaëtane 163  
 Levard C. 159  
 Lezama-Pacheco J. 26  
 Liang Xiaoliang 41  
 Li Guotian 62  
 Li K. 190  
 Li L. 45, 206  
 Li Lin 205  
 Lin C. 116  
 Liu C. 118  
 Liu C., 135  
 Liu Dong 75, 99  
 Liu Fan 165  
 Liu H.J. 51  
 Liu Hongmei 75  
 Liu Junxin 205  
 Liu J.X. 45, 206  
 Liu Kangkang 99  
 Liu Y., 118  
 Liu Y. C. 135  
 Liu Yifan 62  
 Liu Yuanyuan 106  
 Li Yaxuan 50  
 Li Yilong 62  
 Lomenech Claire 65  
 Long P.E. 26  
 López T. 169  
 Lorgeoux C. 42  
 Lu G. 150  
 Łukowska M. 127  
 Lu Nanxi 106  
 Lützenkirchen J. 114
- M**
- Macarie H. 98  
 Macé N. 136  
 Madybekova G.M. 172  
 Magnenet C. 85  
 Ma J. Z. 135  
 Maloula A. 76  
 Mamytbekov G. 86  
 Ma Q. X. 135  
 Marchal Benoit 187  
 Marchandea F. 35, 93, 144  
 Marmier N. 114, 136, 141, 186  
 Marmier Nicolas 65  
 Martin J. 168  
 Masion A 184  
 Masion A. 159  
 Mbey J. A.1 137  
 Meckenstock R. 56  
 Mefti A. 87
- Mehennaoui Kahina 187  
 Mercury L. 193  
 Merlin C. 84, 166  
 Mesjasz-Przybylowicz J. 27  
 Messadi Mohamadou A. 88  
 Meyer A. 56  
 Meyer C. 56  
 Michau N. 23  
 Michel C. 73, 201  
 Michel E. 182  
 Michot L.J. 23, 29, 30, 130  
 Miller C. 39  
 Mingorance M.D 146  
 Mingorance M.D. 94  
 Missana T. 138, 139, 140, 169  
 Mizuno T. 155  
 Mnif I. 141  
 Mohan D. 129  
 Mongin S. 116, 142  
 Monné J. 189  
 Montarges-Pelletier E. 30, 117  
 Montargès-Pelletier E. 23, 27, 28, 31, 170  
 Moreau P. 119  
 Mori H. 147  
 Mori K. 47  
 Morisaki H. 171  
 Moura Leila 91  
 Mouton L. 30  
 Munger J. William 58  
 Munoz J.F. 84  
 Mutaliyeva B.Zh. 172
- N**
- Najafi N. 83  
 Narkiewicz-Michałek J. 173, 179  
 Ndjeri M. 176  
 Nesztor D 191  
 Neveu S. 182  
 Nguyen Thanh H. 106  
 Nielsen Sanne Skov 48  
 Nie Yulun 40  
 Nishiyama T. 37  
 Nitnai M. 133
- O**
- Okamoto Hideyuki 52  
 Ollivier P. 193  
 Oltéan C. 44  
 Orgogozo L. 44  
 Oszust-Cieniuch M. 36  
 Oueslati W. 89, 174, 175  
 Oustan S. 83
- P**
- Pagnout C. 197  
 Pagnout Christophe 187  
 Pain-Devin Sandrine 187  
 Pasquini L. 84
- Patelli A. 140  
 Pedrosa Ylara H. 97  
 Pelinovskaya N. 184  
 Pelletier M. 23, 29  
 Peña A. 146  
 Peña A. 94  
 Pensel A. 176  
 Petrus H.T.B.M. 52  
 Pettito C. 126  
 Peulon S. 90  
 Peulon S. 176  
 Philipp H. 38  
 Pichon R. 31, 117  
 Pillai Smitha 196  
 Pilloni G. 56  
 Pina Gata F.J. 146  
 Pinheiro J. P. 91, 168  
 Piriou P. 82, 92  
 Pittman, Jr. C.U. 129  
 Planchon Mariane 188  
 Poinssaint Jean-François 187  
 Pointeau I. 136  
 Polidori A. 182  
 Polubesova T. 164  
 Polyakov Pavel 160  
 Pons M.N. 84, 143  
 Pontoni D. 130  
 Pontvianne S. 143  
 Popa C. 80  
 Portet-Koltalo F. 64  
 Potin-Gautier Martine 163  
 Prelot B. 93, 144, 145  
 Prelot B., 35  
 Prieto D.M. 128  
 Przybylowicz W. 27  
 Puy J. 116, 142, 189
- Q**
- Qiu X 113  
 Quantin C. 28, 31, 117  
 Qu Dan 50, 131  
 Queiroz Alexandre 61  
 Qu J.H. 51  
 Qu Jiuhui 40, 55
- R**
- Rakhmanova Zh. 69  
 Rakovan J. F. 49  
 Raous S. 46  
 Razafitianamaharavo A. 170  
 Regazzoni A 121  
 Reiller P. E. 105, 119  
 Reiller P.E. 132  
 Remy P.-P. 124, 199  
 Rennert T. 156  
 Rey-Castro C. 142, 189  
 Riba O. 53  
 Rigato V. 140  
 Rivard C. 23, 29

Roberto Ramos Carlos 61, 96  
 Rodríguez-Liébana J.A. 94, 146  
 Rose H el ene M. 115 Rose J. 159  
 Rossini Oliva S. 146  
 Rotureau E. 168, 170  
 Rotureau Elise 177  
 Rousselle Philippe 187  
 Ruby C. 79, 125, 203  
 Rudziński W. 178  
 Ryzhikov Andrey 123

## S

Sagynbaev S. O. 69  
 Saito T. 149, 155  
 Salles F. 145  
 Salsi L. 170  
 Salvador J. 189  
 Sameut Bouhaik I. 193  
 Sammartino S. 182  
 Sano N 147  
 Sasaki K. 113  
 Sasaki Keiko 52  
 Satta N. 133  
 Sayen S., 122  
 Sch afer T. 22  
 Schr oderC. 156  
 Scott M. T. B. 53  
 Sebti K. 87  
 Sechogela P. 27  
 Semrany S. 80  
 S equaris J.-M. 167  
 Sergent A.-S. 124, 199  
 hafiqul Alam SM 63  
 Sharma S. K. 59  
 Sienkiewicz A. 173, 179  
 Simon S. 73  
 Simunek Jirka 183  
 Sineva Alisa V. 95  
 Sivry Y. 31, 117  
 Skali-Lami Salah 160  
 Soler A. 98  
 Souahi F. 87  
 oulier Coralie 65

Spalla Olivier 188  
 Sterckeman T. 46  
 Stipp S.L.S. 111  
 Stolpe B. 192  
 Stubbs J.E. 26  
 Stylo M. 26  
 Suvorova E. 26  
 Szekeres M. 191  
 Szymula M. 173, 179

## T

Taha S. 80  
 Tamon H. 147  
 Tanaka Y. 47  
 Tan Daoyong 75, 99  
 Tan Wenfeng 165  
 Temdrara L. 148

Terashima M. 149  
 Tharaud M. 117  
 Thiele B. 38  
 Thill A 159  
 Thomas F. 46, 137  
 Tichit Didier 123  
 Tomb acz E 191  
 T oth I. 191  
 Totsche Kai U. 161  
 Totsche K.U. 156  
 Town R. M. 158  
 Toyama T. 47  
 Traballi Amanda G. M. 61, 96  
 Traballi R.C. 97  
 Traballi Rogerio 96  
 Traballi Rogerio, 61  
 Trapp Judith 187  
 Trens Philippe 123  
 Tsuchiya Y. 171  
 Tsujimoto Y. 180

## U

Uribe R 116  
 Uribe R. 142  
 Usman M. 79

## V

Vald es Castrill on B. 146  
 Van Damme H. 145  
 Van Leeuwen Herman P. 154  
 Vantelon D 23  
 Vantelon D. 28  
 V ek as L. 191  
 Vereecke J. 170  
 Vereecken H 167  
 Vereecken Harry 183  
 Villi eras F. 23, 29  
 Voegelin A. 25

## W

Wadwogel Y. 170  
 Wagner Philippe 187  
 Waiman C. 121  
 Waite T.D. 39  
 Waite T. David 24  
 Wajima T. 37, 49  
 Walcarius A. 115  
 Wang H. 64  
 Wang H. 150  
 Wang Haibo 55  
 Wang H. J. 150  
 Wang Hongjie 50, 131  
 Wang L. 185  
 Wang Mingxia 165  
 Wang Tong 75  
 Wang Xuan 58  
 Wang Yafei 60  
 Wang Yuxuan 58  
 Weber F.-A. 25  
 Wei  B. S. 186

Werner C. 107  
 Xiao J. 110  
 Wieczorek A.K. 156  
 Wilk K. A. 173  
 Williams K. H. 26  
 Woignier T. 98  
 Wu Chih-Chao 54  
 Wu Honghai 62  
 Wu Jerry J. 54  
 Wu Z. 103

## X

Xu Meng 50, 131

## Y

Yang C. 151  
 Yang Min 40, 55  
 Yang S.1 129  
 Yassaa N. 57  
 Yiang Yan 183  
 Yoshida A. 180  
 Youcef L.Dali 67  
 You L.Y. 51  
 Yuan Peng 41, 75, 99  
 Yu H. 39  
 Yui M. 149  
 Yu Wen-Zheng 104  
 Yu Yating 165  
 Yu Y.B. 185  
 Yu Yunbo 60  
 Yvon J. 71

## Z

Zaied M. 90  
 Zajac J. 35, 93, 144  
 Zanini G. 121  
 Zanuttini Cyrielle 187  
 Zardawi Mustafa I. 66  
 Zegeye A. 125, 199, 203  
 Zelano I. 117  
 Zeng G. 103  
 Zh ai Yujia 50, 131  
 Zhanburshin E.T. 69  
 Zhang Changbin, 60  
 Zhang Changyong 106  
 Zhang H. 116  
 Zhang Hao 131  
 Zhang L.M. 198  
 Zhang P. 103  
 Zhang Q. 151  
 Zhang W 190  
 Zhang X. 103  
 Zhao X. 51  
 Zheng X. 105  
 Zhong Yuanhong 41, 99  
 Zhou C. 103  
 Zhu Jianxi 41  
 Zhu, Jianxi 75  
 Zi eba E. 178  
 Zimmermann R. 107



# TABLE OF CONTENTS

Introduction	p. 3
International advisory board	p. 4
Organisation committees	p. 5
Scientific and social program	p. 7
List of posters	p. 15
Abstracts	p. 19
Index of Authors	p. 207
Table of contents	p. 211