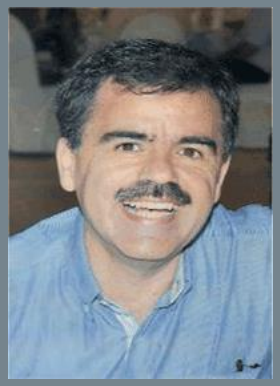
UNIVERSITY OF PATRAS
Department Of Chemical Engineering
ChemEngUP

Environmental Chemical Engineering

Dionissios Mantzavinos, Professor in Wastewater Engineering

Research Groups



Atmospheric pollution & climatic change

Prof. S. Pandis

Atmospheric pollution control

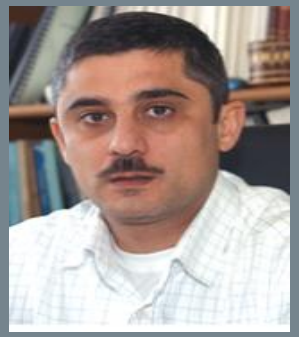
Lect. D. Spartinos

Biochemical waste/WWT

Assist. Prof. M. Kornaros

Advanced oxidation processes in H_2O/WWT

Separation processes in WWT



Assist. Prof. C. Paraskeva

What We Think EnvChE Is All About

Areas of interest

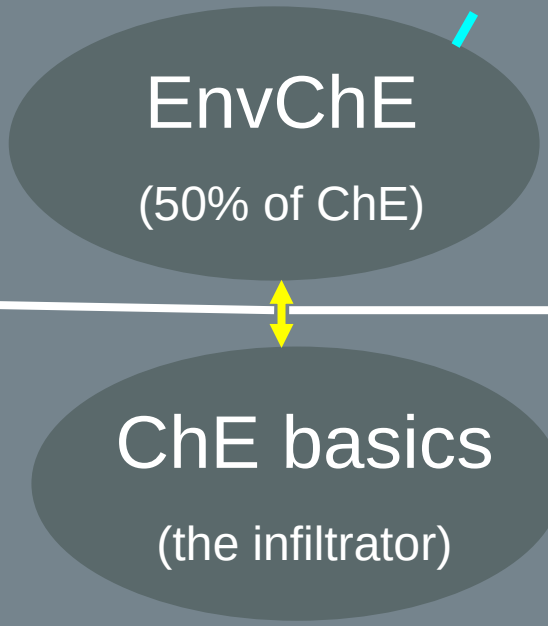
- Man-made operations (mainly industrial)
- Man-made interventions to ecosystems
- Monitoring of operations and interventions

The Environment

- Water/Wastewater
- Air
- Solid wastes

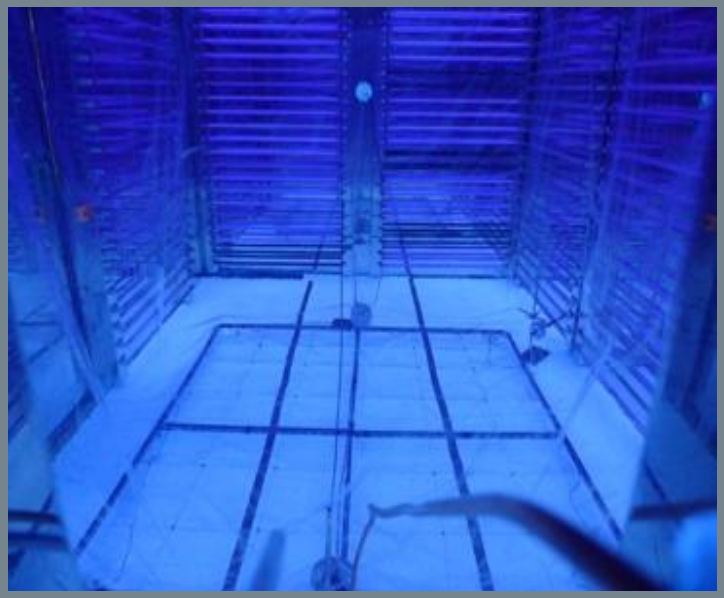
Processes

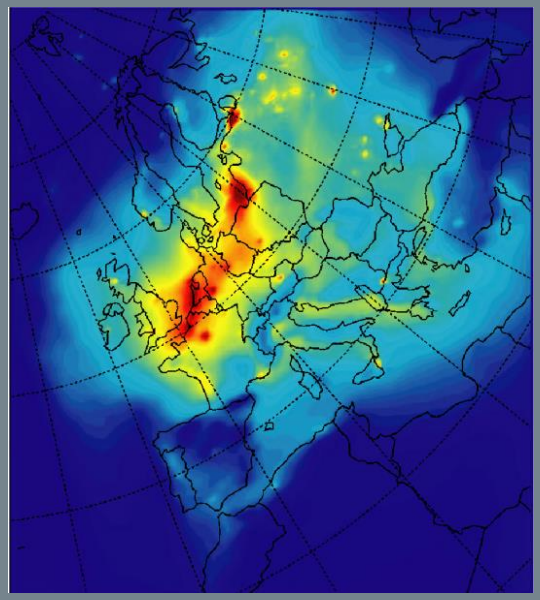
- Chemical
- Biochemical
- Separations
- Physicochemical
- Transport



Inter-disciplinarity

- Analytical chemistry
- Organic chemistry
- Biology
- Physics
- Socioeconomic studies





Atmospheric Pollution

Prof. Spyros Pandis

Research Activities

Sources of Air Pollutants

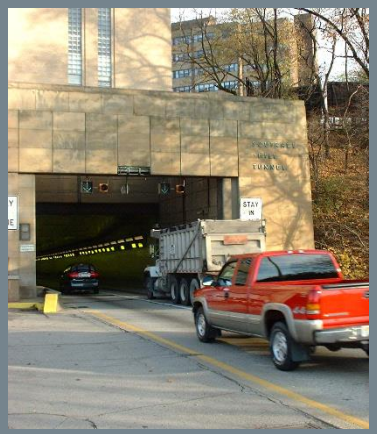
Laboratory Studies

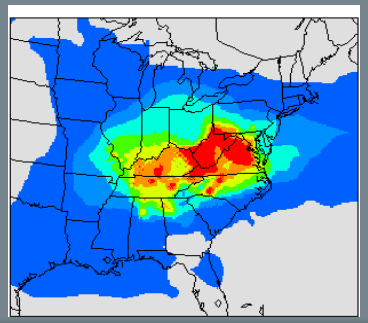
3D Chemical Transport Models

Design of Control Strategies

Field Measurements

Model Evaluation



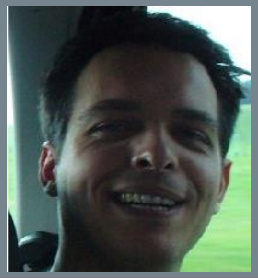
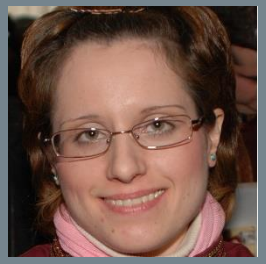


Researchers

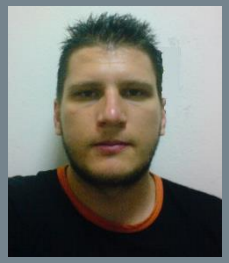
Postdocs:




PhD:

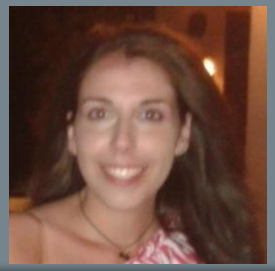
MS:







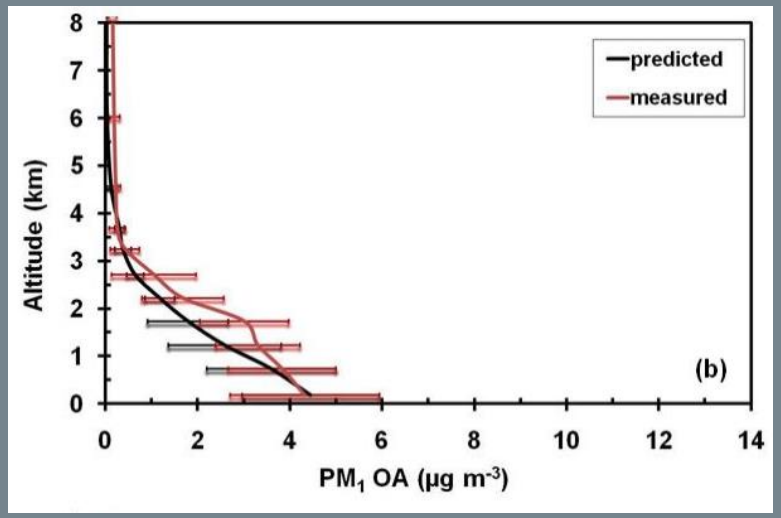




+ 10 undergraduate students

Pan-European Gas Aerosol Study (PEGASOS)

- Integrated project to study the interactions of air quality and climate over Europe and to advise policy makers.
- Led by the Patras team (25 groups from 16 countries, 15 M€).
- Uses for the first time a Zeppelin as a measurement platform.
- Win-win strategies to improve air quality while limiting climate change.



Current Research Projects

- ATMOPACS: Atmospheric organic aerosol, European Research Council, Advanced Investigator Award, 2.5M€.
- PEGASOS: Air quality and climate in Europe, EU FP7 IP, Coordinator, 25 groups from 16 countries, 1 M€.
- MEGAPOLI: Air pollution in megacities, EU FP7 IP, 15 groups from 10 countries, 300 k €.
- ARISTEIA: Atmospheric nanoparticle formation and growth, GSRT, 300 k€.
- SYNERGASIA: Effects of climate change on air quality in Greece (with Democritos), GSRT, 300 k€.
- THALIS: Air quality in Greece (with 6 Greek universities), GSRT, 100 k€.

Some Highlights

- Our 3D-Chemical Transport Model (PMCAMx) is currently used by authorities in the US, Mexico, Chile, Australia, France, Switzerland, Sweden, etc. to design air pollution control strategies
  - Its free commercial version (CAMx) is maintained by ENVIRON Inc.
- Our atmospheric aerosol thermodynamic model ISORROPIA is now used by the vast majority of the 3D-CTMs worldwide.
- The U. Patras group has a branch in Carnegie Mellon University (around 10 PhD students). Continuous interaction (trips, common seminars, projects, etc.)
- Participation in the Advisory Group to the EU for new airborne particle standards and in the Intergovernmental Panel for Climate Change (IPCC).

Publications

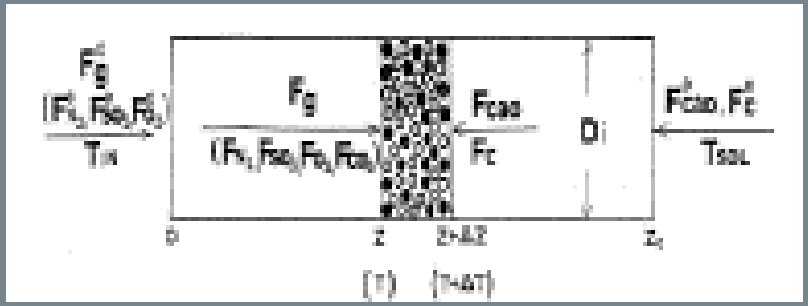
- Book on "Atmospheric Chemistry and Physics" (with J. Seinfeld" (20,000 copies, 15,000 citations) (3rd edition is under preparation)
- Publication in Science (2007): Rethinking organic aerosols (600 citations)
- The group publishes around 15 papers per year
- Some recent examples:
  - Adams P. J., N. M. Donahue, and S. N. Pandis (2013) Atmospheric nanoparticles and climate change, *AICHE J.*, **59**, 4006-4019.
  - Megaritis, A. G., C. Fountoukis, P. E. Charalampidis, C. Pilinis, and S. N. Pandis (2013) Response of fine particulate matter concentrations to changes of emissions and temperature in Europe, *Atmos. Chem. Phys.*, **13**, 3423-3443.
  - Karydis V. A., A. P. Tsimpidi, W. Lei, L. T. Molina, and S. N. Pandis (2012) Formation of semivolatile inorganic aerosols in the Mexico City Metropolitan Area during the MILAGRO campaign, *Atmos. Chem. Phys.*, **11**, 13305-13323.

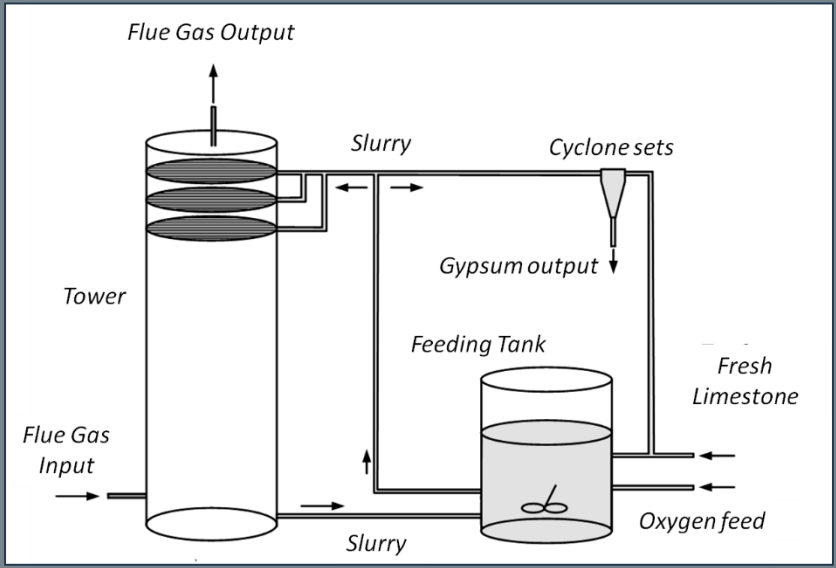
Atmospheric Pollution Control

Lecturer Dimitris Spartinos

Research Activities

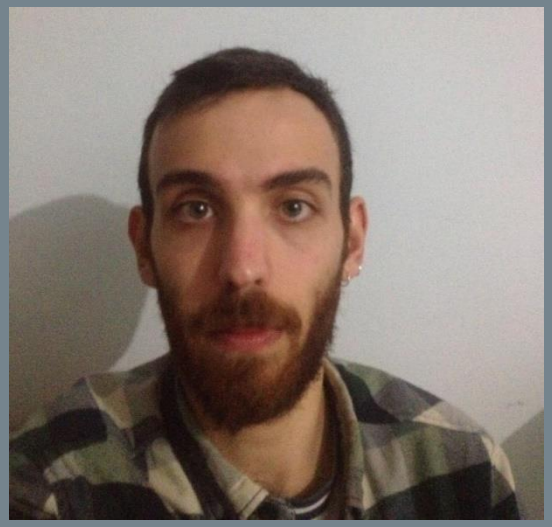
Non-catalytic Gas-Solid Reactions for Air Pollution Control (SO_2 Emissions)





- Use of dry or wet process for reducing SO_2 emission of pulverized lignite power plants
- Study of the SO_2 removal from stack gases of pulverized lignite combustors using dry process in limestone/lime and lignite reactors
- Experimental study in limestone/lime and lignite lab-scale fixed bed reactors
- Mathematical modeling, numerical simulation, parametric analysis and optimization in moving bed reactors at laboratory conditions
- Simulation of the operation of an industrial wet flue gas desulfurization system

Researchers

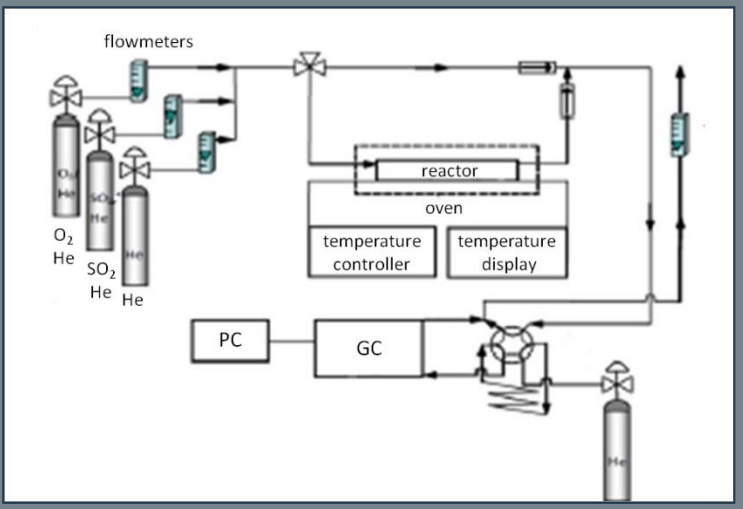


Mr. Theodorakopoulos Christos

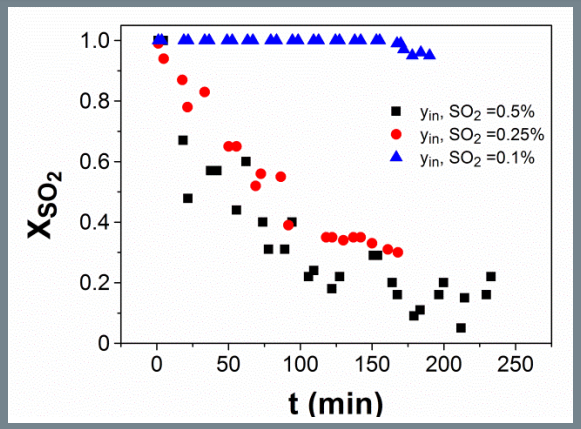
Mr. Bonjolis Christos

Undergraduate students who elaborate Diploma Thesis

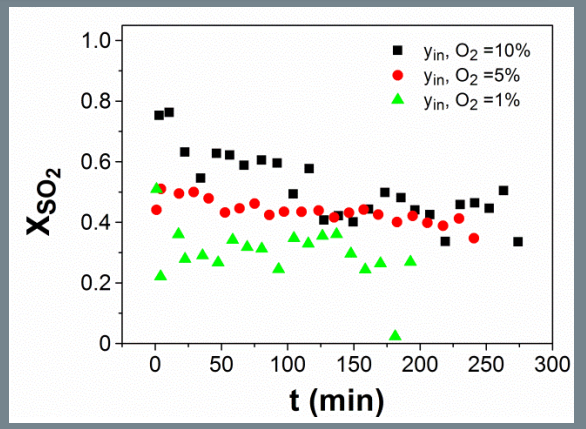
Dry Method - Fixed Bed Reactor



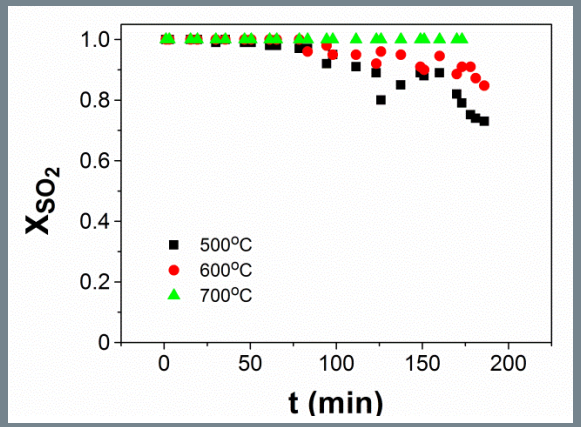
Experimental apparatus which includes supply system, reactor with oven and analysis system (Gas Chromatograph, Shimadzu GC-14B)



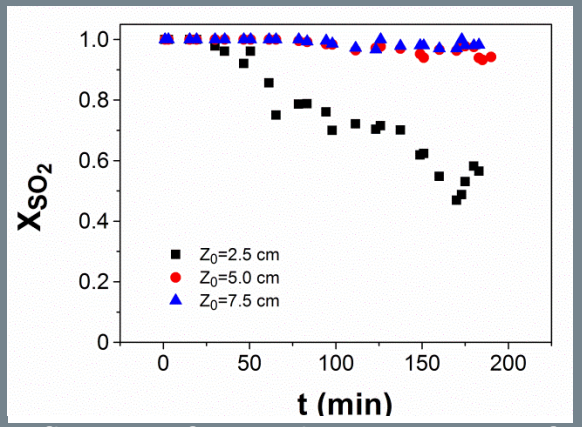
Influence of $y_{in,SO2}$ in the conversion of SO_2, $y_{in,O2}$ = 1%, T = 500°C, F = 500cc/min



Influence of $y_{in,O2}$ in the conversion of SO_2, $y_{in,SO2}$ = 0.5%, T = 600° C, F = 500 cc/min



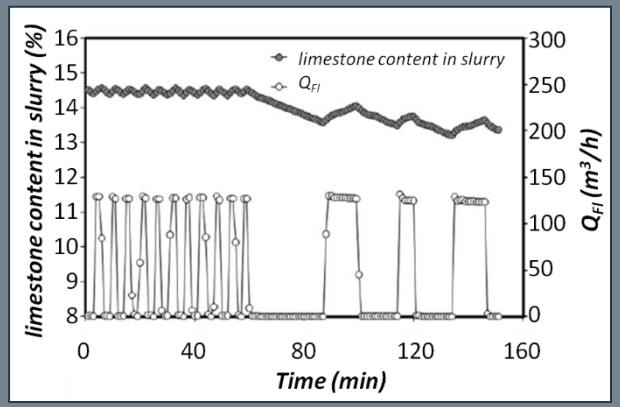
Influence of T in the conversion of SO_2, $y_{in,SO2}$ = 0.5%, $y_{in,O2}$ = 3.3%, F = 500cc/min, Z_0 = 7.5cm



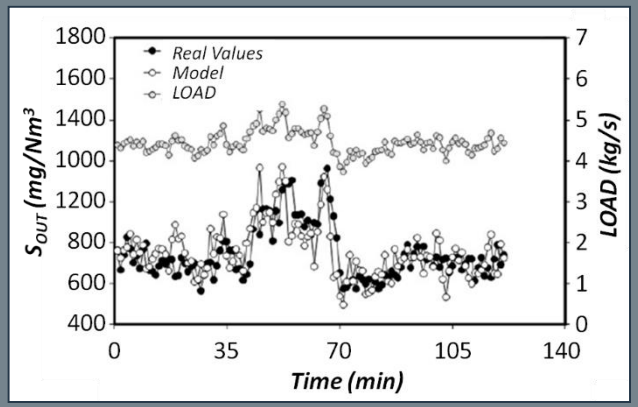
Influence of Z_0 in the conversion of SO_2, $y_{in,SO2}$ = 0.5%, $y_{in.O2}$ = 3.3%, T= 500° C, F = 250 cc/min

Wet Method Simulation and Results

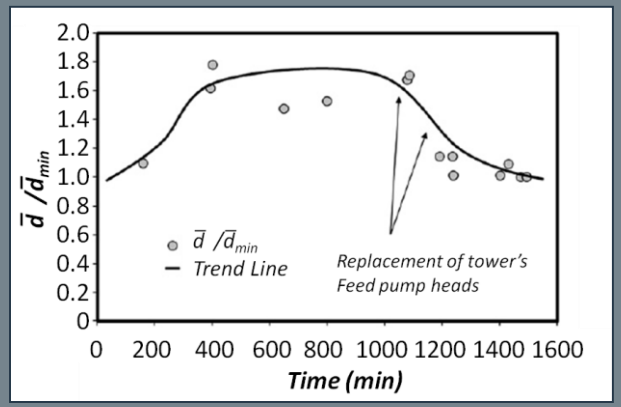
- A dynamic model for a wet flue gas desulfurization system with spray tower of an industrial power plant was developed.
- All physical and chemical processes take place (limestone dissolution, calcium sulfite and gypsum crystallization, sulfite ions oxidation) were taken in account.
- The gas absorption by the liquid droplets was based on two film theory
- The model has been validated with operational data collected over a long period of time



Calcium carbonate concentration in the feed tank and at the inlet of the absorption tower and volumetric feed rate of fresh limestone to feed tank (Q_{FL}). vs. time.



Sulfur dioxide load introduced to the tower and real and simulated values of sulfur dioxide concentration of flue gas at the outlet of the absorption tower. Mean sulfur dioxide load introduced to the tower: 4.46 kg/s (d/ d_{min}: 1.70).



Normalized mean diameter of the slurry droplets .vs. system operation time before and after replacement of the tower feed pumps heads.

Recent Publications, Conferences

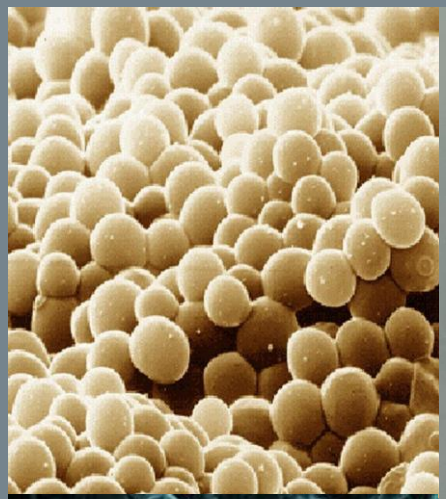
- A.P. Stavrianeas, P. L. Kizas, D.N. Spartinos, «Experimental study and parametric analysis of limestone fixed bed reactor to capture SO_2», (in Greek), Proceedings of the 9th Panhellenic Scientific Conference in Chemical Engineering, Athens, Greece (2013).

- M.K. Petraki, J.X. Efthimiou, D.A. Panagiotopoulou, P.G. Mermigis, D.N. Spartinos, «Experimental study and parametric analysis of limestone fixed bed reactor to capture SO_2», (in Greek), Proceedings of the 8th Panhellenic Scientific Conference in Chemical Engineering, Thessaloniki, Greece (2011).

- L.E. Kallinikos, E.I. Farsari, D.N. Spartinos, N.G. Papagiannakos, «Simulation of the operation of an industrial wet flue gas desulfurization system», Fuel Processing Technology, 91, 1794-1802 (2010).

- E. T. Vlassi, D.N. Spartinos, «Parametric Analysis and optimization in countercurrent flow moving-bed lime and lignite reactor to capture SO_2» (in Greek), Proceedings of the 7th Panhellenic Scientific Conference in Chemical Engineering, Patras, Greece (2009).

- J. Stefas, T. Lekkas, D. Spartinos, «Parametric analysis and optimization in countercurrent flow moving-bed lime and lignite reactor to capture SO2» (in Greek), Proceedings of the 6th Panhellenic Scientific Conference in Chemical Engineering, Athens, Greece, 809-812 (2007).

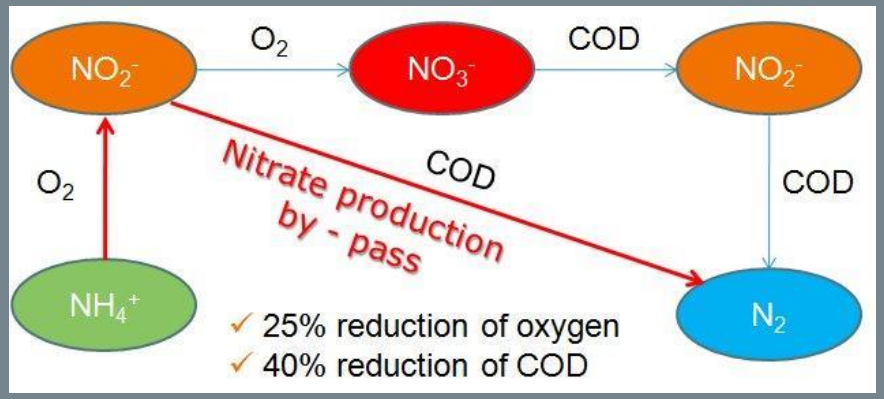


The “LBEET” Research Group

Michael Kornaros, Assistant Professor

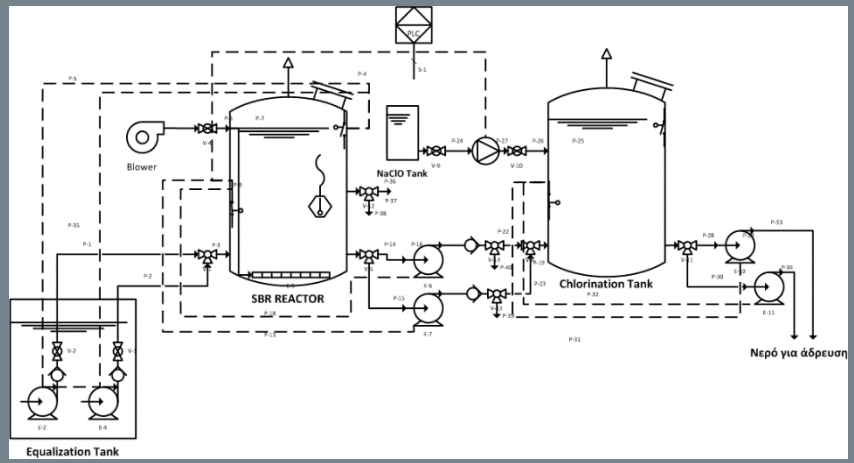
Research Activities – PND process

Partial nitrification - denitrification (PND) for the simultaneous removal of organics & nutrients from wastewater streams in an SBR reactor.



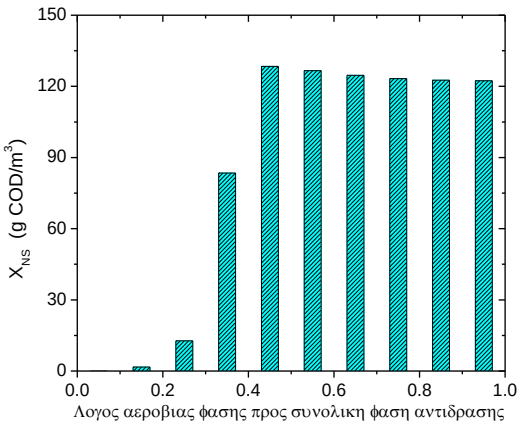
Advantages :

- 40% reduction of the COD demand during denitrification.
- Higher rate of denitrification.
- 25% reduction of oxygen demand for nitritification compared to complete oxidation to nitrate.
- 30% lower biomass yield during anoxic growth.

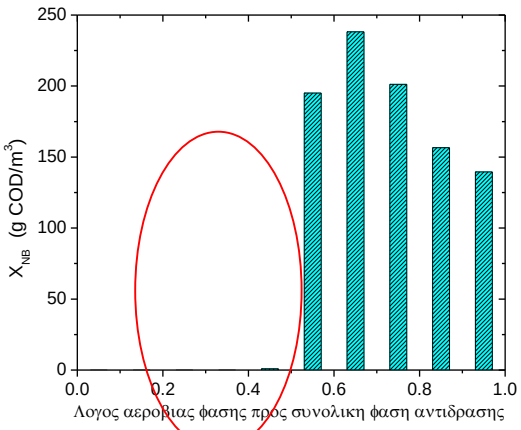


Research Activities – PND process

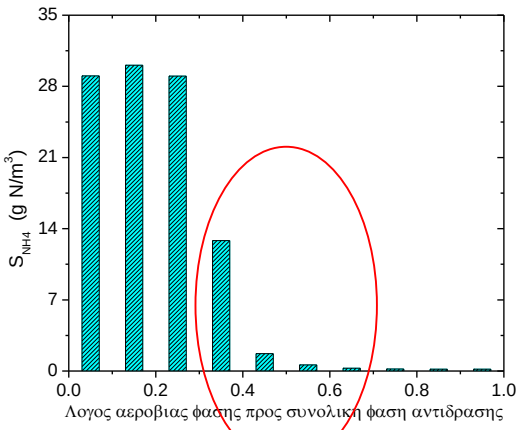
Ammonia oxidizers



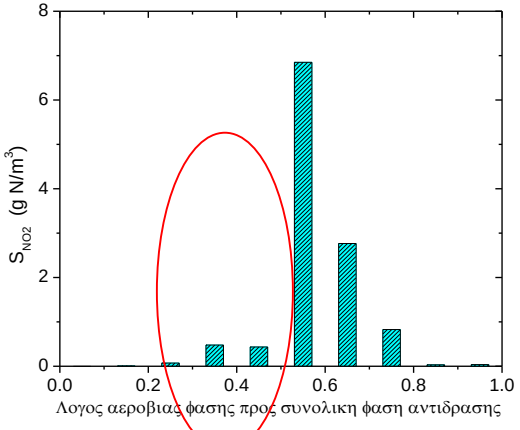
Nitrite oxidizers



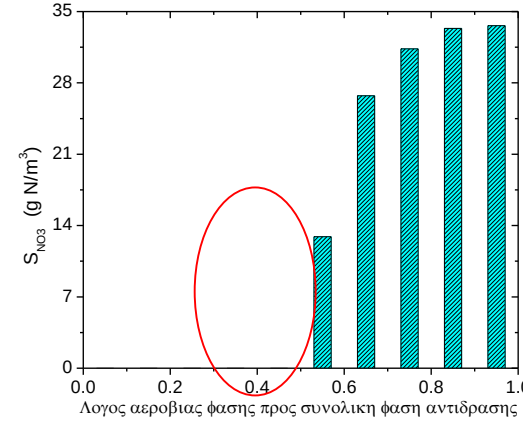
ammonium-N



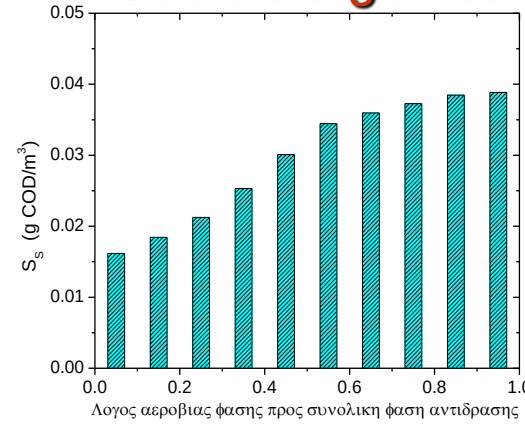
nitrite-N



nitrate-N

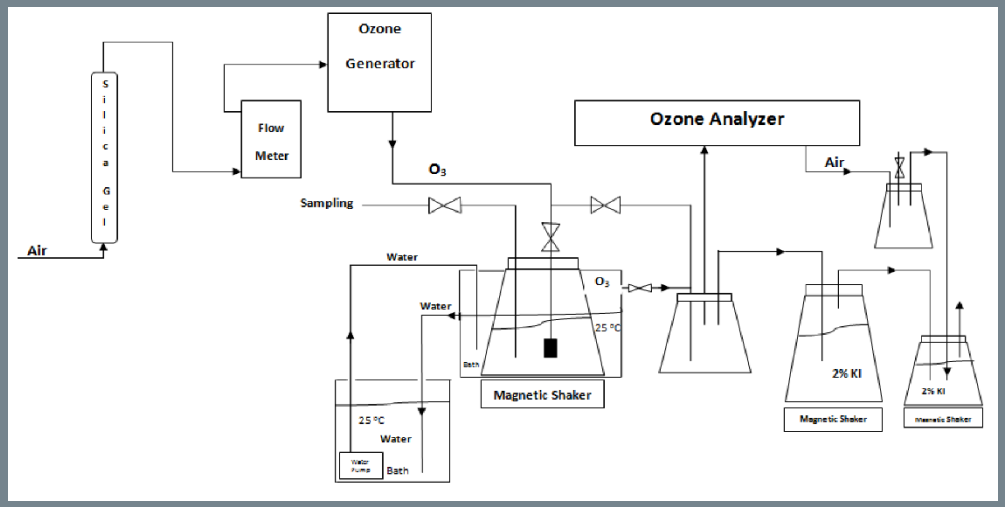


Soluble organics



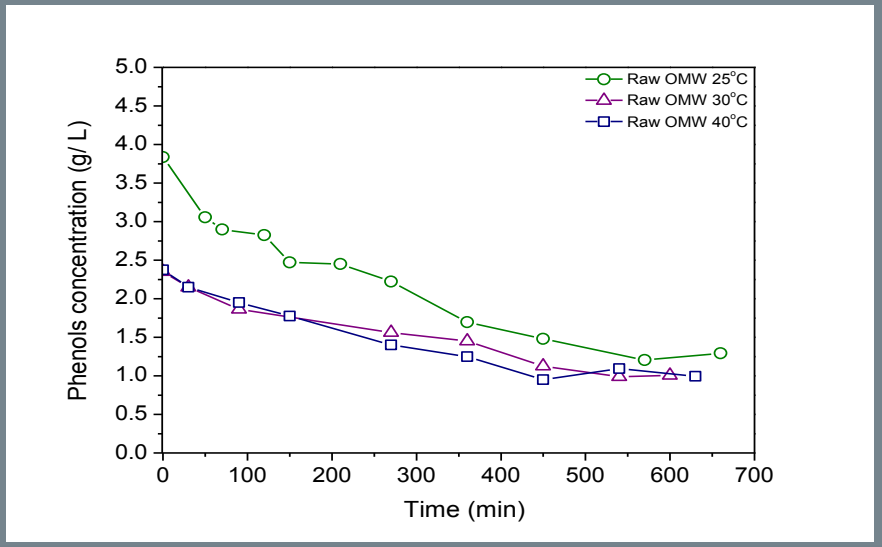
Research Activities – ozonation of OMW

- Removal of phenolics via ozonation as pre-treatment of OMW prior to anaerobic digestion



Raw olive mill waste

Ozone treated olive mill waste



Researchers

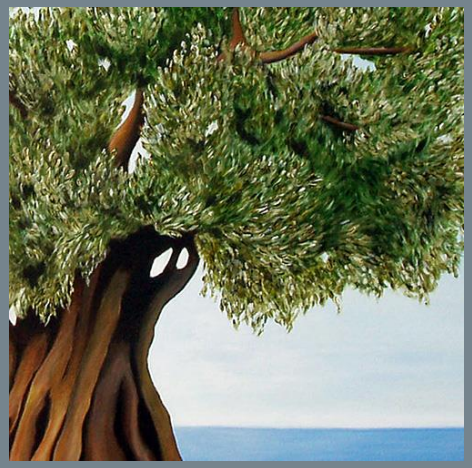
A. Kophahelis (MSc)
Researcher

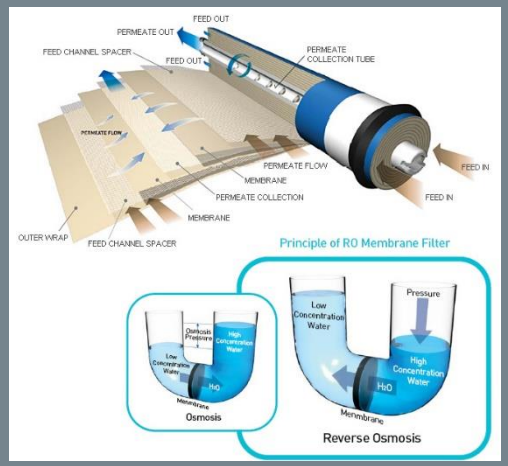
T. Vgenis,
Researcher

Research Projects - Some Publications

- *Project Title : "Biological nitrogen removal via nitrite in continuous operating wastewater treatment systems (Pythagoras I)". Program: European Social Fund (ESF) and Operational Program for Educational and Vocational Training II (EPEAEK II)/ Ministry of National Education and Religious Affairs. Budget (LBEET) : 80 k€. Duration : 2004-2007.*
- *Project Title : "Preservation and treatment of Greek raisins using ozone (PAVET 2005)". Program: General Secretariat of Research & Technology (GSRT)/ Ministry of Development. Budget (LBEET) : 61.3 k€. Duration : 2006-2007.*

- *Kornaros et al. (2010) "Demonstration that the slow response of nitrite oxidizing bacteria to periodic anoxic disturbances is responsible for partial nitrification/denitrification", **Environmental Science & Technology**, 44 (19), pp. 7245-7253.*
- *Tsintavi et al. (2013) "Ozone pretreatment of olive mill wastewaters (OMW) and its effect on OMW biochemical methane potential (BMP)", in press in **Water Science and Technology.***
- *Pakou et al. (2009) "On the fate of LAS, NPEOs and DEHP in municipal sewage sludge during composting", **Bioresource Technology**, 100 (4) 1634–1642.*
- *Fountoulakis et al. (2002) "Removal of phenolics in olive mill wastewaters using the white rot fungus Pleurotus Ostreatus", **Water Research**, 36(19), 4735-4744.*





Laboratory of Transport Phenomena and Physicochemical Hydrodynamics

Assistant Prof. Christakis Paraskeva, Dimitris Zagklis, PhD cand.,
Spyros Kontos, Iakovos Iakovides, Eystathia Pavlakou, Graduate students

- Membrane Filtration- isolation of phenols

Research Activities

- **Scope and objectives**
  To develop a method for the for maximum, cost-effective exploitation of agro-industrial wastewaters, using a combined process of membrane filtration and other physicochemical processes.
  → Profit from the exploitation of compounds with high added values
  → Effective treatment of wastewaters

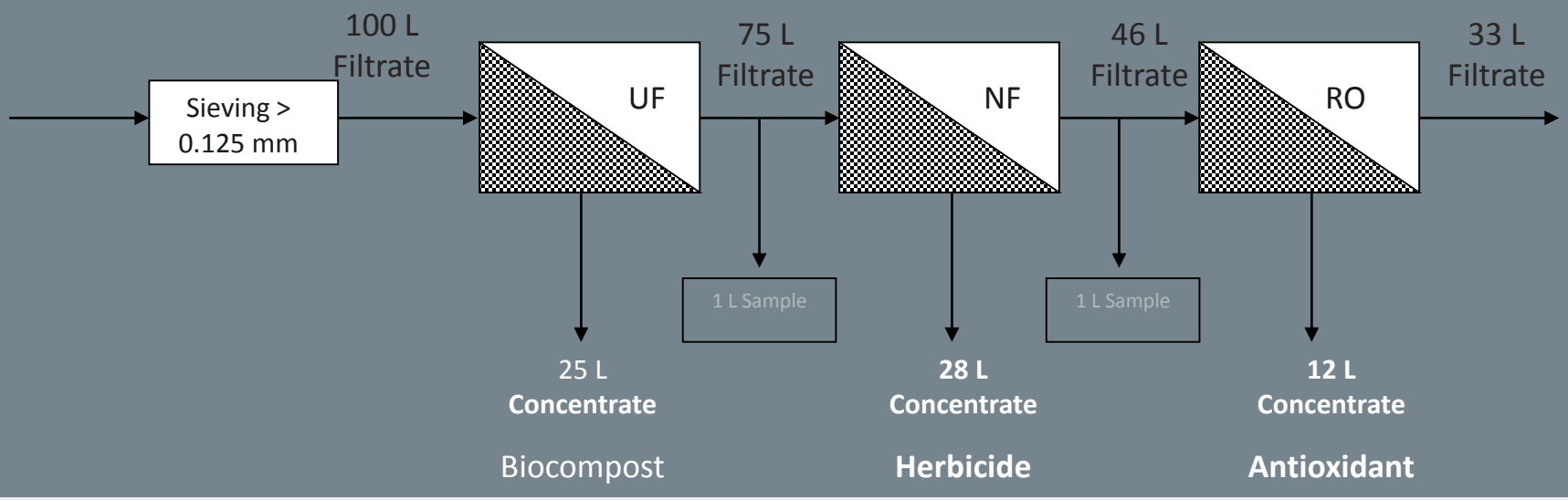
OLIVE MILL WASTEWATERS

- Hydroxytyrosol 6 euro/mg (98%)
- p-Tyrosol
- p-Coumaric acid
- Caffeic acid
- Exploitation of other organics for pharmaceuticals, food industry, animal food, co-composting, etc

- **DEFECTIVE WINES- Grapes**
- Catechin (15 Euros/mg, 99%)
- Procyanidin
- dimers and trimers,
- Resveratrol 1 Euro/mg (99%)
- Exploitation of other organics for pharmaceuticals, food industry, animal food, co-composting, etc

•PROPERTIES of phenols: Powerful Antioxidants, Anti-inflammatory, Possible cure diabetes, it can improve the activity of anticancer drugs, activate longevity genes and obesity

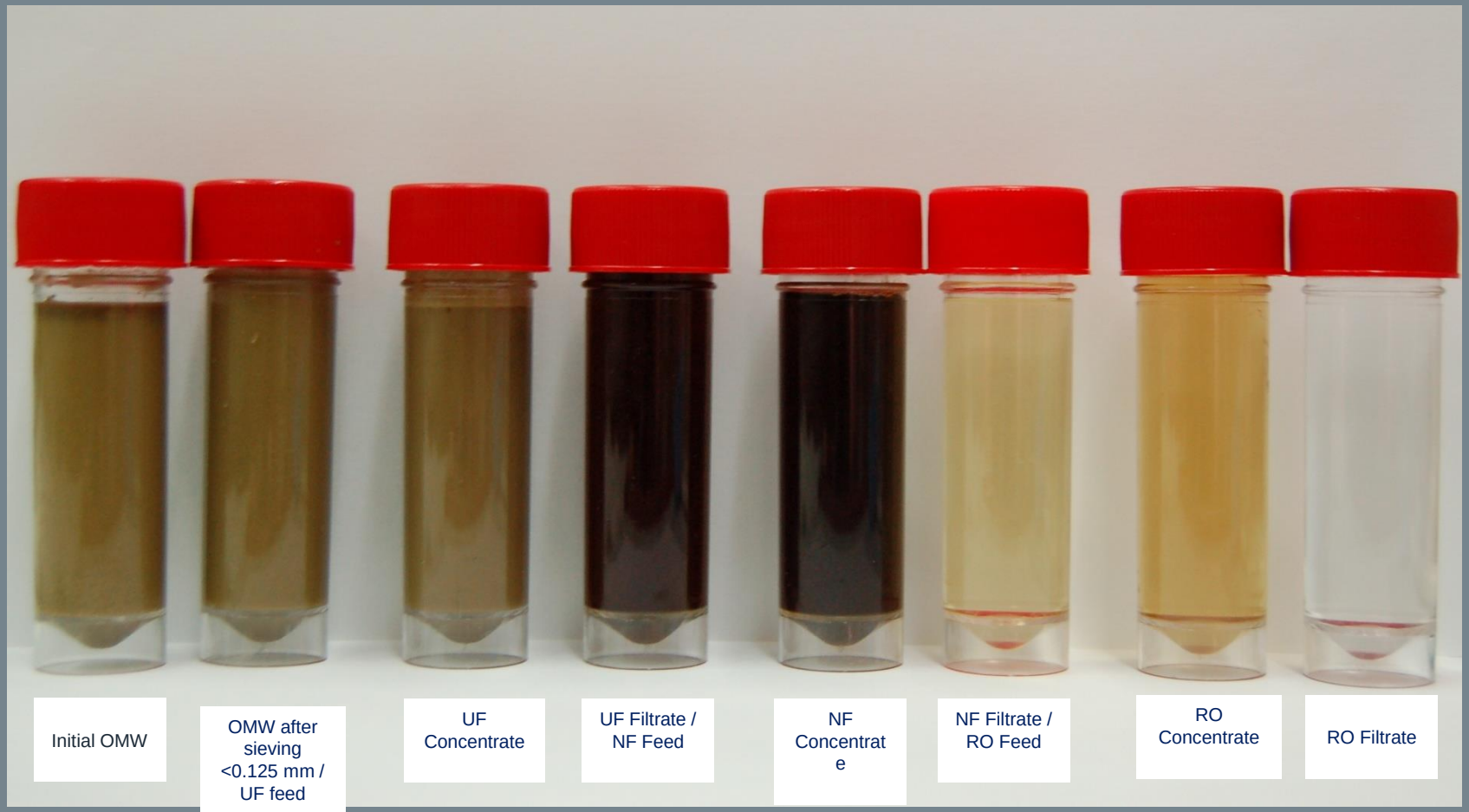
Filtration Process for OMW Valorization



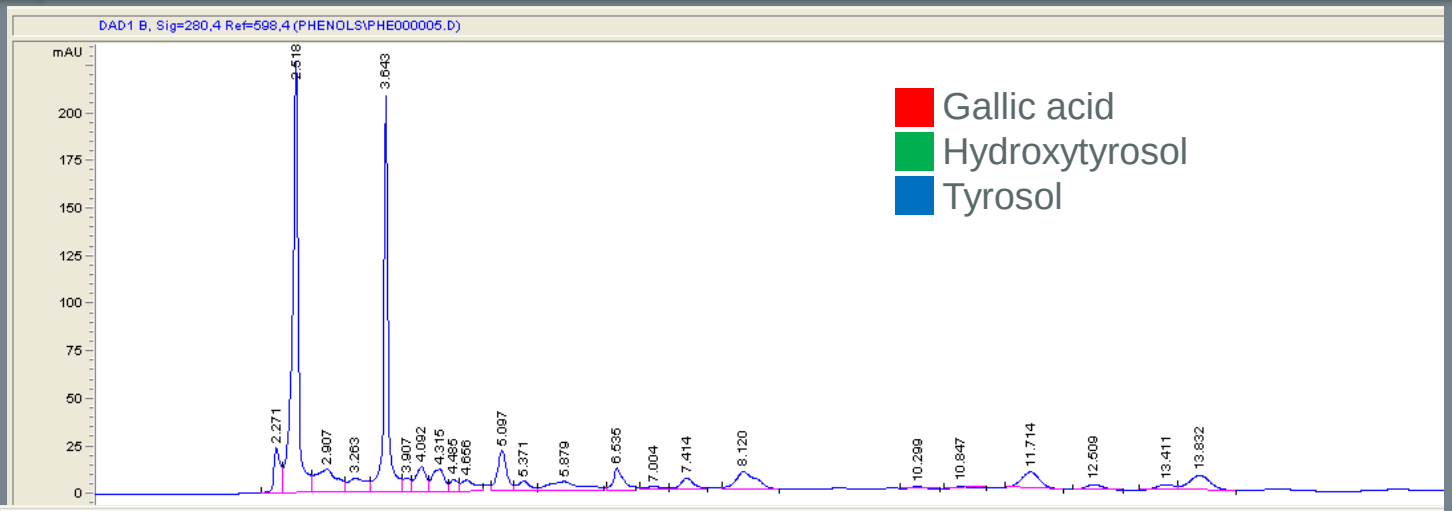
- For the reduction of the larger suspended solids, consequential sieving was done with four stainless steal filters (0.63, 0.45, 0.180, 0.125 mm).
- The OMW was then treated with UF, NF and RO pilot units in line.
- The phenolic compounds should be concentrated in the RO concentrate.
- Samples were kept and analyzed from every step.

Other polyphenols and organics with high molecular size concentrated in NF can be used as constituents of ecological herbicides, as additive antioxidants in common cooking oils (corn oils, kern oils, etc)

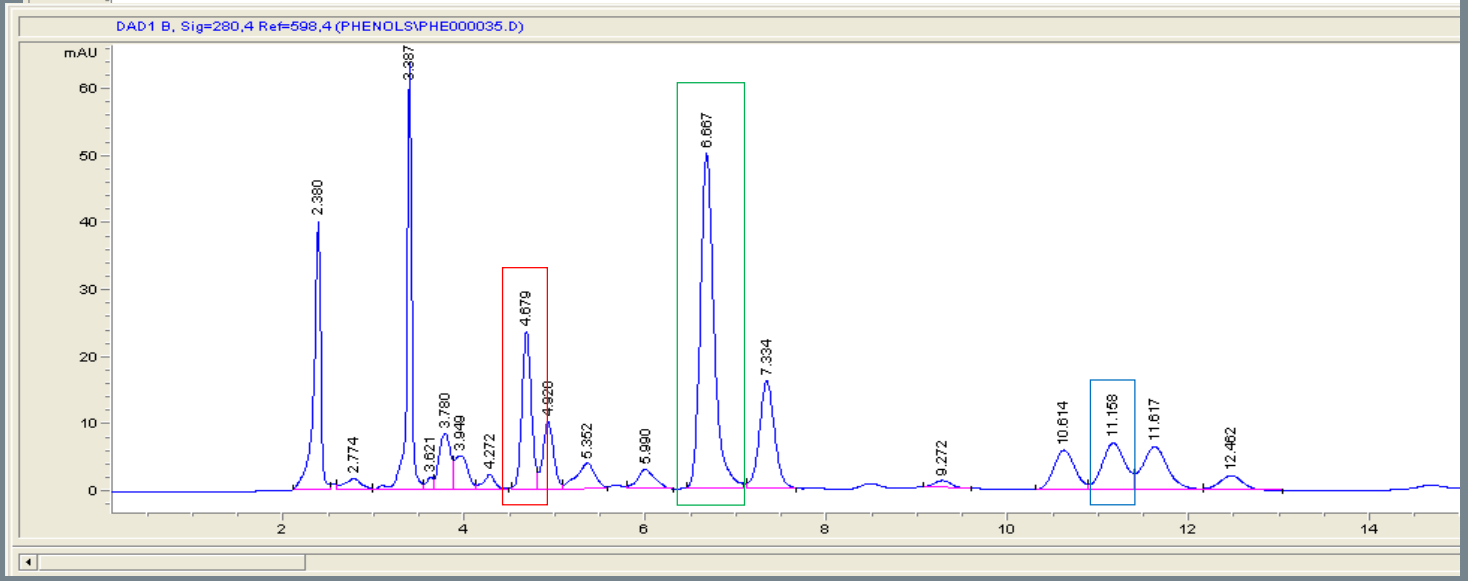
OMW Purification and Valorization



Phenolic Content of the Samples at the Outlet of Resin Columns



Initial



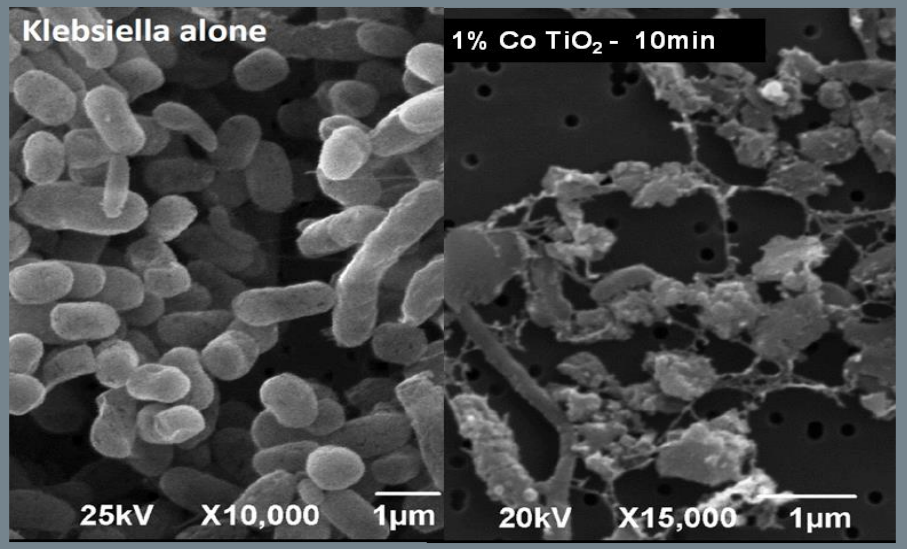
Final

Projects

- PANELEA: A cost effective system development for complete exploitation of olive mill wastewater, (CEU/CRAFT, Regional
- Innovation Poles, GGET, Development of sustainable solutions for the management of olive mill wastewaters with emphasis on the valorizarion of by-products, 2006-2009
- STInno - Sustainable Innovations and Treatment in Industrial Waste Water Clusters, 2 009
- Innovation coupons, GSRT (Innovation Coupons for SMEs), 2009
- SWAM - Increasing the regional competitiveness and economic growth through the RTD&I on sustainable water management, 2010
- Development of new polymeric membranes with carbon nanotubes for the treatment of aqueous wastewaters' MEKKA-SYNERGASIA, GSET, 2010
- Tempus IV, Noria: 'Strengthening Innovation Strategy and Improving the Technology Transfer in the Water Technology Sector of Morocco, 2012

Publications

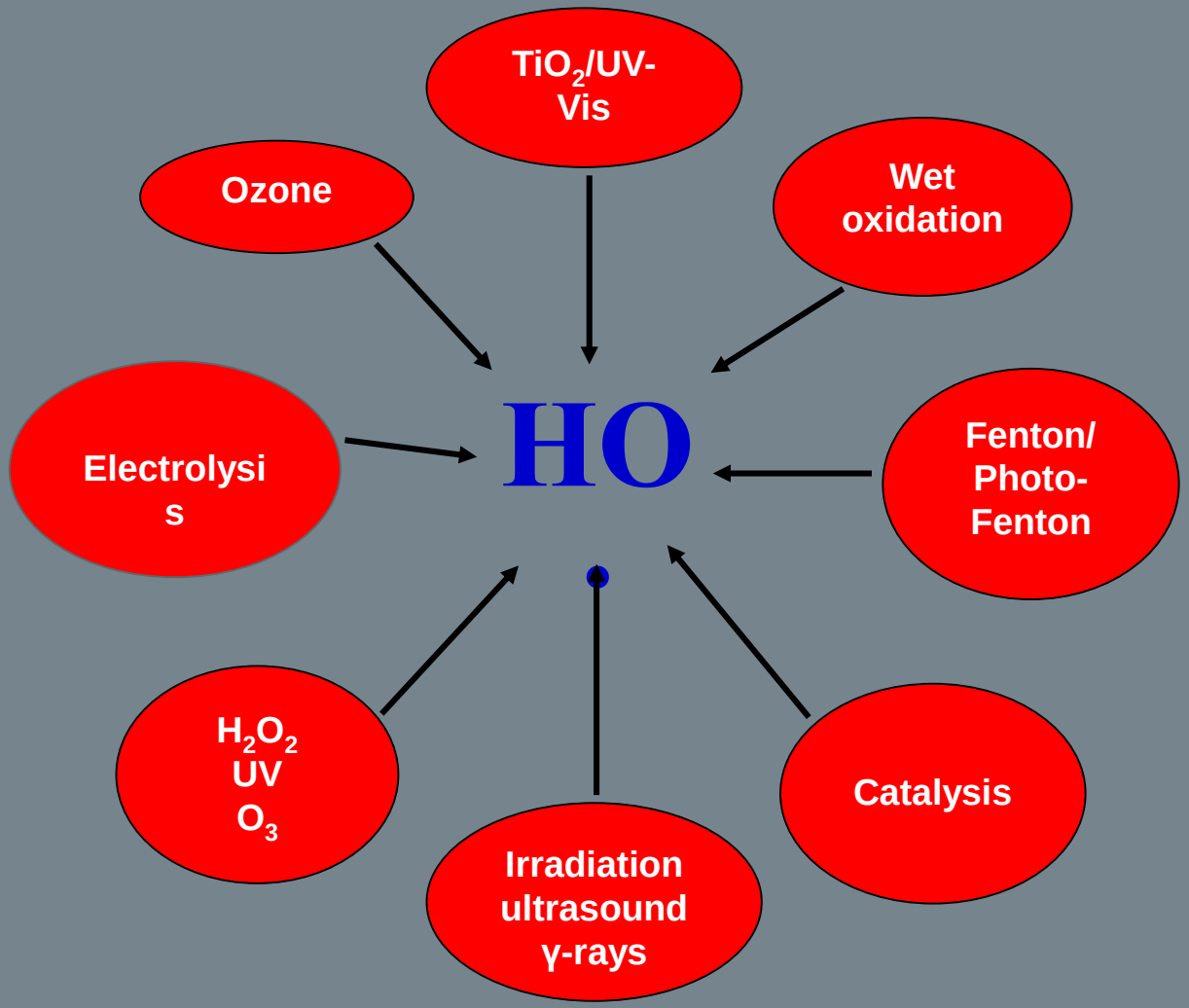
1. Dimitris P. Zagklis, Christakis A. Paraskeva, 'Isolation and purification of phenols contained in Olive Mill Wastewaters using a combination of physicochemical separation process', in preparation
2. Kontos Spyros S., Koutsoukos Petros G., Paraskeva Christakis A., REMOVAL AND RECOVERY OF PHENOLIC COMPOUNDS FROM OLIVE MILL WASTEWATER BY COOLING CRYSTALLIZATION, submitted to J. of Crystal Growth, 2013
3. Dimitris P. Zagklis, Christakis A. Paraskeva, 'Membrane filtration of agro-industrial wastewaters and isolation of organic compounds with high added values', to appear, October 2013, Water Science and Technology, 2013
4. Amit Bhatnagar, Fabio Kaczala, William Hogland, Marcia Marques, Christakis A. Paraskeva, Vagelis G. Papadakis, Mika Sillanpää, 'Valorization of solid waste products from olive oil industry as potential adsorbents for water pollution control – A review', Environmental Science and Pollution Research, April, 2013
5. Zagklis, D.P., Arvaniti, E. C., Papadakis, V.G. and Paraskeva, C.A., Review, sustainability analysis and benchmarking of olive mill wastewater treatment methods, submitted, J. of Chemical Technology and Biotechnology, 2012.
6. E. C. Arvaniti, D. P. Zagklis, V. G. Papadakis, and C. A. Paraskeva, "High-Added Value Materials Production from OMW: A Technical and Economical Optimization," International Journal of Chemical Engineering, vol. 2012, Article ID 607219, 7 pages, 2012. doi:10.1155/2012/607219
7. K. Stamatelatou, A. Kopsahelis[1], P.S. Blika, C.A. Paraskeva, G. Lyberatos, 'Anaerobic digestion of olive mill wastewater in a periodic anaerobic baffled reactor (PABR) followed by further effluent purification via membrane separation technologies', Journal of Chemical Technology and Biotechnology, Volume 84, Issue 6, pages 909–917, June 2009**.** DOI:10.1002/jctb.2170
8. C. A Paraskeva, V. G. Papadakis, E. Tsarouchi, D. G. Kanellopoulou, P.G Koutsoukos, "Membrane Processing for Olive Mill Wastewater Fractionation", Desalination, **213**, 218-229, 2007, http://dx.doi.org/10.1016/j.desal.2006.04.087,
9. C. A. Paraskeva, V.G. Papadakis, D.G. Kanellopoulou, P.G. Koutsoukos and K.C. Angelopoulos, "Membrane filtration of olive mill wastewater (OMW) and OMW fractions' exploitation", Water Environment Research, **79** (4)**,** 421-429, 2007, **DOI:** http://dx.doi.org/10.2175/106143006X115345



The “AOPs” Research Group

Prof. Dionissios Mantzavinos

Research Activities (within EnvChE)



Research interests

- ❑Kinetics & mechanisms
- ❑By-products and properties
- ❑Modeling & optimization
- ❑Scale-up

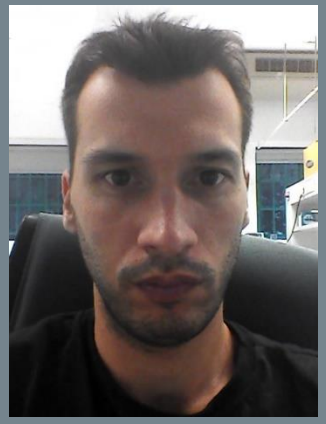
Applications

- ❑(Agro-) Industrial effluents
- ❑Emerging micro-pollutants
- ❑Pathogens
- ❑Effluent organic matter

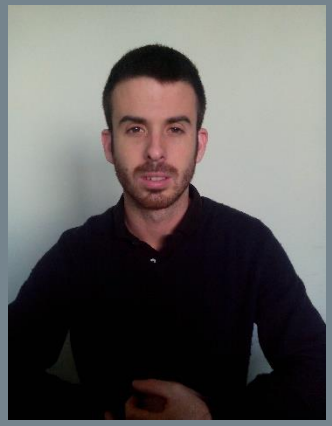
Researchers

- DM is the latest addition to the Dept (3/2013), so the group has to be reborn from its ashes (hopefully not !)

- Nonetheless…



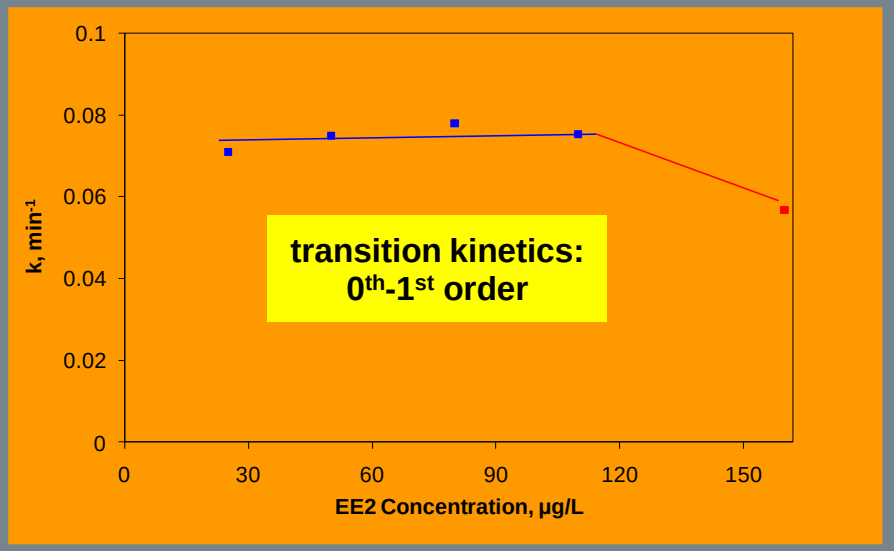
Dr Z. Frontistis
post-doc researcher

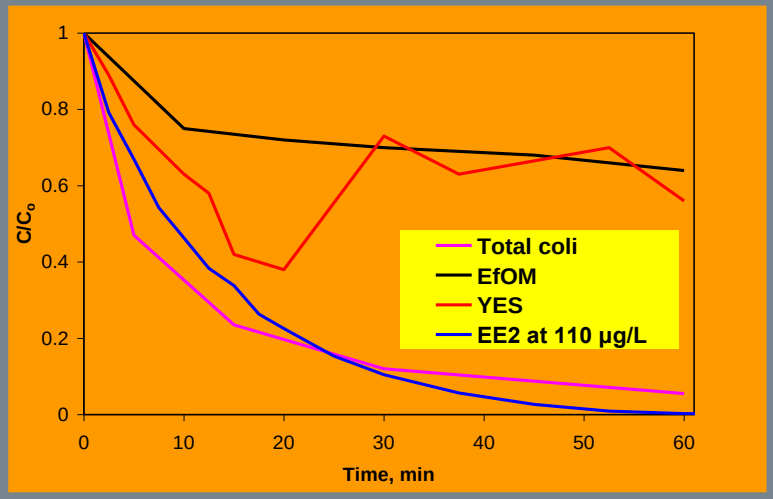


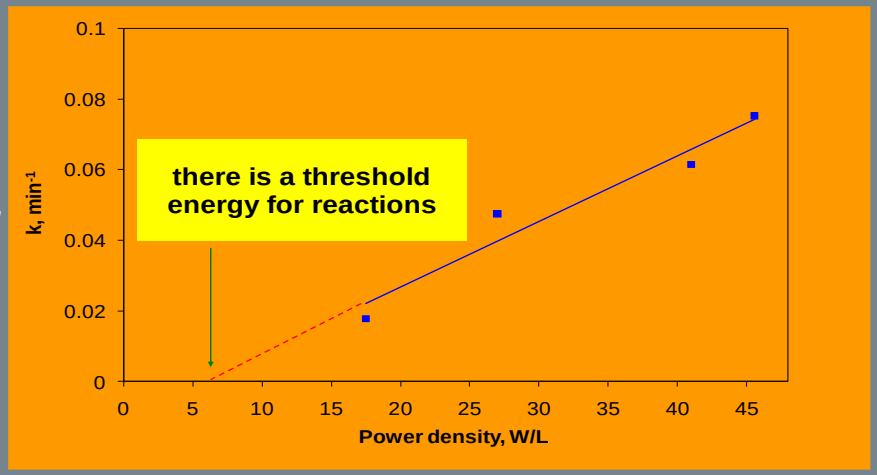
Mr E. Marti Mestres
Erasmus student
Uni. of Barcelona, Spain

Sonodegradation of estrogens in H_2O

- Ultrasound at 80 kHz degrades EE2
- Kinetics
- Cost implications
- Real life applications







Research Projects at UP (within EnvChE)

- THALIS, 2012-2015, 600 k€: Development of AOPs with the use of nanomaterials and sunlight for the removal of organic toxic micropollutants, endocrine disrupters and cyanotoxins from natural waters and sewages (Uni. of Ioannina, TU-Crete, Demokritos);
- CARATHEODORY PROGRAM for post-doctoral research, 2014-2015, 51.5 k€, under evaluation: Hybrid AOPs for the removal of emerging endocrine disruptors from aqueous matrices;

AOPs RG - Highlights

- Founding member of the so-called “European Union PhD School on AOPs” (to begin officially in 2014);
- Founder of the international conference on “environmental applications of AOPs” (Chania, Greece 2006; Nicosia, Cyprus 2009; Almeria, Spain 2013)

Some Recent Publications (within EnvChE)

- D.Venieri et al, Inactivation of *Bacillus anthracis* in water by photocatalytic, photolytic and sonochemical treatment, *Photochemical & Photobiological Sciences*, **12(4)**, (2013), 645-652.
- L.Ioannou et al, Sunlight, iron and radicals to tackle the resistant leftovers of biotreated winery wastewaters, *Photochemical & Photobiological Sciences*, **12(4)**, (2013), 664-670.
- D.Venieri et al, Photoelectrocatalytic disinfection of water and wastewater: performance evaluation by qPCR and culture techniques, *Journal of Water & Health*, **11(1)**, (2013), 21-29.
- E.Lacasa et al, Electrochemical disinfection of simulated ballast water on conductive diamond electrodes, *Chemical Engineering Journal*, **223**, (2013), 516-523.
- A.Zacharakis et al, Solar photocatalytic degradation of bisphenol A on immobilized ZnO or TiO2, *International Journal of Photoenegy*, **2013**, (2013), Article ID 570587, doi:10.1155/2013/570587, 1-9.
- V.Koutantou et al, Solar photocatalytic decomposition of estrogens over immobilized zinc oxide, *Catalysis Today*, **209**, (2013), 66-73.
- V.M.Daskalaki et al ,Solar light-induced photoelectrocatalytic degradation of bisphenol-A on TiO_2/ITO film anode and BDD cathode, *Catalysis Today*, **209**, (2013), 74-78.