

Proposition de sujet de thèse CNRS-L/UPPA

2017-2018

Mechanisms of transfer and accumulation of toxins in fish following Cyanobacteria bloom in a lake ecosystem

Mécanismes du transfert et de l'accumulation des toxines dans des poissons suite à l'efflorescence de cyanobactéries dans un écosystème lacustre

Co-dirigé par:

Kamal Slim, professor in hydrobiology

and

Ryszard Lobinski, research director at CNRS

Thématiques prioritaires :

- **Ressources aquatiques**
- **Environnement**

Pièces jointes :

- CV du co-directeur libanais
- CV du co-directeur français

II. Fiche de Renseignements sur le laboratoire d'accueil au Liban

Université ou centre de recherche : La Commission Libanaise de l'Energie Atomique – le Conseil National de la Recherche Scientifique

Laboratoire d'accueil : Laboratoire des analyses inorganiques

Nom du Directeur du laboratoire : Dr. Rola Bou Khozam

Adresse : Rue Principale de l'Aéroport, Beirut

Tél./Fax/Mél : office+9611450811, mobile : +96113120800, fax : +9611450810

Faculté ou organisme auquel est affilié le laboratoire d'accueil : CLEA - CNRS

Nom du Directeur de thèse : Pr. Kamal Slim

Le Directeur de thèse fait-il partie du laboratoire d'accueil : Oui / Non

Professeur en hydrobiologie - Attaché scientifique au CNRSL-Commission Libanaise de l'Energie Atomique

Principaux thèmes de recherche de l'équipe où sera effectué le travail de thèse

- Monitoring of physico-chemical parameters and toxicity of waters of the lake of Karaoun
- Modelling of the cyanobacteria dynamics in the lake of Karaoun
- Construction and analysis of the temporal evolution of algal blooms events using remote sensing techniques

Liste des publications récentes de l'équipe (pertinentes au sujet proposé- 3 dernières années) :

FADEL A., FAOUR G., **SLIM K.** (2016) ASSESSMENT OF THE TROPHIC STATE AND CHLOROPHYLL-A CONCENTRATIONS USING LANDSAT OLI IN KARAOUN RESERVOIR, LEBANON *Lebanese Science Journal, Vol. 17, No. 2, 2016*

TEMSAH M., TARHINI K., FADEL A., **SLIM K.** (2016) Effect of Irrigation with Lake Water Containing Cyndrospermopsin Toxin on Seed Germination and Seedlings Growth of Cucumis Sativus and Lycopersicon Esculatum. *Inter.jour. Sci. (IJSBAR) 27,3:108-122*

FADEL A., LEMAIRE B., VINCON-LEITE B., **SLIM K.**, ATOUI A., TASSIN B (2016) "Modelling the seasonal competition between toxic cyanobacteria *Microcystis aeruginosa* and *Chrysochloris ovalisporum* using a simplified model". (Submitted to *Ecological Modelling*).

FADEL A., ATOUI A., TEMSAH M., MATAR M. and **SLIM K.** (2015) Monitoring the trophic state and phycocyanin pigment of Karaoun reservoir, *Jour.Env.Hydrol.* 23,7:8p

FADEL A, ATOUI A. LEMAIRE B. Vinçon-Leite B., **SLIM K.** (2015).

Environmental factors associated with phytoplankton succession in a Mediterranean reservoir with a high fluctuating water level (accepted) *Envir Monitoring assessment journal*

FADEL A, ATOUI A, LEMAIRE B, VINCON-LEITE B, **SLIM K** (2014). "Dynamics of the toxin cyndrospermopsin and the cyanobacterium *Aphanizomenon ovalisporum* in a Mediterranean eutrophic reservoir". *Toxins*, 6 (10) 3041-3057

SLIM K., ATOUI A., FADEL A. (2014) Global warming as a driving factor for cyanobacterial blooms in lake KARAOUN, Lebanon. *Dessalination and water treatment*, 52(10-12), 2094-2101

FADEL.A., ATOUI A., LEMAIRE B., VINCON-LEITE B., AMACHA N., **SLIM K.** TASSIN B., (2014) First assessment of the ecological status of karaoun reservoir, Lebanon, *Lakes and reservoirs: research and management*, 19(2),142-157

La thèse sera effectuée en **co-direction**

III. Fiche de Renseignements sur le laboratoire

d'accueil à l'UPPA

Laboratoire d'accueil : Institut des Sciences Analytiques et de Physico-chimie pour l'Environnement et les Matériaux (IPREM), UMR 5254

Nom du Directeur du laboratoire : Ryszard LOBINSKI

Adresse : Hélioparc, 2, av. Pr. Angot, 64053 Pau, FRANCE

Tél./Fax/Mél : + 33 559807755/

Ecole doctorale auquel est affilié le laboratoire d'accueil : ED211 Sciences Exactes et ses Applications

Nom du Directeur de thèse : Ryszard LOBINSKI

Le Directeur de thèse fait-il partie du laboratoire d'accueil : Oui / Non

Nombre de thèses dirigées (ou codirigées) actuellement :

Une à partir du 1 Octobre 2017

Pour les cinq dernières années, précisez les thèses soutenues, la durée en mois pour chacune d'entre elle, la liste des publications et la situation actuelle de chaque diplômé

PH.D. thesis defended under supervision of R. Lobinski since 2013

- 2013 Guillaume Bucher
Développements analytiques pour la spéciation de l'uranium dans les branchies du poisson zèbre (*Danio rerio*) après exposition
Emploi actuel : post-doc à une université canadienne
- 2013 Paulina Flis
Large-scale metabolomics of trace metals in plants
Emploi actuel: ICP MS platform manager at University of Nottingham
- 2014 Hiba Abdallah,
Analyse de multiresidues d'antibiotiques dans la viande alimentaire par la spectrométrie de masse de haute résolution
Emploi actuel : ATER à l'Université Libanaise de Beyrouth
- 2014 Maria Aoun
Spéciation dans les métaux dans les organismes marins de la côte libanaise
Emploi actuel : cadre à la Commission d'Energie Atomique à Beyrouth
- 2017 Ivan Eb-Levadoux
Identification des ligands biologiques suite à l'exposition d'écrevisses à l'uranium
- 2017 Shuanglong Wang (to be defended on Septembner 25th 2017)
Spéciation des métaux dans les plantes : devenir des nanoparticules
- 2017 Sara Gutierrez-Sama en co-direction avec B. Bouyssiere (to be defended on September 26th 2017)
Spéciation des métaux dans le pétrole

List of publications of the Ph.D. students above

1. Eb-Levadoux, Y.; Frelon, S.; Simon, O.; Arnaudguilhem, C.; Lobinski, R.; Mounicou, S., In vivo identification of potential uranium protein targets in zebrafish ovaries after chronic waterborne exposure. *Metallomics* 2017, 9, 525-534.
2. Romão, W.; Tose, L. V.; Vaz, B. G.; Gutierrez Sama, S.; Lobinski, R.; Giusti, P.; Carrier, H.; Bouyssiére, B., *Petroleomics by Direct Analysis in Real Time-Mass Spectrometry*. *Journal of the American Society for Mass Spectrometry* 2016, 27, 182-185.
3. Gutierrez Sama, S.; Desprez, A.; Krier, G.; Lienemann, C. P.; Barbier, J.; Lobinski, R.; Barrere-Mangote, C.; Giusti, P.; Bouyssiére, B., Study of the Aggregation of Metal Complexes with Asphaltenes Using Gel Permeation Chromatography Inductively Coupled Plasma High-Resolution Mass Spectrometry. *Energy and Fuels* 2016, 30, 6907-6912.
4. Ghsein, G.; Brutesco, C.; Ouerdane, L.; Fojcik, C.; Izaute, A.; Wang, S.; Hajjar, C.; Lobinski, R.; Lemaire, D.; Richaud, P.; Voulhoux, R.; Espaillet, A.; Cava, F.; Pignol, D.; Borezée-Durant, E.; Arnoux, P., Biosynthesis of a broad-spectrum nicotianamine-like metallophore in *Staphylococcus aureus*. *Science* 2016, 352, 1105-1109.
5. Flis, P.; Ouerdane, L.; Grillet, L.; Curie, C.; Mari, S.; Lobinski, R., Inventory of metal complexes circulating in plant fluids: a reliable method based on HPLC coupled with dual elemental and high-resolution molecular mass spectrometric detection. *New Phytologist* 2016, 211, 1129-1141.
6. Bucher, G.; Mounicou, S.; Simon, O.; Floriani, M.; Lobinski, R.; Frelon, S., Insights into the nature of uranium target proteins within zebrafish gills after chronic and acute waterborne exposures. *Environmental Toxicology and Chemistry* 2016, 35, 736-741.
7. Abdallah, H.; Arnaudguilhem, C.; Abdul Rahim, H.; Lobinski, R.; Jaber, F., Monitoring of twenty-two sulfonamides in edible tissues: Investigation of new metabolites and their potential toxicity. *Food Chemistry* 2016, 192, 212-217.
8. Aoun, M.; El Samad, O.; Bou Khozam, R.; Lobinski, R., Assessment of committed effective dose due to the ingestion of ²¹⁰Po and ²¹⁰Pb in consumed Lebanese fish affected by a phosphate fertilizer plant. *Journal of Environmental Radioactivity* 2015, 140, 25-29.
9. Aoun, M.; Arnaudguilhem, C.; El Samad, O.; Khozam, R. B.; Lobinski, R., Impact of a phosphate fertilizer plant on the contamination of marine biota by heavy elements. *Environmental Science and Pollution Research* 2015, 22, 14940-14949.
10. Abdallah, H.; Arnaudguilhem, C.; Lobinski, R.; Jaber, F., A multi-residue analysis of sulphonamides in edible animal tissues using QuEChERS extraction and HPLC-MS/MS. *Analytical Methods* 2015, 7, 1549-1557.
11. Grillet, L.; Ouerdane, L.; Flis, P.; Hoang, M. T. T.; Isaure, M. P.; Lobinski, R.; Curie, C.; Mari, S., Ascorbate efflux as a new strategy for iron reduction and transport in plants. *Journal of Biological Chemistry* 2014, 289, 2515-2525.
12. Bucher, G.; Mounicou, S.; Simon, O.; Floriani, M.; Lobinski, R.; Frelon, S., Different uranium distribution patterns in cytosolic protein pool of zebrafish gills after chronic and acute waterborne exposures. *Chemosphere* 2014, 111, 412-417.
13. Bucher, G.; Frelon, S.; Simon, O.; Lobinski, R.; Mounicou, S., Development of non-denaturing off-gel isoelectric focusing for the separation of uranium-protein complexes in fish. *Analytical and Bioanalytical Chemistry* 2014, 406, 3517-3520.
14. Abdallah, H.; Arnaudguilhem, C.; Jaber, F.; Lobinski, R., Multiresidue analysis of 22 sulfonamides and their metabolites in animal tissues using quick, easy, cheap, effective, rugged, and safe extraction and high resolution mass spectrometry (hybrid linear ion trap-Orbitrap). *Journal of Chromatography A* 2014, 1355, 61-72.
15. Grevenstuk, T.; Flis, P.; Ouerdane, L.; Lobinski, R.; Romano, A., Identification of the tri-Al tricitrate complex in *Plantago almogravensis* by hydrophilic interaction LC with parallel ICP-MS and electrospray Orbitrap MS/MS detection. *Metallomics* 2013, 5, 1285-1293.

Liste of recent publications of Lobinski group (5 last years):

1. Kubica, P.; Vacchina, V.; Wasilewski, T.; Reynaud, S.; Szpunar, J.; Lobinski, R., Rapid ion-exchange matrix removal for a decrease of detection limits in the analysis of salt-rich reservoir waters for fluorobenzoic acids by liquid chromatography coupled with tandem mass spectrometry. *Analytical and Bioanalytical Chemistry* 2017, 409, 871-879.
2. Eb-Levadoux, Y.; Frelon, S.; Simon, O.; Arnaudguilhem, C.; Lobinski, R.; Mounicou, S., In vivo identification of potential uranium protein targets in zebrafish ovaries after chronic waterborne exposure. *Metallomics* 2017, 9, 525-534.
3. Bierła, K.; Suzuki, N.; Ogra, Y.; Szpunar, J.; Łobiński, R., Identification and determination of selenohomolanthionine – The major selenium compound in *Torula* yeast. *Food Chemistry* 2017, 237, 1196-1201.

4. Shimura, M.; Shindou, H.; Szyrwił, L.; Tokuoka, S. M.; Hamano, F.; Matsuyama, S.; Okamoto, M.; Matsunaga, A.; Kita, Y.; Ishizaka, Y.; Yamauchi, K.; Kohmura, Y.; Lobinski, R.; Shimizu, I.; Shimizu, T., Imaging of intracellular fatty acids by scanning X-ray fluorescence microscopy. *FASEB Journal* 2016, 30, 4149-4158.
5. Romão, W.; Tose, L. V.; Vaz, B. G.; Sama, S. G.; Lobinski, R.; Giusti, P.; Carrier, H.; Bouyssièr, B., Petroleomics by Direct Analysis in Real Time-Mass Spectrometry. *Journal of the American Society for Mass Spectrometry* 2016, 27, 182-185.
6. Gutierrez Sama, S.; Desprez, A.; Krier, G.; Lienemann, C. P.; Barbier, J.; Lobinski, R.; Barrère-Mangote, C.; Giusti, P.; Bouyssièr, B., Study of the Aggregation of Metal Complexes with Asphaltenes Using Gel Permeation Chromatography Inductively Coupled Plasma High-Resolution Mass Spectrometry. *Energy and Fuels* 2016, 30, 6907-6912.
7. Ghsein, G.; Brutesco, C.; Ouerdane, L.; Fojcik, C.; Izaute, A.; Wang, S.; Hajjar, C.; Lobinski, R.; Lemaire, D.; Richaud, P.; Voulhoux, R.; Espaillet, A.; Cava, F.; Pignol, D.; Borezée-Durant, E.; Arnoux, P., Biosynthesis of a broad-spectrum nicotianamine-like metallophore in *Staphylococcus aureus*. *Science* 2016, 352, 1105-1109.
8. Flis, P.; Ouerdane, L.; Grillet, L.; Curie, C.; Mari, S.; Lobinski, R., Inventory of metal complexes circulating in plant fluids: a reliable method based on HPLC coupled with dual elemental and high-resolution molecular mass spectrometric detection. *New Phytologist* 2016, 211, 1129-1141.
9. Bucher, G.; Mounicou, S.; Simon, O.; Floriani, M.; Lobinski, R.; Frelon, S., Insights into the nature of uranium target proteins within zebrafish gills after chronic and acute waterborne exposures. *Environmental Toxicology and Chemistry* 2016, 35, 736-741.
10. Bierla, K.; Flis-Borsuk, A.; Suchocki, P.; Szpunar, J.; Lobinski, R., Speciation of Selenium in Selenium-Enriched Sunflower Oil by High-Performance Liquid Chromatography-Inductively Coupled Plasma Mass Spectrometry/Electrospray-Orbitrap Tandem Mass Spectrometry. *Journal of Agricultural and Food Chemistry* 2016, 64, 4975-4981.
11. Abdallah, H.; Arnaudguilhem, C.; Abdul Rahim, H.; Lobinski, R.; Jaber, F., Monitoring of twenty-two sulfonamides in edible tissues: Investigation of new metabolites and their potential toxicity. *Food Chemistry* 2016, 192, 212-217.
12. Szyrwił, L.; Shimura, M.; Shirataki, J.; Matsuyama, S.; Matsunaga, A.; Setner, B.; Szczukowski, L.; Szewczuk, Z.; Yamauchi, K.; Malinka, W.; Chavatte, L.; Łobinski, R., A novel branched TAT47-57 peptide for selective Ni²⁺ introduction into the human fibrosarcoma cell nucleus. *Metallomics* 2015, 7, 1155-1162.
13. Szyrwił, Ł.; Liauchuk, V.; Chavatte, L.; Lobinski, R., In vitro induction and proteomics characterisation of a uranyl-protein interaction network in bovine serum. *Metallomics* 2015, 7, 1604-1611.
14. Studzińska, S.; Mounicou, S.; Szpunar, J.; Łobiński, R.; Buszewski, B., New approach to the determination phosphorothioate oligonucleotides by ultra-high performance liquid chromatography coupled with inductively coupled plasma mass spectrometry. *Analytica Chimica Acta* 2015, 855, 13-20.
15. Martínez, M.; Lobinski, R.; Bouyssièr, B.; Piscitelli, V.; Chirinos, J.; Caetano, M., Determination of Ni and v in Crude Oil Samples Encapsulated in Zr Xerogels by Laser-Induced Breakdown Spectroscopy. *Energy and Fuels* 2015, 29, 5573-5577.
16. Kubica, P.; Garraud, H.; Szpunar, J.; Lobinski, R., Sensitive simultaneous determination of 19 fluorobenzoic acids in saline waters by solid-phase extraction and liquid chromatography-tandem mass spectrometry. *Journal of Chromatography A* 2015, 1417, 30-40.
17. Aoun, M.; El Samad, O.; Bou Khozam, R.; Lobinski, R., Assessment of committed effective dose due to the ingestion of ²¹⁰Po and ²¹⁰Pb in consumed Lebanese fish affected by a phosphate fertilizer plant. *Journal of Environmental Radioactivity* 2015, 140, 25-29.
18. Aoun, M.; Arnaudguilhem, C.; El Samad, O.; Khozam, R. B.; Lobinski, R., Impact of a phosphate fertilizer plant on the contamination of marine biota by heavy elements. *Environmental Science and Pollution Research* 2015, 22, 14940-14949.
19. Abdallah, H.; Arnaudguilhem, C.; Lobinski, R.; Jaber, F., A multi-residue analysis of sulphonamides in edible animal tissues using QuEChERS extraction and HPLC-MS/MS. *Analytical Methods* 2015, 7, 1549-1557.
20. Xu, M.; Frelon, S.; Simon, O.; Lobinski, R.; Mounicou, S., Non-denaturing isoelectric focusing gel electrophoresis for uranium-protein complexes quantitative analysis with LA-ICP MS. *Analytical and Bioanalytical Chemistry* 2014, 406, 1063-1072.
21. Xu, M.; Frelon, S.; Simon, O.; Lobinski, R.; Mounicou, S., Development of a non-denaturing 2D gel electrophoresis protocol for screening in vivo uranium-protein targets in *Procambarus clarkii* with laser ablation ICP MS followed by protein identification by HPLC-Orbitrap MS. *Talanta* 2014, 128, 187-195.
22. Shao, S.; Mi, X.; Ouerdane, L.; Lobinski, R.; García-Reyes, J. F.; Molina-Díaz, A.; Vass, A.; Dernovics, M., Quantification of Se-Methylselenocysteine and Its γ -Glutamyl Derivative from Naturally Se-Enriched Green Bean (*Phaseolus vulgaris*)

- vulgaris) After HPLC-ESI-TOF-MS and Orbitrap MSⁿ-Based Identification. *Food Analytical Methods* 2014, 7, 1147-1157.
23. Pedrero Zayas, Z.; Ouerdane, L.; Mounicou, S.; Lobinski, R.; Monperrus, M.; Amouroux, D., Hemoglobin as a major binding protein for methylmercury in white-sided dolphin liver. *Analytical and Bioanalytical Chemistry* 2014, 406, 1121-1129.
 24. L'Azou, B.; Passagne, I.; Mounicou, S.; Tréguer-Delapierre, M.; Puljalté, I.; Szpunar, J.; Lobinski, R.; Ohayon-Courtès, C., Comparative cytotoxicity of cadmium forms (CdCl₂, CdO, CdS micro- and nanoparticles) in renal cells. *Toxicology Research* 2014, 3, 32-41.
 25. Grillet, L.; Ouerdane, L.; Flis, P.; Hoang, M. T. T.; Isaure, M. P.; Lobinski, R.; Curie, C.; Mari, S., Ascorbate efflux as a new strategy for iron reduction and transport in plants. *Journal of Biological Chemistry* 2014, 289, 2515-2525.
 26. Cheajesadagul, P.; Bianga, J.; Arnaudguilhem, C.; Lobinski, R.; Szpunar, J., Large-scale speciation of selenium in rice proteins using ICP-MS assisted electrospray MS/MS proteomics. *Metallomics* 2014, 6, 646-653.
 27. Bucher, G.; Mounicou, S.; Simon, O.; Floriani, M.; Lobinski, R.; Frelon, S., Different uranium distribution patterns in cytosolic protein pool of zebrafish gills after chronic and acute waterborne exposures. *Chemosphere* 2014, 111, 412-417.
 28. Bucher, G.; Frelon, S.; Simon, O.; Lobinski, R.; Mounicou, S., Development of non-denaturing off-gel isoelectric focusing for the separation of uranium-protein complexes in fish. *Analytical and Bioanalytical Chemistry* 2014, 406, 3517-3520.
 29. Bianga, J.; Touat-Hamici, Z.; Bierla, K.; Mounicou, S.; Szpunar, J.; Chavatte, L.; Lobinski, R., Speciation analysis for trace levels of selenoproteins in cultured human cells. *Journal of Proteomics* 2014, 108, 316-324.
 30. Bianga, J.; Bouslimani, A.; Bec, N.; Quenet, F.; Mounicou, S.; Szpunar, J.; Bouyssiére, B.; Lobinski, R.; Larroque, C., Complementarity of MALDI and ICP mass spectrometry for platinum anticancer imaging in human tumor. *Metallomics* 2014, 6, 1382-1386.
 31. Barbier, J.; Marques, J.; Caumette, G.; Merdrignac, I.; Bouyssiére, B.; Lobinski, R.; Lienemann, C. P., Monitoring the behaviour and fate of nickel and vanadium complexes during vacuum residue hydrotreatment and fraction separation. *Fuel Processing Technology* 2014, 119, 185-189.
 32. Abdallah, H.; Arnaudguilhem, C.; Jaber, F.; Lobinski, R., Multiresidue analysis of 22 sulfonamides and their metabolites in animal tissues using quick, easy, cheap, effective, rugged, and safe extraction and high resolution mass spectrometry (hybrid linear ion trap-Orbitrap). *Journal of Chromatography A* 2014, 1355, 61-72.
 33. Vacchina, V.; Ionescu, C.; Oguey, S.; Lobinski, R., Determination of Zn-, Cu- and Mn-glycinate complexes in feed samples and in-vitro and in-vivo assays to assess their bioaccessibility in feed samples. *Talanta* 2013, 113, 14-18.
 34. Grevenstuk, T.; Flis, P.; Ouerdane, L.; Lobinski, R.; Romano, A., Identification of the tri-Al tricitrate complex in *Plantago almogravensis* by hydrophilic interaction LC with parallel ICP-MS and electrospray Orbitrap MS/MS detection. *Metallomics* 2013, 5, 1285-1293.
 35. Galano, E.; Mangiapane, E.; Bianga, J.; Palmese, A.; Pessione, E.; Szpunar, J.; Lobinski, R.; Amoresano, A., Privileged incorporation of selenium as selenocysteine in *Lactobacillus reuteri* proteins demonstrated by selenium-specific imaging and proteomics. *Molecular and Cellular Proteomics* 2013, 12, 2196-2204.
 36. Frelon, S.; Mounicou, S.; Lobinski, R.; Gilbin, R.; Simon, O., Subcellular fractionation and chemical speciation of uranium to elucidate its fate in gills and hepatopancreas of crayfish *Procambarus clarkii*. *Chemosphere* 2013, 91, 481-490.
 37. Bierla, K.; Bianga, J.; Ouerdane, L.; Szpunar, J.; Yiannikouris, A.; Lobinski, R., A comparative study of the Se/S substitution in methionine and cysteine in Se-enriched yeast using an inductively coupled plasma mass spectrometry (ICP MS)-assisted proteomics approach. *Journal of Proteomics* 2013, 87, 26-39.
 38. Anan, Y.; Yoshida, M.; Hasegawa, S.; Katai, R.; Tokumoto, M.; Ouerdane, L.; Łobiński, R.; Ogra, Y., Speciation and identification of tellurium-containing metabolites in garlic, *Allium sativum*. *Metallomics* 2013, 5, 1215-1224.

IV. Sujet de thèse

A faire signer obligatoirement par tous les co-directeurs

IV.1. Titre

Transfer and accumulation of toxins in fish following Cyanobacteria bloom in a lake ecosystem

La thèse fait-elle partie d'un projet de recherche financé par le CNRS-L : / x Non

La thématique sous laquelle s'inscrit la thèse fait-elle partie des priorités de cet appel pour l'année 2017-2018 (voir annexe) : x Oui

- **Ressources aquatiques**
- **Aménagement/ télédétection**
- **Environnement**

IV.2. Résumé (ne pas dépasser 200 mots)

Harmful algal blooms resulting from anthropogenic nutrient enrichment in natural waters are known to produce acute and chronic toxicity to humans and farmed animals and is a serious health problem in water ecosystems and supplies. Cyanobacteria produce a variety of natural toxins, called cyanotoxins, which are classified into three broad groups according to chemical structure: cyclic peptides, alkaloids and lipopolysaccharides. Several analytical and biochemical screening methods are currently in use for determination of cyanotoxins. However, there is increasing evidence that the evaluation of the impact of cyanobacteria proliferation requires one to take into account the presence of several other organic and inorganic components such as nutrients, trace metals, pesticide residues, pharmaceutical and personal care products released into the aquatic systems. The objective of the thesis is to develop a holistic analytical approach for the monitoring this set of parameters using the latest generation of high-throughput high resolution mass spectrometry for organic compounds and multielemental analysis including their speciation (determination of individual chemical forms) in algae, water and fish, including organs and tissues of the lake Qaraoun and proposing a multiparameter model to study the transfer and accumulation of toxins in fish and crops grown in fields irrigated by contaminated waters.

IV.3. Contexte et problématique (ne pas dépasser 200 mots)

Contexte : The problem of invasive Cyanobacteria or blue-green algae has been attracting a lot of interest for many years. Due to enhanced urbanization, industrial and agricultural practices, the contamination of water basins, rivers and underground wells become an endemic issue leading to drastic perturbation, mainly eutrophication, of aquatic ecosystems (nitrogen and phosphate enrichment), and other residual effect on agricultural crops in surrounding area, eco-touristic impact and environmental hazards. A major phenomena of degradation of water quality is the proliferation of cyanobacteria secreted toxins which neurotoxins, cytotoxins, endotoxins, and hepatotoxins (e.g., the microcystin-producing bacteria genus microcystis), and collectively known as cyanotoxins,

Problématique: The impact of toxins released by cyanobacteria is critically dependent of the presence of several other organic and inorganic components such as nutrients, trace metals, pesticide residues, pharmaceutical and personal care products released into the aquatic systems. The other factors as well as environmental stress conditions (e.g. low precipitation) can increase or decrease their toxicity. The analytical methods used at present address individual toxins whereas a global view of the entire set of contaminants is necessary. The advent of high-throughput high resolution mass spectrometric techniques makes the challenge considered impossible till a few years ago within reach.

IV.4. Descriptif des objectifs et de l'impact (ne pas dépasser 200 mots)

This project proposes a comprehensive study of the sanitary risk associated to proliferation of cyanobacteria toxins at Qaraoun Lake. In term of biota we will particularly focus on carp, river water fish, concerned by a number of deaths in the recent years. We will investigate the set of cyanobacterial metabolites: cyclic peptides, alkaloids and lipopolysaccharides in water and in different fish organs, along with the residues of pesticides, pharmaceutical and personal care products, and anthropogenic trace metals (and their speciation) released into the lake ecosystem. As the lake water is used for the irrigation of the surrounding fields, an assessment is to be done for the extent of dissemination of toxins. Study will be done on edible part of agricultural crops growing in that area to measure toxins and its metabolites, and toxic elements residual to this contamination. The principal impact will be the understanding of the level and distribution of the contamination and the interdependence of the levels of different contaminants on the fish mortality. On the training level, the Ph.D. student will be initiated to the cutting edge mass spectrometric techniques (Fourier-Transform high resolution high mass accuracy) and hyphenated techniques for the trace element speciation analysis.

IV.5. Aspect appliqué et/ou aspect innovateur (ne pas dépasser 200 mots)

Aspect appliqué: The persistence of algal blooming episodes in the Qaraoun lake results in the decreasing live quality of the concerned population, the contamination of waters used for the irrigation results in the contamination of fruit and vegetables and the cyanotoxin levels in fish making them improper for consumption. This ecosystem is considered to undergo a natural catastrophe on the national level. The monitoring part of the project aims at the quantification of these risks and rising the awareness of the authorities charged to work out preventive strategies

Aspect innovateur: the holistic aspect of the evaluation of the cyanobacterial contamination including other persistent pollutants has never been attempted before. Also, in terms of trace elements, the effect of cyanobacterial toxins on metal speciation, and hence bioavailability, is a totally novel question that will be investigated using cutting-edge analytical techniques.

IV.6. Etat des recherches dans le domaine avant la thèse (ne pas dépasser 200 mots)

An increase in the frequency and intensity of occurrence of harmful algal blooms is not a novel topic and the global attention has been directed towards the presence of MCs in aquatic systems. The effects of cyanotoxins on fish have been verified in a number of studies including histological, biochemical and behavioral effects. The toxicological effects are known to be related to the exposure route (intraperitoneal injection, feeding or immersion), the mode of uptake (passive or active transport) as well as biotransformation and bioaccumulation capabilities by different organs.

However, the recent review (*Aquatic Toxicology*, 2013, 142-143, 1-16) points out the insufficiency of such studies and indicates the need for the determination of the interrelationship of cyanobacterial toxins with other environmental pollutants such as organic and inorganic constituents (nutrients and heavy metals) in order to draw realistic conclusions regarding toxic effects of HABs. These components are regularly found in aquatic water systems all around the world and hence, it is important to take them into account as they are known as interferences to cyanobacterial toxins. These estimations are particularly important in order to avoid any kind of over/under estimations of the effects of HABs on aquatic systems. Such a holistic approach is the goal of the thesis.

Pavagadhi, S., Balasubramanian, R., (2013) Toxicological evaluation of microcystins in aquatic fish species: Current knowledge and future directions (Review), *Aquatic Toxicology*, 2013, 142-143, 1-16.

Imai H., Chang K, Nakano S. (2009)- Growth responses of harmful algal species *Microcystis* under various environmental conditions. *Inter. Studies on Env. Chem* 269-275

Kagalou I, Papadimitriou T. (2008)-Assessment of microcystin in lake water and the omnivorous fish in lake Pamvotis containing dense cyanobacterial bloom. *Env.Monit.Assess* 137:185-195

Shukla B. I. (2007) Potassium-induced inhibition of nitrogen and phosphorus metabolism as a strategy of controlling *Microcystis* blooms. *World J Microb.Biot.*23:317-322

Quesada A., Moreno E., Sukenik A. (2006) Toxicity of *Aphanizomenon ovalisporum* (cyanobacteria) in a Spanish water reservoir. *Eur Jour.Phycol* 41,1 :39-45.

Ghachtoul M., Gabi H. (2005)- Eutrophication des eaux des retenues des barrages Smir et Sehla (Maroc): causes, conséquences et consignes de gestion-*Revue Sci.Eau* 18 :75- 89

Vardaka E., Lanaras T. (2005)- Cyanobacterial blooms and water quality in Greek waterbodies. *Jour.Appl. Phyco.* 17; 391-401

Sabbour B., Loudiki M., Oudra B. (2002) First results on microcystin sp. Toxic blooms in the hypertrophic Oued Mellah reservoir (Morocco). *Ann.Limnol.*38 (1) :13-22.

Albay M ,Codd G. (2003) – Depth profiles of cyanobacterial hepatotoxins (microcystins) in three Turkish freshwater lakes - *Hydrobiologia* 505: 89-95

Cherifi O., Loudiki M. (1999)- Flood transport of dissolved and suspended matter in the El Abid river basin (Morocco) – *Hydrobiologia* 410: 287-294

Perez-Martinez, Castillo P. (2001)- Temporal occurrence of *Ceratium hirundinella* in Spanish reservoirs . *Hydrobiologia* 452 : 101-107.

IV.7. Programme de recherche prévu pour la thèse et contribution des différents partenaires (ne pas dépasser 200 mots)

The Lebanese side will take care of the design and carrying out of the sampling campaign in a way that it is meaningful for the future design of the remediation and prevention strategy. The tasks coordinated include identification and quantification of cyanobacteria in hydrographic networks (Kamal Slim), identification, sampling and preparation of fish and organs for the study (Ghassan Elzein), teledetection and biogeochemical modelling (Ali Fadel). Sample treatment, total metal analyses and toxicological analyses will be carried out under the supervision of Rola Bou Khozam.

The French side will take care of the coordination of the development of analytical methodologies for the cyclic peptides, alkaloids and lipopolysaccharides, pesticide residues, pharmaceutical and personal care residues (R. Lobinski and MARSS platform, Simon Godin) and for the trace metals speciation analysis (Ryszard Lobinski, Katarzyna Bierla). The data treatment of the large data volumes and modelling of the transfer of the contaminants among the different compartments will be done together by the both sides.

IV.8. Calendrier prévisionnel des mobilités

Month 0 to Month 6 (Beirut)

Understanding the subject, bibliographic survey, sampling campaign, preparation of representative samples to serve for the method development, set of the measurement of physicochemical parameters (temperature, precipitation, salinity, ...), total element measurements

Month 6 – Month 18 (Pau)

Method development by LC – MS/MS (high resolution high mass accuracy) for the different families of contaminants: cyclic peptides, alkaloids and lipopolysaccharides, pesticide residues, pharmaceutical and personal care residues

Month 19 –Month 21 (Beirut)

Analysing the results, definition of the representative samples for the high throughput studied, definition of interesting samples for the metal speciation studies on the basis of the results obtained at CLEA.

Month 22-27 (Pau)

Completion of the organic analysis studies, speciation analysis of samples identified as interesting

Month 28 – 36 (Beirut)

Collation of the data, modeling of the transfer between water and biota, finalizing the manuscript and preparation for the defense of the thesis

IV.9. Diffusion/valorisation des résultats

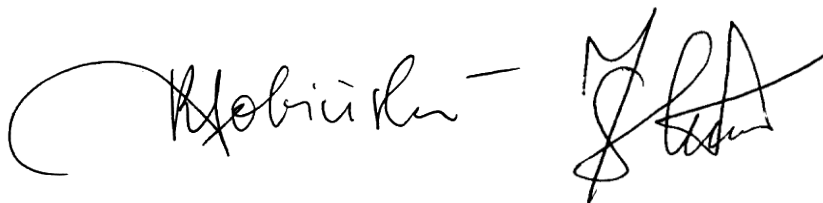
The conditions of the Ph.D. thesis are strictly defined by the rules of the Doctoral School of the University of Pau. The results will bring at least two publications in international journal with an IF>4 and will be presented by the student at least two international meetings in the form of an oral presentation. A series of presentations in Lebanon for the general public sensitizing to the need of the restauration of the site are foreseen.

IV.10. Compétences requises

The PhD. Student to be recruited should have a master degree in the area of environmental and/or analytical chemistry. He/she should be familiar with the sampling and analytical techniques based on chromatography and mass spectrometry.

Date September 08th, 2017

Noms et signatures (directeurs de thèse)

The image shows two handwritten signatures in black ink. The signature on the left is written in a cursive style and appears to be 'M. J. J. J. J.' followed by a horizontal line. The signature on the right is more stylized and appears to be 'M. J. J. J. J.' followed by a horizontal line.

Curriculum vitae of Ryszard Lobinski

Ryszard LOBINSKI

Born on 11 August 1963

Married, 3 children

Home address: 5, allée de Diane, 64140 LONS, France

Professional address:

IPREM, Hélioparc, 2, av. Pr. Angot, 64053 Pau, France

E-mail: ryszard.lobinski@univ-pau.fr

Phone: +33559407754



Degrees and titles

Combined engineer and master degree in chemical technology (Warsaw University of Technology), 1986

Ph.D. in analytical chemistry (Warsaw University of Technology), 1989

D.Sc. (*habilitation*) in analytical chemistry (Warsaw University of Technology), 1995

Professor of chemical sciences, title bestowed by the President of the Republic of Poland, 1999

Employment record

- since 2000 research director (directeur de recherche 1ère classe since 2008) at the National Research Council of France (CNRS), University of Pau
- 1994-2000 research scientist (chargé de recherche) at the CNRS (1994-1997 University Bordeaux I, 1997- 2000 University of Pau)
- 1986 – assistant, assistant professor (1994), associate (*extraordinary*) professor (1999) and full (*ordinary*) professor (2003) at the Warsaw University of Technology, Warsaw, Poland
- 1991 - 1994 senior scientist in "Global Change" and "Eurocore" programmes at the University of Antwerp, Belgium
- 1990 fellow of the Max Planck Society at the Institute of Applied Spectrochemistry and Spectroscopy in Dortmund, Germany (12 months)

Others:

- Visiting professor at the Institute for Coastal Research, GKSS-Geesthacht, Germany (3 months in 2003)
- Guest scientist at the Institute of Nuclear Chemistry and Technology (INCT) in Warsaw, Poland (3 months in 1989),
- Visiting professor at the INCT (2 months in 2006)
- Visiting professor at the Chuo University, Japan (1 month in 2008)

Principal positions:

- 2016 - Director of the Institute of Analytical and Physical Chemistry for Environment and Materials, *Institut des Sciences Analytiques pour l'Environnement et les Matériaux*, IPREM – UMR 5254 (250 people), Pau, France
- 2007-2015 Head of the Laboratory of Analytical Bioinorganic and Environmental Chemistry (LCABIE, ex-UMR5034, 75 people)
- 1999-2008 co-founder (1999) and co-director (1999-2008) of Ultratrace Analyses Aquitaine (UT2A, non-public service and consulting laboratory, 10 employees)

Other functions:

vice-president, president and past-president (2002-2008) of the Analytical Chemistry Division of IUPAC

Awards:

- Polish Prime Minister Biennial Scientific Award (1996)
- Silver medal of the National Research Council of France (*Médaille d'argent CNRS*) (2006)
- Admitted *Fellow of the Royal Society of Chemistry*, Cambridge (2007)
- Japan Society for the Promotion of Science Invitation Fellowship (2011)

Publishing record:

- 270 articles in peer reviewed journals
- 3 books and 3 edited journal issues
- 19 book chapters
- 130+ invited (plenary and keynote) lectures at international meetings

H-index: 57 (SCOPUS), 65 (Google Scholar)

Number of citations: >9500 (SCOPUS), >12,900 (Google Scholar)

Average journal impact factor: 4.1

Training record:

Supervisor of 29 Ph.D. theses and 15 post-doctoral fellows

Grants and industrial contracts:

more than 10 M€ (as Principal Investigator) since 1995



Curriculum Vitae of KAMAL SLIM

Kamal A. Slim

Professor

Disciplinary Field:

Environmental Science

Ecologist

Lebanese University, Faculty of Sciences,

Department of Natural Sciences, since 1985

Phone(home): 961 1 555188 -

961 3 25 6075

Kslim@cnrs.edu.lb- Kamal.slim@hotmail.com

National Council for Scientific Research Lebanon
CNRSL

Department of Research and Developpement -
Microorganisms Laboratory.

Phone (office):961 1 450810 Fax: 961 1 450811

Education

1979 PhD in Université de Rennes: Hydrobiological Laboratory and

physiology.

Thesis director: René le Cohu

Research Subject: Premier bilan dans l'étude hydrobiologique du

barrage de la Chèze: Ile-et-Vilaine:

Etude du périphyton à l'aide des substrats artificiels (Jury: Prs.Serge Villeret,

P.Bourrelly, J.C. Lefeuvre)

Mention: **Very honorable**, with congratulations of the jury.

1977 Master II in Ecology-Ethology. Université de Rennes et Tours I

Thesis subject:"*Approche expérimentale en vue d'étudier les variations des*

Populations algales du périphyton à l'étang au Duc Ploermel

1976 Master I in Université de Rennes I,

1975 License in Biology. Lebanese University-Faculty of Sciences.

Individual memberships

- Researcher in **NCSR (National Council for Scientific Research).**
- Director of the first cycle (First and Second year) at Saint-Joseph University, 1985.
- Head of department of Natural Sciences in Lebanese University -
Faculté of Sciences V.
- Team member on biodiversity in **LEBANON (PNUE), 1996**
- Group Coordinator of the Freshwater Ecosystem
(National Biodiversity Convention) **UNDP, 1998**
- Team member: Arab Integrated Water Resources management, AWARNET in ESCWA, 2005.
- Militant ecologist since 1985
- Member of the Scientific Committee of Ibrahim Abdel Al Foundation for Sustainable Development 2016

Teaching

- | | |
|-------------------|--|
| 1979-1981 | Assistant professor at Faculty of Medicine
University of Louvain - Antonin University, Baabda |
| 1981-1985 | Assistant professor at agro-food school
Saint-Joseph University – Kfar Fallous |
| 1986-1987 | Assistant Professor of Cell Biology at the Agricultural University,
Lebanese University |
| 1988-1998 | In charge for T.P. in the Faculty of Medicine, Lebanese University |
| 1985 | Assistant Professor - Faculty of Sciences, Lebanese University |
| Since 2010 | Professor - Faculty of Sciences, Lebanese University. |

Biodiversity Projects

- 1996- **SLIM K.**, ALOUF N., DIA A. et EL ZEIN G.
Study of biological diversity of Lebanon. Aquatic fauna and flora.
Ministère de l'Agriculture + PNUE- Beyrouth
- 1998- **SLIM K.** ALOUF N. et EL ZEIN G.
National biodiversity strategy and action plan. Lebanon
- 1999- **SLIM K.** Etude de la diversité biologique de la reserve naturelle d'Ammiq.
Ministère de l'environnement + CNRS + UNDP
- 1999- MOUHEIDDIN H., HARB N., ALOUF N. SAFA A. ET **SLIM K.**
National database for water resources in Lebanon- CNRS- Liban
- 2003- **SLIM K.**, DIA A.et JRADI G.
Biodiversity assessment and monitoring in the protected areas (Ammiq+Tyr)
Lebanon Leb /95/G31. UNDP +GEF +MOE +UL
- 2005- **SLIM K.**,
Addendum on fresh water Biodiversity
MOE + UNDP + AUB

Participation in Projects: 'CEDRE'

- 2001 –Les ressources des eaux à AKKAR: Contribution à l'étude des diatomées d'eaux douces.
- 2002- Transport des polluants et traitement des eaux des rivières libanaises : Nahr Ibrahim.
- 2010- Etude du développement du phytoplancton dans les lacs de barrage de karaoun au Liban et de
Grangent en France

Projects in the quality of watercourses in Lebanon

2001- Etudes environnementales du Nahr el Assi, projet Libano-syrien

SAAD Z., **SLIM K.** El SAMAD O.

Commission Libanaise de l'énergie atomique (CNRSL). 76 p.

2005 – Evaluation de la qualité des eaux du Nahr el Bared d'après les méthodes indiciaires:

Impact de l'anthropisation

KHALAF G., **SLIM K.**

BID for negotiated procedures about water quality studies 32p.

The Humanitarian office of European communities.

2012 – Project of dragging the water from karaoun lake to the South: Evaluate environmental impact on the top basin of the Litani river

Mouin Hamze- Talal Darwich – **Kamal Slim**-Amin Chaabane

CNRS L

2016 –The actual situation of the Karaoun lake after the fishes' death:Reasons-outcomes-solutions

Kamal Slim –Omar Samad – Ali Fadel – Rana Baydoun

CNRSL

REFEREED PUBLICATIONS

1. El SAMAD O., BAYDOUN R., AOUN M, and **SLIM K.** (2017) Investigation of seawater intrusion using stable and radioisotopes at coastal area south of Beirut, the Capital of Lebanon. *Environ Earth Sci.* 76:187
DOI 10.1007/s12665-017-6514-z

2. FADEL A., FAOUR G., **SLIM K.** (2016) ASSESSMENT OF THE TROPHIC STATE AND CHLOROPHYLL-A CONCENTRATIONS USING LANDSAT OLI IN KARAOUN RESERVOIR, LEBANON *Lebanese Science Journal, Vol. 17, No. 2, 2016*

3. TEMSAH M., TARHINI K., FADEL A., **SLIM K.** (2016) Effect of Irrigation with Lake Water Containing Cylindrospermopsin Toxin on Seed Germination and Seedlings Growth of Cucumis Sativus and Lycopersicon Esculatum. *Inter.jour. Sci. (IJSBAR)* 27,3:108-122
4. FAYSSAL N., **SLIM K. (2015)** the impact of urban growth on ground water salinity rates on the Lebanese coast. *WIT Transactions on Ecology and the Environment* Vol. 200.:249-273
5. ASSAKER A., PROBST J-L, DARWISH T., **SLIM K. (2016)** Diversity and ecology of Diatoms in relation with the physicochemical characteristics from freshwater of the Ibrahim River Lebanon
6. FADEL A, LEMAIRE B., VINCON-LEITE B, **SLIM K**, ATOUI A, TASSIN B(2016) "Modelling the seasonal competition between toxic cyanobacteria *Microcystis aeruginosa* and *Chrysochloris ovalisporum* using a simplified model". (Submitted to *Ecological Modelling*).
7. FADEL A., ATOUI A., TEMSAH M., MATAR M. and **SLIM K. (2015)** Monitoring the trophic state and phycocyanin pigment of Karaoun reservoir, *Jour.Env.Hydrol.* 23,7:8p
8. FADEL A, ATOUI A, LEMAIRE B, Vinçon-Leite B., **SLIM K. (2015)**. Environmental factors associated with phytoplankton succession in a Mediterranean reservoir with a high fluctuating water level (accepted) *Envir Monitoring assessment journal*
9. FADEL A, ATOUI A, LEMAIRE B, VINCON-LEITE B, **SLIM K(2014)** "Dynamics of the toxin cylindrospermopsin and the cyanobacterium *Aphanizomenon ovalisporum* in a Mediterranean eutrophic reservoir". *Toxins*, 6 (10) 3041-3057
10. **SLIM K.**, ATOUI A., FADEL A. (2014) Global warming as a driving factor for cyanobacterial blooms in lake KARAOUN, Lebanon. *Dessalination and water treatment*, 52(10-12), 2094-2101
11. FADEL.A., ATOUI A., LEMAIRE B., VINCON-LEITE B., AMACHA N., **SLIM K.** TASSIN B., (2014) First assessment of the ecological status of karaoun reservoir, Lebanon, *Lakes and reservoirs: research and management*, 19(2),142-157
12. MIKATI F.M., SAADE N.A. **SLIM K.A.**, EL JAMAL M.M. (2013) Bioabsorption of methylene blue on chemically modified *Chaetophora elegans* (algae) by HCL and citric acid. *Jour.Chem.Techn.Metall.* 48, 1: 1-1
13. **SLIM K.**, ATOUI A.and FADEL A. (2013) Suivi spatio-temporel des communautés zooplanctoniques et les interactions avec les cyanobactéries toxiques du lac karaoun (LIBAN) *USTHB-FBS-4th inter.cong.populations and animals communities CIPCA* ,114-120.
14. **SLIM K**, ATOUI A., TEMSAH M. (2013) Impact of margins on the water quality of Hasbani River (south Lebanon) by special references to diatoms indices. *Nature and Technology* 9, 2-12.
15. ATOUI A., HAFEZ H., **SLIM K. (2013)** Occurrence of toxic cyanobacterial blooms for the first time in Lake Karaoun-Lebanon. *Water and Environment Journal* 27,42-49.
16. **SLIM K**, ATOUI A, ELZEIN G, TEMSAH M. (2012) Etude de l'impact du changement climatique sur la qualité de l'eau et la prolifération toxique des cyanobactéries du lac karaoun (Liban) *Larhyss.* 10, 29-43

17. KHALAF G, **SLIM K**, ABI GHANEM C, NAKHLE K. (2009) Caractérisation et corrélation des paramètres biotiques et abiotiques des eaux du Nahr el Bared . *Lebanese science journal*. **10,1. 3-21**
18. KHALAF G., **SLIM K.**, SAAD Z., NAKHLE K. (2007) Evaluation de la qualité biologique des eaux du Nahr el Jaouz (LIBAN) : application des méthodes indicielles. *Bull. Mens.Soc.Linn.Lyon* **76 (9-10) :225-268**
19. SAAD Z., KAZPARD V. EL SAMARANI A.G., **SLIM K.** NABHAN P. (2006) Relations entre métaux traces dans le tabac et la nature du sol au Liban *Cahiers Agriculture*, **15, 2,1-9.**
20. SAAD Z., KAZPARD V., EL SAMARANI A.G., **SLIM K.**, OUAINI N. (2006): Use of hydrochemistry and environmental isotopes to evaluate water quality, Litani River, Lebanon. *Journal of environmental hydrology*, **4, 16, 1-11.**
21. SAAD Z., KAZPARD V., EL SAMARANI A.et **SLIM K.** (2005) Chemical and isotopic composition of rain water in coastal and highland regions in Lebanon *Journal of environmental Hydrology* **13, 29:1-11**
22. SAAD Z., **SLIM K.**, EL ZEIN G. et EL SAMAD O. (2005 Evaluation de la qualité des eaux de la retenue de Karaoun(Liban) *Bull.Soc.Neuch.S.N.* **128 :71-80**
23. EL SAMARANI A., KAZPARD V., OUAINI N., LARTIGES B., **SLIM K.** et SAAD Z. (2005) Trace element carriers in rivers sediments (Ibrahim River-Lebanon). Investigation natural and anthropogenic inputs. *Inter.Jour.of civil and Env. Eng.***1, 3:1-16**
24. SAAd Z., KAZPARD V., **SLIM K.** and MROUEH M. (2005 A hydrochemical and isotopic study of submarine fresh water along the coast in Lebanon *Jour. Env. Hydrol.* **13 : 8-16**
25. SAAD Z., KAZPARD V. et **SLIM K.** (2005) Utilisation de la coagulation- floculation pour la dépollution des eaux de surface au Liban. *Cah.Assoc.Sci.Europ.Eau et santé* **10, 1:63-69**

26. **SLIM K.**, SAAD Z., EL SAMAD O. et KAZPARD V. (2005) Caractérisation chimique et algologique des eaux superficielles de la rivière Oronte dans un climat semi-aride : *Sécheresse*, **15** :1-5
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Bull.Soc.Neuchâtel.Sci.Nat. **127/1** ; 69-82
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33. **SLIM K.**, SAAD Z. & NASREDDINE M. (2001) Les algues des sources libanaises : Influence de l'apport éolien sur la distribution des espèces caractéristiques.*Bull Soc.neuchâtel. Sci. nat.* **124** : 107 – 117
34. KHALAF G., **SLIM K.** & KRAIEM M.M. (2001) Etude Zoocénétique et qualité des eaux du Nahr Beyrouth. *IEEF OO EX* **493** : 133 – 139

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37. OULABI, SAAD Z. & **SLIM K. (1999)** Study of metal concentrations in water and sediment of some springs of LeJour.*Eur.Hydr.* **30, 2: 245 – 260**
38. **SLIM K. (1996)** Contribution à l'étude de la flore algale du bassin du Litani. *Leb.Sci.Res.Reports.* **1,1 :65 – 73**
39. **SLIM K. (1992)** Diatomées des sources de la région Saïda- Jezzine-Jbaa (Sud- Liban). *Bull.Soc.Sci.Bretagne* **62(1-4): 93-111**
40. **SLIM K. (1986)** Diatom flora of some springs in the south-eastern Lebanese area. *7th Int.Diatom Symp .(Paris 1984) : 367-373*
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43. **SLIM K., ALOUF N. (1984)** Contribution à l'étude de la flore diatomique de Nahr Yahfoufah (Liban) - *Bull.Inst Roy.Rabat.N°* **8:85-100**