

Research Group Bulletin

Núcleo de Estudos em Poluição e Ecotoxicologia Aquática – NEPEA

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Abstract

This manuscript briefly describes the history of the Núcleo de Estudos em Poluição e Ecotoxicologia Aquática (NEPEA), which is currently based at the São Paulo State University (UNESP) and the Federal University of São Paulo (UNIFESP). It also lists some of the main research projects developed by the group since its inauguration, as well as its members and collaborators until the present.

Key words: NEPEA-UNESP; research group, Ecotoxicology, aquatic

The “Núcleo de Estudos em Poluição e Ecotoxicologia Aquática” (NEPEA) (Figure 1) is a research group born in the São Paulo State University (UNESP) in the mid 2000’s decade, and which members are currently spread in different Brazilian states and other countries forming a network. Currently NEPEA is coordinated by the Drs. Denis Abessa (UNESP) and Lucas Buruaem Moreira (UNIFESP). The group is registered in the CNPq directory (<http://dgp.cnpq.br/dgp/espelhogrupo/7238>).

Since its beginning, NEPEA’s main fields of work involved aquatic toxicology, specially marine and estuarine, and also ecology, conservation, and management of coastal environments. Our group has been working together with public authorities in order to provide information, technical assistance, or expertise, for solving problems, establishing public policies or assisting them during decision making. Also, we have cooperated with NGOs, professional institutions, and private companies, in a sort of projects and actions involving education, public awareness, citizenship, sustainability, solutions for environmental problems, or technological development.

Since its creation, NEPEA has been ruled and managed focusing firstly on people, considering the members (and collaborators) well-being, and their technical and personal evolution. Also we have constantly attempted to produce sound science and relevant scientific questions. Thus, any description of our group demands mentioning the people and the main themes we have studied.

The embryo of the group started between 2003 and 2004, involving four undergraduate students from the course of Biological Sciences from São Camilo Faculty, namely Robson Seriani, Priscilla Romano, Fernanda Voietta Pinna and Fabiana Silveira. These students developed an ecotoxicological study on the environmental quality of Itanhaém River, coast of São Paulo. Afterwards, other students from UNESP, namely Ana Carolina Famá, Marcos Rogério Rosa, Andrea Ambrozevicius, Melina Cabral, Fernando Perina, Marina Stefanoni, Marcela Davanso, Rodrigo Imai, Felipe Bondezan de Oliveira, Luciane Maranhão, Carolina Carmo, Fernanda Rocha, Renata Nascimento, Fabiana Barbosa, Cíntia Rojas, Felipe Zanusso de Souza joined them and contributed to the very kick start of the group. Other students, under co-supervision, took part of the team, such as Iara de Sousa, Léo Ferreira, and Andrea Alonso, as well as three students from Santa Cecília University (Fernanda Biselli F. de Camargo, Camila Santana, and Rodrigo Malimpensa).

We obtained an initial funding from a project conducted in the Port of Santos, involving sediment toxicity testing, and were invited to participate, as collaborators, in two projects financed by the São Paulo Research Foundation (FAPESP), and also an international cooperation funded by the Coordination for the Improvement of Higher Education Personnel (CAPES) - all involving sediment quality

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assessment in the Santos Estuarine System or the influence of contamination sources. These projects provided us a modest and basic structure to conduct toxicity tests and some cellular and genotoxic biomarkers; it also allowed us to obtain fellowships to undergraduate students and keep the ball rolling. Anyway, the sediment quality assessment, by means of multiple lines of evidence (LOEs), became a central axis of NEPEA's research, which included different aspects such as environmental evaluations, development of new bioassays and approaches to integrate environmental data, and the establishment of local and regional sediment quality guidelines.

Concomitantly, we were also conducting projects on coastal management. In 2006, we took part in an international cooperation with the Agrocampus Ouest (France) and received the first foreigner student, Catherine Gonnot. This partnership provided conditions for a set of studies on the coastal management in São Paulo, combining references from Human Ecology and Social Sciences, and involved many students from Brazil (Fernanda Terra Stori, Felipe Zanusso de Souza, Paola Gonçalves, Michele Lau, Henrique Pozo, Kaline Melo, Mariany Martinez dos Santos, Ana Flora Sarti de Oliveira, Ana Paula Garcia, Kátia Maia Correia, Luana da Silva, Dominique Gallo, Jussara de Freitas) and France (Sohelen Marie, Nelson Daurelle, Juliette Champagnat). Within this field, in the last years our group has given some attention to the coastal governance at local level. This includes research on food security, focusing on potential human health risks due to consumption of contaminated seafood (projects coordinated by Professor Davis Sansolo), and research-action regarding the establishment of different forms of beach management, such as the blue flag certification, the planning and creation of coastal and marine protected areas, and the implementation of surfing reserves. These projects also have had students involved, such Davi Tainã Martins, Gabriela Cabrera, Gabrielle Hayek, Allan Felipe de Lima Bonfim, and Andrezza Pinheiro Anhaia.

Between the mid and late 2000's, we could participate in other projects, as collaborators, bringing additional resources to our young group. Some important partners during that period were Drs. Antonio Mozeto (UFSCar), Joseph Harari (IOUSP), Tomas Angel Del Valls (Universidad de Cádiz), Letícia Veras Costa-Lotufo (ICBUSP), Amadeu Soares (Universidade de Aveiro), Valéria Prósperi (CETESB), Newton Rodrigues da Silva (CATI), Guy Fontenelle (Agrocampus Ouest), Rogério Toppa (UFSCar), and Augusto Cesar (UNISANTA). At that time, our experiments were conducted in a multi-users laboratory, as the campus of UNESP could not provide individual laboratories for all of its researchers.

In 2008, we started collaboration with Professor Joel Sígolo (IGc-USP) and Dr. Valéria Guimarães, who had been supervised by Dr. Sígolo during her PhD. The partnership involved studies on the contamination and ecological risks in the Ribeira de Iguape River, due to the release of mining residues. Firstly, Dr. Sígolo obtained a funding from CNPq (Universal call); next we approved a more robust project funded by FAPESP (Process #2009/52762-6), and the Post-

Doctorate fellowship of Dr. Guimarães (Process #2008/54607-5), allowing us to consolidate NEPEA and acquire more equipment for conducting toxicity tests, and biochemical and molecular biomarkers. As a continuation of this project, we extended the study to the estuarine complex (Lagamar), with support of CNPq, because the metal-rich particles carried by the Ribeira de Iguape River were being deposited in the estuarine regions. Many undergraduate and graduate students were involved in this project and contributed to the NEPEA's consolidation at the early 2010's decade, namely Lucas Morais, Giuliana Araújo, Ana Carolina Cruz, Bruno Campos, Fernando Perina, Paloma Gusso-Choueri, Jessica Ruiz. These projects also produced a good number of articles and presentations in meetings.

Still at mid-2000's, our group established a strong cooperation with Dr. Letícia Veras Costa-Lotufo, who coordinated a research group at Federal University of Ceará at that time. This cooperation led to the NEPEA's association to the post-graduation course on Tropical Marine Sciences from the Institute of Marine Sciences (LABOMAR-UFC), and opened the opportunities of receiving students at graduate level, starting with Lucas Buruaem Moreira and Marcela Bergo Davanso, followed by Katherine Fiedler Choi, Ligia Maria Santana, Renan Saes, Allyson Queiroz, and Ivanildo Surini. All these students developed important projects for the semi-arid coast of Brazil, on different themes, and produced a countless number of papers. Currently, three students of NEPEA develop their master projects at LABOMAR-UFC: Luiza Mello (impacts of the oil of mysterious origin), Ana Carolina Soares, and Letícia Monteiro da Fonsêca (both studying impacts of microplastics).

During the NEPEA's establishment phase, a number of students developed independent projects, focusing on specific problems or demands (Kaline de Mello, Joaquim do Marco Neto, João Marcelo Carvalho, Carlos Cantarelli, Helen da Cruz, Júlio Cesar Borges, Caio Ribeiro, Deborah Gallo, Cláudia Santana Ferreira, Ana Carolina Gandolphi, Isabela Morita, Carolina Andreu, Marcelo Marques, Gilberto Peres Jr, Valéria Britos, Marina Lopes, Amanda Barduche, Ana Livia Ferreira Furtado, Lucas Gomes Ávila, Gilberto Peres Júnior, Ana Paula Mariko Aoyama Kajihara, Ana Julieta Ratzka Guedes Santos). In fact, the consolidation process continues until the present, by the expansion of national and international collaborations and students' exchange.

From the early 2010's decade, new challenges arise. The NEPEA took part of the INCT-TMCOcean (Instituto Nacional de Ciência e Tecnologia sobre Transferência de Materiais na Interface Continente-Oceano na Costa Leste-Sudeste do Brasil), under the coordination of Professor Luiz Drude de Lacerda (UFC). Our group also took part of the RNEA (Rede Nacional de Estudos de Anti-incrustantes), coordinated by Professor Gilberto Fillmann (FURG), and funded by FINEP, and several students were involved (Ana Carolina Feitosa Cruz, Renan Canute Kamikawachi, Lucas Gonçalves Morais, Bruno Galvão de Campos, Fernando Perina, Guacira de Figueiredo Eufrasio Pauly, Giam Luca Altafim). We obtained

additional resources from CNPq to work on this subject. These partnerships have generated a set of scientific contributions, until today. The involvement with research on antifouling coatings lately opened other collaborations, as further shown in this manuscript.

Another project was approved by CNPq under NEPEA's coordination, involving the study of gene expression in bivalves using "omics" techniques – this project included a partnership with researchers from Padova University, Italy (Prof. Tomaso Paternello), UNESP (Prof. Marcos Antonio de Oliveira), UFSC (Prof. Afonso Bainya), UNIFESP (Prof. Igor Dias Medeiros), and UDESC (Dr. Karim Lüchmann). This investigation involved a graduate student from UFSC (Flávia Zacchi), a post-doctorate investigator (Dr. Luciane Maranhão), and an undergraduate student (Andrey Bragagnolo).

Also with support of CNPq, our group was pioneer in studying the sediment quality in marine protected areas, with involvement of many students (Marcela Davanzo, Roberta Antonioli, Camila Hashimoto, Tainá Garcia da Fonseca, Henrique Pozo, Giuliana Araújo, Júlia Camargo, Maurici de Lara Dias, Heitor Albuquerque, Bruna Belletato Marques, Pedro Ricardo Bellini Dantas Leite, Sarah Maria Figueira Navi). This effort continues until the present, as this field has been historically overlooked worldwide.

Our group also took part in many other projects as collaborator. Some of them regarded environmental risks of pharmaceuticals and personal care products (PPCPs), illicit drugs, and endocrine disruptor compounds (EDCs) on marine organisms, under the coordination of Drs. Camilo Pereira, Rodrigo Choueri, and Augusto Cesar (UNIFESP), Mary de Marchi (UNESP), and Maria João Bebianno (University of Algarve). Students involved in these projects were Valéria Aline Britos, Bruno Campos, Mayana Fontes, Tainá Fonseca, Luciane Maranhão, and Luiza Mello.

Other collaborations with various institutions involved sediment quality assessments of Brazilian coastal bays and lagoons. A very first one consisted on the application of a sediment quality triad to assess the Patos Lagoon, under the coordination of Professor Gilberto Fillmann. Following, several projects were developed with colleagues from Rio de Janeiro (Professors Wilson Machado, Ricardo Santelli, Ana Paula Castro Rodrigues, and Ricardo Cesar) regarding the sediment quality of the Guanabara Bay, and the Rodrigo de Freitas and Tijuca lagoons, producing very relevant information. We also could participate in environmental studies at Todos os Santos Bay (Bahia), in collaboration with the Professors Francisco Barros, Vanessa Hatje, and Eduardo Mendes da Silva, from UFBA, and one of their talented students (Marcos Krull).

In addition, NEPEA has historically involved in actions and studies aimed to evaluate the impacts of environmental accidents and disasters, in order to provide technical information to the public authorities. First, we developed independent studies to assess the ecotoxicological effects of two oil spills occurred on the coast of São Paulo. One of them

involved a fishing boat that sunk near the coast and released fuel that reached a beach from the Ilha Anchieta State Park, while the second occurred at the São Sebastião Channel and affected several beaches; in that case we analyzed samples collected by the NGO Sea Shepperd and shared the results publically. Our research on oil spills was strengthened when Dr. Ágata Romero joined our group, as a Post-Doctoral researcher. Together with some students (Fernanda Filipini Mansur dos Santos, Mayara de Oliveira) Dr. Romero coordinated projects involving development and application of new tools for emergency preparedness, combining ESI-maps, modelling and biological sensitivity. Further, in cooperation with other post-doctoral investigator of our group (Dr. Isabella Bordon), and an undergraduate student (Mayra de Freitas Preto), we made investigations aimed to develop new biosorbents to remove oil from the water.

More recently, our group participated in studies involving two major disasters involving oil spills. The first one consisted of a major fire in a petrochemical terminal situated in the Port of Santos. In that case, we established a collaboration with IBAMA (the Federal Environmental Agency) to study part of the environmental impacts caused by the release of chemicals into the Santos Estuary, including an ecotoxicological assessment of sediment and water samples collected across the affected region, and the profile of the aqueous film forming foams (AFFFs) used to combat the fire. The AFFFs are little known (at global level), in terms of chemical composition and toxicity, but are potentially dangerous because they contain per and polyfluoroalkyl substances, which are toxic and persistent. This study involved post-docs (Luciane Maranhão, Lucas Moreira, Fernando Perina), many students (Maysa Ueda de Carvalho, Lauriney Gomes de Oliveira, Debora Cristina Nascimento de Santana, Gabriela Daniel), and also collaborations with researchers from Czech Republic (Dr. Karla Pozo - RECETOX), IOUSP (Dr. Rafael Lourenço), Portugal (Dr. Susana Loureiro, University of Aveiro), and Colombia (Dr. Diana Marcela Ibarra Mojica and two students accomplishing internships at NEPEA, Karen Forero Ariza and Laura Peñuela). Some results of this investigation we already published, but the main findings are still to be published (currently submitted or being written). However, IBAMA could use the preliminary results to start planning the regulation of AFFFs in Brazil.

A second episode regards the mysterious oil spill that reached the coast of Brazil in 2019. Our group is involved, as a collaborator, in three different investigations, at different states (Ceará, Bahia and Pernambuco), in order to assess the part of the impacts. Students involved in this theme include Maysa Ueda de Carvalho, Debora Santana, and Luiza Costa Mello; Dr. Gilberto Dias de Alkimin participated of this project at its beginning as a post-doctorate fellow.

Still regarding environmental emergencies, our group has developed studies to assess the environmental impacts associated with the rupture of the Fundão Dam (Mariana, MG, Brazil), in which millions of tons of mining tailings were released and affected the Rio Doce basin and the coastal zone adjacent

to the river mouth. Initially, we were invited to be part of the Independent Group for Assessing the Environmental Impacts (which acronym is GIAIA), just after the disaster (personal invitation made by Dr. Dante Pavan). GIAIA involved a large group of investigators, citizens, research centers, and NGOs from Brazil and other countries, who have studied the event at multiple knowledge fields. We received water and sediment samples collected all along the river basin, at different times after the dam breakage. These samples have been studied for chemical composition and acute toxicity. Further, with support of FAPESP (Processes #2018/23279-4; 2016/15229-1; 2020/09297-0), CNPq (PIBIC-CNPq 1260;) and CAPES (Process 88887.144657/2017-00), we were able to expand our research and collect fish samples for a set of analyzes (biochemical and histopathological, bioaccumulation), as well as more water and sediment samples for conducting chronic and subchronic bioassays with burrowing bivalves. Four post-doctorate level investigators have been involved in this project (Flávia Yamamoto, Fernando Perina, Caio Rodrigues, Ana Carolina Feitosa Cruz) as well as graduate (MSc. Guacira Pauly) and undergraduate students (Thaís Ralha, Kaori Onishi, Isabela Beverari Couto). These efforts resulted in a set of submitted papers (and others under preparation) and communications in congresses, which provide important information on the impacts along time and how the river is recovering after the disaster.

Concomitantly to the projects involving major environmental emergencies, our group also had the chance of start research on the presence and toxicity of plastic pellets and microplastics, in cooperation with Professor Hideshige Takada (University of Tokyo), head of the International Pellet Watch. Some students were involved in such researches, namely Gabriel Izar, Letícia França, Maysa Ueda, Isabella Beverari Couto, Giovana Gimiliani, Ana Carolina Soares, João Pedro Mukai, and Letícia Monteiro da Fonseca. We highlight the involvement of notorious researchers in these projects as well, as Professors Alexander Turra, Camilo Pereira, and Rivelino Cavalcante, and Dr. Satie Taniguchi.

The last five years also marked an involvement with research on the toxicity and environmental risks of nano-engineered materials. A strong partnership was established with colleagues from the University of Aveiro (Drs. Roberto Martins and Susana Loureiro and their students), the private company Smallmatek Ltda (João Tedim) and Brazilian investigators (Dr. Cristiane Ottoni from UNESP, Dr. Jeanylle Nilin Gonçalves from UFU, and Dr. Rubens Figueira from USP), aiming to study new antifouling biocides and corrosion inhibitors, in order to support the development of new environmental friendly and effective products. Such projects have been supported by FAPESP (Process #2020/03004-0), CAPES (Process #88881.156405/2017-01), and FCT (Process CIRCNA/BRB/0291/2019), and currently they comprise a good number of students (Bruno Galvão de Campos, Mariana Bruni Marques do Prado e Silva, Juliana Vitoria Nicolau dos Santos, Isabela Martins, Maria Luiza Regueira Lima, Thaís Ralha Rodrigues, Isabela Beverari Couto, Letícia Albanit

França) and post-docs (Dr. Ana Carolina Feitosa Cruz, and Dr. Adriano Marchello).

Recently, we also started studies focusing the effects of pollutants on coral species, in collaboration with Dr. Miguel Mies (Coral Vivo / USP). Professor Marcelo Kitahara (UNIFESP), and Dr. Kátia Capel (CEBIMAR-USP). Three students have worked on this topic (Amanda Escarabichi Bueno Mariano; Isabela Martins, and Letícia May Fukushima), and we hope to keep advancing into this subject.

After the removal of the main activities restrictions related to the Covid-19 pandemics, a group of undergraduate students arrived to NEPEA, and they are welcome! They just started as apprenticeships in 2022 and their projects are still being defined. I am proud to name them: Marcos Gabriel Silva Santos, Pedro Henrique Paixão de Moura, Vitória Nogueira Soares, Ana Vitória Strilicherk, Lilly Cristine Cunha de Oliveira, Vinícius Gonçalves Pereira, Matheus Francisco Requejo, Felipe Teixeira Santana, João Vitor Castro, Camila Prieto Martins, and Paloma Richter Santos.

Along these 17 years, a number of external students have joined the group to develop part of their projects, under formal or informal co-supervision, whereas other researchers (visiting professors, post-doctorate investigators, and others) also used the NEPEA's infrastructure. They have been provided us opportunities to exchange information and learn together. They are also part of our family, and their names could not be missed. This long of former students list includes Dr. Ronaldo José Torres, Dr. Ana Carolina Famá Ayoub e Silva. Dr. Deloar Duda de Oliveira, MSc. Gisele Witt Said, Dr. Marcos Krull, Dr. Mayana Karoline Fontes, MSc. Gabriela Pustiglione Marinsek, MSc. Catalina Musrri, Dr. Estefania Bonnail, Dr. Marina Passarelli, Dr. Mariana Capparelli, Dr. Jeanylle Nilin Gonçalves; Dr. Dayana Moscardi, MSc. Cristiane Moreira, Dr. Manoela de Orti, Dr. Luís Felipe Duarte, MSc. Aline Vecchio Alves, Dr. Fábio Hermes Pusceddu, Dr. Caio Rodrigues Nobre, MSc. Tierry Medeiros; Dr. Fernando Sanzi Cortez, MSc. Beatriz Barbosa Moreno, Dr. Lorena Souza, Eng. João Emanuel Almeida, MSc. Andressa Ortega, MSc. Letícia Silva, Biol. Jonas Rosa, Dr. Renata de Souza Leão Martins, Dr. Sarah Karoline Rodrigues, MSc. Vithória Carolyn Trindade dos Santos, MSc. Cristiane Ramon Sampaio, MSc. Kainã Rocha Cabrera Fagundes, Dr. Renata de Souza Leão, Dr. Liv Ascer, MSc. Marina Santana, Dr. Natasha Hoff, MSc. Laís Abujamara, MSc. Rodofley Moraes, Dr. Angélica Megda da Silva, MSc. Carla Capoletti, Dr. Flávia Lucena Zacchi; and Vithória Carolyn Trindade dos Santos. Collaborators from other institutions around the world are listed in the acknowledgements section of this manuscript, in order to express our gratitude.

As described above, NEPEA has written its story within the global and national science, with support of many hands and brains, assisted by a large number of researchers, who source of inspiration to us all. We hope this story can continue to be built by our members and those who are still to come, and that we can remain collaborating with the scientific

community to keep generating information on aquatic pollution, ecotoxicology, and coastal management, as well as keep forming human resources. There is a lot to do concerning to these topics, and together with you all, we can make a difference towards a better, unpolluted world.

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Figure 1. Part of the NEPEA's current staff.

