

FÓRUM AMBIENTAL DA PETROBRAS NA BAIXADA SANTISTA

Proteção dos Oceanos e Rios

FORUM AMBIENTAL DA PETROBRAS NA BAIXADA SANTISA



SANTOS, 24 DE JUNHO DE 2020

Proteção dos Oceanos e Rios

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30 ANOS

LABORATÓRIO DE ECOTOXICOLOGIA - UNISANTA

Aldo Ramos Santos
Augusto Cesar
Camilo Dias Seabra Ferreira
Fábio Hermes Pusceddu
Fernando Sanzi Cortez

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Sumário

- *Resumo histórico*
- *Principais atividades*
- *Ensino, pesquisa e extensão*
- *Sistema de qualidade*
- *Política de qualidade*
- *Produção*
- *Equipe*

RESUMO

O Laboratório de Ecotoxicologia Professor Caetano Belliboni (Lecotox), da Universidade Santa Cecília (Unisantia), **começou as suas atividades em 1990 e foi oficialmente fundado em 5 de junho de 1991**, foi o primeiro no país a obter o Certificado de Qualidade Internacional ISO 9002, para a realização de ensaios de toxicidade em efluentes líquidos e amostras ambientais. Desde 2006, o Lecotox está acreditado pelo Instituto Nacional de Metrologia, Qualidade e Tecnologia – INMETRO de acordo com os requisitos estabelecidos na norma da ABNT (NBR ISO/IEC 17025). Essa acreditação junto ao INMETRO refere-se à excelência na realização das atividades de prestação de serviços.



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ATUAÇÃO

Há 30 anos, o Laboratório de Ecotoxicologia atua no **ensino, pesquisa e extensão** com uma equipe altamente capacitada, formada por doutores especializados na área. Durante esses anos, foram realizados **mais 5 mil ensaios de toxicidade e diversos estudos ambientais** atendendo demandas de diversas empresas, tanto do Polo Petroquímico de Cubatão e do interior do Estado de São Paulo, como de outras regiões do país.

EXTENSÃO



PESQUISA

Quanto às atividades de pesquisa, o Lecotox também é referência, participando de diversos projetos, tanto individuais, como em colaboração com diversas instituições de ensino e pesquisa nacionais e internacionais, tais como por ex.: Unifesp, Unesp, USP, UFSCar, UFSC, FURG e Universidades de Murcia, de Alicante e de Cádiz na Espanha, Algarve, Nova de Lisboa, Aveiro e Coimbra de Portugal, entre outras...

Principais Atividades desenvolvidas no Lecotox

Principais Pojetos de Pesquisa

- *Estudo Ecotoxicológico Integrado em Sistemas Estuarinos e Portuários Atlânticos (CAPES/BEX 2503-03/3);*
- *Cátedra da UNESCO-UNITWIN/WICOP, pesquisas voltadas à Gestão Integrada de Zonas Costeiras (EUROPE NETWORK);*
- *Monitoramento da área de descarte do material dragado no porto de Santos – FUNDESPA/ CODESP/COSIPA;*
- *Monitoramento do litoral de São Pulo através do uso de biomarcadores;*
- *Diagnóstico de resíduos sólidos, efluentes líquidos e fauna sinantrópica nociva nos portos de Santos e São Sebastião. Secretaria Especial de Portos da Presidência da República-SEP.*
- *Efeito do CO₂ sobre a biodisponibilidade de contaminantes em sedimentos marinhos associados a vazamentos de reservatórios petrolíferos (ECO2Mar)- CAPES/CNPq/ Processo # 402921/2012-7.*
- *Avaliação dos efeitos da acidificação dos oceanos sobre a biodisponibilidade de poluentes emergentes – ACIDOCEAN; FAPESP/ Processo # 2017/07353-7.*

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Principais Atividades desenvolvidas no Lecotox

Testes de Toxicidade - Escopo Sistema de Qualidade

- **Teste de Toxicidade Aguda com *Daphnia similis* Claus, 1876** (Cladocera, Crustacea) – Metodologia: ABNT NBR-12713;
- **Teste de Toxicidade Crônica de Curta Duração com ouriços** (Echinodermata, Echinoidea) - Metodologia: ABNT NBR 15350;
- **Teste de Toxicidade Crônica, com *Ceriodaphnia dubia* Richard, 1894** (Cladocera, Crustacea) - Metodologia: ABNT NBR-13373.



Estudos atuais

Principais FPCP estudados / Diferentes Cenários de Acidificação

- Triclosan (bactericida);
- Diclofenaco (analgésico, anti-inflamatório e antipirético);
- 17-Alfa Ethynylestradiol (hormônio estroênio-anticoncepcional);
- Ibuprofeno (analgésico e anti-inflamatório);
- Losartan (anti-hipertensivo);
- Orfenadrina (relaxante muscular - dorflex);

Drogas ilícitas: Crak e Cocaína - Benzoilecgonina;

Antiretrovirais: Nevirapina, Atazanavir, Efavirenz;

Bloqueadores solares - Benzofenona-3 (BP3);

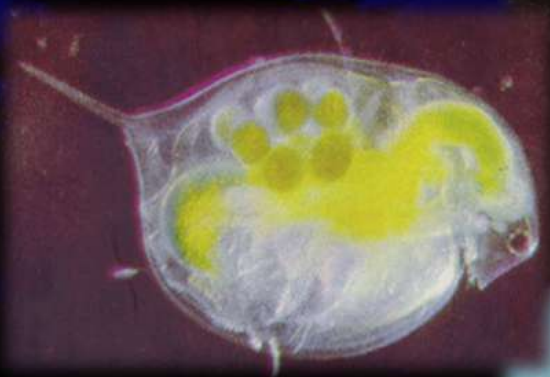
Microplástico



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Ecotoxicologia

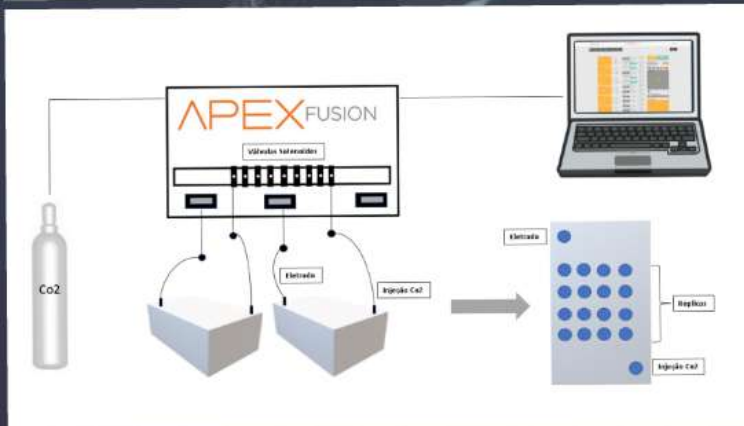
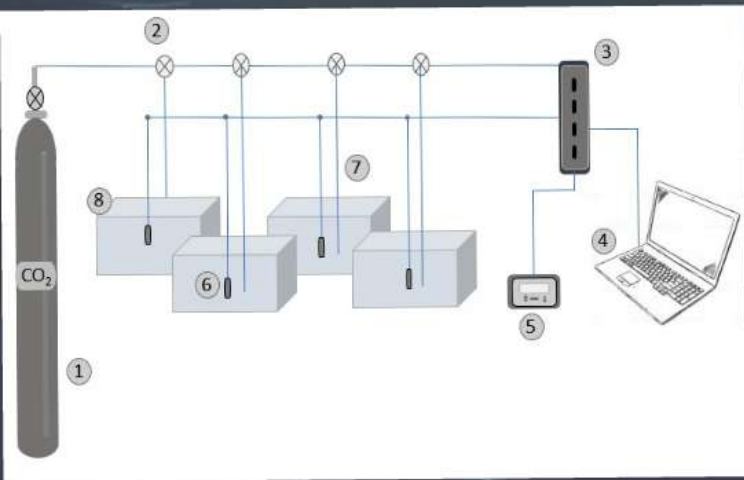
Testes de Toxicidade



Drogas ilícitas: Crak e Cocaina - Benzoilecgonina;

Antiretrovirais: Nevirapina, Atazanavir, Efavirenz;

Bloqueadores solares - Benzofenona-3 (BP3);



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Principais Atividades desenvolvidas no Lecotox

Ensino

Ensino de graduação

- Ciências Biológicas,
- Farmácia,
- Engenharias (Química e de Petróleo).

<https://stricto.unisanta.br>

Ensino de pós-graduação

- Mestrado Acadêmico em Ecologia de Ecossistemas Costeiros e marinhos;
- Mestrado e Doutorado Acadêmico em Ciência e Tecnologia Ambiental.
- Mestrado Profissionalizante em Auditoria Ambiental

Internacionalização

Programa Erasmus Mundus
(European Joint Masters in Water and Coastal Management)
Curso de Mestrado e Doutorado Europeu em Gerenciamento Costeiro

PARCEIROS

- Universidade do Algarve - PT
- University of Bergen - NO
- Universidad de Cádiz - ES
- University of Plymouth - UK
- Universidad de Baja California - MX
- Universidad de Eafit - CO
- Universidade Federal do Rio Grande - BR
- Universidade do Istado - BR
- University of Miami - US
- Universidad Nacional del Sur - AR
- Nanjing University - CN
- Ningbo University - CN
- Ocean University of China - CN
- Universidade de Santa Cecília - BR
- State Hydro-meteorological Univ. of St. Petersburg - RU



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Programa Erasmus Mundus

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- Universidad de Baja California - MX
- Universidad de Eafit - CO
- Universidade Federal do Rio Grande -
- Universidade do Itajaí – BR
- University of Miami – US
- Universidad Nacional del Sur – AR
- Nanjing University – CN
- Ningbo University – CN
- Ocean University of China – CN
- Universidade de Santa Cecília – BR
- State Hydrometeorological Univ. of St. Petersburg - RU



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Sistema de Qualidade

O Laboratório de Ecotoxicologia da UNISANTA está acreditado pela Coordenação Geral de **Acreditação** (CGA) - **Instituto Nacional de Metrologia, Qualidade e Tecnologia – INMETRO** nos requisitos estabelecidos na **ABNT NBR ISO/IEC 17025**, que constitui a expressão formal do reconhecimento da sua competência para realizar os ensaios e fornecer resultados tecnicamente válidos inseridos no Escopo de Acreditação.



Link de acesso ao escopo de Acreditação:

http://www.inmetro.gov.br/laboratorios/rble/detalhe_laboratorio.asp?nom_apelido=ISESC%2FLET#

Política da Qualidade

A administração do ISESC - Instituto Superior de Educação Santa Cecília, compromete-se a desenvolver continuamente as atividades e recursos humanos do Laboratório de Ecotoxicologia com objetivo de melhoria constante das boas práticas profissionais e da qualidade dos serviços prestados, para atender as necessidades e satisfazer as expectativas de seus clientes.

Objetivos da Qualidade

- *Implantar e manter o Sistema da Qualidade de forma a atender a Norma NBR ISO/IEC 17025;*
- *Reduzir o número de não Conformidades;*
- *Aperfeiçoar continuamente a capacitação de seus Funcionários;*
- *Realizar suas atividades com segurança no trabalho;*
- *Garantir a integridade e confidencialidade dos resultados dos ensaios que realiza;*
- *Atender e satisfazer o cliente em suas solicitações.*

Produção Recente

Marine Pollution Bulletin

Effects of CO₂ enrichment on metal bioavailability and bioaccumulation using *Mytilus galloprovincialis*

M.C. Passarelli¹, K. Ray², A. Cesar³, T.A. DeValis⁴, L. Riba⁵

<https://doi.org/10.1016/j.marpolbul.2018.02.022>

Marine Pollution Bulletin

What is the best endpoint for assessing environmental risk associated with acidification caused by CO₂ enrichment using mussels?

M.C. Passarelli¹, K. Ray², A. Cesar³, T.A. DeValis⁴

<https://doi.org/10.1016/j.marpolbul.2018.02.022>

Science of the Total Environment

Ecotoxicological effects of bacteria on chironomid larvae (*Procladius*) and their recovery in regular littoral zones (Brazil)

M.C. Passarelli¹, K. Ray², A. Cesar³, T.A. DeValis⁴

<https://doi.org/10.1016/j.scitotenv.2018.02.022>

Water Research

A tiered approach to assess effects of diclofenac on the brown mussel *Perna perna*: A contribution to characterize the hazard

Maryna Karoline Fostes¹, Juliana Barbal Gomes-Dos-Santos², Luciane Alves Serrano³, Oreste Mollato de Sousa Almeida⁴, Wesley Almeida Matar⁵, Bruno Galvão de Campos⁶, Luciano Soares Guimarães⁷, Marcos Sérgio de Toledo⁸, Daniel Lócio⁹, Igor Rodrigues Marques¹⁰, Amanda Araújo Pereira¹¹, Augusto Lócio¹², Eliandara Alves Almeida¹³, Camilla Dool Seabra Pereira¹⁴

<https://doi.org/10.1016/j.watres.2017.12.027>

Ecotoxicology and Environmental Safety

Using a mesocosm approach to evaluate marine benthic assemblage alteration associated with CO₂ enrichment in coastal environments

M.C. Passarelli¹, L. Riba², A. Cesar³, A. Neustadt⁴, T.A. DeValis⁵

<https://doi.org/10.1016/j.ecoenv.2018.02.022>

Science of the Total Environment

Revisiting the influence of ocean acidification on mussel recruitment: A meta-analysis

M.C. Passarelli¹, K. Ray², A. Cesar³, T.A. DeValis⁴

<https://doi.org/10.1016/j.scitotenv.2018.02.022>

Chemosphere

Comparative evaluation of sea-urchin larval stage sensitivity to ocean acidification

M.C. Passarelli¹, A. Cesar², L. Riba³, T.A. DeValis⁴

<https://doi.org/10.1016/j.chemosphere.2018.02.022>

Chemosphere

Harmful effects of cocaine byproduct in the reproduction of sea urchin in different ocean acidification scenarios

Laura da Silva Souza¹, Talita Henriques Passarola², Fernando Santos Cortez³, Mariana Romano de Oliveira⁴, Alencar Alves Serrano⁵, Augusto César⁶, Tomás Angel Del Valle Castillo⁷, Camilla Dias Seabra Pereira⁸

<https://doi.org/10.1016/j.chemosphere.2018.02.022>

Chemosphere

Assessment of the environmental impacts of ocean acidification (OA) and carbon capture and storage (CCS) leaks using the amphipod *Hyale* young

L.A. Guedes¹, M. H. de Oliveira², D. Souza³, M. D. Riosalva⁴, T.A. DeValis⁵, A. Cesar⁶

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<https://doi.org/10.1016/j.marpolbul.2018.05.021>

Effects of CO₂ enrichment on metal bioavailability and bioaccumulation using *Mytilus galloprovincialis*



M.C. Passarelli^{a,*}, S. Ray^{a,b}, A. Cesar^{c,d}, T.A. DelValls^{a,d}, I. Riba^a

^a Department of Physico Chemistry, Aquatic Systems Research Group, UNESCO/UNITWIN WiCop, Faculty of Environmental and Marine Sciences, Cádiz, Spain

^b Center of Integrated Studies on the Sundarbans (CISS), University of Khulna, Bangladesh

^c Department of Ocean Sciences, Federal University of São Paulo (UNIFESP), Santos, São Paulo, Brazil

^d Department of Ecotoxicology, Santa Cecília University (UNISANTA), Santos, São Paulo, Brazil

ARTICLE INFO

Keywords:

Metal mobility

Multivariate analysis

Laboratory simulations, bioaccumulation

Acidification of contaminated sediments

ABSTRACT

The main aim of this study was to evaluate the bioavailability of metals related to CO₂ enrichment on the mussels *Mytilus galloprovincialis* by metal's bioaccumulation analysis. Two sediment samples were selected and subjected to different pH levels. Concentrations of metals were measured in the overlying seawater and in the whole body of mussels exposed on the 7th, 14th and 21st days. Results showed that the CO₂ enrichment in aquatic ecosystems cause significant ($p < 0.05$) changes on the concentrations of Cu, Zn, Ni, Mn and As between the control pH and pH 7.0 after 7 days of exposure; and in the concentration of Fe at pH 6.0 using the RSP sediment. The multivariate analysis results showed that the increase in the bioaccumulation of some metals in mussels was linked to the acidification. It was concluded that many factors may interfere in the results when the acidification and bioavailability of metals are inquired.



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What is the best endpoint for assessing environmental risk associated with acidification caused by CO₂ enrichment using mussels?



Passarelli M.C.^{a,*}, Riba I.^a, Cesar A.^{b,c}, DelValls T.A.^{a,c}

^a Department of Chemistry, Aquatic Systems Research Group, UNESCO/UNITWIN WiCop, International Campus of Excellence of the Sea (CEIMAR), Cádiz, Spain

^b Department of Ocean Sciences, Federal University of São Paulo (UNIFESP), Santos, São Paulo, Brazil

^c Department of Ecotoxicology, Santa Cecília University (UNISANTA), Santos, São Paulo, Brazil

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Keywords:

Acidification
Toxicity tests
Mussels (*Mytilus galloprovincialis*)
Neutral red retention time
Elutriates
Sediment

ABSTRACT

Carbon capture and storage is a technology that has been widely determined to be one of the best choices for the short-term reduction of atmospheric CO₂ emissions. The aim of this study was to analyze the effects of CO₂ enrichment in the ocean on the mussel species *Mytilus galloprovincialis* using three different endpoints: mortality, embryo-larval development, and neutral red retention time assays (NRRT). Acute effects were found to be associated with a pH values of 6.0 while cytotoxicity effects and embryo-larval development were associated with a pH value of 7.0. The NRRT assay and embryo-larval development can be recommended as good endpoints for assessing the environmental risk associated with acidification by CO₂ enrichment because they provide sensitive responses on the effects of changes in seawater pH on mussels in a short period of time. Moreover, this study may support policymakers in finding appropriate solutions for the conservation of marine ecosystems.



Ecotoxicological effects of losartan on the brown mussel *Perna perna* and its occurrence in seawater from Santos Bay (Brazil)

Fernando Sanzi Cortez^{a,b}, Lorena da Silva Souza^c, Luciana Lopes Guimarães^a, João Emanuel Almeida^d, Fabio Hermes Pusceddu^a, Luciane Alves Maranhão^{a,b}, Luciana Gonçalves Mota^d, Caio Rodrigues Nobre^b, Beatriz Barbosa Moreno^d, Denis Moledo de Souza Abessa^b, Augusto Cesar^{a,d}, Aldo Ramos Santos^a, Camilo Dias Seabra Pereira^{a,d,*}

^a Unisantia - Universidade Santa Cecília, Santos, SP, Brazil

^b Unesp - Universidade Estadual Paulista Julio de Mesquita, São Vicente, SP, Brazil

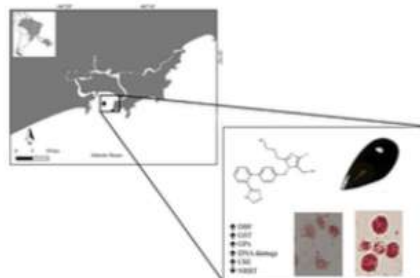
^c UCA - Universidad de Cádiz, Spain

^d Unifesp - Universidade Federal de São Paulo, Santos, SP, Brazil

HIGHLIGHTS

- Losartan concentrations in seawater from Santos bay ranged from 0.2 to 8.6 ng/L
- Reproductive parameters were altered after acute exposure up to 75 mg/L
- Cyto-genotoxic effects observed after short-term exposure (48–96 h) to ng/L
- *Perna perna* is a sensitive model for assessing losartan toxicity.
- Lysosomal membrane stability was the most sensitive endpoint.

GRAPHICAL ABSTRACT



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Editor: D. Barcelo

Keywords:

Antihypertensive

Seawater

Emerging contaminants

Pharmaceuticals

Ecotoxicology

ABSTRACT

The antihypertensive losartan (LOS) has been detected in wastewater and environmental matrices, however further studies focused on assessing the ecotoxicological effects on aquatic ecosystems are necessary. Considering the intensive use of this pharmaceutical and its discharges into coastal zones, our study aimed to determine the environmental concentrations of LOS in seawater, as well as to assess the biological effects of LOS on the marine bivalve *Perna perna*. For this purpose, fertilization rate and embryolarval development were evaluated through standardized assays. Phase I (ethoxyresorufin O deethylase EROD and dibenzylfluorescein dealkylase DBF) and II (glutathione S-transferase GST) enzymes, glutathione peroxidase (GPx), Cholinesterase (ChE), lipoperoxidation (LPO) and DNA damage were used to analyze sublethal responses in gills and digestive gland of adult individuals. Lysosomal membrane stability was also assessed in hemocytes. Our results showed the occurrence of LOS in 100% of the analyzed water samples located in Santos Bay, Sao Paulo, Brazil, in a range of 0.2 ng/L–8.7 ng/L. Effects on reproductive endpoints were observed after short-term exposure to concentrations up to 75 mg/L. Biomarker responses demonstrated the induction of CYP450 like activity and GST in mussel gills exposed to 300 and 3000 ng/L of LOS, respectively. GPx activity was also increased in concentration of exposure to 3000 ng/L of LOS. Cyto-genotoxic effects were found in gills and hemocytes exposed in concentrations up to 300 ng/L. These results highlighted the concern of introducing this class of contaminants into marine

* Corresponding author at: Departamento de Ciências do Mar, UNIFESP, Campus Baixada Santista, Maria Maximo st. 168, PC 11030100, Brazil.
E-mail address: camilo.seabra@pq.cnpq.br (C.D.S. Pereira).



<https://doi.org/10.1016/j.watres.2017.12.077>

A tiered approach to assess effects of diclofenac on the brown mussel *Perna perna*: A contribution to characterize the hazard



Mayana Karoline Fontes^{a, b}, Paloma Kachel Gusso-Choueri^b, Luciane Alves Maranhão^{a, c}, Denis Moledo de Souza Abessa^b, Wesley Almeida Mazur^{c, d}, Bruno Galvão de Campos^b, Luciana Lopes Guimarães^{c, d}, Marcos Sergio de Toledo^d, Daniel Lebre^e, Joyce Rodrigues Marques^e, Andreia Arantes Felício^f, Augusto Cesar^{a, c}, Eduardo Alves Almeida^g, Camilo Dias Seabra Pereira^{a, c, *}

^a Departamento de Ciências do Mar, Universidade Federal de São Paulo, Rua Maria Máximo, 168, 11030-100 Santos, Brazil

^b Instituto de Biociências, Campus do Litoral Paulista, Universidade Estadual Paulista "Júlio de Mesquita Filho", Infante Dom Henrique, s/n, 11330-900 São Vicente, Brazil

^c Laboratório de Ecotoxicologia, Universidade Santa Cecília, Rua Oswaldo Cruz 266, 11045-907 Santos, Brazil

^d Departamento de Bioquímica da Universidade Federal de São Paulo, Rua Botucatu, 862, 04023-901 São Paulo, Brazil

^e CEMSA – Centro de Espectrometria de Massas Aplicada, CIETEC/IPEN, Av. Prof. Lineu Prestes, 2242, Salas 112 e 113, 05508-000 São Paulo, Brazil

^f Universidade Estadual Paulista Júlio de Mesquita Filho – Campus São José do Rio Preto, Rua Cristóvão Colombo 2265, 15054-000 São José do Rio Preto, SP, Brazil

^g Fundação Universidade Regional de Blumenau, Rua Antônio da Veiga 498, Itoupava Seca, 89030-103 Blumenau, Brazil

ARTICLE INFO

Article history:

Available online 29 December 2017

Keywords:

Pharmaceuticals
Nonsteroidal anti-inflammatory drug
Marine environment
Non-target organism

ABSTRACT

Pharmaceutical discharges into the aquatic ecosystem are of environmental concern and sewage treatment plants (STPs) have been pointed out as the major source of these compounds to coastal zones, where oceanic disposal of sewage occurs through submarine outfalls. Diclofenac (DCF) is one of the most frequently detected pharmaceuticals in water, but little is known about the effects on marine organisms. In this study, we employed a tiered approach involving the determination of environmental concentrations of DCF in marine water and the adverse biological effects for fertilization, embryo-larval development and biomarker responses of the mussel *Perna perna*. Results indicate that effects in fertilization rate and embryo-larval development were found in the order of $\text{mg}\cdot\text{L}^{-1}$. However, low concentrations of DCF ($\text{ng}\cdot\text{L}^{-1}$) significantly decreased the lysosomal membrane stability and COX activity, as well as triggered DNA damage, oxidative stress and changes in antioxidant defenses. Our results point to an environmental hazard at coastal ecosystems and suggest the need for improvements in the treatment of domestic wastewater aiming to reduce DCF concentrations, as well as regulation on current environmental legislation and monitoring of aquatic ecosystems.



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Using a mesocosm approach to evaluate marine benthic assemblage alteration associated with CO₂ enrichment in coastal environments



M.C. Passarelli^{a,*}, I. Riba^a, A. Cesar^{b,c}, A. Newton^{d,e}, T.A. DelValls^{a,c}

^a Department of Physico-Chemistry, Aquatic Systems Research Group, UNESCO/UNITWIN WiCop, Faculty of Marine and Environmental Sciences, Cádiz, Spain

^b Department of Ocean Sciences, Federal University of São Paulo (UNIFESP), Santos, São Paulo, Brazil

^c Department of Ecotoxicology, Santa Cecília University (UNISANTA), Santos, São Paulo, Brazil

^d Department of Earth, Environmental and Marine Sciences, Centre for Marine and Environmental Research (CIMA), University of Algarve (UA), Faro, Portugal

^e Department of Environmental Impacts and Economics (IMPEC), Norwegian Institute of Air Research (NILU), Norway

ARTICLE INFO

Keywords:

Acidification
 Macrobenthic
 Biological indices
 Sediment metals
 Multivariate analysis

ABSTRACT

The effects of acidification related to the CO₂ enrichment in the coastal environments on marine macrobenthic abundance, diversity and richness were analyzed in a medium-term (21 days) using mesocosm experiments. Two sampling sites located in the Bay of Cadiz – SW, Spain were selected and tested at pH values ranged from 7.9 to 6.0 (± 0.1). Moreover, variations in the concentrations of metals in the sediment samples were analyzed at the end of each experiment. The results showed low variation in the concentrations of metals in the sediment among the pH treatments. A significant decrease ($p < 0.05$) in the abundance, diversity and richness of assemblages were measured between the control and the lowest pH level in both sampling sites tested in this study (Rio San Pedro and El Trocadero). The majority of species were found in all samples except in pH 6.0 which only two species were found (*Hydrobia ulvae* and *Scrobicularia plana*,) in Rio San Pedro sediment fauna. In general, the results of cluster analysis showed 60% and 40% similarity in all replicated tests in El Trocadero and Rio San Pedro of sediment fauna, respectively. The results of the Principal Component Analysis (PCA) showed that both sediment parameters and pH reduction can interfere in the benthic assemblage indices. Although the assemblages' indices have shown decreases only in the lower pHs, the organisms also could be impacted by chronic effects. Therefore, the extension of this study is important in order to improve the knowledge about the risks associated with CO₂ enrichment in on marine organisms.



<https://doi.org/10.1016/j.chemosphere.2019.07.015>

Harmful effects of cocaine byproduct in the reproduction of sea urchin in different ocean acidification scenarios



Lorena da Silva Souza^{a,*}, Fabio Hermes Pusceddu^b, Fernando Sanzi Cortez^b,
Manoela Romano de Orte^c, Alessandra Aloise Seabra^b, Augusto Cesar^{b,c},
Daniel Araki Ribeiro^c, Tomás Angel Del Valls Casillas^b, Camilo Dias Seabra Pereira^{b,c}

^a Department of Physico-Chemistry, Aquatic Systems Research Group, UNESCO/UNITWIN WiCop, Faculty of Marine and Environmental Sciences, University of Cádiz, Cádiz, Spain

^b Department of Ecotoxicology, Santa Cecília University (UNISANTA), Santos, São Paulo, Brazil

^c Department of Marine Sciences, Federal University of São Paulo (UNIFESP), Santos, São Paulo, Brazil

HIGHLIGHTS

- Impact of different acidification scenarios by enrichment of CO₂ on contaminants of emerging concern.
- Toxicity of a cocaine byproduct in different scenarios of ocean acidification.
- Combined effects of crack cocaine and low pH on reproduction of sea urchin.
- Hazards and risks of illicit drugs pose to public health and the environment.

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Early life stages

Ocean acidification

Sea-urchin

ABSTRACT

This study has as main objective assessing the toxicity of crack-cocaine combined with different scenarios of ocean acidification on fertilization rate and embryo-larval development of *Echinometra lucunter* sea urchin. Effects on early life stages were assessed at five different concentrations (6,25 mg.L⁻¹; 12,5 mg.L⁻¹; 25 mg.L⁻¹; 50 mg.L⁻¹ and 100 mg.L⁻¹) of crack-cocaine at four different pH values (8.5; 8.0; 7.5; 7.0). The pH values were achieved using two different methodologies: adding hydrochloric acid (HCl) and injecting carbon dioxide (CO₂). The fertilization test did not show significant differences ($p \leq 0.05$) compared with control sample at pH values 8.5; 8.0 and 7.5. Results of embryo-larval assays showed a half maximal effective concentration (EC50) of crack-cocaine at pH values tested (8.5, 8.0, 7.5) as 58.83, 10.67 and 11.58 mg/L⁻¹ for HCl acidification and 58.83, 23.28 and 12.57 mg/L⁻¹ for CO₂ enrichment. At pH 7.0 the effects observed in fertilization rate and embryo development were associated with the acidification. This study is the first ecotoxicological assessment of illicit drug toxicity in aquatic ecosystems at different ocean acidification scenarios.

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Assessing the influence of ocean acidification to marine amphipods: A comparative study



M.C. Passarelli^{a,*}, I. Riba^a, A. Cesar^{b,c}, F. Serrano-Bernando^d, T.A. DelValls^a

^a Department of Chemistry, Aquatic Systems Research Group, UNESCO/UNITWIN WiCop, International Campus of Excellence of the Sea (CEIMAR), Cádiz, Spain

^b Department of Ocean Sciences, Federal University of São Paulo (UNIFESP), Santos, São Paulo, Brazil

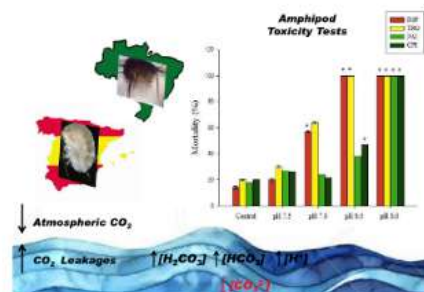
^c Department of Ecotoxicology, Santa Cecília University (UNISANTA), Santos, São Paulo, Brazil

^d Department of Civil Engineering, Advanced Technical School for Civil Engineering, University of Granada (UGR), Granada, Spain

HIGHLIGHTS

- CO₂-induced acidification may change the metal mobility from sediments;
- The tropical amphipod *Hyale youngi* shows to be more tolerant to ocean acidification than *Ampelisca brevicornis*;
- The Zn dissolved in overlying water was strongly correlated with the pH reduction and toxicity of the sediment;

GRAPHICAL ABSTRACT



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ABSTRACT

CO₂ increases in the ocean may occur both by the capacity of CO₂ exchanges with its dissolved form between atmosphere and surface seawater as well by CO₂ leaks during the carbon capture and storage (CCS) process. The decrease in seawater pH may result in a reduction in the concentration of both hydroxide and carbonate (OH⁻ and CO₃²⁻). The main aim of this work is to conduct an ecotoxicology comparative survey using two amphipod species from Europe and Brazil exposed to different acidification (CO₂) scenarios. For it, an integrative approach based on the weight of evidence was used for comparative proposes to identify the effects on the amphipods association with the acidification and with the related mobility of metals. The results demonstrate that the *Ampelisca brevicornis* species is more sensitive to pH reductions than the *Hyale youngi* species. Furthermore, this study has demonstrated that the CO₂ enrichment in aquatic ecosystems would cause changes on the mobility of certain metals (Zn, Cu and As). The results of Principal Component Analysis (PCA) showed that the dissolved Zn in overlying water was strongly correlated with the decrease in the pH and was associated with increased toxicity of the sediment to the exposed organisms, mainly for the *A. brevicornis* species from Spain. Nevertheless, similar results were found in relation to the mortality of amphipods in low pH values for all sediment tested. Concluding, it is highlighted the importance of comparative studies in different types of environment and improve the understood of the risks associated with the ocean acidification.



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Comparative evaluation of sea-urchin larval stage sensitivity to ocean acidification



M.C. Passarelli ^{a,*}, A. Cesar ^{b,c}, I. Riba ^a, T.A. DelValls ^a

^a UNESCO/UNITWIN WiCop, Physico Chemical Department, Faculty of Marine and Environmental Studies, CEIMAR, University of Cádiz, Spain

^b Department of Ocean Sciences, Federal University of São Paulo (UNIFESP), Santos, São Paulo, Brazil

^c Department of Ecotoxicology, Santa Cecília University (UNISANTA), Santos, São Paulo, Brazil

HIGHLIGHTS

- CO₂-induced acidification changes the metal mobility from Brazilian and Spanish sediments.
- The pH reduction causes effects on embryo-larval development of sea urchins.
- The tropical sea urchin *Lytechinus variegatus* shows to be more tolerant to ocean acidification than *Paracentrotus lividus*.
- The ICpH₅₀ for the embryo-larval development was ranged from pH 7.30 to 6.79.
- The As dissolved in the elutriate sediment was correlated with the pH reduction and toxicity of the sediment.

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ABSTRACT

Changes in the marine carbonate system may affect various calcifying organisms. This study is aimed to compare the sensitivity of embryo-larval development of two species of sea urchins (*Paracentrotus lividus* and *Lytechinus variegatus*) collected and exposed to samples from different coastal zone (Spain and Brazil) to ocean acidification. The results showed that the larval stages are very sensitive to small changes in the seawater's pH. The larvae from *P. lividus* species showed to be more sensitive to acidified elutriate sediments than larvae from *L. variegatus* sea urchin. Furthermore, this study has demonstrated that the CO₂ enrichment in aquatic ecosystems cause changes on the mobility of the metals: Zn, Cu, Fe, Al and As, which was presented different behavior among them. Although an increase on the mobility of metals was found, the results using the principal component analysis showed that the pH reduction show the highest correlations with the toxicity and is the main cause of embryo-larval development inhibition. In this comparative study it is demonstrated that both species are able to assess potential effects of the ocean acidification related to CO₂ enrichment by both near future scenarios and the risk associated with CO₂ leakages in the Carbon Capture and Storage (CCS) process, and the importance of comparative studies in different zones to improve the understanding of the impacts caused by ocean acidification.

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Assessment of the environmental impacts of ocean acidification (OA) and carbon capture and storage (CCS) leaks using the amphipod *Hyale youngi*

T. A. Goulding¹ · M. R. De Orte² · D. Szalaj³ · M. D. Basallote² · T. A. DelValls¹ · A. Cesar²

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Abstract This study aims to ascertain the effects of CO₂ induced water acidification and leaks from Carbon Capture and Storage activities on the South American amphipod *Hyale youngi*. A 10-day acute toxicity test was performed using sediments from two sites located inside the Santos Estuarine System. They were subjected to five pH treatments (8.1, 7.6, 7.0, 6.5, and 6.0). Metals (Cd, Cu, Cr, Pb, Ni and Zn) and the metalloid As were analyzed to determine the influence of their acidification-related mobility on the amphipods mortality. The results showed that mortality becomes significant when compared to control in pH 6.5 in the *Canal de Piaçaguera* sediment (contaminated) and at pH 6.0 in *Ilha das Palmas* sediment (reference).

Keywords Carbon dioxide capture and storage (CCS) · Ocean acidification (OA) · Climate change · Metal mobilization · Amphipod · *Hyale youngi*

Introduction

Climate change is the defining issue facing the human population this century. The rate of change affecting the planet has rapidly increased since the beginning of the industrial revolution (Peters et al. 2012; Temme et al. 2014; Widdicombe et al. 2013) and is now seen as a major threat to the stability of the planet (Okken et al. 2012; Spillman et al. 2011). The increase to approximately 400 ppm of CO₂ now in the atmosphere is one of the factors contributing to this rapid change, up from ~300 ppm 50 years ago (Cvijanovic and Caldeira 2015). This unprecedented increase in CO₂ has been linked with an array of environmental issues from the warming of the planet (Peters et al. 2013; Cvijanovic and Caldeira 2015) to the decrease of pH of our oceans (Spillman et al. 2011; Raha 2015) which could achieve pH 7.6 by the end of the next century (Caldeira and Wickett 2005).

Equipe



Aldo Ramos Santos

[ACESSAR CURRÍCULO LATTES](#)



Augusto Cesar

[ACESSAR CURRÍCULO LATTES](#)



Camilo Dias Seabra Pereira

[ACESSAR CURRÍCULO LATTES](#)



Fabio Hermes Pusceddu

[ACESSAR CURRÍCULO LATTES](#)



Fernando Sanzi Cortez

[ACESSAR CURRÍCULO LATTES](#)



Mery dos Santos Filho

[ACESSAR CURRÍCULO LATTES](#)

FÓRUM AMBIENTAL DA PETROBRAS NA BAIXADA SANTISTA
Proteção dos Oceanos e Rios



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aucesar@unisanta.br
 @augus07

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- Aldo Ramos Santos - rsantos@unisanta.br
- Augusto Cesar - aucesar@unisanta.br
- Camilo Dias Seabra Ferreira - camilo@unisanta.br
- Fábio Hermes Pusceddu - fabiohp@unisanta.br
- Fernando Sanzi Cortez - cortez@unisanta.br

