



UCSC

R+D+I CAPABILITIES

WATER RESOURCES UCSC

SCIENTIFIC TECHNOLOGICAL PORTFOLIO



PROLOGUE

A photograph of a modern building facade with a grid of windows and a large red 'UCSC' logo on top. The building is set against a clear blue sky.

UCSC

Welcome,

As Vice Chancellor of Research and Postgraduate Studies of the Universidad Católica de la Santísima Concepción, we are pleased to present the Manual of UCSC Capabilities in Water Resources, which highlights the work in applied research and innovation carried out by our university in this area and presents the services available for society outside the university.

In the framework of the 68-InES institutional project “Strengthening the innovation ecosystem based on R+D and technology transfer of UCSC”, financed by the National Research and Development Agency (ANID), which has among its specific objectives to strengthen the link between national and international players that promote the development of innovation based on R+D and technological transfer in response to the demands of the external environment, with a focus on the areas of Energy and Water Resources, this Manual of UCSC Capabilities in Water Resources has been created.

As a bi-regional university with a presence in Ñuble and Biobío, we are committed to articulating, developing, and proposing technological solutions to provide answers to the existing problems in the area of Water Resources. For this reason, UCSC has established this as an emerging area of research and innovation in order to advance in this issue and generate initiatives to strengthen the territory.

Through this manual, we hope to promote more strategic links with the external society, disseminating the professional and infrastructure capabilities our university possesses in Water Resources.

Research and Postgraduate Vice-chancellorship.



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UCSC CAPABILITIES IN WATER RESOURCES

Chile is going through important challenges in the area of water resources, and for this reason academia has gradually involved itself to solve the problems through research, development, and innovation (R+D+i).

Due to the water crisis the country has been suffering since 2010, different initiatives, which involve different actors, have been generated to mitigate the impacts of the scarcity of water. In 2013, the National Strategy of Water Resources 2012-2025, was created with the aim of identifying priority aspects and setting important challenges which would need to be faced as competition for water increases, as interdependencies between users, and their associated conflicts, grow, and as environmental pressures intensify.

Our university has made a commitment to the Objectives of Sustainable Development of the United Nations part of its institutional seal as part of its Agenda 2030. In addition, since 2020, the Universidad Católica de la Santísima Concepción added Water Resources as an emerging area of R+D+i, allowing advances in the multidisciplinary work and collaborating actively to contribute solutions to the country and territories in this area.



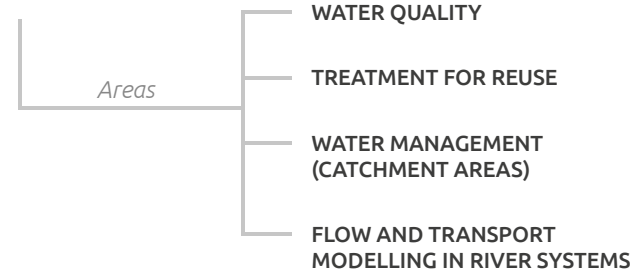


- ▶ The Manual of UCSC Capabilities in Water Resources aims to disseminate the R+D+i, infrastructure, and human capital competencies related to this issue, highlighting the areas of Water Quality, Treatment for Reuse, Water Management, and Flow Modelling.

In addition to disseminating areas of knowledge, it presents the laboratories and centers related to the previously mentioned areas, detailing the professional experience, infrastructure, and equipment available to the university community and external society to resolve R+D+i challenges and/or problem issues for an efficient and sustainable water management.



Water Resources UCSC



WATER QUALITY

AREA DESCRIPTION

Water quality refers to the protection of a set of physical, chemical, and biological characteristics that allow a determined use of this element and is an essential ecological value for health and economic growth. In Chile, the NCh 1.333 norm sets a water quality criterion in line with scientific requirements of physical, chemical, and biological aspects according to the predetermined use: human consumption, water for animals, recreation, and aesthetics, irrigation, and aquatic life.

The main problems of water quality in the country refer to aspects of eutrophication, salinity, non-conventional contaminants (meals and metalloids), and emerging contaminants (drugs, antibiotics, home-cleaning products, etc.).

Universidad Católica de la Santísima Concepción has the Regional Environmental Studies Center (CREA), which is in charge of carrying out studies and research related to sea sciences, earth sciences, sciences related to the environment, and biological sciences.

The Center carries out work in diverse sectors and has important experience in the area of water quality management in the area of irrigation, offering services to public institutions of the sector and agricultural companies of differing sizes.

► HIGHLIGHTED CASES

Development and implementation of a decision-making support platform for the management of the quality of water for irrigation for farmers in the Biobío province:

Developed by CREA, with the support of CORFO Biobío in the line of Public Goods, the project seeks to implement a water quality management model for irrigation channels in the channel network of the Laja Channelists Association, to diminish the risk of contamination in water that meets the national and international norms for the export of different crops of economic importance for the province.

Biobío Water Quality Observatory for Irrigation Water Management (OCAB):

This is a project financed by the Biobío Regional Government, from the Fund of Innovation for Competitiveness (FIC), which aims to monitor the water quality in irrigation channels in the Biobío region through an open consultancy platform that facilitates decision making by linked public and private actors for the management of water resources in the agricultural sector.



The stages of the project correspond to:

- **Stage 1:** Selection and characterization of catchment areas, in which available secondary information with respect to natural and artificial catchment areas where there are Water User Organizations (OUA) is gathered. Then, the catchment areas to incorporate into the study are selected, considering pressures that affect them and the quantity of users. Once the selection is made, an inventory (primary information) is carried out of specific sources of pollution and run-off in catchment areas.
- **Stage 2:** Development of a monitoring network, considering the development of two big campaigns: one of surveillance, where the greatest quantity of parameters will be analyzed, and the other of operation where those parameters that it is necessary to control are monitored and followed up on.
- **Stage 3:** Development and use of a dissemination platform that includes a mobile application that captures information and, from SIG tools, facilitates use and decision making.

ADDITIONAL INFORMATION

- A database of specific sources of pollution was made that covered the 256 km of the irrigation network of the Channelist Associations of Laja and Biobío Negrete, laying out critical zones. Additionally, through studies of 19 catchment areas, strategies for monitoring and reducing pollution problems were determined. From this, the design of the monitoring network, which includes more than 70 stations, was generated.

All of the water users that participate in a user organization, be it Channelists, Water Communities, or Surveillance Committees, benefit directly from this service. In the same vein, it provides information for all the decision makers involved in water management at a regional level.

TREATMENT FOR REUSE

AREA DESCRIPTION

Bioremediation is a process using microorganisms that permits the decontamination of liquid and solid residues. The term was coined in 1980, when the capacity of certain microorganisms, such as bacteria, microalgae, and fungi, to degrade toxic compounds was discovered, along with their potential to decontaminate altered environments.

Initially, the efforts were centered on detecting and isolating organisms capable of decontaminating naturally. However, with the advance of biotechnology, these organisms can, today, be modified in a laboratory to increase their capability to resist in aggressive environments and degrade contaminants more easily.

In Chile, there are several challenges where microbial bioremediation could be an important part of the solution, such as in the treatment of industrial residues, contaminant reduction in mine tailings, decontamination in surface and underground waters, plastic degradation, and more efficient transformation of biological residues into gas and fertilizers.

Through the research carried out in the Science Faculty and the UCSC Regional Environmental Studies Center, bioremediation

initiatives have been executed at a regional level, with the aim of contributing to sustainability and competitiveness.

In this way, in UCSC, the treatment of residual water for its reuse must be part of the solution to the problems of scarcity and contamination of water, as it can be used to replace fresh water for irrigation, industrial processes, or recreational purposes. It can also be used to maintain the environmental flow, and the products derived from its treatment can generate energy and nutrients.



► HIGHLIGHTED CASES

Bioremediation method to degrade chemicals coming from industrial effluents:

Technology developed by Dr. María Cristina Yeber and M.Sc. Carolina Soto of the Science Faculty of UCSC, that uses a strain of *Pseudomonas aeruginosa*, isolated in the Biobío region. This technology is capable of treating water with residues of colorants, hydrocarbons, and heavy metals, and can be used in the Riles treatment in the textile, cellulose, petrol, aquaculture, and mining industries. In relation to traditional physical and chemical methods, this a more economical and eco-friendly process for the treatment of residual water.

ADDITIONAL INFORMATION

- Licensing and technology transfer of the process of bioremediation to the company Servicios de Tratamiento de Residuos Senaril Ltda., that treats mud contaminated with hydrocarbons and heavy metals.
- The project “Development and implementation of bioremediation mechanisms to improve sustainability and touristic competitiveness of Lake Lanalhue”, financed by CORFO, was executed.



WATER MANAGEMENT (CATCHMENT AREAS)

AREA DESCRIPTION

Today it is recognized that the components of aquatic ecosystems are the ones that allow us to satisfy the water demand for varied purposes in a catchment area, both as an input for production and as a relevant factor for the conservation of biodiversity. This recognition argues, on one hand, for a new way of valuing the local ecosystems that provide the water and, on the other hand, the importance of water as a critical element of the system on land. Globally, it has been recognized that, in recent centuries, the consumption of water has increased exponentially, and this increase is directly related to population growth and economic development.

From the Universidad Católica de la Santísima Concepción, proposals have been generated that consider technical aspects and public policies that help to strengthen and improve water management at a local and regional level.

▶ HIGHLIGHTED CASES

Biobío Water Quality Observatory for Irrigation Water Management (OCAB):

This project, financed by the Biobío Regional Government through the Fund for Innovation for Competitiveness FIC-R, seeks to benefit a total of 859 agricultural businesses in the region, contributing to strengthening competitiveness in the agriculture and livestock sector through an observatory for the quality and management of water to facilitate decision making by public and private actors linked to the management of water resources. Among its specific objectives, a baseline for water quality at a regional level was drawn, a network of monitoring and quality control for surface water was implemented, and a public record of discharges of natural and artificial waterways, in addition to disseminating and transferring experiences of regional and national actors.



Diploma in Strategic Planning of Water Resources:

With the aim of contributing to the formation of professionals that can make an impact in this area, UCSC, in collaboration with Essbio, the Chilean Association of Municipalities (ACHM), the Biobío River Surveillance Board, the Latin American Association of Underground Hydrogeology (Alhsud), the Chilean Wood Corporation (CORMA), Women in Water, Hidrogestión, and AWUA; set up a Diploma to form professional with the capabilities to make a multidimensional diagnosis of the water resources in a territory or management unit, define sustainability objectives, formulate a strategic plan in a participative way, and contribute to its implementation over time.

ADDITIONAL INFORMATION

- Adjudication of the Fund of Innovation for Competitiveness FIC-R 2022, to execute the project "Landscape management for water security", whose objective is to develop a local water management strategy based on the concept of Conservation Landscapes that would provide water security for people that live in non-concentrated sectors of the Biobío region.
- Adjudication of the Fund of Innovation for Competitiveness FIC-R 2022 of Direct Assignment titled "Water Security for adaptation to climate change", that seeks to contribute to water security in the Biobío region in a scenario of adaptation to climate change, implementing a management model of local actors and technological transfer that permits the establishment of water management at a territorial level.



FLOW AND TRANSPORT MODELLING IN RIVER SYSTEMS

AREA DESCRIPTION

The volume of flow of a river is the quantity of water that passes through a determined section in an instant of time and is recorded in units of volume versus time (m^3/s). In natural conditions, rivers increase their volume of flow as the waterway descends, and their magnitudes present seasonal variations in terms of their respective hydrological regime (pluvial, nival, mixed). These volumes of water transport different types of substances and sediments available in the riverbed. For this reason, it is important to determine the relationship that exists between the quantity of water, the frequency of occurrence of the volume of flow, and the form of the riverbed, as they define the present and future flow conditions (for example, water heights, speeds, pressure, and cutoff efforts, etc.).

In hydraulic engineering in rivers, modelling is used to simulate real scenarios by means of numeric or laboratory methods. The objective is to calibrate and validate the models in order to generate a predictive tool to simulate hypothetical scenarios associated with potential responses to problematic issues in hydraulic or environmental engineering.

Since 2012, UCSC has specialized in this type of modelling and initiatives that have been carried out with the aim of studying mitigation alternatives for different scenarios of river

flooding located especially in Biobío and Ñuble. This area has been implemented in the formation of professionals in the university where they also study hydrodynamic processes and transport in river systems. The modelling of flows allows us to comprehend the effects of the physical processes that take place in these systems in order to quantify phenomena of erosion/deposition, changes in the riverbed, transport of contaminating substances, and the consequent response from the ecosystem. The information and knowledge generated provide tools for the correct management of river systems and their sustainability.

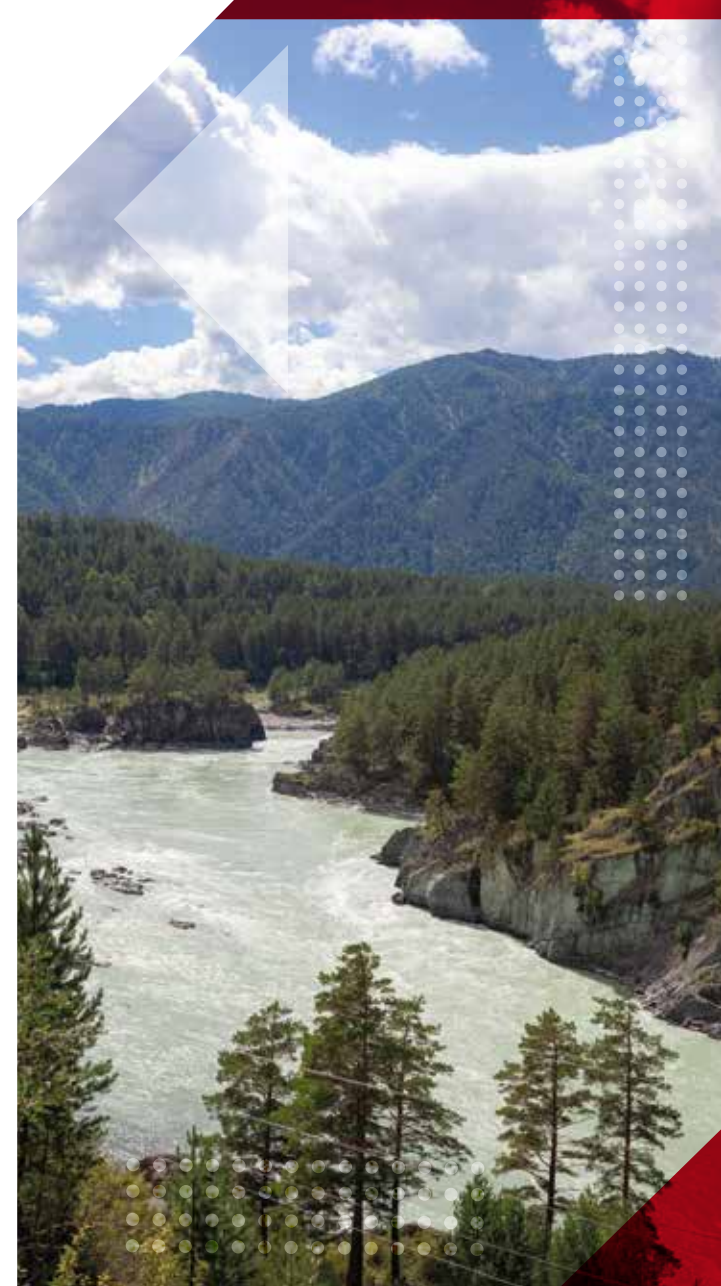
HIGHLIGHTED CASES

2018 - 2020 DINREG07. "Effects of spatial variability of the granulometry on the flow and transport of sediments". Lead researcher.

2015 - 2019 NSF-IGERT. "Adaptation to change in water resources: science to inform decision making across disciplines, cultures and scales". Chilean academic representative.

2012-2014 FONDECYT 1120878. "Characterization of nearshore processes and morphology variability for the highly energetic wave dominated central Chile coast". Co-researcher.

2010-2012 FONDECYT 11100399. "Sustainability of morphology features in alluvial rivers and



coastal systems in Chile: The Biobío River as study case”. Lead researcher.

2010 - 2012 Innova 10CREC-8453 2010, “Water, emergency situations, and technical viability to use urban lagoons as a drinking water resource”. Co-researcher.

2010 - 2011 DIUC 211.310.059-1SP, “Transport, Fate, and Effects of Sediments in the Chilean Patagonia”. Lead researcher.

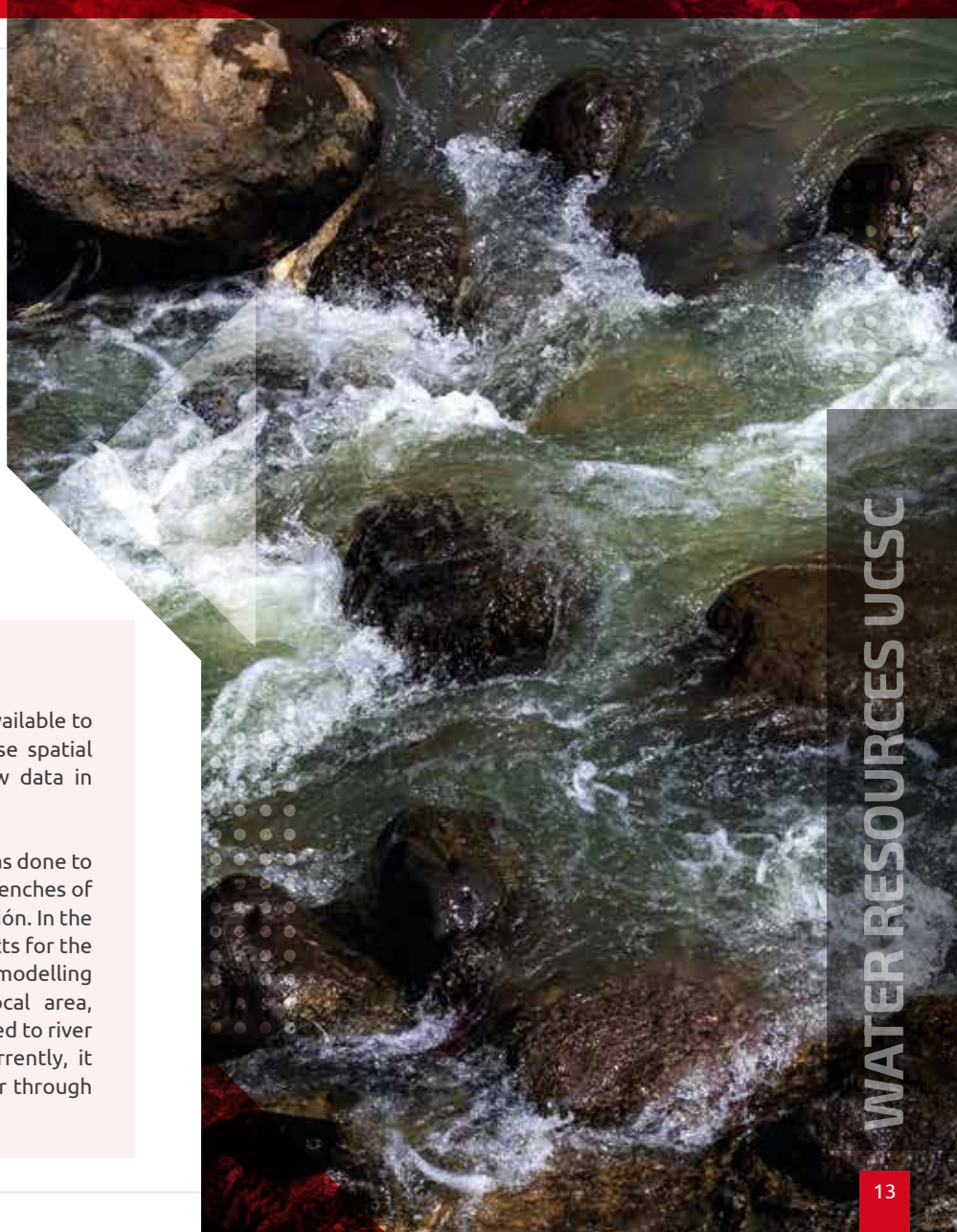
2009 U.S. Bureau of Reclamation, USBR ID 4362. “Identifying indicators and guides for sustainability of pools in gravel-bed rivers”, Boise, Idaho – USA. Co-researcher.

2007 - 2008 FEMA FY2006, “Map Modernization Management Support for the State of Idaho”, combined project between the Idaho Department of Water Resources (IDWR) and the Center for Ecohydraulics Research (CER), University of Idaho, USA. Co-researcher.

ADDITIONAL INFORMATION

- UCSC has human resources, infrastructure, software, and laboratories available to carry out hydraulic modelling in river and estuarine systems in diverse spatial configurations. In addition, it has instruments to collect precise flow data in terrain.

In December 2022, the collection of instant speeds in the Biobío River was done to evaluate the response to the undermining that occurred in one of the trenches of the rail bridge linking the communes of San Pedro de la Paz and Concepción. In the same way, the university has participated in different engineering projects for the Ministry of Public Works and has offered training courses in hydraulic modelling for the environmental tribunals of the city of Valdivia. In the local area, collaborative work initiatives have been developed and flood maps related to river systems located in neighboring communes have been generated. Currently, it offers consultancy services and outreach actions with the private sector through agreements to find solutions together.



UCSC CAPABILITIES





WATER RESOURCES UCSC

BIOREMEDIATION METHOD TO DEGRADE CHEMICAL CONTAMINANTS FROM INDUSTRIAL EFFLUENTS**DEVELOPED TECHNOLOGY**

The technology consists of a method of bioremediation that uses a strain of *Pseudomona aeruginosa*, isolated in the Biobío region, that works for the treatment residual water, meeting discharge standards. The technology permits the removal of intense colorants of black, red, and yellow tones, degradation of petroleum and its derivatives, RILES treatment with arsenic III, RILES treatment with lignin, and removal of ammonium.

TECHNOLOGICAL OFFERING

The technology is available for licensing.

STATE OF DEVELOPMENT

TRL 7, with validated semi-industrial testing in a real-operational setting, well integrated with other systems.

INTELLECTUAL COPYRIGHT – PATENTS GRANTED

United States: US10883150B2

Germany: EP3406739

Spain: ES2886430

France: EP3406739

United Kingdom: EP3406739

Chile: CL201801976

▶ BENEFITS/ADVANTAGES

- Biological process that does not require more energy than that used by the bacteria.
- Low operating costs for industry.
- Helps in the recuperation of treatment plants by the addition of a bacteriological compound.
- Diminished the amount of contaminant sludge produced in treatment plants.
- In relation to traditional physical and chemical methods, it is a process that is more economical and friendlier with the environment, which, because it is a natural process, tends to have very good acceptance from public opinion.



▶ **USES/APPLICATIONS**

The method designed can be used in RILES from the textile, cellulose, petrol, aquaculture, and/or mining industries.

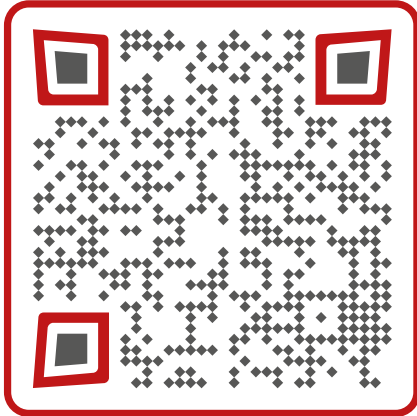
▶ **RESEARCHERS**

Dr. María Cristina Yeber, Science Faculty.

M. Sc. Carolina Soto, Science Faculty.

▶ **VIDEO OF THE TECHNOLOGY**

Scan the QR code to visualize the multimedia content.



REACTOR FOR THE TREATMENT OF CONTAMINATED WATER BASED ON HETEROGENOUS PHOTOCATLYSIS

DEVELOPED TECHNOLOGY

This is a reactor for treatment of water, or other liquids, based on a process of advanced oxidation, with different functional capacities depending on the volume and characteristics of the fluid to be treated. It is a multifunctional water treatment system that simultaneously removes ammonium, nitrite, and dissolved organic material, as well as disinfecting the water continuously and stably. This reactor is called "Photofilter".

TECHNOLOGICAL OFFERING

The technology is available for licensing.

STATE OF DEVELOPMENT

TRL 4, with a functional, laboratory-scale prototype, developed and tested successfully for water recirculation systems in culture (closed systems) in the removal of ammonium, nitrite, nitrate, COD, BOD5, water color and taste, disinfection of bacteria associated with BKD and SRS, or related to the IPN and ISA viruses.

INTELLECTUAL COPYRIGHT – PATENTS GRANTED

Chile: CL1852005

United States: US8038938

► BENEFITS/ADVANTAGES

- Multifunctional product. One piece of equipment satisfies the functions that are met with a biofilter, UV filter, ozone filter, foam fractionator, and carbon filter together.
- Does not require prior conditioning to initiate water treatment.
- Can operate in a wide range of water temperatures.



▶ USES/APPLICATIONS

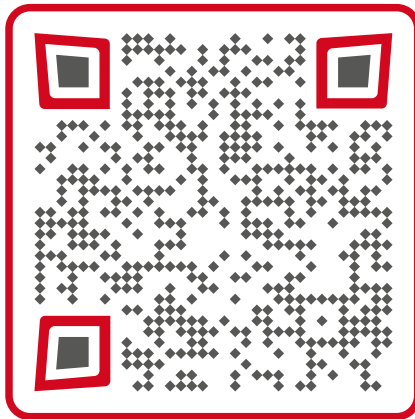
The technology can be used in aquaculture for water treatment in cultured systems with recirculation; in the agriculture and livestock industry for the treatment of liquid residues in abattoirs or processing plants and in plants that process sea products; in the forestry industry for the treatment of cellulose residues; in mining for the treatment of arsenic; in the treatment of liquids percolated from industrial or domestic landfill, among others. It is a cost-efficient treatment process for recalcitrant liquid residues with low biodegradability.

▶ MAIN RESEARCHER

M. Sc. Pablo Venegas Cabello, Engineering Faculty.

▶ VIDEO OF THE TECHNOLOGY

Scan the QR code to visualize the multimedia content.



PHOTOCATALYSIS LABORATORY

DESCRIPTION

The Photocatalysis Research Laboratory was created in 2001 to carry out basic and applied scientific research in the area of environmental chemistry.

DEPENDENCE

Environmental Chemistry Department, Science Faculty.

AREAS OF KNOWLEDGE

- Treatment of industrial water residues and toxic organic and inorganic compounds through advanced oxidation and bioremediation processes.
- Bioremediation of liquid and solid industrial residues that contain toxic organic compounds and heavy metals.

TECHNOLOGICAL OFFERING

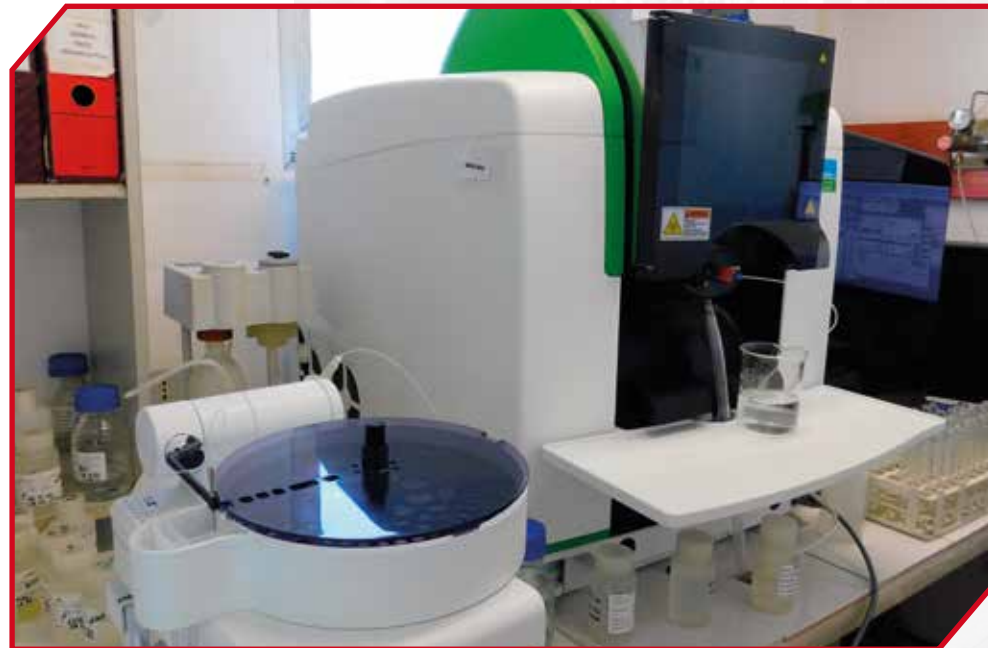
It has the capability to carry out basic and applied scientific research in the areas of organic chemistry and environmental chemistry for industry and society. It has installed capabilities and R+D projects in applied research.

▶ INFRASTRUCTURE

The laboratory has a surface area of 25 m².

▶ EQUIPMENT

- Culture chamber for microbiological cultures.
- Reaction chamber for photocatalysis.
- Analytical weighing scales.
- Spectrophotometer, for sample analysis.
- Thermo-reactor, for sample digestion.



UNIT EXPERIENCE

► PROJECTS EXECUTED

- Science for innovation 2030, ANID 20 CEIN2-142146. Development of capabilities in R+D+i+ebct (2020 - 2023).
- DINNOVA 02-2020-II Remediation of lixiviates landfill for reuse in irrigation (2021 - 2022).
- Science for innovation 2030. South-Subantarctic Alliance. Ci2030, CORFO Innovachile 18 CEIN-9350 (2018 - 2019).
- Application of bioremediation technology for the treatment of industrial residues. Scaling stage of 100 kg in plant. CORFO innovation voucher, company SENARIL. Licensing and Technology Transfer (2018).
- Laboratory testing for the bioremediation process for the residues of the company INTAC PROCESOS SPA. R+D+i Technological Contract (2018).
- R+D+i technological contract for the execution of the project "Laboratory testing for the bioremediation process in sludge for the Senavin company" (2016 - 2017).
- R+D+i technological contract for the execution of the project "Semi-industrial testing for the bioremediation process in sludge for the Senavin company" (2016 - 2017).
- Technological Licensing Contract Sena-RiL Ltda. (2016 - 2017).
- Degradation of effluent generated from obtaining Kraft cellulose from Eucalyptus through a biological treatment using the *Pseudomonas aeruginosa* bacteria. INNOVA BIOBIO project (2011).



ENVIRONMENTAL SCIENCES LABORATORY – LACA

DESCRIPTION

This laboratory has been dedicated since the year 2014 to support research work and undergraduate and postgraduate teaching in the area of (paleo) biogeochemistry.

DEPENDENCE

Environmental Chemistry Department, Science Faculty.

AREAS OF KNOWLEDGE

- Environmental and climate change.
- Biogeochemistry of aquatic systems.
- Terrestrial biogeochemical footprint.

TECHNOLOGICAL OFFERING

Currently the laboratory runs school internships, research seminars, undergraduate theses (environmental chemistry and marine biology), postgraduate these (Master's in Environment, Master's in Marine Ecology, and UCSC Doctorate in Science, major in Biodiversity and Bioresources), technical assistance, and service agreements.

WEBSITE

www.labensci.com

▶ INFRASTRUCTURE

The laboratory has a surface area of 120 m².

▶ EQUIPMENT

The laboratory currently has a MAE (Microwave Assisted Extraction) instrument for the extraction of total lipids in diverse environmental matrixes (for example, air, water, sediment, and animal and vegetable tissue) different solid phases to separate lipids as hydrocarbons, ketones, sterols, and fatty acids. In addition, it possesses an improved and efficient line of drying under nitrogen.



UNIT EXPERIENCE

► PROJECTS EXECUTED

- “Revealing past variations in coastal fog moisture during the Holocene using buried *Tillandsia landbeckii* dune ecosystems in the Atacama Desert” FONDECYT REGULAR (N° 1231820). Co-researcher (2023 - 2027).
- “Landscape management for people’s water security”. Fund of Innovation for Competitiveness FIC-R 2022. Biobío Regional Government. Consulting researcher (2023 - 2024).
- “Past and present impacts of megadroughts in high Andean lakes of northern and central Chile”. Strategic Research Fund in Drought Year 2021. FSEQ210021. Associated Researcher (2022 - 2023).
- “Paleo-LINGLOBAL: the temporal dimension of the Anthropocene and the impacts on Global Change on Lakes in in Ibero-America”. Ibero-American Scientific Cooperation Project. Higher Council of Scientific Research of the Spanish Ministry for Science and Innovation INCGL00029. Lead Researcher (2021 - 2023).
- “Applicability of bacterial membrane lipids as temperature and pH proxies in continental settings” France-Chile Exchange Project. Scientific operation Program ECOS-ANID (N°190011). Lead Researcher (2020 - 2023).
- “Determining the sensitivity of lake sediment proxies to late Holocene climate variability: a test from a longitudinal study in Northern Patagonia across the Andes” FONDECYT REGULAR (N° 1201277). Co- Researcher (2020 - 2023).
- “Assessing a regional hydroclimate signal from southern South America for the last two millennia through a suite of lake sediment biogeochemical records” FONDECYT REGULAR (N° 1190398). Lead Researcher (2019 - 2023).
- “The impact of wildfire severity on soil pyrogenic carbon across contrasting fire-prone ecosystems in central Chile: Temporal dynamics and related-effects on soil properties.” FONDECYT REGULAR (N° 1191905). Co-Researcher (2019 - 2023).
- “Hydroclimatic influence on estuarine-land interactions in northern Chilean Patagonia (Reloncaví fjord): Impacts on organic matter, sustainable resources, and human health” FONDECYT (N° 3180307). Co-Researcher (2018 - 2021).
- “Constraining the hydroclimate gradient in Southern South America using molecular isotopic proxies” FONDECYT REGULAR (N° 1160719). Lead Researcher (2016 - 2018).



RIVER AND COASTAL HYDRAULIC LABORATORY

DESCRIPTION

Created with the purpose of experimenting and exploring different problematic issues of river and coastal hydraulics.

DEPENDENCES

Civil Engineering Department, Engineering Faculty.

AREAS OF KNOWLEDGE

- River and coastal hydraulics.
- Ecohydrology.
- Port engineering.
- Tsunamis.
- Marine energies.
- Transport of sediments, riverbed, estuary, and beach morphology.
- Numeric modelling of rivers, estuaries, beaches, and maritime climate.

TECHNOLOGICAL OFFERING

- Collection of river variables.
- Studies for incipient movement of sand particles, analysis of undermining, and bed protection.
- Studies of river and coastal erosion, and of stability of structures in aquatic mediums.
- Forensic engineering services to determine responsibilities.
- Studies of water-structure interaction.

- Advanced numeric modelling services covering hydrodynamic and morphological aspects, and water quality.

► INFRASTRUCTURE

Infrastructure of approximately 700 m², which includes equipment for research and development of technological solutions in the areas of hydraulic engineering, coastal engineering, and port engineering.

► EQUIPMENT

- Wave channel 20 m long, 1.2 m high, and 0.77 m wide with a generator of piston-type waves for regular and irregular swell with passive swell absorption.
- Variable slope channel 5 m long, 0.7 m high, and 0.32 m wide. This allows unidimensional flow characterizations for slopes between 0 and 14%. It possesses an electric flow volume controller capable of representing progressions and hydrographs.
- Varied instrumentation to measure variables inside the channels.
- Water recirculation system that permits the supply of potential physical models.
- Flow tracker 2, that permits the measurement of speeds and flow volumes in rivers and fordable creeks (depths < 1 m).
- ADCP Rio Grande, that permits the measurement of speeds and flow volumes in rivers of greater dimensions (depths > 1 m).
- Pluviometers, that permit the recording of rainfall with a frequency of one minute and a precision of 0.2 mm.
- Pressure sensors, that permit the recording of absolute pressures for estimation of water heights with a frequency of one minute.
- GPS-RTK, that permits the determination of spatial positioning with centimetric precision.
- OBS 5+ Optical Backscatter Sensor to measure turbidity and sediment concentration in suspension.
- Sieves for granulometric analyses.
- 150°C oven for sample drying.
- 3D Crealty CR-10 Smart Printer for manufacturing special prototypes and structures for the channels.
- Kayak and inflatable zodiac boats for assembling measuring equipment.
- Echo sounder Hi Target.

UNIT EXPERIENCE

▶ PROJECTS EXECUTED

- Analysis of tsunami scour around on-shore structures. FONDECYT REGULAR 1210496 (2021 - 2024).
- Coastal evolution and factors of change in Chile: criteria for adaptation and resilience in the coastal zone FONDECYT REGULAR 1200306 (2020 - 2022).
- Coastal evolution, morphodynamic, and factors of change in the littoral line on a coast with tectonic influence – orientations for an integrated management of the coast. FONDECYT REGULAR 1151367 (2015 - 2019).

▶ ASSOCIATED PUBLICATIONS

- Andrew W. Tranmer, Diego Caamaño, Stephen R. Clayton, Abolfazl Nazari Giglou, Peter Goodwin, John M. Buffington, Daniele Tonina (2022). Testing the effective-discharge paradigm in gravel-bed river restoration, *Geomorphology*, Volume 403, 2022, 108139, ISSN 0169-555X, <https://doi.org/10.1016/j.geomorph.2022.108139>.
- J. Vasconcelos, D. Caamaño, V. M. Tuset, R. Sousa, R. Riera (2021). The shell phenotypic variability of the keyhole limpet *Fissurella latimarginata*: insights from an experimental approach using a water flow flume, *Journal of Molluscan Studies*, Volume 87, Issue 4, December 2021, eyab043, <https://doi.org/10.1093/mollus/eyab043>.
- Fuentes-Aguilera, P., Caamaño, D., Alcayaga, H., Tranmer, A. (2020). The influence of pool-riffle morphological features on river mixing. *Water* 2020, 12, 1145; <https://doi.org/10.3390/w12041145>.
- Aránguiz, R., Villagrán, M., (2013). Beach Profile Study of a Lacustrine System using a Low-Cost Wave Recorder. *Coastal Dynamics* 2013, June 2013, France.
- Aránguiz, R., Dinamarca, J., Bravo, V., Link, O., (2023). Physical experiments of tsunami scour around on-shore square structures. *International Conference on Scour and Erosion ICSE11*. September 2023, Denmark.
- Gómez, M.; Villagrán, M.; Martínez, C., and Belmonte, A., 2018. Characterizing the longshore Sediment Transport Pattern on Beaches in the Gulf of Arauco, Chile, to Assess Morphological Shoreline Evolution. In: Shim, J.-S.; Chun, I., and Lim, H.S. (eds.), *Proceedings from the International Coastal Symposium (ICS) 2018 (Busan, Republic of Korea)*. *Journal of Coastal Research*, Special Issue No. 85, pp. 656–660. Coconut Creek (Florida), ISSN 0749-0208.
- Villagrán, M.; Gómez, M.; Martínez, C. Coastal Erosion and a Characterization of the Morphological Dynamics of Arauco Gulf Beaches under Dominant Wave Conditions. *Water* 2023, 15, 23. <https://doi.org/10.3390/w15010023>.



WET LABORATORY OF AQUACULTURE ENGINEERING - LHIA

DESCRIPTION

Laboratory for teaching, research, and specialized services in Aquaculture Engineering of the Civil Engineering Department of the Engineering Faculty.

Since the year 2002, it has been dedicated to R+D+i and technological transfer, together with offering specialized services for the evaluation of medication, feed, solutions, and technologies for confined aquaculture of fish and mollusks, contributing to the development of the regional and national aquaculture industry.

DEPENDENCE

Engineering Faculty.

AREAS OF KNOWLEDGE

- Hydraulics and Fluid Dynamics in cultured on-land systems.
- Water treatment and conditioning in confined aquaculture.
- Aquacultural Engineering and on-land farmed systems.
- Small-scale Multitrophic and confined aquaculture.
- Innovation and processes of change, environmental management, and management of conflict with communities.

▶ TECHNOLOGICAL OFFERING

- Development and innovation in farming of fish, mollusks, and algae: new technologies, processes, and water treatment and conditioning systems.
- Technical, economic, and environmental evaluation of on-land projects.
- Execution of testing for feed, medication, and other pharmaceuticals for use in aquaculture.
- Technological transfer for Small-Scale Aquaculture on land (APE).
- Environmental evaluation for aquaculture projects and redesign of projects to meet norms.
- Consulting for collaborative and organized work between companies and communities in their area of influence.

▶ INFRASTRUCTURE

The LHIA has 250 m² of laboratory and 5 workspaces.

▶ EQUIPMENT

- Room equipped for monitoring water quality.
- Room set up for the animalization of viruses and/or bacteria in fish.
- Wet room for the challenge of vaccines and anti-viral medication.
- Room for acclimatization and reception of fish.
- Machine and equipment room.
- SRA cultivation system for reception and acclimatization of 6.5 m³ capacity, with two farming units of 4 m³ and 2.3 m³.
- SRA cultivation systems for the challenge of vaccines and anti-viral medication
- SRA cultivation system for the animalization of viruses and bacteria in fish.
- Aeration blower of 2HP, 1 HP and 450 liters/minute.
- Water pumps for the recirculation of different capacities.
- Automatized electric generators, of 5 kW and 40 kW.
- Equipment for measuring water quality.
- Equipment for reducing and increasing temperature in fresh and salt water.
- Varieties of fiberglass and plastic tanks of 200, 500, 1000, 2000, and 2400 liters for fish cultivation.
- Main equipment for the maintenance and operation of SAR cultivation systems.

UNIT EXPERIENCE

▶ PROJECTS EXECUTED

- Project "Tank self-cleaning system" from the program "Fill the Gap", HUB APTA (FTG005-UCSC007) (2021 - 2023).
- Applied Research Project DINNOVA UCSC 2019. Development of a Functional Prototype of an Autonomous System for the Maintenance and Commercial Distribution of Live Fisheries Resources. Collaborating Researcher (2019 - 2023).
- Technological Contract "Initial development and implementation of Intervention Programs for Approaching, Integrating, and Gaining Loyalty in Fisheries Providers and their Direct Surroundings". Private financing Pesquera Blumar (2020 - 2021).
- Technological Contract "Olive Oil Production enriched with fucoxanthin from brown algae" project code 20CYC-BB-136164. D&M Consultores EIRL and CORFO, line "Connect and Collaborate" (2021).
- Technological dissemination "Integrated on-land small-scale aquaculture for small businesses of artisanal fishing and coastal communities of the eight region, as a tool for diversifying their productive activities and income generation". Regional Productive Development Committee. Prospection, Dissemination, and Absorption – Biobío region. Line 2. Technological Dissemination. Code18CHTT98072 (2018 - 2021).
- Project "Marine algae: Massification of a sustainable technological strategy for the formulation of active ingredients used in functional foods with anti-obesity properties". Code 18IPP-93644, Biobío region, Chile (2018 - 2020).
- Study of Technical and Economic Pre-feasibility for the production and commercialization of organic trout in Arauco Province in the Biobío region. Fund for the Development of Artisanal Fishing. Lead Researcher (2017 - 2018).
- Program of Consulting and Support Services for the participative and co-guided creation and execution of productive development projects with artisanal fishermen in the commune of Coronel, Biobío region. Santa María de Colbún Power Station, Coronel. Lead Researcher (2011 - 2023).
- Technical and management consulting for artisanal fishing unions of Coronel. 16 Organizations. Support in entrepreneurship, management, organization, commercialization, resource leverage, implementation, and control of business ventures (2013 - 2023).



- Evaluation challenge “Medications for disease control in salmon” (2008 - 2014). Diagnotec S.A. Company and USACH.
- Challenge and Evaluation Program of recombinants vaccines and natural molecules for the management and control in Atlantic Salmon of the ISA virus and SRS bacteria. USACH and UCSC Project. Main Researcher (2014).
- Study of Energy Efficiency in the removal, management and re-utilization of Suspended Solids generated in a fish farm with water recirculation. Project DIN-UCSC-07/2011 Main Researcher (2011).
- roject Evaluation of Feed for Kingfish (*Seriola Lalandi*). Experience developed for the North American company Low Salinity Inc and LHIA-UCSC (2010 - 2011).
- Design, dimensioning, and operation of a fish farming system with partial reuse of water for the evaluation of the Antibiotic VIROTOP with the company Diagnotec. S.A. (2009 - 2010).
- Design, dimensioning, and operation of a fish farming system with recirculation of fresh and salt water for the development of challenges and evaluations of medications and recombinant vaccines for the ISA virus, in fry, pre-smolt, smolt reproducers of *Salmo Salar*. Empresa Diagnotec S.A. (2008 - 2014).
- Design, dimensioning, and operation of a fish farming system with partial reuse of water for the development of field testing and challenges of peptide in fish against the *Saprolegnia* sp. Fungi. Pontificia Universidad Católica de Valparaíso and UCSC. (2008 - 2009).
- Design, dimensioning, and operation of a saltwater recirculation system for the evaluation of diet and growth in *Seriola lalandi* (KingFish). Company Low Salinity Inc (LSI, USA) and UCSC. Lead researcher (2010 - 2011).
- Design, dimensioning, and operation of a saltwater recirculation system for the development of preliminary challenges of a recombinant vaccine for ISA virus. Company Diagnotec and UCSC. Lead Researcher (2009 - 2010).
- Project FONDEF (DO4T-2038) “Photocatalysis technology licensing for water treatment in recirculation systems used in confined aquaculture”. Lead researcher (2006 - 2007).
- Project FONDEF (DO2I1108) “Use of heterogenous photocatalysis for water treatment in recirculation systems used in national aquaculture”, presented for the tenth FONDEF project tender. Lead researcher (2003 - 2005).
- Project “Biological and technological bases for the innovation and development in productive systems of on-land intensive aquaculture”. Interdisciplinary project financed by the Universidad Católica de la Santísima Concepción. Lead researcher (2005).



- “Study of comparative and competitive advantages for the promotion of investment and development of the aquaculture industry in the Biobío region”. Biobío Regional Government and CORFO. Lead researcher (2002 - 2003).
- Use of heterogenous photocatalysis for water treatment in recirculation systems in national intensive aquaculture. CONICYT - FONDEF X Nation R+D projects tender. Code D02I-1108 (2003).
- Project “Conformation of an international consortium for the development of Security Fishbox, intelligent recirculation aquaculture system for farming aquatic species of high commercial value”. Project CORFO (208-7093) (2009).

► TECHNOLOGICAL PORTFOLIO

- Eductor for a fluid injection system in aquaculture tanks and the system that runs it. Patent application PCT/IB2021/061090.
- Non-invasive self-cleaning system and method that permits the continual removal of solid residues in aquaculture cultivation tanks. Patent application PCT/IB2019/060712.
- Technical protocols for the installation, operation, and production of an integrated cultivation system on a small scale. Intellectual copyright N° 2021-A-2699.
- Process of Riles treatment based on Photocatalysis. Patent granted in Chile N° 184-2005, year 2012.
- Photo-catalytical Reactor for Riles treatment. Patent granted in Chile N° 185-2005, year 2012.
- Photocatalytic Reactor and Process for Treating Wastewater. Patent granted USA N° Application 11669670, year 2011.



CLEAN TECHNOLOGIES LABORATORY - LTL

DESCRIPTION

Created with the aim of promoting research linked to the control of environmental pollution and the development of clean technologies for the industrial sector over a foundation of environmental protection.

DEPENDENCE

Engineering Faculty.

AREAS OF KNOWLEDGE

- Environmental catalysis.
- Technologies for the control of atmospheric pollution.
- Ethylene control during storage and distribution of agricultural products.
- Unconventional technologies for water and residual water treatment.
- Processes of advanced oxidation for the treatment of water and residual water.

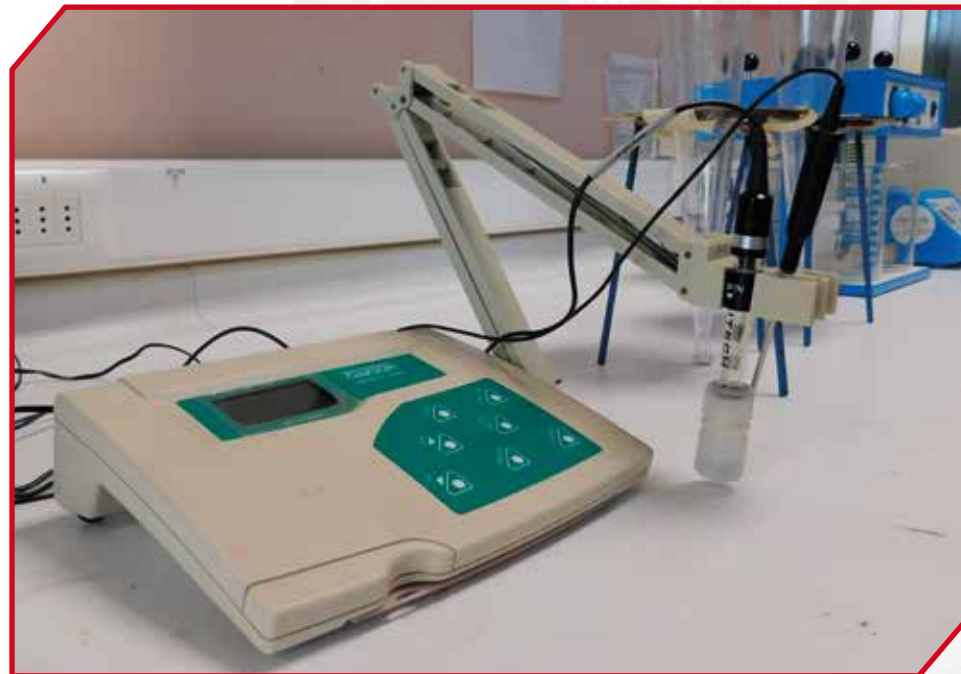
TECHNOLOGICAL OFFERING

- Training service in analytical water control techniques.
- Coagulation-flocculation rehearsals.
- Training service in the use of gas chromatography with flame ionization detector and thermal conductivity.
- Specialized technical assistance.

- Training service in the use of the Fourier Transformed Infrared Spectroscope (FTIR).
- Measurement of the respiration rate of climacteric fruit (determining of O₂, CO₂, and ethylene).

► INFRASTRUCTURE

- Infrastructure of 80 m² with equipment for analytical determinations of quality control of residual water.
- 80 m² room with infrastructure for theoretical/practical training sessions.



► EQUIPMENT

- Gas chromatograph with FID and TCD detector.
- ThermoScientific Nicolet™ iSTM50 FTIR Spectrometer.
- Jasco FT/IR 4700 spectrometer with DRIFTS Praying Mantis reaction cell.
- Digital module for temperature control.
- DRIFTS accessory.
- DRIFTS Pike reaction cell.
- Hamamatsu UV light source with light guide (365 nm).
- Light power meter (Hamamatsu, Japan).
- PIKE IR gas cell (100×25 mm) with CaF₂ windows (25×4 mm).
- EGEO hydraulic press with 13mm pellet mold (Perkin elmer).
- 12 hermetically closed glass desiccators (10 L) with stainless steel basket hanging in the center of each desiccator.
- System for DTP couple with a thermal conductivity detector.
- 2 gauges of ozone in gas phase.
- 7 mass flow controllers.
- UV-visible spectrophotometer.
- Water deionizer.
- Thermo-regulated bath.
- Masterflex peristaltic pump with head.
- PH meter.
- Conductometer.
- 2 magnetic agitators.
- Oxygen cylinder and regulator.
- Oxygen regulator.
- 3 computers.
- Printer.
- 2 glass reactors with a 1L capacity.
- Glass reagents and materials.
- Ozone generator.
- Analytical scales.
- Heater.
- Water distiller.
- Rotavapor IKA model RV 10 Basic V.
- BIOBASE extractor fan.
- Acclimatized light incubation chamber BIOBASE BJPXA500II.



UNIT EXPERIENCE

► PROJECTS EXECUTED

- Photocatalytic oxidation of ethylene emissions from fruit storage facilities under simulated visible light irradiation using reduced graphene oxide modified anatase black TiO₂ nanostructures with exposed {001} at low temperature and high relative humidity. FONDECYT REGULAR 2020 1200858 (2019).
- Development of new functional nanocomposites based on graphene quantum dots supported metal/metal oxide nanoparticles for electrochemical biosensing of DNA/RNA molecules. FONDECYT Post doctorate N° 3190256 (2018).
- Low temperature photocatalytic oxidation of ethylene emissions from fruit warehouses and cold-storage facilities using hydrophobic zeolites doped with zinc and copper oxide nanoparticles under high relative humidity. FONDECYT REGULAR 1170694 (2017).
- Elimination of volatile sulfur organic compounds (COVs-S) of cellulose manufacturing plants through a hybrid system of adsorption/oxidation with hydrogen peroxide and activated carbon. FONDECYT Post doctorate 2015 (2014).
- Low temperature removal of chlorinated volatile organic compounds based on the combined use of transition metal-exchanged Chilean natural zeolite and ozone as a detoxification process. FONDECYT REGULAR 1130560 (2013).
- Application of synthetic French zeolites and natural Chilean zeolites for the elimination of toxic organic pollutants in advanced oxidation processes. ECOS-CONICYT Project C11E08 (2012).
- Water and chemicals recovery from segregated kraft cellulose bleaching effluents using membrane separation and advanced electrooxidation processes. FONDECYT REGULAR 1100738. How are the sewage waters of my commune treated? Explore project ED14/024. UCSC-ESSBIO S.A. (2010).
- Heterogeneous catalytic gas phase ozonation of vocs using Chilean zeolite at low temperature. FONDECYT REGULAR 1090182 (2009).
- Water and chemical resource recovery from effluents segregated from the bleaching of Kraft cellulose through a combined system of separation by membrane and advanced electro-oxidation processes. Basal financing program, Technological and Scientific Center of Excellence (CTE-UDT), Seed Capital (2009).
- Catalytic ozonation of toxic organic compounds promoted by volcanic sands. FONDECYT REGULAR 1060304 (2006).





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CONIYT

TU-1810 Split Beam
UV-VIS Spectrophotometer



WATER RESOURCES UCSC



BIODIVERSITY AND SUSTAINABLE ENVIRONMENTS RESEARCH CENTER - CIBAS



Centro de Investigación en
Biodiversidad y
Ambientes
Sustentables

DESCRIPTION

The mission of the Biodiversity and Sustainable Environments Research Center (CIBAS) is to develop fundamental and applied interdisciplinary scientific research, contribute new technologies, carry out innovation, and support postgraduate formation in order to contribute to the understanding of natural systems and the generation of productive and technological solutions aimed at the sustainable use of habitats and existing resources in coastal marine and continental environments.

For this, CIBAS has a team of 21 highly qualified researchers in a wide range of disciplinary areas, supported by a set of postgraduate researchers, undergraduate and postgraduate students, and research assistants.

DEPENDENCE

Vice-chancellor of Research and Postgraduate Studies.

WEBSITE

www.cibas.cl

▶ AREAS OF KNOWLEDGE

CIBAS focusses its work in two large research areas:

- **Biodiversity and Environment:** oriented toward the study of biodiversity and its environments and the natural, anthropic, and social factors that affect them with the objective of contributing to their conservation and sustainable use.
- **Sustainable Processes, Production, and Technologies:** oriented toward the study and development of processes or transformations applicable to the productive and technological areas in a framework of action that prioritizes the sustainable use of renewable and non-renewable resources, considering integration of systems to achieve greater energy efficiencies and lower environmental costs.



► TECHNOLOGICAL OFFERING

Within its two central research areas, CIBAS develops different sub-areas in specific topics that, in addition, allow it to articulate multidisciplinary and interdisciplinary approaches to deal with complex situations or problem issues. The main sub-areas currently available are:

- Aquaculture, management, restocking, and conservation.
- Architecture, engineering, and software reuse.
- Biogeochemistry and water and soil pollution.
- Bioremediation and treatment of industrial waste.
- Scientific didactics and literacy, environmental education.
- Ecology, genetics, evolution, and biodiversity.
- Renewable energies and efficient energy conversion.
- E-health and persuasive technologies.
- Hydrology, hydrodynamics, hydroecology, and water management.
- Nutrition, genetics, behavior, and health.
- Optimization of microbial bioprocesses.
- Parasitism and the use of parasites as biomarkers.
- Perturbations and resilience of natural systems.
- Development policies and strategies.
- Biotechnological production of biomolecules and food.
- Natural products and biomaterials.
- Valuation of biomass and biorefinery

► EQUIPMENT

CIBAS does not have exclusive physical infrastructure, as the members of the Center develop their activities in research laboratories belonging to four distinct faculties in UCSC: Science, Education, Engineering, and Medicine. All the general and specialized equipment of those laboratories is available for the work of the Biodiversity and Sustainable Environments Research Center - CIBAS.



REGIONAL ENVIRONMENTAL STUDIES CENTER - CREA



CREA UCSC
CENTRO REGIONAL DE ESTUDIOS AMBIENTALES
UNIVERSIDAD CATÓLICA DE LA SANTÍSIMA CONCEPCIÓN

DESCRIPTION

This research and service center was created in the year 2006 and is dedicated to the generation of scientific-technical research and the development of studies in the environmental area as a response to the growing need of companies in the region and country to count on opportune assistance, collaboration, and environmental consulting that allows them to respond to internal corporative requirements and those demanded by the country's environmental authorities.

DEPENDENCE

Vice-chancellor of Market Relations.

AREAS OF KNOWLEDGE

- Ecology and environmental sciences.
- Ecotoxicology.
- Limnology.
- Oceanography.
- Fishing and pisciculture.

WEBSITE

www.creaucsc.cl

▶ TECHNOLOGICAL OFFERING

- Desalination of sea water. Water supply, and analysis and treatment of residual water.
- Exploration and exploitation of territorial environment, fishing, and aquaculture.
- Environmental and urban planning.
- Marine prospections and seabed depth.
- Environmental follow-up, agricultural technology and productivity.

▶ INFRASTRUCTURE

CREA has an infrastructure of 1500 m², distributed in:

- Bioassay laboratory.
- Biomarker laboratory.
- BIOTECMAR chemistry laboratory.

▶ EQUIPMENT

- Bioassay laboratory has equipment for maintaining organisms under standard criteria for executing assays, for example, analytical scales, multiparameters, extraction fan, microscopes, cultivation chambers, incubators, thermoregulated baths, autoclave, among others.
- Biomarker laboratory, equipment for carrying out quantitative analysis of physiological and biochemical parameters; specialized equipment; refrigerated centrifuge, microplate equipment with measurement of absorption, luminescence, and fluorescence.
- Equipment for maintaining biological material (liquid nitrogen container); workspaces with necessary fungible material.
- BIOTECMAR chemical laboratory has ICP optical equipment, gas chromatograph, atomic absorption spectrophotometer, UV visible spectrophotometers, liophytilator, infrared equipment, Kjeldahl digester, nitrogen and phenol distillers, and minor equipment for quantitative analysis of chemical parameters.
- Additionally, the center has a vessel, oceanographic equipment, equipment and instruments for administration and offices, equipment and instruments for ecotoxicology, equipment and analytical instruments of an environmental chemistry laboratory, and licenses for specialized software.

UNIT EXPERIENCE

► PROJECTS EXECUTED

Works in the terrestrial area (2008 - 2016):

- Meteorological bulletin sector Constitución. Cellulose plant Constitución. Celulosa Arauco and Constitución S.A. (2008 - 2011).
- Inventory of flora and fauna Lagartija Island, Calbuco. Compañía de Petróleos de Chile, Copec S.A. (2010).
- Characterization of Terrestrial Flora and Fauna and Ictiofauna present in Lota basin, Biobío region. Celulosa Arauco and Constitución S.A. (2011 - 2014).
- Characterization of Flora and Fauna present in Raqui sector, Arauco province, Biobío region. Celulosa Arauco and Constitución S.A. (2011 - 2014).
- Inventory of terrestrial Fauna present in Coyanmahuida Park, commune of Florida, Biobío region. Celulosa Arauco and Constitución S.A (2012).
- Characterization of Terrestrial Flora and Fauna and Ictiofauna present in Lota basin, Biobío region. Pre and post-harvest campaigns. Celulosa Arauco and Constitución S.A (2012).
- Characterization of Terrestrial Fauna present in Raqui sector, Arauco province, Biobío region. Celulosa Arauco and Constitución S.A (2012).
- Characterization of Flora and Vegetation present in Raqui sector, Arauco province, Biobío region. Celulosa Arauco and Constitución S.A (2012).
- Aquatic and Marine Avifauna of the coastal sector of Constitución. Celulosa Arauco and Constitución S.A. (2006 - 2016).
- Characterization of the Terrestrial Fauna present in Raqui sector, Arauco province, Biobío region. Celulosa Arauco and Constitución S.A. (2014 - 2015).
- Characterization of Flora and Vegetation present in Raqui sector, Arauco province, Biobío region. Celulosa Arauco and Constitución S.A. (2014 - 2015).
- Limnological Characterization of six bodies of water located in the Raqui-Horcones sector. Celulosa Arauco and Constitución S.A. (2014 - 2015).



Work in the marine and fresh water- aquaculture area (2006 - 2019):

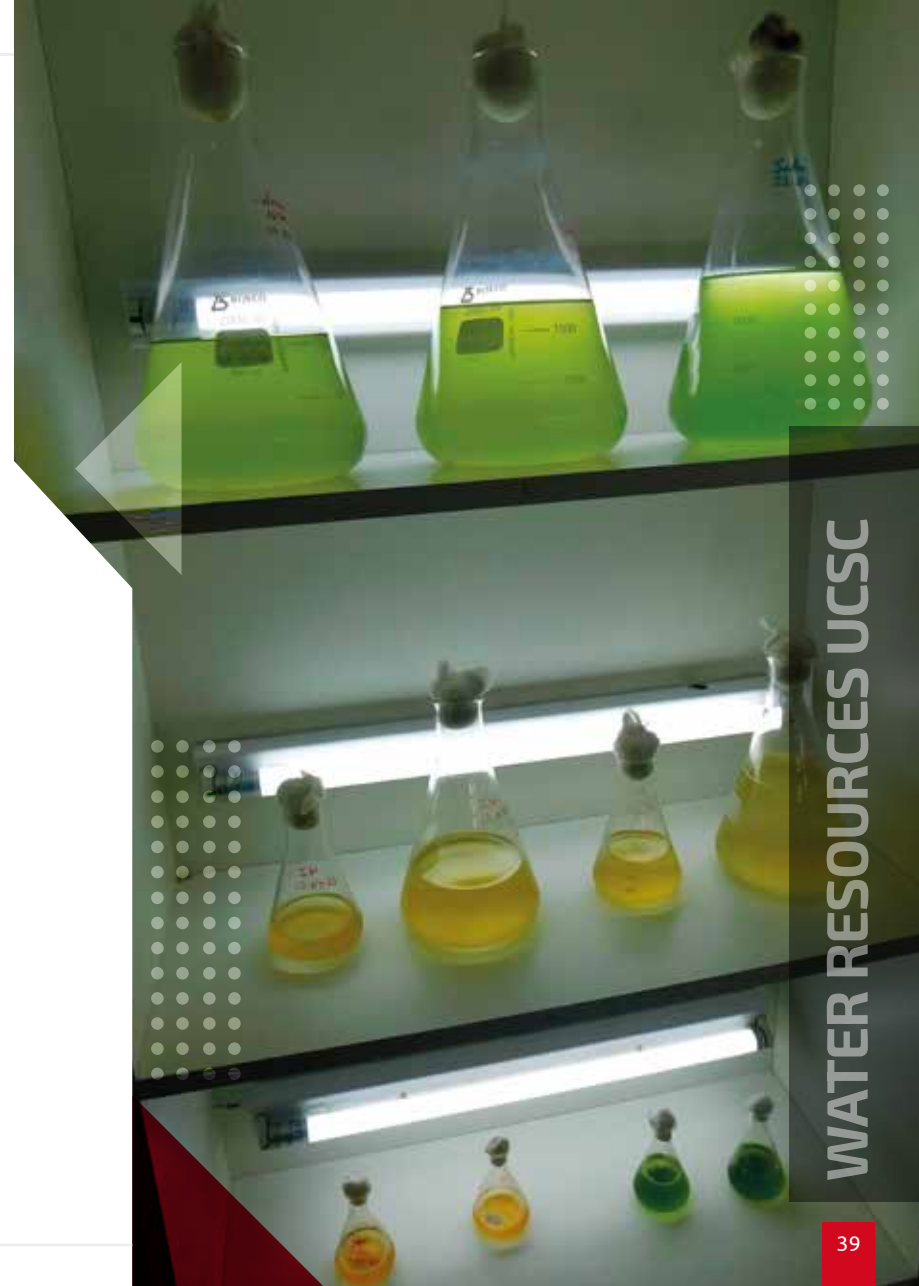
- Holistic monitoring of the lower section of the Mataquito River. Maule region. Licancel Cellulose Plant. Celulosa Arauco y Constitución S.A. (2008 - 2019).
- Nueva Aldea Plant monitoring program. Toxicity bioassays in marine environment. Celulosa Arauco and Constitución S.A. (2006 - 2019).
- Nueva Aldea Plant monitoring program. Biomarkers in the marine environment. Celulosa Arauco and Constitución S.A. (2006 - 2019).
- Arauco Plant monitoring program. Toxicity bioassays in the marine environment. Celulosa Arauco and Constitución S.A. (2015 - 2019).
- Arauco Plant monitoring program. Biomarkers in the marine environment. Celulosa Arauco and Constitución S.A. (2015 - 2019).
- Marine environment monitoring program Constitución Plant. RCA N°34/2006. Celulosa Arauco and Constitución S.A. (2007 - 2019).
- Marine environment quality. Physical-chemical characteristics of the body of water and sediment of the area of dredging of the overpass pier of Enap Refinerías S.A. (2008; 2012; 2015 - 2016).
- Environmental follow-up plan for the expansion of the Santa Fe Plant, CMPC Celulosa S.A. (2014 - 2016).
- Environmental follow-up plan for the expansion of the Laja Plant, CMPC Celulosa S.A. (2014).
- Establishment of the state of health of fish in the Biobío River, effluent sector Santa Fe Plant, CMPC celulosa S.A. (2012 - 2014).
- Seasonal study of the abundance of hydrobiological species in the Mataquito river and estuary. Celulosa Arauco and Constitución S.A. (2008 - 2010).
- Analysis of trace elements and organic compounds in Choro Zapato (*Choromytilus chorus*) Underwater Emissary of El Arenal Beach, Maule region. Celulosa Arauco and Constitución S.A. (2010).
- PVA of the coastal sector adjacent to the underwater emissary of Asmar Talcahuano. (2010).
- Evaluation of the toxicological quality of the area adjacent to the embarking pier of the Compañía Minera Doña Inés de Collahuasi, Punta Patache, Iquique. (2009 - 2010).
- Evaluation of the toxicological quality of the area adjacent to the underwater emissary Arauco Plant, PVA. Celulosa Arauco and Constitución S.A. (2008 - 2019).
- Evaluation of the Ictic Fauna of the Ciénaga del Name wetland, Cauquenes province. Celulosa Arauco and Constitución S.A. (2010 - 2011).



- Coloso marine environment monitoring program, composed of the long-term environmental surveillance program, monthly desalination campaign, copper inventory mini-campaigns, control of desalination effluent, control of copper in edible organisms, and follow up with artisanal fishing. Minera Escondida Ltda. (2011 - 2019).
- Monitoring Coloso sector. Statistical study of the database. Minera Escondida Limitada. (2012).
- Estimation of the time of residence of waters in the Arauco Gulf. Elaborated for Celulosa Arauco and Constitución. Arauco Plant (2012).

Recent work in the area of fostering production (2017 - 2019):

- Arauco Fisheries Node, for the commercial development of artisanal fishing in Arauco province.
- Itata Olives, node for commercializing olives.
- Development and application of a management model for improving irrigation water quality for agricultural businesses and water user organizations in the Biobío province.
- Update of the communal development plan of Contulmo.
- Development and implementation of bioremediation mechanisms to improve sustainability and touristic competitiveness of Lanalhue Lake. Arauco province .15BP – 45839.
- Implementation and dissemination of technological alternatives for the reduction of microbiological contamination in the use of water resources in blueberry producers in the Biobío province.







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