El Colegio de la Frontera Norte
FRONTERA NORTE
e-ISSN: 2594-0260
Revista internacional de fronteras, territorios y regiones / International Journal of Borders, Territories and Regions

FRONTERA NORTE, VOL. 37, ART. 18, 2025
e-ISSN 2594-0260 https://doi.org/10.33679/rfn.v1i1.2406

# The Effects of the Discharge of Industrial Wastewater in Ensenada, B. C. Mexico: Between Regulation and Self-Regulation

# Los efectos de las descargas de aguas residuales industriales en Ensenada, B. C., México: entre la normativa y la autorregulación

Ritter de Jesús De Basabe Ibarra,[1] & Patricia Rivera-Castañeda[2]

ABSTRACT

The management of wastewater discharge by the industrial sector is a poorly understood process. From a critical environmental economics perspective, this study analyzes the regulatory procedures followed by industry in Ensenada, Baja California. Using a mixed-methods approach, the study reviews newspaper and statistical data, conducts semi-structured interviews with key stakeholders, and performs preliminary water monitoring in the bay of this city. The findings demonstrate an interrelationship between industrial and domestic wastewater management, where industries prioritize administrative procedures to obtain discharge permits without complying with regulatory quality standards for the discharged water. This reveals that self-regulation and agreements are insufficient tools to address the reality of coastal pollution, limiting the realization of recreational and economic benefits for the study area and jeopardizing public health.

*Keywords:* 1. industrial management, 2. marine pollution, 3. environmental legislation, 4. water quality, 5. sewage.

RESUMEN

La gestión que se efectúa en el sector industrial para la descarga de sus aguas residuales es un proceso poco comprendido. Desde una perspectiva crítica de economía ambiental, en el presente trabajo se analizan los procedimientos regulatorios que sigue la industria en Ensenada, Baja California. Mediante una metodología mixta, se revisan datos hemerográficos y estadísticos, se realizan entrevistas semiestructuradas con actores clave y un monitoreo preliminar del agua en la bahía de dicha localidad. Los hallazgos demuestran una interrelación entre la gestión del agua residual industrial y doméstica, donde las industrias priorizan los trámites administrativos para obtener los permisos de descarga, sin cumplir con la calidad reglamentaria del agua descargada. Esto revela que la autorregulación y el convenio son herramientas insuficientes para enfrentar la contaminación costera, lo que limita la obtención de beneficios recreativos y económicos para el área de estudio y pone en riesgo la salud pública.

*Palabras clave:* 1. gestión industrial, 2. contaminación marina, 3. legislación ambiental, 4. calidad del agua, 5. aguas residuales.

Received: June 12, 2024
Accepted: October 17, 2024
Available online: December 30, 2025

[1] Universidad Autónoma de Baja California (https://ror.org/05xwcq167), ritter.basabe@gmail.com, https://orcid.org/0009-0005-2081-6933

[2] (Corresponding author) El Colegio de la Frontera Norte (https://ror.org/04hft8h57), privera@colef.mx, https://orcid.org/0000-0002-5462-4690

## INTRODUCTION

Water management should be understood as a cyclical process in which the provision of drinking water and the discharge of wastewater function as interconnected components of the same resource (Montesillo-Cedillo, 2021). In practice, however, wastewater and its impacts remain largely invisible and politically unrewarding (Castro & Lacabana, 2005; Walteros & Ramírez, 2020), which partly explains the substantial information gaps that persist between water supply and sanitation. Public discourse tends to frame water provision in a positive light, and reported advances often become a tool for political promotion by government institutions, whether to highlight progress in specific neighborhoods or regions or to demonstrate compliance with international targets. Sanitation[3] does not receive comparable attention. Even when improvements are made, they are consistently limited, and the most common explanations point to insufficient information and to economic, technical, and infrastructural constraints, among other factors (Llanes et al., 2022).

If the challenges are substantial in the sanitation of domestic water, the availability of information and data on industrial wastewater management is even more complex. Information circulates primarily between government authorities and private companies, which creates a sense of opacity for the general public. This study examines the management of industrial wastewater in Ensenada, Baja California, considered the most important commercial port on the Pacific coast of Mexico. Its predominant productive activities, fishing and tourism, depend heavily on the preservation of marine resources. Although the city is internationally recognized for its environmental initiatives, it is noteworthy that in recent years it has experienced recurring difficulties in meeting wastewater quality standards (Comisión Federal para la Protección contra Riesgos Sanitarios [COFEPRIS], n.d.).

In Ensenada, major companies are classified into service, industrial, and aquaculture sectors according to the Sistema Nacional de Información del Agua[4] (SINA, 2025). Their discharges account for one third of the total volume of wastewater released, while the remaining volume corresponds to domestic sources. Beyond the significance of this contribution, analyzing the management of industrial wastewater becomes a priority because contaminant concentrations are generally higher than those found in domestic wastewater (WWAP, 2017). Understanding this dynamic requires familiarity with the regulatory framework that governs industrial wastewater management. This includes relevant regulations, maximum permissible limits (MPLs), compliance procedures, information-generation processes, evaluation mechanisms, technical factors involved,

[3] It is important to emphasize that, at the discursive level, the concept of wastewater management has expanded toward a more integrated approach that incorporates preventive measures and post-treatment uses. According to the United Nations World Water Assessment Programme (WWAP, 2017, p. 177), it "includes the prevention or reduction of pollution at the source (in terms of pollution load and the volume of wastewater produced), the collection and removal of contaminants from wastewater streams (that is, treatment), and the beneficial use and/or disposal of treated wastewater and its by-products." Despite this conceptual shift, statistical data that demonstrate the incorporation of these elements remain limited.

[4] National Water Information System (unofficial translation).

issues related to waste quality and chemical concentrations, and the administrative capacities of the actors responsible for these processes.

From the perspective of environmental economics (Sterner, 2007; Enríquez Andrade, 2008), this study proposes analyzing regulatory procedures through a critical lens to evaluate self-regulation mechanisms and economic incentives applied to the sanitation of industrial wastewater. Two dimensions are considered. The first involves the federal authority, the Comisión Nacional del Agua[5] (CONAGUA) through the Registro Público de Derechos de Agua[6] (REPDA), which grants discharge permits and encourages individual corporate self-regulation. The second involves a more local process, in which small enterprises rely on the services of the Organismo Operador de Agua[7] (OOA), specifically the Comisión Estatal de Servicios Públicos de Ensenada[8] (CESPE). Through a joint treatment agreement, CESPE assumes co-responsibility with the company by providing treatment and monitoring services.

By documenting and analyzing the management process, this study aims specifically to describe the handling of industrial wastewater discharged into Ensenada Bay. The case of this city can serve as a national reference for management practices, illustrating mechanisms designed at a more centralized level and highlighting the social consequences of noncompliance and local impacts. This approach also allows for the identification of potential alternatives to enhance existing processes.

The article is organized into four sections. The first provides a brief overview of the institutional management of industrial wastewater and the main criticisms of REPDA, emphasizing the need for analysis. The second outlines the methodological aspects of the case study. The third describes the characteristics of Ensenada and its pollution challenges, presents basic data on industrial wastewater discharges, and documents local regulatory procedures for industrial water management. The fourth highlights the four most significant elements in the analysis of industrial wastewater management. The article concludes with a brief summary of the main findings.

## INDUSTRIAL WASTEWATER MANAGEMENT

### *Institutions, Regulations, and Agreements*

Advances in industrial wastewater management by companies, driven by command-and-control measures developed in the 1990s, stem from global recognition of environmental challenges, with the central aim of protecting the environment and contributing to sustainable development. The establishment of institutions dedicated to these objectives also reflects commitments arising from the North American Free Trade Agreement (now USMCA), which encouraged corporate environmental management to enhance competitiveness and ensure regulatory compliance. In

[5] National Water Commission (unofficial translation).
[6] Public Registry of Water Rights (unofficial translation).
[7] Water Utility (unofficial translation).
[8] State Commission of Public Services of Ensenada (unofficial translation).

subsequent years, these efforts were further complemented by the incorporation of economic incentives to support environmental policy.

As part of the consolidation of Mexico's relatively recent environmental policy, the Department of the Secretaría del Medio Ambiente, Recursos Naturales y Pesca[9] —now the Secretaría del Medio Ambiente y Recursos Naturales[10] (SEMARNAT, 2022b)—, was established as the leading national environmental authority. It is responsible for designing, planning, implementing, and coordinating public policies related to natural resources, ecology, environmental sanitation, water, fisheries, and urban sustainability. Within the water sector, the CONAGUA, a decentralized administrative body under SEMARNAT, is the government institution tasked with managing, regulating, controlling, and protecting the country's national waters (CONAGUA, 2022a). Through REPDA, CONAGUA regulates users' rights related to water use and discharges. The institution issues discharge permits for both companies and local water utilities (OOAs), including the CESPE (2025).

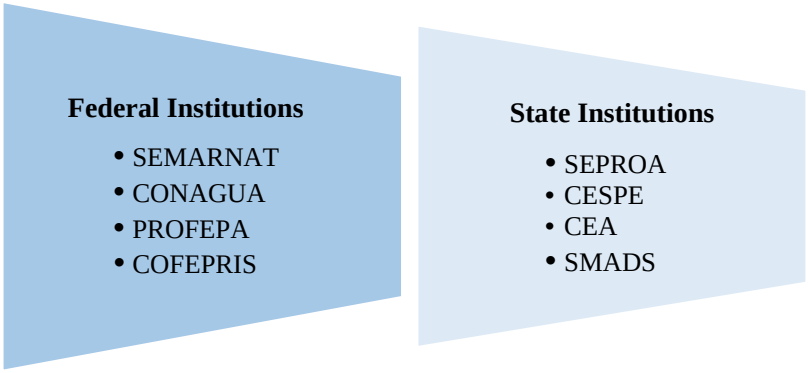
Another federal authority involved in water management is the Comisión Federal para la Protección contra Riesgos Sanitarios[11] (COFEPRIS), which is responsible for safeguarding the population from health risks associated with the use and consumption of goods and services, health inputs, and exposure to environmental and occupational factors. COFEPRIS also provides support during public health emergencies and delivers health services through the regulation, control, and prevention of sanitary risks (COFEPRIS, 2022). In the water sector, the agency conducts pre-season monitoring at Mexico's most frequented beaches to prevent health risks to the public. At the federal level, the Procuraduría Federal de Protección al Ambiente[12] (PROFEPA) is also involved in water-related processes, overseeing the enforcement of environmental legislation and issuing corresponding sanctions (PROFEPA, 2022).

At the state level, the institutions involved in managing industrial wastewater in Baja California include the Secretaría para el Manejo, Saneamiento y Protección del Agua[13] (SEPROA), the Comisión Estatal de Agua en Baja California[14] (CEA), the CESPE, and the Secretaría de Medio Ambiente y Desarrollo Sustentable[15] (SMADS). SEPROA is responsible for designing and coordinating public policy on water resource management in the state (SEPROA, 2022). The CEA, a parastatal agency, manages the operation and maintenance of intermunicipal aqueducts and other facilities responsible for bulk water conveyance and distribution (CEA, 2024), while CESPE (2025) provides drinking water and sanitation services to Ensenada. Finally, SMADS enforces regulations related to sustainable development, the prevention, preservation, and restoration of

[9] Environment, Natural Resources, and Fisheries (unofficial translation).
[10] Department of Environment and Natural Resources (unofficial translation).
[11] Federal Commission for Protection Against Sanitary Risks (unofficial translation).
[12] Federal Attorney for Environmental Protection (unofficial translation).
[13] Department for Water Management, Sanitation, and Protection (unofficial translation).
[14] State Water Commission of Baja California (unofficial translation).
[15] Department of Environment and Sustainable Development (unofficial translation).

ecological balance, and environmental protection within the state territory (SMADS, 2024) (Figure 1).

*Figure 1.* Institutions Involved in the Management of Industrial Wastewater




*Source:* Created by the authors based on based on information from SEMARNAT (2022b), CONAGUA (2022a), PROFEPA (2022), COFEPRIS (2022), SEPROA (2022), CEA (2024), CESPE (2022) and SMADS (2024).

The establishment of institutions laid the groundwork for the formulation of laws and regulations. At the federal level, the right to a healthy environment is enshrined in Articles 1 and 4 of the Constitución Política de los Estados Unidos Mexicanos[16] (CPEUM, 1917), which serve as the foundation for environmental regulation. Specifically, regarding the protection of water resources, the Ley General del Equilibrio Ecológico y la Protección al Ambiente[17] (LGEEPA, 1988) and the Ley de Aguas Nacionales[18] (LAN, 2020) promote the management of water resources and the prevention of water pollution.

Following the enactment of LGEEPA, Mexican Official Standards (NOMs, for its acronym in Spanish) were introduced to guide the national wastewater management process. In 2003, NOM-001-SEMARNAT-1996 established the maximum permissible limits (MPLs) for contaminants in wastewater discharges (SEMARNAT, 2003a). Its 2021 amendment (SEMARNAT, 2022a) made the standard more stringent by incorporating toxicity, true color, temperature, and Chemical Oxygen Demand (COD) as metrics for measuring industrial waste and by aligning its requirements with international standards. This regulation is complemented by NOM-002-SEMARNAT-1996, which specifies the MPLs for contaminants in wastewater discharged into sewer systems (SEMARNAT, 1998a).[19] Additionally, the Mexican Standards (NMX, or its acronym in Spanish),

[16] Political Constitution of the United Mexican States (unofficial translation).

[17] General Law of Ecological Balance and Environmental Protection (unofficial translation).

[18] National Waters Law (unofficial translation).

[19] There are two standards related to wastewater reuse and sludge (NOM-003-SEMARNAT-1997 and NOM-004-SEMARNAT-2002) which, although important in the field, are not particularly relevant for this analysis (SEMARNAT, 1998b, 2003b).

technical reference documents that facilitate compliance with the NOMs, include NMX-AA-004-SCFI-2013, NMX-AA-034-SCFI-2015, and NMX-AA-042-SCFI-2015 (Secretaría de Economía, 2013, 2016a, 2016b).

These regulatory advances have been influenced by various international agreements to which Mexico is a party, reflecting obligations that entail specific commitments, such as the 1992 Agenda 21, a non-binding United Nations action plan to promote sustainable development (Naciones Unidas, n.d.), and, more recently, the Sustainable Development Goals (SDGs) adopted under the Agenda 2030. In the water sector, the SDGs emphasize the conservation of oceans, with Goal 14 advocating for the conservation and sustainable use of oceans, seas, and marine resources for sustainable development (United Nations, 2018, p. 63). Goals 6 and 14 further stress the importance of ensuring clean water and sanitation and protecting marine life.

Institutions, legal procedures, and the signing of agreements are all components of national water policy, specifically in industrial water management. They reflect a traditional management approach primarily based on regulatory compliance at the national level, supported or complemented by economic incentives designed to ensure the achievement of environmental objectives (Sterner, 2007). These incentives are grounded in Article 22 of LGEEPA (1988) and are classified into three categories: financial, generally aimed at providing social support for access to drinking water and sanitation; fiscal, such as the collection of fees; and market-based instruments, including concessions, allocations, and permits.

Financial incentives are commonly employed by OOAs as mechanisms to exchange CONAGUA debt for specific investments.[20] In Ensenada, this practice is illustrated by the collaboration agreement between CESPE and local companies, under which CESPE charges for the provision of monitoring services and the management of wastewater discharges. This represents the most thoroughly documented case of such an arrangement.

*Main Criticisms of Industrial Wastewater Management*

At the national level, the federal water permitting policy predominates, and most companies, particularly the largest and most significant, comply with it, as is the case in Ensenada. This procedure, administered by CONAGUA through the REPDA, has faced criticism for several reasons, including inadequate environmental impact analysis, centralization, limited transparency and access to information, lengthy processing times, and issues related to classification.

The primary criticism of this model is the deficiency in CONAGUA's evaluation of applications, which has resulted in the indiscriminate allocation of water rights without adequately considering the impacts on the environment and other users (Hatch-Kuri et al., 2021), generating distrust and resentment toward the institution. A second criticism from REPDA users concerns the lack of

[20] For example, the Programa de Devolución de Derechos (PRODDER) (Water Rights Refund Program [unofficial translation]) allows OOAs to receive full reimbursement of the water use and sanitation fees they pay, provided that the funds are reinvested in the improvement of water infrastructure. This includes projects eligible for financing through green bonds (CONAGUA, 2024).

transparency, as outdated information and ambiguity regarding the requirements for registering and modifying water rights create uncertainty and hinder the efficient management of water resources (Jacobo-Marín, 2021; Villa Córdova, 2022; Corona Moreno & Cruz Rueda, 2023). In Ensenada, this lack of transparency and challenges in classification are illustrated by the categories assigned to discharge permits for the various treatment plants within CESPE's local system, with some classified as services and others as urban public (CONAGUA, n.d.). Additionally, the desalination plant that discharges brine from its process is assigned two categories, "services" and "industrial," highlighting inconsistencies in the classification criteria applied (CONAGUA, n.d.).

In addition to classification issues, the management of water rights procedures is slow, indicating the need for measures to streamline processes and improve communication with registry users. Despite regulatory advances and the establishment of procedures for managing wastewater, significant deficiencies persist in the current systems.

For this reason, the issue is analyzed as water treatment and reuse extend beyond the interaction between government and companies, involving other key actors in this interrelationship. In the pursuit of sustainable water management, the natural cycle cannot be maintained without proper sanitation and wastewater disposal. Accordingly, this study aims to provide a framework for understanding the complexity of these challenges and to highlight the limited channels of communication between authorities and the public regarding information use, as well as the need to improve coordination of actions to prevent pollution in the port.

## METHODOLOGICAL ASPECTS

### *Secondary Review*

This study employs a mixed-methods approach, integrating quantitative and qualitative perspectives. The secondary data review includes statistics from the REPDA (CONAGUA, n.d.) on discharge permits for both domestic and industrial wastewater, covering volumes, sectors, and georeferencing. It also incorporates data from COFEPRIS (n.d.), including pre-season monitoring results. Information from both institutions was further supplemented through data requests submitted via the Instituto Nacional de Transparencia, Acceso a la Información y Protección de Datos Personales[21] (INAI) (CESPE, 2022; CONAGUA, 2022b).

A press review was also conducted for the period 2017–2022, focusing on the highest-impact newspapers in Ensenada (*Zeta*, *El Vigía*, *La Jornada*, *Cadena Noticias*, *Milenio*, *El Sol de México*, and *El Universal*), since the data reported by COFEPRIS are limited and focus exclusively on pre-season inspections. Regarding the number of companies with discharge permits included in the analysis, 106 out of a total of 139 were selected, representing 80% of the sample. The remaining

[21] National Institute for Transparency, Access to Information, and Personal Data Protection (unofficial translation).

20% consists of 26 companies that arrange discharge services through CESPE under a joint treatment agreement.

*Interviews*

Regarding field-generated information, seven semi-structured interviews were conducted with key actors selected for their expertise and specialization. Each interview lasted between 45 and 60 minutes and was analyzed using Atlas.Ti, version 22. Five of the interviews were conducted with CESPE personnel, focusing on the administrative, operational, and financial aspects of the processes that industries follow for wastewater treatment, particularly compliance with the agreements CESPE establishes with companies (E1, personal communication, December 14, 2021; E2, personal communication, December 22, 2021; E3, personal communication, March 8, 2022; E6, personal communication, April 11, 2022; E7, personal communication, April 11, 2022).

To complement the locally obtained information, an official from CONAGUA was interviewed, providing detailed clarification on the federal-level process regarding permit obligations, including both compliance measures and self-regulation factors (E4, personal communication, March 12, 2022). The final interview was conducted with technical personnel responsible for the operation and maintenance of the wastewater treatment plant at the Universidad Autónoma de Baja California[22] (UABC), Sauzal Campus. As an academic and consulting actor involved in industrial wastewater management, this interview offered insights into efforts occurring outside the government sector (E5, personal communication, March 29, 2022).

*Sampling and Laboratory Analysis*

To complement the information and as part of the fieldwork, bacteriological and physicochemical studies were conducted at ten sites adjacent to Ensenada Bay, Baja California. This water quality sampling was carried out in collaboration with graduate students in Environmental Geology from the Centro de Investigación Científica y de Educación Superior de Ensenada[23] (CICESE), two professors from the same institution, and one professor from the Centro de Estudios Tecnológicos del Mar[24] (Cetmar) (CICESE, 2022).

Sampling was conducted on Saturdays, with laboratory analyses performed on Sundays, between January and March 2022. The sampling sites were limited to the urban area and selected to provide a representative overview of the impacts on Ensenada Bay,[25] covering the area from north to south over ten sessions: San Miguel, Sauzal, Ramona RV Park, Irish Pub Ensenada Sauzal, Mirador Mosquito, Arroyo El Gallo, Playa Hermosa, Playa Pacífica, Playa Monalisa, and Playa La Joya Maneadero (Map 1).

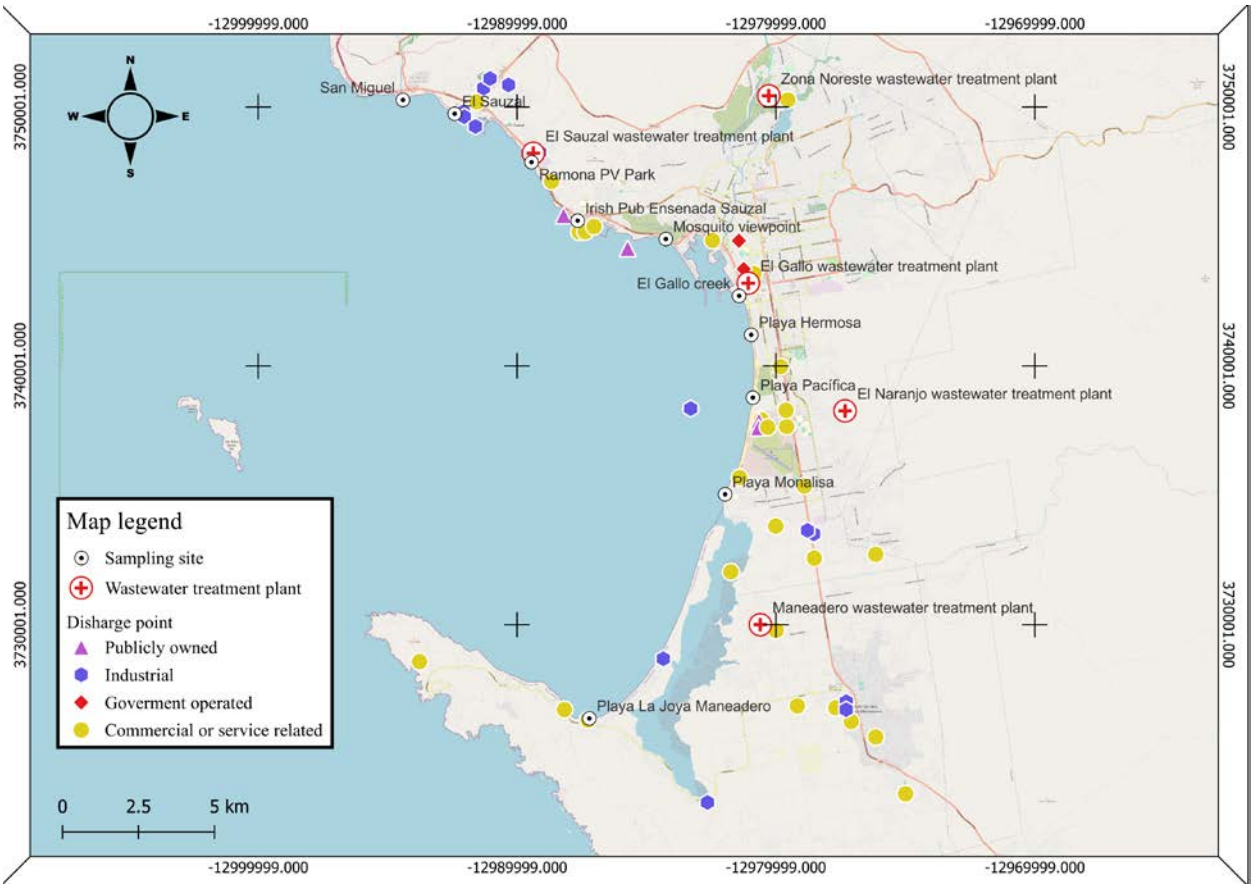
[22] Autonomous University of Baja California (unofficial translation).

[23] Ensenada Center for Scientific Research and Higher Education (unofficial translation).

[24] Center for Technological Studies of the Sea (unofficial translation).

[25] It should be noted that Sempra was excluded from the analysis due to its location and because its discharge volume would have distorted the data under study.

*Map 1.* Treatment Plants, Discharge Points, and Sampling Sites in Ensenada Bay




*Source:* Created by the authors.

The results obtained were compared with the standards NMX-AA-004-SCFI-2013, NMX-AA-034-SCFI-2015, and NMX-AA-042-SCFI-2015 (Secretaría de Economía, 2013, 2016a, 2016b). On-site measurements included acidity or alkalinity (pH), oxidation-reduction potential (Eh), electrical conductivity (EC), total dissolved solids (TDS), temperature (T), salinity, density, and dissolved oxygen (DO). In the last four sampling campaigns, nutrient concentrations (nitrites and ammoniacal nitrogen) and bacteriological analyses (total and fecal coliforms) were also measured. Finally, in the CICESE laboratory, analyses were performed for total volatile solids (TVS), total suspended solids (TSS), and settleable solids (SS), which were compared against NMX-AA-004-SCFI-2013 and NMX-AA-034-SCFI-2015, while microbiological results were processed at Cetmar in accordance with NMX-AA-042-SCFI-2015.

### *Analysis and Systematization of Information*

Table 1 presents the systematization of the information, identifying the type and source of data, the institutions and actors involved, the methods of data collection, and the main contributions to the analysis. Data obtained from REPDA allowed for determining the number of domestic and

industrial treatment plants, their classification, and their graphical representation (Map 1). In other words, these data helped establish the context of industrial wastewater in Ensenada and support the argument regarding REPDA's classification deficiencies. Information requested from REPDA through the INAI was limited and temporally constrained, further corroborating the criticisms directed at the system.

*Table 1.* Systematization of Information: Sources, Data, and Contributions

| Type | Sources | Information Collected | Contribution to the Analysis |
|---|---|---|---|
| Information collected (secondary data) | REPDA | Industry classification<br>Discharge points<br>Discharge volumes | - Industrial sanitation context<br>- Georeferencing of discharges |
| | | INAI request | - Classification limitations<br>- Need for information transparency |
| | CESPE | Sanitation information | - Connection requirements<br>- Agreements |
| | | INAI | - Connected companies and treatment plants |
| | COFEPRIS | Pre-season monitoring | - Pollution context |
| | | INAI request | - Sampling methodology |
| | Local Newspapers | Closure of Playa Hermosa | - Pollution context<br>- Social participation |
| Information generated (primary data) | CESPE | Interviews | - Local discharge procedure<br>- Process limitations<br>- Procedure comparison<br>- Interrelation between domestic and industrial processes |
| | CONAGUA | Interview | - Discharge permit procedure<br>- Procedure comparison |
| | Academia | Interview | - Context of Ensenada<br>- Sector innovations<br>- Participation in alternative monitoring |
| | CICESE<br>Sampling | Water sampling<br>Laboratory analysis | - Pollution context<br>- Regulatory compliance |

*Source:* Created by the authors.

The information provided by CESPE personnel was highly comprehensive and allowed for a detailed understanding of the procedures followed by small industrial companies in Ensenada for discharging their wastewater, contributing to the comparison of procedures (E1, personal communication, December 14, 2021; E2, personal communication, December 22, 2021; E3, personal communication, March 8, 2022; E6, personal communication, April 11, 2022; E7, personal

communication, April 11, 2022). Triangulation of data from the press review, COFEPRIS, and the sampling campaigns corroborates the local impact of water pollution on Ensenada's beaches between 2017 and 2022. Information from the interviews also strengthened understanding of the implementation of local procedures, enabling the identification of limitations and potential improvements in the industrial wastewater management process in Ensenada.

## THE ISSUE OF WASTEWATER MANAGEMENT IN ENSENADA

### *The Port and its Pollution Problems*

Until the 1993 crisis caused by the tuna embargo imposed by the United States on Mexico, fishing was the primary activity in the Port of Ensenada. This event prompted a diversification and expansion of productive activities, including the arrival of cruise ships and increased trade, positioning Ensenada regionally as a port of international significance with a commercial, tourist, and fishing-oriented vocation (Padilla y Sotelo, 2016). As a result, the sea and its bay represent a vital sector and a conservation challenge, as many key productive, economic, and recreational activities depend on them.

The importance of Ensenada within the regional tourist corridor, along with its border location that has facilitated international trade, has positioned the port as the most visited on the Pacific coast of Mexico. Over the past two decades, the city has seen a significant influx of external companies, which has influenced its population dynamics and, in turn, increased the demand for services. Between 1995 and 2010, Ensenada's population grew steadily; however, starting in 2010, it began to decline. By 2020, the municipality registered 443 807 inhabitants (Instituto Nacional de Estadística y Geografía [INEGI], 2020).

In 2015, Ensenada was recognized as a "Green Port" by the European Sea Ports Organisation (EcoPorts, 2015), becoming the first port in Mexico and the second in the Americas to receive this distinction. The city also holds the "Clean Industry" certification granted by SEMARNAT through PROFEPA (Administración del Sistema Portuario Nacional de Ensenada [ASIPONA], 2025).

Despite its status as a high-profile, competitive, and environmentally attractive port, the population experienced severe water quality issues between 2017 and 2022, as evidenced by COFEPRIS pre-season monitoring at the most frequented tourist beaches. Consequently, Ensenada lost its "Green Port" recognition, and its most visited beach, Playa Hermosa, was classified as unsuitable for recreational use according to NOM and NMX standards.

Although COFEPRIS data are not sufficiently consistent to allow for continuous monitoring, they do highlight pollution issues at Playa Hermosa, at least through 2023. To supplement this information, a press review was conducted of the main newspapers and blogs in Ensenada for the period 2017–2022, documenting successive beach closures due to contamination. This cross-referencing demonstrates the value of media sources in supporting analysis when official information is fragmented (Llanes et al., 2022) and enabled the identification of three coinciding

beach closure dates in March 2017, March 2021, and July 2021, along with eight additional closures during the period (Table 2).

*Table 2.* Press Review of Beach Closures Due to Pollution in Ensenada, 2017–2022

| Publication Date | Source |
|---|---|
| February 23, 2022 | *Zeta* |
| October 16, 2021 | *El Vigía* |
| July 15, 2021* | *La Jornada* |
| March 25, 2021* | *Cadena Noticias* |
| April 02, 2020 | *Zeta* |
| January 07, 2020 | *Milenio* |
| September 07, 2019 | *Cadena Noticias* |
| January 24, 2019 | *El Vigía* |
| August 12, 2017 | *El Sol de México* |
| April 11, 2017 | *La Jornada* |
| March 26, 2017* | *El Universal* |

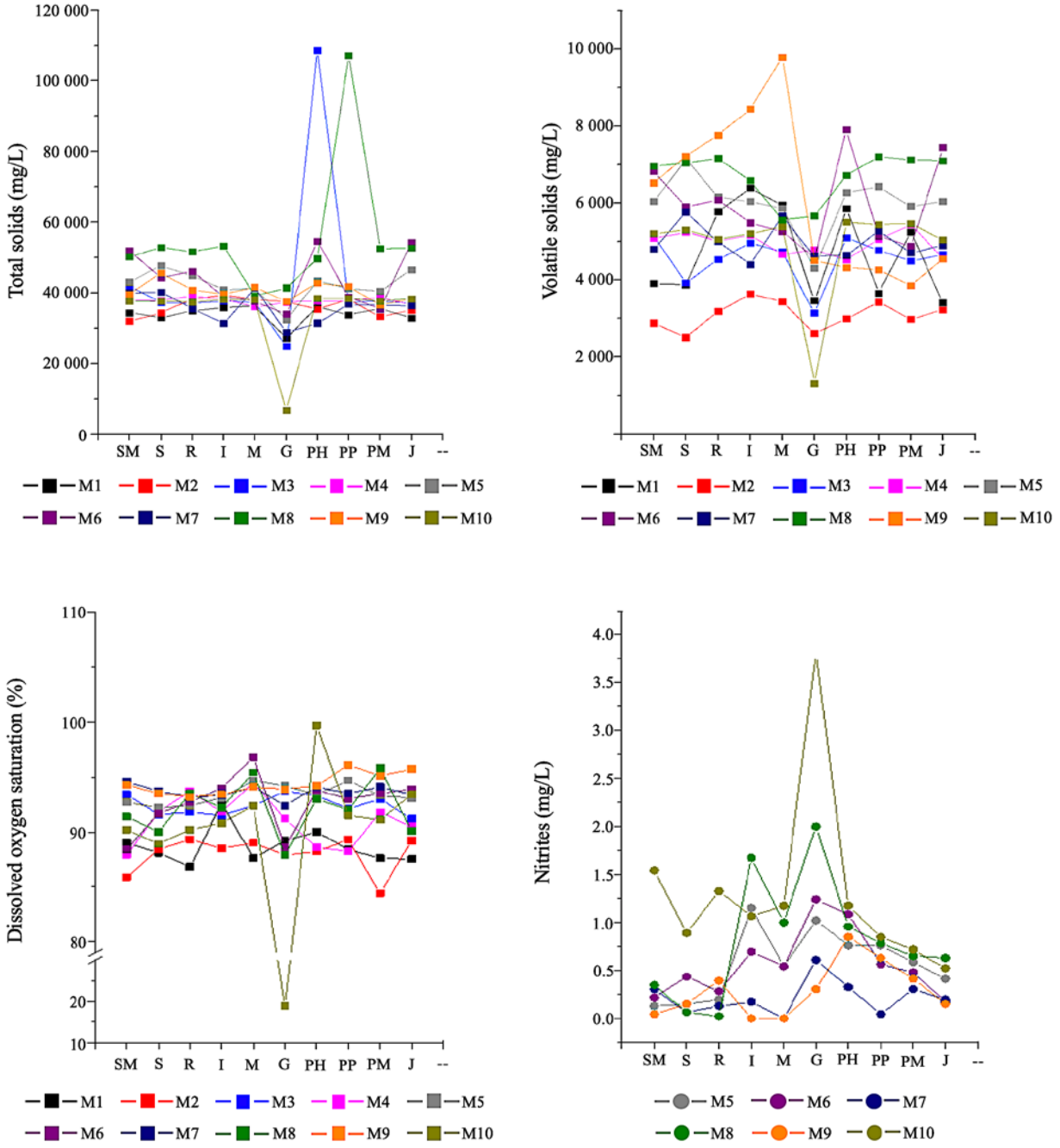
* Beach closures on the indicated dates correspond with public data from COFEPRIS. The other eight closures were documented solely in local media.

*Source:* Created by the authors based on information collected from newspapers (Descubre cuales son las playas, 2019; Cierre precautorio de Playa Hermosa, 2021; Agencia NTMX, 2017; Redacción El Vigía, 2019, 2021; Heras, 2017, 2021; Notimex, 2020; Redacción El Universal, 2017; Redacción Zeta (2020) and Lamas (2022).

When these findings are combined with the results of the sampling conducted in the present study, although they cannot be considered conclusive due to limitations in spatial and temporal representativeness, it is observed that discharges from the "El Gallo" treatment plant are the point at which analyzed parameters, including nitrites, oxygen saturation percentage, volatile solids, and total solids,[26] tend to exceed the MPLs (Figure 2). This site receives effluents from 16 companies, representing 62% of the industries that contract CESPE's services, as well as other domestic effluents entering the stream and affecting Playa Hermosa (De Basabe, 2022), confirming the recurrent pollution problems at this location.

[26] Only selected parameters were chosen for graphical representation. For a more in-depth analysis of the sampling results, refer to De Basabe (2022).

*Figure 2.* Selected Sampling Data Illustrating the Non-Compliance Trend at the El Gallo (G) Sampling Point

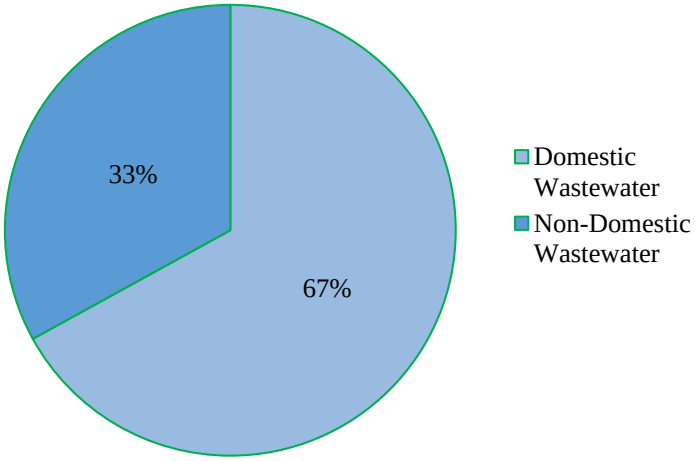



*Source:* CICESE Sampling Campaign (2022).

### *Industrial Wastewater in Ensenada as a Key Contributor to Bay Pollution*

Domestic wastewater, or sewage, is defined as "water originating from daily human activities, discharged through sewer systems or directly into the environment" (Osorio-Rivera et al., 2021, p. 229) and is typically conveyed via sewer systems managed by the OOA (Montesillo-Cedillo, 2021). Non-domestic wastewater refers to wastewater outside CESPE's management, for which REPDA grants companies permits to discharge autonomously, provided they operate a treatment plant and comply with established quality parameters. In Ensenada, 67% of the total wastewater generated corresponds to domestic wastewater, while 33% corresponds to non-domestic wastewater (Graph 1).

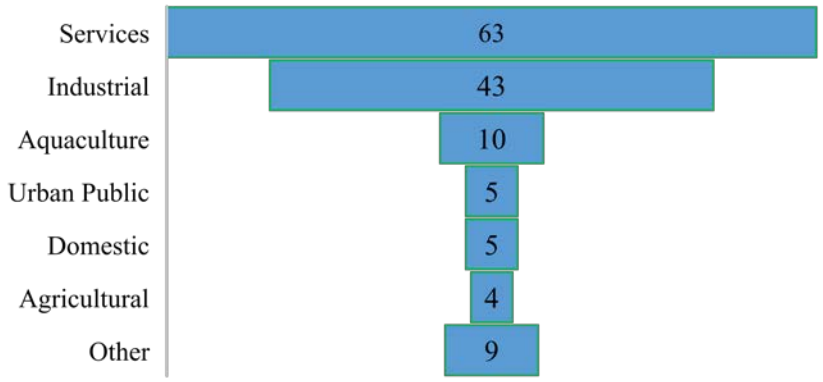
*Graph 1.* Classification of Wastewater Volume in Ensenada




*Source:* Created by the authors based on information from the National Water Information System (SINA, 2025).

It is important to acknowledge that pollution issues in Ensenada Bay involve potential impacts from both domestic and non-domestic discharges. Industrial wastewater, however, is considered a greater potential risk due to the contaminant loads inherent in its processes (WWAP, 2017), making its management particularly important. According to REPDA data, 139 discharge permits were identified, classified as 63 for services, 43 industrial, 10 aquaculture, five domestic, five urban, four agricultural, and nine as "other" (Graph 2). A closer examination of REPDA's classification reveals a lack of clarity, as it does not explain why fisheries and packing plants are included under service industries, nor does it provide a classification by type of discharge and contaminants, which could be highly useful for decision-making.

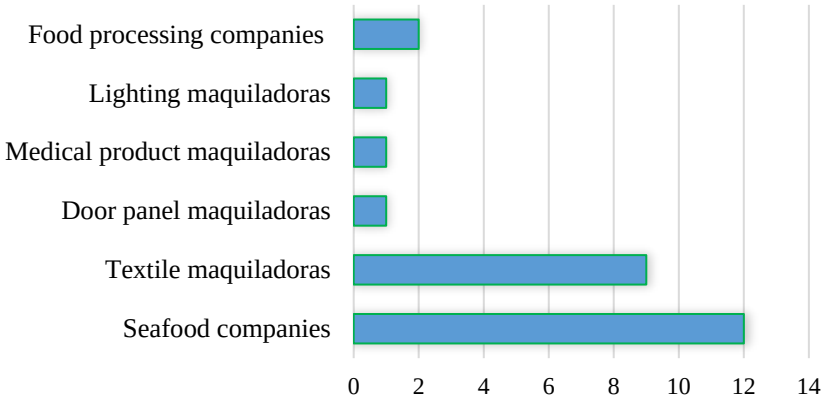
*Graph 2.* Wastewater Discharge Permits Granted by CONAGUA in Ensenada




*Source:* Created by the authors based on information from CONAGUA (n.d.).

Due to these inconsistencies, 106 of the permits were selected for the present analysis, encompassing those classified as "services" and "industrial," the two categories with the highest representation in Graph 2. These permits account for 76% of all permits granted in the locality according to REPDA and are represented on the map (Map 1) by hexagons and circles. In terms of the number of companies, the analysis includes a total of 132: 106 companies (80%) that process their permits through CONAGUA (63 service and 43 industrial) and 26 companies (20%) that utilize the services provided by the Ensenada OOA under a collaborative agreement (Graph 3).

*Graph 3*. Companies Collaborating with CESPE for Joint Wastewater Treatment




*Source:* Created by the authors based on information obtained from interviews (E1, personal communication, December 14, 2021).

The decision by small companies to treat wastewater through a collaborative agreement with CESPE is based on a prior analysis that determines the most operationally and economically feasible option. In other words, the company evaluates whether to discharge its wastewater into

CESPE's sewer system after pre-treatment, as established by NOM-002-SEMARNAT-1996 (SEMARNAT, 1998a), allowing it to be treated alongside domestic wastewater, or to operate its own treatment system and obtain a permit directly from CONAGUA.

As shown in Graph 3, CESPE plays a fundamental role in the port of Ensenada by treating the wastewater of smaller companies, which represent nearly one-fifth of the local industry and seek to comply with environmental regulations. These companies include 12 seafood processing firms, nine textile maquiladoras, two food processing companies, one lighting maquiladora, one medical product maquiladora, and one door panel maquiladora.

It is noteworthy that, in addition to serving companies, CESPE operates six domestic wastewater treatment plants: El Naranjo, El Gallo, El Sauzal, Noreste, Maneadero, and Francisco Zarco (shown on Map 1).[27] These plants hold five discharge permits issued by CONAGUA, three in CESPE's name and two in CEA's name, and are classified as urban public facilities according to REPDA. With the exception of Francisco Zarco and Noreste, which discharge into streams located away from the bay due to their geographic positions, the remaining treatment plants discharge directly into or just a few meters from Ensenada Bay.

Of the six domestic treatment plants in the locality, El Naranjo and El Sauzal also treat wastewater from industry, specifically the 26 small companies under the OOA agreement. Both plants require investment for rehabilitation due to the considerable age of the facilities involved in the treatment process (E3, personal communication, March 8, 2022). For example, El Gallo has been in operation for over 50 years, while El Sauzal and El Naranjo have been active for more than 30 years. This underscores the urgent need for maintenance, as suboptimal operational conditions directly compromise the quality of the treated water.

Another important aspect to highlight is that the El Naranjo, El Gallo, and Maneadero plants are structurally interconnected. When El Gallo, located in the city center, experiences operational problems, its wastewater is diverted to El Naranjo. Similarly, when deficiencies or maintenance occur at El Gallo or El Naranjo, the water is discharged to Maneadero, which releases it into a more rural area.

The interconnection entails two key aspects. First, El Naranjo sends treated water to the rural area of Maneadero to support the use of treated water in flower production. However, when the plant experiences limitations or treatment deficiencies, it may also discharge raw or partially treated water, negatively impacting the area. Second, deficiencies at the Maneadero plant require a reduction in its treatment capacity, which redirects some of the incoming discharge to the San Carlos Canyon, ultimately affecting the Punta Banda estuary where it flows.

Considering the physical characteristics of the estuary, these actions lead to an increased accumulation of wastewater contamination, which may be more difficult to remediate in the medium and long term. In other words, while the problem is addressed in the central area of

[27] The Francisco Zarco treatment plant is located in the rural northeastern part of Ensenada, which is why it does not appear on Map 1.

Ensenada, untreated discharges continue to impact other zones. This situation highlights the urgent need for full rehabilitation of the treatment plants and reveals a lack of public visibility and understanding of the ecosystems receiving urban wastewater (Llanes et al., 2022; Castro & Lacabana, 2005).

### *The Industrial Wastewater Management Process in Ensenada*

Industrial wastewater management in Ensenada is primarily led by CONAGUA through REPDA, with CESPE playing a secondary role. Table 3 contrasts the requirements and characteristics of the water discharge processes for companies at both the federal and local levels. The first column details the information and documentation required by the federal government to grant permits through REPDA, while the second column presents the data and information requested by CESPE.

*Table 3.* Requirements and Information Requested from Companies for Granting Permits or Managing Wastewater

| CONAGUA | CESPE |
|---|---|
| General company information and production aspects | |
| Company name or legal entity | Company name or legal entity |
| Tax ID (RFC) | Tax ID (RFC) |
| Cadastral key | Cadastral key |
| Nationality | Nationality |
| Address and contact number | Address and contact number |
| Application | Description of activity |
| Legal status accreditation | Shifts per day |
| Technical report | Hours worked |
| | Number of employees |
| | Articles of incorporation |
| | Raw materials |
| | Products and by-products |
| Information on processes | |
| *Supply* | |
| | Source |
| | Volume |
| | Treatment |
| | Use |
| | Machinery |
| | Adhesion contract |

*(continues)*

| CONAGUA | CESPE |
|---|---|
| *(continuation)* | |
| *Discharge* | |
| Volume and discharge pattern | Hydrosanitary plan |
| Name of receiving body | Processes, equipment, and assets |
| Discharge sketch (points X, Y) | Average hydraulic balance |
| Process inputs | Flow diagram |
| Physicochemical and bacteriological characteristics of the process | Characteristics of the treatment system, if available |
| Description of treatment systems and processes | Hazard study |
| | Receiving body |
| *Reuse* | |
| Reuse measures | Hydrosanitary plan and process description |
| | Hydraulic balance |
| | Plant and treated volume, with process description |
| | Receiving body |
| | Monitoring points prior to sewer entry |
| | Average monthly volume of water treated for reuse |
| | Type of reuse |
| | Analysis results: an initial analysis is presented prior to the service contract to identify the type of contaminants handled by the company; if CESPE services are required, periodic laboratory reports from CESPE are provided. |
| *Other* | |
| Permits to carry out works | Compliance with NOM-003-SEMARNAT-1997 |
| Permit to carry out hydraulic works | |
| Concession for the use of federal lands | |
| Application | |
| Proof of payment of fees | |

*Source:* Created by the authors based on De Basabe (2022).

From this comparison, several differences can be observed, particularly regarding the general information and characteristics of the companies requested. Although CONAGUA asks for less information than CESPE, the most significant distinction is that CESPE requires data on all three phases: supply, discharge, and reuse. This approach provides a more precise understanding of the company's entire cycle and a detailed view of its discharges. In contrast, the information

requested at the federal level focuses primarily on the discharge phase and includes only one element related to reuse, since, in theory, each company operates its own treatment plant.

CONAGUA requests additional information of a different type, focusing on the treatment plant, its construction permits, and its design. In contrast, CESPE requires initial information regarding compliance with NOM-003-SEMARNAT-1997, which specifies the MPL for contaminants in wastewater discharged into the sewer system. CESPE's objective is to ensure that industrial discharges are equivalent in quality to domestic wastewater (SEMARNAT, 1998b).

At the federal level, there is no precise information on response times for submitted requests. The data obtained through REPDA extend only up to 2021, and the available details are limited to discharge volume, sector type, and the georeferencing of each discharge. Consequently, a transparency request was submitted to access laboratory compliance analyses. Information from CESPE (2022) was received three months later, as it was considered public, but it covered only up to 2019. A subsequent request to CONAGUA (2022b) for private industry data was fulfilled four months later, covering only up to 2017. As a result, a complete and up-to-date analysis of industrial wastewater management at the federal level was not possible.

Despite these limitations, the information request allowed documentation of the limited accountability of companies applying for permits through CONAGUA: only 20% of companies that discharge wastewater directly submit the requested information (CONAGUA, 2022b). In summary, the information required by REPDA focuses on the constructed treatment plant, its design, and compliance with NOM-001-SEMARNAT-1996, NOM-002-SEMARNAT-1996, NOM-003-SEMARNAT-1997, and NOM-004-SEMARNAT-2002. In contrast, CESPE focuses on compliance with specifications required for the domestic sector and the connection to the sewer system to facilitate wastewater treatment. This section demonstrates that understanding the administrative requirements alone is insufficient, as they represent only the legal portion required by the authority to grant the permit.

## FINDINGS: HOW IS IT WORKING?

This study demonstrates that the treatment of industrial wastewater, when considered solely within the company-authority framework, is poorly understood and inefficient. Management reveals a lax approach to environmental compliance, as legal and regulatory mechanisms do not function effectively. Compliance is observed in only about 40% of the companies analyzed, with 20% among small companies and 20% among those that continue to practice self-regulation.

The scale of contamination problems at Playa Hermosa and social pressure prompted an investment of 31 million pesos in 2023 for the ongoing rehabilitation of the El Gallo plant. However, this does not imply that the contamination issues are fully resolved. In fact, problems persist and are transferred to other areas of the city, as evidenced by the functional interconnection of the CESPE plants. The following section highlights the key elements of the analysis considered most important.

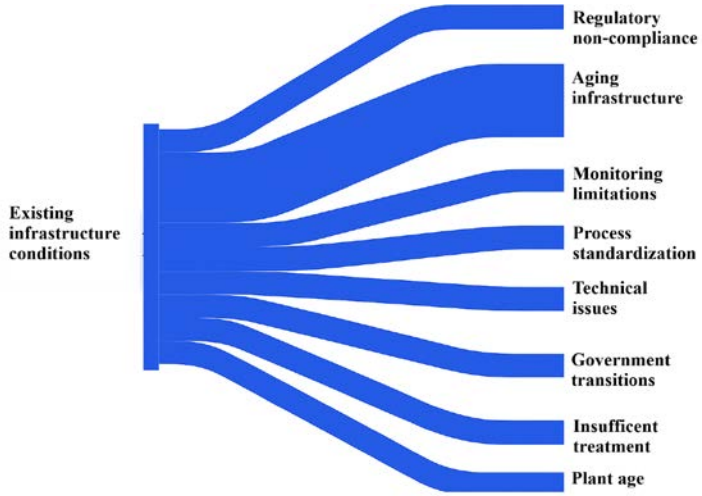
### *The REPDA and Information Limitations in the Federal Procedure*

The analysis of REPDA in Ensenada documents the administrative process regarding the authority's requirements, which is heavily focused on discharge information and the construction and design of treatment plants. However, it also reveals inconsistent and confusing classifications, with limited access to information as a central issue, since the system lacks tools for open consultation or exploration. Although a transparency request was submitted, the data obtained were minimal, preventing a more robust analysis. It is also important to note that the information provided by the federal government has a lag of five to six years. Taken together, these limitations in available and obtainable information suggest that the industrial wastewater treatment process may conceal greater complexities and uncertainties, calling into question the transparency, accessibility, and openness of this institution (Bohórquez López et al., 2023; Hernández, 2022).

### *Uncoordinated Processes*

Although the federal and local regulatory procedures share some similarities in their permit application requirements, they do not complement each other, which limits institutional coordination in the treatment of industrial wastewater at both levels (De Basabe, 2022). It is noteworthy that the local process is subordinated to the federal one. This lack of coordination shows that the OOA addresses urgent problems within a financial system that does not allow it to tackle underlying issues independently. Their main concerns relate to plant infrastructure, including age, obsolescence, impacts from government transitions, and low maintenance levels (De Basabe, 2022) (Figure 3). In other words, CESPE's challenges are compounded in a hierarchical system that fails to achieve horizontal cooperation in decision-making.

*Figure 3.* CESPE Concerns Related to Current Infrastructure




*Source:* Created by the authors based on information obtained from interviews (E1, personal communication, December 14, 2021; E2, personal communication, December 22, 2021; E3, personal communication, March 8, 2022; E6, personal communication, April 11, 2022; E7, personal communication, April 11, 2022).

### *Access to Local Information*

Regarding the local process of industrial wastewater treatment carried out by CESPE, access to information was broader and more detailed, including both documents provided by local authorities and information obtained from key stakeholders. This openness not only helped document the process but also facilitated understanding of different perspectives and the identification of opportunities for improvement. For example, at El Sauzal, it was found that the connection network could be expanded to enable a dedicated module for industrial wastewater treatment, as a considerable number of companies require this service (De Basabe, 2022). This finding highlighted both operational advances and limitations. Additionally, the inclusion of other actors, such as the academic sector, revealed innovative practices, including the self-coagulation method applied to wastewater treatment at UABC.

### *The Local Collaboration Agreement and its Implications*

At the local level, compliance with the standard has been promoted through a solidarity-based agreement between the OOA of Ensenada and the industry. This hybrid method combines regulatory measures with economic incentives (Sterner, 2007) to encourage and ensure that companies meet the established standards. The procedure is recognized as a collaboration agreement and classified as a financial instrument (Enríquez, 2008), while also creating joint legal responsibility in cases of noncompliance.

The above reflects a mutual and shared commitment. The local institution thus acts both as a regulator, requiring companies to comply and providing the means to do so, and as a responsible party in cases of severe noncompliance with CONAGUA, since both are jointly accountable when a fine is imposed. However, the monitoring and analysis of regulatory compliance fall primarily on the OOA, which in practice assumes the responsibility alone. For example, improvements in the most severe contamination issues at Playa Hermosa were achieved through the rehabilitation of the El Gallo treatment plant, under the responsibility of the OOA, with federal and state government intervention and financial support from the North American Development Bank (Planta de tratamiento El Gallo, 2022; Gobierno de Baja California, n.d.; Explican a CICE beneficios, 2023). In other words, operational responsibility rests with CESPE, while financial responsibility lies with the institutions providing the funding for plant repairs.

### *The Interrelation Between Domestic and Industrial Wastewater*

A relevant fact is that the local industrial water management process is closely linked to domestic wastewater management. In most cases, the authority, according to NOM-002-SEMARNAT-1996, grants industrial wastewater discharge permits to domestic treatment plants, meaning that both types of wastewater share the same treatment infrastructure. This arrangement often leads to overloads in each plant’s capacity and contributes to deficiencies in treatment processes (SEMARNAT, 1998a). Such conditions increase risks when discharges are not fully treated, resulting in contaminated water

being released into ecosystems and affecting public health. In other words, any technical or financial deficiencies in domestic wastewater treatment, as in the case of the El Gallo plant, directly affect the treatment outcomes of industrial wastewater because both rely on the same infrastructure.

Although one might assume that controlling contaminants in local companies' discharges would be straightforward due to the proximity of the actors involved, this is not the case. Authorities often lack precise knowledge of industrial processes, and domestic treatment plants are not designed to handle industrial effluents. While the joint treatment agreement requires that the industrial pollutant load be equalized to domestic levels, this is not always feasible given the diversity of businesses, which can compromise the operation of domestic treatment plants and, in turn, affect both ecosystems and the general population. Furthermore, in most cases there is insufficient personnel to adequately monitor small companies, so the OOA relies primarily on information provided by the companies themselves and on laboratory services it receives.

## CONCLUSIONS

The contamination problems in Ensenada Bay make it clear that existing economic instruments and regulations are insufficient to protect water resources, highlighting the consequences of limitations in sanitation, whether domestic, industrial, or combined. Having precise legislation or laws with specific requirements is not enough; effective institutional coordination and proper implementation are essential (Walteros & Ramírez, 2020). Moreover, the capacity for oversight and follow-up by REPDA remains questionable.

The above highlights the challenge of having institutional structures and laws that remain in the "ought to be" stage, failing to be effectively implemented. Coastal contamination is difficult to trace and address due to the complex network of actors and managers involved. Therefore, it is necessary to reorganize the enforcement of domestic and industrial sanitation laws, with the primary goal of preventing pollution through effective information systems and data sharing among all stakeholders.[28]

It is necessary to rethink natural resources, in this case, water, from a comprehensive perspective, considering availability, supply, treatment, and reuse, and recognizing it as an essential shared good for the survival of localities and regions. By adopting a preventive rather than reactive approach, ensuring proper treatment of both industrial and domestic wastewater, and promoting open participation of the government and community as primary overseers and co-responsible actors (Castro & Lacabana, 2005), contamination problems could be drastically reduced. To ensure the legitimacy of its actions, CONAGUA must implement accountability

[28] The case of Brazil, with its National Water and Sanitation Data System, can serve as an interesting reference, as it represents the largest information system for water and sanitation services. Since 2019, its platform collects, organizes, analyzes, and provides information and indices on services across Brazilian municipalities, presenting both historical trends and the most current data. Its main objectives are to support the planning and implementation of public policies, evaluate service performance, and guide regulatory and supervisory activities (Borges et al., 2022).

mechanisms and public consultation processes (Castro & Lacabana, 2005). Additionally, it is important to establish more efficient and accessible communication channels so that users can more easily access information and submit inquiries or complaints in a timely manner.

Regarding REPDA, it is necessary to conduct a thorough review of its functioning and implement the required improvements. Investments in technology and human resources are recommended to streamline procedures and enhance the efficiency of the registry. Similarly, periodic audits should be carried out to ensure the integrity of the information and to prevent potential cases of corruption or data mismanagement.

In general, it is essential that CONAGUA take into account critiques and perspectives such as those presented here to strengthen its work and ensure proper and transparent management of both centralized processes and those of the REPDA. At the local level, it is necessary to reflect on the role of the CESPE in assuming responsibility for the small-scale industry and to recognize that the study of this case can serve as a reference for future analyses of other OOAs across the country.

### *Limitations of the Analysis and Future Research*

The main limitation of the analysis conducted thus far is also one of its key findings: the functional interrelation between domestic and industrial wastewater treatment (De Basabe, 2020). This connection hinders a direct identification of those responsible for water contamination in Ensenada Bay, an aspect that could be explored more thoroughly in future studies. In this work, the focus was on industrial wastewater management, which made a more comprehensive analysis operationally unfeasible. Consequently, it is necessary to reconsider the simple domestic-versus-industrial classification and propose alternative systematizations that could support more complex analyses in subsequent research.

Similarly, it is recommended to further examine the overload of responsibilities placed on OOAs by CONAGUA regarding small businesses, as well as to critically assess the limited knowledge of contaminants required to comply with the standardization of domestic wastewater discharges. The specific findings from the Ensenada case suggest the value of a comparative study with other municipalities in the country or even a nationwide analysis of how OOAs manage small-scale industry. Finally, while documenting the limitations in access to information from REPDA reinforces existing critiques of the system, it also highlights the need for further investigation into transparency and information accessibility.

Translation: Erika Morales.

## REFERENCES

Administración del Sistema Portuario Nacional de Ensenada (ASIPONA). (2025). *Puerto Verde*. https://www.puertoensenada.com.mx/puerto-verde

Agencia NTMX. (2017, August 12). Cierran playa en Ensenada por derrama de aguas negras. *El Sol de México.* https://www.elsoldemexico.com.mx/republica/sociedad/cierran-playa-en-ensenada-por-derrama-de-aguas-negras-241089.html

Bohórquez López, E., Ehrman, R., Matallana, S., & Zamora Saenz, I. (2023, April 26). *Evaluación de impacto legislativo: Iniciativa de Ley General de Aguas de la senadora Gloria Sánchez.* Senado de la República-Instituto Belisario Domínguez. http://bibliodigitalibd.senado.gob.mx/handle/123456789/5951

Borges, M. C., Abreu, S. B., Lima, C. H., Cardoso, T., Yonamine, S. M., Araujo, W. D., & Meireles, S. (2022). The Brazilian National System for Water and Sanitation Data (SNIS): Providing information on a municipal level on water and sanitation services. *Journal of Urban Management, 11*(4), 530–542. https://doi.org/10.1016/j.jum.2022.08.002

Castro, J. E., & Lacabana, M. (2005). Presentación. Agua y desarrollo en América Latina: por una democracia sustantiva en la gestión del agua y sus servicios. *Cuadernos del CENDES*, *22*(59), 9–15. https://saber.ucv.ve/ojs/index.php/rev_cc/article/view/11456

Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE). (2022). *Trabajo de campo: Muestreo de enero a marzo y resultados de los sitios seleccionados* [Unpublished technical report].

Cierre precautorio de Playa Hermosa en Semana Santa. (2021, March 25). *Cadena Noticias.* https://cadenanoticias.com/regional/2021/03/cierre-precautorio-de-playa-hermosa-en-semana-santa

Comisión Estatal de Agua de Baja California (CEA). (2024). *Comisión Estatal de Agua de Baja California.* http://www.cea.gob.mx/

Comisión Estatal de Servicios Públicos de Ensenada (CESPE). (2022, May 16). [Response sheet to information request, reference number 021163722000027]. Plataforma Nacional de Transparencia.

Comisión Estatal de Servicios Públicos de Ensenada (CESPE). (2025). *Comisión Estatal de Servicios Públicos de Ensenada.* http://www.cespe.gob.mx/public/historia

Comisión Federal para la Protección contra Riesgos Sanitarios (COFEPRIS). (n.d.). *Resultados de calidad de agua de mar: Ensenada, Baja California*. https://apps1.semarnat.gob.mx:8443/dgeia/gob-mx/playas/destinos/ensenada.html

Comisión Federal para la Protección contra Riesgos Sanitarios (COFEPRIS). (2022, August 12). *¿Qué hacemos?* https://www.gob.mx/cofepris/que-hacemos

Comisión Nacional del Agua (CONAGUA). (n.d.). *Registro Público de Derechos de Agua* [Dataset]. Gobierno de México. https://app.conagua.gob.mx/ConsultaRepda.aspx

Comisión Nacional del Agua (CONAGUA). (2022a, August 12). *Misión y visión.* https://www.gob.mx/conagua/acciones-y-programas/mision-y-vision-63915

Comisión Nacional del Agua (CONAGUA). (2022b, July 7). [Response sheet to information request, reference number 330009422001333]. Plataforma Nacional de Transparencia.

Comisión Nacional del Agua (CONAGUA). (2024, July 18). *Programa de Devolución de Derechos PRODDER.* Gobierno de México. https://www.gob.mx/conagua/acciones-y-programas/programa-de-devolucion-de-derechos-prodder

Constitución Política de los Estados Unidos Mexicanos [CPEUM]. February 5, 1917 (Mexico). http://www.diputados.gob.mx/LeyesBiblio/pdf/1_280521.pdf

Corona Moreno, M. M. G., & Cruz Rueda, E. (2023). Situación de desigualdad en el acceso al agua y saneamiento de la región hidrosocial-política e intercultural de Las Margaritas y La Trinitaria, Chiapas, México. In S. De la Vega Estrada , & H. M. Sáenz Vela (Eds.), *Desigualdad regional y empobrecimiento. Gestión de los territorios con inclusión social* (pp. 115–136). UNAM; Asociación Mexicana de Ciencias para el Desarrollo Regional. http://ru.iiec.unam.mx/6268/

De Basabe Ibarra, R. J. (2022). *Gestión de las aguas residuales industriales: Ensenada, Baja California, México* [Master's thesis, El Colegio de la Frontera Norte].

Descubre cuales son las playas más peligrosas de Ensenada. (2019, September 7). *Cadena Noticias.* https://cadenanoticias.com/regional/2019/09/descubre–cuales-son-las-playas-mas-peligrosas-de-ensenada

EcoPorts. (2015). Port Environmental Review System (PERS) version 4. [Certificate of verification]. https://www.puertoensenada.com.mx/upl/sec/ECOPORTS%20PERS%20CERTIFICATE%202015%20PORT%20OF%20ENSENADA.PDF

Enríquez Andrade, R. R. (2008). *Introducción al análisis económico de los recursos naturales y del ambiente*. Universidad Autónoma de Baja California.

Explican a CICE beneficios de Bono Verde para Ensenada y BC. (2023, May 4). *BC Noticias.* https://www.bcnoticias.net/post/explican-a-cice-beneficios-de-bono-verde-para-ensenada-y-bc

Gobierno de Baja California. (n.d.). *Plantas de tratamiento El Gallo y Noreste están 100% rehabilitadas y funcionan adecuadamente: CESPE*. https://www.bajacalifornia.gob.mx/Prensa/Noticia/17386

Hatch-Kuri, G., Schmidt, S., & Carrillo-Rivera, J. J. (2021). Agua-poder: la gestión del agua subterránea en México y su soslayada dimensión transfronteriza, 1948–2018. *Cuadernos de Trabajo Waterlat-Gobacit*, *8*(4). https://doi.org/10.5281/zenodo.7469827

Heras, A. (2017, April 11). Playas de Ensenada, BC, las más contaminadas del país. *La Jornada*. https://www.jornada.com.mx/2017/04/11/estados/022n1est

Heras, A. (2021, July 16). Por contaminación, cierran playas de Ensenada y Tijuana. *La Jornada*. https://www.jornada.com.mx/notas/2021/07/16/estados/por-contaminacion-cierran-playas-de-ensenada-y-tijuana/

Hernández Flores, G. (2022). *Evaluación integral del ambiente cárstico para generar un modelo de manejo sostenible del acuífero en la isla de Cozumel* [Doctoral dissertation, Universidad de Quintana Roo].

Instituto Nacional de Estadística y Geografía (INEGI). (2020). *Panorama sociodemográfico de Baja California: Censo de Población y Vivienda 2020* https://www.inegi.org.mx/app/biblioteca/ficha.html?upc=702825197735

Jacobo-Marín, D. (2021). Acumulación de derechos de agua en el sector energético-minero en México: una lectura de justicia hídrica. *Revista de la Facultad de Derecho de México*, *71*(281-1), 261–294. https://doi.org/10.22201/fder.24488933e.2021.281-1.80253

Lamas, L. (2022, 24 de febrero). Aplazan apertura de Playa Hermosa por contaminación hasta el verano. *Zeta*. https://zetatijuana.com/2022/02/aplazan-apertura-de-playa-hermosa-por-contaminacion-hasta-el-verano/

Ley de Aguas Nacionales [LAN], reformed, *Diario Oficial de la Federación*, January 6, 2020 (Mexico). https://www.diputados.gob.mx/LeyesBiblio/ref/lan/LAN_ref08_06ene20.pdf

Ley General del Equilibrio Ecológico y la Protección al Ambiente [LGEEPA], reformed, *Diario Oficial de la Federación*, January 28, 1988 (Mexico). https://www.diputados.gob.mx/LeyesBiblio/pdf/LGEEPA.pdf

Llanes, A. L., Poca, M., Jiménez, Y. G., Castellanos, G., Gómez, B. M., Marchese, M., Lana, N. B., Pascual, M., Albariño, R., Barral, M. P., Pascual, J., Clavijo, A., Díaz, B., Pessacg, N., & Jobbágy, E. G. (2022). ¿De dónde viene y a dónde va el agua de las ciudades? Base de datos integrada para 243 centros urbanos argentinos. *Ecología Austral*, *32*(3), 1133–1149. https://doi.org/10.25260/EA.22.32.3.0.2028

Montesillo-Cedillo, J. L. (2021). Suministro de agua entubada y saneamiento en México: Una unidad inseparable. In J. I. Juan Pérez, J. L. Montesillo-Cedillo, & J. J. Dimas Mojarro (Eds.), *Agua y descargas residuales sin tratar: hacia la insustentabilidad hídrica en México* (pp. 25–62). Colegio de Ciencias Geográficas del Estado de México.

Naciones Unidas. (n.d.). *Programa 21*. División de Desarrollo Sostenible. https://www.un.org/spanish/esa/sustdev/agenda21/agenda21sptoc.htm

Notimex. (2020, January 7). Cierran playas en Ensenada por contaminación. *Milenio*. https://www.milenio.com/estados/cierran-playas-en-ensenada-por-contaminacion

Osorio-Rivera, M. A., Carrillo-Barahona, W. E., Negrete-Costales, J. H., Loor-Lalvay, X. A., & Riera-Guachichullca, E. J. (2021). La calidad de las aguas residuales domésticas. *Polo del Conocimiento*, *VI*(3), 228–245. https://polodelconocimiento.com/ojs/index.php/es/article/view/2360

Padilla y Sotelo, L. S. (2016). Diversificación sectorial y proyección internacional del municipio de Ensenada, México. *Revista Transporte y Territorio*, (15), 241–273. http://www.redalyc.org/articulo.oa?id=333047931015

Planta de tratamiento El Gallo opera dentro de norma. (2022, June 1). *Diario Tijuana.* https://diariotijuana.info/2022/06/planta-de-tratamiento-el-gallo-opera-dentro-de-norma

Procuraduría Federal de Protección al Ambiente (PROFEPA). (2022, August 12). *¿Qué hacemos?* Gobierno de México. https://www.gob.mx/profepa/que-hacemos

Redacción El Universal. (2017, March 26). Cierran playas de Ensenada por presencia de enterococos. *El Universal.* https://www.eluniversal.com.mx/articulo/estados/2017/03/26/cierran-playas-en-ensenada-por-presencia-de-enterococos/

Redacción El Vigía. (2019, January 24). Cierran Playa Conalep por alta contaminación. *El Vigía.* https://www.elvigia.net/general/2019/1/24/cierran-playa-conalep-por-alta-contaminacion-320504.html

Redacción El Vigía. (2021, October 16). Continúa cerrada Playa Hermosa. *El Vigía*. https://www.elvigia.net/general/2021/10/16/continua-cerrada-playa-hermosa-379767.html

Redacción Zeta. (2020, April 2). Ayuntamiento cerró Playa Hermosa en Ensenada. *Zeta.* https://zetatijuana.com/2020/04/ayuntamiento-cerro-playa-hermosa-en-ensenada-2/

Secretaría de Economía. (2013). NMX-AA-004-SCFI-2013. Water analysis - Determination of settleable solids in natural water, Wastewaters and treated wastewaters - Test method. November 13, 2013. https://www.gob.mx/cms/uploads/attachment/file/166763/NMX-AA-004-SCFI-2013.pdf

Secretaría de Economía. (2016a). NMX-AA-034-SCFI-2015. Water analysis - Measurement of salts and solids dissolved in natural water, wastewaters and treated wastewaters - Test method. February 11, 2016. https://www.gob.mx/cms/uploads/attachment/file/166146/nmx-aa-034-scfi-2015.pdf

Secretaría de Economía. (2016b). NMX-AA-042-SCFI-2015. Análisis de agua. Enumeración de organismos coliformes totales, organismos coliformes fecales (termotolerantes) y *escherichia coli*. Método del número más probable en tubos múltiples. February 11, 2016. https://www.gob.mx/cms/uploads/attachment/file/166147/nmx-aa-042-scfi-2015.pdf

Secretaría de Medio Ambiente y Desarrollo Sustentable (SMADS). (2024, September 12). *¿Quiénes somos?* https://www.bajacalifornia.gob.mx/medio_ambiente/

Secretaría de Medio Ambiente, Recursos Naturales (SEMARNAT). (1998a). NOM-002-SEMARNAT-1996, que establece los límites máximos permisibles de contaminantes en las descargas de aguas residuales a los sistemas de alcantarillado urbano o municipal. June 3, 1998. https://www.profepa.gob.mx/innovaportal/file/3295/1/nom-002-semarnat-1996.pdf

Secretaría de Medio Ambiente, Recursos Naturales (SEMARNAT). (1998b). NOM-003-SEMARNAT-1997, que establece los límites máximos permisibles de contaminantes para las aguas residuales tratadas que se reúsen en servicios al público. September 21, 1998. https://diariooficial.gob.mx/nota_detalle.php?codigo=4893449&fecha=21/09/1998#gsc.tab=0

Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). (2003a). NOM-001-SEMARNAT-1996, que establece los límites máximos permisibles de contaminantes en las

descargas de aguas residuales en aguas y bienes nacionales. April 23, 2003. https://www.profepa.gob.mx/innovaportal/file/3290/1/nom-001-semarnat-1996.pdf

Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). (2003b). NOM-004-SEMARNAT-2002, Protección ambiental.- Lodos y biosólidos.- Especificaciones y límites máximos permisibles de contaminantes para su aprovechamiento y disposición final. August 15, 2003. https://dof.gob.mx/nota_detalle.php?codigo=691939&fecha=15/08/2003#gsc.tab=0

Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). (2022a). NOM-001-SEMARNAT-2021, que establece los límites permisibles de contaminantes en las descargas de aguas residuales en cuerpos receptores propiedad de la nación. March 11, 2022. https://dof.gob.mx/nota_detalle.php?codigo=5645374&fecha=11/03/2022#gsc.tab=0

Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT). (2022b). *¿Qué hacemos?* Gobierno de México. https://www.gob.mx/semarnat/que-hacemos

Secretaría para el Manejo, Saneamiento y Protección del Agua (SEPROA). (2022, August 12). *¿Quiénes somos?* Gobierno del Estado de Baja California. https://www.bajacalifornia.gob.mx/seproa

Sistema Nacional de Información del Agua (SINA). (2025). *Calidad del agua (nacional)*. Comisión Nacional del Agua. https://sinav30.conagua.gob.mx:8080/SINA/?opcion=salud

Sterner, T. (2007). *Instrumentos de política económica para el manejo del ambiente y los recursos naturales*. Centro Agronómico Tropical de Investigación y Enseñanza.

United Nations. (2018). *The 2030 Agenda and the sustainable development goals: An opportunity for Latin America and the Caribbean* (LC/G.2681-P/Rev.3). ECLAC. https://www.gob.mx/cms/uploads/attachment/file/311197/agenda-2030-y-los-objetivos-de-desarrollo-sostenible.pdf

Villa Córdova, A. (2022). *Gestión y visualización de datos de usuarios del Registro Público de Derechos de Agua en Sonora, México* [Master's thesis, El Colegio de Sonora]. http://www.repositorioinstitucional.uson.mx/handle/20.500.12984/7028

Walteros, J. M., & Ramírez, A. (2020). Urban streams in Latin America: Current conditions and research needs. *Revista de Biología Tropical*, *68*(2), S13-S28. https://doi.org/10.15517/rbt.v68iS2.44330

World Water Assessment Programme (WWAP). (2017). *Informe mundial de las Naciones Unidas sobre el desarrollo de los recursos hídricos, 2017. Aguas residuales. El recurso desaprovechado*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000247647