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Methodological proposal for monitoring basins that drain into the Pacific Ocean. Case study Tomatlán - Tecuán basin (RH15Ca)

Propuesta metodológica para la vigilancia de las cuencas que drenan al Océano Pacifico. Estudio de caso cuenca Tomatlán - Tecuán (RH15Ca)

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Abstract

In this article it is proposed to assess the state of the RH15Ca basin and the use that its population gives to the water, to finally see what state it is in when it empties into the Pacific Ocean. Through the realization of maps of the location of rural and urban populations, climatology, vegetation and land use, ggeology and bathymetry, it is intended to understand the conditions of the water resource and whether or not it is suitable for its waters to flow into the Ocean. This methodology can be applied to the study of other basins in the state of Jalisco or the Mexican Republic.

Basin, Ocean, Flow

Resumen

En el siguiente artículo se propone valorar el estado de la cuenca RH15Ca y el uso que su población le da al agua, para finalmente ver en que estado se encuentra al desembocar al Océano Pacifico. A través de la realización de mapas de ubicación de poblaciones rurales y urbanas, climatología, vegetación y uso de suelo, geología y batimetría se pretende entender en que condiciones se encuentra el recurso hídrico y si es apto o no que sus aguas desemboquen al Océano. Esta metodología puede ser aplicada para el estudio de otras cuencas en el estado de Jalisco o la República Mexicana.

Cuenca, Océano, Desembocar

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Introduction

Society is constantly growing and, above all, requires more and more satisfiers, such as food, water, and various supplies, which, once used, are disposed of in liquid or solid form, and many of these end up on the coasts; part of the population living in the interior of the continent spends their free time vacationing on the beaches, To satisfy the growing demand for water for the agricultural, industrial or recreational sector, the rivers that feed the beaches have been dammed, impacting aquatic ecosystems by modifying the physical and chemical characteristics of the water and draining the coasts, fish, waste disposal and the use of these areas for transportation. Consequently, the deterioration of the coastal environment has become a critical problem and recent reports indicate that the deterioration of an important source of protein, the sea, is on the rise (National Research Council 2000).

More than half of the world's population is located within this region and this proportion is growing due to both population growth and migration to coastal regions (Dennison, W. C. 2008). Approximately 19 million people reside within 1 km of the coast in the American United States (IAI 2010).

Coastal regions of the United States are economically vital areas that support a diverse range of industries and large tourism and population centers. This increase in part is due to recreational use, coupled with the impact of large year-round populations, demonstrates the great importance people place on the environmental quality of coastal areas but people place increasing pressure on coastal ecosystems and make management of these areas increasingly challenging (NRC, 2000).

The infamous plastic islands of the sea is a reflection of the tons of garbage that people from different nations dump into the seas. It is a problem that is expected to grow due to the increasing population growth in coastal areas, which, according to Aranda 2004, causes habitat modification, degradation of water resources, pollution, as well as the introduction of exotic species, which together are causing changes in the coasts that range from greater erosion and vulnerability to the deterioration of the environmental health of a coastal area. The deterioration of the environmental health of an ecosystem directly impacts the health of the population. This type of pollution that alters the quality of coastal water is known as eutrophication (Aranda, N., 2004).

Eutrophication is the process of organic enrichment of an ecosystem where the increased supply of organic matter causes changes in that system. In coastal ecosystems, eutrophication can lead to excessive, and sometimes toxic, production of algal biomass; loss of important nearshore habitats; changes in marine biodiversity and species distribution; increased sedimentation of organic particles; and reduction of the reach of sunlight and depletion of dissolved oxygen (NRC 2000). Most of the organic matter comes from sewage generated both onshore and upstream. The proportion that is discharged into the environment without being collected or treated beforehand is considerable. This is especially true in low-income nations where only 8% of domestic and industrial wastewater is treated, a very low percentage compared to 70% in high-income countries. Due to this lack of treatment, in many regions of the world, wastewater contaminated by bacteria, nitrates, phosphates and solvents is discharged into lakes and rivers and ends up in the sea, with consequent negative environmental and public health impacts (UNESCO 2017).

Mexico is a country with a fortunate geographic location as it is located in the middle of two oceanic slopes, which largely explains the enormous biological and ecosystemic diversity it gathers, having a wide range of marine resources and ecosystems. Seventeen of the 32 states of the Mexican Republic have a total of 11 122 km of coastline (Secretaría de Medio Ambiente y Recursos Naturales, 2018).

Within the continental territory, Mexico has lakes, lagoons, rivers among other bodies of water that were grouped into hydrological regions. According to the National Water Commission (CONAGUA) hydrological regions are territorial areas conformed according to their morphological, orographic and hydrological characteristics, in which the hydrological basin is considered the basic unit for the management of water resources. Its purpose is the grouping and systematization of information, analysis, diagnoses, programs and actions related to the occurrence of water in quantity and quality, as well as its exploitation, use or exploitation. Mexico has 37 of these regions, within which more than one hydrological basin can be found. These basins could be defined as a surface morphographic unit delimited by the course of a river and its tributaries as secondary rivers that feed the main river. It covers from the area where the river originates to the place where it flows into the sea (lakes, lagoons and/or sea) (SEMARNAT, sf). Unfortunately, overexploitation and misuse of water resources have led to serious contamination problems, not only of the water body but also of the watershed itself.

Location

The RH15Ca sub-basin is located in the central western part of the Mexican Republic in the state of Jalisco, located in the Administrative Hydrological Region VII Lerma-Santiago-Pacific, covering part of the territory of 3 municipalities, Cabo corrientes, Tapalpa de Allende and Tomatlán (Fig. 1). Two of the three municipalities are coastal municipalities. It is located between the coordinates 19.967125, -105.237420. It has an area of 2,706 km2, and its elevation ranges from 0 to 2,578 meters above sea level.

The territorial occupation of the basins in the municipalities is 32.23% of Talpa de Allende, in Cabo Corriente it covers 7.18% of the total area of the municipality and in the municipality of Tomatlán it has the largest territorial occupation of the basin with 52.2%. This sub-basin belongs to the RH15C basin complex, which corresponds to the Tomatlán-Tecuán rivers.

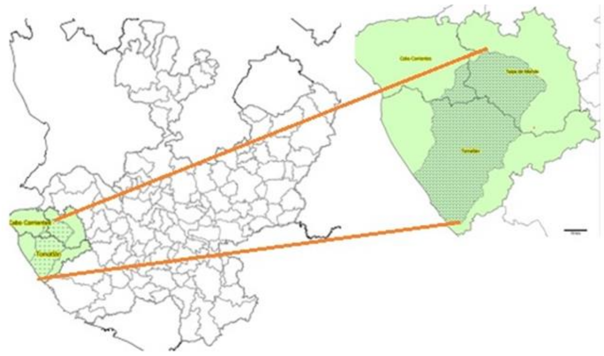

Figure 1 Location of the RH15Ca watershed, Digital Map of Mexico, Data taken from INEGI.

Objective

To assess the RH15Ca watershed and its anthropogenic use in order to describe the state of eutrophication in which it is found.

Specific objectives

- Qualitative assessment of the environmental health of the RH15Ca watershed.
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- Delimit the watershed used for the case study.
- Define the size of the population living within the watershed.
- Analyze the environmental services that exist in the watershed among its different treatment plants and landfills.
- Review current legislation regarding water quality in a watershed.
- Identify the industrial activity carried out in the watershed.
- Review the analysis of SEMARNAT's clean beaches program to observe its changes. Development of Sections and Sections of the Article with subsequent numbering.

Methodology

In order to carry out the present work, an extensive bibliographic search of diverse topics related to the current state of the RH15Ca watershed was carried out, in addition to the creation of a series of maps with the use of the Digital Map of Mexico.

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All the integrated information was prioritized in Table 4 and percentages were assigned to define the value of the positive and negative parameters.

RH15Ca Watershed

The RH15Ca watershed is drained by numerous streams and rivers (Fig. 2), one of the main ones being the Tomatlán River, which is divided into two sections: Tomatlán A, which runs from the municipality of Tapalpa de Allende to the Cajón de Peñas dam, and Tomatlán B, which runs from the Cajón de Peñas dam to the Pacific Ocean coast. The Cajón de Peñas dam has an operating capacity of 510.56 m3. Water from this basin is mainly used for urban public use, agriculture, livestock, and a hydroelectric plant, which consists of a power generation plant that takes advantage of the existing irrigation infrastructure of the Tule canal (SINAT, sf).

Most of the water used by the urban and rural communities in the watershed is not treated in treatment plants because some of the existing plants are in disuse; in Cabo Corrientes there is one plant out of operation capable of treating 6 liters of wastewater per second and in Tomatlán there are a total of 5 plants out of operation with the capacity to treat a total of 49 liters of water per second. The municipality of Talpa de Allende is the only municipality that has a wastewater treatment plant. Basin Name and description Cp Ar Uc (a) R Ex Ev Av Av Ab Rxy Ab-Rxy D Classification 1504 Rio Tomatlán A: From its headwaters to the Cajón de Peña dam 854.83 0 995.65 533.4 0 26.73 2.49 363.35 267.9 95.45 95.43 Available 1505 Tomatlan River B: From where Cajon de Peña Dam is located, to the mouth of the Tomatlan River in the Pacific Ocean. 316.28 363.35 155.94 493.98 212.4 0 0 0 805.2 496.9 308.3 308.3 Available has a wastewater treatment plant in operation, which sanitizes 30 liters of sewage per second (CEA, 2015).

Figure 2 Hydrology of the RH15Ca watershed, Digital Map of Mexico, data taken from INEGI

Water use and management in the basin is monitored every three years by the National Water Commission (CONAGUA) in order to make an update of the basin's surface water use. According to the Official Gazette of the Federation (DOF, 2020) considering that Article 22 of the National Water Law, states that, in order to grant concessions or allocations, the average annual water availability must be considered, which will be published by the National Water Commission, making public the availability of national surface waters by hydrological basin, hydrological region or locality Table .1.

Article 15 of said Law updates the average annual availability of national surface waters of the hydrological basins that integrate the Hydrological Region number 15 Coast of Jalisco to be as follows:

1504.- Tomatlán river hydrological basin A: volume available at the outlet of 95.453 million cubic meters. Classification: (availability).

1505.- Tomatlan river basin B: available volume at the outlet of 308.306 million cubic meters. Ranking: (availability) (DOf, 2020).

Symbology

Cp.- Average annual volume of natural runoff.

Ar.- Average annual volume of runoff from the upstream basin.

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Uc(a).- Annual volume of surface water withdrawal through titles currently registered/assigned in REPDA.

R.- Annual volume of returns.

Ex.- Annual volume of exports.

Ev.- Average annual volume of evaporation in reservoirs.

Av.- Average annual volume of storage variation in reservoirs.

Ab.- Average annual volume of runoff from the basin downstream.

Rxy.- Current annual volume committed downstream, volumes corresponding to reserves, environmental use, regulations and programming.

reserves, environmental use, regulations and water programming.

Watershed	Name and description	Cp	Ar	Uc (a)	R	Ex	Ev	Av	Ab	Rxy	Ab-Rxy	D	Classification
1504	Tomatlán River A: From its source to Cajón de Peña dam	854.83	0	995.65	533.4	0	26.73	2.49	363.35	267.9	95.45	95.43	Available
1505	Tomatlán B River: From the Cajón de Peña dam to the mouth of the Tomatlán River in the Pacific Ocean.	316.28	363.35	155.94	493.98	212.4	0	0	805.2	496.9	308.3	308.3	Available

Table 1 Hydrological Region number 15 Coast of Jalisco. Summary of values of the terms involved in the calculation of surface availability. *Values in millions of cubic meters DOF, 2020

D.- Average annual surface water availability in the hydrological basin.

EH. - Hydrometric station.

EC.- Climatological station.

The equations used for the calculation of surface water availability are the following:

$$Ab = Cp + Ar + R + Im - (Uc(a) + Uc(b) + Uc(c) + Ev + Ex + Av)$$

$$D = Ab - Rxy$$

After calculating the surface water availability in the basin, it was concluded that its current status is AVAILABLE, referring to those basins where there is an available volume of surface water to grant new concessions by the CONAGUA (CEA, 2015).

Following this series of results the Official Journal of the Federation decreed that the closed areas previously in force in the hydrological basins Río Tomatlán A and Río Tomatlán B, belonging to the Hydrological Region Number 15 Coast of Jalisco, were abolished and established as a partial reserve zone of national surface waters for environmental use or ecological conservation in the hydrological basins published on June 6, 2018.

RH15Ca watershed Rural populations

Along the basin are settled rural populations, in the populations inhabit between 1-1000 people. As can be seen in the map (Fig. 3) the vast majority of the populations are located near the different bodies of water along the basin. As is well known, water is an indispensable resource for human use and consumption; in these regions it is mainly used as drinking water and for irrigation in the agricultural and livestock sector.

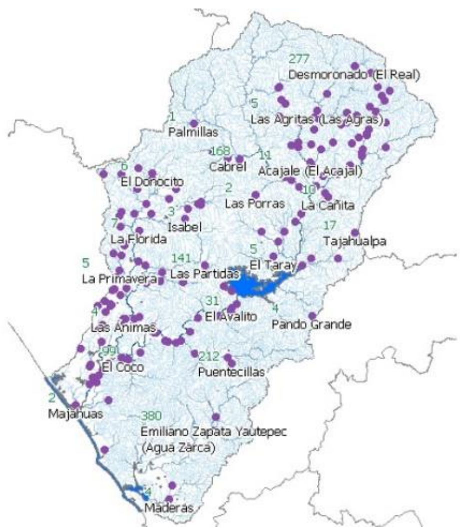

Figure 3 Rural populations of watershed RH15Ca, Digital Map of Mexico, data taken from INEGI.

Watershed RH15Ca urban populations

In the RH15Ca watershed, there are few urban population centers, the main cities being Tomatlán with 9,030 inhabitants, Campo Acosta with 2,638 and José Maria Pino Suárez (Nuevo Nahuapa) with 2,554 (Fig. 4).

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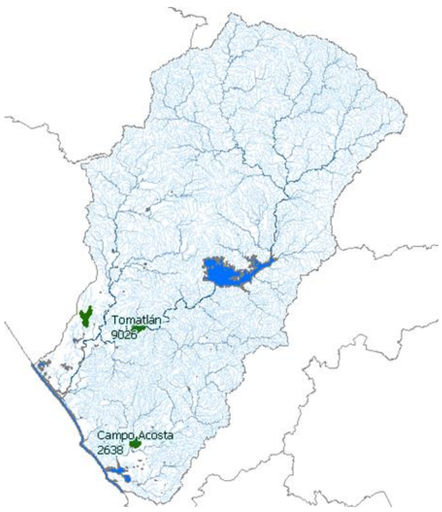

Figure 4 Urban populations in the RH15Ca watershed, Digital Map of Mexico, data taken from INEGI.

Climatology

The watershed has 3 types of climate; Temperate sub-humid, Warm sub-humid and Dry very warm (Fig. 5), with 1,124 mm of average annual precipitation and an average annual temperature of 23.2°C while its average maximum and minimum temperatures range between 36.0°C and 14.5°C respectively, being in the month of June when the highest temperatures are recorded and the month of January the coldest. (CEA, 2015).

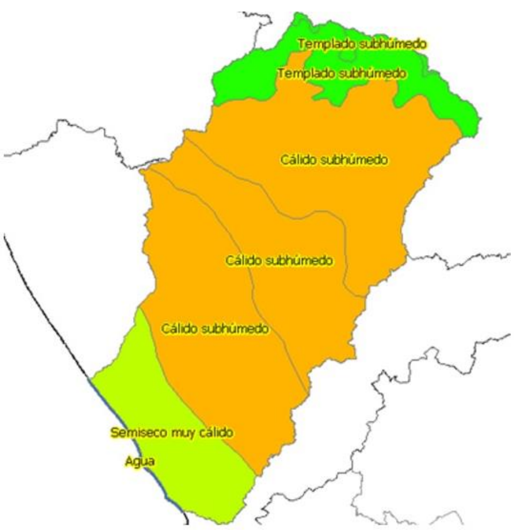

Figure 5 Climatology of the RH15Ca basin, Digital Map of Mexico, Data taken from INEGI.

Geology and rock types

Most of the basin is composed of intrusive igneous rock (Fig. 6). This type of rock is formed when the solidification of magma occurs within the lithosphere, i.e. it is formed within the earth's crust and reach the earth's surface through orogenic processes (tectonic deformations) or through external processes of erosion (Servicio Geológico Mexicano, 2017). It is observed is that the main flows of Rio Tomatlán run over alluvial rock, these are soils of materials transported or deposited in the coastal plains and inland valleys. They are recent or recently deposited soils (Fig. 7).

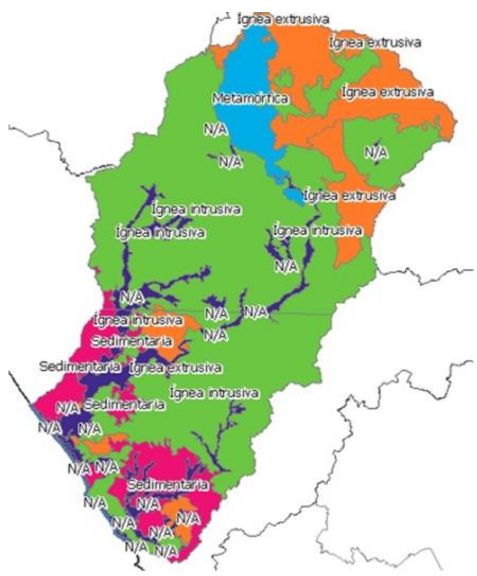

Figure 6 Geology and rock type of the RH15Ca basin, Rock class, Digital Map of Mexico, data taken from INEGI

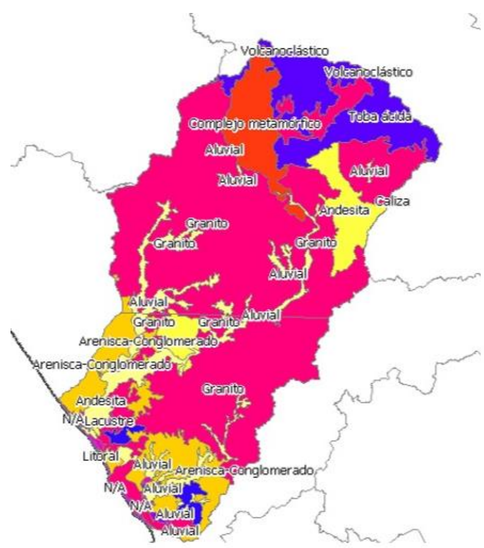

Figure 7 Geology and rock type of the RH15Ca basin Rock subclass, Digital Map of Mexico, data taken from INEGI

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Vegetation cover and land use

Part of the watershed is located in the southern Sierra Madre, so its main vegetation is pine-oak forests, grasslands and jungles. Irrigated agriculture covers a notable part of the basin, as Tomatlan is an important producer of mango in the state of Jalisco (Fig. 8).

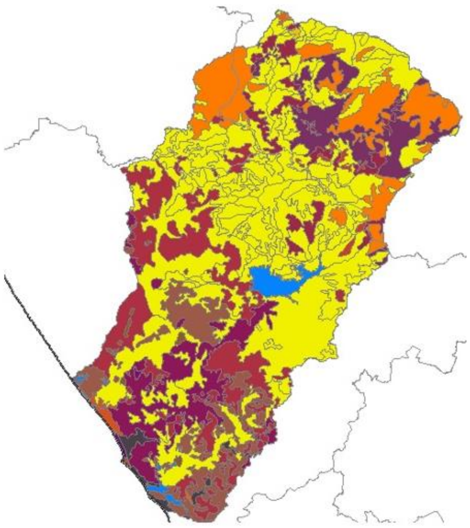

Figure 8 Land cover and land use in the RH15Ca watershed, Digital Map of Mexico, data taken from INEGI

Coasts of Jalisco

On the coasts of the Mexican Pacific Ocean the waters, especially those of the state of Jalisco, are very productive waters thanks to the different hydrophysical and chemical variables of the area. Knowing all these variables helps us to know the dynamics of the oceanic waters and the influence that the continental waters have on the coast.

The coasts are mainly formed by rocky coastline, sandy beaches, bays and inlets of different dimensions. The continental shelf off the coast of Jalisco is very narrow, its width at 200 m from the coast can be as little as 7 to 10 km (Fig. 8). The dynamics of the waters in this region on average flow in a northwesterly direction during the summer and in the opposite direction in the winter months creating small marine currents along the coasts of Jalisco. In this part of the continental shelf there are internal tides of diurnal and semi-diurnal period, causing them to propagate from the continental slope to the coast in the form of solitary waves which cause the deformation of the thermocline generating orbital currents.

These currents cause water submergence of up to 25 m, changing the dynamics of the water with variations in temperature and salinity (Filonov,

A.E.et all, 2000). This whole series of events demonstrates the dynamics of the ocean along the coast of Jalisco, and consequently what happens to the water of the basins that flow into the Mexican Pacific and how they end up mixing with everything they carry upstream.

In Jalisco, most of the state's registered fishing comes from inland waters and is obtained using rustic techniques. In this case the fishermen, depending on their own skills and resources, build their own fishing gear and in most cases, their own boats, which are small. In fact, only 10% of the boats in the state are larger, and most of the time the deep-sea fishing in the state is carried out by fleets belonging to other states. In the state's fishing activity in localities located between Puerto Vallarta and Barra de Navidad, around 136 species have been identified in the commercial catch of which 89% were fish, 8% crustaceans, 6% mollusks and 1% echinoderms (Dagostino, R. & Lemus, J. 2014). Because the continental shelf off the coast of Jalisco is narrow, fishery production tends to be lower compared to northern coastal states, as these have an extensive continental shelf on which they have the capacity to host a greater amount of marine life and fishery resources.

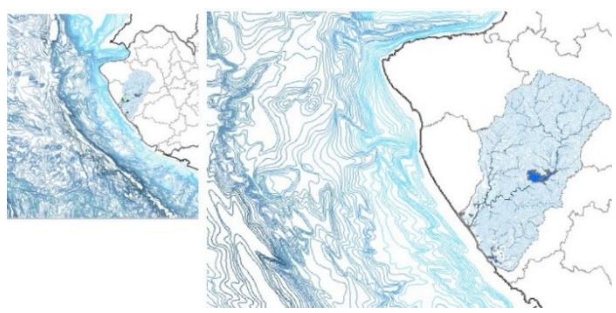

Figure 8 Bathymetry of the coasts of Jalisco, Digital Map of Mexico, data taken from INEGI

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BACTERIOLOGICAL QUALITY OF SEAWATER 2022 (NMP ENTEROCOCCI/100ML)					
Beach	Sampling site	Coordinates	Sampling date	NMP/100ml	Ranking
Yelapa Beach	Yelapa	20° 29' 24.8" 105° 26'34.8" Coordenadas	March 15 -24	23	APTA
	Yelapa		17-18 de julio	181	APTA

BACTERIOLOGICAL QUALITY OF SEAWATER 2021 (NMP ENTEROCOCCI/100ML)					
Beach	Sampling site	Coordinates	Sampling date	NMP/100ml	Ranking
Yelapa Beach	Yelapa	20° 29' 24.8" 105° 26'34.8" Coordenadas	2 y 10 de marzo	106	APTA
	Yelapa		29 de nov-9 de dic	17	APTA

BACTERIOLOGICAL QUALITY OF SEAWATER 2019 (NMP ENTEROCOCCI/100ML)					
Beach	Sampling site	Coordinates	Sampling date	NMP/100ml	Ranking
Yelapa Beach	Yelapa	20° 29' 24.8" 105° 26'34.8"	19-27 de marzo	10	APTA
	Yelapa		10-19 de junio	29	APTA
	Yelapa		29 de nov- 10 de dic	19	APTA

Table 2 Data was collected from the Clean Beaches Program by SEMARNAT to review the bacteriological quality of the beaches surrounding the RH15Ca watershed to estimate water quality

MPN Enterococci /100ml	Beach classification
De 0 a 200	APTA
Greater than 200	NO APTA

Table 3 Classification criteria for seawater quality, Secretary of Environment and Natural Resources, 2019

Results

The analysis of this basin, according to Table 4, indicates that it has more favorable parameters for draining rainwater to the sea than unfavorable parameters, among the most important parameters is the presence of sanitary landfills and treatment plants.

Tomatlán-Tecuán sub-basin (RH15Ca)		
Parameters to assess	Valores	
	Favourable	Unfavourable
	State	Federal
Size of the sub-basin	10	0
Total population of the sub-basin	Distributed throughout the basin	Concentrated in the lower part
	9	1
5t Natural vegetation cover	In full	Partial
	8	2
Land use	Forestry	Agriculture
	8	2
Lithology type	Permeable	Waterproof
	2	8
Precipitation	Greater than 1000 mm	Less than 1000 mm
	10	
Treatment plants	10	
Landfills	10	
Total	47	13

Table 4 Analysis of the favorable or unfavorable parameters for a basin to drain water of good or bad quality to the coasts of Jalisco

Acknowledgements

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Conclusion

It is considered necessary to apply this methodological analysis in the rest of the watersheds in Jalisco that drain to the sea and if possible in the coasts of the Mexican Republic, prioritizing the watersheds that need to be studied in greater detail due to their evident pollution problems.

Moving to a phase of qualitative methodological analysis, installing sensors and making a periodic systematic monitoring of the watersheds would be an interesting proposal to implement as a second phase of analysis of the state of eutrophication of the watersheds.

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