Journal of Positive School Psychology
2022, Vol. 6, No. 3, 3636–3646 http://journalppw.com

Evaluation of the Impact of Effluents Fisheries and Domestic Industries in the Water Quality of the Bahia El Ferrol - Chimbote

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Abstract

The present research aims to analyze the degree f compliance of the physical-chemical and microbiological parameters of the water of El Ferrol Bay during the period 2015 - 2019; the bay has been affected in the last four decades due to industrial activities, mainly fishing (production of fishmeal, oil, and canned fish) and the progressive increase of the population that generates municipal wastewater and solid waste. The collection of information was obtained through physical-chemical monitoring of water quality in the Chimbote - El Ferrol Bay sea directed by NWA (National Water Authority), whose annual averages were compared with the National Environmental Quality Standard (EQS) for water, established by Supreme Decree No. 004-2017-MINAM according to the classification of the marine-coastal water body established by the Chief Resolution No. 030 – 2016 - ANA. As results obtained, the parameters that fully comply with the EQS in the studied period are: pH, total suspended solids, dissolved oxygen, nitrates and sulfates and partially oils and fats, biochemical oxygen demand and thermotolerant coliforms with 92.86%, 92.31%, and 68.75% respectively while Escherichia coli has 0% and in terms of years considering only these parameters 2015 complies 83.33%, 2016 complies 100%, 2017 complies 90.32%, 2018 complies 83.33%, 2019 complies 92.58%.

Keywords— El Ferrol Bay - water quality – physical-chemical parameter - microbiological parameter.

INTRODUCTION

In Peru, fishing contributes between 1.5% and 2.5% of GDP to the national economy and represents 7% of total exports. The industry has donated US$1 billion in foreign exchange, which has enabled the government to continue raising resources for the fight against the pandemic. [1] Although this industry helps Peru's economy, the environmental aspects associated with the process generate impacts that could mainly affect the quality of the air and the receiving marine body during the production period. [2]. For this reason, it is necessary to carryout actions to monitor and control the quality of water resources to evaluate their quality in order to plan and implement measures to prevent, mitigate, and manage adverse impacts. [3] Within the framework of determining the water quality of the receiving marine bodies (sea), there are indicators whose measurement helps us define the degree of contamination, the so-called EQS (Environmental Quality Standards) that set critical values for Temperature, pH, Dissolved Oxygen (DO), Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD5), Nitrates, Phosphates and Sulfides [4] which have values or intervals defined according to the classification of the coastal marine water body created under technical criteria with normative support related to the oceanographic environmental conditions and the national reality of the marine environment, considering the geomorphology of the coast, the submarine relief and the influence of freshwater resources that generate a varied habitat of aquatic ecosystems [5]. In this sense, the National Water Authority carries out surveillance and monitoring of the quality of water resources, which it does in each hydrographic unit or basin. To establish the monitoring points in a basin, the pollutant sources are identified, and the monitoring, route, and sampling implements are programmed. The services of a laboratory accredited by the Instituto Nacional de Calidad, with the ISO 1725 standard, are used to analyze the collected samples following an established protocol. [6] El Ferrol Bay, also known as Chimbote Bay, is a semi-enclosed bay, which due to its configuration allows for a longer residence time for its waters [7] which means that the water masses remain in the bay longer, making it difficult for marine waters to be quickly purified [8] Peru's main fishing port is located in the most productive area for fishmeal and fish oil on the coast. Over the years, this bay has shown signs of environmental deterioration [9] . The most critical activities identified are the activities of industrial fishing establishments (IFE), which are mainly engaged in processing fishmeal and fish oil, complemented by processing activities of products for direct human consumption such as canning, freezing, and curing. [10] Research related to marine pollution in this area indicates that a study should be conducted to determine fishmeal and fish oil production capacity to generate non-municipal solid waste [11] and that industrial anchoveta processing activities have had a negative influence on the specific richness and equity indices [12]. Therefore, this research work provides important information on the state of the environment in terms of water quality to guide decisions of various natures that affect El Ferrol Bay's environment and surroundings.

2. Method

The type of research method developed is quantitative because it is based on the measurement of variables [13] in which data generated in the years 2015 - 2019 from the participatory monitoring of water quality conducted by NWA is contrasted and non-experimental longitudinal or evolutionary. After all, the evolution of one or more variables is studied (pH, oils and fats, total suspended solids, dissolved oxygen, biochemical oxygen demand, nitrates, sulfides, thermotolerant coliforms, and *E.coli*) and the changes are analyzed over time by collecting data in determining periods to make inferences regarding the variations of these variables. [14]

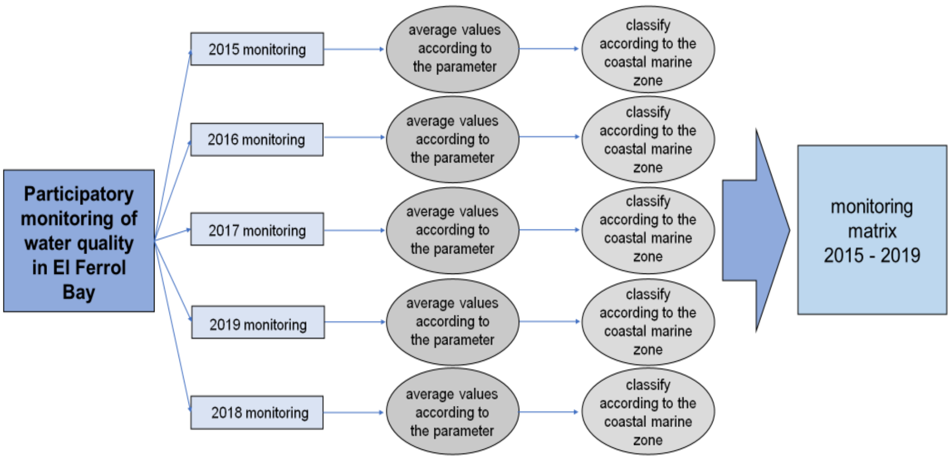

Figure 1: Methodological scheme for obtaining the matrix of monitoring values for the period 2015 - 2019

2.1 Study area

Ferrol Bay is located in the northern part of Peru, in the Province of Santa, Department of Ancash, between the coordinates: West Longitude [78°40' - 78°33"] and South Latitude [09°03" - 09°11"]. This bay is bounded on the north by Chimbote hill and the south by Peninsula hill. [15] The bay is 11.1 km long and 6.5 km wide; it is located 425 km north of Lima, is semi-enclosed, and has slow water circulation [16]

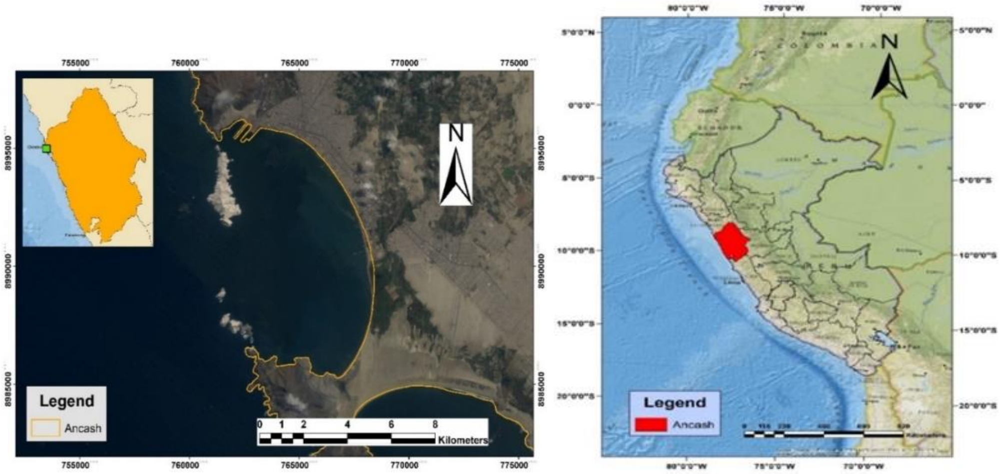

Figure 2. Location of El Ferrol Bay

2.2 Instrumentos

2.2.1 Characterization of the study area

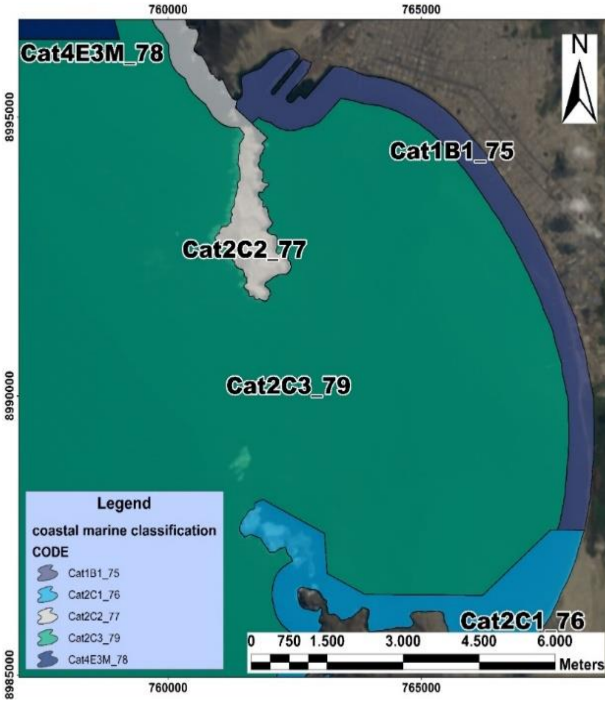

Figure 3. Classification of the coastal marine water in El Ferrol Bay

Figure 3 shows the categories of the coastal marine classification in El Ferrol Bay graphically, with Cat2 - C3 being the most extensive.

Table 1. Coastal marine classification in the Bay of El Ferrol

Code	Categoría	Subcategoría
Cat1B1_75	1: Population and recreational	B1: Primary Contact
Cat2C1_76	2: Coastal and inland marine extraction and cultivation activities	C1: Extraction and Cultivation of Bivalve Molluscs
Cat2C2_77	2: Coastal and inland marine extraction and cultivation activities	C2: Extraction and Cultivation of other Hydrobiological Species

Cat2C3_79	2: Coastal and inland marine extraction and cultivation activities	C3: Other Activities

Table 1 describes the categories and subcategories of the coastal marine classification corresponding to El Ferrol Bay.

2.2.2 monitoring network

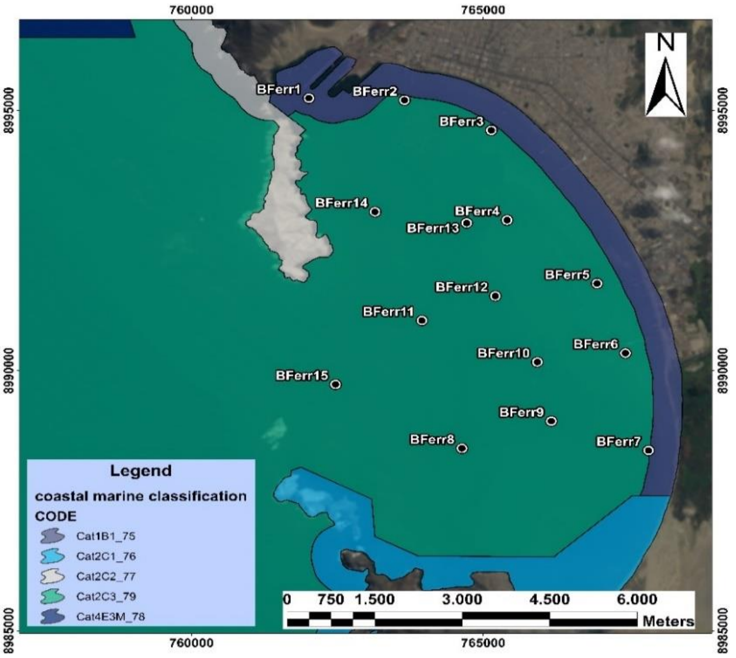

Figure 4. Monitoring network 2015

Figure 4 in the 2015 monitoring network, 15 surface samples were taken at 15 points, of which 14 belong to Cat.2 - C3 and 1 to Cat.1 - B1.

Table 2. Monitoring network 2015

Monitoring points	Depth level	UTM 17 S Coordinates		Coastal marine classification
		X	Y	
BFerr1	Superficial	762013	8995234	Cat. 1 - B1
BFerr2	Superficial	763651	8995196	Cat. 2 - C3
BFerr3	Superficial	765138	8994618	Cat. 2 - C3
BFerr4	Superficial	765408	8992891	Cat. 2 - C3
BFerr5	Superficial	766950	8991674	Cat. 2 - C3
BFerr6	Superficial	767436	8990337	Cat. 2 - C3
BFerr7	Superficial	767832	8988465	Cat. 2 - C3
BFerr8	Superficial	764635	8988506	Cat. 2 - C3
BFerr9	Superficial	766167	8989028	Cat. 2 - C3
BFerr10	Superficial	765926	8990164	Cat. 2 - C3
BFerr11	Superficial	763950	8990961	Cat. 2 - C3
BFerr12	Superficial	765207	8991433	Cat. 2 - C3
BFerr13	Superficial	764716	8992837	Cat. 2 - C3
BFerr14	Superficial	763146	8993050	Cat. 2 - C3
BFerr15	Superficial	762469	8989733	Cat. 2 - C3

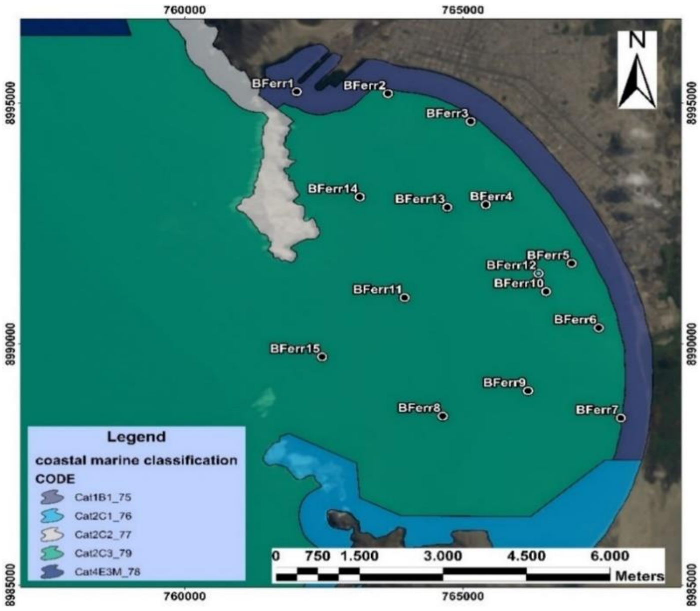

Figure 5. Monitoring network 2016

Table 3. Monitoring network 2016

Monitoring points	Depth level	UTM 17 S Coordinates		Coastal marine classification
		X	Y	
BFerr1	Superficial	762013	8995234	Cat. 1 - B1
BFerr2	Superficial and medium	763651	8995196	Cat. 2 - C3
BFerr3	Superficial	765138	8994618	Cat. 2 - C3
BFerr4	Superficial	765408	8992891	Cat. 2 - C3
BFerr5	Superficial	766950	8991674	Cat. 2 - C3
BFerr6	Superficial	767436	8990337	Cat. 2 - C3
BFerr7	Superficial	767832	8988465	Cat. 2 - C3
BFerr8	Superficial	764635	8988506	Cat. 2 - C3
BFerr9	Superficial	766167	8989028	Cat. 2 - C3
BFerr10	Superficial and medium	765926	8990164	Cat. 2 - C3
BFerr11	Superficial	763950	8990961	Cat. 2 - C3
BFerr12	Superficial	765207	8991433	Cat. 2 - C3
BFerr13	Superficial and medium	764716	8992837	Cat. 2 - C3
BFerr14	Superficial and medium	763146	8993050	Cat. 2 - C3
BFerr15	Superficial and medium	762469	8989733	Cat. 2 - C3

In the 2016 monitoring network 2016, 15 surface and five bottom simples were taken, of which 14 belong to Cat.2 – C3 and 1 to Cat.1 – B1.

In the 2017 monitoring network, 25 surfaces, seven medium, and 13 bottom samples were taken at 25 points, of which 11 belong to Cat.1 - B1, 13 to Cat.2 - C3, and 1 to Cat.2 - C1. In figure 7, 2018 monitoring network, 26 surfaces, ten medium, and 15 bottom samples were taken at 26 points, of which nine belong to Cat.1 - B1, 15 to Cat.2 - C3, 1 to Cat. 2 - C2, and 1 to Cat. 2 - C1.

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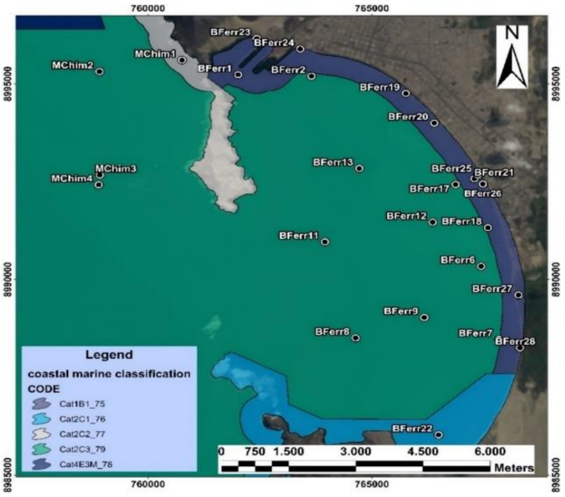

Figure 6. 2017 monitoring network

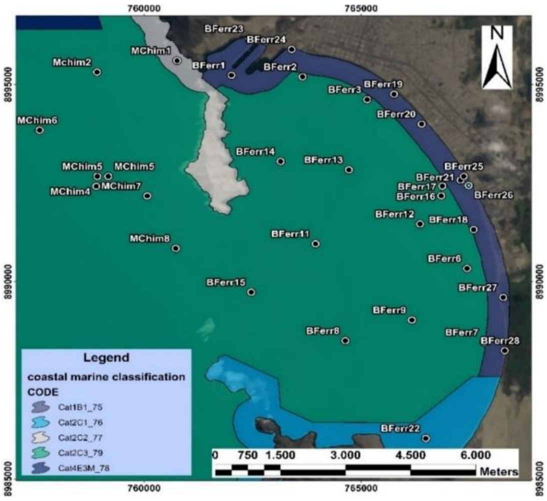

Figure7. 2018 Monitoring network

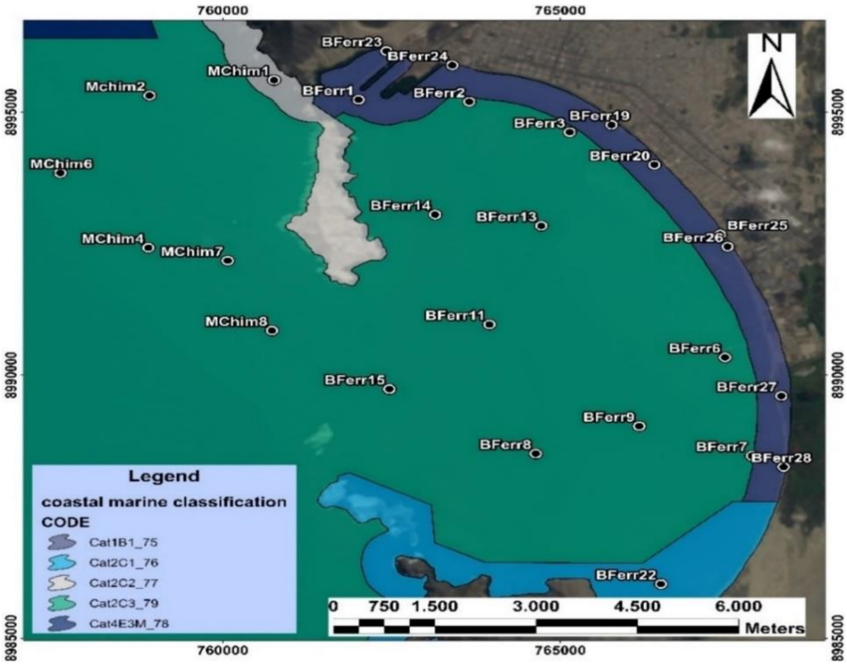

Figure8. 2019 Monitoring network

In the 2019 monitoring network, 25 surfaces, ten medium, and 15 bottom samples were taken at 25 points, of which 14 belong to Cat. 2 - C3, 1 to Cat.2 - 2, 1 to Cat. 2 - C1, and 9 to Cat. 1 - B1.

2.3 Collection of information

This research obtained data from the Chimbote - El Ferrol Bay participatory seawater quality monitoring reports led by the National Water Authority (NWA) processed in Excel 2016. From the information from each year's monitoring points, the annual averages for each parameter were determined, and graphs were elaborated, classifying them according to the coastal marine classification. Therefore, the issues belong from 2015 to 2019. The chemical analysis was performed by the laboratories "Servicios analíticos generales S.A.C" (2015), "NSF Inassa Envirolab S.A.C" (2016) and "ALS LS Perú S.A.C" (2017-2019).

2.4 Parameters analyzed

Water quality parameters are the chemical, physical or biological characteristics of water bodies that are measurable. Their classification is established in three main groups: physical parameters (they define the organoleptic characteristics of water, such as suspended solids, turbidity, color, taste, odor, and temperature), chemical parameters (they are related to the water's capacity to dissolve various substances, among which we can mention total dissolved solids, alkalinity, hardness, metals, organic matter, and nutrients) and biological parameters. [17]

3. Results

The statistical analysis of the monitoring matrix 2015 - 2019 results in the following:

There are 106 average values of the annual monitoring, of which 11 do not meet the EQS and there are 25 values in which there is no EQS in 3 parameters (Biochemical oxygen demand, Nitrate, and *Escherichia coli*). There is a total of 53 blank data because they were not analyzed in the respective monitoring. The most challenging parameter that fails the EQS is Fecal coliform with five average values, followed by *Escherichia coli* with 4. The most EQS compliant parameter is pH, with 15 average values, followed by Grease and oil with 13. The parameter *Escherichia coli* only has EQS in Cat. 1 - B1 and does not meet it in the period studied.

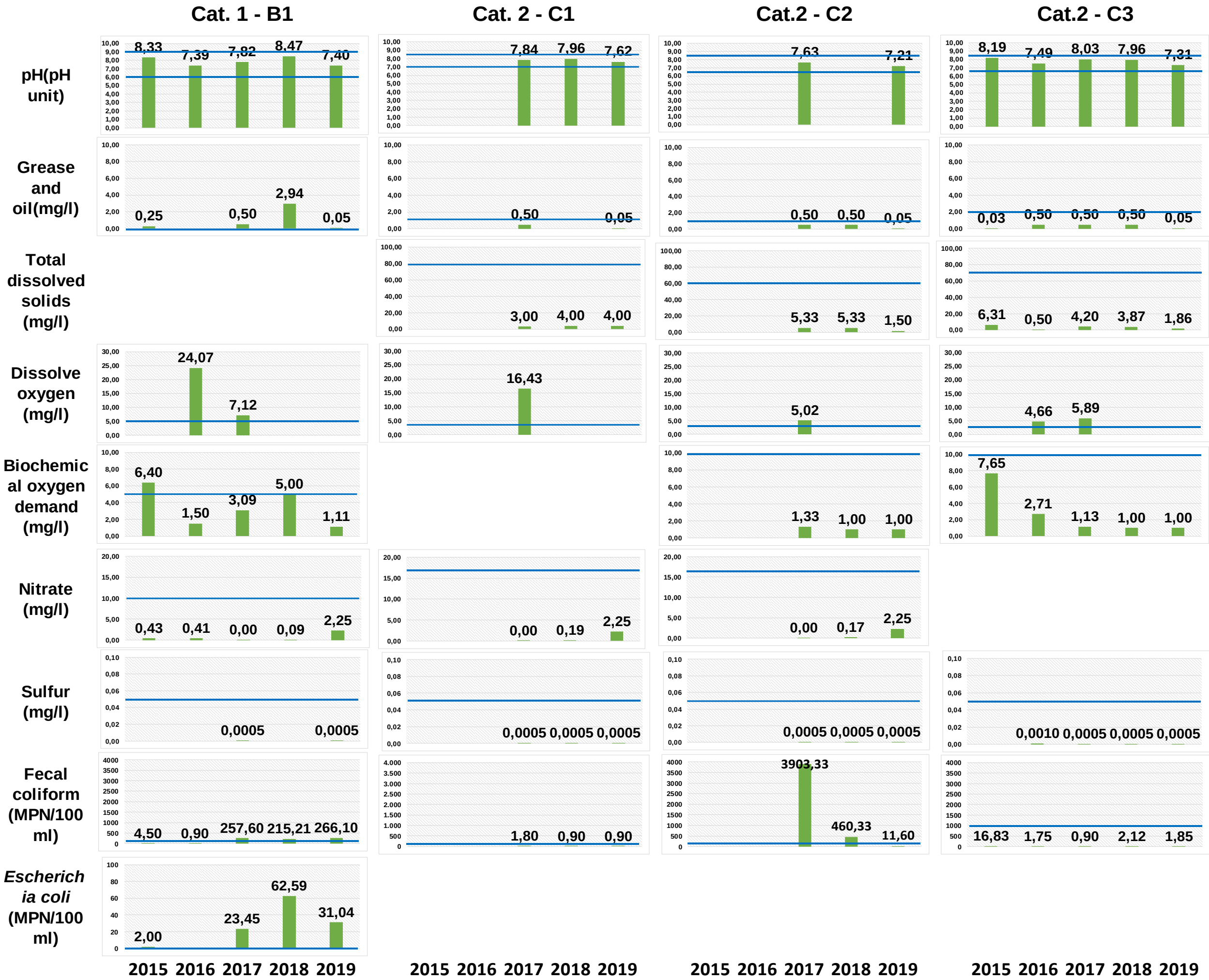

Figure 9, show category and parameter

Figure 9. Parameter values according to year and category and the corresponding EQS

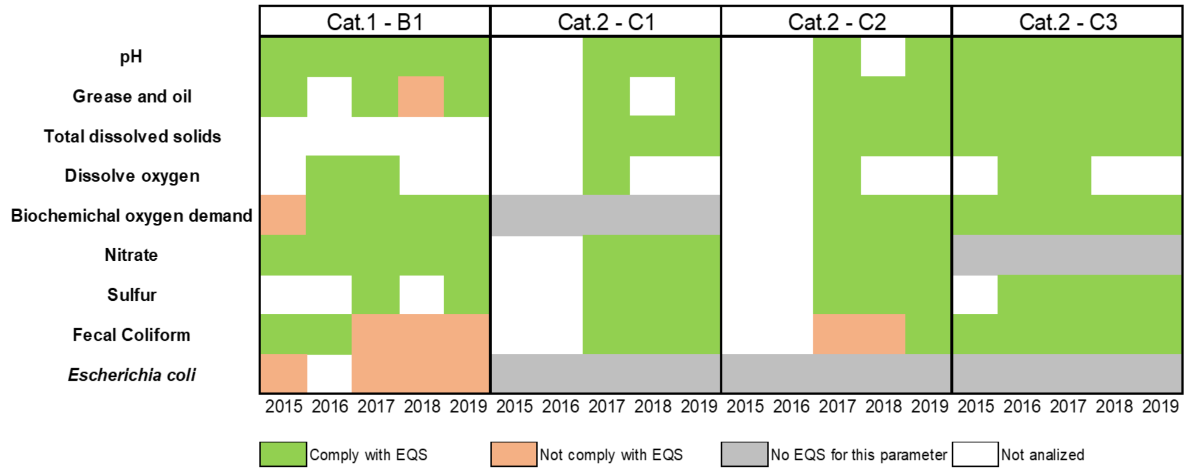

Figure10. EQS compliance according to year and category

In Figure 10, the values are averages whose data have been extracted from the matrix generated from the monitoring, and the horizontal lines symbolize the EQS whose limit value or interval (for pH) varies according to the classification, determining compliance with the EQS according to the variables year.

4. Discussion of results

The results of the present study are comparable by the methodology used with Ibárcena (2017) in the article "Contamination of the bay of the fishing port Morro Sama, by liquid waste discharged from fishing activity" since the pH is within the range(6,0 - 8,5) and do not exert influence on marine resources, in dissolved oxygen no value lower than 4,0 mg/l was obtained, the importance of total coliforms exceed the permissible limits. Consequently, the area would be contaminated by these bacteria [18,19,20,21], so there is a simile with the analysis obtained in the research. (Cabral 2020) analyzed the degree of compliance with the Maximum Permissible Limits(MPL) established by Supreme Decree N° 010-2008-PRODUCE for pH, oils and fats, total suspended solids, and biochemical oxygen demand using the regulations of the country of Ecuador in the latter in the period 2012-2016 of the effluents of 4 fishing companies in his article "analysis of the degree of compliance with the quality of effluents in the IIE in the Bay of Chimbote (2012 - 2016)" has found a relationship with compliance with the EQS in the category Cat.1 - C1 in the years 2015-2016 because this coastal marine area is adjacent to the discharge points of these companies such as pH(100% MPL - 100% EQS) and Biochemical Oxygen Demand(0% MPL - 50% EQS) [22,23].

5. Conclusion

The pH is 100% compliant with 15 average values extracted from the matrix generated by the monitoring analysis and grease and oil comply 92.86% with 14 average values extracted from the matrix generated by the monitoring analysis. Total dissolved solids are 100% compliant with 11 average values extracted from the matrix generated by the monitoring analysis and dissolved oxygen is 100% compliant with six average values extracted from the matrix generated by the monitoring analysis [24, 25].

Biochemical oxygen demand complies 92.31% with 13 average values extracted from the matrix generated by the monitoring analysis.

Nitrates are 100% compliant with 15 average values extracted from the matrix generated by the monitoring analysis.

Sulfur is 100% compliant with 12 average values extracted from the matrix generated by the monitoring analysis.

Fecal coliform complies 68.75% with 16 average values extracted from the matrix generated by the monitoring analysis. Escherichia coli complies 0% with 4 average values extracted from the matrix generated by the monitoring analysis. [26,27].In terms of percentage for each coastal marine zone considering all Parameters in the period 2015 - 2019:

The Cat 1 - B1 classification complies 71.88% with 32 average values extracted from the matrix generated by the monitoring analysis.

The Cat 2. - C1 classification is 100% compliant with 18 average values extracted from the matrix generated by the monitoring analysis.

Cat 2. - C2 complies 90.48% compliance with 21 average values extracted from the matrix generated by the monitoring analysis.

The Cat 2. - C3 classification is 100% compliant with 35 average values extracted from the matrix generated by the monitoring analysis and in terms of percentage for each year considering all Parameters in all coastal marine zones in the period 2015 - 2019:

2015 is 83.33% compliant with 12 average values extracted from the matrix generated by the monitoring analysis. The year 2016 is 100% compliant with 12 average values extracted from the matrix generated by the averaged monitoring analysis. The year 2017 is 90.32% compliant with 31 average values extracted from the matrix generated by the monitoring analysis. [28,29].

The year 2018 is 83.33% compliant, with 24 average values extracted from the matrix generated by the averaged monitoring analysis and the year 2019 is 92.59% compliant with 27 average values extracted from the matrix generated by the monitoring analysis [30,31].

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