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TOXICITY OF WASTEWATER FROM FISHMEALS PRODUCTION AND THEIR INFLUENCE ON COASTAL WATERS

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ABSTRACT

Wastewaters from the fishmeal industry that are discharged without treatment into the sea induce loss of ecological functions and ecosystem services in coastal waters. The objective of this study was to assess the toxicity of wastewater generated by the fishmeal industry, as well as the receiving coastal ecosystem of the Gulf of California. The samples of water were gathered in both summer and autumn in four sites of wastewater discharges, and three sites of the receiving coastal body (El Paraje cove). Microtox® bioassay was used to evaluate toxicity. The results showed that wastewaters from the fishmeal industry have high toxicity and the coastal body water has zones with moderate toxicity and zones without toxicity. These results indicate the importance of having effective treatment of these types of discharges before they are poured into the sea in order to avoid deterioration of coastal ecosystems.

KEYWORDS:
wastewater, toxicity, fishmeal industry, Gulf of California.

INTRODUCTION

Coastal and marine ecosystems are among the most valuable for their ecosystem services, but are also the most pressing global anthropogenic [1] with different associated problems, including toxic pollutants contributed by different types of wastewater. This has supported marine toxicity assessments have been applied for regulatory purposes, mainly wastewater, but have also been useful for environmental monitoring, evaluating contaminated sites and identify environmental risks [2, 3].

Sensitive and practical techniques in biomonitoring are needed in all of the strategic approaches from toxic chemical rating and classification, to pollution source control, status and trends monitoring, and assessments of "marine ecosystem health", for providing accessible information to environmental managers and policy makers [4].

In particular, the fishmeal industry produces environmental impacts to coastal ecosystems due to the dumping of untreated wastewater [5, 6]. In the port of Guaymas, Mexico, where fishing 65% (~ 500,000 t yr^{-1}) of sardines in the country and where most of the industry fishmeal [7] is located has provided evidence that discharges of wastewater from industry provide excessive loads of organic matter that induce processes of hypoxia and anoxia in coastal ecosystems [8] and produce imbalance in the physical, chemical and biological properties in the sediment water and marine environment [9].

The basis of this study originated from the observation that the acidic pH and the high degree of saturation found in fatty acids of fish oils contained in wastewater could lead to toxicity in the marine environment [10]. Its relevance is that the detection of environmental toxicity in wastewater and coastal waters is important for human and ecological health [11].

The bioassay Microtox® has proven to be useful in determining the toxicity of wastewater [12, 13, 14, 15] and coastal waters [2, 4, 16]. In this study toxicity bioassays were performed with Microtox® order to know the extent of the toxicity of wastewater processing fishmeal and its effect on the toxicity of coastal receiving water body.

MATERIAL AND METHODS

Fisheries Industrial Park of the city of Guaymas, Mexico, has seven processing plants fishmeal operating during the fishing season sardine from October to August, have a capacity to process 600,000 t yr^{-1} of sardines and pour 20 mm^3 yr^{-1} wastewater Cove El Paraje. This body of water has an area of 33 hectares, an average depth of 5 m and a mouth communicating it with the sea 500 m wide.

Sampling to determine the toxicity of wastewater and coastal waters started a month after the start of sardine fishing season (November), and a month before the start of the closed season (June)

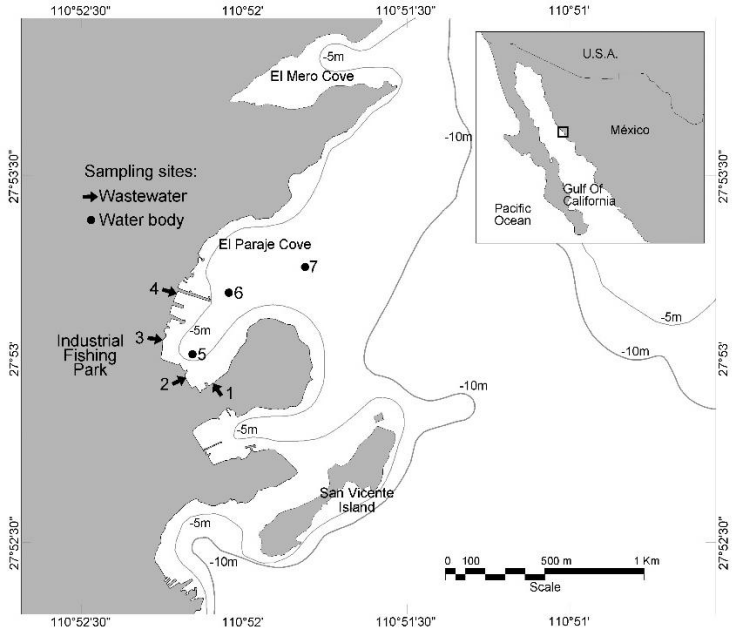

FIGURE 1
Location of the study area showing the sampling sites in the Cove El Paraje. Arrows indicate sampling sites of wastewater discharges; the dots indicate sampling sites of the receiving coastal water body.

(Fig. 1).The fieldwork consisted of collecting water samples at four sites were wastewater discharge occurs due to processing of fish meal at three sites in the Cove El Paraje that receive the wastewater. Additionally, in this body of water at each sampling site they were recorded in surface and bottom temperature, salinity, pH and dissolved oxygen in the water, using a multiparameter probe mark DataSonde 5SX Hydrolab model.

TABLE 1
Toxicity levels of Microtox bioassay.

Subjective levels	Toxicity units
Not toxic	< 1.00
Low	1.00 - 1.33
Moderate	1.34 – 5.00
High	> 5.00

The toxicity of the water samples was determined Microtox® technique, a bioassay based on examining the toxicity reducing natural bioluminescence of Vibrio fischeri marine bacterium in the presence of pollutants. Luminescence of the bacteria was detected with an analyzer Microtox model M 500 at 15 ° C in periods of 5 and 15 minutes of exposure, following the protocol manual Microbics Corporation [17]. The toxicity is expressed as the concentration of agent which produces 50% reduction of the initial luminescence (EC50) and toxicity scale shown in Table 1.

The data presented are the average of three independent determinations of the EC50 values obtained with the Microbics Corporation [18] software.

Toxicity values were analyzed by comparison of means with one-way analysis of variance.

TABLE 2
Toxicity of wastewater and in the coastal receiving water body due to the fishmeal industry in autumn and summer in the Cove El Paraje.

Period and sampling sight #	Type of sampling sight	Toxicity units		Toxicity subjective levels
		5 MIN	15 MIN	
Autumn (November)				
1	Wastewater	18.56	20.47	High
2	Wastewater	21.44	19.35	High
3	Wastewater	18.51	17.32	High
4	Wastewater	29.92	29.94	High
5	Receiving waters	1.55	1.99	Moderate
6	Receiving waters	2.65	3.95	Moderate
7	Receiving waters	<1	<1	Not toxic
Summer (June)				
1	Wastewater	3.58	4.61	Moderate
2	Wastewater	28.32	25.14	High
3	Wastewater	17.99	20.06	High
4	Wastewater	23.98	27.39	High
5	Receiving waters	3.14	3.16	Moderate
6	Receiving waters	<1	<1	Not toxic
7	Receiving waters	<1	<1	Not toxic

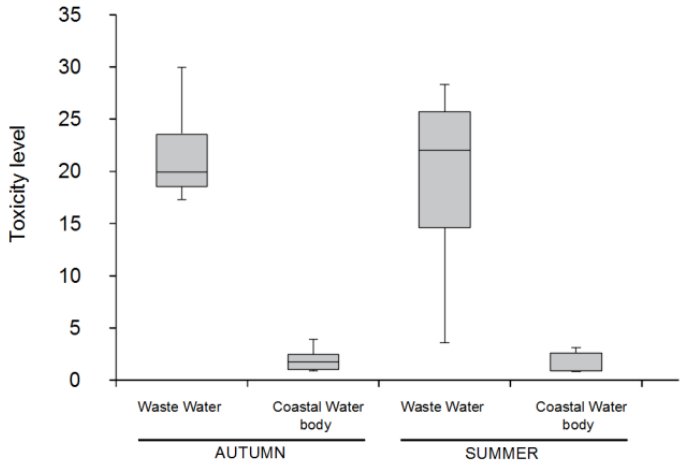

FIGURE 2
Comparative analysis of the toxicity of wastewater from the processing fishmeal and in the receiving coastal water body in autumn and summer in the Cove El Paraje.

RESULTS

In autumn, wastewater processing industry fishmeal had high toxicity (Table 2). In the Cove El Paraje moderate toxicity was observed at two sites and no toxicity at another site (Table 2). In summer, the wastewater had high toxicity at three sites and moderate toxicity at a site (Table 2). In the body of water, a site had moderate toxicity and two sites were free of toxicity (Table 2). The toxicity values showed statistically significant differences between wastewater and coastal waters (Fig. 2).

In the Cove El Paraje the changes observed between autumn and summer were that water had: (1) 10 °C higher temperature values in summer; (2) salinity variation of 1 psu with higher values in autumn; (3) similar pH in both periods prone to be acidic; and (4) dissolved oxygen was similar in both periods with a tendency to has hypoxia (Table 3).

TABLE 3
Variability of temperature, salinity, pH and dissolved oxygen water in autumn and summer in the Cove El Paraje

Variable	Autumn		Summer	
Temperature (°C)	16-22,	18.7 ± 1.5	26-31,	29.4 ± 1
Salinity (psu)	31-38,	36.8 ± 0.8	24-37,	35.6 ± 5.1
pH	6.7 – 8.2,	7.8 ± 0.3	6.4 – 8.3,	7.8 ± 0.4
Dissolved oxygen (mg L^{-1})	0.1 – 8.7,	3.7 ± 2.8	0.0 – 8.1,	3.7 ± 2.5

DISCUSSION

The Microtox® bioassay was sensitive to detect the toxicity of wastewater and receiving water body. This coincides with what was observed in contributions that have implemented this bioassay wastewater [13, 14, 15, 19,], as well as receiving water bodies pollutants toxic [2, 4, 12, 16 20], where it has been observed their sensitivity to organic and inorganic contaminants.

The results obtained by bioassay Microtox® provided evidence that: (1) wastewater processing industry fishmeal has high toxicity and (2) there is an adverse effect on the coastal ecosystem receptor showed areas with moderate toxicity. Observed in the wastewater industry fishmeal high toxicity due to the high organic matter content, acidic pH and high degree of saturation found in the fatty acids of fish oils that have been observed in previous studies [5, 9, 10].

Significant statistical difference with increased toxicity in wastewater and lower toxicity in coastal waters, is attributed to the dilution of wastewater with seawater, as well as the rate of water removal Cove (<5 days) which is induced by the ebb and flow of the tide [8]. In this regard, it is important that the influence of toxicity in the marine environment depends, firstly, the volume and extent of toxicity of the wastewater, and moreover, the volume of water and the hydrological and hydrodynamic characteristics of the receiving water body. This implies a variability throughout the year because the cost of wastewater discharged into the sea are variable. They depend on the volume of fish processed through the fishing period and also because the waterbody exhibits variability of hydrological conditions in the annual cycle, specifically the results of this study showed that the water temperature has a difference of 10 °C between summer and autumn.

Wastewater from the processing industry fishmeal have high toxicity and are effective in the cove the place where there is evidence of areas with moderate toxicity, plus the prevailing conditions of acidity and hypoxia observed reflect excessive input of organic matter by the wastewater and environmental

impact to the system by limiting the proper development of the marine life. This results highlight the importance of wastewater from industry fishmeal receive effective treatment before being discharged into the sea, and to establish a monitoring program for both the toxicity of the wastewater and the receiving coastal waterbody in order to determine the effectiveness of these actions in protecting the marine environment.

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