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Assessment of the Environmental Impact of Discharges from Fishmeal Factories Located in Levrier Bay, Nouadhibou-Mauritania

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ABSTRACT

Levrier Bay, located in the western part of Mauritanian Cost, has a strategic position in Mauritania's fish economy and reproduction environment. Recently, fishmeal factories have multiplied in the bay. This study was carried out in Levrier Bay. It is the first one in this area which is interested in assessing the environmental impact of fishmeal factory discharges by measuring several parameters such as suspended matter, chemical oxygen demand (COD), biological oxygen demand (BOD), conductivity, turbidity, and salinity. A total of 27 samples were collected at 9 sites distributed on the link between effluents from factories and the Atlantic Ocean (discharge site). Results show that some parameters are over permissible values, like suspended matter content (SS), which reached 2020 mg. L^{-1} level. The turbidity measure shows excessively high values (50 to 961 mg.L^{-1}); impacted by effluents at the reject point, the seawater conductivity and salinity are particularly low (4.53 to 188.2 and 13 to 56.4, respectively). The total organic carbon (TOC) values ranged from 200 to 780 mg/L, whereas the highest measured level of chemical oxygen demand was 4010 mg.L^{-1} Biochemical oxygen demand content ranged from 685 to 961 mg/L. The biodegradability index (COD/BOD) shows that these effluents are not easily biodegradable because the index > 3.

INTRODUCTION

The Mauritanian coastline, recognized as one of the most productive in the world, particularly illustrates the fragility of the coastal ecosystems. Their productivity and functionality are closely linked to the quality of the water that composes them. The Levrier Bay, located in the western part of Mauritanian Cost, has a strategic position in Mauritania's fish economy and reproduction environment. Recently, fishmeal factories have multiplied in the bay. They have an important economic role, but they reject effluents directly into Ocean without treatment, so Levrier Bay suffers from the discharge of untreated wastewater from fishmeal factories (Cheick et al. 2020). Water volume discharged. However, Fishmeal wastewater contains 140 g COD.$L^{-1,}$ which consists of 60% oil and grease, 27% protein, and 13% mixture of soluble organic and suspended solids (Putra et al. 2020). The fish processing industry uses large amounts of water to wash the raw product and manufacture by-products. These factories are generally located in areas with high water content, and they consume more water than needed for seafood processing processes (Ben et al. 2017)

On the other hand, effluents from fishmeal factories may lead to serious pollution problems, especially if they are not treated enough. They contain an important amount of nitrogen and organic load, which conduce, in aquatic,

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to the eutrophication phenomenon. This phenomenon is a severe problem caused by industry discharge (Bhuyar et al. 2021a, 2021b).

The most significant anthropogenic pollution is defined by the introduction through the activities of substances or energy in the marine environment that can cause harmful effects. The impact of wastewater discharges in the marine environment has long been minimized due to the significant dilution phenomena of these discharges when they contact the oceanic marine environment (Bezama et al. 2012, Ferraciolli et al. 2018, Vallejos et al. 2020).

In addition, ship-unloading operations are often carried out using pumps that transport the fish from the hold to the land. Besides seawater, pump water contains considerable amounts of fish residue and can have a wide variety of oil and fat residue. Direct discharges of industrial wastewater affect the water quality and coastal marine ecosystems (Holmer et al. 2003, Moncada et al. 2019, Quimpo et al. 2020). Changes induce a variation in physicochemical characteristics such as the salinity of the water, but also the decrease in oxygen required by marine species, the modification of nutrient concentrations, etc. (Gebauer 2004, Anh et al. 2010, Venugopal & Sasidharan 2020).

The studies that have been carried out on the levels of trace metals in fish and sediment in Levrier Bay (Legraa et al. 2019, Cheikh et al. 2020) lack information about the impact of discharges from fish processing, especially when fishmeal manufacturing is involved.

This study aims to determine some wastewater indicators, such as turbidity, conductivity, salinity, suspended solids, Chemical oxygen demand (COD), and biological oxygen demand at the reject point, to evaluate the environmental impact of discharges from fishmeal factories. It is the first one in this area that is interested in this question; Its outcomes will contribute to the global Levrier Bay environmental investigation and give wide information about the resources of environmental pollution.

MATERIALS AND METHODS

Description and Location of the Study Area

The study area is focused on the Bountiya sector located on Levrier Bay in the extreme northwest of Mauritania (Fig.1). It is characterized by strong industrial activity represented by all the factories manufacturing fishmeal and fish oil. Nine sites around fishmeal factories represent the link between the affluent and Ocean.

The samples were collected in accordance with the guidelines of international organizations (WHO 2004) and the recommendations of some literature (Rodier 2010). Briefly, the samples were collected at low tide in aseptically sterile uncolored 500 mL plastic bottles and washed

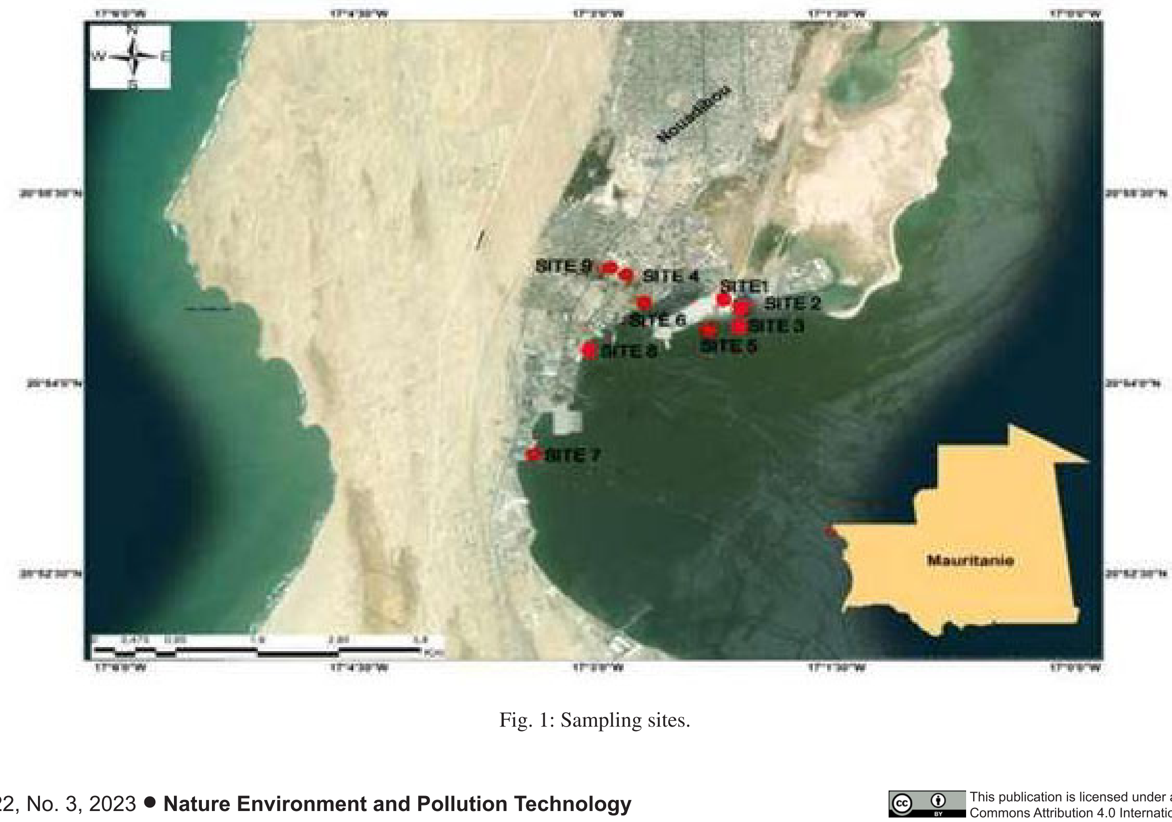

Fig. 1: Sampling sites.

Table 1: Parameters studied.

Parameters	Methods
Turbidity	NF ISO 7027-1: Water quality - Determination of turbidity - Part 1: quantitative methods
Salinity	NF 8502-9: In situ method for the determination of water-soluble salts by conductimetry
Suspended matter	NF EN 872: Water quality - Dosage of suspended solids - Method by filtration on glass fiber filter
Conductivity at 25°C	NF EN 27888: Water quality - Determination of electrical conductivity
Chemical Oxygen Demand (COD)	NF T 90 101: Water quality - Determination of chemical oxygen demand (COD)
Biological Oxygen Demand (BOD) for 5 days	NF T 5815-1: Water quality - Determination of the biochemical oxygen demand after n days (BODn) - Part 1: method by dilution and inoculation with the addition of allylthiourea
Total Organic Carbon (TOC)	MA. 415 –COT 1.0: Determination of organic carbon in effluents: oxidation by persulfate and UV rays – dosage by infrared spectrophotometry

beforehand with 10% acid baths (HCl). Then, the bottles were rinsed with distilled water and sent to the laboratory for further physico-chemical analysis. The samples were stored at a temperature below 4°C and in uncolored bottles for the shortest possible time.

Sampling deep was between 30 and 50 cm to characterize the various effluents discharged by the factories. Three samples per factory were taken. They were 30 meters from each other near the spill point (the first sample is located just at the discharge point, and others are distributed over a radius of approximately 100 m from the discharge point). The analysis was carried out by the ONISPA laboratory in Nouadhibou (Mauritania) according to the methods listed in Table 1.

RESULTS AND DISCUSSION

Effluents from fishmeal factories are discharged into the ocean without treatment. So they may pose a serious problem for the Levrier Bay environment, especially the biodiversity of aquatic ecosystems. This study assessed the concentration of certain parameters indicatives of the pollution of industrial effluents generated by the activity of fishmeal factories. The results obtained from the examination of 27 samples of seawater from 9 reject points are presented in the five figures below (from Fig. 2 to Fig. 6).

Conductivity and Salinity

The conductivity values were low and ranged from 4.53 to 188 $\mu S.cm^{-1}$ at sites 2 and 3, respectively (Fig. 2). Most sites have a conductivity value of around 50 $\mu S.cm^{-1}$. The low conductivity value in this study means that the effluents were sampled before enough time to be well mineralized or the fishmeal factories use urban water in the cleaning process.

Sea water at the ejected point has a salinity between 13 and 56.4 $mg.L^{-1}$. Only three sites have salinity very low (13, 23, and 23.4 at sites 9, 1, and 2, respectively; Fig. 3). In normal cases, sea water salinity is 36 $mg.kg^{-1}$.

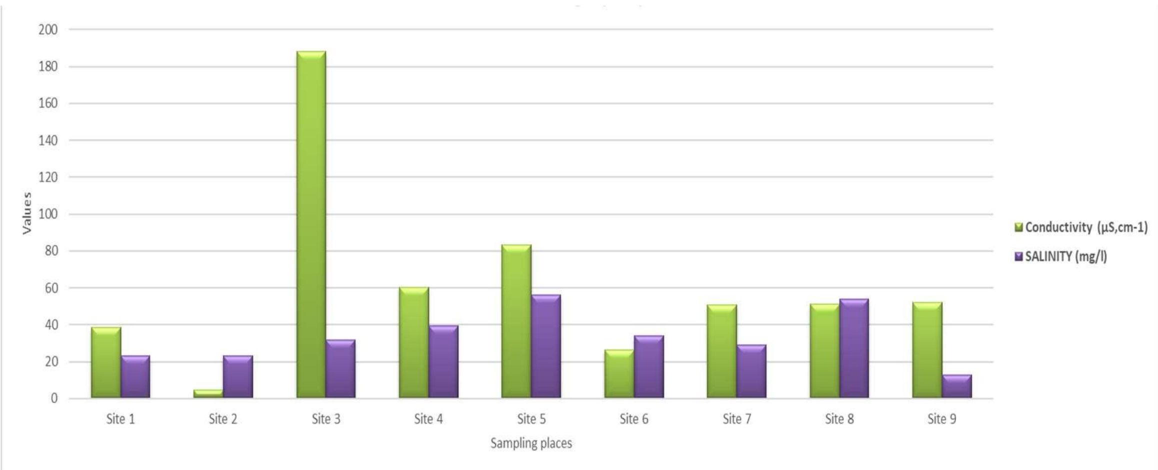

Fig. 2: Conductivity and salinity values.

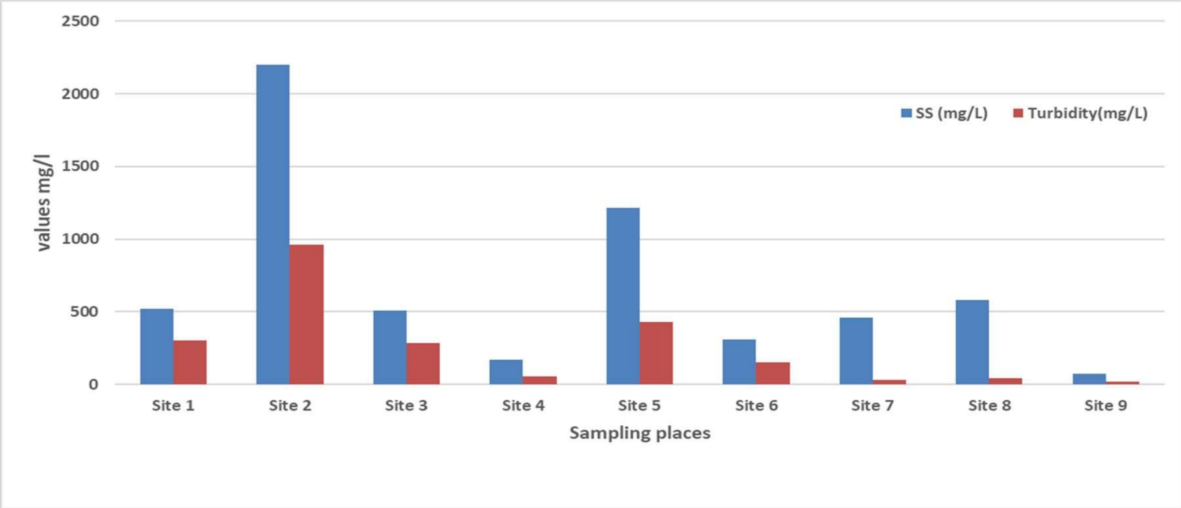

Fig. 3: SS and turbidity values.

Turbidity and Suspended Solids

The mean values of turbidity show a disparity variation between different plants. This difference is variable from 20 to 961 $mg.L^{-1}$ (Fig. 3). The highest value is found at site number 2, and the lowest is at site 9. The difference could be caused by activities period which is different from one to other.

Suspended solids concentration in the effluents of the fish processing plants measured in this study varies between 73 $mg.L^{-1}$ and 2200 $mg.L^{-1}$ (Fig. 3). Like turbidity, the difference between factory effluent SS content is linked to work period.

There is a perfect proportionality between turbidity and SS (Fig. 3). This result was found by a previous study that demonstrated a relationship of proportionality between suspended matter and turbidity. Remili & Kerfouf (2013) studied how to use turbidity to continuously estimate the concentration of suspended matter. Thus, we observe a high content of turbidity and SS at the level of Site2, which is attributed to suspended solids (SS) constituting the main vector of pollutants transported in rainy weather in the sewers. The importance of pollution from urban discharges during rainy weather and the negative impact of this pollution on receiving environments is a phenomenon highlighted in the literature as early as 1970. However, low turbidity and SS content are recorded for the sampling points least exposed to rainwater, such as Site 4.

Total Organic Carbon

The lowest total organic carbon (TOC) content (200 $mg.L^{-1}$) is found at site number 6, and the highest one (780 $mg.L^{-1}$)

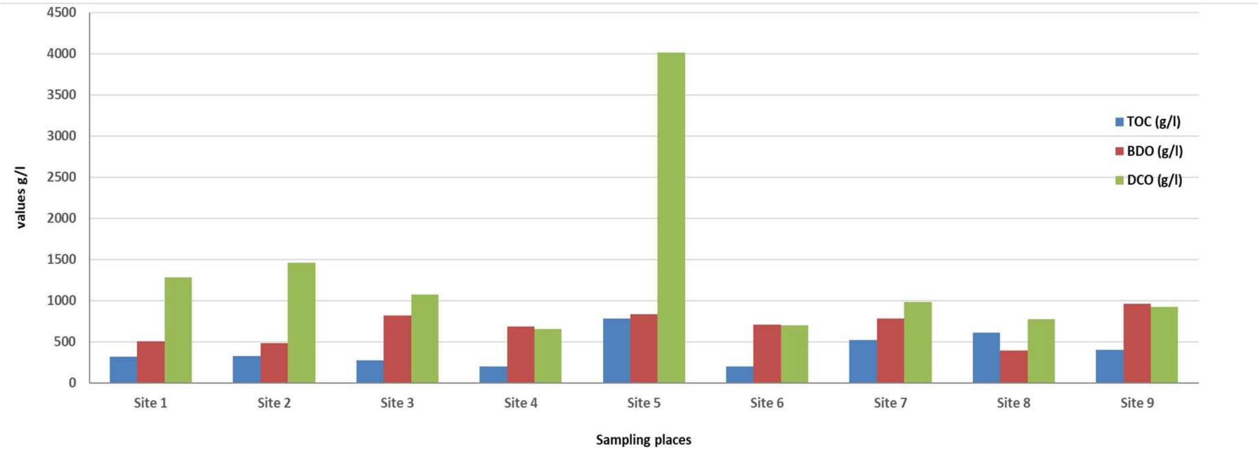

Fig. 4: TOC, $BOD_{5,}$ and COD values.

is detected at site number 5 (Fig. 4). The majority of sites have COT content comprised between 317 and 609 $mg.L^{-1}$. It reveals an additional clue showing the presence of organic matter. The wastewater from these fishmeal and oil factories contains high levels of protein and oils, so their recovery is a financially viable operation. This is partly explained by an excessive discharge of organic matter and, more particularly, in the case of site 5.

Biochemical Oxygen Demand (BOD5)

The DBO_5 values show an inequality variation between different plants. This difference is variable from 396 to 961 $mg.L^{-1}$ at sites number 8 and 9, respectively (Fig. 4). The difference could be linked to the activities period, which differs from one to another.

Chemical Oxygen Demand (COD)

COD values recorded during this study ranged from 655 to 4010 $mg.L^{-1}$. The highest value was found at site number 5 and the lowest at site 4 (Fig. 4). Most sites have COT content comprising between 774 and 1465 $mg.L^{-1}$. The chemical oxygen demand (COD) indicates the organic load in the water. It is an important parameter for water quality characterization (Mathurin & Kisto 2021).

Biodegradability Index COD/BOD

All effluents from fish processing plants points have a COD/BOD_5 biodegradability index low or equal to 3 except point 5, which has an index of 4.79 (Fig. 5). So, those effluent (that has an index low than 3) are biodegradable. However, a high value of this ratio (higher than 3) indicates that a large part of the organic matter is not biodegradable. In this case, it is better to consider the water treatment by physicochemical methods (Johan & Mizier 2004).

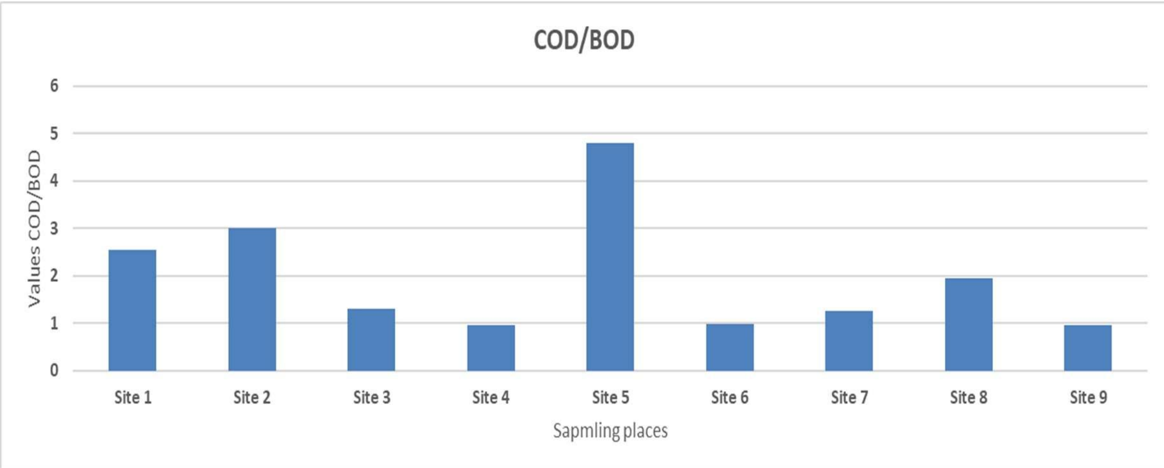

Fig. 5: COD/BOD ratio biodegradability index.

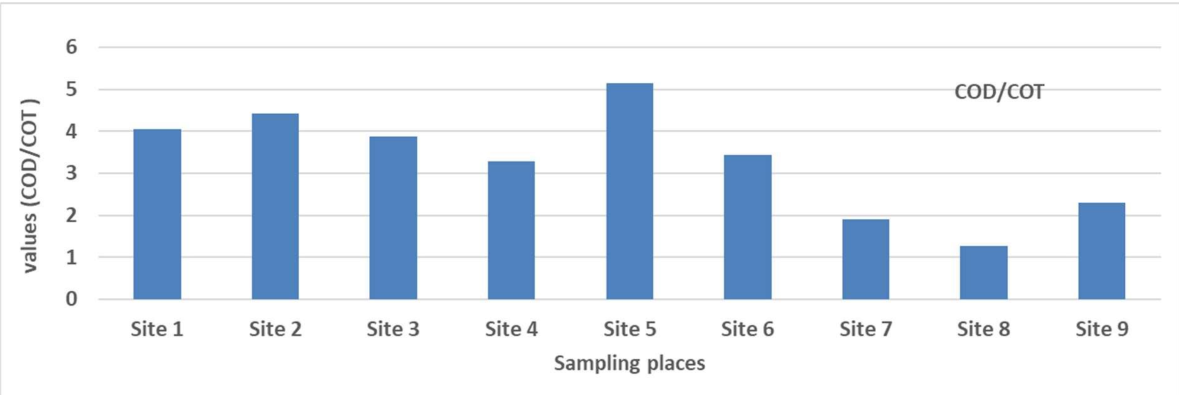

Fig. 6: COD/TOC ratio.

COD/TOC Ratio

Determining this ratio for wastewater allows the assessment of nutriment doses in treatment plants. These ratios comprise between 3.28 and 5.14 mg.L^{-1} (Fig. 6), which is extended to the ratio frequently found for urban and industrial wastewater.

As this work is the first in Mauritania interested in fishmeal factories discharged into the environment, the results will be compared with similar ones conducted in other counties (near or far from Mauritania). Table 2 summarizes the study finding.

Conductivity reflects the degree of global mineralization. It is one of the simplest and most important for wastewater quality control (Chikh et al. 2018). The low conductivity values of seawater at reject points are related to the use of pure water by Fishmeal factories. Pure water has a low conductivity, and a huge amount rejected by the factory dilutes the conductivity at the discharge place.

Turbidity and suspended solids have particularly the same meaning because they reflect the water load of insoluble substances. They give important and direct information on water quality variation (Merbouh et al. 2020). Turbidity results in this study show that effluent rejected in the environment is non-treated. Bay et al. (2017) findings show that the content of suspended solids can reach 13,980 mg/L in wastewater from fish processing. Our results are twice lower as those found by John and Mizier (2004) along wastewater discharged from fish processing plants.

Biochemical oxygen demand (BOD) indicates the amount required for oxidizing the organic matter and inorganic oxidizable contained in the sample (Chikh et al. 2018). The BOD_5 results show a similarity in the biodegradable organic matter content of the loads for the different effluents analyzed. This could be explained by the fact that all these factories use the same procedure for processing fishery products. We note that these waters have very high inputs of biodegradable organic matter. The highest levels of BOD_5 can be attributed to the concentrations of oils and fats measured in the wastewater from the butchering process. At the same time, the remaining proportion is generated during fish processing operations (Ben et al. 2007).

Other investigations on the effluents from a fish canning factory reveal levels five times higher than ours (Colic et al. 2007). Effluents from Tunna processing contain 6600 g.L^{-1} of BOD_5 (Venugopal et al. 2020), which is very high compared with effluents of fishmeal in this study. BOD values reported by Putra et al. from Japon fishmeal are very low than the literature. The difference between the value is related to the factory recycling system. Some factory reuse effluent to collect protein residues that reduce BOD.

Beannassi et al. (2004) reported that the COD content could reach 190000 mg.L^{-1} for industrial extractions of fish oils. Fishmeal effluent has 50000 g.L^{-1} as COD load (Colic et al. 2007). This load in processing plant effluents comprises total suspended solids, fats, oils, and grease. COD in effluent from Tunna processing is 11100 g.L^{-1} (Venugopal et al. 2020); however, effluents from the seafood processing plan contain 1717 g.L^{-1} (Jamieson et al. 2017). This value is comparable with ours.

COD/BOD_5 ratio results are comparable with the results of investigations by John and Mizier (2004) in an earlier study concerning the characterization of leachate from a landfill. John and Mizier (2004) showed that this ratio could

Table 2: Comparative analysis with similar studies.

Matrix	SS (g.L^{-1})	COD (g.L^{-1})	BOD_5 (g.L^{-1})	COD/BOD	Reference
Effluent from Fishmeal	173 to 2200	655 to 4000	467 to 990	0.96 to 4.79	This study
Fishmeal	30,000	50,000	30,000	0.60	Colic et al. (2007)
Effluent from tuna processing	1570	11100	6600	-	Venugopal et al. (2020)
Fish processing	-	13,180	3,250	0.25	Dhanke et al. (2019)
Effluents from seafood processing plant	27.2 to 1201	458 to 1717	179 to 276	-	Jamieson et al. 2017
Fishmeal wastewater	35 to 37	131 to 140	21 to 23	-	Putra et al. (2020)

Table 3: comparing regional and international standards (PNUE/PAM 2004).

Parameter	This study	Regional standard			International standards				
		Morocco	Algeria	Tunisia	France	Turkey	Italy	Egypt	Malta
COD mg.L^{-1}	655 to 4000	500	120	90	125	180	160	100	600
BOD mg.L^{-1}	467 to 990	100	40	30	25	50	40	60	350
TSS mg.L^{-1}	173 to 2200	50	30	30	35	60	80	60	500

be around 7 for leachate. Other high values were detected in wastewater of a fish canning plant (Ben et al. 2017); However, effluents from Fish and fishmeal processing had a ratio of less than 1 (Colic et al. 2007, Dhanke et al. 2019).

In general, all analyzed parameters have values more important than other types of non-treated effluent. This can be related to many factors, such as the type of production and the factory recycling system. In the case of fishmeal, it is normal that COD and BOD_5 levels to be very important, but this level should be reduced by treatment before it is realized in the environment. Putre et al. (2020) reported that fishmeal wastewater treatment reduces more than 94% of COD and BOD amounts.

Assessment of the Impact

The impact associated with the disposal of fish wastes into the ocean environment (seawaters) includes reduced oxygen levels in the seawaters at the ocean bottom, burial or smothering of living organisms, and introduction of disease or non-native and invasive species to the ecosystem of the sea floor. The high level of COD and BOD leads to an imbalance of phosphorus and nitrogen, which produces a proliferation of algae. Some cases were recorded in Levrier Bay at the beginning of the operation of the fishmeal factories.

We will compare the results found by regional and international standards to show the environmental situation of the discharge points of the effluents of the fishmeal factories.

Comparing Obtained Results with Regional or International Standards for Wastewater Quality

All critical parameters (COD, BOD, and SS) of effluent from fishmeal exude regional and international standards for wastewater (Table 3). These effluents will pose a serious problem for Levrier Bay if we do not act and pay for rigorous treatment of these discharges.

CONCLUSIONS

This work is the first in this area interested in the environmental impact of discharge from fishmeal factories in Levrier Bay. It concluded that the discharge had affected some seawater parameters like suspended matter content (SS) which reached a level of 2200 $mg.L^{-1}$; moreover, the turbidity shows excessively high values (50 to 961 $mg.L^{-1}$). The water conductivity and salinity are particularly low. Chemical oxygen demand (COD) and biological oxygen demand (BOD) values are very high that they are permissible, and the biodegradability index (COD / BOD) varies from 0.96 to 4.79. These effluents are not easily biodegradable (index> 3). In general, all analyzed parameters have values that exceed the international standards for wastewater, especially COD, BOD, and SS.

These results show that it is urgent to take some actions like treatment of the effluent before it is rejected into Ocean. The factories must apply serious environmental politics to protect us and our fish resources.

The outcomes of this study can be used as a reference for upcoming research and decision on fishmeal factoring, especially regarding the environmental control of this activity.

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