

Worm-Filter in the Recovery of Wastewater from the Commercial Activity of Hydrobiological Products

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The wastewater generated in the commercialization activity in specific markets for the sale of hydrobiological products has the characteristic of having a high content of organic matter from fish, shellfish and other marine products that are handled there. The wastewater generated in these places has a high potential for contamination, which, if not properly treated, would have negative environmental impacts on the receiving body. The objective of the research was to evaluate the treatment of wastewater generated in a fish market using the worm filter technology. We sought to determine the amount of substrate and earthworm (*Eisenia foetida*) in the biofilter to make the treatment more efficient; 5, 10 and 15 days of retention in the biofilter were considered. As a result, the chemical oxygen demand was reduced by 90 %, turbidity by 82 %, total suspended solids by 96 %, total coliforms by 100 %, fecal coliforms by 56 % and organic matter by 91 %. Thus, it is established that the worm filter of this type is efficient to recover wastewater from commercial fishing activity, for its probable reuse and avoiding environmental damage.

1. Introduction

The commercialization of hydrobiological products, such as fish, shellfish, algae and others, is an important economic activity in many countries of the world; however, this activity also produces an important environmental impact, associated with the wastewater produced during the capture, transport and commercialization process. It is in the commercialization stage where organic matter is mainly generated from the remains of hydrobiological products, nutrients such as nitrogen and phosphorus and toxic substances such as heavy metals and organic chemicals, all generated by the body fluids of the species and the cleaning and disinfection products used, which constitute the main pollutants in wastewater (Amin and Akter, 2022).

The negative impacts of pollutants can be on human health (gastrointestinal, respiratory diseases and cancer), as well as on ecosystems, such as eutrophication and contamination by toxic substances in aquatic environments, affecting fauna, flora and other ecosystem services.

Given this reality, the concern is to implement measures to reduce wastewater production and improve the efficiency of processes where water is used; other ways will be to look for control and treatment measures for wastewater to reduce the pollutant load, implement biological treatments or physicochemical treatments (Sánchez-Muñoz, et al., 2020); for this, it is estimated that biological processes are the most convenient from the environmental point of view, whether they are aerobic such as activated sludge, filters, rotary biological contactor to eliminate the organic load, even anaerobic processes are also used that eliminate up to 90% of organic matter and produce gas that can be used as energy (Parvathy, et al., 2017). In other cases, plant products such as palm kernel treated with NaOH are also used as a natural adsorbent to reduce turbidity by up to 85% (Al-Dawey, et al., 2023). Biofilters are also applicable for odor removal with good results (Vela-Aparicio, et al., 2022).

The application of worm-based biofilters has been used in the treatment of domestic wastewater with good efficiency (Singh, et al., 2019) and with good results (Vela-Aparicio, et al., 2022). In some cases, macrophyte plants can be incorporated into these biofilters with worms to improve the process (Samal, et al., 2017). In this context, although biofilters are efficient for the treatment of domestic wastewater, there is not much information regarding the treatment of industrial and/or commercial wastewater, so the objective of the research was to evaluate the result of the treatment of water from the handling and cleaning of hydrobiological products (fish and others) in a large-scale fishing market.

In this context, the research sought to find the efficiency of worms to improve the physicochemical and microbiological parameters of the wastewater of a fishing market, constructing 3 biofilters that differed in the number of worms in the filtration bed, proving that the waters residuals improved the quality of their parameters such as: total suspended solids, biochemical oxygen demand, Chemical Oxygen Demand, Oils and fats, Total Coliforms and organic matter in the range from 85 to 91 %, as detailed in the results.

2. Methodology

For the research, three biofilters were designed and constructed to carry out the tests in triplicate. Then, worms of the *Eisenia foetida* species were obtained and conditioned and incorporated into the biofilters. Finally, the treatment of effluent water from the industry and commercialization of hydrobiological products generated in a wholesale market was carried out.

2.1 Design and construction of the biofilter

Three biofilters were constructed according to the design shown in Figure 1. The system was then set up for treatment according to Figure 2.

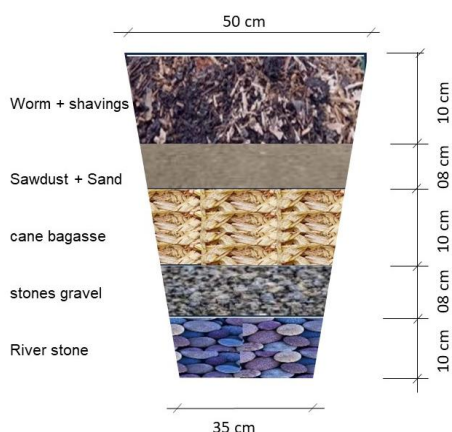


Figure 1: Biofilter design

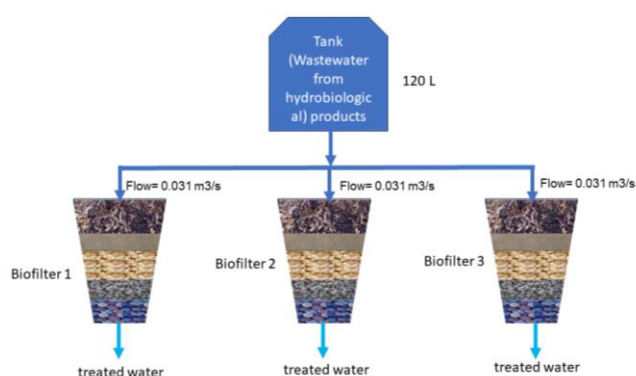


Figure 2: Biofilter system

2.2 Worm conditioning

The worms were acquired from the company LombriWasi, certifying the species called red worms *Eisenia foetida*. They were conditioned in an environment (habitat) at a temperature (between 20 to 25 °C), humidity (between 70 - 80 %) and pH (between 6.8 to 7.2), in order to habituate them before incorporating them into the biofilters.

2.3 Treatment of wastewater from hydrobiological products

The treatment was carried out by uniformly passing 120 liters of wastewater through the biofilter system, with a flow rate of 0.031 m³/s for each biofilter, the retention time was 15 days, carrying out control and sampling every 5 days. The biofilters were of similar design, except for the layer of worm next to the wood chips. The composition of this layer is indicated in the Table 1.

Table 1: Composition of worm layer

Composition	Filter 1	Filter 2	Filter 3
Earthworm <i>Eisenia foetida</i> (g)	250	500	1000
Shavings (g)	3000	3000	3000

3. Results and discussion

3.1 Environmental conditions for redworms *Eisenia foetida*

The conditioning of the worms was carried out under the parameters indicated in Table 2, carrying out monitoring and control at 0, 15, 31 and 46 days, to then be incorporated into the biofilters. This conditioning is important so that the worms adapt to the environmental conditions of the biofilter, such as temperature, humidity and composition of the substrate (so that they do not suffer stress and die), it helps the worms develop a healthy intestinal microbiota and have the ability to degrade organic matter, reproduce and form a stable, population essential for the optimal functioning of the biofilter, acclimatization of 2 to 4 weeks is recommended (Sánchez-Muñoz, et al., 2020). The earthworm species *Eisenia foetida* requires a temperature between 15 to 25 °C and a humidity level of the substrate between 60 to 80% (Barbado, 2003, cited by Paco et al., 2012)

Table 2: Parameters of earthworm habitability conditions

Control(days)	Temperature (°C)	Humidity (%)	Hydrogen potential (pH)
0 (initial)	18	57.5	6.5
15	18	80.0	7.0
31	18	77.5	7.0
46	20	70.0	7.0

3.2 Physicochemical and microbiological parameters of treated wastewater in biofilter 1

The wastewater from the management and marketing of hydrobiological products after treatment in biofilter 1, which contained 250 g of *Eisenia foetida* worms, presented the levels of physicochemical and microbiological parameters shown in Table 3. Biofilter 1 (also biofilters 2 and 3) was designed and built on the theoretical basis of the Tohá treatment (created by Dr. José Thoá) (Paico, 2017), considering the filter bed made up of five strata: Worms *Eisenia foetida* + Shavings, Sawdust + Sand, Cane Bagasse, Gravel stones and river stones; (Castillo and Chimbo, 2021). This design is very versatile and applicable to different urban waters and lately to industrial wastewater (Esquivel and Castañeda, 2022).

The level of reduction of physicochemical and microbiological parameters was evident and important, reaching a level very similar to the use of *Moringa oleifera* and activated carbon packaging biofilters (Bertolotti and Benites, 2020), it can be observed that the greatest reduction occurred from of the 15 days of treatment.

Table 3: Characteristics of the wastewater after treatment with Filter 1 (250 g de *Eisenia foetida*)

Parameters	No treatment	Treatment time (days)		
		5	10	15
Electrical conductivity ($\mu\text{mho/cm}$)	8.43	7.44	7.9	3.46
Temperature (°C)	16.5	19.1	21.3	22.5
TSS (mg/L)	345	64.52	17.21	15.18
Color (PCU)	285	125	63.23	47.23
Turbidity (NTU)	146	140.67	104.67	36.07
pH	7.43	7.01	7.15	7.75
BOD5 (mg/L)	744	453	87.22	75.07
COD (mg/L)	1118	580	141.5	124.37
Oils and fats (mg/L)	87	21.05	15.14	11.06
Total Coliforms (NMP/100mL)	240000	1200	1200	1100
Thermotolerant coliforms (NMP/100 mL)	2500	1200	1100	1100
Organic matter (mg/L)	631	87.03	63.22	56.09

3.3 Physicochemical and microbiological parameters of treated wastewater in biofilter 2

Filter 2, with 500 g of worms, showed a level of reduction similar to filter 1, according to the results shown in Table 4, indicating that the efficiency does not depend relatively on the number of worms in the biofilter, the

most important thing is the good habitability of the biofilter related to humidity (Loro, 2018), temperature (De Lima Rodríguez et al., 2013) and pH (Paico, 2017).

Table 4: Characteristics of the wastewater after treatment with Filter 2 (500 g de Eisenia foetida)

Parameters	No treatment	Treatment time (days)		
		5	10	15
Electrical conductivity ($\mu\text{mho/cm}$)	8.43	8.69	8.9	4.67
Temperature ($^{\circ}\text{C}$)	16.5	19.33	22.17	22.3
TSS (mg/L)	345	58.49	17.42	16.14
Color (PCU)	285	131.67	78.5	41.37
Turbidity (NTU)	146	143	141.33	26.27
pH	7.43	6.74	7.05	7.62
BOD ₅ (mg/L)	744	317	83.05	78.18
COD (mg/L)	1118	483	139.27	128.77
Oils and fats (mg/L)	87.03	17.22	13.73	13.04
Total Coliforms (NMP/100mL)	240000	4400	1100	1100
Thermotolerant coliforms (NMP/100 mL)	2500	1100	1100	1100
Organic matter (mg/L)	631	89.14	65.16	56.36

3.4 Physicochemical and microbiological parameters of treated wastewater in biofilter 3

In biofilter 3, with 1000 g of worms, after retention of wastewater for 5, 10 and 15 days, the control samples presented levels of physicochemical and microbiological parameters very similar to biofilters 1 and 2 as shown in Table 5, despite the fact that a greater number of worms were loaded in this biofilter; Therefore, the results corroborate the scientific theory that indicates that the efficiency in improving the physicochemical parameters of the treated water does not depend on the number of lorices, but on the conditions of their habitat to be able to act.

Comparing the three biofilters, it can be deduced that the longer the hydraulic retention time, the better the physicochemical and microbiological properties of the treated water, according to Mamyuchi, et al. (2019) indicate that the longer the hydraulic retention time, the greater the activity of the worms for the degradation and transformation of the matter, obtaining better results. Another aspect to analyse is the flow rate in the biofilter, but this was not evaluated because the flow rates in the three biofilters were the same.

A significant decrease in BOD₅ and COD was obtained, this corroborates that the use of this type of biofilters is also applicable for waters from the fishing industry with removal values similar to those achieved by Saboya (2018); It also significantly decreased the total suspended solids due to its conversion to vermicompost (Xing et al, 2015). The solids that are retained in the sawdust filter bed are consumed by the worms and are not sludge as in other cases, and can be used as fertilizer.

Table 5: Characteristics of the wastewater after treatment with Filter 3 (1000 g de Eisenia foetida)

Parameters	No treatment	Treatment time (days)		
		5	10	15
Electrical conductivity ($\mu\text{mho/cm}$)	8.43	5.31	8.09	4.18
Temperature ($^{\circ}\text{C}$)	16.5	19.33	21.93	35
TSS (mg/L)	345	52.82	17.64	17.12
Color (PCU)	285	143	66.67	49.6
Turbidity (NTU)	146	138.67	135.67	65
pH	7.43	6.35	6.82	7.57
BOD ₅ (mg/L)	744	443	89.66	76.86
COD (mg/L)	1118	543.33	143.57	131
Oils and fats (mg/L)	87	23.05	13.65	11.66
Total Coliforms (NMP/100mL)	240000	1300	1200	1100
Thermotolerant coliforms (NMP/100 mL)	2500	1200	1200	1166.67
Organic matter (mg/L)	631	87.03	63.22	56.09

By decomposing organic matter and recycling nutrients, worms can cause the release of basic cations (calcium, magnesium, potassium), as well as the activity itself of increasing microbial populations, which can neutralize the acidity of the water and increase the pH (Aishwarya et al., 2025). The same happens with the temperature, which will increase due to the energy released by the microbial processes involved in the decomposition of organic waste (Ma et al., 2020).

3.5 Percentage improvement in the improvement of physicochemical parameters of treated water in the filters

From the results obtained, in Table 6 shows the percentage improvement of water parameters. Significant improvement was achieved in TSS (95 %), BOD₅ /89.5-89.7 %), COD (88.3-88.5 %), oils and fats (85-86.6 %), total coliforms (95.5 %) and organic matter (91.1 %), values that were even within the maximum permissible limits of Peruvian regulations (D.S. N° 003-2010-MINAM, 2010).

Table 6 Percentage of variation in the physicochemical and microbiological parameters of the water after treatment, in the three filters (F1, F2, F3)

Parameters	Filter 1 (250 g of worms)	Filter 2 (500 g of worms)	Filter 3 (1000 g of worms)	Standard deviation
Electrical conductivity (%)	50.4	44.6	50.4	3.3559
Temperature (%)	112.1	35.2	112.1	44.4385
TSS (%)	95.0	95.3	95.0	0.1640
Color (%)	82.6	85.5	82.6	1.6672
Turbidity (%)	55.5	82.0	55.5	15.3156
pH (%)	1.9	2.6	1.9	0.3885
BOD ₅ (%)	89.7	89.5	89.7	0.1024
COD (%)	88.3	88.5	88.3	0.1152
Oils and fats (%)	86.6	85.0	86.6	0.9128
Total Coliforms (%)	99.5	99.5	99.5	0.0000
Thermotolerant coliforms (%)	53.3	56.0	53.3	1.5397
Organic matter (%)	91.1	91.1	91.1	0.0247

4. Conclusion

It was established that the biofilters, having as a filter bed one with a main layer of *Eisenia foetida* worms, were efficient in improving the physicochemical and microbiological parameters in wastewater from the commercialization of hydrobiological products, reaching a percentage of 95% for TSS, 90% for BOD₅, 89% for COD, and 100% for total coliforms as the most important improvement; Therefore, it is also an efficient and environmentally sustainable method for the treatment of industrial waters where further research is still pending, considering the diversity of industrial effluents..

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