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Physicochemical characterization of wastewater from the Al-Hoceima slaughterhouse in Morocco

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ABSTRACT

In the context of the current policy of sustainable management of water resources, the forecasting of pollution risks and the protection of these resources are of paramount importance. For this purpose, the quality of these resources must be safeguarded in the medium and long term. Industrial development in Morocco has made this situation worrying for all socio-economic actors. In recent years, this economic growth has been marked by the establishment of slaughterhouses that discharge their liquid waste into watercourses or sewage networks. These discharges are likely to destabilize the environmental balance in the years to come, hence the need to take responsibility for treating all sources of pollution. The clean-up of these discharges requires several steps from the identification of the various pollutants to their treatment. This is why this initial work was carried out to characterize the wastewater from the Al-Hoceima slaughterhouse and to assess the performance of the treatment plant at this slaughterhouse. The results of the physicochemical analyses showed that the wastewater generated by this slaughterhouse is characterized by a neutral pH of 7.47, a high organic load of 1280 mg O_2 L^{-1} COD, and a remarkable suspended solids content of 259 mL^{-1}. Regarding the performance of the wastewater treatment plant connected to this slaughterhouse; The results show that this plant operates very efficiently, eliminating 65% of the COD, 70.6% of the BOD5 and 65.44% of the TSS, thus eliminating the organic matter, which is 67.82%. For the microbiological charge of these wastewater, the results showed that at the entrance the concentrations of fecal coliforms are 1×10^6 UFC mL^{-1}, 15×10^7 UCF mL^{-1} fecal streptococci and 15×10^5 for yeast. The effluents discharged by the treatment plant comply with Moroccan standards.

Keywords: Slaughterhouse, Al-Hoceima, Wastewater, Organic matter, Sewage treatment plant.

INTRODUCTION

The red meat sector in Morocco has 39 million head (2/3 of which are sheep) distributed among cattle (3.2 million), sheep (19.2 million), goats (6.2 million), camels 200,000 head in 2017. And as the population increases, so does the amount. This increases water pollution due to inadequate discharge of wastewater from slaughterhouses, particularly in developing countries (Gopala *et al.* 2009). This is why the treatment of waste water from slaughterhouses has become a necessity for the development of countries, on the one hand, and on the other hand to meet the increasingly strict standards for waste water discharge and then to ensure environmental sustainability (Boukhari *et al.* 2011) .The animal slaughter industry is known for its environmental impacts due to its wastewater discharges that are highly loaded with organic matter, such as the destabilization of ecosystems and microbiological and toxicological risk (Peiffer 2002; Chatoui *et al.* 2017; Naderi *et al.* 2017; Zaribafan *et al.* 2017). The concentration of organic matter (Kitane *et al.* 2020) in slaughterhouse effluents is generally high and the residues are moderately solubilized, resulting in a polluting effect due to high levels of organic matter

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(Bustillo-Lecompte & Mehrvar 2015). Such a release into the natural environment is a threat to public health. It has the potential to destabilize the nitrogen cycle of the ecosystem and lead to eutrophication, resulting in nitrite dominance (Benkaddour *et al.* 2020) and release of toxins from cyanobacteria (Anderson *et al.* 2019), which can be found in wastewater; the discharges are harmful to human health (Anie *et al*. 2020) such as Staphylococcus spp, Escherichia coli, *Salmonella typhi* and *Giardia lamblidia* (ElOuali *et al.* 2014, Amazzal *et al.* 2018). Over-consumption of water in this sector is also a major challenge.

The aim of this work is to evaluate the efficiency of wastewater treatment at the Al-Hoceima slaughterhouse and to characterize these effluents from a physicochemical point of view.

MATERIALS AND METHODS

Presentation of the study site

The study site is a part of the Al Hoceima region, located in the north-east of Morocco on the Mediterranean coast (D'Acremont *et al.* 2014), with a surface area of 3550 km². It is bordered to the west by Chefchaouen and Taounate, to the east by Nador, to the south by Taza and by 120 km of Mediterranean coastline to the north. It has a unitary APPN sanitation network (Laghzal *et al*. 2014).

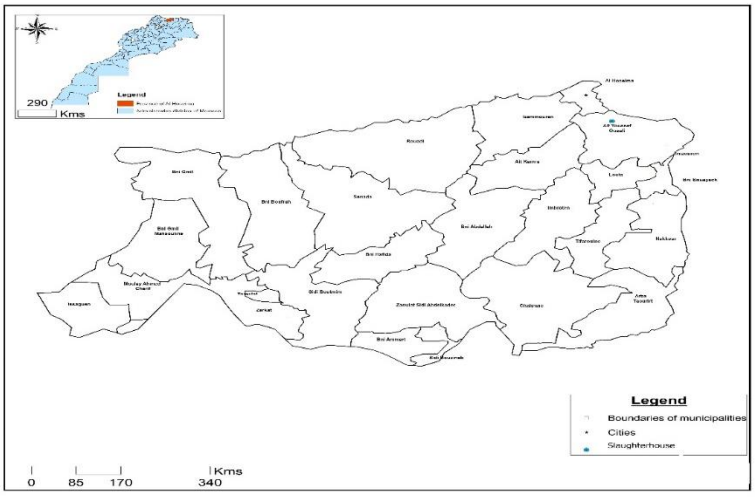

Fig. 1. Location of Al-Hoceima slaughterhouse.

This study specifically concerns the Al Hoceima intercommunal slaughterhouse (Fig.1), which opened its doors in June 2013, designed on 10,000 m^2 of surface area at a total cost of 25 million dirhams. The new slaughterhouse, which complies with the Moroccan standards of the Moroccan National Office for Food Safety (ONSSA) in terms of equipment and hygiene, has slaughter (cattle, sheep and goats) and storage rooms, cold rooms, a stabling area, a quarantine area, an incinerator, as well as a wastewater treatment plant, which was the subject of this environmental impact study in view of the large daily slaughter production capacity of 100 cattle and 150 sheep and goats. The latter is equipped with a clarification tank and screening devices that are essential for the pre-treatment phase (Robertson *et al*. 2000).

Production potential

Following several visits to the Al-Hoceima slaughterhouse, we have determined that the number of animals slaughtered in 2019 is 16,452 animals. The following figure 2 illustrates the number of slaughterhouses by type.

The Al-Hoceima slaughterhouse more to the main production which produces meat, it generates two by-products, solid waste and liquid waste are the ones we studied in this study.

Sampling

Regarding the sampling component, the physicochemical parameters (Elabdouni *et al*. 2020) are determined from bi-monthly samples (between February and June 2019) taken at the municipal slaughterhouse of Al-Hoceima. All representative samples for chemical analysis were extracted during peak morning and/or early afternoon hours. Raw sewage was collected, as an entry point, after screening, since this sample did not include washing water (Ort *et al*. 2010). The second sample was taken from the settling pond, containing the washing liquid effluent. The last

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sample was taken after primary treatment, at the outlet of the treatment plant. The samples were carefully stored according to the criteria specified in the general guide for the storage and handling of samples according to ISO 5667/3 (Dimane *et al*. 2016).

Physicochemical Parameters

In order to achieve the objectives attributed to this study, the methodology adopted was based on the monitoring of several physical and chemical parameters characterizing the wastewater from the Al Hoceima inter-municipal slaughterhouse; The parameters determined in situ were pH, temperature and electrical conductivity, while the overall quality parameters analyzed in the laboratory were Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD_5) (Merimi *et al*. 2017), Suspended Solids (SS) and chloride content.

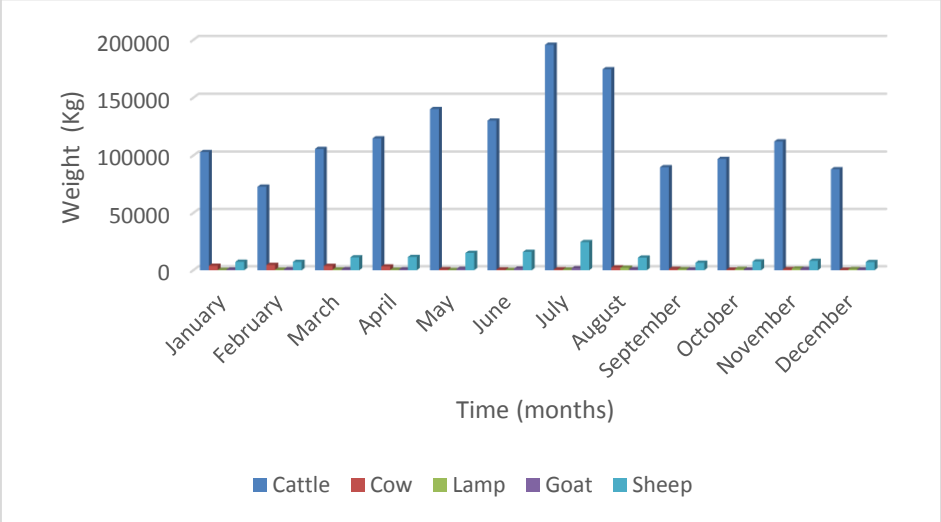

Fig. 2. Production of Al-Hoceima slaughterhouse in 2019.

Fig.3. Sampling point.

Fig. 4. Coliform test.

Microbiological analyzes

The sampling was carried out under strict aseptic conditions to avoid accidental contamination during handling. It was carried out in sterile vials which are carefully labeled, kept in a cooler kept at temperature (4 °C) and transported to the laboratory in the same day for testing analyses of the Alhoceima slaughterhouse examined the counts of total and fecal coliforms (CT and CF) and yeast (L). A series of cascading dilution in sterile distilled water was performed from 10^{-1} to 10^{-9} dilution. The dilutions were obtained in test tubes from 1 mL of solution and 9 mL of sterile distilled solution. One mL of each dilution was deposited in three tubes containing 10 mL^{-1}

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sterilized culture medium. All tests were repeated three times low (Kharrati *et al*. 2001). Figs. 3 and 4 depict the sampling point and coliform analyses.

RESULTS AND DISCUSSION

Physicochemical characteristics

The Physicochemical characteristics of slaughterhouse wastewater are presented in Table 1.

Table 1. Physicochemical parameters of wastewater from the Al-Hoceima slaughterhouse.

Parameters	Sample 1 Input measured values	Sample 2 Measured values to the decantation Basin	Sample 3 Values measured at the outlet	Station performance
Temperature (°C)	19.8	20.7	21.1	-
pH	7.47	7.32	6.97	-
Electrical conductivity (mS^{-1} cm)	4.69	3.1	1.2	40%
COD (mg O_2 L^{-1})	1280	1008	448	65%
BOD_5 (mg O_2 L^{-1})	740	460	220	70.2%
TSM (mg L^{-1})	259	201	89 .5	65.4%
Chloride (mg L^{-1})	124.09	142 .8	124.04	-

The results of the physicochemical analyses show that the sample studied has an electrical conductivity of about 4.69 mS cm^{-1} and has a neutral pH equal to 7.47. Indeed, the blood present in this type of effluent contains mainly complexes concerning the organic matter expressed in terms of BOD_5 and COD. The analyses indicated that the effluents at the inlet are rich in organic matter. Thus, according to Table 1, the values obtained can reach 740 mg O_2 L^{-1} (BOD_5) and 1280 mg O_2 L^{-1} (COD), exhibiting that the high oxygen demand for the complete oxidation of the organic matter contained in these effluents which reflects their very high polluting powers. Although the SM content is of the order of 259 mg L^{-1} which indicates that the majority of the polluting matter fractions of these effluents is in soluble form, however, the chloride content of this sample taken at the inlet is of the order of 124.09 mg L^{-1}, similar to those presented in the literature (Khennoussi *et al*. 2013). The temperature plays a very important role in all chemical reactions. The temperature recorded at the outlet which was about 21.1°C, was in accordance with the Moroccan standards. It is lower than the limit value for direct discharges into the receiving environment set at 30 °C (Ministère 2013).

In the case of pH, which influences the growth of microorganisms (Mazhari & Ferguson 2018) and indicates the alkalinity of the wastewater, the value obtained at the outlet indicates a relatively neutral sample 6.97. This value is within the range proposed by the literature (5.5 - 9.5; ONEP & GTZ 1998) and it does not go out beyond the 6-9 limit. Electrical conductivity is used to estimate the level of effluent mineralization and is considered one of the essential parameters for wastewater quality control. At the outlet point, we obtained an electrical conductivity of about 1.2 mS cm^{-1} which is close to that found by Gauri (2006). Comparison of the electrical conductivity values at the level of the wastewater (Mohammadi & Fataei 2019) analyzed with the limit value for direct discharge into the receiving environment of 2.7 mS cm^{-1} allows us to deduce that this wastewater is within the standards. Suspended solids are all the solid, organic or mineral matter contained in wastewater. They allow a good evaluation of the degree of pollution of a water. Most of the pathogenic microorganisms contained in wastewater are associated with TSM. The SM concentration measured at the outlet is about 89.5 mg L^{-1}, this value does not exceed the limit value for indirect discharge which is 600 mg L^{-1} (ONEP & GTZ 1998). The BOD_5 and COD values of the outlet samples are in the order of 220 mg O_2 L^{-1} and 448 mg O_2 L^{-1} respectively. These values are lower than the limit values for indirect discharges, which can reach 500 mg L^{-1} for BOD_5 and 1000 mg L^{-1} for COD. The following Fig. 5 shows the variation in organic matter and TSM for the three sampling points. Analyses show that the wastewater treatment plant at the Al-Hoceima slaughterhouse is remarkably efficient, since it removes 65% of COD, 70.6% of BOD_5 and 65.44% of TSM; that is to say, 67.82% of organic matter is removed. For a better appreciation of the origin of the pollution of the studied effluents, the COD/BOD_5, BOD_5 /COD and MES/BOD_5 ratios must be determined. The values obtained as well as the estimate of the Oxidizable Matter (OM) are presented in Table 2.

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Table 2. Al-Hoceima slaughterhouse wastewater ratios.

Ratios	To the entrance	At the decanting basin	At the outlet
OM (mg L^{-1})	920	642.6	296
COD/BOD_5	1.72	2 .19	2.03
BOD_5 / COD	0.57	0.45	0.49
TSM/ BOD_5	0. 35	0 .43	0.40

To characterize industrial pollution, the BOD_5/COD ratio (Cossu *et al.* 2017) is often considered, which gives very interesting indications on the origin of wastewater pollution and the appropriate methods for its treatment.

Based on the following rule:

BOD_5 / COD: The report indicating the biodegradability of an effluent.

BOD_5 / COD > 0. 6: the effluent is biodegradable.

0. 6 > BOD_5 / COD > 0. 3: the effluent is partially biodegradable (Ministère 2013).

For our samples, the ratio is 0.57. This is the general case for discharges loaded with organic matter. This organic load makes the wastewater quite unstable, that is to say that they evolve quickly into forms "digested" forms with the risk of odors.

For the COD/BOD_5 ratio, it is possible to deduce whether the wastewater discharged has characteristics of domestic wastewater (COD/BOD_5 ratio less than 2.5) and gives an assessment of the biodegradability of its wastewater. Wastewater from the Al-Hoceima slaughterhouse has an average rate of 1.72 at the inlet and 2.03 at the outlet. It can be concluded that the wastewater from these discharges has a domestic character, with a high organic load and is easily biodegradable, the results of this report are an indication of the importance of pollutants that are not or cannot be biodegraded.

The usual TSM/BOD_5 ratio values are between 1.2 and 1.5. This ratio explains the percentage of sedimentation of suspended solids in relation to the organic load (ONEP 1998).

The values obtained from the MES/DBO_5 ratio are low in comparison with those of the usual ratio. They are of the order of 0.35 at the station inlet, 0.43 at the settling basin and 0.40 at the outlet; the low concentrations are due to the rapid sedimentation of the SM.

For oxidizable matter, the values obtained are as follows: 920 mg/l at the inlet, 642.6 at the settling pond and 296 at the outlet.

Microbiological characteristics

This study was devoted to the enumeration of the microbial load of liquid waste from the Al-Hoceima slaughterhouses. The effluents show a load of microorganisms as indicators of fecal pollution with average values of 1×10^6 CFU L^{-1}, 15×10^7 CFU L^{-1} and 15×10^5 for fecal coliforms, fecal streptococci and yeasts. Despite the existence of these microorganisms, there is no danger of contamination of the population or animals, since the effluent treated by the slaughterhouse filter treatment plant are collected in the sewage system.

CONCLUSION

Slaughterhouses are places where water consumption is very important because of the many uses to which it is put. Wastewater from these industries has an impact on the environment. For example, the present study made it possible to measure the physicochemical characterization of the effluents of the Al Hoceima inter-municipal slaughterhouse in the raw state and after treatment in order to monitor the performance of the treatment plant. The results of the physicochemical analyses showed that the wastewater generated by this slaughterhouse is characterized by a neutral pH, a high organic load and a remarkable content of suspended matter. In the majority of treated effluent samples, the purification performance was 70.6% for BOD_5 and 65% for COD. The removal of suspended solids in the treated effluent was also successful, with average effluent concentrations at the outlet not exceeding 89.5 mg L^{-1}, with a 65.44% efficiency. We have concluded that the effluents discharged by the treatment plant do not exceed the values required by Moroccan standards. So that, the quality of these effluents at the outlet and the satisfactory yield make it possible to accept the future throughput of the slaughterhouse while maintaining a safety margin. The interventions necessary to maintain or achieve a good level of performance.

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Although microorganisms are present, there is no risk of contamination of the population or animals, since the effluents are treated by the slaughterhouses. In addition, the quality at the exit is very satisfactory and the water is reused by the slaughterhouse for cleaning. We have concluded that the effluents discharged by the treatment plant do not exceed the values required by Moroccan standards, so that the quality of these effluents at the outlet and the satisfactory yield make it possible to accept the future throughput of the slaughterhouse while maintaining a safety margin. The interventions necessary to maintain or achieve a good level of performance. In addition, the quality at the exit is very satisfactory and the water is reused by the slaughterhouse for cleaning.

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