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PHYSICO-CHEMICAL CHARACTERIZATION OF WASTEWATER FROM SLAUGHTERHOUSE: CASE OF RABAT IN MOROCCO

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ABSTRACT

Several environmental and health problems caused by industrial and domestic wastewater were identified scientifically decades. Slaughterhouses are probably typical example of those industries where water is used for washing by-products (offal) and the disposal of waste (feces, debris paunch and blood).Our main objective is to characterize the wastewater from the municipal slaughterhouse in the city of Rabat, in order to recommend appropriate treatment to their reuse, reducing their impact on the receiving environment (the Atlantic coast) and enjoy this rich water source into reusable materials. The physicochemical characterization of raw sewage revealed significant organic matter load varying between 668 mg/L and 1203 mg/L. The TSS concentration wastewaters analyzed vary between 603 mg/L and 1068 mg/l with an average of 835 mg/L. The temperature of the water remains below 30°.The pH is relatively neutral, whereas the electrical conductivity varies between 590 microseconds/cm and 1910 microseconds/cm. The turbidity varies between 590 and 1384 NTU. The mean levels of nitrates and Orthophosphates respectively of the order of 2.65 mg /Let 0.1mg/L. This wastewater has a high organic load in terms of COD that varies between 960 and 2018 mg O_2/l and BOD_5 fluctuates between 470 and 960 mg O_2/l. However the COD/BOD_5=2.20, indicating a satisfactory biodegradability of these releases. Biological treatment therefore seems entirely appropriate to their reuse one hand and reducing their impact on the receiving environment (the Atlantic coast). Analysis of heavy metals from wastewater from the slaughterhouse of Rabat, show relatively low concentrations do not exceed 0.5 mg/L. These values meet Moroccan standards of water quality for irrigation.

Keywords: waste water, slaughterhouse, physicochemical characteristics, receiving environment treatment.

1. INTRODUCTION

In the current context of the policy of sustainable management of water resources, the prediction of the risk of pollution and protection of these resources are of paramount importance. For this, the medium and long term backup of the quality of these resources is essential.
However, water is an essential element of most large food processors of animal origin. After being used, the largest part of the process effluent is returned to the environment. As this water is usually loaded with organic matter, it becomes an important source of pollution of the receiving environment which receives it. These food processing industries include abattoirs. These produce effluent partly because they put the body fluids of animals slaughtered in contact with the external environment, partly because they consume water as a solvent for cleaning tasks. In Europe, the volumes of waste water discharged are measured between 6 and 9 liters per kg of bovine carcass, and from 5 to 11 liters per Kg of pig carcass [1]. The effluents of these slaughterhouses are characteristic and require appropriate treatment (separation of solid waste and fat, specific treatments). Several studies have focused on the characterization and treatment of this type of wastewater through treatment plants either aerobic or anaerobic processes. Other treatment methods are adopted for slaughterhouse wastewater treatment namely infiltration of sand and electro coagulation [2-6]. Slaughterhouses by their natural food generate liquid having a very substantial pollution load and often produce a negative impact on the natural environment.

The municipal slaughterhouse in the city of Rabat (Morocco), the subject of this study, has a design capacity of about 5700 tons of carcasses slaughtered annually generating over 720 tons of waste [7]. The present work is to assess the effluents of the municipal slaughterhouse in Rabat, then make a physicochemical characterization by determination of some major and global parameters of the waste water pollution.

2. MATERIALS AND METHODS

2.1 Study site

Rabat is the capital of the Moroccan Kingdom, situated on the left bank of the estuary of the Bouregreg, extended over an area of 118.5 km^2. [2] It has a municipal slaughterhouse opened in 1956, with an area of 1800 m2, which is a part of the traditional municipal slaughterhouses, located in one of the most popular neighborhoods (Yacoub Al Mansour) of the Capital (Figure-1). According to statistical data of 2014, the production of red meat is 787.835 tons, 82% of sheep origin, 16% of cattle origin and 2% of goat origin. Discharges from wastewater are quite loaded by solid waste, grease materials, with plenty of organic matter (debris rumen) and a relatively high concentration of the blood of slaughtered animals [8].

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Figure-1. Block diagram of the slaughterhouse in the city of Rabat.

2.2 Sample

To characterize wastewater from slaughterhouse, the sample was taken at the global rejection of the slaughterhouse. The latter evacuated (Figure-2):

- The diluted blood with soil washing water during slaughter operation
- rumen Wash water and rumen contents during evisceration operation,
- The waters of the great cleaning rooms at the end of the slaughtering operation.

Figure-2. Total rejection of Yacoub El Mansour slaughterhouse.

2.3 Characterization of discharges

Conservation of wastewater samples was done according to the general guide for the preservation and handling of samples according to ISO 5667/3. [9]

The pH and temperature were determined by a pH meter 206 Lutron provided with a probe measuring the temperature. The electrical conductivity was measured by a type of conductivity meter WTW LF90.La turbidity was determined by turbidity HACH 21009. The SS (suspended solids) are determined by filtering a volume of waste water on cellulosic filter (0.45 microns) according to Rodier. COD is determined by the oxidation, in an acid medium by excess potassium dichromate at a temperature of 148°C, of oxidizable material under the conditions of the assay in the presence of silver sulfate as a catalyst and mercury sulfate as a complexing [10]. BOD_5 is determined by the breathing method using a meter-mark BOD WTW OxiTop, according to DIN described [11] technique. The orthophosphates are determined by the colorimetric method by phosphomolybdic complex according to DIN [12]. Nitrates are determined by the spectrophotometric method (sodium salicylate), chlorides was carried out by Mohr's method.

Concerning trace metals (Cd, Cr, Cu, Fe and Pb) of raw wastewater are determined at the National Center for Scientific and Technical Research (CNRST) in Rabat.

3. RESULTS AND DISCUSSIONS

The physicochemical results of raw sewage from Rabat slaughterhouse were illustrated in Table-1.

Table-1. Physico-chemical parameters of wastewater from the slaughterhouse Rabat.

Parameters	Max.	Min.	Medium	Ecart-type	Number of sampling
T°C	24.60	15.60	19.06	3.73	9
pH	7.71	6.76	7.33	0.29	9
Turbidity (NTU)	1384.00	590.00	853.11	258.39	9
E.C (µs/cm)	1910.00	590.00	1211.56	401.98	9
BOD_5 (mg/l)	960.00	470.00	640.89	186.95	9
COD (mg/l)	2018.00	960.00	1385.78	427.43	9
MES (mg/l)	1068.00	603.00	834.89	161.13	9
Organic matter (mg/l)	1203.00	668.00	960.56	156.26	9
Nitrates (mg/l)	3.53	1.70	2.65	0.87	9
Chlorides (mg/l)	480.00	230.00	320	115.76	9
Orthophosphate (mg/l)	0.24	0.04	0.10	0.08	9

The temperatures of these 9 samples of wastewater from the slaughterhouse vary between 15.6°C and 24.6°C with an average value of about de19.06°C (Table-1). These values remain below the limit value of direct discharge into the receiving environment (30°C). Similarly, these values are considered indicative limit value for water for irrigation (35°C) [14] (Table-2).

The pH remains somewhat variable with relatively neutral values, ranging from 6.76 to 7.71 (Table-1). These values are in the range of Moroccan standards of water quality for irrigation and in between the limits of direct discharges (Table-2). These values are comparable to those found elsewhere in the wastewater of abattoirs in Canada and El Jadida which generally have a neutral pH to slightly basic [15-17]. However, they are different from those encountered at the slaughterhouse wastewater of Burkina Faso [18].

Generally, MES involved in the composition of water by effect of ion exchange or absorption on both chemical elements in trace and microorganisms and it shows the particles inorganic and organic contained in the effluent. MES concentrations of wastewater from the slaughterhouse are between 603 mg/L and 1068 mg/L (Table-1). However, the organic filler ranged from 668 mg/L and 1203 mg/L with a mean value of 960 mg/L.

The average values of TSS in the analyzed wastewater are greater than the value set by Moroccan standards of indirect release (600 mg/L) and acceptable standards of water for irrigation (2000 mg/L) (Table-2). These values are quite high compared to results found in the slaughterhouse of Kenitra [19].

The conductivity values recorded (at wastewater analyzed) fluctuate between 590 microseconds/cm and 1910 microseconds /cm with an average of 1211.56 microseconds/cm (Table-1). These levels could be explained by mixing between the waste water and the strongly mineralized municipal slaughterhouse waste connected to the main collector of the slaughterhouse. Comparing the values of electrical conductivity in wastewater analyzed with the standards of quality of water intended for irrigation can be deduced that the waste water is acceptable for crop irrigation. Similarly, these values remain below the limit value (2700 microseconds/cm) for direct discharge into the receiving environment [15] (Table-2). Chlorides Values in the waste water are between 230 mg/L and 480 mg/L with 320 mg/L as mean value (Table-1).

BOD_5 is an expression to indicate the amount of oxygen that is used for the destruction of decomposable organic materials by biochemical processes. The organic pollution values expressed in BOD_5 have more or less significant variations, fluctuating between 470 mg/L (minimum) and 960 mg/L (maximum value) with an average value of 641 mg/L (Table-1). The high values of BOD_5 could be explained by the abundance of organic material (belly debris), and the concentration of the effluent through the blood of releases drained from the municipal slaughterhouse. The values of BOD_5 fluctuate between 470 mg/L and 960 mg/L, these values exceed the limit values for the various indirect discharges (500 mg/L) [14] and comparable to those found at the slaughterhouse of Congo [20].

COD has a fairly wide variation, ranging from 960 mg/L 2018 mg/L with an average of 1385 mg/L, having a significant change during the study period; this can be explained by the influence of the operation of the bleeding and evisceration (Table-1) [7]. These values are higher than those of Moroccan urban water (500-1500 mg/L) [8]. Similarly, the wastewater is classified as very bad by the standards of quality of surface water [14] (Table-2).

The pollution load of waste water, as measured by the DCO, is one of the most important criteria used in the design of a wastewater treatment to determine the degree of treatment required [21]. Furthermore, these values are lower and are not consistent with those reported at Kenitra and Congo slaughterhouses [19, 20].

Viewpoint heavy metals, waste water from Rabat slaughterhouse, show relatively low concentrations that do not exceed 0.5mg/L. Thus, the concentration of cadmium, 0.019 mg/L, Chrome 0.006 mg/L, copper 0.005 mg/L, 0.005 mg/L of iron and 0.046 mg/L of lead. These values meet Moroccan standards of water quality for irrigation [13].

The ratio COD/BOD_5 is important for the definition of the effluent treatment chain (ratio COD /BOD_5 less than 3) (ONEP and GTZ. 1998). Indeed, a low value of the ratio COD/BOD_5 implies the presence of a large proportion of biodegradable materials and allows considering biological treatment. The result of this report is 2.20 which emphasizes that the effluent from Rabat slaughterhouse is of a biodegradable nature and a biological treatment therefore seems entirely appropriate.

The nitrogen present in the waste water may have an organic or inorganic nature. Organic nitrogen is mainly a component of proteins, polypeptides, amino acids and urea. The mineral nitrogen including ammonium (NH_4^+), nitrites (NO_2^-) and nitrates (NO_3^-) constitutes the major part of total nitrogen. Very high values of total nitrogen (Nt) were recorded in wastewater slaughter of Brazil (between 133 and 179 g/L) and an average grade of 163.7 mg NH_4^+/L [17]. At the level of sewage slaughter of Kenitra, a mean value of 1.742 mg/L [19], while the levels of nitrates in the effluent of the Rabat slaughterhouse vary between 1.74 mg/ L and 3.53 mg/L with a mean concentration of 2.65mg/L (Table-1). According to water standards for irrigation (50 mg/l), wastewater of Rabat slaughterhouse can be used in irrigation [14] (Table-2).

Phosphorus compounds exist in natural water and waste water in various forms namely soluble orthophosphate, water-soluble phosphates and derivatives organophosphates [22]. The levels recorded in orthophosphate show no significant variations during sampling cycle made. The found values vary between 0.04 mg/L and 0.24 mg/L with a mean value of 0.1 mg/L (Table-1). At the level of slaughterhouse wastewater in the city of El Jadida, an average content of orthophosphate in the order of 1.8 g/L [16].

Table-2. Limit values for different releases either direct (rainwater), indirect (waste water) or water for crop irrigation [14].

Parameters	direct rejection value	indirect rejection value	Water for irrigation
T °C	30	30	35
pH	6.5-8.51	6.5-8.51	6.5-8.51
BOD_5 (mg/l)	100	500	-
COD (mg/l)	500	1000	-
MES (mg/l)	50	600	2000
Conductivity (µs/cm)	2700		8700
Bicarbonate (HCO_3^-) (µs/Cm) spraying Irrigation	-	-	518
Sulfate (mg/l)	-	400	250
Kjeldahl nitrogen (mg/l)	30		
Total phosphorus (mg/l)	10	10	
Chloride (Cl)(mg/l)	Chlore actif Cl_2(0.2)	-	surface Irrigation (350) spraying Irrigation (105)
N-NO_3 (mg/l)			50

Evaluation of the organic wastewater pollution

For a better understanding of the origin of these wastewater effluents studied the municipal slaughterhouse of Rabat, the reports calculation COD/BOD_5, BOD_5/COD, TSS / BOD_5 and estimating material Oxidizable (MO) have very important interests of the degree of pollution of slaughter raw effluent (Table-3).

Table-3. Rations wastewater from the slaughterhouse of Rabat.

	Min	Midum	Max
COD/BOD_5	1.570	2.20	3.50
BOD_5/COD	0.489	0.49	0.475
MES/BOD_5	1.28	1.3	1.11
Oxidizable materials (mg/L)	630	850	1300

Waste water from the municipal slaughterhouse have an average ratio of COD/BOD_5 which is 2.20 mg/L

in line with that of urban wastewater for domestic dominance with a COD/BOD_5 less than 3 [8]. So we can conclude that even if the wastewater of this urban rejection have high organic load, they are easily biodegradable. Consideration of this report underlines the biodegradability of mixed wastewater of the municipal slaughterhouse, to which a biological treatment seems entirely appropriate. These results are consistent with those of wastewater from the city of Fes and municipal slaughterhouse of Sidi Slimane [21, 23] (Table-3).

Similarly, there is a significant linear correlation between COD and BOD_5 of the wastewater with a correlation coefficient (R) of about 87% and an equation of Y = 211.81 + 1.6856X (Y = COD and BOD_5 = X) (Figure-3).

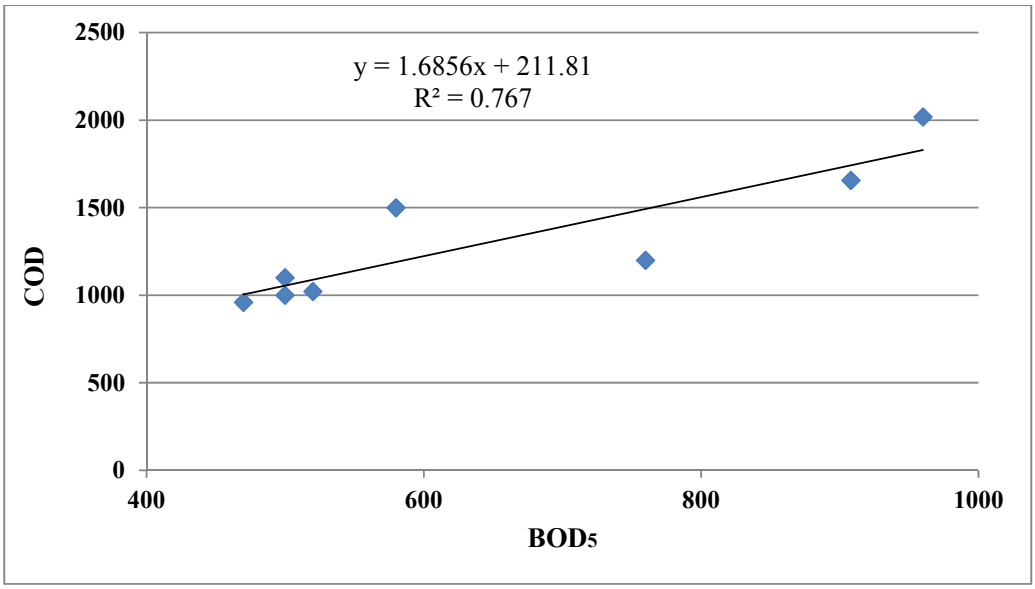

Figure-3. Correlation established between BOD_5 and COD wastewater rejection of the slaughterhouse Rabat (Morocco).

To characterize industrial pollution is often considered the BOD_5/COD, which tells us about the origin of sewage pollution and its treatment options. For our study, this ratio is relatively high in the order of 0.49 (Table 3). This is the general case for discharges loaded with organic matter. This organic load makes this wastewater rather unstable, is they quickly evolve towards forms "digested" with the risk of odors. Indeed, the wastewater of this collector is predominantly organic. [19]

The fact that the BOD_5/COD ratio is 0.49, this result is confirmed by estimating the Oxidizable material, which is of the order of 850 mg/L with an average ratio of MES/DBO_5 de 1.3 mg/L. This allows us to deduce that the organic load in the waste water of this collector is readily biodegradable [24].

CONCLUSIONS

Slaughterhouses are places where water consumption is very important because of the multiple uses made. The wastewater from these industries is not without impact on the environment. This study allowed to proceed to the physicochemical characterization of wastewater from the slaughterhouse of Rabat which present major pollution values that exceed relatively the general limits of direct and indirect discharges into receiving waters (the Atlantic coast) which represents a risk of environmental pollution for the latter where the need for treatment of the raw sewage. After assessing the degree of organic pollution, we can see that all of the parameters (especially BOD_5, COD and TSS) classify the analyzed wastewater in a high concentration range. [25] Moreover, according to the classification of urban effluents conducted by the National Office of Drinking Water, the waste water is 5 to 7 times more loaded with organic matter that Moroccan urban water [8]. In addition to organic matter they contain adequate amounts of organic nitrogen to support the purifying microorganisms of the biological systems; however, orthophosphate with low concentrations can present a problem for biological treatment. [26] It can be concluded that wastewater for rejection are biodegradable although reports BOD_5/COD and SS/BOD_5 are high. The review of the COD/BOD_5 underlines the biodegradability of wastewater from the slaughterhouse to which a biological treatment seems entirely appropriate. The treatment of wastewater is required to produce an effluent that meets the standards of direct and indirect discharges according to the Ministry of Environment of Morocco. [14] The Rabat slaughterhouse generates waste water that is suitable for biological treatment in terms of BOD_5, TSS, and nutrients (nitrate and orthophosphate).

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