ISSN 2321-807X

Physicochemical characterization of municipal wastewater slaughterhouse for the implementation of a suitable treatment (Maradi city -Niger Republic)

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Abstract

The goal of this study is to determine physicochemical characteristics of the effluent of the municipal slaughter-house of the Maradi city and to recommend a suitable treatment allowing it's recycling, thus reducing the harmful effect which undergoes the receiving environment. The experimental results obtained showed that average values of pH, temperature, turbidity and conductivity are respectively of 7.3, 26.6°C, 326 NTU and 4720 µs/cm. Average concentrations in phosphorus, phosphate, nitrite, nitrate, calcium, calcium carbonate, magnesium, iron, fluor and organic matter, in milligram per liter, are: 0.73, 2.23, 1.7, 211.64, 148.33, 8.53, 42, 9.24, 0.15, 32.08 and 426.67, respectively.

Keywords: pH; temperature; turbidity; conductivity; ions; organic matter.

Council for Innovative Research

Peer Review Research Publishing System

Journal: Journal of Advances in Chemistry

Vol 11, No. 6

editorjaconline@gmail.com, www.cirjac.com

ISSN 2321-807X

1. Introduction

Water is an essential element for most large industrial companies particularly food products of animal origin. After being used, the largest part of the wastewater is returned to the environment. This water is usually loaded with organic matter; it becomes a major source of pollution to the environment that receives it [1]).

Slaughterhouses are probably a typical example of those industries where water is used for washing by-products (offal) and waste disposal (faeces, debris rumen and blood). In Europe, the wastewater discharged volumes are measured between 9 and 6 liters per kilogram of carcass of cattle, and from 5 to 11 liters per Kg of pig carcass [2]. The effluents from these slaughterhouses are characteristic and require appropriate treatment (separation of solid waste and fats, specific treatments). Several studies have focused on the characterization and treatment of this type of wastewater through treatment plants or by aerobic processes [3, 4], either by anaerobic processes [5, 8]. Other methods of treatment are adopted for sewage treatment slaughterhouse namely sand infiltration [9, 10].

Most data on the quality of waste water from slaughterhouse were produced in Europe [11, 14]), Australia [15], the USA [16] and Africa [17, 19]. However, no scientific study has been published about the quality of municipal slaughterhouse wastewaters of Maradi. This work aims therefore, to determine some physicochemical characteristics of wastewaters generated by Maradi city slaughterhouse to assess its quality and recommend a suitable treatment.

2. Material and methods

2.1. Study site

This study was conducted at the municipal slaughterhouse of Maradi city located in the far north of that city between 13°31’36’’ north latitude and 7°06’09’’ East longitude.

Figure 1: Aerial image of Maradi municipal slaughterhouse (Google earth, 2011)

2.2. History and Mission

Maradi municipal slaughterhouse was built in 1985 with a loan from a Germany bank. It was put into operation on 1 October 1986. Its purpose is to export meat to neighboring countries in its early years. It also works for:

- Preserving human health by prohibiting animals meat consumption with diseases communicable to humans or can cause poisoning in humans;
- Checking the hygiene of meat from the animals slaughtered to provide safe food that meets the standards of hygiene for local consumption and for export;
- Supporting the recurrent costs of the slaughterhouse;
- Epidemiological surveillance of diseases with high epidemic potential.

ISSN 2321-807X

2.3. Staff

The staff at this slaughterhouse is composed of:

- 4 officials from the Ministry of Livestock: 1 Veterinary doctor, the director of the municipal slaughterhouse, 1 breeding senior, 1 inspector agent, and 2 breeding technical agents. One of them is the director assistant.

- 18 auxiliaries whose salaries are paid from the budget of the slaughterhouse (salaries, allowances and family benefits): 1 Accounting Assistant, 2 electrical engineers, 1 Collector, 2 guards, 2 labors, and 5 butchers.

2.4. Infrastructure:

- A slaughterhall having a capacity of 50 large ruminant animals and 600 small ruminant animals per day.

- A cold room, with a storage capacity of 7 tons but a state of deterioration;

- A scale to weigh which is in fair condition;

- A logistic composed of: 1 refrigerated truck of 23 years old with a capacity of 3.5 tons, 1 4X4 vehicle for animal health, 2 bikes in fair condition, 1 wastewater treatment plant equipped with a capacity of 613m^3 water storage (1 automatic engine, 3 electric generators, 1 suppressor, and 1 pumping station.

2.5. Production

Currently, nearly 170 small ruminants and 25 large ruminants are slaughtered daily. The average daily production is of around 5 tons and 380 kg (a usage rate of about 76%).

The following table shows the evolution of the production of the meat (kg) between 2006 and 2011.

Table 1: Production of meat per year

Year	Production of meat (kg)
2006	51340
2007	54316
2008	42214
2009	54906
2010	76061
2011	67209

2.6. Difficulties

The lack of status, very aging technical equipment, pricing of m^3 water increased (from 0.40 to 0.65 and 0.74 €), professional disorganization of the livestock / meat (cattle refueling and sell the meat), illegal slaughter

2.7. Sampling

The sampling was conducted at the wastewater storage basin of the slaughterhouse. It was made three times a week interposed. The first two samples were collected in the basin and the third sample was collected light to enter of the effluents in the basin.

The materials used are: three vials that contained the three samples, a sieve to remove water micro-particles, gloves, plastic cup.

2.8. Analyzes

Sampling analysis was performed in two laboratories: Regional Headquarter of Water laboratory and operating company of the waters of Niger. Temperature, pH, turbidity, conductivity, and phosphorus concentration were measured by using a spectrophotometer DR/2000 HACH RANGE. Concentrations of iron, Fluor, nitrite, nitrate, calcium, magnesium, and organic matter were measured via a spectrophotometer DR/3900 HACH RANGE. Phosphates concentrations were deduced from corresponding phosphorus concentrations by the following equation: $[PO_4^{3-}] = 3.07\times [P]$

ISSN 2321-807X

3. Results and discussion

Table 2: Physicochemical parameters of Maradi slaughterhouse wastewater

Parameters	Sample 1	Sample 2	Sample 3
Temperature	26	26.4	26.3
Conductivity (µS/cm)	5260	4970	3930
Turbidity (NTU)	208	210	560
Suspend solids (mg/L)	2630	2485	1965
Phosphate concentration (mg/L)	2.39	2.18	2.12
Phosphorus concentration (mg/L)	0.78	0.71	0.69
Iron concentration (mg/L)	0	0	0.45
Fluor concentration (mg/L)	26.75	29	40.5
Nitrate concentration (mg/L)	330	110	5
Nitrite concentration (mg/L)	443.44	189.75	1.73
Calcium concentration (mg/L)	12	7.2	6.4
Magnesium concentration (mg/L)	10.56	10.75	2.78
Organic matter concentration (mg/L)	520	140	620
Calcium carbonate concentration (mg/L)	56	52	18
pH	7.61	7.74	6.47

Analysis of wastewater of municipal slaughterhouse of Maradi showed a slight difference of temperature between the three samples taken at the slaughterhouse. The average temperature of these three samples is approximately in the range of 26.18 ° C. That temperature is in agreement with national discharge standard temperature (not more than 50° C). This temperature is roughly equal to that found in Lagos slaughterhouse wastewater [20]. Also it slightly exceeds that found in Mina (Niger state, Nigeria) slaughterhouse wastewater [21].

The values of pH obtained showed that Maradi slaughterhouse wastewater was acid light to enter of the effluents in the basin and basic in the basin. This is due probably to the degassing of CO_2 occurred in the basin. Indeed, several studies showed that the degassing of CO_2 from a medium cause a rising of pH values [22, 24].

Otherwise, the pH values obtained are in agreement with those found by Belghyti et al. in (2009) [1] and national discharge standard pH. However, Nyanchaga and Elkanzi [25] and Adesemoye et al. [20] have previously obtained acid pH values.

The values of the conductivity of the three (3) samples were different. Against by the conductivity of the sample 3 are by far the weakest of all, this is explained by the fact that this sample was taken at the point of arrival of the month mineralized wastewater. The average conductivity of these 3 samples is 4720 µS /cm. This result is not in agreement with those of Belghyti et al.[1], Chukwu et al. [21], and Wu and Mittal [26] for similar studies.

The values of suspended solids were higher in sample 1 and sample 2 than in sample 3. This is due to decantation occurred in samples 1 and 2. The average of concentration of the tree samples is found to be 3540 mg/L and is higher than those found by Atuanya et al. [27], Woke and Wokoma [28]), and Adesemoye et al. [20].

The sample 3 is more turbid than sample 1 and sample 2. This difference is due to sampling location of sample 3 (entry point of the wastewater into the basin). Indeed, in the basin, slaughterhouse wastewater undergoes decantation with time. The average of turbidity (326 NTU) is not in agreement with similar studies [20, 21].

Phosphate concentration is sensibly the same in the three samples but slightly higher in sample 1. The presence of phosphate in the samples is due to the use of detergents for washing slaughterhall and other ustensils. Indeed, polyphosphate are the main constituents of detergents. Similar studies have also found the presence of phosphate with higher concentrations [1, 20, 27]

Nitrites ions concentration is three times higher in sample 1 than in sample 2 and very low in sample 3. This difference is due probably to degradation of organic matter. Indeed, nitrites ions can result to incomplete degradation of ammonium ions and reduction of nitrates ions [1]. The average of nitrites concentration is higher than those found by Worku [29] and, Agarry and Owabir [30].

Nitrates Ions concentration is three times higher in sample 1 than in sample 2 and very low in sample 3. The value of nitrates concentration found in sample 2 is due probably to its denitrification while the lower value of sample 3 is due to non degradation of organic matter in this sample. The value of average concentration is significantly higher than those found by Atuanya et al. [27], and Akan, [31].

Calcium ions concentration of sample 3 is the lowest value of the three samples. This result is probably due to the lower alkalinity of this sample than samples 1 and 2. The average concentration is very lower than that found by Wu and Mittal [26].

Magnesium ions concentration values in samples 1 and 2 are near and significantly lower in sample 3. The average concentration is lower than that obtained by Massé et al. [32].

No trace of iron ions was detected in samples 1 and 2 while in sample 3 we noted the presence of these ions in low concentration of 0.45 mg per liter. Very lower iron ions concentrations were also obtained by Massé et al. [32] and Ezeronye and Ubalua [33]. However, very higher concentration of these ions is found in some slaughterhouses wastewater [21, 27]

Concentration of fluoride ions obtained in sample 3 is more important than that obtained in samples 1 and 2. The average concentration (32.08 mg/L) is higher than that obtained by Chukwu et al., (25 mg/L) [21].

Organic matter in sample 3 is more important than in samples 1 and 2. The values of organic matter obtained are higher than that found by Adesemoye et al. [20].

4. Conclusion

This study showed that Maradi slaughterhouse wastewater contains chemical pollutants which can cause environmental pollution health problem. Indeed, higher fluoride ions concentration demonstrates the potential health risk which can cause this element because it can contaminate groundwater. Therefore, it is desirable to find adequate treatment to Maradi slaughterhouse wastewater. To do this, we recommend at short-term the use of calcium hydroxide, calcium chloride and calcium sulfate to precipitate Fluor. At long-term a sewage wastewater treatment plant is to be built.

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