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Quantification and characterization of waste from Sucrivoire de Zuenoula (Central-West of Ivory Coast)

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Abstract

Waste characterization is a crucial step in waste management, as it allows for a better understanding of its composition, properties and potential impact on the environment. Our study consists first of all in quantifying all waste resulting from the transformation of sugarcane into sugar. These are solid waste (scum, bagasse) and liquid waste (wastewater, molasses). The second step aims to determine some physicochemical parameters (pH, COD, NTK, BOD, COD/NTK). These data were obtained by calculating the daily flow rate and recording the daily data in the management system set up by the plant. Then, analyses were done in situ and in the laboratory. The results of this study reveal a daily production of 99.51 tonnes of scum and 854.30 tonnes of bagasse by the plant. Concerning liquid waste, 2746.4 tonnes of crushed cane generate 8932.56m3/dof effluents and 133.62m3/dmolasses. These effluents are acids with a pH value of 4.62. The average COD content is 1709mg/L with NTK of11.91mg/L. The BOD content is 1584mg/Land the COD/NTK ratio of 143.49. All these different parameters are important for optimal and sustainable management of effluents for the anaerobic digestion process.

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Introduction

Global development, continued industrialization and growing global population have contributed to several global problems; climate change is one of them (Nature Québec, 2011). Indeed, industrial development has been marked in recent years by the establishment of large factories that discharge their liquid waste into nature. These industrial discharges contribute to the destabilization of the environmental balance and the disruption of the environmental ecosystem (Dhimni *et al.*, 2015). These environmental changes also include major global problems such as climate change, ozone depletion, changes in ecosystems, reduction in biodiversity, depletion of natural resources and soil degradation (PECB, 2016).

The agri-food industries in general, specifically the activities of the sugar industry, generate large quantities of solid and liquid waste, atmospheric emissions (Alfa, 2005).

This is the case of Sucrivoire, located in the Center-West of Côte d'Ivoire, in West Africa. The Integrated Agricultural Unit (UAI) of Zuenoula is located 400 km from Abidjan and 25 km from Zuenoula. Geographically, it is located between 7°30' and 7°40' North latitude, and between 6°5' and 6°15' West longitude, and located at an altitude of 209 m above sea level (Péné and Assa, 2003). Sucrivoire, a company that belongs to the Ivorian group SIFCA, West African leader in the agricultural industry involved in rubber, sugar cane and oil palm, after the privatization of the sugar industry in 1997. It is present from the raw material to the finished product. The company manages more than 11,0001 hectares of industrial plantations spread over two sites, Borotou and Zuenoula (www.sifca.ci). An environmental assessment, both quantitative and qualitative, is imperative and therefore requires permanent monitoring in order to predict the trend in the receiving environment and recommend appropriate remedies (Zegaoula and Khellaf, 2014); where the need to take charge of the treatment of all sources of pollution and encourage reuse or recovery (Joëlle, 2005). For sustainable and responsible management, waste characterization is important because it helps minimize negative impacts on the environment while optimizing the use of resources. Our work therefore aims to quantify solid waste (scum and bagasse) and liquid waste (molasses and wastewater) from sugar production and to determine the physicochemical parameters (COD, BOD, NTK, pH, COD/NTK) for better treatment.

Materials and methods

Tractors: A motorized vehicle equipped with a powerful engine and a sturdy chassis to support heavy loads. They are used in agriculture for harvesting and agricultural transport.

Molasses tank

Stainless steel tank to avoid any contamination and preserve the quality of the molasses.

Bagasse shed

Constructed of sturdy, weather-resistant materials to protect bagasse from moisture and decomposition.

The amount of crushed sugarcane was obtained using tractors from the cane fields. These tractors are placed and centered on the platform, which allows the weighing system to be activated. The sensors located under the platform measure their weight and the results are displayed on a digital screen that is automatically recorded in a management system.

The volume of effluent was determined by the following expression (m3/h). $Q = \frac{V}{t}$

For molasses, the weight was obtained based on that of the crushed cane after churning the cooked mass of the 3rd jet.

As for the quantity of foam, resulting from the purification of cane juice, it is the sum of the collection trucks which is carried out at the end of the day.

The weight of the bagasse is obtained based on that of the crushed cane.

For the physicochemical parametersand biochemical, pH, temperature, chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), and biochemical oxygen demand (BOD) were performed according to the standard method of the French Association for Standardization (AFNOR) (1994).

The pollutant flow was estimated based on the daily quantity of crushed cane and the daily quantity of wastewater discharged. Pser = Fje x Qmjcb ; Pser : Specific production of discharged effluent (m3/T); Qmjcb: Average daily quantity of crushed cane (T/d); Fje: Daily effluent flow (m3/d).

Results

Quantification of crushed cane

The monthly quantity of crushed cane ranged from 96,279.86 at the beginning of the campaign to 67,056.50 tonnes at the end of the campaign. The total quantity of crushed cane throughout the campaign amounts to 494,359.30 tonnes (see Table 1), i.e. an average daily quantity of approximately 2,746.44 tonnes.

Wastewater volumes

The average daily flow rate per hour is 372.19 m3/h and 8932.56 m3/d which gives us an average monthly flow rate of 267,976.4 m3/month (see Table 2). The total quantity of effluent discharged throughout the campaign (6 months) is 1,607,860.8m3/semester.

Molasses volumes

The quantity of molasses during the campaign varied from 3606.73 to 3682.76 m3 per month (see Table 3). The total quantity of molasses produced during the campaign is 24,052.51 m3, i.e. an average daily production of 133.62 m3.

Table 1. Quantity of crushed cane

	November	December	January	February	March	April
Total (T/Day)	3209.32	2987.77	2956.81	2637.60	2451.77	2235.21
Total (T/Month)	96,279.86	89,633.08	88,704.34	79,128.22	73,553.30	67,056.21

Table 2. Volume of wastewater

	Hour	Day	Month
Total (m3)	372.19	8932.56	267,976.8
Total campaign (m3)		1,607,860.8	

Table 3. Molasses volumes

	November	December	January	February	March	April
Total (m3/Day)	120.22	144.20	131.74	156.09	126.72	122.75
Total (m3/Month)	3606.73	4326.03	3952.39	4682.95	3801.65	3682.76
Total (m3)			24,052.51			

Table 4. Quantity of foam

	November	December	January	February	March	April
Total (T/Day)	115.18	117.25	101.37	91.74	93.14	78.41
Total (T/Month)	3455.36	3517.38	3041.22	2752.12	2794.10	2352.46
Total (T)				17,912.64		

Table 5. Quantity of bagasse

	November	December	January	February	March	April
Total (T/Day)	937.50	888.30	887.06	902.67	803.26	707.99
Total (T/Month)	28,124.97	26,619.07	26,611.79	27,080.23	24,097.86	21,239.94
Total (T)				153,264.86		

The foam

The amount of foam varied from 3455.36 to 2352.46 tonnes during the campaign (see Table 4). The total amount of foam produced is 17,921.64 tonnes, or an average daily production of 99.51 tonnes.

The amount of bagasse

The quantity of bagasse varied from 28,124.97 to 21,239.94 tonnes during the campaign (see Table 5). The total quantity of foam produced is 153,264.86 tonnes, or an average daily quantity of 851.47 tonnes.

Table 6. Estimation of pollutant flows

	Settings		
	Qjmt (T/d)	Fje (m3/d)	Weight (m3/T)
Values	2,746.64	8,932.56	24,534,526.59

Qjmt : Average daily quantity of crushed canes ; Fje : Daily effluent flow ; Psr : Specific production of effluent discharged.

Table 7. The sum of waste produced

Setting		Total campaign	Total
Effluents (m3/semester)	Waste water	1,607,860.08	1,631,912.59
	Molasses	24,052.51	
Solid waste (T)	Bagasse	153,264.86	171,177.5
	Foam	17,912.64	

Estimation of pollutant flows

The average daily quantity of cane crushed by the Integrated Agricultural Unit of Zuenoula for the 2021-2022 campaign is 2746.44 tonnes. The processing of this quantity generates 8932.56 m3/day of water.

For the 2021-2022 campaign which lasted six months, a total of 494,359.30 tonnes of cane were crushed. The processing of this quantity generates 1,607,860.08 m3/year. All the waste from the production of sugar at the Zuenoula IAU during the campaign is 171,177.5 tonnes for solid waste (bagasse + molasses) and 1,631,912.59 m3/semester for effluents (discharged water + molasses) (see Tables 6 and 7).

Table 8. Physicochemical parameters

Settings	Average variations
DCO (mg/L)	1699-1719 1709
NTK (mg/L)	6.91-16.91 11.91
pH	3.62-5.62 4.62
DBO5 (mg/L)	1575-1593 1584
T(oC)	30.24-38 34.12
DCO/NTK	245.87-101.65 143.49

Physicochemical parameters

The physicochemical characteristics of the effluent show an acidic effluent with a pH of 4.62 to 34.12°C, an average organic matter load with the COD which is 1709mg/L and the BOD is 1584 mg/L. A small amount of nitrogen with a value of 11.91mg/L. As for the COD/NTK ratio, the value is 143.49 (See Table 8).

Discussion

The average daily quantity of sugarcane crushed at the sugar production site is 2746.44 tonnes per day.

Crushed, this quantity generates daily 8932.56 m3/day of wastewater, 133.62 m3/day of molasses, 854.29 T/day of bagasse and 99.51 T/day of scum. For the 2021-2022 campaign of the Integrated Agricultural Unit (UAI) of Zuenoula which lasted six months, a total of 494,359.30 tonnes of sugarcane were crushed, thus generating 1,631,912.59 m3/semester of liquid waste (wastewater and molasses) or 267,972.2 m3/month ; 1,607,860.08 m3/semester 4008.75 m3/month and 24,052.51 m3/semester of molasses. Regarding solid waste, there are 171,177.5 tonnes of solid waste (bagasse and scum) or 2985.44 T/month of scum; 17,912.64 T/semester of scum and 2554.14 T/month of bagasse and 153,264.86 T/semester of bagasse.

The amount of solid and liquid waste depends on the time of harvest. At the beginning of the campaign and during the dry season, the harvests are done without interruptions and are abundant, which favors the production of a lot of waste. However, at the end of the campaign, there is the short rainy season, which makes the harvests difficult and also there is not much left to harvest since most of the canes were harvested at the beginning of the campaign and during the dry season.

The sugar industry produces a huge amount of solid and liquid waste. This waste is partly recovered by the Integrated Agricultural Unit (UAI) of Sucrivoire Zuenoula.

After sugar extraction, the bagasse is sent to the boiler. It is used as an energy source for the needs of the factory and the entire complex. The energy value of bagasse is estimated at 420 kWh/tonne. This cogeneration strategy has been developed since 1982 by Réunion and taken up in many sugar-producing countries such as: Brazil, Thailand, Guadeloupe, Mauritius, etc. (Bouchera Nawel, 2015; Rouanne, 2000; Signoret, 2006). Furthermore, excess bagasse could be used for compost which, in combination with molasses and scum, makes it possible to obtain a green fertilizer with a high organic matter content that can reduce the use of chemical fertilizer (afcas-asso.org).

Given the K_2O content (0.2 and 0.3 on average) of molasses, it is spread on the fields of the UAI to replace mineral fertilizers and potash fertilizers. It also provides significant quantities of CaO and MgO, which are also important for cane. In addition, molasses could be used for the production of industrial rum or ethanol (biofuel, pharmaceutical alcohol) (Rivière and Hestot, 1979).

The scums constitute an interesting organic and mineral source because they are rich in nitrogen (0.7%), phosphorus (0.3 to 0.4%) and calcium (0.8%). The scums can replace phosphate fertilizers while improving soil fertility due to the contribution of quality organic matter and the contribution of calcium (reducing soil acidity) (ADEME). They are spread in the fields of the UAI of Sucrivoire Zuenoula. This method is also used in other countries (Alfa, 2005).

The sugar industry generates huge quantities of water (1,607,860.8 m3/semester), this wastewater has a high organic matter content and therefore a high biochemical oxygen demand (1709) mainly due to sugars and organic matter from the cane. It may also contain pesticide residues, agricultural parasites and pathogens (IFC, 2007). The wastewater from the Sucrivoire Zuenoula IAU is discharged successively into the lagoon basin 1 and 2 in order to reduce the pollutant load by a filtration system. Part of this water is stored in an artificial lake and is used for watering the cane fields. The other part flows directly into the Bandama River.

Conclusion

At the end of this study, it appears that the UAI of Sucrivoire Zuenoula for the 2021-2022 campaign generated 171,177.5 tonnes of solid waste (bagasse and scum) which are recovered and 1,631,912.52 m3 of effluents per semester. These effluents from sugar production are characterized by an acidic pH, a nitrogen deficiency and a high COD concentration.

These bio-recalcitrant effluents subjected to a lagoon system are used for watering cane fields and the surplus is discharged into the Bandama River. It is therefore necessary to propose a treatment channel to significantly reduce the pollutant load of these effluents before their discharge into the natural environment.

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