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Beer and soft drinks industry wastewater treatment using an anoxic-aerobic membrane bioreactor (MBR) coupling with nanofiltration in Sahelian context

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ABSTRACT

The beverage industries release large amounts of wastewater containing organic and mineral pollutants (sodium). The conditions of biomass acclimation as well as the influence of environmental factors pertaining to the Sahelian context are not well documented in previous studies with regards to industrial wastewater treatment by membrane bioreactor (MBR).This work shows the biomass behavior during the acclimation period and the effluent treatment effectiveness. The experimental system consists of an association of anoxic and aerobic reactors with a ceramic ultrafiltration membrane followed by a nanofiltration unit as post-treatment for treated water reclamation. The hydraulic retention time ranged from 16 to 57 h and a solid retention time of 30 d was defined. The volume loads increased from 0.3 to 15.9 kg_{COD} m^{-3} d^{-1}. The results reveal the need for pH, temperature and feed flow control during start-up phase. COD removal rate up to 95% was reached at the end of the treatment step with a turbidity reduction of 92%. The nanofiltration allowed retention of more than 90% of the concentrations of principal ions contained in the treated wastewater with a COD and sodium concentration less than 175 and 186 mg/L, respectively.

Keywords: Beverage industry wastewater; Biomass acclimation; Membrane bioreactor; Nanofiltration; Sahelian context

1. Introduction

The beverage industry is an important component of the economic sector in most countries. Water is one of the main ingredients of the products in the beverage industry [1,2]. It is used for most activities including, beverage production, rinsing and cleaning, cooling and sanitation. The quantities of fresh water consumed are, for example, evaluated between 2.5 and 3.5 L per 1 L of soft drink produced [3] and between 4 and 11 L per 1 L of beer produced [4,5].

Beverage production generates large volumes of wastewater daily [4,6,7]. The nature of the pollutants and the volumes of water discharged vary according to the stages of the industrial process. The use of different raw materials, as well as the variation of the rinsing operations of tanks, bottles and the cleaning of the production facilities leads to a great variability of the discharged effluents. These rejected wastewaters are highly biodegradable and constitute various blends of chemicals coming from the raw material and the rinsing or cleaning products. It consists mainly of sugar,

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starch, ethanol, fatty acids, artificial sweetener, fruit juice concentrates, flavoring agents, dissolved carbon dioxide/carbonic acid, bicarbonates, coloring agents, preservatives (phosphoric acid and tartaric acid) and mineral salts that are used during production. The pH level can vary considerably from acidic to alkaline with values ranging from 2 to 12 and can be influenced by the amount of chemicals (caustic soda, phosphoric acid, nitric acid) used for cleaning and disinfection. The concentrations of nitrogen and phosphorus present in the effluents depend mainly on the raw material and yeast dosage. High phosphorus levels usually come from cleaning activities. The obtained temperature range from 25°C to 38°C and can occasionally increase [8–11].

The fate and management of these wastewaters vary from one unit to another and is often a function of regulations of these activities in the area where the unit operates. Some are discharged directly into water streams or sewage collection network, while others are pretreated before being discharged into sanitation networks and routed to the treatment plants [6]. There are, therefore, wastewater treatment facilities using physical, chemical, biological techniques or a combination of these methods [12]. Taking into consideration evolving factors such as increasing stringent regulations for the discharge of wastewater into the environment, increasing of freshwater prices, the preservation of water resources and environmental sustainability, there is therefore the need for development of novel approaches for wastewater treatment. The world is currently witnessing a desire for the development of sustainable water use with the practice of wastewater reuse and recycling in industries, particularly in breweries [7,13,14].

The use of membrane processes for the industry's wastewater treatment has shown interesting results in terms of efficiency. To limit the impact of brewery wastewater on the environment, the development of flourishing pretreatment systems such as the membrane bioreactor seems to be the appropriate solution. Membrane bioreactor technology is proven in the treatment of industrial wastewater while also allowing water reuse [15–19]. It combines biological treatment in anoxic, anaerobic and/or aerobic environment, physical treatment by membrane separation ensuring a total retention of the solid phase (biomass) and the liquid phase (treated water), which thus makes it possible to obtain treated water of high purity. It offers several advantages over conventional activated sludge systems, namely the stability of treated effluent quality, the ease of operation, the low footprint or the absolute elimination of bacteria and certain viruses [20]. In addition, the MBRs make it possible to simultaneously clarify and disinfect water without the risk of formation of halogenated organic compounds, thus allowing the reuse of the treated effluents.

On the other hand, on this flourishing technology, very little work has been done in the climatic and environmental conditions of the Sahelian context, where the beverage industries produce both beer and soft drinks. This band located in the south of the Sahara, crosses the African continent from Mauritania to Ethiopia and is characterized by a strong sunshine for about 8 months per year causing rapid evaporation of surface water. The climate is the Sudano-Sahelian type with average monthly temperature between 17°C and 40°C [21]. Significant population growth and changing consumption patterns are putting pressure on water resources. Moreover, this situation is accentuated by the negative effects of climate change [22]. The present work thus proposes to study the optimal conditions of beverage wastewater treatment by membrane technologies (coupling membrane bioreactor with external membrane – nanofiltration) in the Sahelian context. Since the water to be treated is both loaded with organic and mineral matter, it will be necessary to carry out beverage effluent treatment tests on membrane bioreactor and nanofiltration laboratory pilot plants.

2. Materials and methods

2.1. MBR system and nanofiltration unit

The laboratory-scale membrane bioreactor used in this study consists of a two stages aerobic and anoxic reactor. A 20 L mechanically mixed anoxic tank and a 40 L aerobic tank offer a total working volume of 60 L. Schematic representation of the bioreactor is presented in Fig. 1. A feed peristaltic pump, controlled by two level sensors (between a high level and a low level of the anoxic tank), and ensures a continuous substrate supply of the reactor. The system is equipped with a pH controller (sulfuric acid 1 N/sodium hydroxide 1 N addition) and a cooling system. Aeration is provided by four diffusers arranged at the bottom of the aerobic compartment, to ensure oxygen for the biological process. The aeration is regulated by the oxygen transmitters that control the air blowing. The recirculation between both tanks is done by a peristaltic pump working at a recirculation flow rate of 400%. The biological reactor is coupled with an external ultrafiltration membrane. This membrane module includes a single ceramic working in inside/outside mode. The characteristics of the membrane are summarized in Table 1. The membrane bioreactor system was equipped with a cooling system which allowed an operational temperature control. A pH controller was used to maintain the pH at a desired value by adding 0.5 mole per 1 L of sulfuric acid solution. The temperature, pH, redox potential and transmembrane pressure (TMP) were monitored and recorded by computer software. The pumps and sensors were connected to a programmable logic controller for an automatic running of the membrane bioreactor.

The nanofiltration unit is fed with a high pressure multicellular centrifugal electropump. The NF270 membrane module has a total filtration area of 1.3 m^2. The material used

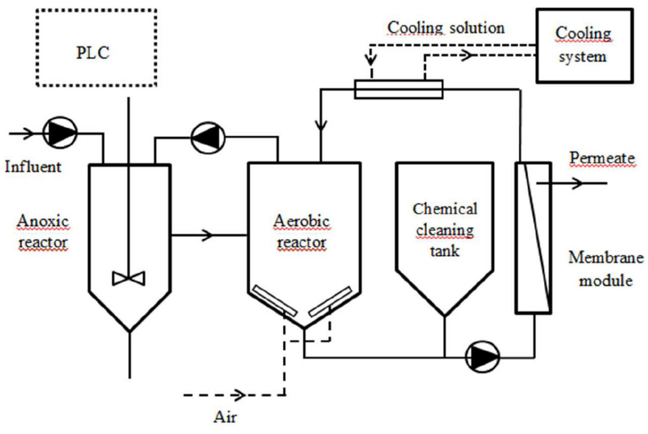

Fig. 1. Schematic representation of the laboratory-scale MBR.

Table 1
UF and NF membrane module characteristics

Membrane	UF (MBR)	NF
Material	Ceramic	Composite
Module	Tubular type P10	Spiral NF270
Total filtration area (m^2)	0.45	1.3
Cut-off threshold	15 kD	200 Da
Diameter of the channels (mm)	6	–
Membrane length (mm)	1,178	1,016
Provider	Pall Exekia (France)	Dow Filmtec (China)

is a thin-film composite membrane consisting of an assembly of three layers: a polyester support layer (120 µm), a microporous polysulfone interlayer (40 µm) and a polyamide ultra-thin active layer on the surface (0.2 µm) which is characterized by NaCl retention of 50%.

2.2. Wastewater characteristics

For biomass growing, reactor start-up and beverage wastewater treatment assessment, the reactor was fed with several wastewaters in different stages. The reactor feed started with a solution containing carbon (C), nitrogen (N) and phosphorus (P) in a C/N/P ratio of 100/5/1 for biomass growing at an initial concentration of 200 mg_{COD} L^{-1} (0.3 kg m^{-3} d^{-1}). It was prepared with sodium acetate, ammonium chloride and phosphorus buffer with potassium hydrogen phosphate and potassium dihydrogen phosphate [23]. Sodium acetate was used as a carbon source in the substrate promoted a salt-rich environment and allowed the biomass to be subjected to an increase of sodium content in the influent.

After the start-up period, a synthetic brewery wastewater was used for the feeding of the MBR. It was prepared through a slight adjustment of the recipe used by Chen et al. [24]. The synthetic brewery wastewater consists of beer, glacial acetic acid, yeast extract, ammonium chloride, potassium hydrogen phosphate, magnesium sulphate, sodium hydroxide and trace element solution [25]. The chemical oxygen demand (COD) content in this influent was set at 6,000 mg_{COD} L^{-1}, taking into account the industrial wastewater characterization data to be used in the present study.

The beverage wastewater tested in the present study was taken from a local industrial unit producing beer and soft drinks. The wastewaters were taken daily for the feeding of the membrane bioreactor. The main wastewater characteristics were measured before feeding the reactor. These actual wastewater characteristics changed significantly from one sample to another. For a fine analysis of the characteristics, an automatic sampler was used. Individual samples were analyzed and an average sample on the 24 h was formed for the bioreactor feeding. The physico-chemical characteristics of real beverage industry wastewater are reported in Table 2. The BOD/N/P ratio is low: 100/0.71/0.62, making the biodegradation difficult with a lack of nitrogen and phosphorus made it possible to increase the development of cyanobacteria. But what might also be emphasized is that the C/N/P ratio for anaerobic bacteria is 100/1.75/0.25. In addition to this, the concentration of sodium in the wastewater is important.

Table 2
Physico-chemical characteristics of the beverage industry wastewater

Parameters	Average	Minimum	Maximum
pH	11.7	5.4	12.7
Temperature (°C)	28	23	38
Electric conductivity (µS/cm)	5,275	460	23,400
Turbidity (NTU)	462	175	866
Suspended solids (mg SS/L)	234	51	2,184
COD (mg O_2/L)	5,900	744	10,610
BOD_5 (mg O_2/L)	1,846	248	3,850
NTK (mg/L)	9.3	2.2	17.6
Ammonium NH_4^+ (mg/L)	6.2	1.0	10.9
Nitrate NO_3^- (mg/L)	17.0	16.4	44.0
Sulfate SO_4^{2-} (mg/L)	28.4	4.0	120.0
Orthophosphate PO_4^{3-} (mg/L)	34.9	17.0	71.0
Chloride Cl^- (mg/L)	0.3	0.0	0.4
Sodium Na^+ (mg/L)	684	237	1,138
Calcium Ca^{2+} (mg/L)	6.9	4.4	14.0
Magnesium Mg^{2+} (mg/L)	2.7	0.1	11.3
Potassium K^+ (mg/L)	15.2	11.4	21.8

The experiment has been designed to degrade organic pollution. The presence of the membrane should also reduce the colloid contents. The system should ensure a proper treatment of the beverage industry wastewater. The effectiveness of the treatment will be judged by the ability of the facility to reduce the concentrations of the different pollutants but also to provide a treated effluent meeting the standards for release into the environment and offering the possibility of reuse.

2.3. Membrane bioreactor operations

The membrane bioreactor was inoculated with sludge from a conventional activated sludge plan treating domestic wastewater. The starting sludge pH value was 7.1 with suspended solids (SS) and volatile suspended solids (VSS) concentrations of 160 and 136 mg/L, respectively. The bioreactor was continuously fed by a peristaltic pump connected to the influent reservoir. The acclimation solution was used for the reactor feeding during the first 196 d of operation. During this period, temperature, pH and organic load effect on the reactor biomass were studied. The acclimation period has been experimented with three different phases of the reactor operation. During the first phase, there was no pH and no temperature control. During the second phase, the pH was set at 7–7.5 but the temperature was not controlled. As the temperature has reached a critical level (46°C) which is higher than the limit conditions reported by the literature, both pH and temperature were controlled during the third phase. The last two phases involved the use of beverage industry wastewater. Then, the fourth phase was conducted at a constant organic loading rate (OLR) of 9 g_{COD}/L/d with synthetic brewery influent whereas the fifth phase was fed with real beverage influent. To accelerate biomass build-up, there was no sludge wasting during acclimation period. The initial influent COD was 200 mgCOD/L and was gradually increased to reach 6,000 mgCOD/L at the end of the acclimation period, that is, the OLR was increased from 0.3 to 9 kg m^{-3} d^{-1}. At the end of the acclimation period, the brewery synthetic wastewater was used to evaluate reactor performance with controlled conditions after the acclimation period (i.e., an OLR of 9 kg_{COD} m^{-3} d^{-1} and an hydraulic retention time of 16 h). The real beer and soft drink industry wastewater collected locally was used during day 271 to day 340. The solid retention time (SRT) was regulated at 30 d by the daily wasting of 2 L of sludge. The hydraulic retention time (HRT) was set to 16 h. The temperature was controlled between 30°C and 35°C by circulating fresh cooling liquid through the cooling network. During this phase, the OLR varied in the range of 1.1–15.9 kg_{COD} m^{-3} d^{-1} and the membrane flux was set to 8.3 LMH. The used operating conditions are shown in Table 3.

In order to perform chemical membrane cleaning, the membrane was isolated from the biological tank and the cleaning solution was injected and recirculated from the stainless steel cleaning tank to the membrane loop. During all reactor operation, the membrane was cleaned two times following a cleaning protocol consisting of successive recirculation throughout the filtration pump of citric acid, sodium hydroxide and sodium hypochlorite solutions (22 g/L, 2 g/L and 0.4 mL/L, respectively).

The nanofiltration post-treatment used was operated in batch mode. The MBR permeate was stored and used as an influent for nanofiltration module. The transmembrane pressure was set to 10 bar.

2.4. Analytical methods

Samples were taken three times per week from anoxic and aerobic reactors and from membrane permeate. Sludge and real beverage wastewater were collected for SS and VSS quantification. SS and VSS were obtained using the filtration methods. Hach kits were used with a UV-visible spectrophotometer (DR 5000 Hach Lange). The soluble parameters were obtained after samples filtration through a 0.45 µm glass fiber membrane. All of these analyses were performed in accordance with the recommendations of the Standard Methods for the Examination of Water and Wastewater [26]. Pressure, electric conductivity, pH and temperature were continuously recorded during MBR operation time. Sodium, calcium, potassium and magnesium concentrations were determined with atomic absorption spectrometry (AAS). The instrument used is an AA/flame spectrophotometer from PerkinElmer, USA (AAnalyst 200). Samples were filtered before measurement to remove SS, and nitric acid was added to prevent adsorption and precipitation. Concerning industrial wastewater, pH, temperature, electrical conductivity and turbidity were measured directly at the sampling site. The equipment used includes a WTW 3310 pH meter, a WTW 3110 conductivity meter and an Aqualytic AL450T-IR turbidimeter. Sludge density and morphology during reactor operation were monitored by microscopic observation with an epifluorescence microscope (Optika, Italia) equipped with a camera at 20 times magnification.

3. Results and discussions

3.1. Membrane Bioreactor system start-up

Fig. 2 shows the evolution over time of VSS in the reactor. From an initial value of 136 mg VSS/L, it increased up to 13,980 mg VSS/L at the end of the acclimation period. On the graph, it appears that there is virtually no evolution of the VSS during the first 100 d of the reactor operation. As expected, once the pH was maintained at 7.0–7.5 and the temperature set at 30°C–35°C, the VSS really increased. It thus appears that the new operating conditions imposed on the reactor have been favorable to the biomass growth. These results reflect the negative influence of non-regulation of pH and temperature on the development of microorganisms. The biological reactor was not able to run itself under the conditions of the study. Previous work has also highlighted the need for pH regulation during wastewater treatment by biological systems and more specifically for industrial waste water [27,28]. Tchobanoglous et al. [29] found that the activity of microorganisms in a biological process decreases with increasing temperature, and Knowles et al. [30] concludes that for optimal growth of

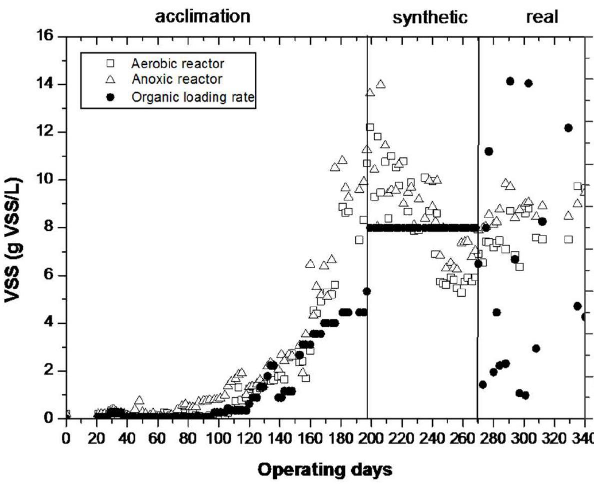

Fig. 2. VSS evolution in the reactors during MBR operation.

Table 3
Operating conditions used during the study

Operating stages	Operating periods	Operating conditions			
		HRT (h)	OLR (kg COD/m^3/d)	pH	Temperature (°C)
Acclimation solution	Day 1 to 75	36	0.3–0.6	5.1–9.2	27–46
Acclimation solution	Day 76 to 100	36	0.3–0.6	7.0–7.5	27–46
Acclimation solution	Day 101 to 196	16-58	0.3–7.5	7.0–7.5	30–35
Synthetic brewery wastewater	Day 197 to 270	16	9.0	7.0–7.5	30–35
Real beverage wastewater	Day 271 to 340	16	1.1–15.9	7.0–7.5	30–35

microorganisms the temperature should be between 28°C and 36°C forcing the need to control the reactor temperature. The variation of the slope of the VSS concentration evolution curve with the reactor operation time and the strong increase of the VSS concentration in the reactor show the sensitivity of microorganisms to the substrate. It thus appears that the growth of the biomass is influenced by the variations in operating conditions. In addition, the microorganisms seem to require ample time for adaptation to the changes of conditions [31,32]. Despite the variation of the operating conditions in the membrane bioreactor, it is important to note that there was a clear evolution of the VSS/SS ratio, which varied from 70%–80% during phase 1, to 80%–95% during phase 2 and 90%–95% at the end of the study. This trend was also observed by Heran et al. [33], and was the result of (i) the absence of particular inorganic material in the influent and (ii) no accumulation of mineral solids in the sludge despite high sludge age. The small fraction of the inorganic particular compounds present in the feed solution is also not significant [34].

Sludge density and morphology in membrane bioreactor have also been monitored in order to observe the impact of operating conditions on sludge structure and proliferation of specific microorganisms [35]. In fact, numerous problems may occur due to sludge structure which could impact the sludge filterability. Fig. 3 shows that the sludge in the reactor has gone from a very low-density sludge stage (Fig. 3(a)) to dispersed flocs (Fig. 3(b)) and sludge clustered very often around an organic support (Figs. 3(c) and (d)).

3.2. MBR system operational performance

3.2.1. Organic pollution treatment efficiency

The evolution of COD concentrations in influent and permeate as well as the COD removal rate over time is shown in Fig. 4. It appears that low COD removal at the beginning of the pilot feeding despite low loads is due to the lack of pH control. The COD removal rate improved as the study progressed despite the increase in the concentration of COD in the feed substrate. The low treatment efficiency observed at the beginning of the season reflects a failure of the biomass to degrade the new synthetic substrate without pH and temperature control. The COD content in the permeate increases from day 132. This can be attributed to an increase in the organic load and in particular the food to microorganism (F/M) ratio due to the presence of dissolved organic matter in the permeate. From day 196, a decrease in the COD removal rate was recorded thus highlighting the disruption of the activity of biomass by some components of the synthetic brewery wastewater. The COD values recorded in the permeate are between 65 and 612 mg_{COD}/L during the real beverage wastewater treatment. During acclimation period and the entire study, despite the increase in organic load, the COD removal rate reaches 98% [24]. The COD concentrations obtained in the MBR permeate during the stable running period are below the allowable limit for discharge into the sewer system and also for reuse in agriculture.

3.2.2. Nitrogen treatment and ion removal

Table 4 shows ions concentrations in both feeding wastewaters, MBR and nanofiltration (NF) permeates. As shown in this table, nitrogenous forms concentrations are relatively low in the membrane bioreactor permeate. During the operating period, the total nitrogen concentration in the influent ranged from 5 to 1,200 mg N/L. The residual concentrations in the NF effluent for their parts ranged from 0.25 to 3.10 mg $N\text{-}NH_4^+/L$ for ammonium, from 0.9 to 9.0 mg $N\text{-}NO_3^-/L$ for nitrates and from 0.03 to 0.21 mg $N\text{-}NO_2^-/L$ for nitrites. The evolution of the concentrations shows disturbances of the nitrogen removal efficiency during reactor malfunctions. It, therefore, appears that the performance of the reactor relative to the nitrogen treatment is influenced by the operating conditions which include aeration and recirculation of the sludge in the reactor.

The total ion removal rate varied from 2.6% for Na^+ and 99.8% for NH_4^+. The strength of ammonium removal is explained by the configuration of the pilot. For the other ions, the elimination rates were less than 50%. For monovalent cations, the removal efficiencies were relatively low (Fig. 5).

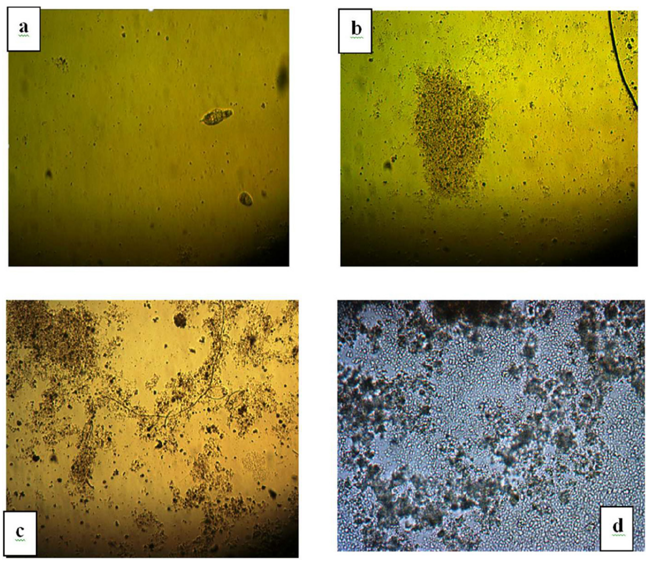

Fig. 3. Sludge evolution during reactor operation (scale 1/20).

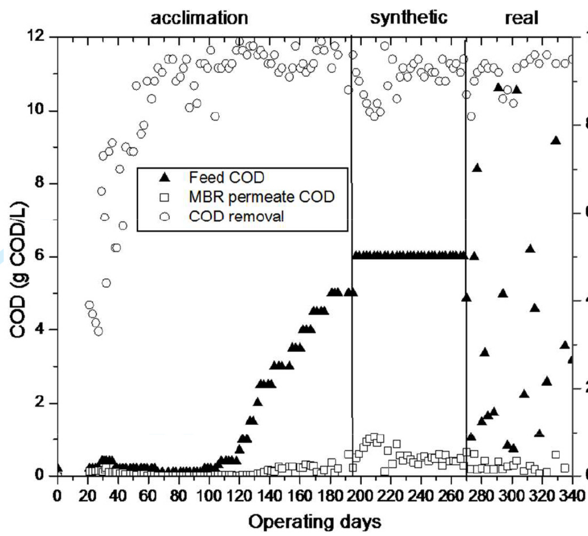

Fig. 4. MBR COD removal efficiency during operation period.

Table 4
MBR and NF permeates physicochemical parameter values and treatment removal rate

Parameters	MBR influent	MBR effluent	NF effluent	MBR removal rate (%)	NF removal rate (%)	Total removal rate MBR + NF (%)
COD (mg/L)[a]	10,610	986	175	98	58	99
Conductivity (mS/cm)	31.4	28.4	4.2	10	85	87
Turbidity (NTU)	51	4.2	1.2	92	71	98
pH	9.2	8.5	6.4	–	–	–
Ca^{2+} (mg/L)	40	24	1.2	40	95	97
Mg^{2+} (mg/L)	9.6	4.2	0.1	56	97	99
N-NH_4^+ (mg/L)	1,200	7	3	98	35	99
N-NO_3^- (mg/L)	440	114	7.5	95	98	98
N-NO_2^- (mg/L)	6.1	3.8	0.2	38	95	97
P-PO_4^{3-} (mg/L)	420	320	11	24	96	97
SO_4^{2-} (mg/L)	200	5,200	30	–	99	99
Na^+ (mg/L)	1,900	1,850	186	3	89	90
K^+ (mg/L)	2,900	2,650	198	7	92	93
F^- (mg/L)	52	28	0.7	46	97	98

[a]All presented values are the maximum obtained.

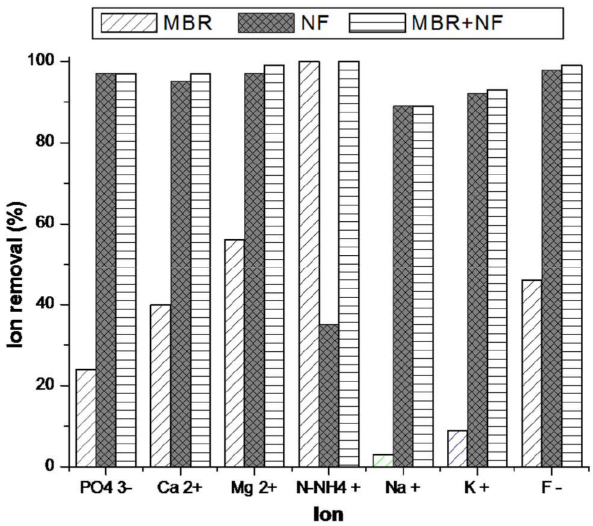

Fig. 5. Ion removal by MBR and NF.

Sodium elimination rate is the lowest while its content in influent is large and its concentration in the treated effluent is a key condition for the reuse in agriculture. The ultrafiltration membrane used in normal condition has no ion retention efficiencies because of its cut-off threshold. The MBR has indeed a good efficiency for the treatment of organic and nitrogenous pollutants but remains very limited for the retention of ions which were potentially be used for bacteria purpose (nitrification NH_4^+, flocs consolidation Ca^{2+}, biomass growth N, P). This explains the need for post-treatment to consider the reuse of treated effluents.

3.3. Post-treatment performance of nanofiltration

The analysis of Table 4 shows that the MBR retains more than 80% whereas the NF retains only about 59% of the organic pollution. The NF permeate has relatively low concentrations of ionic species. Regarding the ion retention rate, there is a reduction in conductivity of about 10% and 86%, respectively, with MBR and NF. The elimination rate of the main ions studied by NF is between 87% and 96%. In a previous study, removal rates between 87% and 98% with a NF membrane were obtained with an NF90 nanofiltration membrane [36]. The concentration of sodium in the final effluent obtained with the coupling of MBR and NF is less than 200 mg/L. It is thus possible to reuse treated water in agriculture in accordance with WFP's agricultural wastewater reuse standards [37]. MBR and NF coupling may be an alternative for beer and soft drink influents treatment for possible reuse.

3.4. Performance of membrane filtration

Fig. 6 shows the TMP time profile over the operation period at a constant pressure. It appears that the increase in TMP occurred for the high OLR recorded during the study. From day 115, for a constant flux of 5.56 LMH, there was a progressive increase of the TMP, translating to clogging of the membrane. This increase coincides with the increase in SS (910 mg SS/L) load in the bioreactor. The membrane is quickly clogged and the TMP reaches a value of 1.42 bar on day 128. From day 138 to day 149, the sharp increase of the TMP to 1.65 bar resulted in a reduction of the permeate flux to 2.31 LMH and the increase of the HRT. A chemical cleaning was carried out causing an increase in the filtration flow. This operation allowed to record large filtration flows despite the increase in the load for the same imposed pressure. During the operation of the system, an accumulation of substances on the surface of the membrane resulting to reduced permeability might be the cause for the drop of the filtration flow. The use of real beverage wastewater leads a change in the curve slope. A regular increasing of the TMP appears during this operating phase. The drop of the permeate flux had lead a chemical cleaning. It is noted that the real wastewater

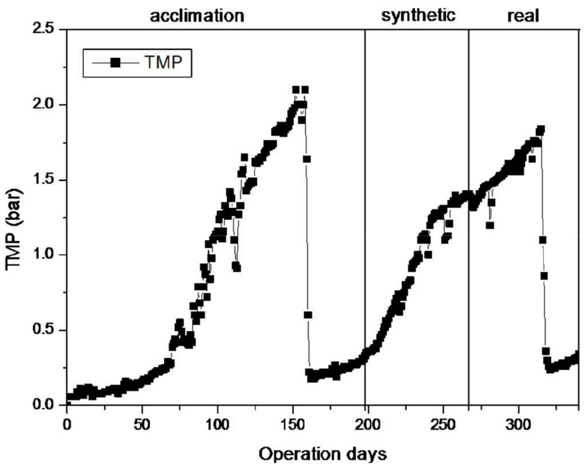

Fig. 6. TMP evolution over MBR operation.

seems to have less effect on the membrane fouling than the synthetic wastewater. This can be due to the regular variation on wastewater concentration and organic loading rate.

4. Conclusion

With sludge from a domestic wastewater treatment plant at very low load, the operating conditions imposed, allowed for a good growth of the biomass once pH and temperature have been controlled. The studied configuration associating two stages anoxic and aerobic with membrane retention allowed the purification of the real beer and soft drink industry wastewater. The nitrogen and COD removal rates obtained were 99% and 98%, respectively. For optimal operation of the MBR in Sahelian climatic conditions, a simultaneous control of the temperature and pH of the influent has been demonstrated. The operating pH was fixed at 7.2 ± 0.2 and the working temperature was in the range of 30°C–35°C. The aerobic-anoxic MBR coupled with nanofiltration offered remarkable potentialities for the treatment of beverage wastewater with regards to reuse standards for agriculture especially for sodium concentrations. Unfortunately, it was not possible to tune the membrane selectivity between toxic compound (sodium) for agriculture reuse and valuable salts (nutrients: K, P).

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