



Evaluation of the Raw Water Treatment Process in the Agro-Alimentary Industry through Physico-Chemical Analysis

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Received : 2021-09-16

Accepted : 2022-01-11

Abstract: In the agro-alimentary industry, the water treatment process plays a crucial role in ensuring the quality of water used in food processing. To assess the effectiveness of this process, we conducted physico-chemical analysis on water samples from an Algerian cannery. Our objective was to develop a decision support tool for evaluating the treatment process and aiding in decision-making. The analyses included pH, electrical conductivity, turbidity, and major elements, comparing the results with recommended standards. Overall, the water quality met the standards, indicating that the current treatment process effectively eliminates drawbacks.

Keywords: Performance Evaluation; Water treatment process; Agroalimentary use; Physicochemical analysis.

Résumé: Dans l'industrie agroalimentaire, le processus de traitement de l'eau joue un rôle crucial pour garantir la qualité de l'eau utilisée dans la transformation des aliments. Afin d'évaluer l'efficacité de ce processus, nous avons réalisé des analyses physico-chimiques sur des échantillons d'eau provenant d'une conserverie algérienne. Notre objectif était de développer un outil d'aide à la décision pour évaluer le processus de traitement et faciliter la prise de décision. Les analyses ont inclus le pH, la conductivité électrique, la turbidité et les principaux éléments, en comparant les résultats aux normes recommandées. Dans l'ensemble, la qualité de l'eau était conforme aux normes, ce qui indique que le processus de traitement actuel élimine efficacement les défauts.

Mots-clés : Évaluation des performances ; Processus de traitement de l'eau ; Utilisation agroalimentaire ; Analyse physico-chimique.

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1. INTRODUCTION

Water is a fundamental constituent of our environment. Its usefulness may vary with the different human needs (food, watering the land, industrial process, etc.). Pure water does not exist in nature. During its different circulations, on the surface of the earth, underground and in the air, it becomes loaded with different materials which may be soluble or insoluble (suspended matter). Indeed, raw, untreated water always contains many substances of natural origin or from human activity. The physicochemical analysis makes known the uses for which a given water is suitable, household needs (cooking or washing water, etc.), industrial needs (cooling or manufacturing water, etc.), it detects water at risk of exert a chemical action on the pipes and facilitates the development of treatments which will eliminate the drawbacks revealed [1-5].

The treatment processes performance in raw water treatment is of great importance and must be evaluated to ensure the successful performance of the processes; it is why many factors such as variability in source water quality or units operational and technical conditions can be applied [6]. There is a need to consider the technical condition assessment comprehensively both in structural and technical terms and in operational and technological terms while, it is required to take in consideration the quantity and the quality of the treated water [7]. The water treatment process applied can be evaluated by testing the quality of the produced water. The identification of water quality parameters varies due to the water sources used [8,9]. In general, physicochemical parameters are considered to be the key parameters for classifying the quality of raw and treated water in any water treatment process, while in other studies the biological parameters of treated water have been included [10].

Water is a staple of most large food processing companies. In a cannery for example, raw water has to be provided at not only an adequate amount, but also of good quality for production of canned food and for supplying boilers. To deal with changes in the nature of raw water within the process water treatment and supply, commonly used treatment technologies have to be evaluated and optimized [11].

At the Amor Ben Amor Cannery, the waste water from Oued Bouati used in the cannery undergoes

several treatments before use to rid it of various pollutants. In the cannery, water is mainly used for cleaning the equipment and premises and the hygiene of cannery staff, washing the raw material (tomato, pepper and apricot), dilution of semi-finished products, boiler feed and cooling cans. This study is a part of the evaluation of the treatment process on the physicochemical quality of water in food industries, focusing on the case of the Amor Ben Amor cannery located in the wilaya of Guelma, Eastern Algeria.

Our objective was to assess the raw water treatment process and to perform physicochemical analyzes of treated and untreated water at the cannery, to evaluate the performance for purification process of water treatment and the quality of raw and treated water, since, to the best of our knowledge, no previous works have been made to cover this important issue related to the public health and the environment. Also to explore the limits of the conventional possibilities used to provide a clean water in agoralimentary industry in Algeria as an example of a developing country.

2. MATERIAL AND METHODS

This experimental study focused on the checks carried out at the cannery and the characterization of the physicochemical quality of the water samples.

2.1 *General conditions and physicochemical parameters determined*

The analyses were carried out on samples taken from raw, softened and osmosed waters, At a daily sampling rate throughout the study period, raw water from the Amor Ben Amor cannery is directly pumped from the Bouati Oued and stored in accumulation basins. The treated softened and osmosed waters refer to the raw water that has undergone all the treatment processes.

Sample containers were polyethylene bottles provided with hermetic-locking caps. Bottles and caps were cleaned, rinsed with desionized water, drained, wrapped in polyethylene bags and stored until required.

Prior to sample collection, sampling device and containers were rinsed twice with the water to be sampled.

The parameters measured are: electrical conductivity (EC), turbidity, pH, total hardness (TH), alkalinity (TA and TAC), chlorides, iron (Fe^{2+}), manganese (Mn^{2+}) and free chlorine.

Prior to collection, the vials were accurately labeled and accompanied by detailed information including the site name, date, time, and collection order, ensuring clarity and preventing any confusion.

2.2 Physicochemical analysis of the water

The physicochemical parameters were determined following the standard protocols [12,13].

3. RESULTS

3.1 Raw water treatment process in the cannery

The treatment of raw water after it has been collected depends on its quality and its constituents, criteria which vary over time. At the cannery, the main source of water used is the water from Bouati Oued. It undergoes several treatments before use. In the following is given a brief description [14] of the raw water treatment process in the cannery:

a) Screening and sieving (Self-cleaning Filter):

remove insoluble waste such as branches, plastics, etc., from the water. In fact, since this waste cannot be eliminated by a physicochemical treatment, it must therefore be eliminated mechanically. To do this, the wastewater passes through several screens whose meshes are increasingly tight. These are equipped with automatic cleaning systems to prevent clogging, and to prevent pump malfunction.

b) Clari-flocculation and settling system:

At this stage, the flocculation and settling treatment takes place in a specific basin, by injecting three chemicals, which are coagulant, soda and bleach. These products cause the particles still present (dust, soil particles, etc.) to agglomerate into flakes. These agglomerate and settle at the bottom of the basin by settling, 90 % of suspended solids are thus eliminated. The quantity of water entering the basin is regulated using a flow meter.

c) Sand filtration:

consists of passing water through a thick layer of fine sand to remove the last flakes. Boiler water just needs sand filtration, but for water used in product manufacturing, it requires ultrafiltration, iron removal and demagnetization.

d) Ultrafiltration system:

The membrane wall acts as a filter for all particles larger than 10-20 nm: bacteria, viruses and germs.

e) Iron removal and demanganisation:

The purpose of removing iron and manganese is to ensure that the water used is of satisfactory quality. Iron removal and demanganization consist in removing Fe and Mn by filtration after an oxidation phase, which allows the formation of insoluble Fe and Mn oxides.

f) Osmosis system:

The water undergoes very strong pressure and passes through a porous membrane, which retains all the particles in suspension and only allows the water molecules to pass. The reverse osmosis unit reduces the mineral salt content by 98%.

g) Softening:

The softener works on the principle of capturing calcium ions (Ca^{2+}) and magnesium ions (Mg^{2+}) responsible for the presence of scale in the installations. The water, which passes through the resin tank, will be freed of calcium and magnesium ions, which are replaced by sodium ions (Na^+).

h) Carbon filter:

Fine filtration is done by activated carbon, for further removal of matters affecting taste and odor and micropollutants still present in the water.

i) UV system:

The water is subjected to UV sterilization, which will oxidize dissolved pollution and eliminate all dangerous microorganisms. It also improves the color and flavor of the water.

The raw water treatment process at the cannery is summarized in Fig. 1.

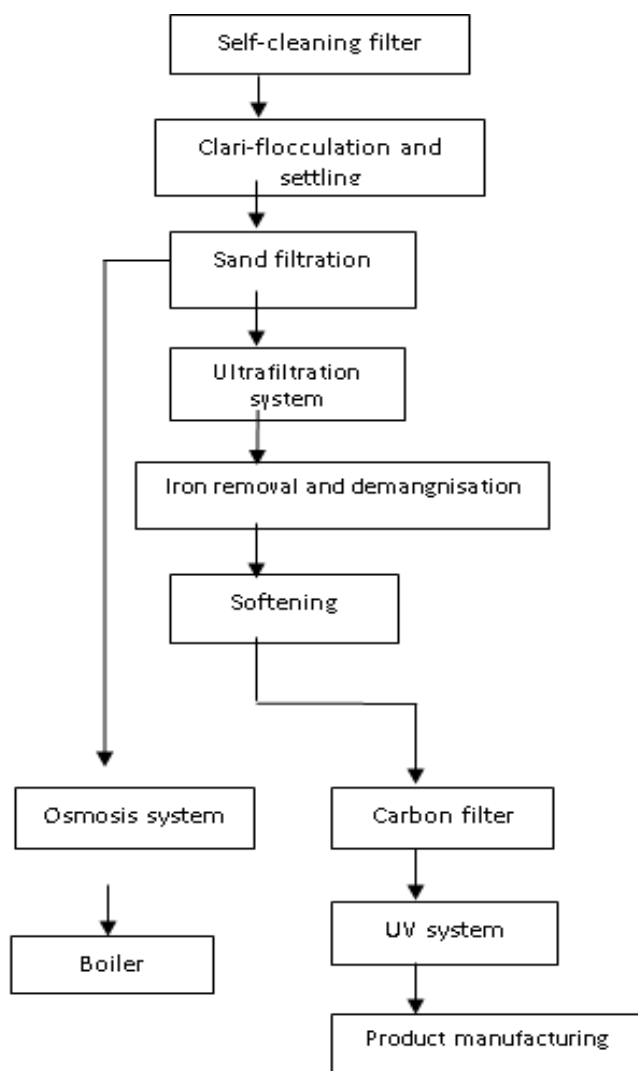


Fig.1. Raw water treatment process at the cannery

3.1 Physicochemical analysis

The analysis of physicochemical characteristics has a very important role in water quality control, hence the need for it to be carried out both during and after treatment, on the samples taken at different

stages of the processing: raw, softened and osmosed waters.

The physicochemical characteristics of the water before and after treatment are grouped together in Table 1.

1. DISCUSSION

In the following is presented the discussion of the results of the physicochemical analysis carried out on the waters of the cannery between April 25 and March 25, 2019.

To learn more about the quality of the water in the cannery through the different treatment steps, as well as the efficiency of the softening and osmosing processes, the results obtained are compared with the Algerian standards for industrial and drinking water parameters [15].

The evaluation of the efficiency of the raw water treatment process at the cannery was made after determining a number of physicochemical parameters characterizing these waters. We analyzed the water by performing measurements of a range of representative physicochemical parameters chosen according to the desired goal. From an industrial point of view, correct water quality is essential for the reliability of operation and the preservation of the life of steam generators. The quality of the water also influences the quality of the steam to be produced and depends on the ultimate use made of it (turbines, superheated steam, process fluid, etc.). The characteristics monitored during this study are the pH to limit corrosion and the dissolved salts to limit deposits, because acid water causes tuberculation and corrosion, whereas alkaline water produces incrustation and sediment deposits [14].

Table 1. Physicochemical characteristics of water before and after treatment.

Parameter	Raw Water (RW)			Softened Water (SW) (Potable Water)				Osmosed Water (OW) (Industrial Water)			
	Avg.	Max.	Min.	Avg.	Max.	Min.	Std *	Avg.	Max.	Min.	Std*
pH	7.78	7.95	7.67	7	7	7	6.5-8.5	12.40	12.58	12	10.5-12.5
E.C. ($\mu\text{S} \cdot \text{cm}^{-1}$)	1091.25	1122	1060	1101.8	1178	997	2800	4701.25	5000	4495	6000
Turbidity (UTN)	12.28	22.9	4.47	0.70	1.16	0.18	0-5	-	-	-	-

Hardness (TH) °f	4.28	5.40	3.56	4.49	5.36	3.84	0 - 6	-	-	-	-
Alkalinity (TA and TAC) °f	0/23.68	0/25.2	0/22	0/23.24	0/25.6	0/22.4	0/20	54.56/65.4	57.9/68.8	49.6/60	60-80/80-120
Cl ⁻ (mg.l ⁻¹)	105.64	119.28	90.88	123.42	130.64	114.44	250	622.8	658.4	599.6	1000
Fe ²⁺	-	-	-	0	0	0	-	-	-	-	-
Mn ²⁺	-	-	-	0	0	0	-	-	-	-	-
Free Chlorine	-	-	-	0	0	0	-	-	-	-	-

* Algerian standards for industrial and drinking water parameters [15]

The recorded pH values vary between 7, for softened water and between 12 and 12.58 for reverse osmosis water (Table 1, Fig. 1). These results are within the drinkability standards for softened water, which require a pH between 6.5 and 8.5, and boiler water, which requires a pH between 10.5 and 12.5 [15].

The conductivity is representative of the concentration of dissolved salts. The conductivity measurement of the circulating water is used to adjust the boiler purge flow rate. The conductivity results of the water analyzed vary between 997 and 1178 $\mu\text{S.cm}^{-1}$ for softened water and between 4495 and 5000 $\mu\text{S.cm}^{-1}$ for reverse osmosis water (Table 1). These values remain below the standard, which is 2800 $\mu\text{S.cm}^{-1}$ for drinking water and 6000 $\mu\text{S.cm}^{-1}$ for industrial boiler water [15].

Turbidity is directly related to matters dissolved or suspended in water. The recorded values vary from 0.18 to 1.16 NTU (Table 1). They are adapted to the standard (0 to 5 UTN) [15].

The results of the determination of TH show values ranging between 3.84 and 5.36 °f (Table 1). The hardness of the softened water is within the norm, TH from 0 to 6 °f [15].

The values obtained for the TA of the softened water are zero. The TAC concentrations vary from 22.4 to 25.6 °f or from 224 to 256 mg.l^{-1} of CaCO_3 (Table 1). These values are admissible although slightly above standard (200 mg.l^{-1}) [15]. In reverse osmosis water, the TAs are higher but they do not exceed the standards (60-80 °f) [15]. Boiler water TAC results meet standards (80-120 °f) [15].

The chloride contents obtained for softened water are lower than the maximum concentration (250 mg.l^{-1}) [15] required. They vary from 114.44 to 130.64 mg.l^{-1} . Likewise for boiler water, where the

chloride content varies between 599.6 and 658.4 mg.l^{-1} (Table 1) for a standard not exceeding 1000 mg.l^{-1} [15].

In addition to these results, one notices the absence of iron, manganese and free chlorine during the investigation.

Although the results obtained at first glance give water treated in the standards, the comparison between the values of the various physicochemical parameters analyzed for raw water and softened water (Table 1) respectively: conductivity (1091.25 and 1101,8 $\mu\text{S.cm}^{-1}$), TH (4.28 and 4.49 °f), TA and TAC (0/23.68 and 0/23.24 °f) and chlorides (105.64 and 123.42 mg.l^{-1}) shows that the treatment process is faulty at the level of softening, which may be due to the resins which may be saturated and which therefore have to be regenerated.

5. CONCLUSION

The water treatment process applicable to achieve the desired quality of industrial water in a cannery from Algeria was evaluated by comparing the physicochemical quality of raw and treated water at the cannery. In depending on our investigation made for a short-term observation, it was found that although the analyzed parameters of the treated water are within the standards, which indicate that the treatment process at the cannery is generally efficient and that it can be used together with the physicochemical analysis to take corrective measures and actions in the event of non-compliance. Although these results, it is strongly recommended to periodically check the operating condition of the existing treatment facilities and to regenerate the resins

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