Study of the Operation of an Industrial Water Treatment Plant of the Northern Soft Drink Company Fez, Morocco

Ibtissame Elmansouri¹, Amal Lahkimi², Omar Mansour³, Faical Elouadrhiri², Mehdi Chaouch², Noureddine Eloutassi², Fehmi Elkhamar³, Hicham Bekkari¹

¹ Laboratory of Biotechnology, Conservation and Valorization of Natural Phytoresources, Faculty of Sciences, University Sidi Mohamed Ben Abdellah, Fez, Morocco
² Laboratory of Molecular Organometallic Materials Engineering and Environment, Faculty of Sciences, University Sidi Mohamed Ben Abdellah, Fez, Morocco
³ Laboratory Step of the Company of the Carbonated Drinks of the North
* Corresponding author’s e-mail: elmansouriibtissam33@gmail.com

ABSTRACT
In order to verify the operation of the NSDC company’s industrial water treatment plant and to optimize the quality of the liquid discharges by coagulation and flocculation, we carried out the physico-chemical characterization of these liquid discharges and optimized the elimination of the organic matter. The results show that the abatement rate of the parameters SM, COD and BOD₅ of the step are respectively 67%, 66% and 89% during November 79% 81% 89% during December and 69% 82% 89% during January. The treated wastewater showed that the WWTP is working properly, but in the coagulation flocculation treatment step instead of using a large amount of Dekfloc alone. We tried to optimize the dose of a plant powder as bio flocculant injected with Dekfloc as coagulant, which will increase the removal rate of organic matter. The tests of coagulation flocculation show that the application of the combination between Dekfloc and the powder of the cactus allows to increase the rate of abatement of COD to 54%, of BOD₅ to 67%, of TSS to 80%, and therefore the reduction of microorganisms.

Keywords: industrial water, NSDC, Dekfloc, cactus powder, coagulation flocculation.

INTRODUCTION
In Morocco, the issue of environmental protection has become a major priority in all development strategies drawn up in both the private and public sectors. Among the anteriorities is the preservation of water resources [Chaouki, 2013]. Water is an essential engine for life, necessary for all human activities (agricultural, industrial...), it is becoming the scarcest and most valuable resource on Earth given the increasing demand to meet the needs of population growth, urbanization and industrialization [El Ghammat & Temsamani, 2017] Environmental awareness and compliance with legislation have led NSDC to work with respect for its surroundings. Within this context, it has launched a project to build a wastewater treatment plant to treat its wastewater before it is discharged into the sewerage system of the city of Fez. The ultimate objective of this Step, which receives a daily hydraulic flow of 240 m³/d [Khammar, 2013], is to produce a purified water of good quality to be used for irrigation and for reuse. The aim of this study is to study the efficiency of the NSDC WWTP and to improve the pollution removal rate by optimizing the coagulation flocculation.

MATERIALS AND METHODS

General presentation of the step
The wastewater collected from the NSDC undergoes: A pre-treatment by screening to eliminate...
bulky waste, followed by a sieving which allows to retain bodies of dimension superior to 1mm which harm the functioning of the installations.

The water is then directed to the homogenization basin, which is equipped with several air diffusers to avoid decantation. The water is then transferred to the distribution chamber where the pH is adjusted to between 7 and 8 (with sulfuric acid) and the nutrients necessary for the development of bacteria are injected. These bacteria perform their role of degradation of pollutants in the biological reactors. The effluent is then sent to the flocculation tank where a flocculant is injected to agglomerate the particles into flocs, which will facilitate the separation of the purified water in the flotation tank (clarifier). Finally, the purified water is directed to the disinfection basin to eliminate pathogenic germs with bleach, and then discharged into the natural environment. The resulting sludge is either stored in a sludge tank for dewatering treatment or recirculated to the bioreactor to maintain the purifying biomass (Figure 1).

**Sampling technique**

Sampling is carried out during 3 months (November, December and January), at the level of the compartment of the treatment plant:
- the entrance of the basin;
- before the flocculation basin;
- the exit of the basin.

**Materials used**

- pH-meter type HANNA instruments.
- Jar-test system type VELP SCIENTIFICA (JLT6),
- UV-Visible spectrophotometer, type Hach lange DR 3900,
- Software graphpad prism 2007.

**Flocculant used**

Materials used were Dekfloc RI-705 and Cactus powder (*opuntia ficus indica*).

**Analysis methods used**

The different physico-chemical parameters were analyzed according to standard methods [AFNOR, 1999] (Table 1).

**RESULTS AND DISCUSSION**

**Physicochemical characteristics of wastewater received by the treatment plant**

The results of the physico-chemical analyses of the raw wastewater received at the inlet

**Table 1. Methods of analysis used**

| Studied parameters | Methods                                      |
|--------------------|----------------------------------------------|
| pH                 | pH meter                                     |
| Temperature        | Thermometer                                  |
| SM                 | Filtration method with suction pump          |
| COD                | Spectrometric method with the Hach lange DR 3900 spectrometer |
| BOD$_5$            | Respirometric method                         |

**Figure 1. General diagram of the NSDC wastewater treatment plant**
of the CBGN WWTP and at the outlet, determined from the samples taken in November, December 2019 and January 2020, are shown in Table 2. The pH values of the wastewater at the inlet are between 11.40 and 11.96, which could be due to the injection of soda during the washing of the bottles (Fig. 2). These values recorded undergo a decrease at the exit of the station between 7.76 and 8.37 (reference term of the technical study). These results corroborate that of Khamar [2013], which showed the reduction of pH after treatment.

**Temperature evolution**

The temperature values of the wastewater recorded, are lower than 30 °C considered as the limit value of direct discharge into the receiving environment (Fig. 3) [Ministry of the Environment of Morocco, 2002].

**Evolution of the SM**

The SM content at the entrance of the plant varies between a value of 404 December and 159 mg/L in January (Table 2). These contents undergo a decrease at the exit of the plant and pass towards 82 mg/L in December and 48.2 mg/L in January meeting the Moroccan discharge standards.

**COD evolution**

The COD content recorded at the Step inlet is between 1673 and 2015 mg/L (Table 2). These contents are strongly reduced during treatment: 316 mg/L and 564 mg/L at the step outlet.

### Table 2. Physico-chemical parameters analyzed in the raw wastewater received by the WWTP of the company CBGN (the inlet of the step)

| Parameters | November values | December values | January values |
|------------|-----------------|-----------------|----------------|
| pH         | 11.54           | 11.96           | 11.40          |
| Temperature (°C) | 20.5           | 19.8            | 16.3           |
| SM (mg/L)  | 229             | 404             | 159            |
| COD (mg/L) | 1673            | 2015            | 1799           |
| BOD₅ (mg/L)| 502             | 510             | 599            |

### Table 3. Physico-chemical parameters analyzed (step outlet)

| Parameters | November values | December values | Values January |
|------------|-----------------|-----------------|----------------|
| pH         | 8.37            | 7.76            | 8.03           |
| Temperature (°C) | 20.4           | 19              | 15.8           |
| SM (mg/L)  | 75              | 82              | 48.2           |
| COD (mg/L) | 564             | 368             | 316.4          |
| BOD₅ (mg/L)| 52.5            | 52              | 62.3           |

![Figure 2. The evolution of the pH before and after treatment](image)

![Figure 3. The evolution of the temperature before and after the treatment](image)
The degree of pollution and the richness of the water in biodegradable organic matter is evaluated by the biochemical oxygen demand [Djermakoye, 2005]. It should be noted that the water at the plant inlet has a BOD$_5$ value that varies between 502 and 599 mg/L. The latter exceeds the discharge standards for treated wastewater (500 mg/L) [Chaouki, 2013]. In addition, the treated water has a BOD$_5$ value in the range (52–62 mg/L) (Table 3). The efficiency of the treatment was assessed visually and analytically by monitoring the removal rate of TSS, COD and BOD$_5$ (Figs. 4–6). The calculation of the removal rate of a parameter was performed using the following equation:

$$\text{Removal rate} = \left(1 - \frac{C_{\text{after}}}{C_{\text{in}}} \right) \times 100\%$$

where $C_{\text{after}}$ is the concentration of the parameter after treatment, and $C_{\text{in}}$ is the concentration at the plant inlet.

### Table 4. Variation in abatement rates

| Parameters | Abatement rate (November) | Abatement rate (December) | Abatement rate (January) |
|------------|---------------------------|---------------------------|--------------------------|
| SM         | 67%                       | 79%                       | 69%                      |
| COD        | 66%                       | 81%                       | 82%                      |
| BOD$_5$    | 89%                       | 89%                       | 89%                      |

**Evolution of BOD$_5$**

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where $C_{\text{after}}$ is the concentration of the parameter after treatment, and $C_{\text{in}}$ is the concentration at the plant inlet.
Table 5. Characterization of raw effluent

| The sample | SM   | COD     | BOD$_5$ |
|------------|------|---------|---------|
| 1          | 240 mg/L | 1472 mg/L | 535 mg/L |

Table 6. Effect of industrial and natural flocculants

| Flocculants used (g/L) | Measured parameters | Abatement rate |
|------------------------|----------------------|----------------|
|                        | SM | COD | BOD$_5$ | SM | COD | BOD$_5$ |
| Dekfloc (2 g/L)        | 82 | 1148| 298    | 65% | AR=22% | AR=44% |
| Cactus powder (5 g/L)  | 179| 1226| 434    | AR=25% | AR=16% | AR=18% |
| Dekfloc (2 g/L) + Cactus powder (5 g/L) | 42 | 652 | 158 | AR=82% | AR=55% | AR=70% |

X, expressed as a percentage, is based on the following formula:
- \( C_i \) – initial concentration of X in the water without treatment;
- \( C_f \) – final concentration of X in treated water.

The purification yields of COD and BOD$_5$ are more or less satisfactory with rates of 89% for BOD$_5$ and 82% for COD (Table 4). These values are almost 90% which is a value that characterizes an efficient purification according to Rejsek [2002].

Improvement of the treatment by coagulation and flocculation

The table represents the effect of treatment with different flocculants, repeated 4 times on samples taken before the flocculation basin. According to the results grouped in Table 6 and Figure 8, 9 and 10, in the case of using cactus powder and Dekfloc we observe a very interesting reduction of SM, COD and BOD$_5$ and subsequently a better abatement of the parameters compared to the treatment by Dekfloc alone. The
use of the powder has shown a great power of elimination as they had shown [Sakr et al. 2015, Bilbahloul et al. 2014, Benalia et al. 2017, Abid 2009, Abid et al. 2009]. In case of using Dekfloc alone, we will have a risk of contamination of the sludge with compounds containing ammonium sulfate that could cause serious consequences on the environment. On the other hand, in the case of using the powder and Dekfloc; we will interfere with a sludge consisting simply of biodegradable organic matter.

CONCLUSIONS

The effluents of the NSDC company present values of the parameters SM, COD and BOD\textsubscript{5} that relatively exceed the general limit values of direct and indirect discharges, which generate an environmental imbalance, hence the need to treat these effluents. The objective of this study was to evaluate the efficiency of the CBGN company’s wastewater treatment plant and to evaluate the efficiency of using a biomaterial (cactus cladode), which is available, biodegradable and less expensive for the treatment of these industrial discharges.

The obtained results allow to conclude that the physico-chemical analyses of the treated water are in conformity with the standards of rejection in the natural environments. The WWTP allows to reduce more than 67% of SM, 66% of COD and 89% of BOD\textsubscript{5} in November. 79% of TSS 81% of COD and 89% of BOD\textsubscript{5} in December and 69% of SM 82% of COD 89% of BOD\textsubscript{5}. It would be interesting to make an optimization of the injected flocculant dose to further improve the treatment. The combination between the cactus powder and Dekfloc presents a very good alternative to improve the treatment of industrial liquid discharges in order to reduce the concentration of dekfloc used per month by 50 kg in half and thus reduce the risk on the environment. In addition, it would be interesting to optimize the dose of coagulant injected to further improve the treatment.

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