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The use of two kinds of algae as biosorbents for industrial wastewater treatment

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ABSTRACT

Nowadays, water defluoridation has become a necessity, for vital human health and for environmental protection through feasible technologies. This present work consists the fluoride absorption study by two algae *Chlorella pyrenoidosa* and *Spirulina*, in the exploiting purpose it for industrial water biological treatment. The results obtained allow to know how these algae behave towards toxic substances that can be found in their environment, and so the ability to be used in the water treatment field. However, in the experiment onset, the different environments have fluoride concentration variation from 0.5 to 2.5 mg/L. Just 3 d after; we could notice the almost total fluoride consumption by the cultured cells. Cultivated microalgae cells demonstrated a high fluoride removal with 100% and 84.5% reduction for *Chlorella pyrenoidosa* and *Spirulina* respectively. According to the study results, we have shown that the algae are a good bioadsorbent of existing elements in water. In addition, it can be considered that the water treatment by algae is the most modern and suitable technology, because of these advantages its: profitability, ease to use, the quickness for the treatment of all wastewater types.

Keywords: Algae; *Chlorella pyrenoidosa*; Fluoride; Growth; *Spirulina*; Water treatment

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1. Introduction

The industrialization has led to an increase in the pollution of ecosystems by metal pollutants that can enter in the food chain [1]; colorants also, can cause significant problems in the aquatic environment and food chain [2]. This pollution has a negative effect on the organisms found [3]. Pollution can alter the structure of an ecosystem and reduce the number of species in a community, leading to decline in the diversity [4] as well as toxic substances, such as heavy metals, pesticide residues, polycyclic aromatic hydrocarbons and pharmaceutical products accumulated in the tissue of fish, molluscs and crustacean, pose a threat to human health when ingested [5]. Recently, many researchers have focused on the reuse wastewater for environmental protection and the renewable resources production such as fuel and animal feed [6].

Fluoride is an undesirable by-product in industrial processes, becoming highly concentrated in the effluent, reaching 1,000 to 50,000 ppm (F^-). However, most defluoridation

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research has focused on treating low fluoride concentrations <100 ppm [7].

Moderate fluoride ions amount (F^-) in drinking water contributes to good dental health. About 1.0 mg/L is effective in preventing tooth decay, particularly in children. Excessive fluoride amounts cause discolored teeth, a condition known as dental fluorosis. The maximum allowable levels of fluoride in public water supplies depend on local climate. In the warmer regions of the country, the maximum allowable fluoride concentration for water potable is 1.4 mg/L [8].

Many industries such as glass, coal-fired power stations, ceramic, semiconductor, beryllium extraction plants, electroplating, brick, iron works and aluminium smelters increase contamination in groundwater by the fluoride [9].

The use of both physicochemical and biological methods together for water defluoridation have proven advantageous when compared to specific methods. Researchers have employed algal biomass for the fluoride biosorption from polluting [9].

During the last years, microalgae attracted increased interest for their implementation in the wastewater context [10]. The microalgae use has become promising for the treatment of agro-industrial wastewater, given their ability to consume nutrients from these waters for their growth, and therefore, they could significantly reduce environmental pollution [6]. In addition, the microalgae use in wastewater treatment is a cost effective and feasible solution CO_2 bio-fixation method [11].

A study conducted on the algo-mycological analysis complexes in Albic Podzolic soils affected by emissions from the Kandalaksha Aluminium Smelter (KAS) was carried out by Redkina et al. [12], who showed that in total, 56 species of eukaryotic algae and 7 cyanobacteria species were found in the maximum fluorine-polluted area, among green algae, families *Chlorophyceae* species and *Trebouxiophyceae* dominated in all plots [12].

Conventional technologies applied to eliminate heavy metals especially at low concentrations are inefficient and/or costly [1]. Recently, wastewater plans have been focusing on sustainability issues through the valorisation of energy and nutrients from water [13]. Indeed, there are various technologies used for treatment of surface water, urban, domestic and industrial wastewater as well as sewage sludge [14], among these, in particular note solutions based on the use of phytotechnology [15,16].

Currently, the possibility of using algae in wastewater treatments processes is important from an environmental protection perspective [17], it is well known that the algae are capable of eliminating pollutants such as nutrients, heavy metals from various types of wastewater [18], through the mechanism of bioaccumulation and biosorption [19–21]. However, microalgae can be used as biosorbents for the elimination of heavy metals by biosorption [22]

In addition, the recovery of biomass that can be used as a raw material for biofuel production [23] and bioactive compounds, showing that the algal approach may also lead to a more sustainable approach to sanitation [24,25].

In addition, microalgae consist of a biofuel raw material and provide an alternative animal feed source [26], they could also be considered as promising approach to wastewater treatments [26,27].

The microalgae culture in commercial environments is costly, while wastewaters contain nitrogen and phosphor, they could also be a feeding source for microalgae culture, which reduces the production costs [28], also allows the reduction of the amount of wastewater discharge, the increase of algal biomass and of lipids production [29].

Algae are photosynthetic living beings, whose life cycle usually takes place in aquatic environments [30]. They constitute a very important part of biodiversity and are the main base of food webs of freshwater, brackish and marine. They are characterized by a simple cellular structure, a rapid growth rate and high photosynthetic efficiency [31]. Various species are used for human food, agriculture or industry [30].

Microalgae are biologically diverse organisms that are very valuable for academic and industrial fields [32]. They are increasingly being used to produce high value products and bioactive substances in a wide range of areas from sustainable energy to healthcare [33], in fact, the main directions the biotechnology of microalgae are biofuels, agriculture, biostimulants for cultivated plants, water treatments, etc. [34]. However, the use of microalgae for wastewater treatments has many advantages over other common chemical and physical technics, making it a promising method [35]. Algae such as *Chlorella*, *Scenedesmus* and *Spirulina* are the most widely used for nutrient removal [1].

Chlorella is a green unicellular freshwater algae, it is round or ellipsoid, with an average of diameter of 5 μm, a single cell of *Chlorella* can be divided into four cells every 16 to 20 h, using sunlight for photosynthesis. It is rich in vitamins, fatty acids and mineral salts [36], this seaweed is a rich source of antioxidants which reserves an important place for uses in medicinal and alimentary fields and food, it caught the attention of biotechnologies as an important source of biomass [37], it is widely used in various applications such as: wastewater treatments, heavy metals elimination, etc. [38].

Spirulina is a microorganism belonging to cyanobacteria group, a multicellular and filamentous blue-green microalgae [39], due to its high proportion of protein, which is 70% order and especially in phycocyanin, it is considered a food source of high nutritional quality. These algae, rich in vitamins including provitamins A, B1 and β carotene [40], it also contains Omega 3 polyunsaturated fatty acids, Omega 6 and linoleic gamma acid [39], this algae grows naturally in subtropical and tropical regions [41], it can live in warm an alkaline environment [35], in environments where this algae grows, no organism can survive to pollute these waters, the thing that makes it an ideal candidate for bioremediation studies, and use it widely for wastewater treatment and for the elimination of xenobiotic compounds [35].

It is within this general framework of research, that our subject of this work is part of it, indeed, the ultimate goal of this study is to show the importance of algae in the field of water treatment, and however, we will study the absorption of fluoride by two different types of algae: *Chlorella pyrenoidosa* and *Spirulina*.

2. Materials and methods

2.1. Algae culture

2.1.1. Chlorella culture

Continuous cultures of *C. pyrenoidosa*, were carried out in six culture systems rated from 0.5 to 2.5 F (Fig. 1), the first chosen as reference, the systems (0.5, 1, 1.5, 2 and 2.5 F) are enriched, by the fluoride (F) in different concentrations from 0.5 to 2.5 mg/L respectively,; cultures are exposed to artificial light provided by four lamps for each culture system, temperature during the experiment range from 25°C to 27°C, Aeration and stirring were done by continues air inflow.

2.1.2. Spirulina culture

At the same operating conditions, cultures of algal strains called *Spirulina* were carried out in six culture systems rated 0 to 2.5 F, the first is chosen as a reference, the system (0.5, 1, 1.5, 2 and 2.5 F) are enriched, respectively, by fluoride (F) in different concentrations from 0.5 to 2.5 mg/L.

The cell concentration of suspension is determined by measuring absorption at 680 nm for *Chlorella* and 663 nm samples, 750 nm respectively for this last (*Spirulina*), using a spectrophotometer, sample collection, for various analyses, are carried out in the mornings in 5 mL sterilized test tubes.

2.2. Analyses carried out

Every day after 24 h, with great care for each culture system of the experiment, the pH measurement is carried out with multiple parameter type HANNA, which is used to measure physical parameters such as pH, temperature, total dissolved solid, salinity, etc.

2.3. Algae growths

2.3.1. Chlorella pyrenoidosa

After 24 h of contacting the samples, the growth of cultivated algae *C. pyrenoidosa* is followed by the measurement of the biomass concentration by a UV-visible spectrophotometer, type Hach DR6000, from the research laboratory: water and environment engineering in Saharan environment at Ouargla University, and at a wavelength of 680 nm, the concentration is in mg/L and it is done by a direct reading.

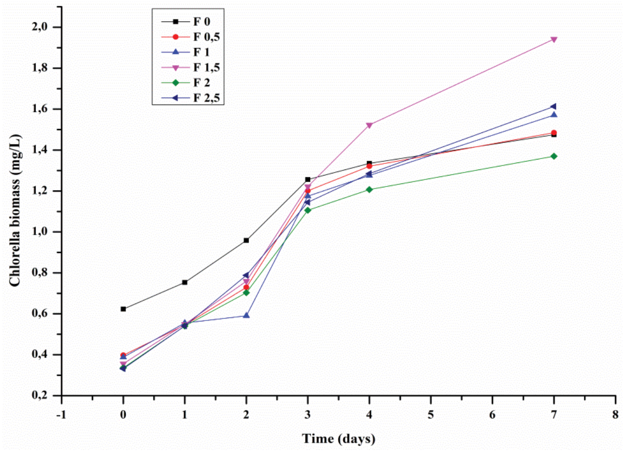

Fig. 1. Evolution of biomass of culture systems (*Chlorella*).

2.3.2. Spirulina

Spirulina growth was determined using the method described by Pearson (1987), by optical density measurement from 663 to 750 nm with the help of spectrophotometer type UV-visible, chlorophyll concentration is determined by the following formula [37]:

$$\mathrm{Chl}\left(\mu/1\right)=\frac{160}{89}\frac{\left(\mathrm{OD\ 66nm}-\mathrm{DO\ 750nm}\right)\times\mathrm{Volume\ of\ solvent}\left(\mathrm{ml}\right)}{\mathrm{sample\ Volume}\left(\mathrm{ml}\right)} \tag{1}$$

where OD: optical density; 160/89: equation constant.

2.4. Concentration of fluoride

Fluoride concentration was monitored each morning with the UV-visible spectrophotometer, the measurements of the samples were made after a dilution of 1 mL between 40 to 60 mL of the solvent, then filled in 10 mL bowl of the diluted solution and the dosed with 2 mL of the SPNADNS fluoride reagent.

The percentage biosorption of fluoride (RF) was calculated using the flowing equation [42]:

$$\mathrm{RF}\ \%=\left(\frac{\left(C_0-C_e\right)}{C_0}\right)\times 100 \tag{2}$$

where C_0; initial concentration, C_e; final concentration

3. Results and discussion

3.1. Growth of algae

3.1.1. Chlorella pyrenoidosa

The growth of the algae *C. pyrenoidosa* results are presented in Fig. 1.

The result analysis of the Fig. 1 tells us that the pace of the graphs is the same for all culture systems, with a small difference between them (from system 0.5 to system 2.5) and this on the first day of the experiment. The growth of *Chlorella* algae increases with time for all systems until the 4th day. From the 4th day we notice the continuous growth for all systems except the 2.5 system which marks a decrease. This can be due to the high concentration of fluoride which is 2.5 mg/L.

Analysis of these results showed that the growth of the algae *Chlorella* is influenced by the presence of fluoride at different concentrations. Indeed, tests have been carried out different concentration of fluoride; 0.5 to 2.5 mg/L depending on the graphs (Fig. 1). It has been noted that the presence of this element has a positive effect on the growth of the studied algae. However, it has been observed that, for all four media, yields vary depending on the variation in the concentration of fluoride.

3.1.2. *Spirulina*

The result of the growth of *Spirulina* algae is presented in Fig. 2.

Analysis of the results of Fig. 2 tells that the graphs are almost the same for all culture systems, with a small difference between them except, systems 0.5 and 2.5 that show a remarkable fall between day 0 and day 1.

It is very remarkable that the *Spirulina* algae have marked a decline through all the duration of the experiment. The maximum values have been recorded for systems 2 and 2.5 L on the first two days of 0.56 g/L then, the decrease continued until the last day, and the minimum value of the experience is noted for the 2.5 system, which is 0.046 g/L.

The analysis of these results shows that the growth of *Spirulina* algae is influenced by the presence of fluoride in different concentrations. However, the realized cultures of *Spirulina*, show a rapid decrease in the growth and in the content of chlorophyll that cancels out on the 7th day of cultivation, which shows the negative effect of the high concentration of enriched fluoride on the algae.

3.2. pH tracking

3.2.1. For *C. pyrenoidosa* culture

The results of pH analyses of the *Chlorella* strain are presented in Fig. 3.

Based on the curves in Fig. 3, it is noted that for the first two days of the experiment, the pH value is between 7.58 and 8.88. On the other hand, we notice a relative stability value of pH from 8.80 to 9.85 in all cultivation systems from 7th day.

3.2.2. For *Spirulina* culture

The pH analyses of the *Spirulina* algae are presented in Fig. 4.

According to the curves in Fig. 4, it is noted that for the first two days of the experience, the pH value is between 8.93 and 9.4. On the other hand, there has been a symmetrical increase in the second to the third day for all systems that reach a maximum (9.57). We notice a relative stability in all culture systems starting from the 4th day when the pH value is 9.1 up to 9.3.

3.3. Removed fluoride by algae

3.3.1. Removed fluoride by *C. pyrenoidosa*

Fluoride concentration evolution analysis for *Chlorella* algae is in Fig. 5a.

The analysis of Fig. 5a shows us that there is symmetry of the curves for all culture systems according to their concentration, from the first to the 3rd day.

At the beginning of the experiment, the different environments have a variation in the concentration of the

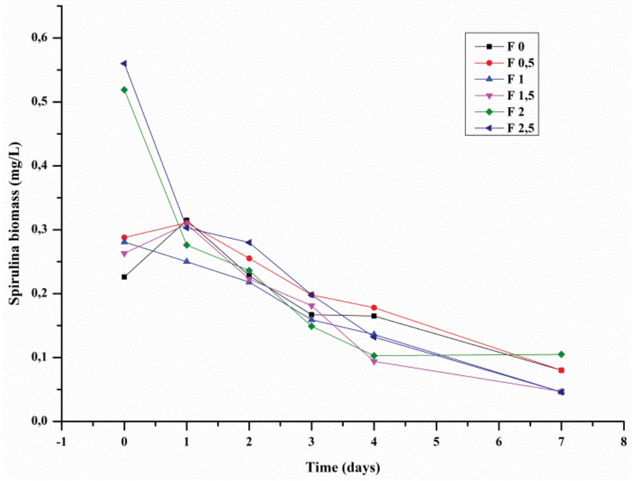

Fig. 2. Biomass evolution of culture systems (*Spirulina*).

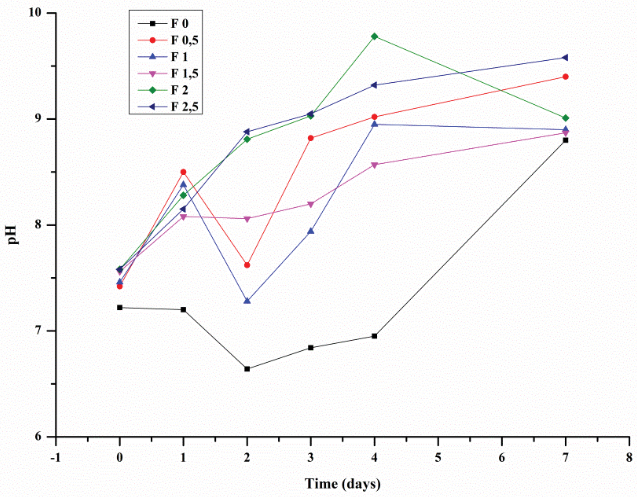

Fig. 3. Variation of pH in the culture medium (*Chlorella*).

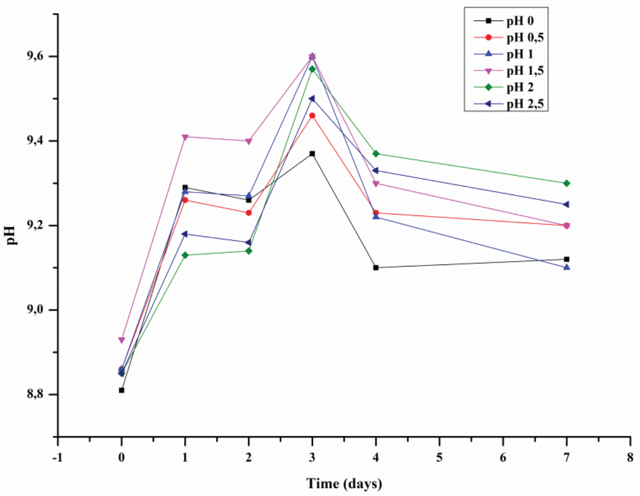

Fig. 4. Variation of the pH in the culture medium (*Spirulina*).

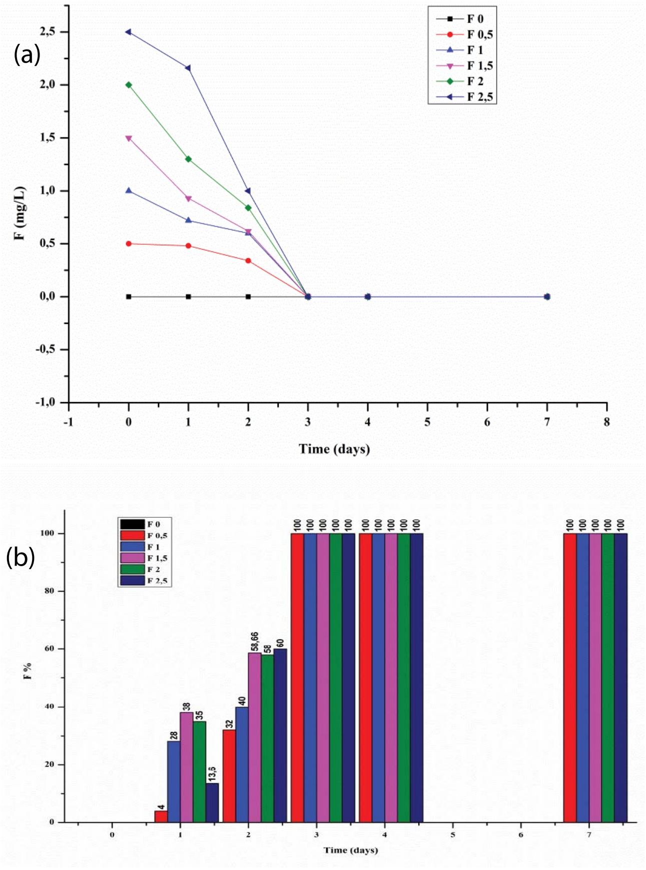

Fig. 5. (a) Fluoride evolution of the culture systems (*Chlorella*) and (b) biosorption percentage of fluoride by *Chlorella*.

fluoride from 0.5 up to 2.5. After 3 d only, we notice a total consumption of fluoride by the cultured cells.

The *Chlorella* algae has a very remarkable ability to accumulate fluoride. Indeed, according to graph 5b, we notice that after culture 1 d the *Chlorella* strains, there is a fluoride biosorption varies from 4% to 38% for the culture systems (Fig. 5b).

From the 3rd day of the culture, all culture systems achieved 100% fluoride adsorption. Which allows us to say that *Chlorella* algae is ideal to absorb the fluoride and presents a primordial choice for use in the water treatment field.

3.3.2. Removed fluoride by Spirulina

The evolution of fluoride concentration for *Spirulina* is presented in Fig. 6a.

Fig. 6 shows us the decreasing pace of the curves of the culture systems according to their concentration and that from the 1st to the 3rd day, which cancels out on the 3rd day symmetrically in all systems. At the beginning of the experiment, the different environments have a variation of fluoride concentration from 0.5 to 2.5 mg/L.

The analysis results presented in Fig. 6a, shows that the algae *Spirulina* has a variable affinity with respect to the fluoride accumulation from one system to another. However, the fluoride adsorption by *Spirulina* varies from 5% to 54% after 1 d of culture (Fig. 6b).

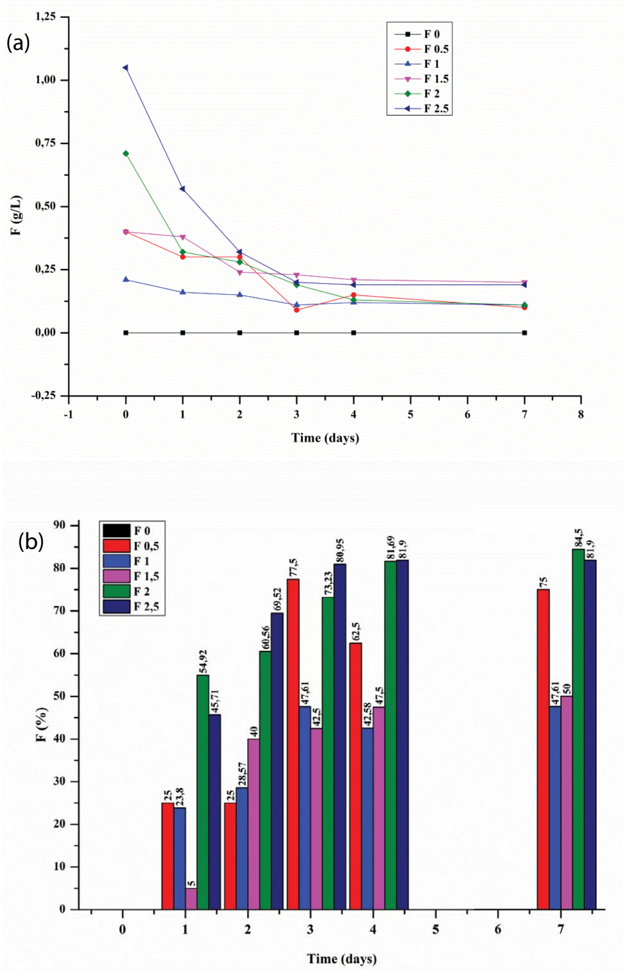

Fig. 6. (a) Fluoride evolution of culture systems (*Spirulina*) and (b) biosorption percentage of fluoride by *Spirulina*.

This adsorption remains variable in all the systems during the experience days. It reaches their maximum, on the 7th day of culture. Indeed, the maximum-recorded values vary by 47.61% and 84.5% for the F1 and F2 systems respectively.

According to these results we can say that the *Spirulina* algae has a maximum adsorption of 84.5% after 7 d of culture, which a low value by their comparison with the *Chlorella* algae, which recorded a total adsorption of 100% from the 3rd day of culture in the same fluoride concentration at the start.

3.3.3. Fluoride removal mechanisms

At present, there is a little research that has explained the fluoride adsorption mechanism by algae; they showed that the cell parishes of algae generally contain either a glycoproteins variety, or polysaccharides variety or the both at the same time. According to this research, the hydrogen ions protonation and the presence of amine groups on the algal biomass were considered the main reason for the fluoride elimination [9].

However, the important mechanisms namely ion exchange, electrostatic attraction and adsorption are believed to influence the elimination of fluoride. Indeed, in our studied cases, amine groups present on the biomass of cultivated algae *C. pyrenoidosa* and *Spirulina*, as well as the phosphorus present on the algal biomass surface are probably the main adsorption sites; these results are consistent with those obtained by Hiremath and Theodore [9], who proved that the amine groups present on the biomass are the main fluoride adsorption sites; the latter bind to the phosphorus groups present on the surface of the algal biomass.

3.3.4. Comparison with other adsorbents

The fluoride ions adsorption percentage by the algae *C. pyrenoidosa* and *Spirulina* presented in this current study, was compared with the values obtained in the literature in Table 1.

Although the operating conditions of other studies may vary from those of the present work, we can say that our results are very acceptable. However, the adsorption percentages by zirconium-doped algal biosorbents are 92.21% and 90.4% for zirconium-doped *Chlorella protothecoides* and zirconium-doped *Nannochloropsis oculata* respectively and are on par with other adsorbents found in the literature [9], indeed, these values are slightly higher than those obtained in this study, for the algae *Spirulina* which has a 84.5% percentage of fluoride elimination, while these values are lower than our results for the algae *C. pyrenoidosa*, which recorded a total fluoride elimination and therefore a 100% adsorption; the fluoride adsorption by the algae *Padina* sp. was in 67.79% to 78.78% the range, in collected groundwater samples [43], these values remain lower than our results.

3.3.5. Economic feasibilities of fluoride adsorption by algae

Today, water defluoridation has become a necessity, for vital human health and for environmental protection through feasible technologies. However, various conventional technologies are applied to the water defluorination, we cite: membrane filtration, flotation, ion exchange, reverse osmosis, electrodialysis and adsorption. Only a few of these technologies can be realized on a large scale, because these technologies require a lot of initials operating investment, as well as high maintenance. Because of these economic reasons, it's important to focus on efficient and cost-effective technologies for the water containing fluoride treatment [44].

Table 1
Comparative evaluation of various adsorbents for fluoride removal

Adsorbents	Adsorption	References
Zirconium-doped *Chlorella protothecoides*	92.21%	[9]
Zirconium-doped *Nannochloropsis oculata*	90.4%	[9]
Padina sp. algae	67.79% to 78.78%	[43]
Chlorella pyrenoidosa	100%	Present study
Spirulina	84.5%	Present study

Therefore, adsorption remains the most suitable technology, due to these various advantages: its cost-effectiveness, ease to use, low chemical consumption and better efficiency [44]; adsorption shows high metal removal and is a fast method for all types of wastewater treatment. In addition, it's becoming a popular technique, given the metal recovery possibility and the adsorbent reuse [45,46].

Agricultural and plant wastes have been used as bioadsorbents for wastewater treatment; these methods are very effective and promising in the biosorption technique, among these biosorbents, the algal biomass [44].

Algae constitute a very important and advantageous ecological biosorbent, indeed, following this study, the algae *C. pyrenoidosa* and *Spirulina*, have high capacities for the elimination of fluoride from wastewater. In addition, the algae resist the severe cultures conditions. Their growth is fast, do not require large surfaces of culture, and especially do not require high investments for the used as biosorbent; are available and low-cost adsorbents, therefore from an economic point of view are the most profitable.

3.4. pH effect on the fluoride adsorption

3.4.1. pH effect on the fluoride adsorption by C. pyrenoidosa

The pH effect study on the fluoride biosorption by *C. pyrenoidosa* is presented in Fig. 7.

The analysis results presented in Fig. 7 shows us that the algae *C. pyrenoidosa* is able to eliminate fluoride ions even at high pH values. However, the pH of the culture systems is globally varied between 7.42 to 9.78 from the first day of culture until the 7th day for all the systems, whose initial fluoride concentrations varied between 0.5 F until at 2.5 F. these pH values are high, but it is very remarkable that the algae *C. pyrenoidosa* has completely absorbed the fluoride ions from the 3rd day of culture, these results allow us to say that this algae is a choice essential for use in the water treatment field, as it resists severe growing conditions.

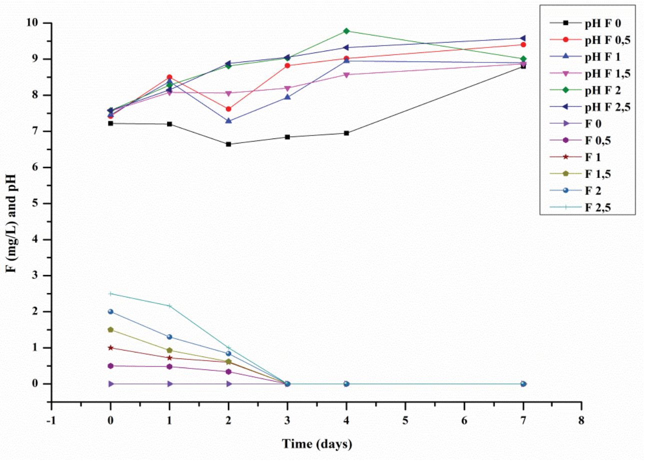

Fig. 7. pH effect on the fluoride adsorption by *Chlorella pyrenoidosa*.

3.4.2. pH effect on the fluoride adsorption by Spirulina

The study of the pH effect on the fluoride biosorption by *Spirulina* is presented in Fig. 8:

From the analysis of the results presented in Fig. 8 it appears very clearly that the algae *Spirulina* is able to absorb fluoride at high pH, varies between 8.85 to 9.6 globally in all cropping systems, which have different fluoride concentrations varies between 0.5 to 2.5 F. the maximum adsorption reached on the 7th day of culture, its order to 80.4% recorded for the 2 F system. This adsorption of fluoride by *Spirulina* algae remains lower than that obtained by the algae *C. pyrenoidosa*, which recorded a total flower ions elimination in only 3 d.

Following the analyzes of the results in Fig. 8, it appears very clearly that there is an increase in the biosorption of fluoride ions with the increase in the initial fluoride concentration, this may be due to the increased driving force for mass transfer to take place, these results are consistent with those reported by Hiremath and Theodore [9].

3.5. Application

In order to track the growth of the two algal strains in different environments, continuous cultivation of *C. pyrenoidosa* and *Spirulina* algae were done.

Two systems are carried out for each algae, where one is grown in its cultivated environment and the second in industrial wastewater noted as follows: (ref 1, used water 1) for *C. pyrenoidosa*, (ref 2, used water 2) for *Spirulina*. The cultures are exposed to artificial light provided by six lamps under a temperature of 25°C ± –2°C. Aeration and stirring are ensured by a continuous air inflow.

The concentration of a suspension's cells is determined by measuring the absorption of each algae using a spectrophotometer; 680 nm for *C. pyrenoidosa* algae and 663, 750 for *Spirulina*. Samples are taken every morning in 100 mL sterilized vials.

3.5.1. Growth of C. pyrenoidosa

The results of the growth of the algae *C. pyrenoidosa* are presented in Fig. 9.

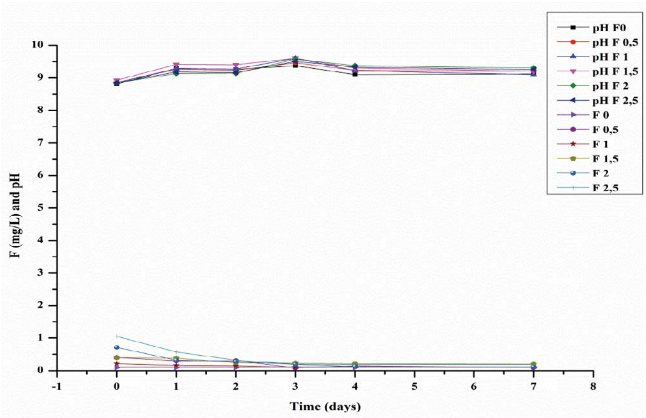

Fig. 8. pH effect on the fluoride adsorption by *Spirulina*.

According to Fig. 9, there has been a continuous evolution of the reference system from the first to the last day of the experiment. On the other hand, we notice that there is no evolution of the strain grown in the used water during the experiment.

It is very important to note that the reference culture system went through an adaptation phase of 0.01 to 0.08 g/L from day 1 to day 3, and then increased to 0.518 g/L on the 7th day. Note that the presence of toxic elements in the wastewater has a negative impact on the growth of these microalgae.

3.5.2. Growth of Spirulina

The results of the growth of the *Spirulina* algae are presented in Fig. 10.

Fig. 10 shows a remarkable difference between the two systems, mentioned by their graphs. It should be noted that the biomass of both systems goes through an adaptation phase the first two days, the highest value is recorded for the rated system (used water 2) and it is in

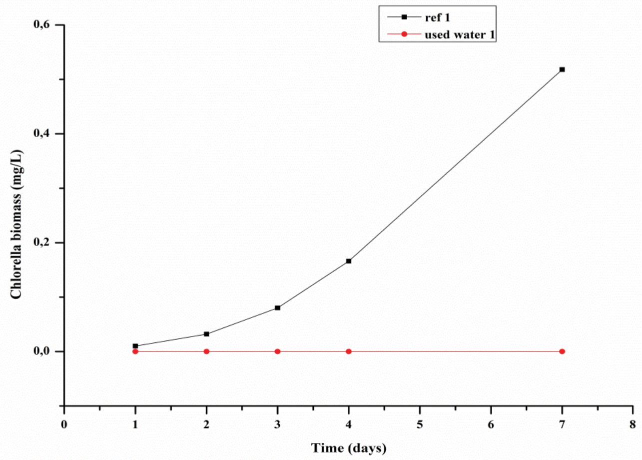

Fig. 9. Biomass evolution of the *Chlorella pyrenoidosa* culture system.

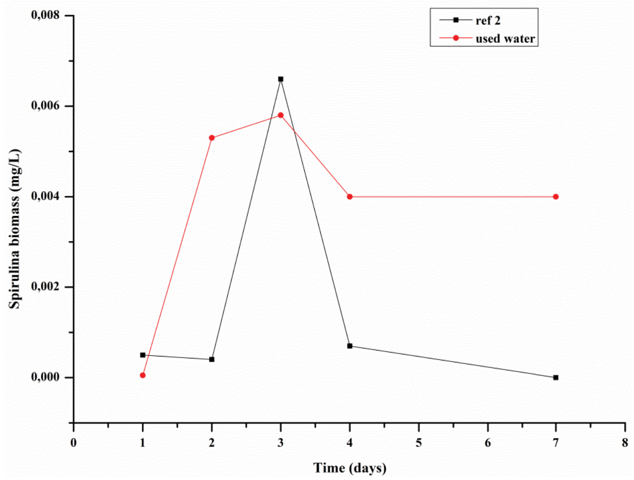

Fig. 10. Biomass evolution of the *Spirulina* algae culture system.

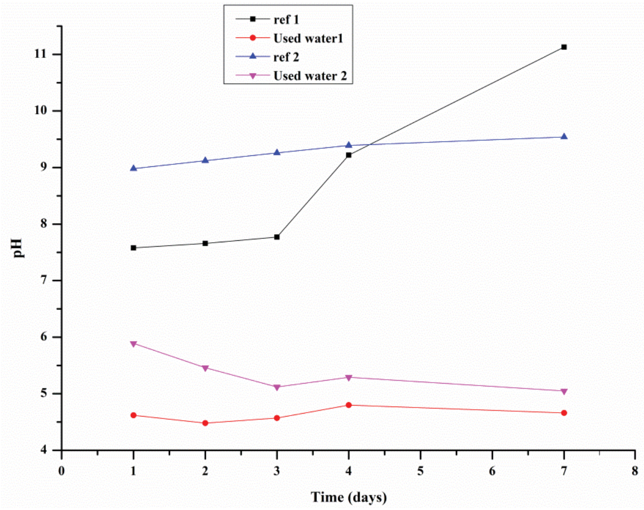

Fig. 11. pH evaluation in culture media.

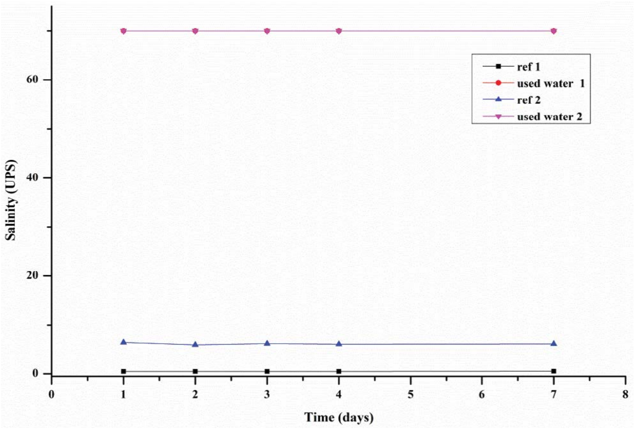

Fig. 12. Salinity variation in culture environment.

the order of 0.0053 g/L. The lowest value is for the system (ref 2) and it is in the order of 0.0004 g/L, then the growth of algae increases. Thus, for both systems, growth reaches its maximum value during the 3rd day when the highest value reached which is in the order of 0.0066 g/L and it is reported for the system (ref 2), while the lowest concern the system (used water 2) which is in the range of 0.0058 g/L. Subsequently, the two systems experienced a remarkable decrease until the 7th day.

From the analysis of these results, we can say that it is very remarkable that the *Spirulina* algae is influenced by the richness of elements contained in the industrial wastewater environment.

3.5.3. pH

pH evolution of aquatic environments is shown in Fig. 11.

The analysis of the curves of Fig. 11 shows a symmetrical graph look during the experiment. We notice that there is a relative stability of pH values between 4.62 and 5.55 for wastewater systems and values, between 7.58 and 9.54. On the other hand, we notice that wastewater systems are environments richer in acids than reference systems, and this acidity comes back to the diversity of elements included in this domestic wastewater.

3.5.4. Salinity

Variations in the salinities of different aquatic environments are presented in Fig. 12.

Analysis of the results shown in Fig. 12 shows a relative stability across all systems during all the experiment. Wastewater systems have the highest value of 70 PSUs and reference systems have the lowest values, between 0.52 and 6.14 UPS. The stability of the salinity of the first to day 7 shows that the strains of algae absorb salts in these growing environments.

4. Conclusion

The present study was carried out to evaluate the biosorption capacity of fluoride by algae *C. pyrenoidosa* and *Spirulina* as biosorbent materials.

According to the results found, the algae *C. pyrenoidosa* has a great ability to eliminate fluoride (100%) as well as *Spirulina* (84.5%). However, the concentration of fluoride was completely eliminated from the third day, but *Spirulina* decreased the concentration of this element in a longer period. Also, it could not resist this toxicity and this last caused a decrease in the biomass of this algae.

According to this study, we have shown that the use of algae allows the gradual absorbent of existing elements in water. In the presence of fluoride, growth varies from one medium to another depending on the concentration of this element present in the environment.

Following the results obtained, we can say that the use of algae as a biosorbent for the elimination of fluoride is an essential choice, because the algae are very advantageous, as well as the adsorption is the low-cost technique, something that has become popular nowadays.

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