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Application of the photocatalysis for the water purification and forthcoming irrigation

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The considerable development of agricultural and industrial activity, has led to the emergence of new classes of organic pollutants say "persistent" which are resistant to the processes of conventional treatment of the waters. The photocatalysis represents of our days, emerging solution to the problems of pollution of groundwater environments, because that can degrade organic matter in basic products and less toxic. This technique associated with a biological method "bio-monitoring" allows to purify the waters effectively, simple and less costly. The use of photocatalytic process in the presence of photocatalyst SnO_2 and *Lemna minor* under UV light has revealed a decrease in the absorbance by report to the initial state and that the rate of absorption varies from 7% to 33% for wastewater and 7% to 34% for the waters of the dam Dahmouni. The treatment of the waters by photocatalysis associated with the lenses of water could be a reality in the countries with strong sunlight to here to a dozen years. This technique is interesting both from the point of view of technology that from the environmental point of view. In effect, this technique may be extended to large scale for addressing releases industrial or domestic or for the purification of contaminated waters.Two water resourses including the dam Dahmounie and wastewater treatment plant in the city of Tiaret are in in the focus of this study.

Key words: photocatalysis, SnO_2, *Lemna minor*, pollutants, wastewater, watershed area

Introduction

The heterogeneous photocatalysis constitutes a promising alternative for the treatment of organic pollutants present in the water. The principle of the photo-catalytic degradation is based on the natural phenomenon of photolysis which intervenes in the environment when the conditions necessary for the conduct of the photochemical reactions are met.

The absorption of a radiation of appropriate wavelength fact pass the molecules to an excited state. The use of a catalyst promotes the formation of free radicals and ensures a strong increase in the speed of the degradation. It is an electronic process occurring at the surface of a catalyst which, under a solar radiation or artificial causes oxidative entities reacting with organic compounds or micro-organisms (Fig. 1).

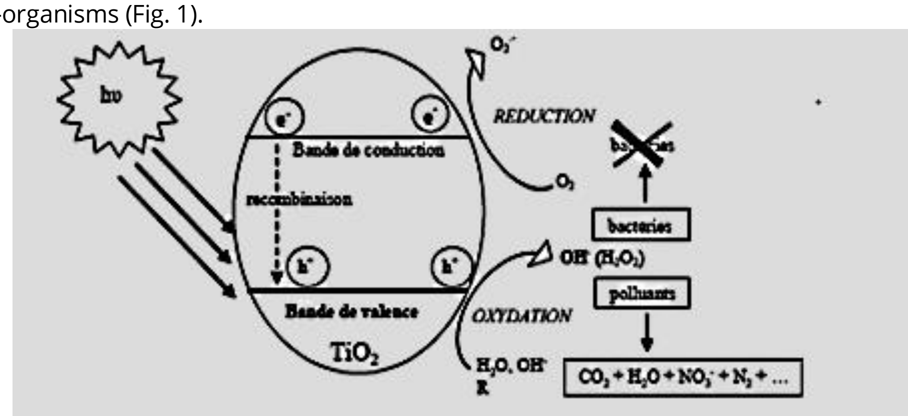

Fig. 1. Principle of photocatalysis (Guillard et *al.*, 2012)

The solar photocatalysis is to use the Share UV from the solar spectrum to activate the catalytic converter (Malato, 2002; Blangis and Legube, 2007; Goetz et *al.*, 2008). The photocatalysis appears as a technique of choice for this type of application. It allows, in effect lead to the complete oxidation of most of the organic pollutants at ambient temperature and atmospheric pressure (Blangis and Legube, 2007). In this regard, these processes are fully within the framework of the sustainable development using the Sun as a source of renewable energy. This technique associated with a biological method "bio-monitoring" allows you to purify the waters effectively, simple and less costly. According Garrec (2007), the use of living organisms presents the interest to observe the life in its various forms and allows you to serve, in the conditions of disturbance, the alarm signal. The study of these resistant plants, by their capacities of detoxification, immobilization or of absorption of heavy metals, could constitute an interesting tool, not only to estimate the risks of potential transfer of heavy metals within the ecosystem, but also as a tool for the rehabilitation of polluted sites (Garrec, 2007).The present study is devoted to the study of the employment of a photocatalytic process, the SnO_2 , associated with an aquatic plant, *Lemna minor*, the whole irradiated under UV light to clean up and purify wastewater and the waters of the dam.

Material and methods

Experimental device

To highlight the role of the photocatalyst (SnO_2) and the water lens on the depollution and purification of water, we have irradiated samples by ultra-violet radiation (UV) for a period of 4 hours. Central wavelength of UV lamps is to 254 - 366 Nm. These lamps are cooled by a fan to avoid the factor of temperature on our samples (Fig. 2).

Fig. 2. Experimental device of the photocatalysis.

We have used 4 systems which are:

1. ***System S1:*** consists to irradiate the water only by UV radiation.
2. ***System S2:*** Irradiation of the water by a UV radiation with the presence of the photocatalyst (SnO_2).
3. ***System S3:*** Irradiation of the water by a UV radiation with the presence of the lens (*Lemna minor*).
4. ***System S4:*** Irradiation of the water by a UV radiation with the presence of the photocatalyst (SnO_2) and the lens of water (*Lemna minor*) at the same time.

The levies have been carried out every 1 hour for a duration of 4 hours of irradiation with UV for each type of water; 4 samples are collected for each water with 3 repetitions, resulting in a total of 24 samples.

This method is intended to break down certain polluting substances present in the water, which are harmful to human health, to transform them into oxidized compounds (carbon dioxide and water, for example) and disinfect the water, as well as the elimination of a large part of pathogenic micro-organisms of this last. (Matsunaga *et al.*,1985; Herrmann, 2003; Guillard *et al*, 2008). During this study, we used two types of water: water worn and water of the dam Dahmounie. The first sampling comes from the wastewater from the wastewater treatment plant in the city of Tiaret.

The station of treatment of wastewater in Tiaret (STEP) is localized in the commune of Ain Bouchakif, 6 km far from the city of Tiaret, it is accessible by a road which debauchery directly in the path of wilaya: CWN 07. This area is characterized by an agricultural activity due to the presence of Oued Ouassel, which pays directly in the dam of Dahmouni (Step, 2007). This sewage plant is working to spread over an area of 9,47 hectares treated waste waters obtained from the municipalities of Tiaret, Sougueur, Dahmouni and Ain Bouchakif. It has the objective to deal with a water capacity of the order of 390,000 EH (inhabitants equivalent), to be 38,000 m^3 of wastewater treated per day (Step, 2007). The second collection comes from the Dahmouni dam. The dam has been carried out on the course of water of Nahr Ouassel which takes its origin from the east of the city of Tiaret and more specifically Zaaroura (Fig.3). The dam to a theoretical capacity: 42 million m^3 and a watershed area: 425 km^2 and a surface area of the lake: 15 km^2. The effluents of the dam Dahmouni are (Benzeghouda, 2015): Oued Merdjidja (Sougueur Tiaret), Oued Medrissa (North West - Police School of Tiaret), Oued Bouchakif (Wadi Malta's - Farcha) + Oued Safsaf.

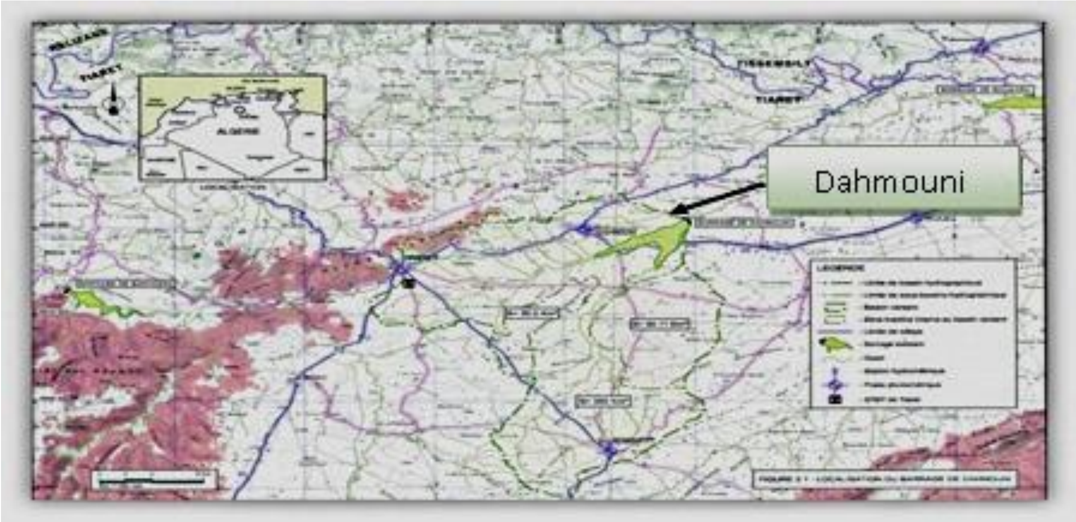

Fig. 3. Geographical situation of Dahmouni dam (scale 1/200.000) (Benzeghouda, 2015)

The waters of the dam are intended for the irrigation of 4000 hectares upstream and downstream of the dam of the following crops: vegetable, arboriculture, farming. These waters are also intended to the water supply industrial (AEI) of the complex of Fatia with a volume of V = 15 l/s.

Optical Analyzes

The samples are placed on a UV spectrophotometer-visible where the measures of the absorbance we give an idea on the dosage of heavy metals before and after treatment by photocatalysis.

Results and discussion

Variation of the absorbance of the UV as a function of time of the photocatalysis without and with the lens of waters and SnO_2 for different waters

To express the ratio between a total value that represents the average absorption of the witness, and the partial value that represents the difference in absorption between the sample Treaty and the witness, the basic formula for the calculation of a percentage is the following (Bezzerrouk, 2016):

$$x(\%) = \frac{X_{Temoin} - X_{Echantillon}}{X_{Echantillon}} \times 100$$

Case of wastewater from the sewage plant in Tiaret

The review of the Fig. 4 illustrates the absorption spectrum of wastewater for the 4 hours of irradiation with the ultra-violet UV (direct photolysis) and the number of a levy each hour.

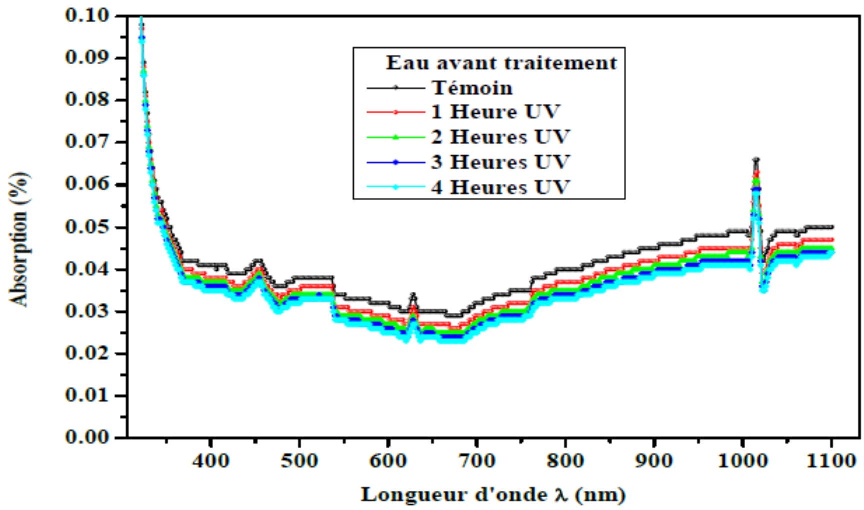

Fig. 4. Absorption spectra of the wastewater from the water treatment station during 4 hours of irradiation by UV

The region of the spectrum chosen is between 300 nm to 1100 nm. A decrease of the absorbance is remarkable for the 4 hours of irradiation of samples, caused primarily by the degradation of molecules photodegradable. This decrease is broader in the first hour with approximately 7%, and a little slow for the following hours: 11% for the second hour, 14% and 16% respectively for the third and the fourth hour; this lowering can be explained by the separation of the pollutants and mineral salts to the water molecules, as well as the degradation of the pollutants appears stronger in the first hour. The track on the Fig. 5 represents the absorption spectra obtained respectively for the different times of exposure to UV and the different methods of purification of wastewater from the sewage plant in Tiaret.

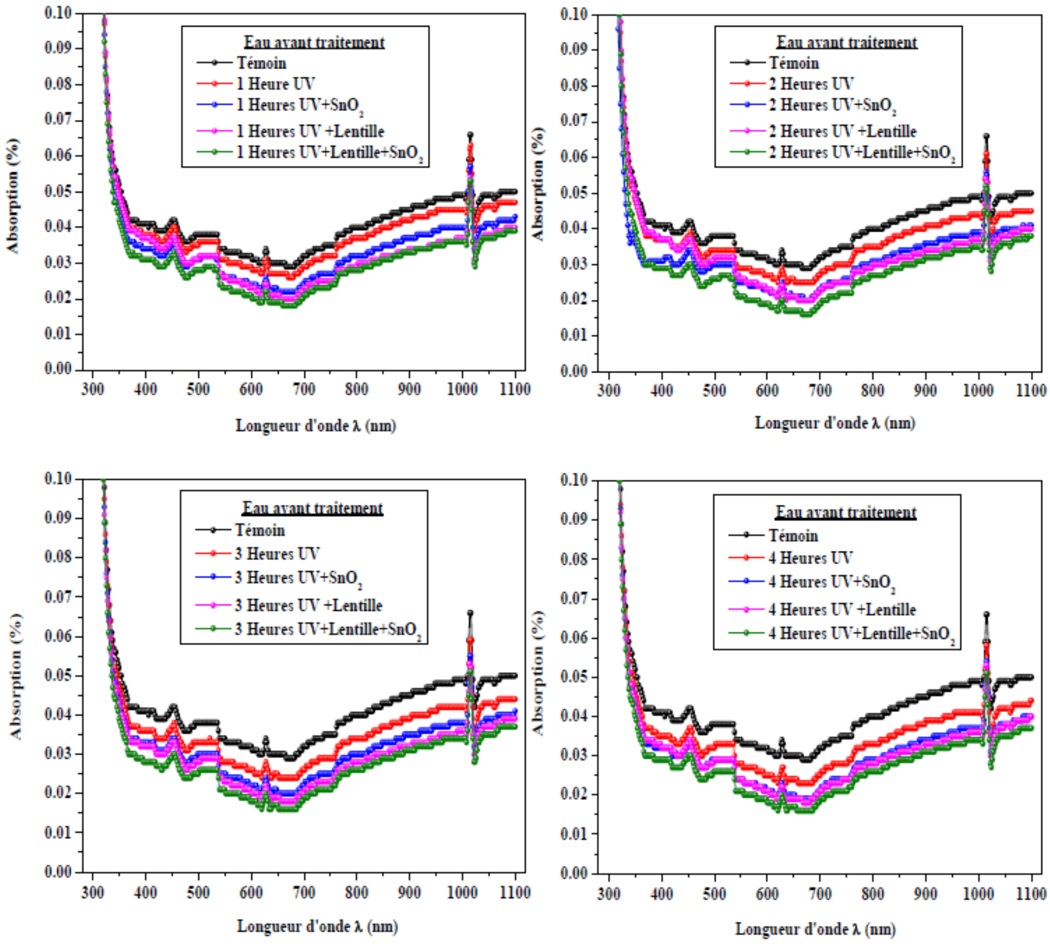

Fig. 5. Absorption spectra of the wastewater from the water treatment station for the different hours of irradiation by UV.

The Fig. 6 represents the variation of the average absorption as a function of time of irradiation for the 4 methods.

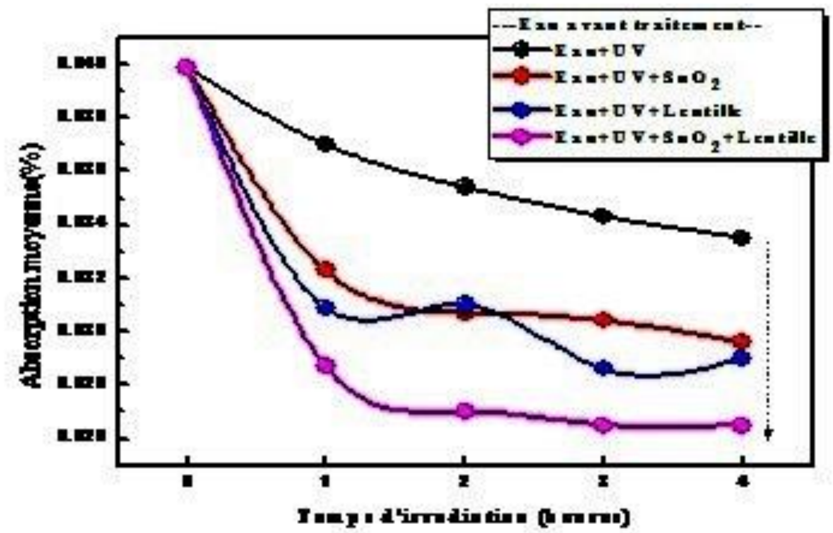

Fig. 6. The average absorption as a function of time of irradiation of wastewater from the sewage plant in Tiaret

The study of the figure 6 shows for the red graph (water + UV + SnO_2) a remarkable reduction of the absorption. Mainly, it is due to an increasing of the kinetics of the organic pollutants degradation, compared to the first in black (water + UV). From this result, we find that the presence of the SnO_2 improves the process of the elimination of pollutants. When the energy of a photon is greater than or equal to the forbidden band of SnO_2, an electron is excited of the valence band to the conduction band with a simultaneous production of a hole. These holes photogenerated can be trapped by the hydroxyl groups adsorbed on the surface of the photocatalyst and produce hydroxyl radicals (OH°).
These hydroxyl radicals decompose the organo-metallic compounds (associated to the water molecules adsorbed), which contains toxic metals. This decomposition gives birth to elements free (pollutants not related to water molecules) which are observed with the naked eye in the form of floating compounds precipitates at the bottom of the test tubes to the short of our study in the laboratory. For the third graph in blue (water + UV + lens), we also note a decrease in the absorption by report to the prime (water + UV). This indicates that *Lemna minor* accumulated to the existing pollutants in the water.
Various studies have shown a high accumulation of polluting elements for Lemna minor (MB et al., 1989; Mallick et al., 1996; Zayed et al., 1998). For the last stroke (water + UV + SnO_2 + lens), the photo-biodegradation is accelerated by report to that of samples with the lens of water (a decrease of absorbance). This result clearly indicates that the presence of the photocatalyst with the lens of water at the same time certainly plays an important role in the purification of water. The photocatalysis decomposes the organometallic compounds (associated to the water molecules) and the lens of water accumulates these pollutants. It is a good experimental model for the detoxification, pollution control and the purification of water.

The case of the water of the dam Dahmouni

The following Fig. 7 designates the absorption spectrum of the waters of the Dahmouni dam under the effect of UV radiation.

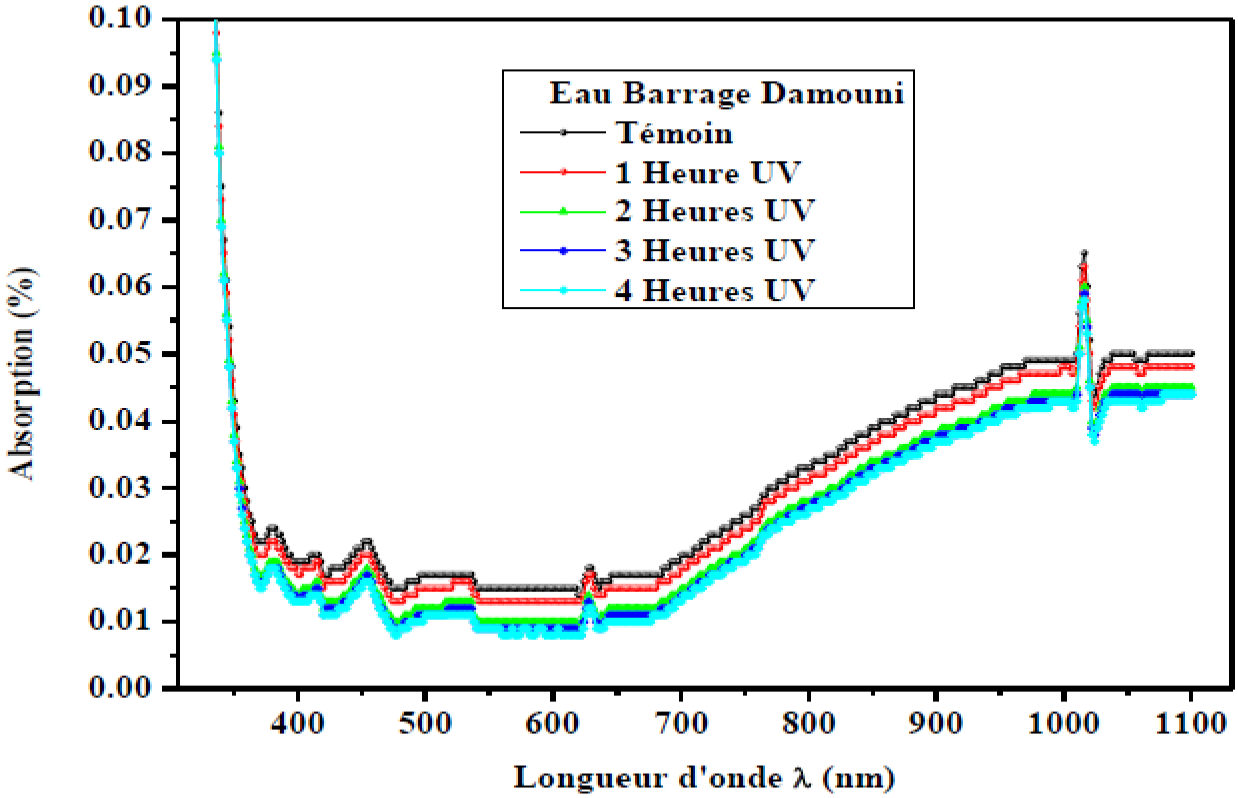

Fig. 7. Absorption spectra of the waters of the Dahmouni dam during the 4 hours of irradiation by UV

By analyzing these curves, we find that there is a decrease in the absorption by report to the initial state. This means that there is an improvement in the performance of the purification of this type of water.
The observed phenomenon with the wastewater from the sewage plant in Tiaret, has been noticed with the waters of the Dam (Fig. 8).
In effect, the rate of absorption (Fig. 9) varies from a minimum value of 7% for the photolysis (UV only) up to a value of 34% (UV + SnO_2 + Lens) during the first hour, the absorption of the 2nd hour is increased from 17% (UV only).
Up to 30% (UV+SnO_2+lens); while the 3th and 4th hour have increased from 21% (UV only) Up to 30% (UV+SnO_2+lens). The decrease in the absorption indicates that the role of the photocatalyst and the lens of water have a great importance.
The treatment of the waters by photocatalysis associated with the lenses of water could be a reality in the countries with strong sunlight to here to a dozen years.
This technique is interesting both from the point of view of technology that from the environmental point of view. In effect, this technique may be extended to large scale for addressing releases industrial or domestic or for the purification of contaminated waters.

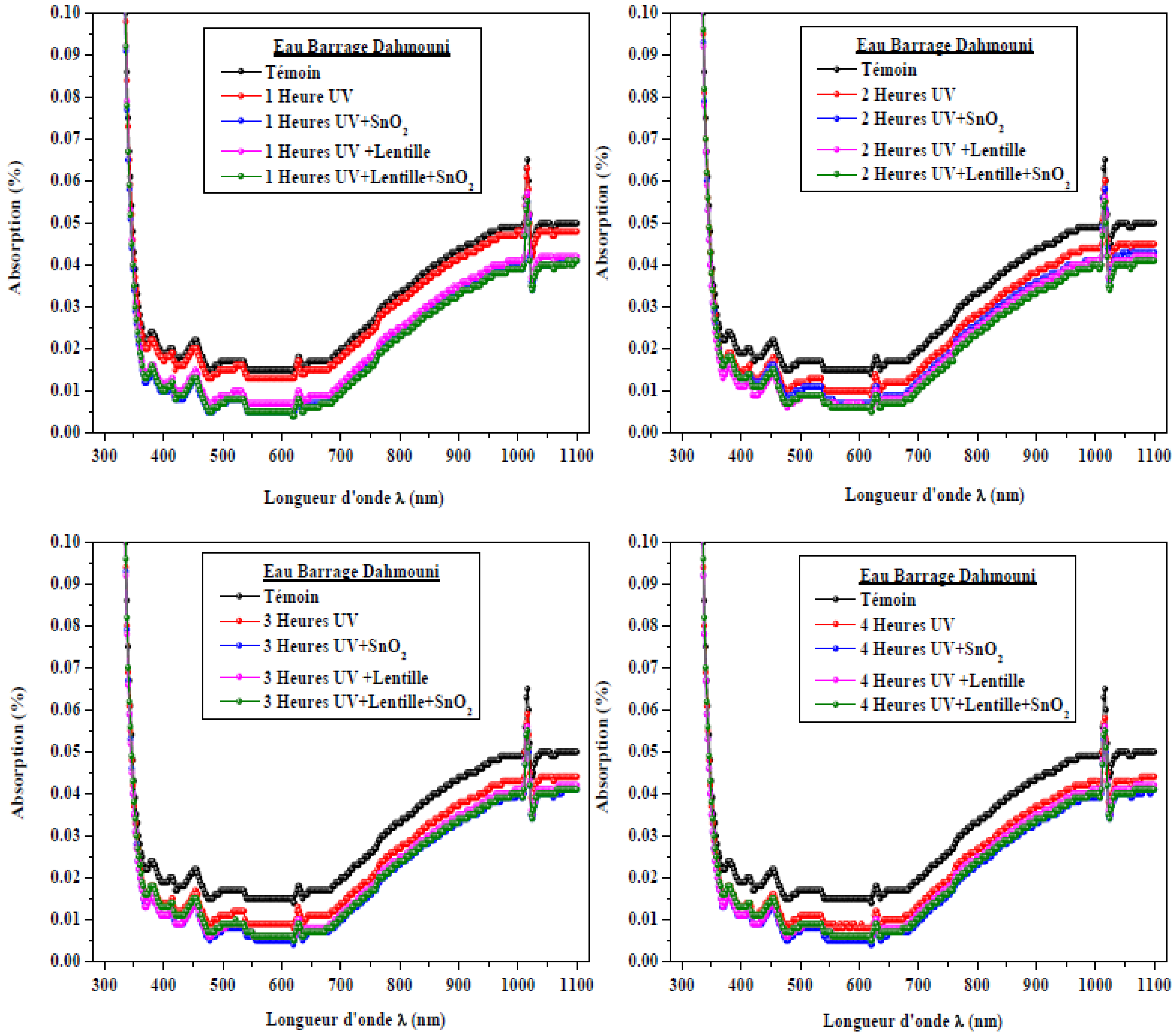

Fig. 8. Absorption spectra of the waters of the Dahmouni dam for the different time of exposure to the UV

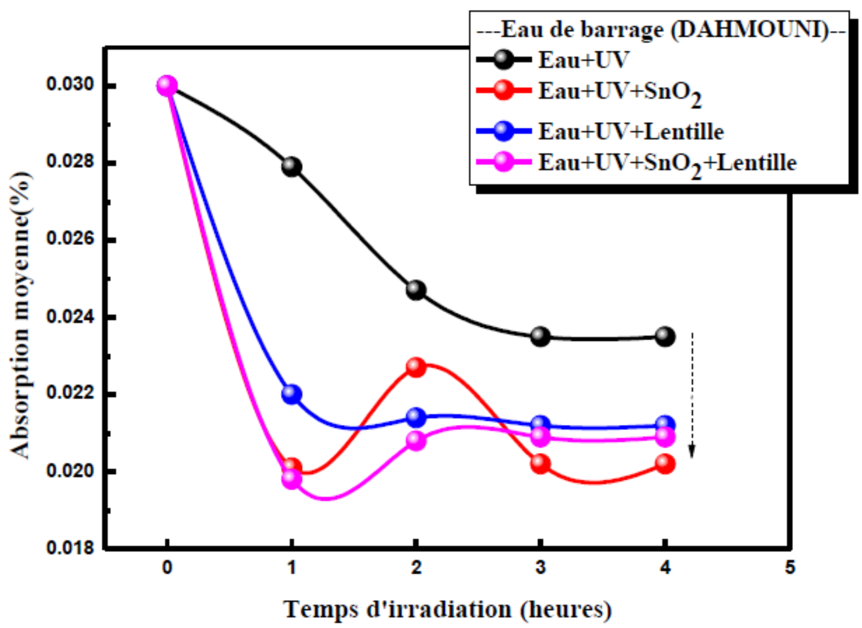

Fig. 9. The average absorption as a function of time of irradiation of the water of the dam Dahmouni

Conclusion

This work was done for evaluation the technique of heterogeneous photocatalysis as an alternative to the traditional treatments of the water for the degradation of the pollutants and the destruction of microorganisms. For this, we have studied the photocatalytic degradation in the presence and absence of photocatalyst SnO_2 and the aquatic plant *Lemna minor* under UV irradiation. The assimilation of the lens of water and the photocatalyst (bioremediation) during photocatalytic treatment has an important role in the purification of water. Rates of degradation photo catalytic-of pollutants in the two types of water are initially fast, which means that the separation of the pollutants and mineral salts to the water molecules appears in the first hour of photacatalyse. Indeed, for Wastewater The rate of absorption, for 4 hours, is increased from 7% to 33%. While the rate of absorption for the waters of the dam Dahmouni is increased from 7% to 34% for 4 hours. The decrease in the absorption indicates that the role of the photocatalyst and the lens of water have a great importance. The presence of the photocatalyst SnO2 improves the process of degradation photo catalytic-by the decomposition of metal pollutants in free elements not associated to the molecules of water rushing to the bottom. The presence of *Lemna minor* also improves the phenomenon of photocatalysis. This means that *Lemna minor* plays a complementary role, by the assimilation of the compounds libers precipitated by the photocatalyst SnO2. It is therefore considered as an intermediate product during the degradation of pollutants.

These results show that the process by photocatalytic UV irradiation is an effective way in the disinfection of contaminated waters, in which the photocatalyst SnO_2 plays a role primordialedans the elimination of the microbial flora. The present study demonstrates an economic strategy and effective to eliminate a large part of organic pollutants which generally coexist in wastewater, as an alternative to several processes of treatment.

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