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EXPERT REPORT
On the dechlorination performance of drinking water from the "LAVIE®" process developed by SOLABLE

Preamble:

SAS SOLABLE has developed an innovative purification system (LAVIE® process) for the water in the network.

According to SOLABLE:

This system, based on UVA radiation, is designed to "break" chlorine molecules while transforming the bottle into POA (Advanced Oxidation Process, proven by the removal of methylene blue in 15 minutes). This POA must also allow deep treatment of taste and odours, or even other dissolved pollutants such as pesticides or traces of drugs, without filtering or passing water through a secondary circuit.
This preserves completely from bacterial pollution such as we can find it in systems of the filtering decanter type, and allows to store the purified water in glass bottles, which fit perfectly in the refrigerators.
The absence of the use of different consumables (materials or chemical reagents) is also a plus which allows to dispose of them at any time, without any error of handling. A safety device (cut off the UVA light when the case is opened) can even extend the use to children.

These new uses, which break away from the use of filter jugs in particular, lead SOLABLE to request scientific expertise on the quantitative dechlorination performance of drinking water and its qualitative capacity to discolour water coloured with methylene blue.

As this product is intended to purify drinking water, the tests were carried out on tap water drawn from Lambesc (13), doped with chlorine within the chlorination limits authorised in France: between 0.2 and 0.4mg / litre.

Introduction :

The so-called drinking water must have a certain number of characteristics in order to
they can be safe for direct human consumption. If the values
different criteria can be applied in different countries, it is nevertheless possible to apply the same criteria in different countries.
into three main categories:
physico-chemical parameters (pH, COT, temperature, conductivity, nitrates, ammonium, chlorides, sulphates,...)
toxic substances
microbiological parameters (pathogens such as faecal coliforms).
For France, these criteria can be found in the decree of January 11,2007 relating to the following criteria
limits and references for the quality of raw and drinking water
human rights referred to in articles R. 1321-2, R. 1321-3, R. 1321-7 and R. 1321-38 of the Code of Human Rights and Fundamental Freedoms.
public health
In order to guarantee the quality of these waters, treatments are applied to the water.
taken, according to their origins (surface water, groundwater, desalination, rainwater, etc.),
reuse) before being able to distribute them, ensuring that they are kept clean and safe for use.
human consumption to their point of use.
The physico-chemical parameters required are reached by the implementation of processes.
physico-chemical treatments and separation. Disinfection requires the installation of
advanced oxidation solutions such as ozonation, chlorination and light treatment
UV. Regardless of the processes implemented, a chlorination stage is very common.
installation before distribution in order to ensure bacteriological quality of the distributed water
to its point of use due to the residual power of chlorine.
Chlorination processes are very frequently used to disinfect water and wastewater.
consumption data (Health Canada, 2009)*. Chlorine has a strong oxidizing power
allowing to kill or inactivate quickly (contact time of about 30 minutes) the
microorganisms contained in water and is generally used in two forms
main solid (pastille) or liquid (sodium hypochlorite or bleach) depending on its size and concentration.
scale of uses (collective or individual). In addition, chlorine has a certain stability
in the water giving it residual power), it is therefore important to be able to add residual power.
sufficient doses of chlorine to ensure water disinfection on the one hand and its supply on the other.
on the distribution time on the other hand.
Chlorination disinfection processes have many real advantages
in the sense that they are efficient, fast, inexpensive, multi-scale and relatively simple.
to set up.
Nevertheless, they do have a number of disadvantages that are
It is important to take this into account as it can have an effect on human health. Indeed, a
Chlorine overdose may cause chlorine to react with other compounds present.
in water, especially organic matter (OM) to form commonly used products.
known as "Chlorination By-products" (CBP) some of which are considered to be harmful to the environment and human health.

* Santé Canada (2009). Recommandations pour la qualité de l'eau potable au Canada : document technique – Le chlore. Bureau de l'eau, de l'air et des changements climatiques, Direction générale de la santé environnementale et de la sécurité des consommateurs, Santé Canada, Ottawa (Ontario) (No de catalogue H128-1/09-588F).

Numerous studies (Mouly et al., 2008) have been able to highlight the following factors conditions for implementing such reactions leading to the formation of TCS.

Nearly 600 CBP have thus been identified among which we can find majority families such as than the trihalomethanes (THM) and haloacetic acids (HAA) which represent to them between 20% and 30% of the total mass of CBP.
In addition, residual chlorine doses too much can give unpleasant taste to drinking water.

Therefore, it is important to be able to limit and control the production of these CBP in the EU processing chains but also in distribution channels.
This is essentially done by an appropriate dosage of chlorine in order to oxidize the organic matter and to limit the residual chlorine concentrations at the end of treatment.
This is a sensitive point for the chlorination processes, and is not always easy to implement in treatment, particularly if the resource has characteristics and levels of OM variables over time.
From this point of view, WHO recommends a free chlorine concentration of treated water distributed between 0.2 and 0.5 mg/l.

Over the past few years, UV light disinfection processes have been manufactured and commercialized. They are based on the principle that UV rays have a huge bactericide effect .
Ultraviolet (UV) radiation is an electromagnetic radiation that is emitted by the sun's rays. Emission wavelength is shorter than that of visible light and longer than X-rays. They account for nearly 5% of the electromagnetic energy emitted by the sun and can be produced by lamps, known as UV lamps.

We classically distinguishes three categories according to their wavelength: UVAs (400-315 nm), UVB (315-280 nm) and UVC (280-100 nm). It should be noted that as a result of absorption of UV rays by the ozone layer in the atmosphere almost all (95%)
UV light coming from the sun and arriving on earth are of the UVA category.

UV rays have effects of modification of the DNA of bacteria which allows, according to exposure time, kill or inhibit them and thus prevent their reproduction. Finally, it is important to note that UV rays also have a destructive effect on some of the following chemical compounds, known as photosensitive compounds, in water or the atmosphere.
They can thus participate in the photodegradation of certain chemical pollutants contained in water and this even at low concentrations.

UV lamp disinfection processes are relatively simple in design because they consist of placing the UV lamp in a small reactor together with the water to be treated, which is commonly referred as the irradiation chamber.
These processes are massively developed on an industrial, collective, and individual scale, in particular because of their ease of use.

† Mouly D, Joulin E, Rosin C, Beaudeau P, Zeghnoun A et al. Les sous-produits de chloration dans l’eau destinée à la consommation humaine en France - Campagnes d’analyses dans quatre systèmes de distribution d’eau et modélisation de l’évolution des trihalométhanes. Saint-Maurice (Fra) : Institut de veille sanitaire, novembre 2008, 73 p. Disponible sur : www.invs.sante.fr

The literature (Oppenheimer et al., 1997)[‡] and industrial developments of these processes are almost exclusively based on the use of UVC-category UV lamps.
With regard to the use of UVA lamps (process radiation category of LAVIE® from SOLABLE), if to my knowledge there is currently no industrial development of such a kind of water treatment lamps, work has been carried out on the following projects and nevertheless proved the bactericidal efficacy of UVA lamps (Hamamoto et al., 2007)[§].
To conclude on UV-lamp disinfection processes, they have a large number of advantages.
In fact, they are simple to use on industrial scale as well on individual scale. They do not require the use of chemical reagents or specific substrates and does not modify the physico-chemical properties of the water to be treated. Finally, if the initial investment in this type of process may appear to be higher, compared to other processes such as chlorination, its operating cost is still very low.
Long life of the lamps used makes it competitive in this respect.
Nevertheless, there are still some disadvantages to the use of these processes. The antibacterial treatment action of UV-lamp processes is not persistent, unlike chlorination, its use must therefore be carried as close as possible to the point of consumption and use. The use of this type of process also requires sufficient clear water in order to ensure that the process does not cause any problems by limiting the transmission of UV radiation in water. Finally, it is difficult to appreciate immediately the effectiveness of the treatment by measuring a residual, as in the case of the use of chlorine, and to optimize the treatment efficiency of these processes in the event of a resource characterized by a temporal variation in its quality (notably bacteriological).

Materials and methods:

The experiments were carried out on 20 November 2017 at the company's site.
SOLABLE TO LAMBESC (13) from drinking water drawn from the company's premises at time of experimentation. It is a low hardness water (12°F on average) distributed.
with a low free chlorine content of less than 0.1 mg/l. This is why, for the experiments on dechlorination using the LAVIE® process, we doped this drinking water in chlorine charge. This doping was carried out on a volume of 15 liters of water from the network in which we used to pump the water.
We added 0.44 ml of a new commercial bleach solution at 3.6% giving us a total of 0.44 ml of commercial bleach, delivering finally a water at a measured free chlorine concentration of 1.04 mg Cl-/l. This solution was then diluted to obtain two solutions of 0.41 and 0.27 for 0.41 and 0.27 respectively, remaining within the limits recommended by WHO. These solutions were prepared each just right before the experiments begin. The SOLABLE company proposes for the use of the
LAVIE® process a 20-minute exposure time to UV light. We have therefore made for each water studied, two trials at 15 minutes and 30 minutes of exposure, respectively.

[‡] Joan A. Oppenheimer, Joseph G. Jacangelo, Jean-Michel Laîné and John E. Hoagland, « Testing the Equivalency of Ultraviolet Light and Chlorine for Disinfection of Wastewater to Reclamation Standards », Water Environment Research, Vol. 69, No. 1 (Jan. - Feb., 1997), pp. 14-24

[§] A. Hamamoto, M. Mori, A. Takahashi, M. Nakano, N. Wakikawa, M. Akutagawa, T. Ikehara, Y. Nakaya1 and Y. Kinouchi, « New water disinfection system using UVA light-emitting diodes », Journal of Applied Microbiology, 103 (2007) 2291–2

The LAVIE® device used for the tests is a prototype with final manufacturing size, equipped with two UVA LED lamp ribbons (6 lamps per ribbon, length emission wave: 365 nm, power consumption: 25.9 W, voltage: 21.6 V, intensity: 1.2A) suitable for a 1 litre cylinder bottle (diameter: 80 mm, height: 280 mm) made of transparent glass (Borosilicate).

Dosing of the total chlorine was carried out on site at the beginning and end of each test using a HANNA H1 711 chlorometer, with specifications given on table 1.

characteristics are given in Table 1. Also in order to check the bacteriological quality of the water before and during the experiments and the final chlorine levels, each experiment was sampled and sent immediately to the SOSCA laboratory ANALYSIS[**] (31120, the Union) by complying with the recommendations of sampling, Packaging and shipping data given by the laboratory.

Technical specifications:

Range	0.00 to 3.50 ppm
Resolution	0.01 ppm
Accuracy	±0.03 ppm ±3% of reading @ 25 °C / 77 °F
Light Source	Light Emitting Diode @ 525 nm
Light Detector	Silicon Photocell
Method	Adaptation of USEPA method 330.5. The reaction between the chlorine and DPD reagent causes a pink tint in the sample.
Environment	0 to 50 °C (32 to 122 °F); max 95% RH non-condensing
Battery Type	1 x 1.5V AAA
Auto-Shut off	After 2 minutes of non-use
Dimensions	81.5 x 61 x 37.5 mm (3.2 x 2.4 x 1.5")
Weight	64 g (2.25 oz.)

Table 1: Technical Specifications of HANNA HI 711 Chlorimeter

Results:
From a general point of view, the totality of the experiments carried out did not show any evidence of the following variations in the bacteriological and physico-chemical quality of the water after exposure time of 15 or 30 min in the LAVIE® process by SOLABLE.
The results provided by the SOCSA laboratory show no change in bacteriologist quality and physico-chemical characteristics of water.
Monitoring the dechlorination capacities of the LAVIE® process:
The results obtained from the experiments carried out on water at initial chlorine concentrations of 0.41 and 0.27 mg Chlorine / L for exposure times of 13 and 30 minutes are shown in Figure 1.

[**] Certification COFRAC de SOSCA ANALYSES : Satisfait aux exigences de la norme NF EN ISO/CEI 17025 : 2005, et aux règles d'application du Cofrac pour les activités d'analyses/essais/étalonnages en : ENVIRONNEMENT / QUALITE DE L'EAUAGROALIMENTAIRE / DIVERS ALIMENTS - SANTE ANIMALE

[††] Flore aérobies revivifiables à 22°C pendant 72H, flore aérobie revivifiables à 36°C pendant 24h, Coliformes totaux, Entérocoques, Escherichia Coli et Sprores d'A.S.R

[‡‡] pH (moyenne : 7,20 +/- 0,07), conductivité (moyenne : 399 +/- 4), turbidité, Chlore totaux, Ammonium, Fer et Nitrates (inférieurs au seuil de mesure)

It is clear that the dechlorination efficiency of the LAVIE® process is more than 90% as from 15 minutes of exposure of solutions doped in Chlorine. Residual chlorine concentrations measured at 15 and 30 minutes are in the detection threshold, to the accuracy of the measurement error, of the assay method used. The analyses carried out by the SOSCA laboratory confirm the absence of total and free Chlorine at 15 and 30 minutes for all samples.

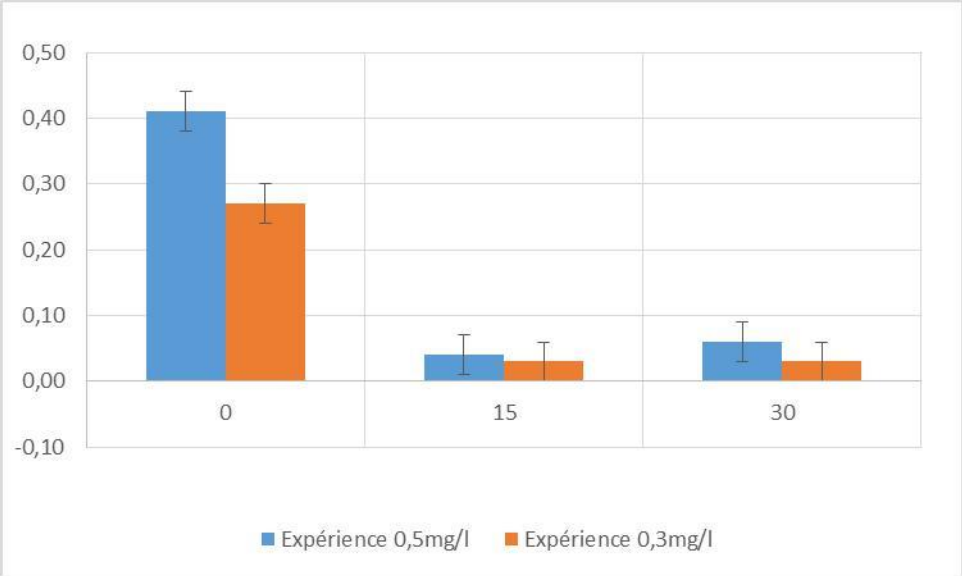

Figure 1: Changes in chlorine concentration for exposure times of 15 and 30 minutes for an initial solution at 0.41mg/l chlorine (blue) and an initial solution at 0.27mg/l of Chlorine (orange)..

Monitoring of the discoloration capabilities of the LAVIE® process:

The water bleaching test using the LAVIE® process was carried out on the mother water (doped at 1.04mg/litre of Chlorine) prepared for dechlorination tests after the addition of 6 drops of Methylene Blue solution per litre of water. This addition was made in two bottles and a bottle was then subjected to UVA radiation for 30 minutes, the observations made are presented in Figure 2

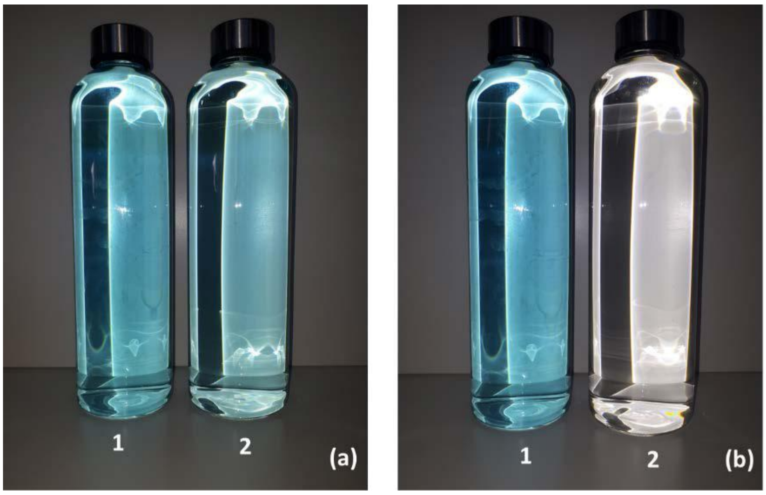

Figure 2: Follow-up of the discolouration of water coloured with methylene blue in the state initial (a) and after 30 minutes of UVA exposure for bottle 2 (b)

This test clearly shows that the LAVIE® process has in addition to its capabilities of dechlorination properties studied below, clear discolouration capabilities contributing to the following improvement of the quality of drinking water which may present problems of light colours.

Conclusion :

The tests conducted on November 20,2017, on the LAVIE® process developed by the company SOLABLE on chlorine-doped drinking water and coloured with the addition of Chlorine and Methylene blue clearly show that, without any addition of reagents or the use of carriers ion exchange or filtration:

- In the case of free or residual Chlorine and for concentrations that can be used in the following waysimportant in the light of the WHO recommendations, the process LAVIE® presents dechlorination yields from a quantitative point of view more than 90% and this from 15 minutes of exposure to UVA radiation.
- For its effect on water colouring (important for water quality) particularly from the point of view of its societal perception), the LAVIE® process presents, from a qualitative point of view, discolouration capabilities that can be considered as complete on samples colored with methylene blue. These observations show good potential for oxidation and degradation of chemical molecules contained in LAVIE® process water.

In addition, the use of UVA rays also provides an additional guarantee on maintenance or improving the bacteriological quality of water.

Done at Aix en Provence on 06 December 2017

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