

# The purification performance of LaVie system on the degradation of chlordecone



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## 1-Introduction and aims

The quality of tap water is of great concern and LaVie system answers a double issue provides pure, high-quality water, ideal for health and enjoyable to drink, and for people in developing countries, clean drinking water makes a large difference. This system purifies chlorine-containing network water while killing bacteria and viruses in all types of water. However, the processes implied in LaVie system is not well-known as well as its performance to remove other compounds such as organic pollutants. However, it has been proved that it allows the degradation of organic compound by photolysis, *i.e.* by the direct absorption of light. In addition, the LaVie system has proved its abilities to degrade pharmaceutical compounds present in tap water (even with concentrations  $10^6$  times more important than real ones) with an improved efficiency in the presence of traces of Javel water (free chlorine). These results clearly demonstrate that Lavie system appears to be a powerful system to eliminate traces of pharmaceuticals in these experimental conditions (concentration of pharmaceuticals around mg/L and concentration of free chlorine around 0.6 mg/L).

Today, among the organic pollution of the environment, the extensive use of chlordecone until the beginning of the 1990s is responsible of the contamination of both soil and surface waters (Cabidoche et al., 2009; Coat et al., 2011). Thus, chlordecone has been detected in soils, rivers, springs and drinking waters of Antilles making it a major ecological, economic and social crisis in Guadeloupe and Martinique Islands.

The objectives of this work is to demonstrate the potential elimination of chlordecone in LaVie system at different concentrations between 1mg/L to around 10 µg/L. To reach this goal, the effect of free chlorine was tested with tap water spiked or not with a small amount of Javel water in aerated conditions. To evaluate chlordecone degradation, kinetics experiments were undertaken indifferent experimental conditions and dark control.

## 3- Material and analytical methods

### 3-1- Products and reagents

Chlordecone, CLD (99% purity) was purchased from Sigma Aldrich (Fluka 45379) and Javel water (3.6% active chlorine) was provided by La Croix (Colgate-Palmolive Company).

### 3-2- Preparation of the solutions:

Stock solution of CLD were prepared with tap water at 1.15 mg/L after 2 days stirring at 25°C. Solutions were stocked in dark at 4°C.

For the first set of experiments, the CLD stock solution was used as prepared in the presence of free chlorine and 25 µL of Javel water was added or not.

For the second set of experiments, 4 L of tap water were spiked with CLD stock solution and Javel water to obtain CLD concentration around 11.5 µg/L and free chlorine concentration around 0.51 mg/L. In addition, 4 L of ultrapure water were also spiked with the same amount of CLD in order to obtain a reference solution without any traces of free chlorine.

### **3-3- Purification system LaVie:**

Two systems were used. The first one (LaVie system 1) was equipped with ten LEDs purchased by Shenzeng Refond Optoelectronics corporation, the reactor was a glass bottle of 1 L and the programmed duration of the exposure was 15 min. The second system (LaVie system 2), recently developed by Solable was equipped with ten LEDs, the reactor was a glass bottle of 1 L and the programmed duration of the exposure was equal to 30 min.

### **3-2-Analytical methods:**

#### **3-1-1- Measurement of free chloride:**

To estimate the concentration of free chloride, AQUALYTIC AL450 photometer was used based on the previous methodology described in the previous report.

#### **3-1-2- Abatement of selected organic compounds by HPLC**

In order to follow the concentration of CLD, the samples have been analysed in La Drôme Laboratoire by liquid-liquid extraction and LC-MS analysis or by LC-HRMS analysis.

## 4- Results

### 4-1- Experiments with high concentration of chlordecone

All experiments were undertaken in aerated solutions with a concentration of chlordecone around 1.15 mg/L and in the first irradiation set up. The results are presented in the following table 1:

[CLD] (mg/L)	Free chlorine (mg/L)	Volume of bleach/L	Irradiation	[chlordecone] (µg/L) ELL and LC-MS	[chlordecone] (µg/L) LC-HRMS
				Abatement (%)	Abatement (%)
1.04	0.37	0	Yes	49.10	36.80
1.26	1	25 µL	No	26.30	5.85
1.15	0.75	25 µL	Yes	33.67	42.5
1.26	0.75	25 µL	Yes	31.58	30.5
1.36	0.86	25 µL	Yes	58.92	35.39

**Table 1:** Experimental conditions and chlordecone abatement in LaVie System 1, [CLD]  $\cong$  1 mg/L

The abatement have been calculated using the following equation:

$$Abatement (\%) = \frac{[chlordecone]_0 - [chlordecone]_{15 \text{ min}}}{[Chlordecone]_0} \times 100$$

where  $[chlordecone]_0$  is the initial concentration of chlordecone and  $[chlordecone]_{15 \text{ min}}$  is the concentration of remaining chlordecone after 15 min of exposure in LaVie system.

In table 1, abatement values obtained by the two methods are presented but only the HRMS results were considered because of high uncertainty on the other ones.

Firstly, one can see that free chlorine concentrations are important both in the absence of bleach and after addition. In fact, in the absence of additional bleach, the result obtained with 0.37 mg/L of free chlorine. This is probably due to the uncontrolled amount of bleach directly added in tap water for

disinfection. This means that the control manipulation without the addition of bleach is not as foreseeing but rather an experiment in the presence of free chlorine in intermediate quantities. Therefore, for the other experiments with an addition of 25 µL of Javel water, the free chloride concentrations are then higher than the expected one of 0.5 mg/L.

The dark control (without exposure) shows that a very low amount (less than 6%) of chlordecone is degraded, suggesting that the reaction of free chlorine with CLD is negligible.

Under irradiation, a significant disappearance of chlordecone is observed with abatement higher than 30% whatever the free chlorine concentration.

For the experiment carried out in triplicate (with an addition of bleach), the results are quite homogeneous with quite similar values, on average, we have 36% reduction (36.1% 5.6%) of chlordecone in these conditions. This is not bad at all in terms of reduction but also in terms of repeatability.

Without the addition of bleach, the residual concentration of free chloride leads to similar reduction of chlordecone with a value of 37%.

From the first set of experiments, it appears that the partial degradation of chlordecone at around 1 mg/L is obtained using La Vie system in the presence of free chlorine. However, this degradation seems to be unaffected by high concentration of free chlorine as the same disappearance is observed with a free chlorine concentration of 0.37 mg/L and higher.

To have more insight in the mechanism improved in the degradation of CLD in LaVie system and to measure the efficiency of the system at low concentration of chlordecone a second set of experiments were undertaken.

#### **4-2- Experiments with low concentration of chlordecone**

All experiments were undertaken in aerated solutions with a concentration of chlordecone around 11.5 µg/L, in the presence and in the absence of free chlorine and in the second irradiation set up. The results are presented in the following table 2 with abatement values calculated as previously.

In the absence of free chlorine, a partial disappearance of CLD around 15% is observed under exposure. This corresponds to its direct photolysis as demonstrated previously by Cruz-Gonzalez et al. (2017) in a previous study using another irradiation set up.

In the presence of free chlorine, CLD degradation is around 31% that is of the same order than the ones observed with high concentration of CLD.

[CLD] (µg/L)	Free chlorine (mg/L)	Volume of bleach/L	[chlordecone] (µg/L) ELL and LC-MS Abatement (%)
14.97	0	0	16.4
11.27	0.32	40 µL	30.6

**Table 2:** Experimental conditions and chlordecone abatement in LaVie System 2, [CLD]  $\cong$  11.5 mg/L

From this result, it appears that the degradation of chlordecone in La Vie system 2 is attributed equivalently to CLD direct photolysis but also to the reaction with species produced in the presence of free chlorine. In addition, the increase of the irradiation time (30 min vs 15 min) in the presence of free chlorine does not affect CLD abatement, probably because of the strong free chlorine concentration decrease after 15 min of exposure as previously demonstrated.

## 5- Results

According to this study, it has been proved that the elimination of chlordecone in LaVie system could occurred but partially (maximum of 49% depending on the experimental and measurement conditions) with concentration of CLD in the range of around 10 µg/L to 1 mg/L. This degradation is attributed to direct photolysis and to CLD induced degradation by species (others than hydroxyl radicals) produced from the irradiation of free chlorine. The direct photolysis of CLD has been demonstrated previously using different mercury lamps (Cruz-Gonzalez et al., 2017) with an elimination range between 10 and 60% after 20 min of exposure with an initial concentration of CLD around 1 mg/L. In addition, other processes like Photo-Fenton, ozonation or Fenton have been investigated in this study with elimination rate in the range 2 to 55% after an irradiation of 20 min. Thus, the results obtained with LaVie system reveal to be in the upper range in the elimination of chlordecone.

## 6-References

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