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## Are sunscreen UV filters polluting our beaches? A case study from consumer habits to water analysis on the French Mediterranean Coast Coauthors

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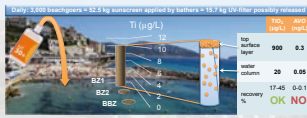
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# Are sunscreen UV filters polluting our beaches?

## A case study from consumer habits to water analysis on the French Mediterranean Coast

### Abstract



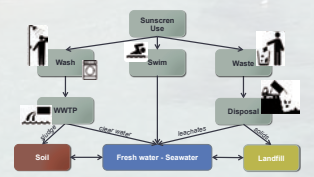
**Daily: 3,000 beachgoers = 52.9 kg sunscreen applied by bathers = 16.7 kg UV filter possibly released**

In order to assess the release of UV filters from the sunscreen used by beachgoers into seawater within the bathing zone, a field campaign was carried out during the summer of 2017 at three beaches in Marseille, along the French Mediterranean coast. A social survey analysed beachgoer attendance, the quantities and types of sunscreen products used and the bathing frequencies, while the bathing water was analyzed spatially and temporally so as to quantify both mineral and organic UV filters directly released and recovered. During the peak recreational time at the three beaches, both mineral and organic UV filters were detected in higher concentrations in the bathing area than offshore. In general, higher concentrations were recovered in the water top surface layer than in the water column, giving respectively 100-900 and 20-50 µg/L for TiO<sub>2</sub>, 10-15 and 1-3 µg/L for ZnO, 40-420 and 30-150 ng/L for octocrylene, and 10-15 and 10-350 ng/L for avobenzone. More than 75% of the 471 interviewees reported bathing every time they go to the beach, with 68% using a sunscreen product 2-6 times on average. From these data we estimated that an average mass of 52 kg/day or 1.4 t/month of sunscreen products are possibly released into bathing water for a beach attended by 3,000 people daily. The mass ratio of UV filters in such products typically ranges from 0.03 to 0.1, allowing us to propose theoretical maximum concentrations in the beach water. Our recovery of measured UV filter concentrations in seawater compared to the theoretical concentrations revealed two distinct scenarios for the mineral and organic filters. While up to 45% of the mineral filters used by beachgoers may be released into the seawater, the organic filters were minimally recovered in the environment, most likely due to internalization through the skin barrier or partial photodegradation.

### Aims of this work

- to estimate the daily flux of sunscreen and UV filters transferred from beachgoers into the bathing water on a standard summer day;
  - to study the possible co-occurrence of organic and mineral UV filters in seawater, both in the water top surface layer and water column;
  - to determine, for the first time, the patterns of UV filter occurrence in the bathing water at three French Mediterranean beaches.
- This study is the first field campaign coupling chemical water analysis to quantify both organic and mineral UV filters in seawater, with a simultaneous social survey of consumer's habits on the beach.

### Scenarios of UV filter release to the water usage cycle



### Field localisation, Marseille, Mediterranean coast, France



### Sampling points on the three beaches studied

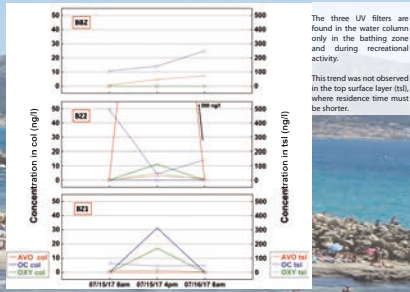


### UV filter quantification in bathing water

**Methodological approach**  
 On Saturday, July 15th, 2017, water samples were collected at 402 pm, during peak recreational activity. The spatial distribution of any UV filters in the water was assessed by sampling at three distances from the shoreline in Bathing Zone 1 (BZ1), Bathing Zone 2 (BZ2) and beyond the bathing zone (BZ3). Water samples were collected at low tide.  
 - the top surface layer (NS) = 1 cm, where hydrophobic compounds would likely be concentrated;  
 - OC was selected as a constant sampling depth to represent the average water column (NS).  
 Additional samplings were conducted at 8:00 am on Saturday, July 15 and Sunday, July 16, 2017, i.e. just before and after the studied peak attendance.

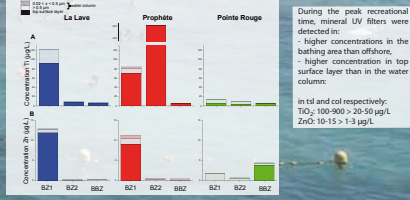
**Mineral UV filter quantification.** After digestion, spectrophotometry (SP) was used to analyze Ti and Zn concentrations as indicators of mineral UV filters. Local geochemical background was expected from the concentrations measured beyond the bathing zone (BZ3).  
**Organic UV filters quantification.** disulphoton (DIOX), avobenzone (OXV), avobenzone (AVO), 2-ethylhexyl-4-methylsarinolate (OMC), and octocrylene (OC) were analyzed using liquid chromatography-mass spectrometry.

### Time evolution of organic UV filter concentrations at the three distances from shore line at Prophète Beach



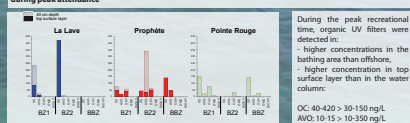
The three UV filters are found in the water column only in the bathing zone and during recreational activity.  
 This trend was not observed in the top surface layer (tsl), where residence time must be shorter.

### Concentrations of Ti and Zn found in different water fractions during peak attendance



During the peak recreational time, mineral UV filters were detected in:  
 - higher concentrations in the bathing area than offshore;  
 - higher concentration in top surface layer than in the water column.  
 In Ti and Zn respectively:  
 TiO<sub>2</sub>: 100-900 > 20-50 µg/L  
 ZnO: 10-15 > 1-3 µg/L

### Concentrations of organic UV filters (ng/L) OC, AVO, OXV, OMC, and DIOX found in different water fractions during peak attendance

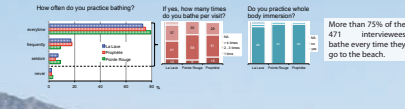


During the peak recreational time, organic UV filters were detected in:  
 - higher concentrations in the bathing area than offshore;  
 - higher concentration in top surface layer than in the water column.  
 OC: 40-420 > 30-150 ng/L  
 AVO: 10-15 > 10-350 ng/L

### Social Survey

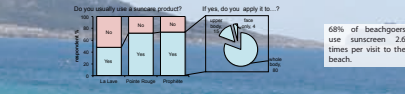
**Methodological approach**  
 We assessed beach attendance through use counts and photographic images. Simultaneously, a questionnaire was carried out on site between 8:00 am and 8:00 pm. We surveyed 471 people. Beachgoers were asked specific questions about their sunscreen use (frequency, quantity, and time of application) and their opinion regarding the possible effects of these products on the marine environment.  
 The containers of the sunscreen products used by the interviewees were photographed and the information on the packaging, such as brand, SPF, and composition were recorded. A total of 124 sunscreen product compositions were registered.  
 This enabled us to estimate the average composition and mass ratio of UV filter (i.e., organic and mineral) quantity that could be released daily into the beach water.

### Beachgoer habits regarding bathing activity at the beach

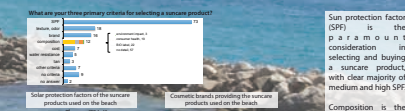


More than 75% of the 471 interviewees bathe every time they go to the beach.

### Sunscreen product consumption habits on the beach



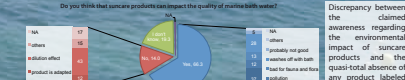
68% of beachgoers use sunscreen 2.6 times per visit to the beach.



Sun protection factor (SPF) is the criterion number 1 in selection and buying a sunscreen product, with clear majority of medium and high SPF.

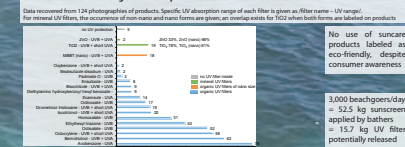


Composition is the criteria number 4.



Discrepancy between the claimed awareness regarding the environmental impact of sunscreen products and the quasi-total absence of any product labeled as eco-friendly among those actually consumed (only 2 out of 170 products).

### UV filter occurrence among the sunscreen products used on the three beaches



No use of sunscreen products labeled as eco-friendly, despite consumer awareness.  
 3,000 beachgoers/day = 52.9 kg sunscreen applied by bathers = 16.7 kg UV filter potentially released

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### Predicted environmental concentrations of UV filters and actual recovery

**Methodological approach**  
 From the mass of UV filter consumed on the beach recovered from our survey, we calculated a predicted environmental concentration in the bathing water, PEC<sub>env</sub>, as follows:



Mass of UV filters consumed and potentially entering the bathing water:  
 52.9 kg/day = 307 ± 114 kg/week = 1.45 ± 0.51 t/month

UV filter	Mineral	Organic
avobenzone	2,607	940-1,378
benzophenone	3,819	471-1,286
octocrylene	1,900	481-1,388
octinoxate	1,399	586-1,647
ethylhexyl triazone	1,396	427-1,217
homosalate	3,819	518-1,678
TiO <sub>2</sub>	433	188-1,398
ZnO	60	36-167
Total mass	18,741	4,902-11,283

UV filter	Mineral	Organic	Mineral	Organic
TiO <sub>2</sub> (µg/L)	17	251	46	21
ZnO (µg/L)	3	44	8	2.4
OC (ng/L)	3	44	8	2.4
OXV (ng/L)	3	44	8	2.4
AVO (ng/L)	80	1,161	217	6.5
OMC (ng/L)	57	842	154	0.03
DIOX (ng/L)	17	251	46	0
OCXV (ng/L)	2	30	5	0.014
OCXV (ng/L)	2	30	5	0.014

Two distinct scenarios found for the mineral and organic filters:  
 While up to 45% of the mineral filters used by beachgoers may be released into the seawater, the organic filters were minimally recovered in the environment, most likely due to internalization through the skin barrier or partial photodegradation.

