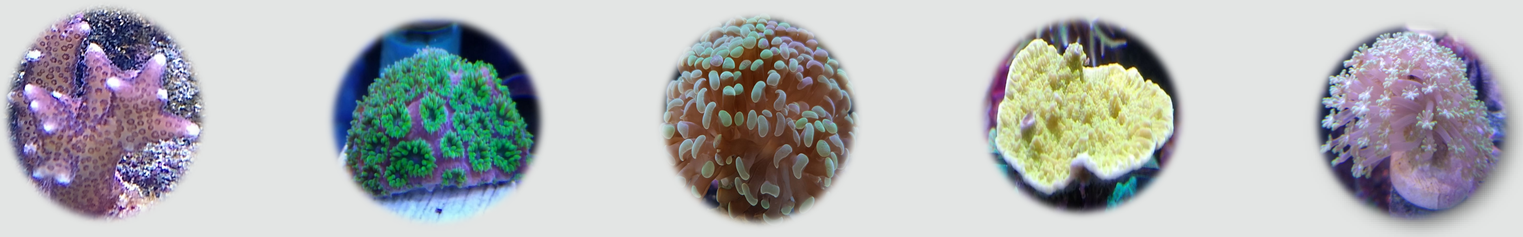
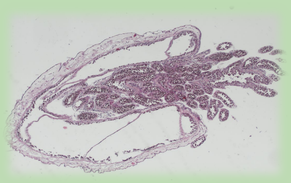


Influence of sun creams on corals



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Corals play a crucial role in the marine ecosystem. They form one of the most species-rich ecosystems on earth. And coral reefs are one of the most endangered ecosystems. The harmfulness to coral ecosystems of various UV filters in sun creams, which are supposed to protect our skin from UV light, was investigated and appears to have been proven. However, the current state of the data is not yet clear. Above all, the question remains as to whether the environmentally relevant concentrations are sufficient to cause toxic effects. In addition, there are still no standardized lab tests. Further, the focus here has often been on individual components of sun creams only. But there are many different formulations on the market. These are not only worn in the water when swimming. Exposure via wastewater after showers should be viewed critically, too. Especially as many hotels located on trophic seas have inadequate wastewater treatment systems. We present data from various sun creams that were applied directly into the water or discharged via waste water in the presence of detergents.

Test conditions

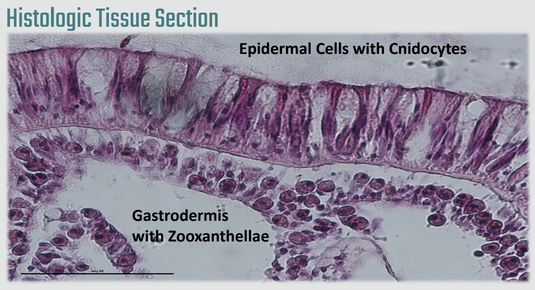
Temperature:	25°C±1°C	Phosphate:	< 0.1 mg/L
pH-value:	8.2±0.2	Nitrate:	< 10 mg/L
Calcium:	410 mg/L	Carbonate Hardness:	7.0 (°dkH)
Magnesium:	1020 mg/L	Oxygen content:	8.40 mg/L
Salinity:	35.4 g/L		

Acute Toxicity Testing up to 96 hours

Screening of 10 different sun creams (concentration 1.00 (TS 1), 10.00 (TS2) and 100.00 (TS3) mg/L)

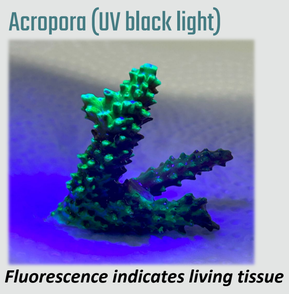
Species selected: ***Acropora tumida***
Replicates: 10 per treatment and control

Histologic Tissue Section



Acropora (day light)

Acropora (UV black light)



Fluorescence indicates living tissue

Selection of test species

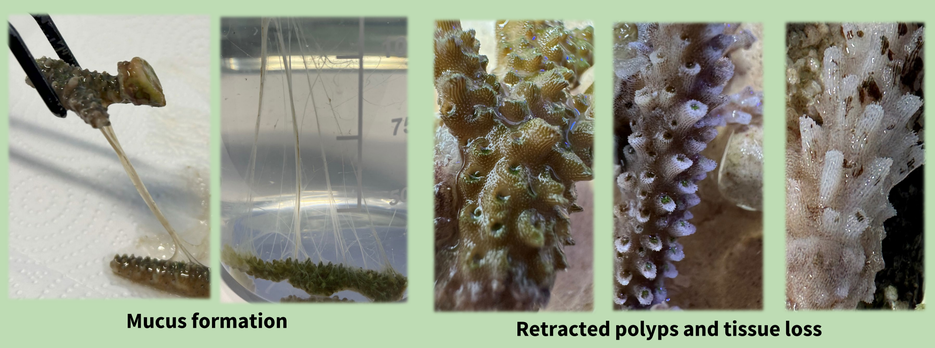
Previous tests with the reference substance 3,5-DCP show that corals react quite sensitive compared to other test species such as algae or macrophytes. It became clear that corals are indicator species, especially corals that live in symbiosis with algae. It was shown that the zooxanthellae were released within a short period of time. This led to coral bleaching in acute tests over 72-96 hours. In addition to bleaching, the observed effects were polyp collapse, edema, loss of polyp movement, retracted polyps, mucus formation and necrosis. *Acropora* species showed similar sensitivity compared to other species and represent a large group of reef building corals. *Acropora tumida* can be cultivated in the lab with acceptable growth rates. Compared to other species *Acropora tumida* reacts with a strong mucus formation which allows to indicate fast reaction to stressor.

Results

Percentage Reduction in the Health of Corals with different Sun Creams

sun cream		*1*	*3*	*4*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Treatment	Conc. [mg/L]	Mortality 48 hours	Mortality 48 hours	Mortality 48 hours	Mortality 48 hours	Mortality 48 hours	Mortality 48 hours	Mortality 48 hours	Mortality 48 hours	Mortality 48 hours	Mortality 48 hours
control	0.00	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
TS1	1.00	80%	100%	80%	10%	0%	0%	0%	10%	80%	0%
TS2	10.00	80%	60%	80%	10%	0%	0%	0%	60%	80%	0%
TS3	100.00	100%	60%	100%	100%	0%	0%	0%	60%	80%	40%
EC_{50}	[mg/L]	<1mg/L	<1mg/L	<1mg/L	<100mg/L	>100 mg/L	>100 mg/L	>100 mg/L	<10mg/L	<1mg/L	>100 mg/L
sun cream		*1*	*3*	*4*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Treatment	Conc. [mg/L]	Mortality 96 hours	Mortality 96 hours	Mortality 96 hours	Mortality 96 hours	Mortality 96 hours	Mortality 96 hours	Mortality 96 hours	Mortality 96 hours	Mortality 96 hours	Mortality 96 hours
control	0.00	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
TS1	1.00	100%	100%	100%	10%	10%	0%	40%	10%	100%	0%
TS2	10.00	80%	100%	100%	10%	10%	0%	10%	100%	100%	100%
TS3	100.00	100%	100%	100%	100%	10%	0%	10%	100%	100%	100%
EC_{50}	[mg/L]	<1mg/L	<1mg/L	<1mg/L	<100mg/L	>100 mg/L	>100 mg/L	>100 mg/L	<10mg/L	<1mg/L	<10 mg/L

Effects on Corals



Mucus formation

Retracted polyps and tissue loss

waste water sun cream / soap		*soap (only)*	*mixure soap/sun cream*	*sun cream (only)*	*soap (only)*	*mixure soap/sun cream*	*sun cream (only)*
Treatment	Conc. [mg/L]	Mortality 24 hours	Mortality 24 hours	Mortality 24 hours	Sublethal effects 24 hours	Sublethal effects 24 hours	Sublethal effects 24 hours
control	0.00	0%	0%	0%	0%	0%	0%
TS1	1.00	n.d.	n.d.	0%	n.d.	n.d.	0%
TS2	10.00	100%	0%	0%	100% (coral bleaching)	0%	100% (mucus formation)
waste water sun cream/ soap		*soap (only)*	*mixure soap/sun cream*	*sun cream (only)*	*soap (only)*	*mixure soap/sun cream*	*sun cream (only)*
Treatment	Conc. [mg/L]	Mortality 48 hours	Mortality 48 hours	Mortality 48 hours	Sublethal effects 48 hours	Sublethal effects 48 hours	Sublethal effects 48 hours
control	0.00	0%	0%	0%	0%	0%	0%
TS1	1.00	n.d.	n.d.	20%	n.d.	n.d.	20% (coral bleaching)
TS2	10.00	100%	100%	100%	100% (mucus formation, coral bleaching)	100% (mucus formation, coral bleaching)	100% (mucus formation, coral bleaching)

Control

Bleaching and necrosis of coral tissue

Note: *Acropora spec.* freshly prepared fragments shows higher sensitivity compared to firmly attached corals with well-developed basis; n.d. = not determined.

Tests with various sun creams showed an effect at high test concentrations. 30% of the sun creams tested showed no effect at the maximum concentration of 100 mg/L. It should be noted that we have a high dilution in marine ecosystems, and it can be assumed that toxic concentrations are not reached in most cases. Only in the inner reef at low tide with a high number of swimmers critical concentrations could be reached. The solubility of sun creams is low, and we have to deal with complex mixtures with up to 25 ingredients. Toxicity cannot always be attributed to one of these ingredients. The laboratory results should be treated with caution as maximum effort was made to saturate the test solution and it makes a significant difference how the system is set up. Due to the oily consistency, a physical effect cannot be ruled out. In most guidelines a control mortality of 10% is allowed for acute testing. However, 10% mortality already indicates a weakening of the coral fragments. Freshly prepared fragments were used for the first tests. This can lead to slime formation and has a negative effect on the water quality. It is strongly recommended to use the corals at least two weeks after fragmentation. It should be noted that species from well-adapted laboratory cultures should be preferred in order to minimise the response to environmental changes and conserve natural resources. Therefore, only corals from our own stock cultures under controlled environmental conditions were used for the tests. An additional outcome of these screenings was that detergents may cause more serious effects on the corals than sun creams. This is a serious finding because not all waster water treatment have the same standard at coral resorts and sun cream can dissolve further in the wastewater via use of soaps. Fast effects on the corals were confirmed by mucus formation after adding sun cream. The fastest mortality was observed by adding of soap to the water. In case soap and sun cream were added together the toxicity was less. This indicates that, in addition to direct exposure by floating persons, a potential interaction and a second exposure phase also occur with wastewater.

Discussion

Corals are indicator species, especially corals that live in symbiosis with algae. Global coral bleaching is one of the most serious observations. Whether sun creams play a significant role in this seems to be questionable. Laboratory tests on corals and anemones may indicate potential risks to coral reef ecosystems, but need to be confirmed by monitoring data of predicted environmental concentrations. Tests with sun creams show that corals will be affected by some formulation of sun creams. However, it is unclear whether toxic concentrations can be reached under natural conditions with high water exchange. As sun creams are complex mixtures, this can only be done through lead compounds. However, it should be noted that laboratory studies can determine the toxicity of each individual active ingredient, but also that of the formulation with all ingredients combined. In the case of exposure to the environment of any kind, the effects on photosynthetic organisms need to be clarified. The results show that potential chemical stressors for coral reefs can be identified under laboratory conditions and included in the risk assessment.

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