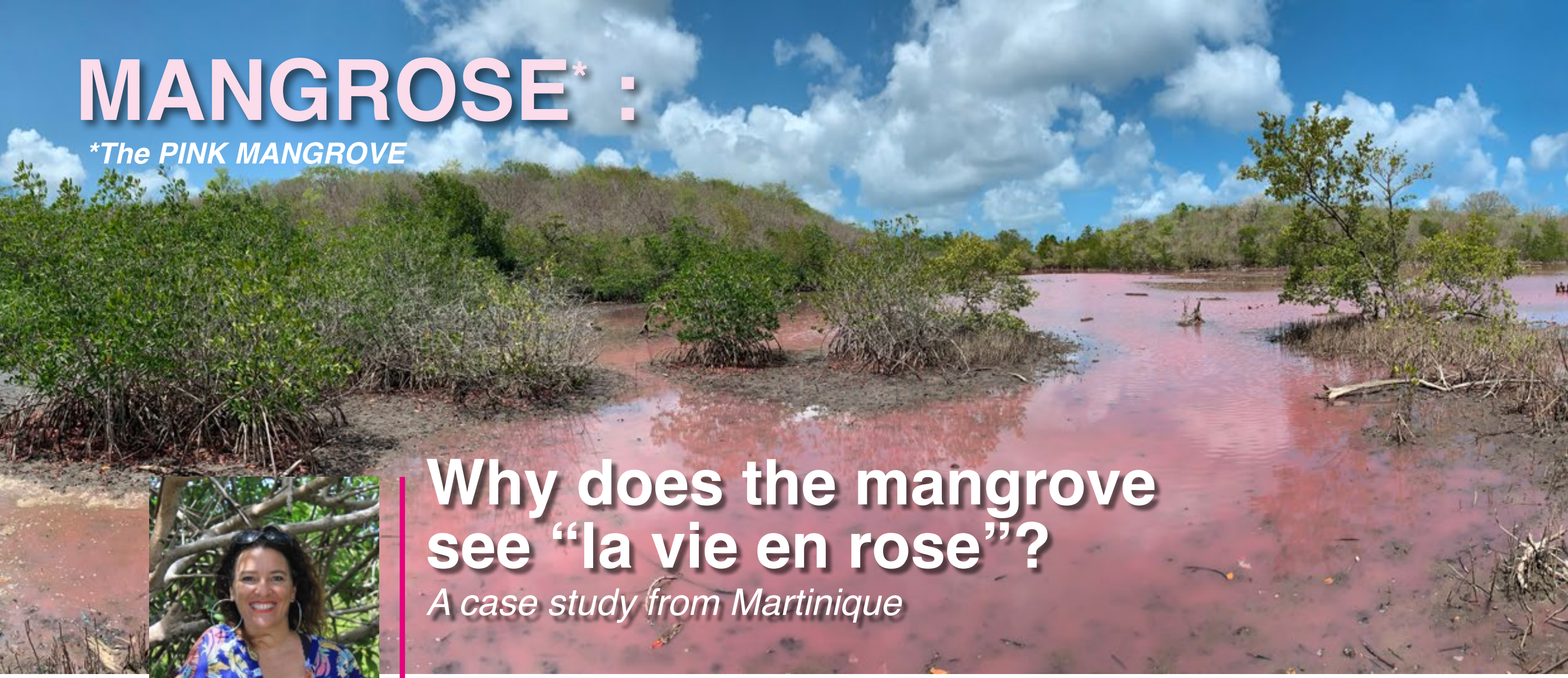

MANGROSE* :

**The PINK MANGROVE*

Why does the mangrove see “la vie en rose”?

A case study from Martinique

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Photo copyright: Laurent Juhel, Nature photographer
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Wonderful, enchanting, splendid, “fout sa bel” (“How beautiful!” in creole), have all been used to describe this fabulous phenomenon of pink mangrove or “Mangrose”. But what are the causes? Is it natural? Will the mangrove recover from it? Is this phenomenon observed in other places around the world? So many questions that everyone is asking when looking at this spectacle, and that deserved clarification and investigation.

A particular kind of pond

It is a very **shallow brackish coastal pond**, typical in the Caribbean islands (as in Saint-Martin, or in Saint-Barthelemy). These ponds or backwaters may be (or not) directly connected to the sea, regulated by the seasons and/or their distance to the sea. Some may be totally disconnected from the sea on the surface, but communicating in the hyporheic zone, below a portion of sand.

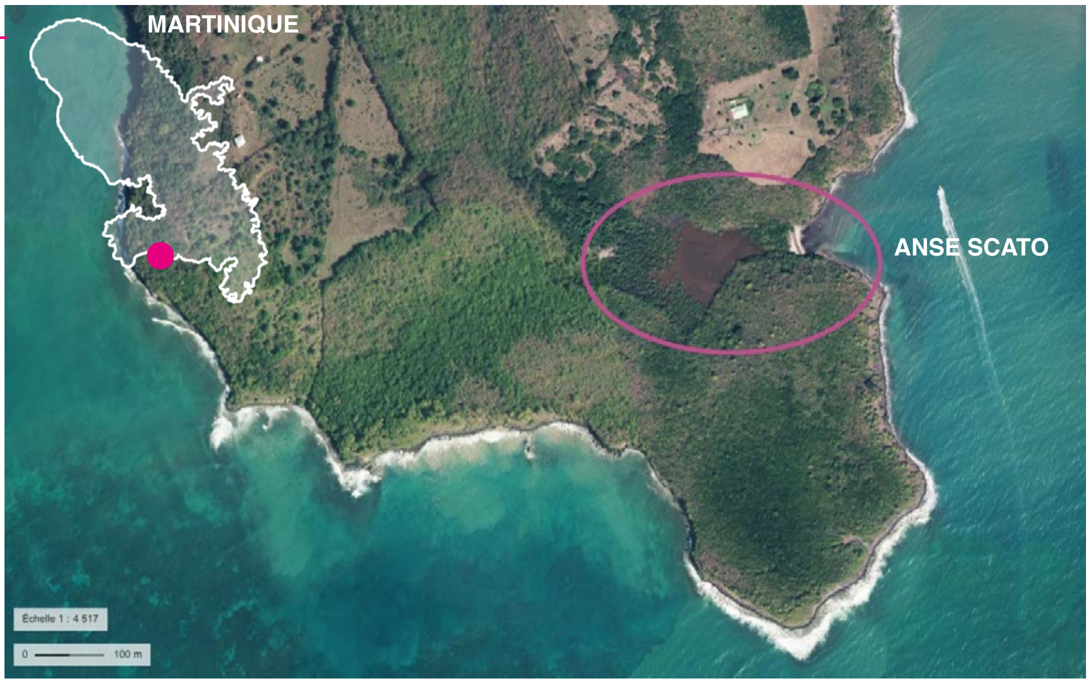


Figure 1:

Location of the Anse Scato mangrove in the town of Le Diamant, at the south of the southwestern peninsula of Martinique. (M. Herteman, 2020, source : Géoportail)

Ponds are not only constituting reservoirs of water. In fact, they are made of three distinct, closely linked and interdependent habitats: the water reserve (characterized by physicochemical parameters such as salinity, pH, temperature, and oxygenation), the sediments or mudflat (consisting of a sandy-clay to clay substrate), the biocenosis, i.e. the fauna (crab, waders, shorebirds, aquatic fauna) and the flora (mangroves, algae, dry deciduous forest nearby).

These backwaters are located at the outlet of the watersheds, and constitute the container of the runoff of fresh water (e.g. rain, gullies, rivers) from the top of the hills. This mix of seawater and freshwater is a special feature of these ponds, that is naturally modulating the salinity level of the environment throughout the year.

Figure 2 :

Pink pond of Anse Scato (Le Diamant, Martinique) located at the outlet of the Morne Cabris watershed. It is surrounded by mangrove trees (light green) and semi-deciduous dry forest (grey-green), separated from the sea by a portion of sand. (Photo ©Autrevue Laurent Juhel, June 2020)

The backwater of Anse Scato (Le Diamant, Martinique) is located at the outlet of the Morne Cabris watershed. It is surrounded by a fringe of mangrove made of three mangrove species: the red mangrove (*Rhizophora mangle*) at the edge of the water, further back, the grey mangrove (*Conocarpus erectus*) and the white mangrove (*Laguncularia racemosa*).

Figure 3 :

Red mangrove (Rhizophora mangle) sinking its roots into the Anse Scato backwater, that turned pink

A water deficit in 2020

Although it is a recurring natural phenomenon across Martinique, this year episode is more pronounced due to weather conditions. Usually, the rains start to rise again in May. This year they were a bit delayed and, in some places, non-existent.
Barely 5 mm fell in Le Diamant! This is the second driest month recorded in the last 40 years in this are; the driest was April 1987 with 4.7 mm.
This represents only 5% of the average monthly rainfall (Weather report of May 2020, from Météo France Martinique). The rainfall in three months (March to May) is exceptionally low. The recurrence of such a deficit is more than 25 years, except in the South of the island.
This water deficit is ongoing since March. In April, the rainfall reported was of only 20 to 30% of the usual average, being about 70-80% short compared to seasonal standards. We need to go back to 1987 to find a drier April month in Martinique.

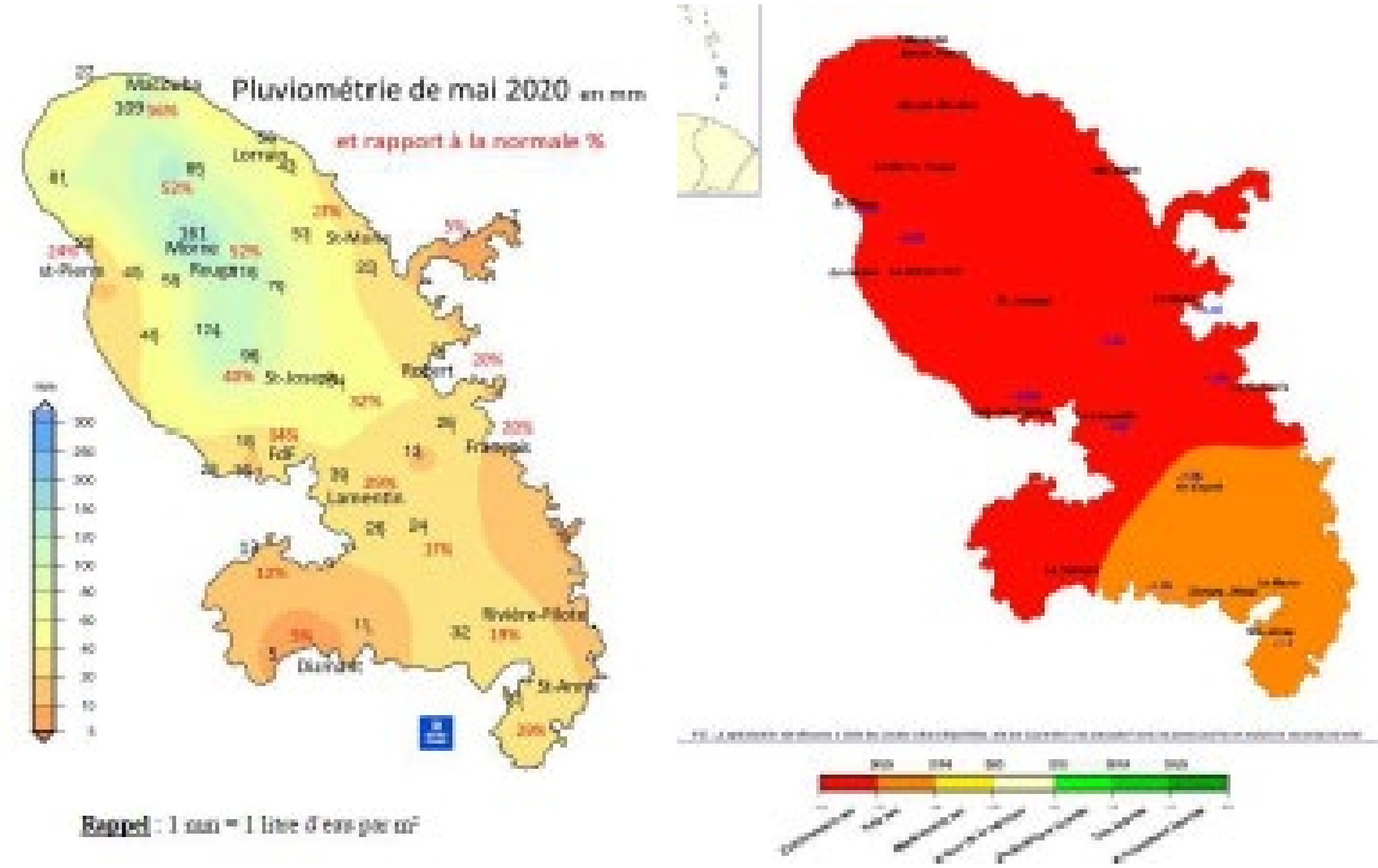


Figure 4 :

Record of precipitations in May 2020 (left) and water balance over three months (March, April, May 2020) (source: Météo France Antilles Guyane)

In addition to this lack of water, another remarkable event was observed in April and March: the atmosphere was particularly clear in the absence of Saharan dust plume (with only two short episodes of low intensity) and the cloud cover was often limited, the solar radiation was also exceptionally high; such observations in April haven't been observed since 1988.
These conditions boost the photosynthesis of plants and algae…

Figure 5 :

The drought also impacts the vegetation around the Taupinière backwater (photo ©Géo-Graphique, Laurent Juhel)

Focus:

Photosynthesis is the process by which green plants and green algae use light to produce their own food. It is crucial for life on Earth. Photosynthesis requires light, chlorophyll, water and carbon dioxide. Chlorophyll is a pigment that gives plants and their leaves their green colour. Plants get water from the soil and use carbon dioxide from the air. Through the roots, plants absorb water and mineral nutrients. It is the raw sap. The raw sap then goes into the leaves. The leaves absorb carbon dioxide and light. This forms the elaborate sap which spreads throughout the plant that feed on it. Finally, the plant expels oxygen.

"Algal bloom" of *Dunaliella salina*

In this particularly dry and long "lent season" (local name for dry season), water evaporation is strong, and led to an increase in salinity, temperature (34 ° C) and pH (recorded at 9, which is the optimum pH for the culture of this type of algae according to Loeblich, 1982) of the water reservoir. This combination of factors caused a drop in the oxygen and nitrogen present in the water. It is precisely these stressful conditions, associated with the increase in light intensity (measured by Météo France), that caused this algal bloom.

In order to characterise the phenomenon and to specifically identify the organism responsible for this colouring, our team went on site to take water samples.

Pink water was collected into flasks, and observations under the microscope allowed us to verify that: this surprising and rare colour observed in the nature is due to a phenomenon called «algal bloom», that is in fact, an i**ntense multiplication (and proliferation) of microalgae**.

Figure 6 :

Water sampling in the backwater of Anse Scato for the determination of the species responsible for the pink colouring (30th of June, 2020)

The species was identified as *Dunaliella salina*, a green unicellular type of microalgae of the class Chlorophyceae). This microalga contains the same elements as other plant cells such as the **nucleus** (holding the genetic material), **chloroplasts** (where photosynthesis happens), **mitochondria** and **Golgi body** (where the energy is produced and stored), **vacuoles**, and **lipid globules**.
On the other hand, this type of microalgae is not made of a polysaccharide wall but of a thin and flexible membrane, unlike most plants, which allows f**aster exchanges with the outside** of the cell. It also has an efficient **Sodium ion (Na +) transport system** adapting to the external osmotic pressure due to the high level of salinity. It also contains a large number of Carotene globules protein - Cgp (the pigment responsible for colouring both the algae and water during such a bloom). Finally, due to the accumulation of glycerol, the microalga manages to balance the salinity of its plasma.

Figure 7:

Dunaliella salina as observed under a microscope (determination by. Herteman, photo credit ©Autrevue, Laurent Juhel)

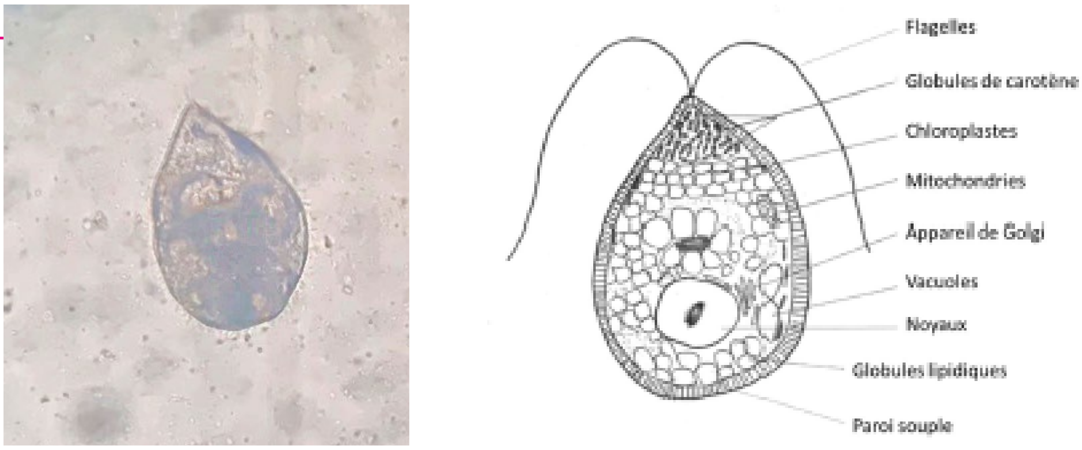


Figure 8:

Left : Dunaliella salina (photo credit ©Autrevue Laurent Juhel. Right : Blueprint modified by M. Herteman)

Only a few organisms are able to live under such conditions, especially such high salinity. Dunaliella salina, is one of these organisms. Through the adaptations of its cells (mentioned above), this microalga, naturally present in salt and brackish ponds such as backwaters, has the particularity of growing in **hypersaline conditions** close to the saturation of the organism. It is in fact capable of carrying out photosynthesis in a hyper saline environment unlike other algae or aquatic plants.
In addition, the environmental stress conditions also cause an intracellular reaction inside the alga. Under these

special conditions of limitation of nutrients supply (nitrogen deficiency in particular), intense luminosity, and a high temperature, **the production of β-carotene increases** with salinity (Hadi et al., 2008). This species is also able to accumulate an important amount of carotenoid droplets in its chloroplasts.

The colouring effect is then **twofold**: The high concentration of the population of Dunaliella salina which itself contains a high concentration of **β-carotene**. This is why this year, high levels of this pigment gives a remarkable pink colour to the water!

Which impacts in the long term?

This change in colour linked to the presence of the *Dunaliella alga* is a **one-off phenomenon** and completely reversible. When the rainy season returns, the salinity of the water will drop, the balance of the ecosystem and of the physicochemical parameters will return to normal, and the pink colour will disappear.

The organisms living in and around this backwater such as crabs (including mudflat fiddler crab, *Minuca rapax*) are also adapted o this habitat with the capacity to tolerate temporary levels of high salinity.

Mangrove trees are also able to live in high-salinity environments. However, not all species react in the same way.

Red mangroves are the least tolerant of very high salinity. If these conditions of salinity stress and lack of oxygenation in the water last a long time, it may lead to an asphyxia of the mangrove trees. A related case was observed in the mangroves of Barrière pond, Saint Martin, in 2015 (Herteman M., 2016 and 2018).

Figure 9:

Mudflat fiddler crab (Minuca rapax) on floating rafts of various shapes (Photo credit ©Autrevue, Laurent Juhel, 2020)

However, under the predicted scenarios of climate change, one wonders if this phenomenon will get worse or more frequent. Météo France Antilles Guyane shows that the dry seasons would be drier and that the number of hot nights would increase, especially in the South of the island (Palany P., 2018, C3AF Project).

On the other hand, according to a new study by NASA and ECOHAB (Ecology and Oceanography of Harmful Algal Blooms), sand mists (Saharan dust plume) are travelling thousands of kilometres, thus iron-fertilizing water off the West coast of Florida, where they have caused an algal bloom. Therefore, we can wonder if, these particularly intense sands mists observed in 2020 would contribute to the increase of this "bloom" phenomenon. Local investigations should be pursued to validate -or not- these hypotheses.

To go further: another colour change…

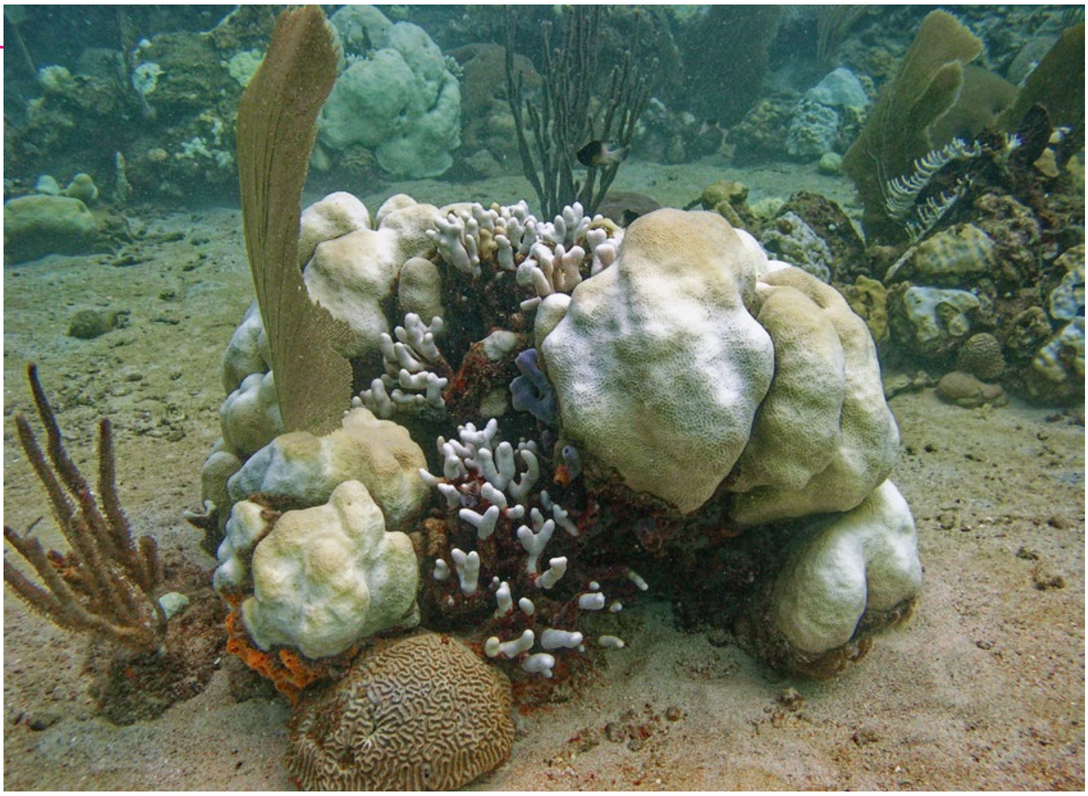
Here we wanted to highlight another type of colour change phenomenon: coral bleaching. Corals constitute symbiotic association of fixed animals called Anthozoans (phylum: Cnidarians) with microalgae called zooxanthella.

In contrary with the "algal bloom" colouration in mangroves, coral bleaching phenomenon may be irreversible in some cases. Coral bleaching is following the expulsion of symbiotic zooxanthellae or can be due to the loss of algae pigmentation. The causes can be linked to climate change effects, such as the increase in ocean temperature and to the impacts of pollution due to human activities.

Bleached corals are not necessarily dying. In fact, corals have the ability to survive to stress but they become much more vulnerable to lower levels of stress. Coral bleaching, which seems to be steadily increasing around the world oceans, can leads to the death of large areas of corals, due to a combination of factors, sometimes including a lack of nutrient supply.

Figure 10:

Coral bleaching observed on the "Caye de Sainte-Luce" reef, Martinique. (photo OMM)



https://www.autrevue.fr/mangrose/visite.htm

Photo ©Géo-Graphique

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