Bacterial communities able to form biofilms and degrade plastics

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Introduction

Because of its indispensable role in human life, plastic production increases every year. However, only a small part of plastic wastes is recycled. Most of them are released in landfill or in the sea. Scientists estimate that 5 trillions of plastic pieces (macro and micro particles) are in marine environment.These synthetic polymers have large ecological and health impacts. Nevertheless, plastics are colonized by microorganisms like bacteria, fungi and diatoms. This distinct environmental niche is called "plastisphere". In addition, it has been shown that a small part of these microorganisms are able to degrade plastics.
In this research, there are 2 main objectives. The first is the phylogenetic profile study of the bacterial community in biofilm on marine plastic samples. Secondly, bacteria from these samples and from wastewater treatment plant samples are cultured with plastics in liquid medium with low concentration of carbon in a way to select bacteria able to degrade 4 types of plastics: Low Density PolyEthylene (LDPE), PolyEthylene Terephtalate (PET), PolyVinyl Chloride (PVC) and PolyStyrene (PS).

Methods

Plastic samples → Mediterranean Sea, Corsica
Plastic samples → Wastewater treatment plant Wasmüel, Belgium

Liquid medium
0.05% yeast extract +
1 type of plastic film
(PVC, LDPE, PET or PS)
140 rpm

Biofilm development

→ Biofilm structure analysis and study of signs of degradation (SEM)
→ Bacterial communities study (DGGE)

Phylogenetic study from Corsica samples

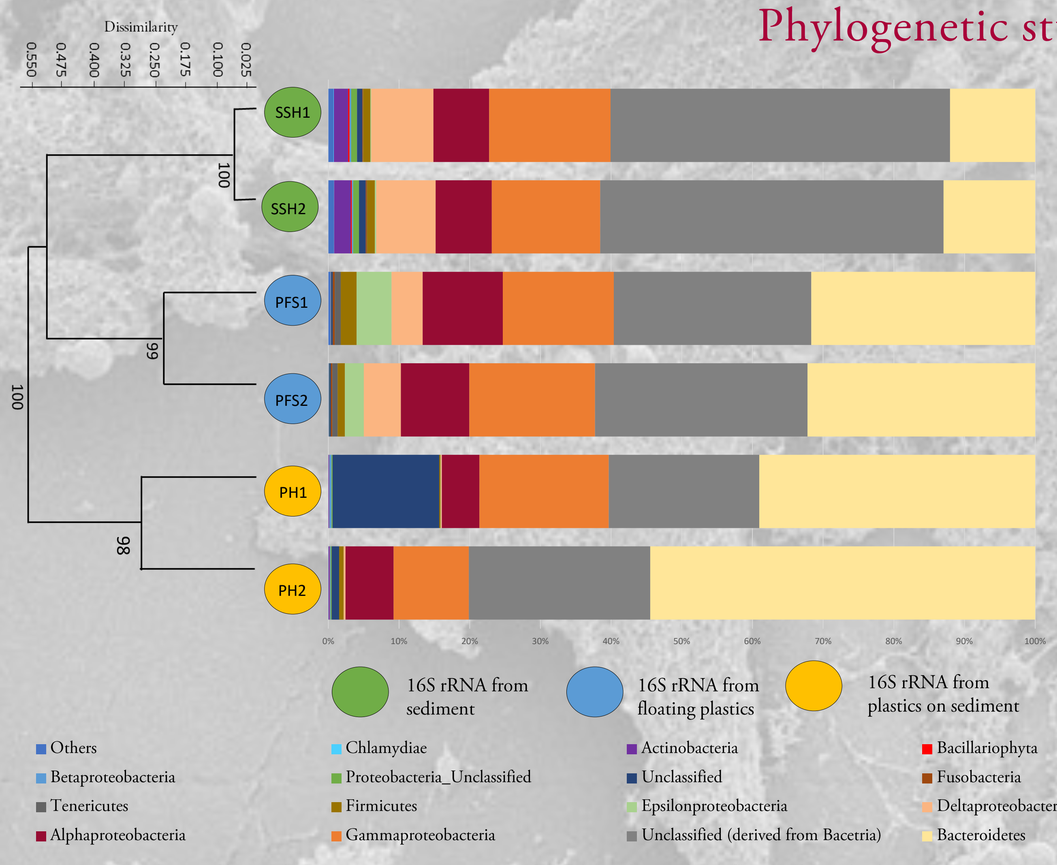

Figure 1: Taxonomic distribution of bacterial communities present on 3 types of samples: sediments (SSH), floating plastics (PFS) and plastics on sediment (PH). These samples come from Stareso, Corsica. Partitioning was performed with the Bray-Curtis index, with 10 000 Bootstrap. The coefficient obtained for this partitioning analysis is 0.9804.

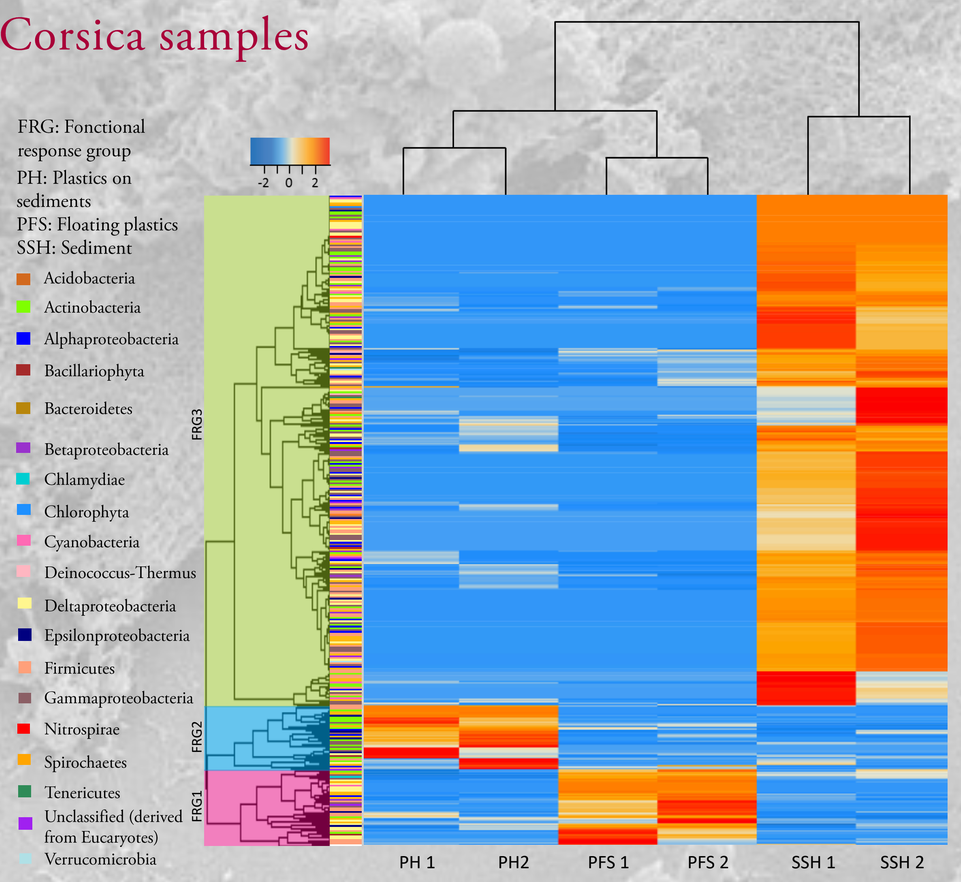

Figure 2: Heatmap performed on OTUs with an index value of more than 0.9 for plastics on floating plastics (PFS), plastics on sediment (PH) and sediments (SSH).

Enrichment culture analysis

Marine samples

Only one species characterises the majority of bacterial community on LDPE biofilms, except one sample that contains another species. The first species corresponds to the bacterium *Alcanivorax borkumensis* and the second to *Microbulbifer* sp. (Fig.3). Moreover, some holes and cracks are observed on LDPE (Fig.4).

Figure 3: DGGE made after 2 months of enrichment culture on the LDPE. The boxes show the 2 bands corresponding to (A) Alcanivorax borkumensis and (B) Microbulbifer sp. which are enriched in the majority of biofilms on the LDPE.

Figure 4: Scanning electron microscopy of the LDPE surface after two months of enrichment culture. (A) Biofilms on plastics, (B) Plastic lacking biofilm, Holes and cracks present on the surface of the plastic are highlighted by circles, NC: Negative Control.

Samples from wastewater treatment plant

In contrast to marine samples, biofilms contain a high richness but no bacterial species are overrepresented (Fig.5). SEM experiments revealed also signs of degradation on the 4 types of plastics (Fig.6).

Figure 5: DGGE made after 1 month of culture on the 4 types of plastic. NE: bacterial community before enrichment culture and E: after enrichment culture.

Figure 6: Scanning electron microscopy one month of enrichment culture. (A) Degradation signs on LDPE (B) Holes on PVC samples, NC: Negative Control.

Conclusion

Results from16S rRNA sequencing performed on marine samples show that bacterial community on sediments is different from those found on plastics. So, these results confirm that plastics represent a distinct environmental niche (Fig.1 and 2).
Two bacteria, *Alcanivorax borkumensis* and *Microbulbifer sp.* are potential candidates for LDPE degradation. These two microorganisms are very interesting because they are known to degrade hydrocarbons and to degrade complex polymers respectively. In the future, it will be interesting to test and to confirm their ability to degrade LDPE plastic but also other types of polymer. Some bacteria from marine sample and wastewater treatment sample seem to be able to degrade numerous polymers. It will be interesting to isolate these bacteria and to identify them.

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