

Bacterial community and system performance of an aerobic granular sludge reactor treating pharmaceutical wastewater

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INTRODUCTION

Pharmaceutical compounds are emerging environmental contaminants that have been detected in various environmental matrices [1]. Their occurrence has been widely reported in domestic and hospital wastewater treatment plants (WWTP) effluents where low removal rates are observed. Even at low levels, they can affect the composition of the microbial communities, and hence disturb the metabolic networks [2].

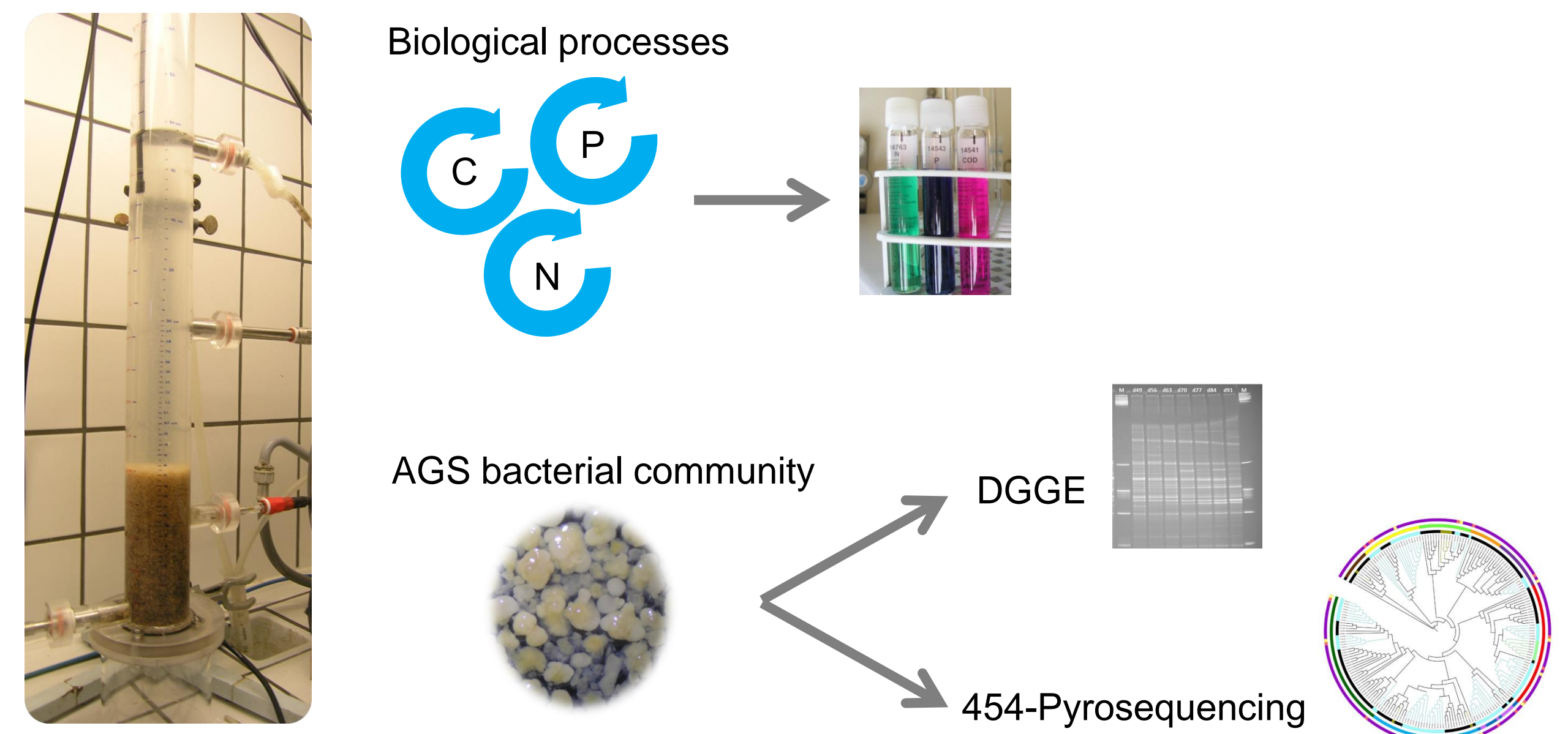
Aerobic granular sludge (AGS) has been successfully applied for the treatment of industrial and domestic wastewaters and the implementation of AGS full-scale facilities has been growing worldwide [3]. The possibility to concomitantly remove carbon, nitrogen and phosphorous in a single unit is one of the attractive aspects of the AGS technology since it greatly reduces the plant footprint. Pharmaceuticals are often present in influent wastewaters, therefore knowledge on their effect on the main biological processes is needed to provide guidance for a stable operation. Moreover, as microorganisms within AGS are key players in removal processes, a better understanding of bacterial composition could be useful to improve wastewater treatment efficiency and to enlarge the knowledge on critical functional groups.

METHODS

Table 1. AGS bioreactor schedule

Phase	Length of operation (days)	Feed with a mixture of pharmaceuticals
I	0-28	×
II	29-57	✓
III	58-86	×

- Pharmaceuticals from three different therapeutic classes were chosen as a model
- Pharmaceuticals supplied at concentrations similar to those found in wastewaters influents.



RESULTS & CONCLUSIONS

COD-, P- and N-removal

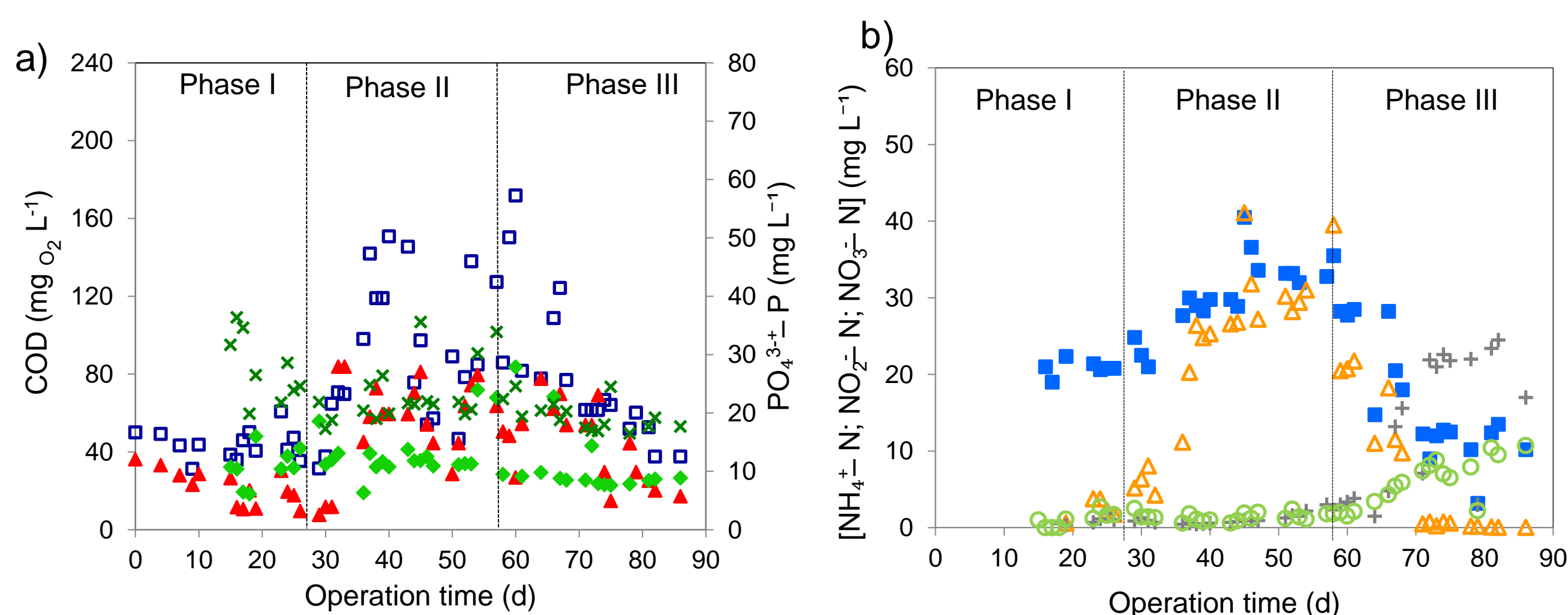


Figure 1 – COD, P (a) and N (b) removal along AGS-SBR operation. The concentration of COD (□), PO₄³⁻-P (x) and NH₄⁺-N (■) in reactor liquid after anaerobic feeding and COD (▲), PO₄³⁻-P (◆), NH₄⁺-N (△), NO₂⁻-N (+) and NO₃⁻-N (○) at the effluent are shown.

- Load of pharmaceuticals slightly decreased COD removal during the anaerobic phase but the maximum COD content at the effluent was below the emission limit value of 150 mg L⁻¹
- The effluent PO₄³⁻-P level was consistent over time but its content at bulk liquid after anaerobic feeding dropped, indicating that polyphosphate accumulating organisms' activity was affected.
- The load of pharmaceuticals transiently affected N-removal.
 - Effluent NH₄⁺-N content increased indicating that probably pharmaceuticals load inhibited ammonia oxidizing bacteria activity which was able to recover after stopping the feeding.
 - Nitrite oxidizing bacteria activity was only partially resumed at the end of the monitoring

Load of pharmaceuticals triggered changes in COD-, P- and N-removal, resumed after reestablishing normal conditions

AGS microbial community

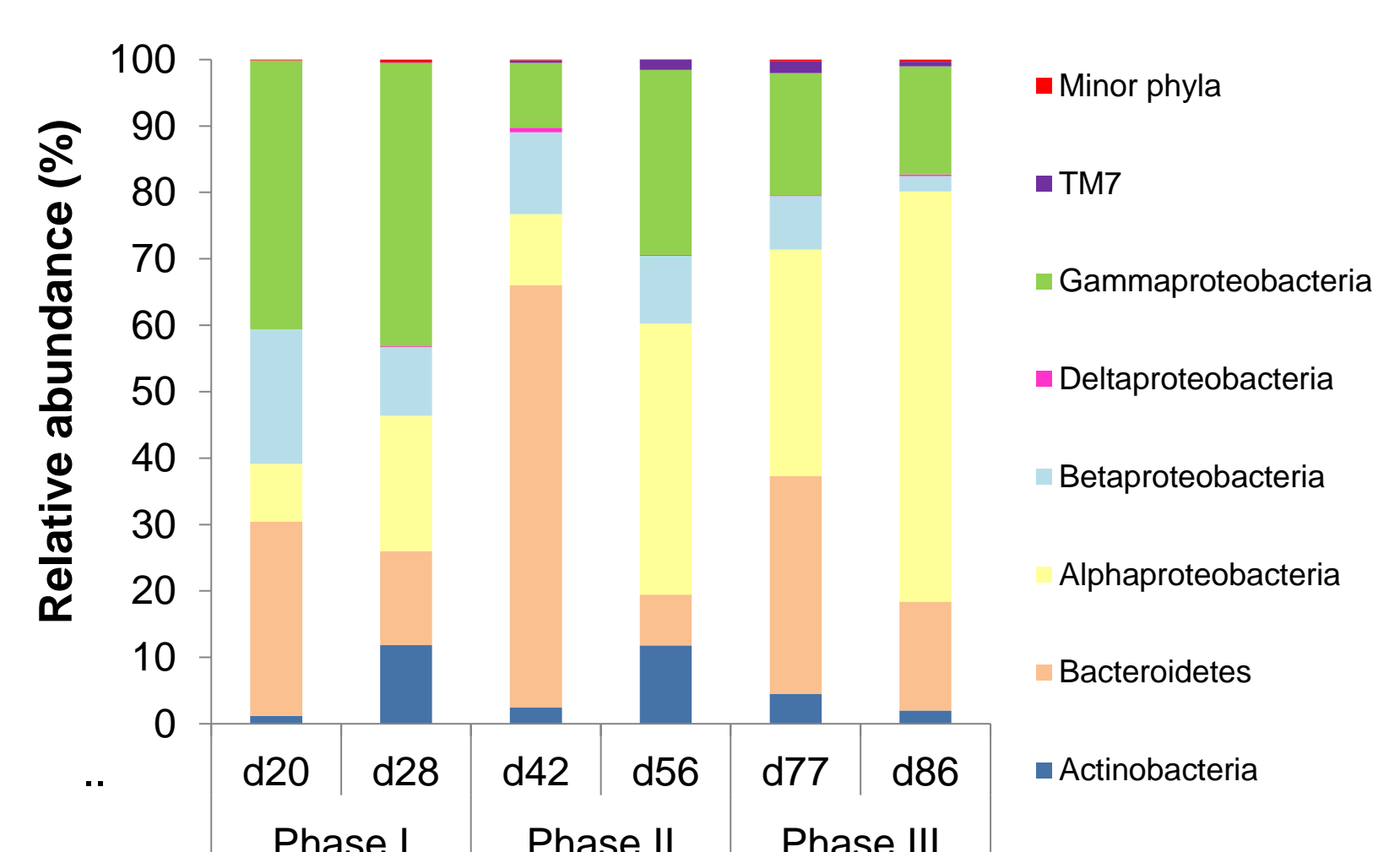


Figure 2 – Relative abundance of phyla and subclasses of Proteobacteria. Phyla which relative abundance on each day was lower than 0.5 % was represented by minor phyla.

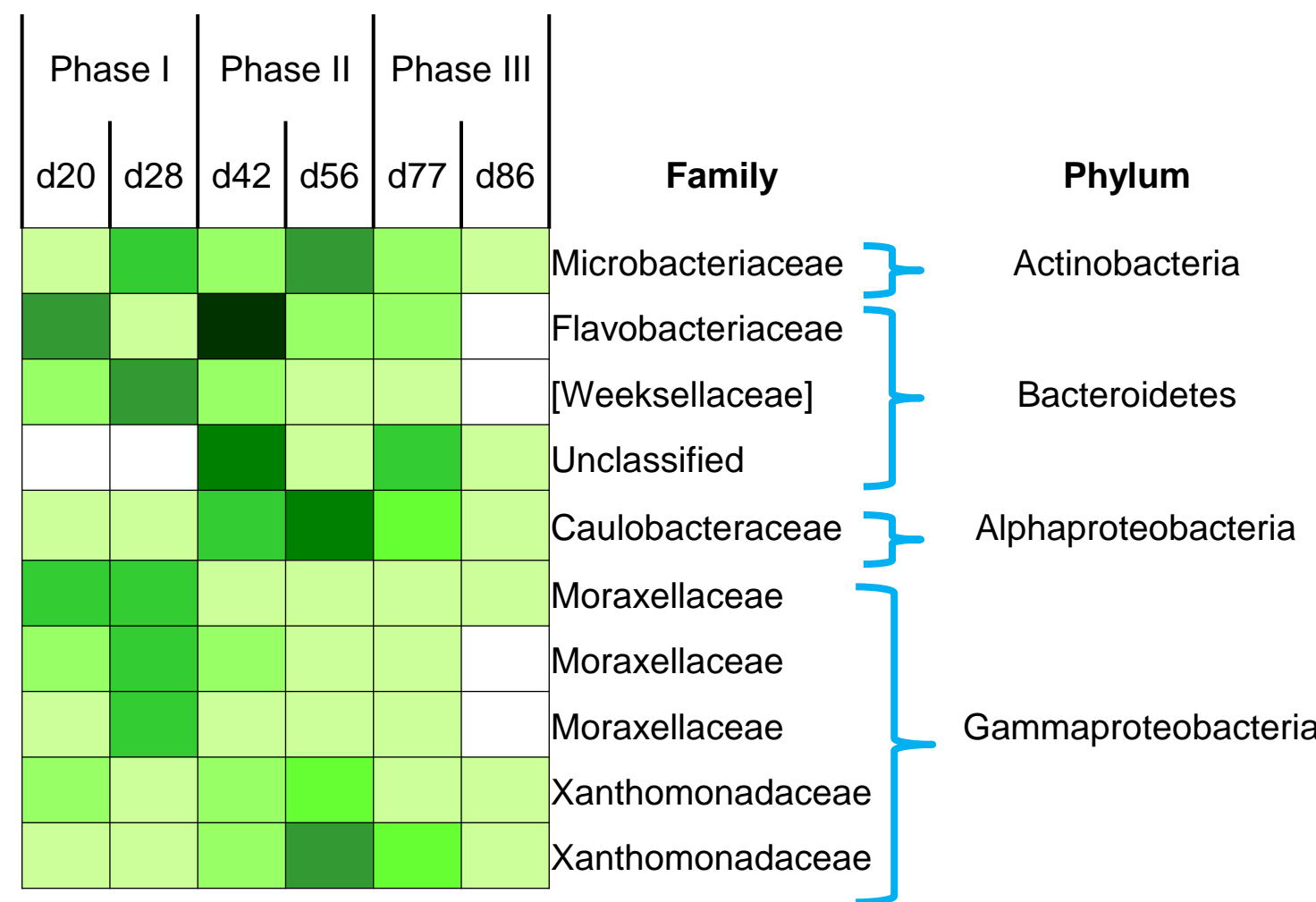


Figure 3 – Heatmap displaying the relative abundance of the dominant populations. Color intensity increases with relative abundance.

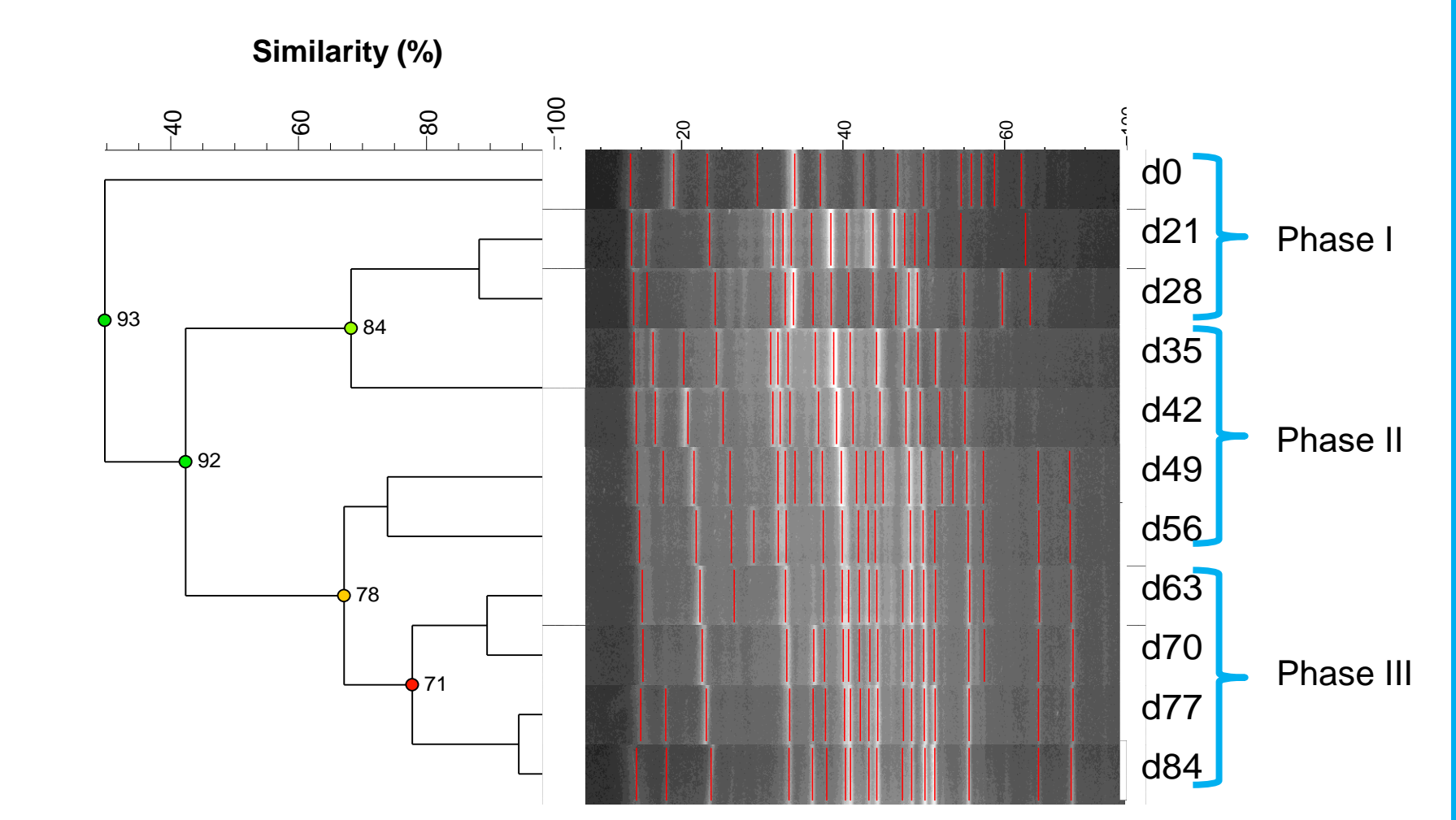


Figure 4 – Cluster analysis based on DGGE profiles of the V3 region from the 16S rRNA gene of bacterial communities. The dendrogram was created using UPGMA method and is based on Jaccard coefficient..

- The composition at both phylum and class levels was different over the operational time;
- Bacteroidetes and Proteobacteria were the predominant phyla in AGS;
- Proteobacteria was dominated by the alpha- and gamma-proteobacterial subdivisions;
- Minor phyla accounted with 10 rare different phyla but its relative abundance was up to 0.44% in each day;
- Accordingly to the heatmap, the most abundant OTU belongs to *Flavobacteriaceae* family but its abundance differ over time
- Some of the top ten OTUs were not shared by all samples.

- Occurrence of shifts and re-structuration of the bacterial community along bioreactor operation;
- Existence of a diverse bacterial population, with some bands present over time, albeit at different intensities;
- During the load of pharmaceuticals a pronounced shift in the bacterial assemblage occurred.

AGS bacterial community was dynamic and able to adapt when subjected to environmental stress situations such as the load of pharmaceuticals

References: [1] Santos LHMLM, et al. 2013. Contribution of hospital effluents to the load of pharmaceuticals in urban wastewaters : Identification of ecologically relevant pharmaceuticals. *Sci. Total Environ.* 461-462:302–316; [2] Petrie B. et al. 2015. A review on emerging contaminants in wastewaters and the environment: Current knowledge, understudied areas and recommendations for future monitoring. *Water Res.* 72:3–27; [3] Pronk M et al. 2015. Full scale performance of the aerobic granular sludge process for sewage treatment. *Water Res.* 84:207-217.

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