Development of a microalgae process to recycle nutrients (N and P) from digestate: effect of the influent color.

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Introduction

Within intensive livestock farming systems as Brittany (France), over-application of manure on agricultural soils leads to nitrogen and phosphorus discharge in the aquatic environment, resulting in eutrophication problems and decreasing of water quality [1]. In the same time, anaerobic digestion of livestock wastes becomes more and more widespread in Europe. In fact, anaerobic digestion allows to produce renewable energy and to reduce direct and indirect greenhouse gas emissions [2]. However, the amount of nitrogen is not modified by anaerobic digestion and additional treatment is required to improve the valorization of the nutrients through exportation out of the intensive livestock region. For that, an accumulation of mineralized nutrients in autotrophic microalgal biomass was identified as a possible efficient process [3]. After accumulation of nutrients, microalgae could be exported and used as organic fertilizer. Nevertheless, one of the main difficulty identified for the culture of microalgae using digestate as substrate is the dark color of the influent [4]. Indeed, such a color reduces light penetration and consequently the available light required for autotrophic microalgae growth.
In this context, the aim of this study was to characterize the digestates in term of coloration and study the effect of this coloration on algae growth and digestate nutrient removal.

Material and Methods

Three anaerobic digestion sites were sampled 3 times over one year and the coloration of the liquid part of the digestate was studied measuring the optical density (O.D.). The different spectra were acquired in visible wavelengths, spectral range corresponding to the activity of photosynthetic pigments. Based on the digestate characterization, the effect of color on nutrient removal and on microalgae growth was studied according to the provided light using a 2-factor 3-level design, in six 2 L photobioreactors (in 2 blocks). The light levels selected were 50, 150 and 250 µmol of photon/m²/s. Digestate color was set to a 680 nm O.D. of 1, 0.5 and 0.2. The fresh microalgae culture, isolated from an urban waste water treatment pond, contained mainly *Chlorella sp.* and *Scenedesmus sp.*.Temperature, pH and mixing were controlled respectively at 25°C, 7.0 and 230 RPM. To maintain the pH, carbon dioxide was added into the solution through a diffuser. Oxygen was recorded continuously. The influent was composed of diluted digestate to set the color; macro-nutrients were equilibrated with synthetic media based on a 10-fold diluted digestate and completed with Gaffron micronutrients [5].

Results

Significant variations of O.D. of the three 1/10 diluted digestates, ranged between 0.19 and 2.35 at 680 nm, were observed whereas only slight variations were obtained over time (less than 0.95 O.D.). Input composition of digesters (percentage of water, grease) and separation technologies used could explain the differences of O.D. between sites. Based on characterization results, the study of the coloration showed the important influence of this parameter on microalgae growth. However, results highlighted that it was possible to observe a significant growth of the microalgae even with the colorful digestate (O.D. at 680 nm of 0.45).

Conclusion and perspectives

The influent color is a critical parameter for the treatment of digestates using microalgae. The light accessibility can be managed by conception, with depth of the pond and agitation, and by exploitation, controlling recirculation and initial dilution. Further study will be achieved concerning the later to optimize the use of this technology.

References

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Keywords
Digestate, nutrient removal, microalgae, color