Use of the microalgae *Chlorella Sorokiniana* for municipal wastewater treatment: batch experiments

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Abstract

Batch experiments were conducted in order to investigate the use of microalgae *Chlorella sorokiniana* for the treatment of different types of municipal wastewater (raw sewage, anaerobically treated wastewater, aerobically treated wastewater) and investigate the role of light and addition of ammonium on its growth. All experiments were conducted in triplicates and lasted for 7 days. Several parameters were monitored during the experiments in order to check the experimental conditions (pH, temperature, DO), the growth of biomass and the removal of major pollutants (COD, NH_4-N, PO_4-P, NO_3-N) from wastewater. According to the results, the target microalgae can be sufficiently developed in raw and anaerobically treated sewage, while it can remove an important part of the major pollutants found in raw sewage, reaching up to 94%, for COD, 99% for PO_4-P and 94% for NO_3-N. The addition of NH_4-N in aerobically treated does not enhance growth of biomass, while the application of mixotrophic conditions (16h light/8h dark) enhanced microalgae growth and major pollutants' removal.

Keywords: wastewater treatment, *Chlorella sorokiniana*, removal, nutrients

1. Introduction

Municipal wastewater originate from households and other sources found in a city. The main contaminants found in wastewater include organic matter (expressed as COD or BOD), nitrogen and phosphorus. Conventional biological wastewater treatment processes are usually applied for municipal wastewater treatment. On the other side, several microalgae have been tested during the last years for their ability to grow in municipal wastewater and their potential to remove the major pollutants (Acien et al, 2016).

Among them microalgae *Chlorella sorokiniana* has the capability to grow at high polluted environment. The species of *Chlorella sp*. belong to the territory of *Eukaryota* and more specifically to the order *Chrorallales* and the family of *Chlorophyceae*. *Chlorella* species occur mainly in freshwater and soil and to a lesser extent in the marine environments. They have the ability to survive in a large temperature range, ranging from 15 °C to 40 °C (Barsanti et al., 2014). Recently, *Chlorella sorokiniana* as well as other microalgae species were tested for wastewater treatment (Ramsudar et al., 2017; Gupta et al., 2016; Chen et al, 2018).

The main objective of this study was to investigate if microalgae *Chlorella sorokiniana* is capable to grow in municipal wastewater containing different pollutants' concentrations and to estimate its capability to remove COD, NH_4-N, PO_4-P and NO_3-N.

2. Methods

Chlorella sorokiniana was gradually acllimatized to anaerobically treated sewage for a period of two months. Afterwards, three different rounds of batch experiments were carried out. The first experiments compared the ability of tested microalgae to grow and remove major pollutants by different types of municipal wastewater. For this reason, three different types of municipal sewage were used: (a) raw sewage originated from the Aegean University Campus, after sieving and filtration (b) anaerobically treated sewage after passing from a lab-scale anaerobic moving bed biofilm reactor (MBBR) that achieved significant reduction of the organic loading and (c) aerobically treated sewage using a lab-scale aerobic MMBR that achieved COD reduction and ammonia removal. The second round of experiments examined the response of the microalgae in aerobically treated sewage where ammonium nitrogen had been added. At the last experiments, the effect of light on organism's growth and wastewater treatment was studied conducting experiments under mixotrophic (16h light/8h dark) and heterotrophic conditions (complete darkness). The

duration of all experiments was seven days and samples were taken at 0, 3, 5 and 7 day. The growth of *Chlorella sorokiniana* was studied measuring optical density, while the evaluation of treatment efficiency was based on measurements of COD, NH_4-N, NO_3-N and PO_4-P. All the experiments were conducted in triplicates, in a incubator at a temperature of 24 °C ± 2 and light intensity of 668 lux.

3. Results

The experimental results show that *Chlorella sorokiniana* has the potential to grow better in the presence of raw sewage (IN) and under mixotrophic conditions (IN, mixtr) (Figure 1).

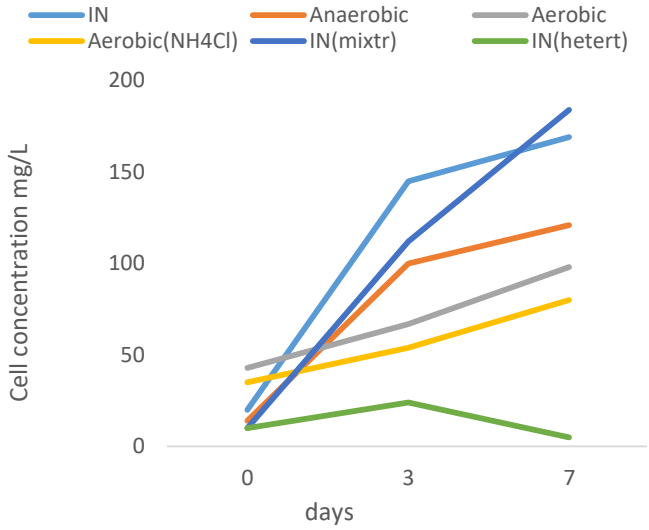

Figure 1. Growth of *Chlorella sorokiniana* in experiments with different types of municipal wastewater and mixotrophic (mixtr) or hetetrophic (hetert) conditions.

The removal rates of major pollutants found in municipal wastewater were higher when raw sewage was used, ranging from 62% for NH_4-N to 99% for PO_4-P (Table 2).

High removal efficiency was also achievedd during treatment of anaerobically treated wastewater, while the removal of COD, NH_4-N and NO_3-N was very low when aerobically treated wastewater were used, indicating the important role of organic loading on the performance of such systems.

Table 1. Removal of majör pollutants in batch experiments with

	In	Anaerobic	Aerobic	Aerobic (NH_4Cl)
COD	94	85	39	15
NH_4-N	62	47	0	11
PO_4-P	99	91	93	84
NO_3-N	92	0	0	0

Chlorella sorokiniana and different types of municipal wastewater.

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