Effects of low-density static magnetic fields on the growth and activities of wastewater bacteria Escherichia coli and Pseudomonas putida

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HIGHLIGHTS

- SMF (B = 17 mT) negatively influenced the growth of Escherichia coli and Pseudomonas putida.
- The SMF driven growth inhibition was less pronounced at B = 5 mT and B = 50 mT.
- The SMF effect was most pronounced at optimal growth temperatures.
- SMF (B = 17 mT) increased dehydrogenase activity and intracellular ATP concentrations.
- SMF increased expression of the rpoS gene in E. coli.

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ABSTRACT

The aim of this study was to explore the influence of a moderate static magnetic field (SMF) of different densities on Escherichia coli and Pseudomonas putida that are commonly found in wastewater treatment plants. In line with literature reports that SMF increases the efficiency of wastewater treatment the findings of this study indicated that SMF negatively influenced the growth but positively influenced the enzymatic activities and ATP levels of the two model bacteria. The inhibitory effect of SMF on growth of E. coli and P. putida was most pronounced at their optimal growth temperature (37 °C and 28 °C respectively) and was reversible shortly after the SMF had been terminated. Finally, the results suggested that the induced energy metabolism reflected in higher dehydrogenase activities and ATP levels may be more important for survival, and adaptation to SMF induced stress than the increase in the expression of the rpoS gene.

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1. Introduction

Magnetic fields (MF) can influence living organisms. Interest in this field is growing because MF were previously implicated as harmful for human health, but recently as also being stimulatory for biological wastewater treatment (Tomska and Wolny, 2008; Yavuz and Celebi, 2000). However, despite the extensive literature (Chen and Li, 2008; Ji et al., 2010; Tomska and Wolny, 2008; Yavuz and Celebi, 2000), there is still the lack of a comprehensive view regarding the mechanisms and biological effects of MF (Hughes et al., 2005). The literature on the influence of MF on biological systems is very heterogeneous in regard to the strength of MF (from 10^-7 to 10 T) and the types of fields (static or time varying) applied. In addition, subjects exposed to MF vary, and studies investigating bacteria as opposed to eukaryotic cell cultures, tissues, and animals are less frequent (Rosen, 2003a, b). In addition, studies applying static magnetic field (SMF), which is unassociated with changes in electrical current, as opposed to time varying MF, are scarce (Rosen, 2003a).

Magnetic fields can cause biological effects and are accordingly classified as weak (<1 mT), moderate (1 mT–1 T), strong (1–5 T) and ultra-strong (>5 T) (Rosen, 2003a,b). The magnetic flux at the Earth's surface is considered weak as it ranges from 0.03 mT to 0.06 mT (Buffett, 2010). Strong and ultra strong SMF induces biological effects that may alter differentiation of Xenopus eggs (Denegre et al., 1998) and were suggested to have occurred due to changes in the orientation of diamagnetic anisotropic organic molecules, such as membrane lipids (Rosen, 2003a,b). The influence of moderate (or low density) SMFs were also studied within numerous eukaryotic model systems, and the observed effects were associated with changes in Ca^{2+} influx and the permeability of membrane ion...