

Effects of extremely low frequency electromagnetic fields on microorganisms from water treatments

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Abstract: Through dielectric spectroscopy measurements, chemical analyses, and specific microbiological techniques, we studied the influence of extremely low-frequency ELF electromagnetic fields (1-500 Hz) on the microbial metabolism of activated sludge, formed in the stage of microbiological treatment of domestic wastewater. Dielectric spectroscopy experimental data revealed that the investigated samples of activated sludge show four representative frequencies 49.9, 99.9, 130.8, and 150.4 Hz, and the evolutions of dielectric loss and conductivity show significant discontinuities indicating oscillation/resonance phenomena in the investigated biomass- unlike sterilized sludge samples (by boiling or electrically, by applying a voltage that creates a 1 V/cm field on the sample) does not show discontinuities instead the values of $tg\delta$ and σ are approx. 5-6 times larger. Chemical and microbiological determinations have shown that the metabolism, growth, and multiplication of microorganisms in activated sludge are significantly increased after exposure to 40-60 mV/cm electromagnetic field of 50 Hz. It is proposed to continue the research by developing an equipment and bioelectrotechnological process to increase wastewater treatment plants' efficiency significantly.

Keywords: Extremely low frequency (ELF), dielectric spectroscopy, microorganisms, active sludge, wastewater, water treatment.

Introduction: The influence of electromagnetic fields on the living matter is a theoretically complex issue with unique practical implications. This complexity arises from the diversity and structural complexity of the living matter. Thus, to develop a process that increases the energy efficiency the water purification processes, in the present work, we studied the effect of the ELF electromagnetic field on the microorganisms from the activated sludge sampled from the wastewater treatment plant.

Experimentals: The evaluation of the effect of electromagnetic fields in the ELF domain on the microorganisms contained in the activated sludge was performed experimentally through dielectric spectroscopy technique and specific microbiological determinations.

The dielectric measurement of the activated sludge suspension was conducted at $12 \pm 0.5^\circ\text{C}$ using the STVP-200-XG thermostat system, equipped with a liquid sample holder and the specialized equipment AMTEK - 1296 Dielectric interface (Solartron Analytical).

To evaluate the activity of the microorganisms from the activated sludge, in the treatment process of domestic wastewater, chemical and microbiological analysis were performed in laboratory scale reactors-with and with and without exposure to 50 Hz field (Fig. 1).

Comparative measurements were performed at $23 \pm 2^\circ\text{C}$, by use of synthetic wastewater (5 g/L sugar, 0.401 g/L NH_4Cl , 0.118 g/L K_2HPO_4 , 0.032 g/L $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ and 0.03 g/L $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) inoculated with 0.2 L of activated sludge suspension with Aeration (bubbling with air 2L/min, 3L synthetic wastewater).

The evolution of the main water quality parameters was monitored by Photometric Cuvette Tests: - Dissolved oxygen- LDO [mg/L], -Chemical oxygen demand COD [mg/L]; - Ammonium- N-NH_4^+ [mg/L]; - Phosphate Ortho (total phosphor) - P_i [mg/L].

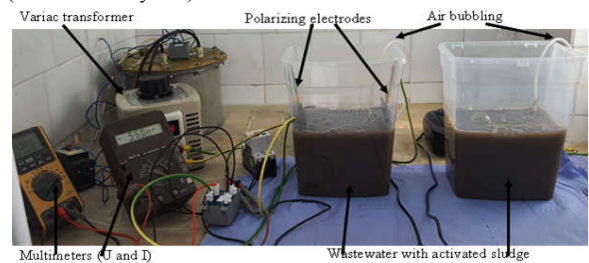


Fig. 1- Experimental setup

Results and discussions:

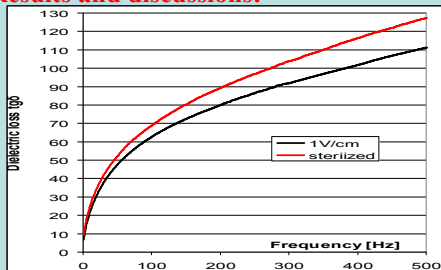


Fig. 4. $tg\delta$ vs. frequency at 1V/cm on sterilized sludge.

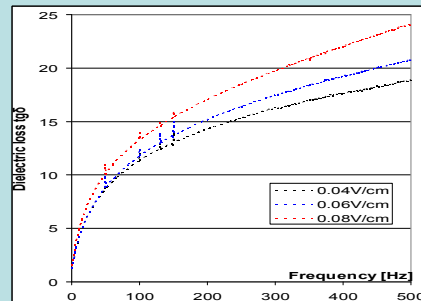


Fig. 2. $tg\delta$ vs. frequency of activated sludge

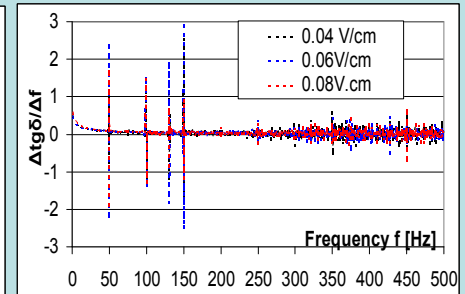


Fig. 3. The evolution of $\Delta tg\delta / \Delta f tg\delta$ vs. frequency

E [mV/cm]	Parameter				
	Time [hours]	LDO [mg/L]	COD [mg/L]	N-NH ₄ ⁺ [mg/L]	P _i [mg/L]
0 (reference)	Initial	0	3210	59.4	10.1
	6	1.19 ± 0.21	2940	37.20	6.45
	12	1.96 ± 0.21	2844	19.65	4.50
	24	2.67 ± 0.21	2643	1.23	3.89
	48	3.32 ± 0.21	1790	0	1.18
15	6	1.25 ± 0.21	2932	37.55	5.95
	12	2.05 ± 0.21	2795	17.55	4.12
	24	2.92 ± 0.21	2505	0.83	3.34
	48	3.65 ± 0.21	1557	0	1.05
40	6	1.37 ± 0.21	2597	20.15	5.55
	12	2.93 ± 0.21	2005	1.92	2.15
	24	3.95 ± 0.21	1180	0	1.22
	48	4.10 ± 0.21	1015	0	0.55
60	6	1.45 ± 0.21	2330	19.29	5.4
	12	3.21 ± 0.21	1775	1.68	2.01
	24	4.12 ± 0.21	1247	0	1.10
	48	4.21 ± 0.21	974	0	0.49

Table 1 : Evolution of the water quality parameters



Fig. 7 Bacterial colonies formed on LB agar, inoculated with 10^4 dilution samples of activated sludge: A sample exposed to 60 mV/cm (50 Hz), B sample not exposed to ELF field.

-Under the electromagnetic field, in the biochemical processes that take place in the microorganisms' cytoplasm of the investigated biomass, significant kinetic changes occur at frequencies 49.9, 99.9, 130.8, and 150.4Hz;
 -The metabolism of microorganisms is significantly accelerated by a 40 and 60 mV/cm applied field;
 -In the sample exposed to 50Hz, 60 mV/cm field, the bacterial colonies formed are significantly higher than the control sample

Conclusions: - in the frequency range 1-500 Hz, activated sludge samples present representative frequencies at 49.9, 99.9, 130.8, and 150.4 Hz; - the evolutions of $tg\delta$ and σ show significant discontinuities (oscillation phenomena in biomass); - the evolutions of $tg\delta$ and σ recorded on sterilized biomass (by boiling or electrically, by applying a 1 V/cm field) do not present discontinuities - the values $tg\delta$, and σ are of approx. 5-6 times higher; - the metabolism of microorganisms in activated sludge are significantly increased after exposure to a 40-60 mV/cm electromagnetic field of 50 Hz.

Based on these results, it can be concluded that the efficiency of the domestic wastewater treatment plants can be considerably increased by 40-60mV/cm field at 50Hz (decreasing the duration of the aeration and microbiological treatment stages and, implicitly, the specific energy consumption).

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