The Effects of Magnetic Fields on Some Biological Activities of Pseudomonas Aeruginosa

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Abstract

Background: A magnetic field is the area of influence exerted by a magnetic force. This field is normally focused along two poles. Most magnetic objects are composed of many small fields called domains. A wide variety of methods have been reported in the literatures which are directed to the use of magnetic energy as a diagnostic technique and also for the treatment of diseases in humans and animals.

Aims: To investigate the effects of different levels of static magnetic field on the ultra-structure of *Pseudomonas aeruginosa* bacterium as well as their colony morphological changes**.**

Materials and Method: Locally prepared dipolar static magnetic field of strength 400, 800, 1200 and 1600 Gauss were used in this study measured by Teslameter. *Pseudomonas* aerug*inosa* isolated from ten urinary tract infected patients. The samples collected from Rizgary hospital in Erbil during period from January to June 2013, then identified by using API (Analytical Profile Index) 20 E test systems in Hawler Medical Research Center. Equal volumes of broth nutrient culture media of bacteria were exposed to the magnetic field for 24 hour. Furthermore, the bacterial growth subculture tested for morphological and biological activity after API 20 E test of treated *Pseudomonas* aerug*inosa* culture media compared with untreated negative control samples.

Results: Results indicated that exposure of the microorganisms to demonstrated magnetic field caused pronounced changes in biological activity of enzymes TDA(Tryptophane deaminase), GLU(Glucose fermentation/oxidation), ARA(Arabinose fermentation/oxidation) were observed on the cell growth. On the other hand, changes in morphology of the *Pseudomonas aeruginosa* colonies were observed on MacConkey agar and became smaller in size with elastic phenomena.

Conclusions*:* We concluded that the magnetic field could change bacterial biological activity on sugar fermentation and colony morphology of bacterial due to mutation.

Keywords: Magnetic field, optical density, *Pseudomonas* aerug*inosa*, mutation.

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Introduction

Pseudomonas aeruginosa is one of the most extensive and serious problems in nosocomial infection which can infect wounds, fester otitis media and cause pneumonia, cystic fibrosis, sepsis, and other diseases [1-3]. *Pseudomonas aeruginosa* infection is the main reason of septicaemia for patients who receive organ transplants [4]. The study by Van der Waaij showed that 10 to 100 cells of *Pseudomonas aeruginosa* can lead to gut colonization in patients admitted in intensive care units and immunosuppressed [5]. It is also a primary cause of morbidity and mortality in patients with cystic fibrosis (CF), and early antibiotic treatment is crucial [2, 6-9].

The power of the magnet is one of the most basic powers in nature. We know that magnetism itself was an ingredient in the primordial soup from which the universe and our planet came forth. Magnetism is the force that keeps order in the galaxy, allowing stars and planets to spin at significant velocities. And in a sense, our own planet's magnetic field is responsible for protecting all life on earth [10].

Various living microorganisms contain tiny quantities of ferromagnetic material most commonly magnetite that orient the host in the geomagnetic field [11- 13].

One can demonstrate the presence of this material within the cell by observing its response to an applied magnetic field. In the past, because its very weak magnetic moment, it was not possible to detect the magnetic field produced by the motion of a single living cell. However, the recently developed magnetic microscope based on a high-transition temperature offers unprecedented sensitivity to magnetic fields produced by nearby specimens [14-1 6]. As a result, it is now feasible to detect the various motions of a single living magnetic microorganism at room temperature and atmospheric pressure.

There are two types of magnetic field; 1st static magnetic field, and 2nd pulsed magnetic field, each one has special medical uses [17]. The development of magnetic field by German, these products have proved to be beneficial in wound healing [18].The effect of magnetic field was variable depending on the type of the microorganism and field. *Noraketal* clarify that magnetic field has significant effect on bacteria's cell as well as on its Life and they added that the effect of magnetic field enclosed in cell membrane [19].

This study aimed to investigate the effects of different levels of static magnetic field on the ultra-structure of *Pseudomonas aeruginosa* bacterium as well as their colony morphological changes**.**

Materials and methods

Sample collection: The tested organism *Pseudomonas aeruginosa* were collected from urinary tract infected patient’s samples in Rizgary hospital during period from January to June 2013 in Erbil and examined carefully. The colony morphology on MacConkey agar were noted and identified by API 20 E system.

Magnetic field preparation: Dipolar static magnetic field of strength 400, 800, 1200 and 1600 Gauss were prepared locally and measured by Teslometer in Physical Department /College of Sciences.

Five colonies taken from the culture media and suspending them into 10 ml nutrient broth, incubated at 37 ºC for 24 hour as a stock culture. 0.1 ml of stock bacterial suspension was added into five treble groups of tubes. Each one tube contains 5ml of nutrient broth. The four treble groups were subjected to magnetic field (400,

800.1200,1600 Gauss) (three tubes to each power) at 37 ºC for 24 hours and one treble tube grope sample did not subjected to magnetic field as control.

Magnetic field effects of an enzyme were investigated using API 20 E test for treated bacterial suspension growth comparing with negative control (non magnetic treated bacterial growth tubes). While MacConkey agar was depended to investigate colony morphological properties comparing between treated and non treated bacteria as control bacterial growth colony.

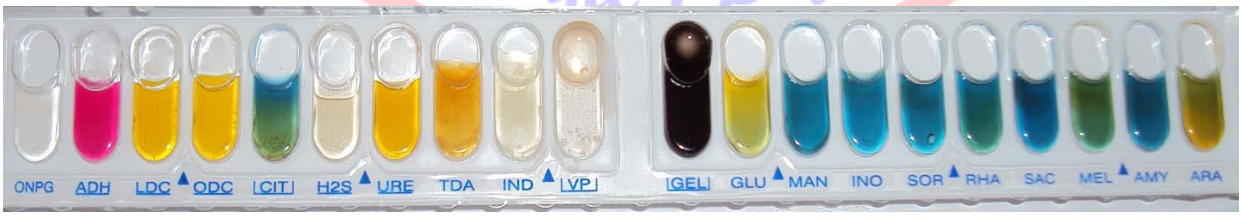
Results

Results of table (1) and figure (1) were showed the exposure of *Pseudomonas aeruginosa* culture to different forces (400, 800, 1200 and 1600 Gausses) within a period of 24 hrs comparing with non treated bacterial culture. It was appeared that magnetic treating bacterial cells can inhibit or promote enzyme activity according to API test, since critical changes in TDA, GLU, and ARA were seen.

Table (1): Result of API test for magnetic exposure *Pseudomonas aeruginosa* at 24 hours compared with control.

ONPG	ADH	LDC	ODC	CIT	H2S	URE	TDA	IND	VP	GEL	GLU	MAN	INO	SOR	RHA	SAC	MEL	AMY	ARA	24 hr.
-	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	Control
-	+	-	-	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	400
-	+	-	-	+	-	-	+	-	-	+	+	-	-	-	-	-	-	-	+	800
-	+	-	-	+	-	-	+	-	-	+	+	-	-	-	-	-	-	-	+	1200
-	+	-	-	+	-	-	+	-	-	+	+	-	-	-	-	-	-	-	+	1600

API 20 E System of *Pseudomonas aeruginosa* before exposure to magnetic field

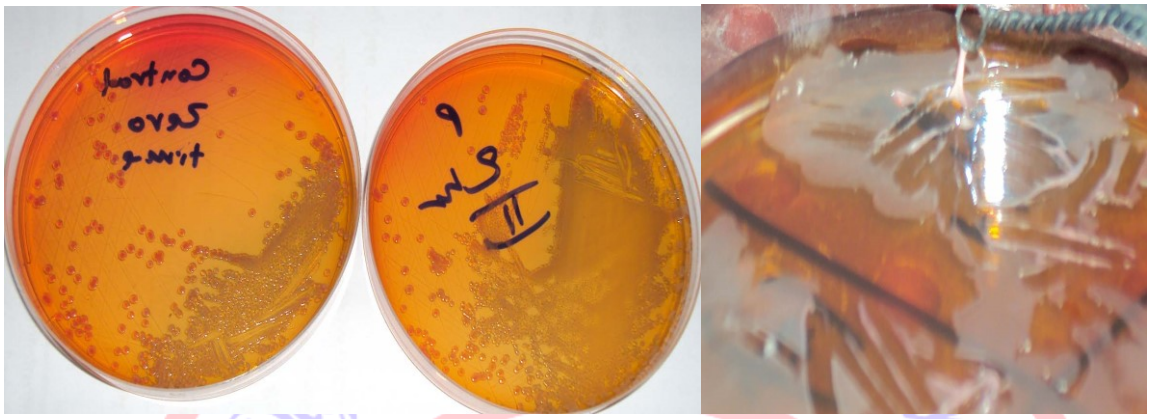


API 20 E System of *Pseudomonas aeruginosa* after exposure to magnetic field

Figure (1): API 20 E System of exposed and unexposed of *Pseudomonas aeruginosa* to magnetic field.

Figure (2A) was presented the morphological change of magnetic treated *Pseudomonas aeruginosa* colony comparing with non magnetic treated bacterial on MacConkey agar,

while the treated bacterial became smaller than untreated bacteria (negative control). Figure (2 B) was showed further changes in colony properties of *Pseudomonas aeruginosa*, where the colony became viscose when attached with laboratory loop on MacConkey agar, may due to magnetic effect on extracellular enzyme or cell membrane properties.



A- Colony morphology B- Colony viscosity

Figure (2): (A)-changes in *Pseudomonas aeruginosa* colony morphology and (B) Colony viscosity.

Discussion

The present study induced changes in the structure and the characteristic behavior of *Pseudomonas aeruginosa* resulting from the exposure to the demonstrated magnetic field. These results maybe of a great importance for evaluating the benefits as well as the hazards of the exposure to magnetic field.

The inhibitory effect of magnetic field after an exposure period of 24 hours on the bacteria growth may be due to the interaction between electric charges induced by magnetic field and that of the cytoplasm membrane resulting in partial abolishment of electric potential of the cytoplasm membrane with a subsequent decrease in the macromolecular biosynthesis. Magnetic field may also cause damage of bacterial DNA and inhibition of its replication [20- 22].

Furthermore the present data proved the cellular membrane of the microorganism had been affected by the external magnetic field, then one expects a disturbance in their metabolic activity and, consequently, a change in their cell division in a good agreement with Mohammed *et al.* [23] who reported that exposing *Salmonella typhi* to a 20 G magnetic field increased their cell division and cell number.

The magnetic fields affect the cells either of two ways. The first is through the cell wall and would include the production and expression of proteins, such as enzymes, the second is affecting the cells intracellular and retained the affect within the cell. The appropriate magnetic field is applied for a time period and an intensity which is based on the recipient of the field, the medium and the desired end result.

Cells, as well as other cells, have been found to decrease certain biological effects when exposed magnetic field. Although research has been done on the effects of magnetism in both fermentation and other biological processes, they have used bipolar, complex or rotating fields. The instant study relates to the consistent use of either a north or south magnetic field to produce a desired

result. Thus, the cell reproduction can be decreased or increased depending on the requirements [24].

It was clear from the figure (2-A) that the magnetic field affected colony morphology of the bacteria, where the colony became smaller comparing to the control bacterial colony. Our opinion reported that the static magnetic fields forces can alter fidelity of replication via a defect on DNA repair systems. The result was suggested by author for instance Lai and Singh [25] whom reported that 60Hz, 0.1–0.5mT magnetic fields inhibit DNA repair in rat cells in *vivo* Miyakoshi reported that the higher density 50Hz MF (400mT) affects DNA repair in a human cell line, and that the mutation frequency varies with induced current [6].

Additional changes (Figure (2 B)) in colony properties of Pseudomonas aeruginosa, where the colony became viscose when attached with laboratory loop, may due to magnetic effect on extracellular enzyme or cell membrane properties. This agreed with Nasher and Hussein who reported that the polarized regions of a large magnet will create highly un-physiological electrical potentials in the bacteria's environment. This potential will overcome any existing potentials in these very small cells, and they will no longer have control over the movement of ions across their membranes [27]. The flow of ions across cell membranes is coupled to many important cellular processes. Bacterial cells become very 'sick' when they lose the ability to regulate the ionic currents through protein channels. Several studies have been done on different microorganism and the effect of magnetic fields was variables due to type of the microorganism [28].

In conclusion, the magnetic field could change bacterial biological activity on sugar fermentation and colony morphology of bacterial maybe due to mutation occurred.

References

[1] Lee CS, Wetzel K, Buckley T, Wozniak D, Lee J. Rapid and sensitive detection of *Pseudomonas aeruginosa* in chlorinated water and aerosols targeting gyrB gene using real-time PCR: J Appl Microbiol.2011; 111:893-903.

[2] Cattoir V, Gilibert A, Le Glaunec JM, et al. Rapid detection of Pseudomonas aeruginosa from positive blood cultures by quantitative PCR: Ann Clin Microbiol Antimicrob. 2010; 9:21.

[3] Wang Y, Dou H, Chen K, Zhang H, Hu C. Development of a colloidal gold-based immunochromatographic test strip for the rapid, on-site detection of Pseudomonas aeruginosa in clinical samples:Scand J Infect Dis. 2011; 43:329-38.

[4] Khan AA, Cerniglia CE. Detection of Pseudomonas aeruginosa from clinical and environmental samples by amplification of the exotoxins a gene using PCR: Appl Environ Microbiol. 1994; 60:3739-45.

[5] Van der Waaij D. Colonization resistance of the digestive tract: clinical consequences and implications: J Antimicrob Chemother. 1982; 10:263-70.

[6] Deschaght P, Van Daele S, De Baets F, Vaneechoutte M. PCR and the detection of Pseudomonas aeruginosa in respiratory samples of CF patients. A literature review: J Cyst Fibros, 2011; 10: 293-7.

[7] Liu C, Zeng GM, Tang L, et al. Electrochemical detection of Pseudomonas aeruginosa 16S rRNA using a biosensor based on immobilized stem-loop structured probe: Enzyme Microb Technol. 2011; 49:266-71.

[8] Wang KY, Zeng YL, Yang XY, Li WB, Lan XP. Utility of aptamer fluorescence in situ hybridization for rapid detection of

Pseudomonas aeruginosa: Eur J Clin Microbiol Infect Dis. 2011; 30:273-8.
[9] Rao AR, Laxova A, Farrell PM, Barbieri JT. Proteomic identification of OprL as a seromarker for initial diagnosis of *Pseudomonas aeruginosa* infection of patients with cystic fibrosis: J Clin Microbiol. 2009; 47: 2483-8.
[10] Sandyk, R. Alzeimer's Disease. Improvement of visual memory and visuoconstructive performance treatment with picotesla range magnetic field: International Journal of neurosci. 1994; 76(3-4):. 185-225.
[11] Spring, S and Schleifer, K H Diversity of magnetotactic bacteria: System. Appl. Microbiol. 1995; 18:147–153.
[12] Frankel, R B Magnetic guidance of organisms. Annu: Rev. Biophys Bioeng.1984; 13:85–103.
[13] Blakemore, R P Magnetotactic bacteria. Annu: Rev. Microbiol.1982; 36:217–238.
[14] Black, R C Magnetic microscopy using a superconducting quantum interference device:Ph.D. Thesis. University of Maryland,1995.
[15] Clarke, J. Squid fundamentals. *In* NATO ASI Series, Vol. 329: SQUID Sensors: Fundamentals, Fabrication and Applications. Weinstock H, editor. Kluwer Academic Publishers, Dordrecht, *the Netherlands*, 1996; 1–62.
[16] Lee, T S, Dantsker, E and Clarke, J. High-transition temperature superconducting quantum interference device microscope: Rev Sci Instru, 1996; 67:4208–4215.
[17] Grace, R.J. Biomagnetic energy for pain relief and promotion of healing: Randa Mechanical Research and Magnacare Pty.Ltd. South Australia. 2000; 32-25.
[18] Henry, S L, Concannon, M J. and Yee, G L. The effect of magnetic field on wound healing, division plastic surgery, university of Missouri hospital: J plastic surgery, 2008; 393-399.
[19] Novak, J, Strasak, L, Fojt, L, Slaninova, I and Vetterl, V Effects of low-frequency magnetic fields on the viability of yeast *Saccharomyces cerevisiae*: Bioelectrochemistry.2007; 70(1): 115-121.
[20] Huson, K.P.The biological effects of electromagnetic fields (Bioassays): PHD, Montana-State-University, 1995.
[21] Lourencini-DA-Silva, R, F Albano, L R Lopes-DOS-Santos, J.R. Tavarea.D., I. Felzenszwalb. The effect of electromagnetic field exposure on the formation of DNA lesions: Redox Rep. 2005, 5(5), 299–301.El-Sayed A. Gaafar et al. 296
[22] Shun, H.L., C. King-Chuen. Magnetic field exposure induces DNA degradation,Biochemical and Biophysical research communications. 2001; 280, 1385–1388.
[23] Mohamed, A A, F M ALI, E A Gaafar, H R Magda. Effects of magnetic field on the biophysical, biochemical properties and biological activity of Salmonella typhi: Master thesis submitted for Biophysics department, Faculty of science, Cairo University, Egypt, 1997.
[24] G. Gaillard, D., Leyvraz, P F. Effect of biomagnetic therapy versus physiotherapy for treatment of knee osteoarthritis: a randomized controlled trial. Department of Orthopaedic Surgery (DAL), Centre Hospitalier Universitaire Vaudois, University of Lausanne, Lausanne, Switzerland. 2009; 41(13):1090-1095.
[25] Lai H, Singh N P. Acute exposure to a 60 Hz magnetic field increases DNA single and double strand breaks in rat brain cells: Bioelectromagnetics. 1997;18: 156–165.
[26] Miyakoshi J, Yamagishi N, Ohtsu S. Increase in hypoxanthine–guanine phosphoribosyl transferase gene mutations

by exposure to high-density 50 Hz magnetic fields, Mutat Res. 1996; 349 : 109-114.
[27] Nasher, S H and Hussein A A. Effect of Magnetic field on the growth of Escherichia coli and *Staphylococcus aureus*: Eng and Tech, 2008; 26(4)23-33 .
[28] Kohno, M F, Yama, Z A, Kimura, I and Wafa, M C. Effect of static magnetic field on bacteria Streptococcus mutans and *Escherichia coli*: J Am Path physiology. 2000, l7(2): 143-148.