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Ecological studies on the effect of magnetic field on water

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A B S T R A C T

In this paper, the experimental results on the effects of a magnetic field on water are reported. Purified water was circulated at a constant flow rate in a magnetic field. After this treatment, the physicochemical properties of water were changed. Water was exposed for different times to weak static magnetic field (MF) generated from a stack of magnets (B = 18 G) or from a single permanent magnet at flow conditions. Samples were collected from tap water of Faculty of Science, Zagazig University, Zagazig, Egypt, and then treated using magnetic field for 7 days and left for recovery. Hence the physical and chemical properties of water samples were measured, in addition to its trace element concentrations. The results showed that the magnetic field has a very great effect on physico-chemical parameters of water , as it decreases its concentrations in water samples. It is obvious that magnetism plays an important and safe role in solving problem of water pollution**.**

Introduction

Water, that for a long time has been considered sufficient and whose existence has been given for granted, may become a limitation factor of the economic development in the future decades. The raising pressure is currently due to the extension of pollution, the exhaustion of some underground reserves, the lowering of subsoil water level and the decline of aquatic ecosystems. The danger is due not so much to the physical exhaustion of the water, but to its pollution, phenomenon primarily caused by the antropic impact. We refer both to pollution caused by industry, agriculture, domestic activities, and to the insufficient purification of waste waters, finally released into emissaries (Iconomu and Redinciuc, 2004).

The biological technique using the magnetic field to purify water was introduced. This technique is considered as a simple simulation of what happens in nature, as when water is subjected to a magnetic field and as a result, becomes more biologically active. The phenomenon of water treatment with an applied magnetic field has been known for many years and has been reported as being effective in numerous instances (Balcavage *et al*., 1996). It was shown that magnetic fields change osmotic processes in muscles, affect the permeability of the cellular membrane, and disturb the hydration ability of tissues in animals (Kholodov, 1974).

From scientific literature, it is known that biological systems give different bio-responses to extremely low frequency magnetic field exposures at gaseous matters in addition to living organisms. Johan-Sohaili *et al*. (2004) explained that, magnetic technology is a promising treatment process that can enhance the separation of suspended particles from the sewage. Tai *et al*. (2008) observed that on subjecting water to magnetic field, it leads to modification of its properties, as it becomes more energetic and more able to flow which can be considered as a birth of new science called Magneto biology. He also pointed out that, it increases the percentage of nutrient elements like phosphorus and potassium. Magnetic wastewater treatment has been introduced to the chemical industry to remove heavy metals (Tsouris, 2001). Amiri and Dadkhah (2006) found that changes in surface tension due to magnetic treatment, can be a key point in tracing impurities in water. Meaningful changes in surface tension of a liquid sample after a day can be a good indicator for the presence of physical and chemical changes in the sample. It was observed that magnetized water helps in dissolving minerals and acids by a higher rate than unmagnetized water, in addition to dissolving oxygen and increasing the speed of chemical reactions (Moon and Chung, 2000). Florenstano *et al*. (1996) concluded that only the mineral content i.e., TDS (Total Dissolved Solids) that builds up after water is contacted with magnetic fields. Among different physical and chemical methods of water and wastewater treatments; magnetic methods attract a special attention due to their ecological purity, safety, simplicity and less operating costs. Alteration of physical and chemical properties of water-dispersed systems in the mode of magnetic treatment implies a certain influence of magnetic field on the structure of water and aqueous solutions. Previous researches made by several scientific societies has discovered that magnetic field can improve technological characteristics of the water, i.e. better salt solubility, kinetic changes in salt crystallization and accelerated colloidal coagulation. Magnetic field is known to create the asymmetry of hydrated shells due to its effect on water molecules situated around the charged particles (colloid). Exposure to magnetic field would lead to higher electro-kinetic movement among the colloid. This will definitely increase the probability of attracting particles to cloak with one another. The theory of magnetic field impact on technological processes for water treatment falls into two main categories, crystallization at magnetic water preparation and impurity coagulation in water systems (Fadil *et al*., 2001).

Therefore, our aim in this study is to improve physical, chemical properties of water by subjecting samples to magnetic fields as a new, safe biological method for man and environment.

Materials and Methods

Sampling sites

Samples were collected from a tape water of Faculty of Science, Zagazig University, Egypt.

Analytical procedures

Water samples were taken from the site where some of the samples were subjected to magnetic field (magnetic liquid modifier L.L.C.) for one and seven days as and then left for recovery without magnetic apparatus for seven days. All the samples were analyzed for water quality (chemical and physical characteristics of water). Trace elements; zinc (Zn), Copper (Cu), cobalt (Co) and Aluminium (Al) were also analyzed.

Water analysis

Physico-chemical analysis of water

Water samples were taken, then placed in a clean sampling glass bottle, according to Boyd (1990).

Temperature: Temperature of water samples was measured using a mercury thermometer of 0 to 50˚C range (Gupta, 2000).

Conductivity: Conductivity was measured according to Gupta (2000) by conductivity meter HI 98302 DIST 2.

Refractive index: It can be determined by Aby refractometer No. 5004.J2.

pH-value: pH was measured by using glass electrode pH-meter (Digital Mini-pH-Meter model 55) (Khater, 2011).

Dissolved oxygen (O_2): It can be determined according to Ibraheim and Khater (2013).

Carbon dioxide (CO2): CO2 can be determined according to Gupta (2000).

Total dissolved solids: Total dissolved solids can be determined according to Ibraheim and Khater (2013).

Chlorinity: It can be measured by using digital chlorimeter (model HI 93711) (Khater, 2011).

Salinity: It can be measured by using digital salinometer (model Atago Hand Refractometer) (Khater, 2011).

Alkalinity: Alkalinity can be determined according to Khater (2014).

Trace elements in water

Twelve water samples were collected from a tape water for trace element analysis, half of which were exposed to the magnetic field, and the others, three samples after recovery and three sample as control, put in cleaned bottles and stored until analysis was carried out. Trace element concentrations were determined by atomic absorption spectrophotometer (Perkin Elmer, 2280). The samples were prepared and analyzed in sequential for zinc, Copper, Cobalt and aluminium according to APHA (1985).

Trace element concentration ppm = reading of A.A. X volume of diluted solution / Volume of water sample.

Statistical analysis

The statistical analysis was performed using the analysis of variance (ANOVA) to determine the differences between treatments mean at significant level of 0.05. Standard deviations were also estimated. All statistics were run on the computer using SPSS program. All graphics and tables were made by using Origin 8 and Microsoft word (2007). The methods used for analysis of the results were done according to Bishop (1980) and McCreadie *et al*. (2006).

Results and Discussion

Water analysis

Physico-chemical analysis of water

Comparing the average means of the same physicochemical parameters of water samples in the different pre and post-exposed levels, the data recorded in table (1) and [fig]. (2-11) showed a remarkable decrease in it except for temperature, chlorinity, salinity and total dissolved solids.

Trace elements in water

Comparing the average concentrations trace elements in the different exposure levels, the data recorded in table (2) and fig. (12) showed remarkable variations in trace element concentrations in water samples. The concentrations had the order: Al > Zn > Cu> Co.

Low frequency magnetic fields are widely applied in electrical appliances and different equipment such as television sets, computers and kitchen appliances. Recently, low frequency magnetic field has been considered to be a therapeutic agent and it has started to be more and more commonly used in medicine. In recent years a large number of multidisciplinary investigations led to the increasing awareness of the existence of multiple effects in biological systems. The responds of acute cardiovascular system to magnetic field is still being analyzed. Several experimental and biological studies have dealt especially with increased incidence of various types of cancer (Ibraheim and Khater, 2013).

The results presented in this work concerned with the induced changes in the physicochemical parameters of water resulting from its exposure to magnetic fields are of biophysical and medical importance and interest. This data when piled together can lead to important conclusions which may be of great importance for evaluating the benefits from the exposures to low frequency low level magnetic fields. The data of the physicochemical parameters of water samples as given in tables: (1-2), it's clear that there are decreasing in the values of conductivity, refractive index, dissolved oxygen, carbon dioxide and alkalinity for the exposed water samples relative to the unexposed one. The amplitude and the frequency of these impulses depend on the amount and frequency of bending. Water pollution is due to the change in physical, chemical and biological properties which is either directly or indirectly caused by human activity and their derivatives. It is thought that modifications to the properties of solutions through the magnetic field changes in the molecular structure of liquids, polarization, resulted from arrangement of particles and finally from changes of the electric potential (Lebkowska, 1991; Szczypiorkowski and Nowak 1995 and Krzemieniewski *et al*., 2002).

Temperature

Water temperature is one of the most influential environmental factors affecting both the metabolism and growth of living organisms and their body composition (Herzing and Winkler, 1986). In this study, there is no change in values of water temperature in the various examined levels due to the magnetic exposure and this range of water temperature was favorable for all living organisms according to results obtained by Owei and Ologhadien (2009); Rahim *et al*. (2009); Sithik *et al*. (2009).

Conductivity

In the present study, the conductivity at all the examined levels decreased and this agreed with Alkhazan and Sadddiq (2010) who stated that it decreased after the magnetic exposure for 30 days**.**

pH-value

In the present study, the pH values at all the examined levels were always at the neutral side and there was an effect of the magnetic field on it. It is disagreed with that of Alkhazan and Sadddiq (2010) who stated that the pH- value increased with magnetic field and agreed with Shatalov (2009) who observed a decrease in pH values with magnetic exposure. The data obtained in this study indicate that the pH values at all the study levels lies within the favorable limits (6.2-8.3) needed for the growth and survival of living organisms and comply with results of Korai *et al.* (2008) and Pandey and Tiwari (2009).

Dissolved oxygen (DO)

The decrease in O_2 after the magnetic exposure in the study is agreed with that of Shatalov (2009). From the obtained data, it is clear that DO content at all examined levels lied below the limit (>5 mg/l) that satisfy the needs of successful production of the living organisms as reported by ANZECC (2000); Ayoola and Kuton (2009); Pandey *et al*. (2009) and Sithik *et al*. (2009). This is due to the type of water (tap water).

Carbon dioxide (CO2)

The decrease in CO2 after the magnetic exposure in the study is agreed with that of Shatalov (2009) and Alkhazan and Sadddiq (2010). From the obtained data, it is clear that CO2 content at all study levels lied below the limit (>5 mg/l) that satisfy the needs of successful production of the living organisms as reported by ANZECC (2000); Ayoola and Kuton (2009); Pandey *et al*. (2009) and Sithik *et al*. (2009), and this is due to tap water (type of water).

Salinity & Total dissolved solids (TDS)

From the present data, it is clear that the salinity and TDS contents were not changed in the study levels and this disagreed with Ni´ am *et al*. (2006) and Alkhazan and Sadddiq (2010), and may be related to the short period of the magnetic exposure and weak intensity of the magnetic field. Although, the range of salinity in the study(<3 mg/l) was suitable for survival of the living organisms and man.

Alkalinity

From the data reported in this study, it is clear that the values of alkalinity decreased after the exposure to the magnetic field and this agreed with Ni´am *et al*. (2006). The range of alkalinity (20 mg/l) was not recommended, as mentioned by ANZECC (2000); Ayoola and Kuton (2009); Sithik *et al*. (2009).

Heavy metals in water

Zinc (Zn)

The mean concentrations of Zn in this study were below the legal limits (3 mg/l) recommended by WHO (2008) at all the study sites. These results are nearly similar to those obtained by İncekara (2009); Miclean *et al*. (2009) and Khater (2011), whereas they are lesser than those reported by Obasohan (2007); Frankowski *et al*. (2009). Moreover, the mean concentrations of Zn decreased after the exposure to the magnetic field.

Copper (Cu)

The present study shows that the mean Cu concentrations were under the permissible levels (2.0 mg/l) recommended by WHO (2008) at all the study levels. A comparison of the results indicated that Cu levels were within the range of Cu levels recorded by Frankowski *et al*. (2009); Miclean *et al*. (2009), but higher than those recorded by Akoto and Adiyiah (2007); İncekara (2009).

Table.1 The physico-chemical parameters (mean ± SD) of water samples before and after the exposure to the magnetic field

Magnetic field / Parameters	Pre-exposure	One day post-exposure	Seven days post-exposure	Recovery
Temperature (□C)	25± 0	25±0	25±0	25±0
Conductivity (ppm)	0.210 ± 0a	0.210 ± 0b	0.190 ± 0ab	0.198 ± 0.004ab
Refractive index	1.333 ± 0	1.332 ± 0	1.332 ± 0	1.332 ± 0
pH value	7.150 ± 0	7.150 ± 0	7.050 ± 0	7.050 ± 0
Salinity (‰)	29 ± 0	29 ± 0	29 ± 0	29 ± 0
Chlorinity (‰)	16.100 ± 0	16.100 ± 0	16.100 ± 0	16.100 ± 0
Total dissolved solids (ppt)	0.200 ± 0	0.200 ± 0	0.200 ± 0	0.200 ± 0
Dissolved oxygen (ppm)	0.450 ± 0.071a	0.450 ± 0.071b	0.150 ± 0.071abc	0.450 ± 0.071c
Carbon dioxide (ppm)	10.50 ± 0.707ab	10.50 ± 0.707cd	4.50 ± 0.707ac	4.50 ± 0.707bd
Akalinity (ppm)	138.50 ± 2.121abc	126.50 ± 0.707a	124.00 ± 1.414b	124.00 ± 1.414c

* Data are represented as mean ± SD, (n = 12).

** Means with the same letters in the same row are significantly different ($p<0.05$), using ANOVA.

Table.2 The trace element concentrations (Mean ± SD) of water samples before and after the exposure to the magnetic field

Magnetic field / Parameters	Pre-exposure	One day post-exposure	Two days post-exposure	Seven days post-exposure
Zinc (Zn) ppm	0.051±3.111E-4a	0.020± 0.002a	0.009±0.006a	0.029±0.003a
Copper (Cu) ppm	0.007±0.002a	0.004± 7.778E-4	0.002± 3.111E-4a	0.004± 6.223E-4
Cobalt (Co) ppm	0.006± 0.001ab	9.350E-4 ± 8.556E-4a	4.400E-4 ± 6.223E-4b	0.003± 0.001b
Aluminium (Al) ppm	0.082± 0.020abc	0.017±0.008a	0.017±0.002b	0.042±0.009c

* Data are represented as mean ± SD, (n = 12).

**Means with the same letters in the same row are significantly different ($p<0.05$), using ANOVA

Fig.1 The magnetic apparatus on the water aquarium

Fig.2 The temperature (Mean ± SD) of water samples before and after the magnetic exposure

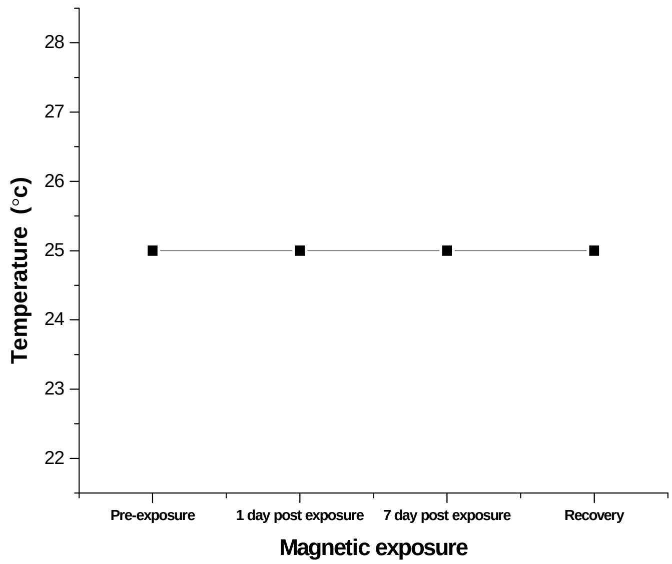


Fig.3 The conductivity (Mean ± SD) of water samples before and after the magnetic exposure

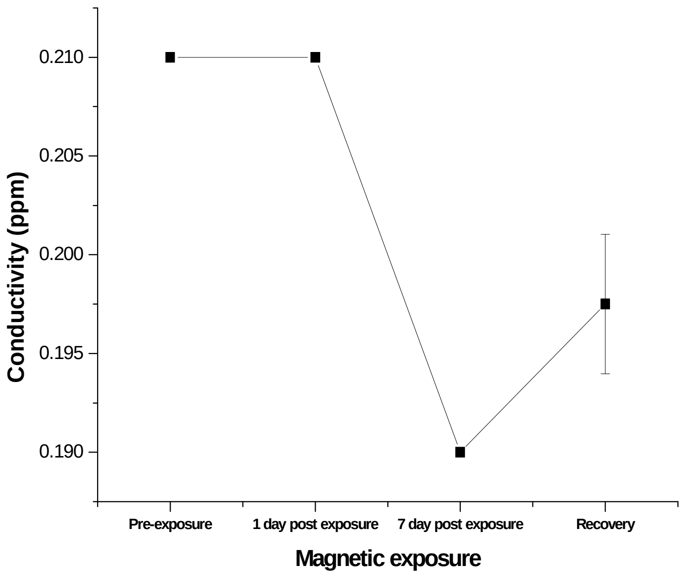


Fig.4 The refractive index (Mean ± SD) of water samples before and after the magnetic exposure

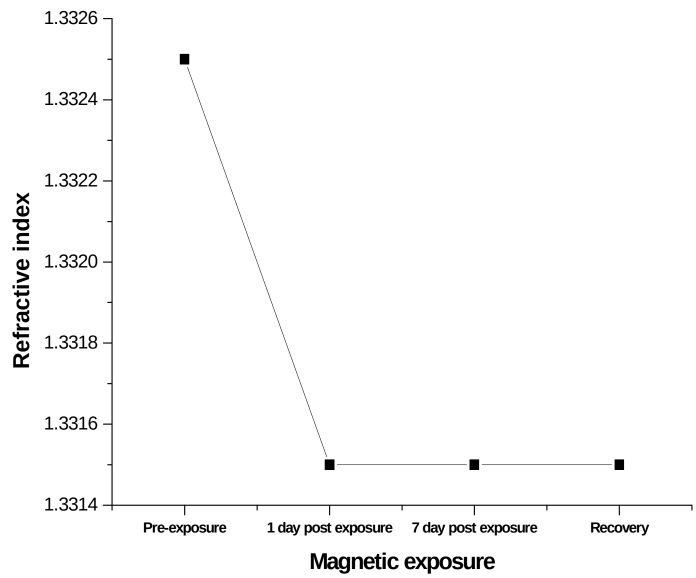


Fig.5 The pH-value (Mean ± SD) of water samples before and after the magnetic exposure

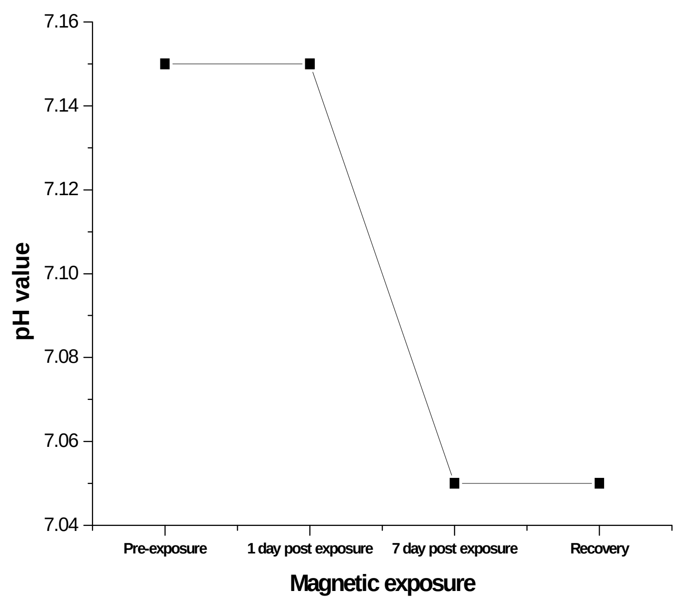


Fig.6 The oxygen content (Mean ± SD) of water samples before and after the magnetic exposure

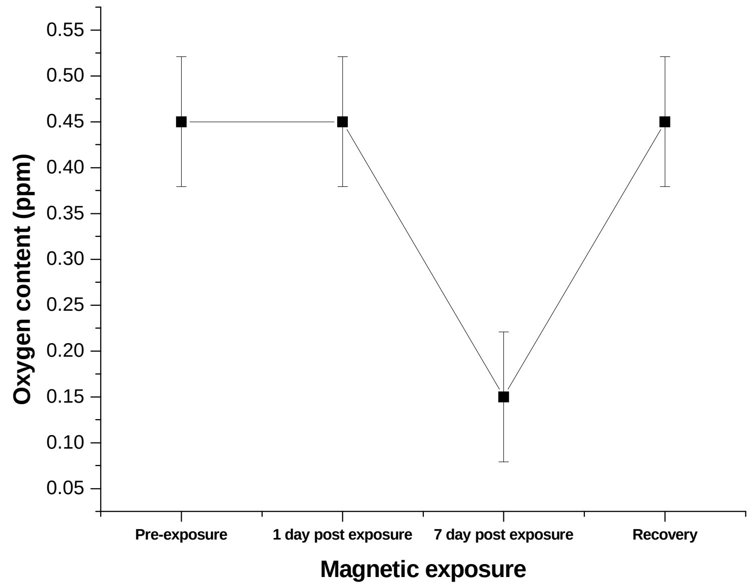


Fig.7 The carbon dioxide content (Mean ± SD) of water samples before and after the magnetic exposure

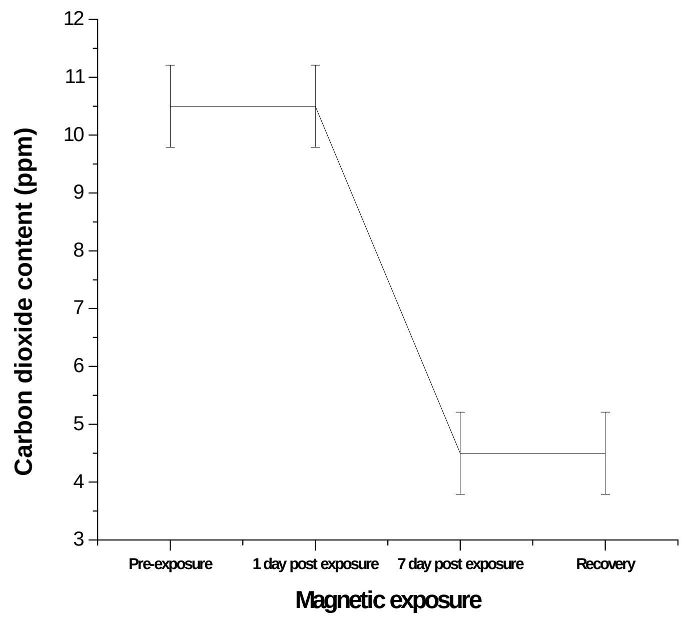


Fig.8 The chlorinity (Mean ± SD) of water samples before and after the magnetic exposure

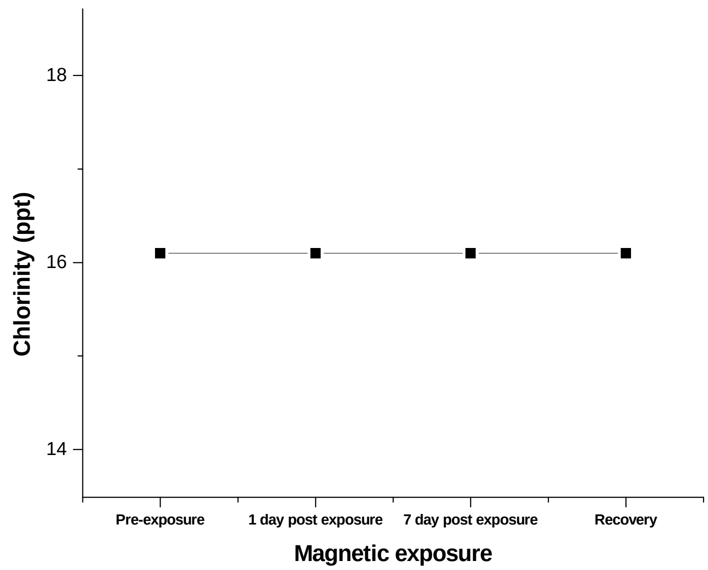


Fig.9 The salinity (Mean ± SD) of water samples before and after the magnetic exposure

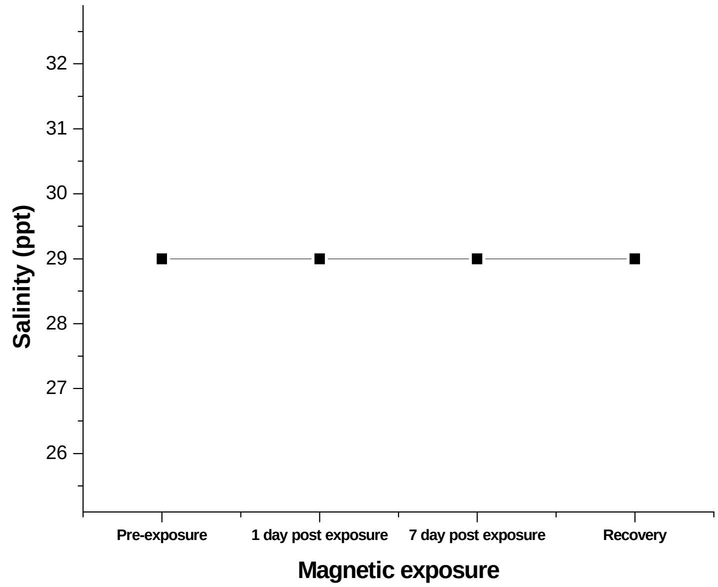


Fig.10 The total dissolved solids (Mean ± SD) of water samples before and after the magnetic exposure

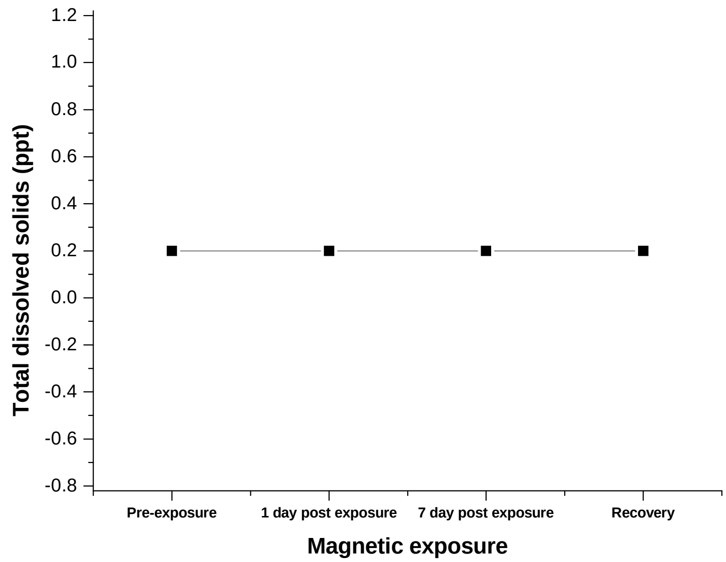


Fig.11 The alkalinity (Mean ± SD) of water samples before and after the magnetic exposure

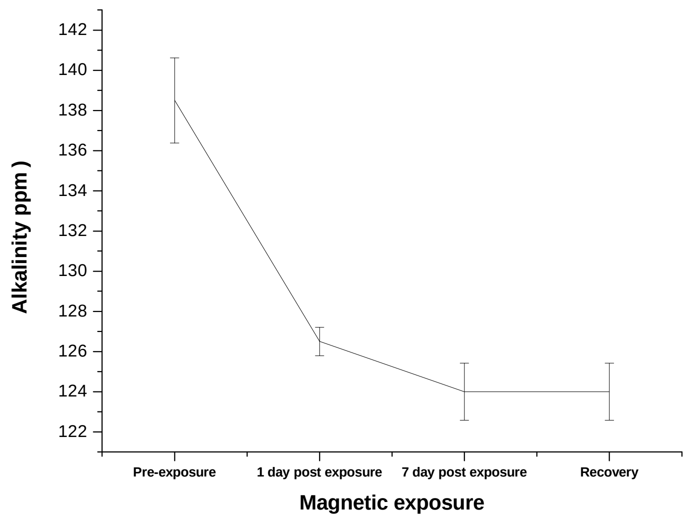
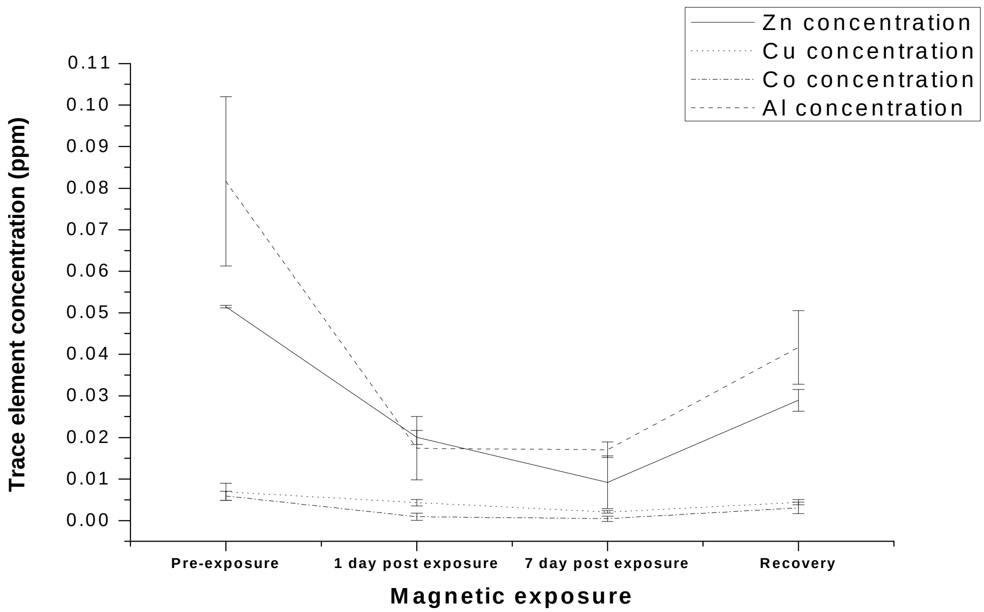


Fig.12 The trace element concentrations (Mean ± SD) in water samples before and after the exposure to the magnetic field



Cobalt (Co)

The mean Co concentrations in this study were higher than the permissible levels (0.0014 mg/l) recommended by ANZGFWQ (2000a) at all the study samples. Comparative Co levels were recorded by Abdul Ghaffar *et al*. (2009), El-Sayed *et al*. (2011) and Khater (2014). Also, as in Zn and Cu, the magnetic exposure decreased the mean concentrations of Co.

Aluminium (Al)

In this study the mean Al concentrations were lower than the permissible levels (0.2 mg/l) recommended by WHO (2008) at all the study levels. The concentrations of Al in the present study were lesser than those recorded by Awofolu (2006); and Abdul Ghaffar *et al*. (2009).

Moreover, the concentrations of all trace elements were decreased in all water samples after the exposure to the magnetic field for seven days, and this may be attributed to the direct effect of the magnetic field on chemical characteristics of water and attraction of macromolecules. It is agreed with those of Kholodov (1974) and Alkhazan and Sadddiq (2010). Also, The decrease can be explained thus, that magnetic force breaks hydrogen bonds between water molecules, so the ions become separated and combine with elements and precipitate Alkhazan and Sadddiq (2010). In addition, Chang and Weng (2008) showed that the enhanced mobility of the ions under a magnetic field, causes serious damage to the hydrogen bond network in the high Na concentration solution. Conversely, in the low concentration solution, the structural behavior is dominated by the properties of the water molecules and hence the hydrogen bonding ability is enhanced, as the magnetic field is increased.

Conclusion

The results of this study concluded that the effects of exposure to extremely low frequency magnetic field depends on the magnetic field intensity, frequency and the period of exposure, and the interference of the applied magnetic field with the water used. Also, the biological treatment of water using magnetic force has a vital role in treating the polluted water. This is one of the interesting findings in this field of research. This encourages more research in this field. Using magnetism to overcome negative effects of water pollution is considered a potential technology. It should be adapted to suit environmental and climatic conditions so that its use can be maximized.

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