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Increased electron density and dissolved oxygen level in water through magnetic effect

Hwang Sheng Lee[1], Augustine Chung Wei Yap[1], Cho Cheng Ng[1], Nuruol Syuhadaa Mohd[2] and Joo Ling Loo[3]

1 Department of Mechanical and Material Engineering, Lee Kong Chian Faculty of Engineering & Science, Universiti Tunku Abdul Rahman (UTAR), Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor, Malaysia
2 Department of Civil Engineering, Faculty of Engineering, University of Malaya, Lembah Pantai, 50603 Kuala Lumpur, Malaysia
3 Department of Mechatronics and BioMedical Engineering, Lee Kong Chian Faculty of Engineering & Science, Universiti Tunku Abdul Rahman (UTAR), Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor, Malaysia

E-mail: leehs@utar.edu.my

Abstract. Water is essential in nature for the survival of all life with significant environmental and economic contribution to the world. The gradual increases in water demand and consumption have led to the discharge of inadequately treated wastewater, thereby, deteriorating water quality and triggering worldwide water quality problem. Water quality is determined by different parameters. In particular, electron density and dissolved oxygen (DO) level in water are important in monitoring and controlling the water property and quality, since both of them are associated with various chemical, biological, and physical processes in water treatment. This project developed a method to increase electron density and dissolved oxygen level in water using principle of reversed electric motor. The essential requirements to achieve this principle are magnetic field, mechanical motion by force, and electron generation. The treated water's pH, conductivity, and dissolved oxygen level showed increment of 0.40, 0.05 μS/cm, and 2.7 % saturation (0.22 mg/L), respectively whereas its oxidation-reduction potential (ORP) showed a decrement of 94 mV, indicating the increment of electron density and dissolved oxygen level in the magnetic treated water. The enhancements of these parameters are highly desirable in the applications of medical treatment, wastewater treatment, agriculture, and aquaculture industries.

1. Introduction

Water is one of Earth's most abundant natural resources as it comprises 70% of Earth's surface. It is the basic necessity for survival of all life with significant environmental and economic contribution. For examples, water is highly used in daily domestic consumption, agriculture, industries and energy production [1]. Furthermore, current global demand for water (4600 km^3 per year) would increase by 20-30% to approximately 5500-6000 km^3 per year by 2050 due to exponential global population rise [1]. As a result of the increasing demand and consumption of water, water quality begins to deteriorate and this creates severe water quality problems on a global scale. Therefore, water quality surveillance has been an important consideration in securing the clean water resource.

Water quality is determined by many parameters, depending on specific applications. Electron density and dissolved oxygen level in water are important in the surveillance and monitoring of water quality

since they are associated with various chemical, biological, and physical processes in water treatment. Electron density in water plays fundamental role in many electron-driven processes and radical chemistry which induce significant effects in treatment of water and wastewater, radiolysis of water, remediation of wastes through photocatalytic process, denaturation of DNA, diagnosis and treatment of diseases [2-3]. In addition, electron density can also serve as an indicator of antioxidant property in water. Water containing electron with negative ORP is claimed able to combat oxidative stress due to free radicals at the cellular level by supplying more electron to the damaged cells [4-5]. However, the reaction mechanisms of radicals and ions created by electron in the water treatment system remain a challenge among research communities.

On the other hand, dissolved oxygen plays a vital role in water quality index. It can indicate the degree of water pollution by estimating the amount of organic matters and microorganisms in aquatic system through the indicators of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) [6]. Many wastewater treatments involve microbial metabolic processes which require high dissolved oxygen level for enhancement of the biochemical reactions. Therefore, improved dissolved oxygen level in water is deemed important not only for wastewater treatment [6] that will enhance its treatment efficiency, operation cost and process stability, but also for agriculture [7-8] and aquaculture [9] in improving the breeding of farm animals, as well as stimulating the growth of plants and aquatic life.

Recent studies have reported the generation of electron in water through photoexcitation of plasmonic nanoelectrodes [10] and exposure to light or ionizing radiation [11-12]. In terms of improving the dissolved oxygen level in water, several conventional methods have been applied in industries to produce or supply oxygen in water through electrolysis, air diffusion, and mechanical aerators. Previous studies also reported that magnetic field was able to alter and enhance water parameters such as pH, conductivity, and dissolved oxygen [7-9, 13-14]. In this project, we developed a natural method to increase electron density and dissolved oxygen level in water using principle of reserved electric motor. The essential requirements to achieve this principle are magnetic field, mechanical motion by force, and electron generation. The principle of reversed electric motor states that when magnetic flux is disrupted by a mechanical force, current shall be induced. Hence, electron shall also be created and captured in the water stream. This can further lead to the increment of water's pH and the dissociation of hydroxyl ions for producing oxygen in water stream.

2. Methodology

2.1. Preparation of magnetic treated water
Water sample was obtained by distillation process from distiller system (Favourit W4L Water Stills). The magnetic treatment system comprised a series of magnets with magnetic field strength of 1000-1500 Gauss. Water stream was flowed through the magnets using a peristaltic pump (Masterflex L/S Economy Pump System with Easy-Load 7518-00 Pump Head) at flow rate of 1.0 ml/s.

2.2. Measurement of water parameters for magnetic treated water
The water parameters such as pH, oxidation-reduction potential (ORP), conductivity, and dissolved oxygen (DO) were measured before and after flowing through magnetic field. pH was measured using Ohaus Starter 3100 pH Bench meter equipped with STPURE electrode. ORP and conductivity were measured using Hanna Instruments HI 2550 Multiparameter pH/ORP and EC/TDS/Salinity Benchtop Meter equipped with ORP and EC electrodes, respectively. Lastly, dissolved oxygen was measured using Eutech DO 2700 meter equipped with EC620SSP BOD amperometric probe. In order to validate the effect of magnetic treatment on the flowing water, a control test was conducted by flowing the water under the same condition without magnetic effect.

3. Results and discussion
Table 1 shows the results of pH, ORP, electrical conductivity and dissolved oxygen for water after flowing through magnetic effect and without magnetic effect (control). The percentage changes were calculated based on equation (1) to indicate the increasing or decreasing trend of the measured parameters.

$$\text{Percentage change} = \frac{V_a - V_b}{V_b} \times 100\%$$

(1)

where V_a = value after magnetic treatment; V_b = value before magnetic treatment.

Table 1. Results of pH, ORP, conductivity and dissolved oxygen for water flowing through magnetic effect and without magnetic effect.

	Control	After magnetic treatment	Δ value (control)	Δ value (magnetic treated)	Percentage change (control)	Percentage change (magnetic treated)
pH	5.21	5.54	0.07	0.40	1.36	7.78
ORP (mV)	440	367	-21	-94	-4.56	-20.39
Conductivity (μS/cm)	1.56	1.60	0.01	0.05	0.65	3.23
DO (mg/L)	6.88	6.90	0.20	0.22	2.99	3.29
DO (% Saturation)	83.3	83.5	2.5	2.7	3.09	3.34

The comparisons of pH, ORP, conductivity and dissolved oxygen level for the control water and water flowing through magnetic effect are depicted in bar chart (Figure 1).
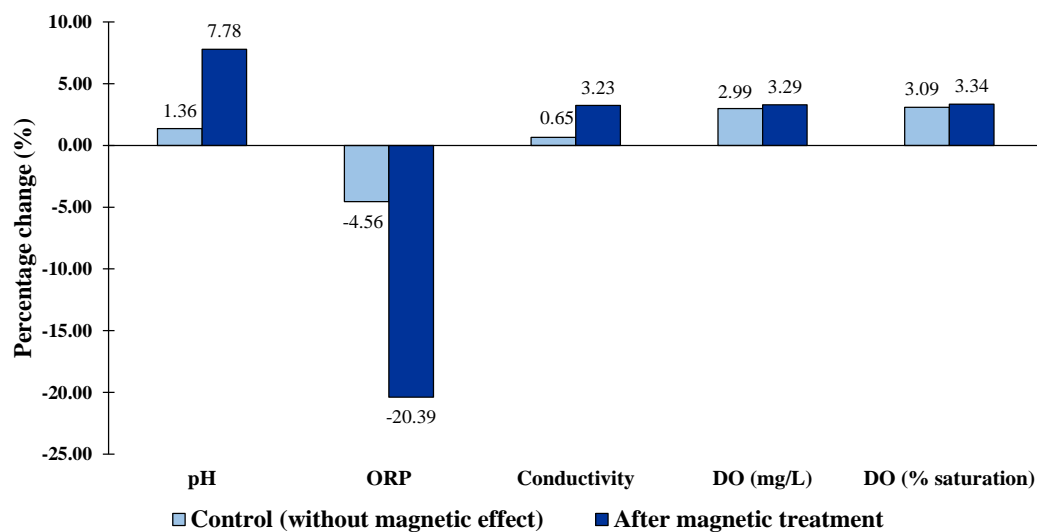

Figure 1. Comparisons of pH, ORP, conductivity and dissolved oxygen level for control water and water flowing through magnetic effect.

The results show that the pH, conductivity, and dissolved oxygen level of water are increased while ORP is decreased via magnetic effect. Most significantly, the ORP of water decreases by 20.39% (-94 mV) after subjected to magnetic effect, suggesting that the electron density in water stream is increased. ORP measures the water's potential to either donate or receive electron, indicating the availability of free electron and the oxidizing or reducing tendency of water [15]. The antioxidant property of water can then be estimated by measuring ORP [16]. When ORP of water decreases or becomes more negative, this implies that the water is a reductant and it contains excess electron. Further validation through conductivity measurement shows that the conductivity of water also increases by 3.23% (Figure 1). Since distilled water is a poor conductor that presumably does not have any impurities besides H^+ and OH^- ions, the rise in water conductivity could be highly due to the presence of electron in water. The phenomenon of free electron generation was also demonstrated by

Mohri et al. (2001) [17]. The resistivity of highly purified water, which is the reciprocal of electrical conductivity decreased due to increase in free electron after treated with a milli-gauss low frequency pulsed magnetic field [17-18].

The generation of electron in water can be explained using principle of reversed electric motor [13]. When the magnetic flux was disrupted by a mechanical motion of water, electron can be generated due to an induced current. In equilibrium condition, water molecules tend to dissociate based on equation (2), forming hydrogen cation (H^+) and hydroxyl anion (OH^-).

$$H_2O \leftrightharpoons H^+ + OH^- \tag{2}$$

Once electron is generated, the electron would have an affinity towards the H^+ cation forming metastable or weak bonding with H^+ cation due to the electron negatively-charged nature. This results in the increment of OH^- concentration and causes the pH of water increases. As a result, the equilibrium condition as shown in equation (2) is disturbed and based on Le Chatelier's principle, excess OH^- anions would further dissociate into H_2O, O_2 and electron as shown in equation (3), leading to the production of oxygen in the water stream. This was observed with the increment of dissolved oxygen level in water stream after the magnetic effect.

$$4OH^- \leftrightharpoons 2H_2O + O_2 + 4e^- \tag{3}$$

The increment of pH, electron density and dissolved oxygen level in water is highly dependent on the type of water sources and the contaminants or ionic concentration in the water. The results can postulate that higher the increment of pH in water, more electron will be captured and this can lead to more oxygen to be produced in the water.

4. Conclusions

The principle of reversed electric motor has been applied to increase electron density and dissolved oxygen level in water. Results showed that the ORP of water decreases, whereas the conductivity, dissolved oxygen level, and pH of water are increased after flowing through magnetic effect. The increased dissolved oxygen level and electron density of water is interrelated with the increased pH of water. These findings can pave the way for improving water quality and property, especially in enhancing dissolved oxygen level and electron density of water for applications in wastewater treatment, agriculture and aquaculture industries as well as medical treatment.

5. References

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