

Disinfection, BOD and COD Reduction via Magnetic Water Treatment

Abstract

Hydrogen peroxide H_2O_2 of low concentration has been produced in water upon water subjected to physical treatment – magnetic field, as reported by many scientists and researchers. Since H_2O_2 is a strong disinfectant and oxidizing agent, the question on biological effect remains as to whether the quantity of H_2O_2 is sufficient to support practical usages on disinfection and organic reduction aspects. Hence the purpose of this report aims at investigating the possibility of utilizing this long-term biological effect to demonstrate on parameters - disinfection and organic oxidation with result-oriented approach. Subsequent results on raw sewage with magnetic treatment indicate a significant disinfection effect on bacteria removal and some effect on organic reduction either in single-pass or circulation modes. The dissolution rate of oxygen is increased significantly with DO content up to 1.9 times that w/o magnet at aeration. Also, the retention time of “magnetic memory of water” has shown to last for 2 hours, at least. Moreover biological effects can further be enhanced with more magnetic devices, more circulation time and aeration in producing the dominant H_2O_2 to cope with the need.

Over the years, many researches and studies have reported the influence of intensive magnetic field and the subsequent changes in the physic-chemical properties of water. Most of the academic studies and hypothesis were attributed to lime scale removal. But a much more important physical effect of Magnetic Water Treatment (MWT) which seems to be disregarded is its biological effects on disinfection and organic reduction. In the report on biological effects of MWT, explanations and hypotheses, phenomena on the results have been referred to studies on scale crystallization.

1. Crystallization

Numerous researchers investigated the feasibility of using permanent magnets in reducing mineral fouling in heat exchanger and reported that the magnetic treatment produced softer scale clinging to surface. The anti-scale effect resulted from changes in crystallization formation promoting bulk solution precipitation rather than the formation of adherent scale (1-3).

The world-wide hypotheses used by most scientists to explain the puzzling phenomena of magnetic effects are ionic, colloidal, and structural. [2]

Recent research has reported that crystallization of carbonates in water was blocked due to initiation of magnetically activation of the colloidal silica, which precipitates from the solution as less adherent scale (aragonite) rather than hard scale (Calcite) [3].

Recently another report has shown that the presence of dissolved oxygen has played the dominant role in initiating magnetic effects and water memory [4]

1.1/ Magnetic memory of water

Many researchers showed that water subjected to physical treatment and dilution upon the properties of water demonstrates long-term biological effects [5-8] Physical treatment - static magnetic field has activated silica and dissolved oxygen (DO) in the process of water memory and called “magnetic memory of water”. In activating DO, the magnetic effect induced hydrogen

bond breakage which may produce reactive oxygen species (singlet oxygen, $^1\text{O}_2$, and hydroxyl radical, $\text{OH}\cdot$) and low concentration of hydrogen peroxide H_2O_2 . Product H_2O_2 in the process has reported to last from hours to days (5-8). " H_2O_2 concentration continued to grow in water containing dissolved oxygen for some time after the completion of any treatment, as if it 'remembered' it" (cited after [7])

2. Biological Effects

Apart from magnetic effect on lime-scale, magnetized water also has many biological effects in treating contaminated water and wastewater to eliminate heavy metals, nutrition and other pollution. The biological

effects of strongly magnetized water inhibit the growth of yeast cultures, but weakly magnetized water stimulates it

[9]. Elimination of organic nitrogen compounds is more effective for activated sludge with magnets [10]. On removal of suspended particles, experiments indicate that Magnetic effect will be increased upon prolonged exposure time of treated water in magnetic field [11]. Magnetized water increases the dissolution rate of oxygen [8]

Since magnetized water containing DO produces low concentration of H_2O_2 which is a strong disinfectant and oxidizing agent. The question of biological effect remains as to whether the quantity of H_2O_2 is sufficient in practical usage on disinfection and organic reduction. These effects are to be examined at Performance Tests.

2.1 Performance Tests

Test 1. Disinfection – Removal of Bacteria E. Coli (Circulation)

[Performance Tests held by: SGS Laboratory]

Scope of Works

A circulation tests through Magnetic Water Activator were conducted to examine the E. Coli Removal Performance.

Apparatus and Methodology

Item	Description
1. Magnetic Water Activator (MWA)	Permanent Magnet plumbed inside S.S. casing Magnetic flux : 0.6T
2. Container	Air sealed plastic box, Water volume : 10L
3. Submersible pump	Flow rate : 20L/min

A tank of known concentration of bacterial solution (as E. Coli : 14,000cfu/mL) was prepared as reservoir with a water pump connected to the product sample at ambient water temperature. After several seconds running of water, water samples from both inlet (i.e. 0s) and outlet (i.e. 30s, 5 mins & 15 mins) of the Magnetic Water Treatment System. Water samples were collected for E. Coli analysis according to AOAC's method. (AOAC Association of Analytical Communities)

Results on E. Coli Removal Performance is shown at [Chart 1](#) below.



System setup

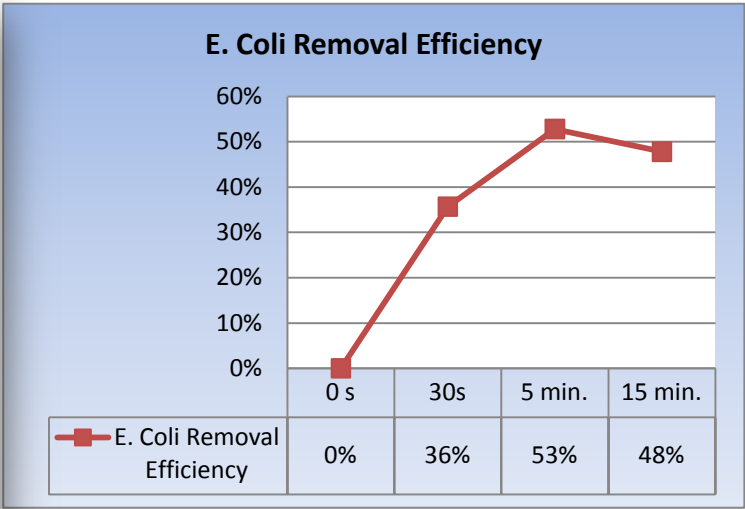


Chart 1. Result on Bacterial E. Coli Removal Efficiency

Test 2. Disinfection and Organic Reduction (Single-pass and circulation)

[Tests conducted by: THE HONG KONG POLYTECHNIC UNIVERSITY, Department of Civil and Structural Engineering].

Scope of Works

The tests were performed by pumping raw sewage (w/o precipitation treatment) through Magnetic Water Activator (MWA). The system was operated in either single- pass mode or circulation mode, and samples were collected at designated time. Results of MWA's performance such as disinfection and organic reduction for raw sewage are determined.

Apparatus and Methodology

Item	Description
1. Magnetic Water Activator (MWA)	Permanent Magnets fabricated outside a S.S. tube of dia.16mm, total length : 200mm Magnetic flux : 0.6T measured inside tube
2. Test Methods	TBC - APHA 9215C; BOD₅ - APHA 5210B; COD - APHA 5220B DO – APHA 4500-0

Two MWAs were linked in series as one treatment system. For single- pass mode, four samples (Raw, 0H, 1H, and 2H) were collected from inlet (i.e. Raw), outlet (i.e. 0H) or collection tank (i.e. 1H, 2H) for further analysis. The

apparatus was shown in the Figure below: the pump on the right was used to circulate the raw sewage at a flow rate of 400 mL/min for mixing purpose, while the left one was used

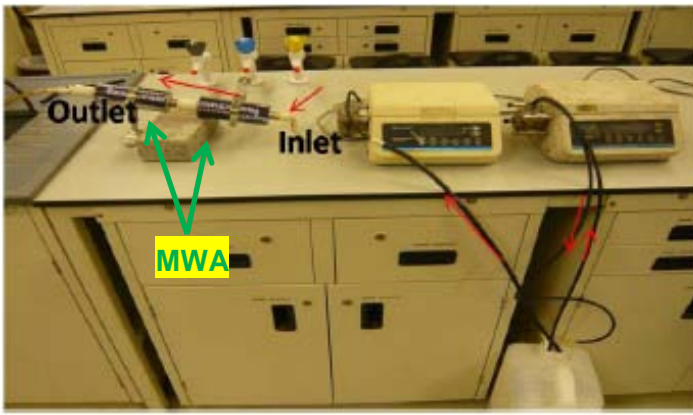


Figure Apparatus and System Setup

to pump the raw sewage through MWA at a flow rate of 160 mL/min. Samples 0H, 1H, and 2H correspond to the retention time in the collection tank after 0, 1 and 2 hours of treatment respectively. For circulation mode, the sample noted as 2+2H was obtained by recycling 8 liters of 2H sample for another 2 hours through the MWA in the collection tank

Results on Removal Performance of parameters are shown at Chart 2a and 2b below

In the instant (just a couple of seconds) of sewage exposing in magnetic field through MWA, there may have been a chain of vigorous physic-chemical actions activated.

In that,

a sudden drop of DO Reduction of 21 % (4.38 → 3.47 mg/L) and a significant TBC Removal of 39% have occurred at that instant simultaneously

apart from other minor biological effects.

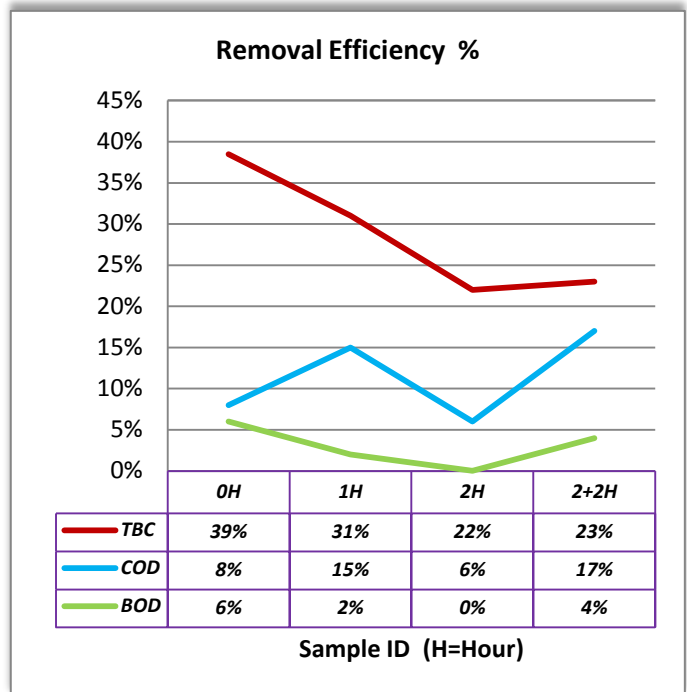


Chart 2a Results on Removal Efficiency of TBC, COD & BOD₅

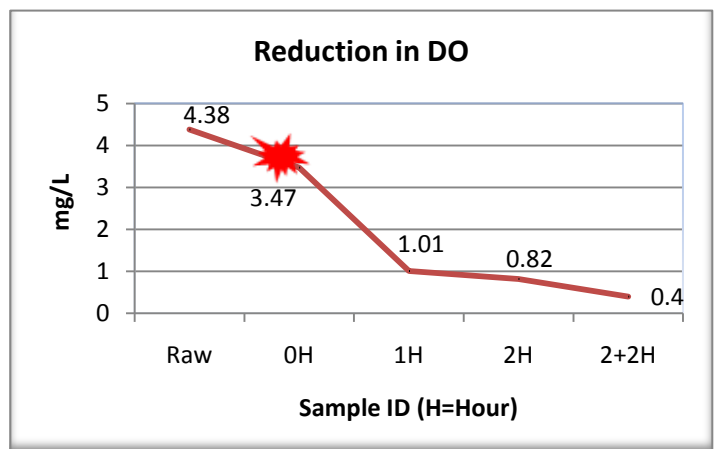


Chart 2b Result on Reduction in DO related to activities at Chart 2a

Test 3 Disinfection and Organic Reduction (Circulation and Aeration)

[Tests conducted by: THE HONG KONG POLYTECHNIC UNIVERSITY, Department of Civil and Structural Engineering].

Scope of Works

A circulation test of raw sewage (w/o precipitation treatment) was conducted to examine the water quality variation under an aeration condition with or without the presence of Magnetic Water Activator (MWA).

Apparatus and Methodology

Item	Description
1. Magnetic Water Activator (MWA)	Same as that at Test 2
2. Test Methods	TBC - APHA 9215C; BOD₅ - APHA 5210B; COD - APHA 5220B DO – APHA 4500-0

The apparatus and system setup are shown in the Figure beside. The tests are performed by pumping raw sewage in a circulation mode, and samples are collected and analyzed after 2 hrs of circulation. Two tanks of 8 liters raw sewage were used and operated simultaneously. The tanks are aerated by air at a rate of 16 L Air/min each and the diffusers are exchanged between the two tanks every 30 min to ensure an even aeration. The raw sewage in the two tanks was recycled by a pump each at a flow rate of 1600 ml/min with or without going through MWA.

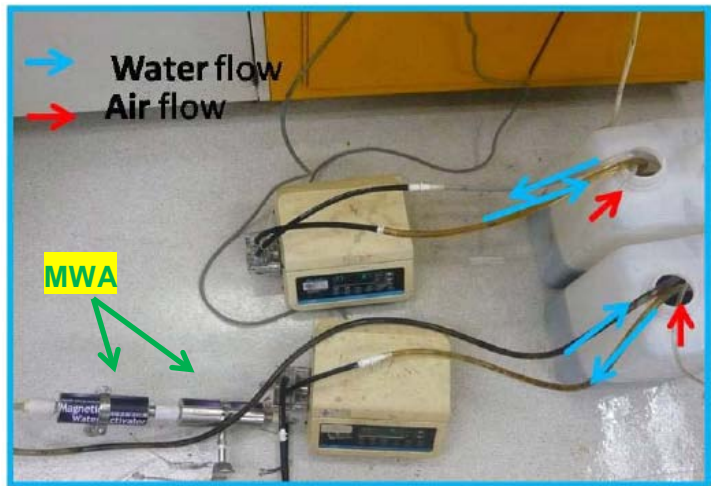


Figure Apparatus and System Setup

Results on comparison with parameters w/ MWA and w/o MWA are shown at [Chart 3a & b](#) below

Parameter	w/o MWA	w/ MWA	Removal Efficiency %
TBC (mg/L)	1,750,000	1,400,000	20
COD (mg/L)	608	557	8.4
BOD ₅ (mg/L)	295	260	11.9
DO (mg/L)	2.02	3.82	(Improved Efficiency %) 89.1
Remarks: 1. Removal Efficiency is calculated by comparing with the value w/o MWA 2. Improved Efficiency is calculated by comparing with the value w/o MWA			

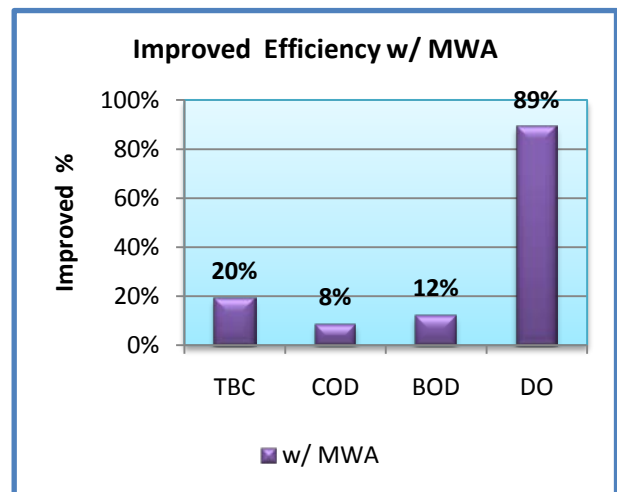


Chart 3a Results on Removal Efficiency of TBC, COD & BOD₅ and Improved Efficiency of DO.

Chart 3b Indication using Improved Efficiency for the system

2.2 Results

Test 1: After bacteria solution circulating through magnetic devices for 30 s (1 cycle of water volume in tank), 36% of E. coli has been removed. After 15 minutes the Removal % seems to be flattened which may attribute to insufficient DO in an enclosed condition.

Test 2: After sewage flowing at single-pass mode and exposing to magnetic field for a couple of seconds, TBC Removal is significantly up to 39% and further removal of 32% persists for an hour in the collection tank. Simultaneously DO content reduces 77% in supporting the process. After 2 hrs retention time in collection tank, sewage circulating w/ MWA for another 2 hrs, the Removal Efficiency is flattened (22%→23%) while DO content is nearly exhausted (0.82→0.4 mg/L).

Concerning organic reduction, there is little effect on BOD₅ whereas COD reduces 15% and 17% after 1 hr retention in collection tank and 2 hrs in circulation modes respectively.

In the test, the retention time of “magnetic memory of water” has shown to last for 2 hours, at least.

Test 3: After comparison with parameters w/ MWA and w/o MWA under circulation and aeration for 2 hrs, result shows that the % of both TBC and BOD Removal w/ MWA are respectively 19% and 12 % higher than that w/o MWA. In addition, the dissolution rate of oxygen is improved significantly and the DO content is 1.9 times that w/o MWA.

From the models of Performance Tests, biological effects of Magnetic water treatment have proved to be effective in disinfection and organic reduction in either single pass or circulation systems. Results also indicate that H₂O₂ has played the role of oxidation process on disinfection

and organic reduction whereas, at the same time, it consumes DO (contained in water) in supporting oxidation process. A reduction of DO content in producing H₂O₂, cited in scientific investigation, is thus confirmed

Biological effects can further be enhanced with:

- a. circulation mode and / or increased circulation time for prolonged exposure time of treated water in magnetic field;
- b. utilization of more magnetic devices for prolonged exposure time of water in magnetic field resulting in extending the retention time of magnetic memory effects in a single-pass system and to shorten the treatment time in a circulation system;
- c. aeration giving more dissolved oxygen and subsequent disinfectant H₂O₂ in treatment process.

3. Conclusion

1. The models of tests cited above may give a good support for conclusion about the dominant role of biological effects which are played by H₂O₂.
2. Biological effects of Magnetic water treatment are effective in disinfection and organic reduction in either single pass or circulation systems. The effects can further be enhanced with more magnetic devices, more circulation time and aeration to cope with the needs in industrial applications.
3. The fact that the dissolution rate of O₂ w/ magnet is 1.9 times w/o magnet will be a useful tool in the field of water treatment.
4. The technology is ecological clean and capable of providing memory effect on disinfection for a considerable time like residual chlorine but without harmful residue. It may be a substitution of residual chloramines / chlorine currently used in water distribution system.

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