Conference 2010 on Powerful Automation Technology, Control and
Instrumentation System for Environmental Protection

Disinfection, BOD and COD Reduction via Magnetic Water Treatment

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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 effects remain 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 in either 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 are 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, phenomena, explanations and hypotheses on the results have been referred to studies on scale crystallization.

1. Crystallization

Numerous researchers has investigated the feasibility of using permanent magnets in reducing mineral fouling in heat exchanger and reported that the magnetic treatment produces softer scale clinging to surface. The anti-scale effect resulted from changes in crystallization formation promotes 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 is blocked due to initiation of magnetic 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 has shown 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 activates silica and dissolved oxygen (DO) in the process of water memory and is called “magnetic memory of water”. In activating the latter DO, the magnetic effect induces hydrogen bond breakage which may produce reactive oxygen species (singlet oxygen, $^1O_2$ and hydroxyl radical, OH·) 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. Magnetized water increases the dissolution rate of oxygen [8]. 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].

Since magnetized water containing DO produces low concentration of H_2O_2, which is a strong disinfectant and oxidizing agent, the question of biological effects remain 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 are 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) is prepared as reservoir with a water pump connected to the product sample at ambient water temperature. The apparatus and system setup are shown in the Figure below. After several seconds running of water, water samples from both inlet (i.e. Os) and outlet (i.e. 30s, 5 mins & 15 mins) of the Magnetic Water Treatment System are collected for E. Coli analysis according to AOAC's method. (AOAC Association of Analytical Communities)

Results on E. Coli Removal Performance are shown at Table 1 with summary at Chart 1 below.

PHOTO APPENDIX - Front View

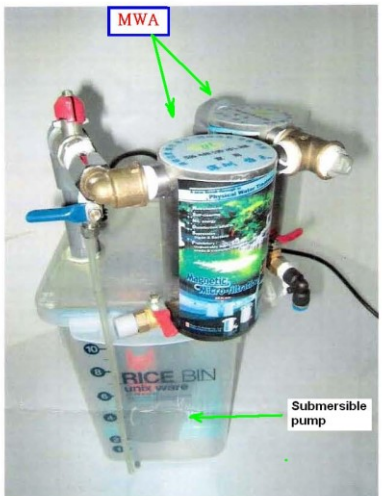


PHOTO APPENDIX - Side View

SGS authenticate the photo on original report only

Figure: Apparatus & System Setup

Parameter	Before	30s	5 mins	15 mins
E. Coli (cfu/ml)	14,000	9,000	6,600	7,300
Removal Efficiency	--	35.7%	52.8%	47.8%

Table 1. Results on Bacterial E. Coli Removal Efficiency

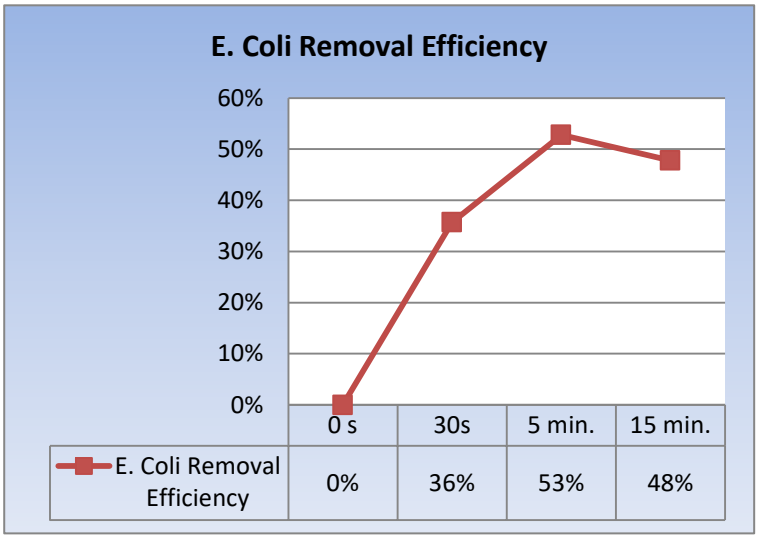


Chart 1. Summary on Bacterial E. Coli Removal Efficiency

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

Apparatus and Methodology

tem	Description
1. Magnetic Water Activator (MWA)	Permanent Magnets fabricated outside a S.S. tube of dia.16mm, total length : 100mm x 2 nos. Magnetic flux : 0.6T measured inside tube

Two MWAs are linked in series as one treatment system. For single- pass mode, four samples (Raw, 0H, 1H, and 2H) are collected from inlet (i.e. Raw), outlet (i.e. 0H) or collection tank (i.e. 1H, 2H) for further analysis. The apparatus is shown in the Figure below: the pump on the right is used to circulate the raw sewage at a flow rate of 400 mL/min for mixing purpose, while the left one is used 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 is obtained by recycling 8 liters of 2H sample for another 2 hours through the MWA in the collection tank

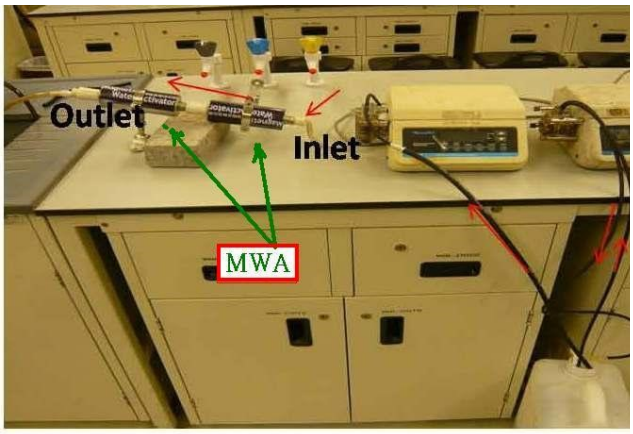


Figure: Apparatus and System Setup

Results on Performance of parameters are shown at Table 2 with summary at Chart 2a and 2b below

Parameters	Raw	0H	1H	2H	2+2H	Test Methods
TBC (cfu/ml)	7,800,000	4,800,000	5,400,000	6,100,000	6,000,000	APHA 9215C
Removal Efficiency	--	38.5%	30.8%	21.8%	23.1%	
COD (mg/L)	452	415	384	426	374	APHA 5220B
Removal Efficiency	--	8.2%	15.0%	5.8%	17.3%	
BOD_5 (mg/L)	164	155	160	165	157	APHA 5210B
Removal Efficiency	--	5.5%	2.4%	-0.6%	4.3%	
DO (mg/L)	4.38	3.47	1.01	0.82	0.4	APHA 4500-0
Remarks: The Removal Efficiency is calculated by comparing with the value of Raw						

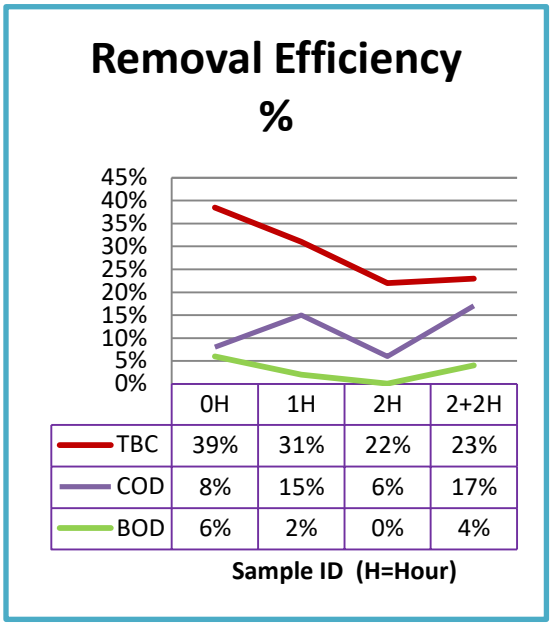
Table 2 Results of performance on parameters TBC, COD & BOD_5 & DO

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



	0H	1H	2H	2+2H
TBC	39%	31%	22%	23%
COD	8%	15%	6%	17%
BOD	6%	2%	0%	4%

Chart 2a Summary on Removal Efficiency of TBC, COD & BOD_5

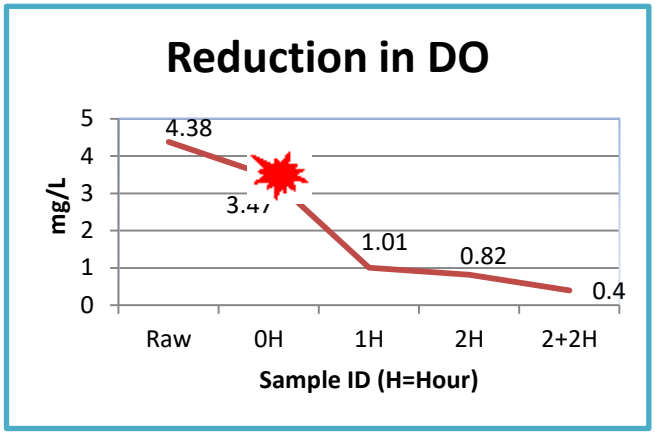


Chart 2b Result on Reduction in DO related to activities at Chart 2a

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) is 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; **BOD_5** – 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 are 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 is recycled by a pump each at a flow rate of 1600 ml/min with or without going through MWA.

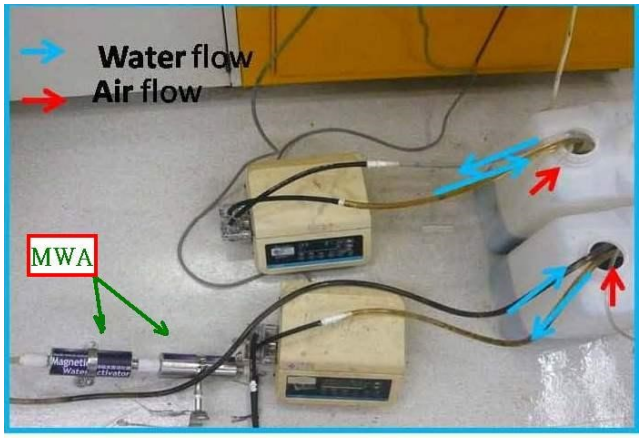


Figure: Apparatus and System Setup

Results on comparison with parameters w/ MWA and w/o MWA are shown at Table 3 and Chart 3 below

Parameter	w/o MWA	w/ MWA	Removal Efficiency %
TBC (cfu/ml)	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 valu w/o MWA
2. Improved Efficiency is calculated by comparing with the value w/o MWA

Table 3 Results on Removal Efficiency of TBC, COD & BOD_5 and Improved Efficiency of DO.

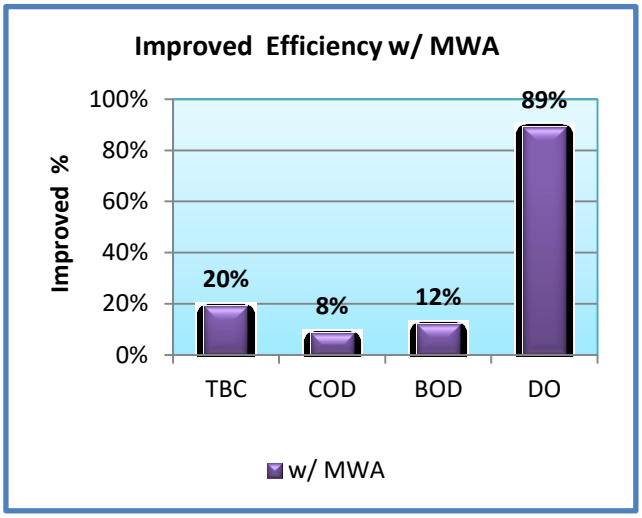


Chart 3. Indication using Improved Efficiency for the system

2.2 Results

Test 1: After bacteria solution circulating through MWA 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 to be replenished 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 the retention on Removal of 32% continues for an hour in the collection tank. Simultaneously DO reduces from 4.3 mg/L to 1.01 mg/L (77%) in supporting the process. Even DO content is nearly exhausted in the tank for 2 hr retention (0.82 mg/L At 2H) and replenished DO from air is slow, TBC Removal has continued after circulating sewage w/ MWA for another 2 hrs. (2+2H).

Concerning organic reduction, there is little effect on BOD_5 whereas COD reduces 15% after 1 hr. retention in collection tank and 17% after 2 hrs. in circulation modes. 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, results show that the % of both TBC and BOD Removal w/ MWA are 19% and 12 % respectively 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 H_2O_2 has played the role of oxidation process on disinfection and organic reduction whereas, simultaneously, it consumes DO in supporting oxidation process.

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 which results in extending the retention time of magnetic memory effects in a single-pass system or in shortening the treatment time in a circulation system;

c. aeration giving more dissolved oxygen and subsequent disinfectant H_2O_2 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 H_2O_2.
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 O_2 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 chlorine /chloramines currently used in water distribution system.

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