EFFECT OF MAGNETIC FIELDS ON SELECTED PARAMETERS IN SEWAGE

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Abstrak

Desain penelitian menggunakan 6 pasang magnet non paralel dengan kekuatan 0,55 Tesla, kecepatan aliran 1,84 ml/s, dengan pH kurang dari 7. Hasil menunjukkan bahwa konsentrasi Biological Oxygen Demand (BOD), NH3-N, Chemical Oxygen Demand (COD) dan Suspended Solid (SS) turun tiga kali lipat dengan menggunakan tes pengendapan dibandingkan dengan menggunakan pengolahan tipikal. Dengan menggunakan magnet dan tanpa magnet penurunan SS sebesar 85,40% dan 29,92%, penurunan BOD sebesar 41,54% dan 17,54%, penurunan COD sebesar 43,43% dan 25,26% dan penurunan NH3-N sebesar 60,99% dan 27,15%. Penelitian ini menyimpulkan teknologi magnet mempunyai potensi digunakan untuk meningkatkan efisiensi pengolahan buangan domestik dengan meningkatkan removal partikel tersuspensi.

Kata kunci: medan magnet, partikel tersuspensi, pengendapan, saluran air buangan

Abstract

Experimental design with a magnetic strength of 0.55 Tesla, a flow rate of 1.84 ml/s, 6 paired of non parallel magnets, with pH less than 7 showed that the concentrations of BOD, NH3-N, COD and SS were decreased up to three times using the settling test compared to typical treatment. The percentage of SS removal was 85.40 compared to 29.92 without magnet, so as BOD was 41.54 compared to 17.54, COD was 43.43 compared to 25.26 and NH3-N was 60.99 compared to 27.15 without magnet. This study concluded that magnetic technology had the potential to be used to further increase the efficiency of domestic sewage treatment by increasing the removal of suspended particles.

Keywords: magnetic fields, suspended particles, settling, sewage

1. INTRODUCTION

Waste treatment is concerned with environmental protection and with the reduction of pollutant discharges into the environment. In the light of growing concern about the environmental impact of wastewater discharges it is likely that tightening regulatory requirements will inevitably lead to increasing wastewater disposal costs. Therefore wastewater treatment is important for long term environmental protection and conservation. Usage of magnetic treatment as an alternative form of water and wastewater treatments are stills remain anecdotal and limited due to lack of credible and proven mechanisms.

Magnetic water treatment has been shown in the past to be a promising treatment process that can be used to avoid scale formation in the water pipe lines especially boiler system.

Currently, the application of magnetic treatment has been used in industrial water treatment (Hibben, 1993), removal of phosphate from water (Bogatin *et al*., 1999) and reducing the formation of wax and paraffin in the oil rigs (Partidas, 1995).

Present technical papers pertinent to magnetic treatment claim that it has the ability to alter the physicochemical properties of water, suppressed nucleation of CaCO3, (Beruto and Giordani, 1995), enhancing the crystallization process (Donaldson and Grimes, 1988), intensify the coagulation and precipitation of colloidal particles and inhibit scaling (Florenstano *et al*., 1996).

Currently applications of magnetite slurry, magnetite particles and magnetic powder in treating wastewater have been becoming the main interest of many researchers. A pretreated fine sized magnetic particles that are known as ‘magnetite slurry’ had been used as a coagulant for colloidal material such as clays, humic acids, bacteria, viruses and algae (Anderson *et al*,. 1989). Research organization (CSIRO) had reported on the successful application of magnetic particles on treating wastewater with respect to adsorption and coagulation process (Bolto, 1990). This study was made on a number of wastewater applications such as sewage sludge, metal recovery from electro-plating and hydrometallurgical effluents.

Magnetic particles or magnetic seeding and a magnetic field have been applied in most of the research conducted by researchers. Sakai *et al*. (1991) added magnetic Ferro oxide powder to activated sludge to improve the efficiency of the sedimentation. Ozaki *et al*. (1991) applied a magnetic particle and magnetic field for phenol biodegradation. Another researcher Van Valsen (1990) had managed to develop an effective magnetic technique for treating sewage effluents. Magnetite that acts as carrier materials had been applied to remove phosphate concentration off the sewage's effluents. On the similar approach Sakai (1994) has studied the submerged filter system consisting of magnetically anistropic tubular support media for the sewage treatment with a biofilm system. Activated sludge was supplemented with ferromagnetic powder for the preparation of the biofilm. The biofilm was formed within 15 min on magnetic support media by magnetic attraction. The magnetic support media were able to treat se-wage containing 0.2g/L COD and remove 72% to 94% COD with a retention time of 8 h.

However these technologies have some disadvantages, such as the use of magnetic particles and the necessity of recovering them considering the environmental viewpoint, practical cost problems and may be too complicated for practical application. Others have reported the sedimentation enhancement of activated sludge with an external magnetic field without addition of magnetite into the sludge, using a cultivated activated sludge that was acclimated with a synthetic sewage, that accompanied the enlargement of the flock size. The flock size and sedimentation were improved by the addition of FeCl3 to the activated sludge. However the mechanism of sedimentation enhancement effects is still unclear.

Previously most studies regarding to magnetically treated wastewater were only concentrating on the usage of magnetite (magnetic particle and slurry). However, there are still lacks of studies that have been published regarding to the specific consumption of magnetic field (non invasive) effect on the sewage properties. Therefore it is the purpose of this study to investigate the feasibility of magnetic technology in enhancing the sedimentation of sewage's suspended particles as well as to look its effect on the sewage properties (i.e. turbidity and pH). In this report, the mechanism of enhancement of sedimentation of suspended particles in wastewater by magnetic field, the effects of a magnetic field on the sedimentation rate due to magnetic field strength and flow rate were investigated using design laboratory magnetic devices.

2. METHODOLOGY

The experimental set up was employed magnetic field that is orientated orthogonal to the direction of sewage flow. Three permanent magnets with different strengths were used in this experiment, namely NdFeB of 0.55T, SmCo of 0.16T and AlNiCo of 0.08T. All magnets are cubic shape rare earth permanent magnet size (50mm x 50mm x 20mm). The experiments carried out in this work are classified into two categories namely static system and flowing system.

Static system, the fluid was kept in a cylindrical glass cell. Two cubic shaped permanent magnets were centered on the outside of the bottle faces, of the sample container with opposite magnetic poles facing each other. They rested on the glass surface vertically, by their magnetic attraction. The distance between the two poles is the diameter of the bottle, i.e. 20mm. The sample is filtered by using filter paper after exposed to the magnetic field for every 10 minutes of interval time. Each filtered sample was dried in an oven for 1 hour before weighted. The second test was carried out by changing the magnetic field strength. Each series consisted of control runs with no applied magnetic field, followed by otherwise identically conducted magnetic runs. During each 1 hour run, the turbidity of both magnetically treated sample and control sample were all carefully monitored. The time dependence of turbidity was then used to make inferences about the precipitation process.

Flowing system, a schematic of the flowing system rig is shown in Figure 1. This rig consists of a 1 liter reservoir for filling and a treatment loop, which permits continuous flows of fluid through a magnetic treatment device, contains 20 units of permanent magnets under controlled laboratory conditions. All pipe work is made of flexible PVC tube or teflon with a nominal internal diameter of 19.05

mm (3/4 in). Other plastic materials are employ wherever possible. Where metal components are required, nonferrous materials such as brass or copper was utilized. The variable speed pumps allow adjustment of the flow rate from zero to 100 ml/s. The fluid is continuously flowed at between 0.1 ml/s to 10 ml/s. The flow was kept as a laminar flow. The fluid flow is design to flow orthogonal to the magnetic field direction. 4 similar rigs will be set up and run simultaneously, each with different magnetic strength and one loop without magnet as a control system. The treated sewage was collected at the end of the tube and then was placed in a settling column of 45cm high and 7cm in diameter. This will consume about 275 ml of treated sewage. Sampling was taken periodically every 10 minutes intended for turbidity analysis.

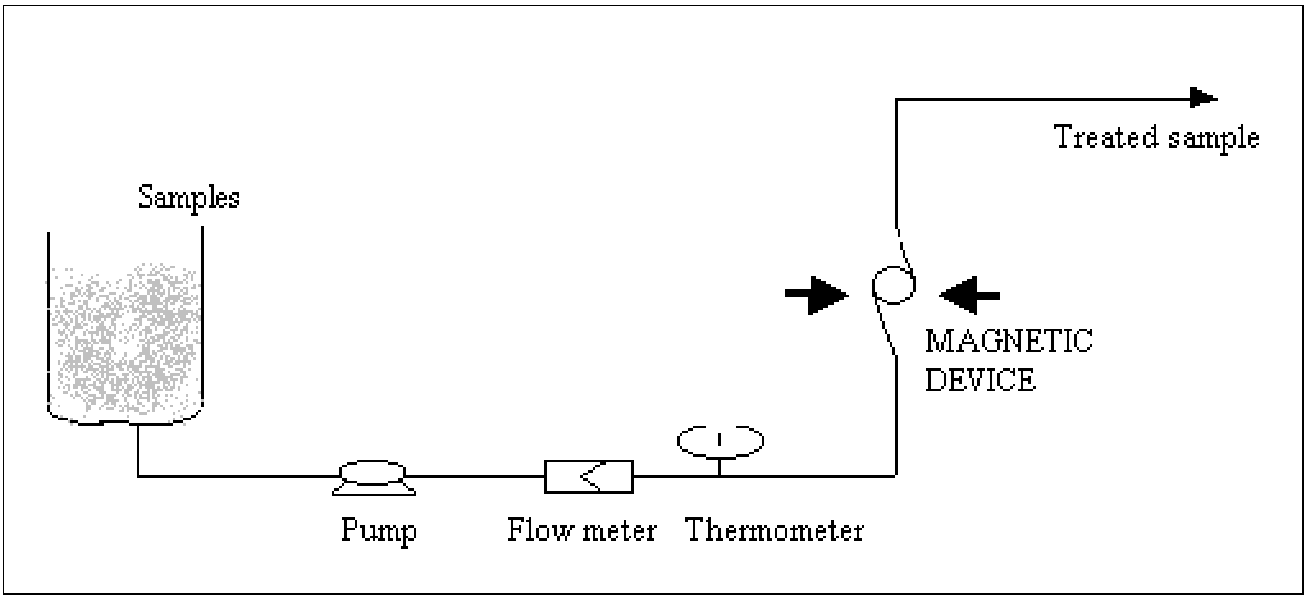

Figure 1. Schematic Layout Of The Flowing System

Settling column, the settling column is made of a cylinder of glass tubing with a 7 cm internal diameter and 1 m high. Samples were collected from the column at 10cm from the top of the column using 10 ml pipette. Samples were collected at 10, 20, 30, 40 minutes and 1, 2 and 3 hours. Analysis of the samples collected throughout the experiment allowed the change in concentration against time to be determined.

3. RESULTS AND DISCUSSION

The effect of the magnetic field strength on the precipitation of colloidal particles is experimentally studied by varying the magnetic field strength between 0 to 0.55T. The magnetic field enhances the removal efficiency of colloidal particles from approximately 8% without magnetic field to 20% with magnetic field of 0.08T at 80 minutes settling time under static system, while removed about 21% without magnet to 40% with magnet when using flowing system.

As shown in Figure 2, the rate of concentration difference after and before treatment that magnetized sewage treatment is seen to have higher removal of suspended particles compared to control.

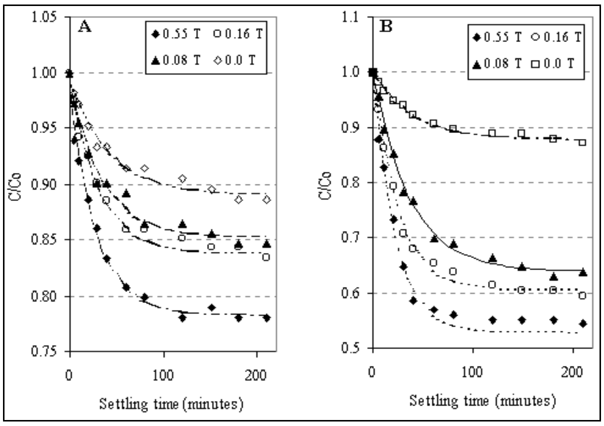

Figure 2. Effect Of Different Magnetic Field Strengths On The Rate Of Suspended Particles Removal Under Static (A) And Flowing System (B)

The percentage of removal seems to be increasing with the settling time but the rate of removal is declined as settling time increases. As the magnetic field is increased further, the particles removal efficiency increases by about 50% to 60% with magnetic field strength of 0.55T. It is found that the removal efficiency increases rapidly until the magnetic field strength becomes approximately 0.2T. Above this field strength, the removal efficiency increases slowly because the concentration of particles in the solution decreases. The reason for this behaviour is that the magnetic force enhances the settling velocity of the suspended particles. This settling velocity is increased when more suspended particles are agglomerate and cloaked together.

Exposed to magnetic field would electrically contribute to a greater ionic charge. This energy will make the charged particles to vibrate excessively. Thus more particles are colliding among themselves. This reaction contributes to additional number of ions (positive and negative charge), which consequently creates a natural magnetic attraction between the opposite charged particles. Particles are then attracted and agglomerated. This phenomenon intensifies coagulation that enables them to flocculate and precipitate.

Another reason that could cause a limitation in the removal efficiency in the experiments is due to the heterogeneous flocculation rate of suspended colloidal particles. The effect of flow rate on the removal efficiency is experimentally shown in Figure 3, where magnetic treatment experiments of colloidal particles were conducted by varying the flow rate from 0.92 ml/s to 5.52 ml/s. It is shown that the removal efficiency decreases as the flow rate is increased. Increased flow rate results in increased drag force, therefore colloidal particles are not easily aggregated or accumulated under high flow velocities.

The effect of the magnetic field intensity on the BOD, COD, SS and NH_3-N removal of sewage is experimentally studied by applying magnetic field of 0.55T, flow rate of 1.84 ml/s with desined magnetic devised comprises of 6 paired magnet. The pH of the samples was maintained below 7. As shown in Figure 4, magnetized sewage treatment reduced the concentrations of BOD, COD, SS and NH_3-N in the sewage. The concentrations of each parameter are reduced due to the reduction of suspended particles in the sewage due to the aggregation effect by the magnetic fields.

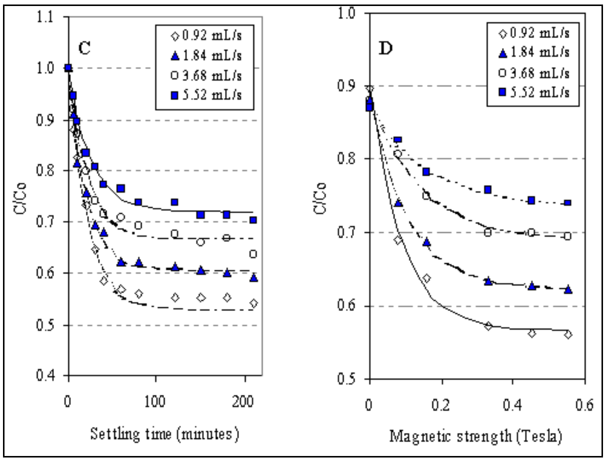

Figure 3. Effect Of Flow Rate On The Rate Of Suspended Solids Removal Under Flowing System Based On Settling Time (C) And Magnetic Strength (D)

This phenomenon again support the theory that magnetic field can speed up the settlement of suspended particles. As more suspended particles settle down the sewage becomes more clarified and consequently leads to the reduction of early mentioned parameters in the sewage

As shown below, the optimum reduction in concentration of each parameter is about 80 minutes of settling time. The concentrations of BOD, NH_3-N, COD and SS were found decreased up to three times using the settling test compared to typical treatment. The percentage of SS removal is 85.40 compared to 29.92 without magnet, so as BOD is 41.54 compared to 17.54, COD is 43.43 compared to 25.26 and NH_3-N is 60.99 compared to 27.15 without magnet. Reduction of the concentration of each parameters mentioned is due to the removal of suspended particles in the sewage

The effect of magnetic fields on the suspended particles in the sewage can be explained based on the colloidal aggregation due to magnetohydrodynamic. Colloidal suspended particles carry a surface charge and this charge is affected by the imposed magnetic fields. The surface charge on the particles is compensated by attraction of counter ions to the surface in the form of a diffuse layer, resulting from thermal motions of ions in the solution. The electric state of the surface is known as an electric double layer. A fixed charge is attached to the solid surface and another layer of charge is diffused or distributed in the liquid in contact with the surface (Satapah, 1989).

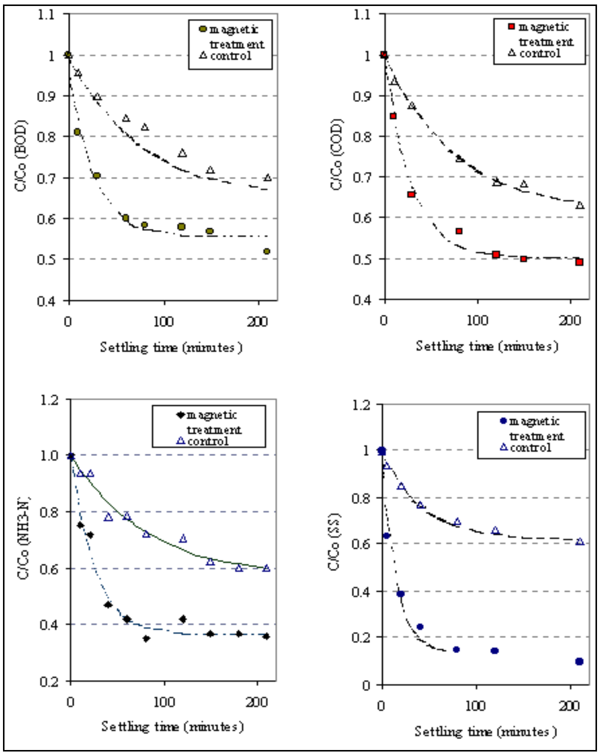

Figure 4. Effect Of Magnetic Treatment On Various Parameter In Sewage I.E. BOD (E), COD (F), NH3-N (G) And SS (H) Under Flowing System With Magnetic Strength Of 0.55T And Flow Rate Of 1,84 ml/s

The concentration of ions not balanced by the counter ions decreases exponentially away from the fixed layer, resulting in an electric potential that decreases away from the particle surface.

In aqueous colloids, suspended charges particles experience double layer repulsion and attraction due to van der Waal's forces. The magnitude of van der Waal's forces, which originates from the charge fluctuations in atoms, does not depend on colloidal chemistry. Fluctuations in charge lead to mutually induced dipoles in interacting particles, which result in an attraction between the particles.

4. CONCLUSIONS

Magnetic technology is potential to be a promising treatment process that can enhance the separation of suspended particles from the sewage. Increased percentages of suspended particles removal have been observed for both static and flowing systems in the presence of an orthogonal applied magnetic field. The study has also concluded that the magnetic treatment has the ability to enhance the sewage treatment plant performance by reducing the concentration of BOD, COD, NH_3-N and SS in the sewage. It is suggested that a magnetic field may enhance the collision rate and efficiency among those colloidal particles and therefore easier to flocculate into bigger aggregates. Expose to magnetic field would electrically contribute to a greater ionic charge (extra energy) that helps the charged particles to vibrate and collide excessively. As a result particles can move closer as the electrostatic repulsive forces have less effect on them. Thus more particles are flocculated and precipitated together. This effect is best explained as a magnetohydrodynamic effects (Johan, 2003). Increased in aggregation was also observed under the magnetically non flowing system (static condition). Expose to magnetic field would enhance the effect of Brownian flocculation as the magnetic field has become the dominant force that drives particles (electrically induced particles) to collide and flocculate together.

Study carried out shows that magnetic field enhances the suspended particles removal by accelerating the settling of aggregated particles as well as increasing the particles density due to coagulation process. Hence this technology is definitely beneficial in reducing the volume of sedimentation tank as well as increasing the treatment plant efficiency.

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