EFFECT OF MAGNETIC FIELDS ON HEAVY METAL AND NUTRIENT REMOVAL IN LEACHATE

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Especially for my family and friends………….

"Thank you for the understanding, my success is yours too"

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ABSTRACT

The capabilities of leachate treatment to achieve the allowable limit standards are well known to be universal problem. All kinds of technology treatment methods are used but still difficult to reach the minimum standard requirements. Magnetic technology is a physical treatment technique, which is commonly used in water processing industry. This situation attracts treatment to use the magnetic technology to further increase the leachate treatment capabilities. This study is mainly focused on the capability of the technology to increase the removal of heavy metals and nutrient. The settling of the treated leachate test, which was done, applied to the behavior of the first kinetic model and the settling time, found out to be most suitable after 60 minutes. The results of the test conclude that the capability of heavy metals and nutrient removal can be further increased using the flowing method with magnetic fields; and with different flow rate and circulation time. The study reveals that lower flow rate and higher circulation time will enhance the removal in leachate. Experimental design with a magnetic strength of 0.55 Tesla, a flow rate of 1 mL/s and circulation time at 7 hour shows that the concentrations of Cr, Fe, Mn and PO_4^{-3} were decreased. The percentage of Cr removal is 92.8 compared to 87.8 without magnet, so as Fe is 72.9 compared to 70.6, Mn is 50.6 compared to 45.5and PO_4^{-3} is 33.2 compared to 19.6. This study concluded that magnetic technology has the potential to be used to further increase the efficiency of leachate treatment by increasing the removal of heavy metals and nutrient.

ABSTRAK

Telah diketahui bahawa kemampuan rawatan air larut lesap untuk mencapai piawaian had yang dibenarkan merupakan masalah umum. Pelbagai kaedah rawatan telah digunakan namun ia masih sukar untuk mencapai keperluan piawaian minimum. Teknologi magnet merupakan teknik rawatan fizikal, yang sering digunakan di dalam industri pemprosesan air. Situasi ini menarik minat penyelidik untuk menggunakan teknologi magnet untuk meningkatkan kemampuan rawatan air larut lesap. Kajian ini memfokuskan pada kemampuan teknologi untuk meningkatkan penyingkiran logam berat dan nutrien. Ujian pemendapan air larut lesap terawat dijalankan mengikut model kinetik pertama dan masa pemendapan diperolehi bahawa selepas 60 minit adalah masa terbaik. Keputusan ujian menyimpulkan bahawa kemampuan penyingkiran logam berat dan nutrien boleh dipertingkatkan menggunakan kaedah aliran dengan medan magnet, menggunakan kadar alir dan masa pengelilingan yang berbeza. Kajian ini mendedahkan penyingkiran dapat ditingkatkan apabila kadar alir rendah dan masa pengelilingan panjang. Rekaan eksperimen dengan kekuatan magnet 0.55 Tesla, kadar alir 1 mL/s dan masa pengelilingan 7 jam menunjukkan kepekatan Cr, Fe, Mn dan PO_4^{-3} menurun. Peratusan penyingkiran Cr ialah 92.8 berbanding 87.8 tanpa magnet, bagi Fe ialah 72.9 berbanding 70.6, Mn ialah 50.6 berbanding 45.5 dan PO_4^{-3} ialah 33.2 berbanding 19.6. Kajian ini menyimpulkan bahawa teknologi magnet mempunyai potensi untuk digunakan bagi meningkatkan keupayaan rawatan air larut lesap dengan meningkatkan penyingkiran logam berat dan nutrien.

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LIST OF SYMBOLS

ε	-	Dielectric constant
τ	-	Retention time of dispersion in the working channel
η	-	Viscosity of solution
ζ	-	Zeta potential (mV)
B	-	A half thickness of cell / Density / Amount of particles settled at time t
C	-	Particles concentration at time t
C_{AO}	-	Particles concentration at first settled
e	-	Electrical charge
F_L	-	Lorentz force
F_{vis}	-	viscosity force
hs	-	Static layer (distance from centre to cell)
L	-	The distance of electrode
l_{Ti}	-	Average diffusion length
t	-	Interval time
U	-	Electrophoretic mobility
v	-	Speed of particles (cm/sec) / Velocity rate
V	-	Voltage (V)
Ze_o	-	charge for ion valence Z

LIST OF ABBREVIATIONS

AMT	-	Antiscale Magnetic Treatment
AOP	-	Advanced Oxidation Processes
BOD	-	Biochemical Oxygen Demand
BOD_5	-	5-day Biochemical Oxygen Demand
CEPI	-	Conditionnement Electromagnktique Par Induction
COD	-	Chemical Oxygen Demand
DC	-	Direct Current
DVLO	-	Derjaguin, Verway, Landau and Overbeek
HHW	-	Household Hazardous Waste
MBAS	-	Methylene Blue Active Substances
MSW	-	Municipal Solid Waste
MTD's	-	Magnetic Treatment Devices
MWT	-	Magnetic Water Treatment
PVC	-	Polyvinylchloride
SS	-	Suspended Solids
TDS	-	Total Dissolved Solids
TOC	-	Total Organic Carbon
TSS	-	Total Suspended Solids
UV	-	Ultra Violet
VDS	-	Volatile Dissolved Solids
VFA	-	Volatile Fatty Acids
VOCs	-	Volatile Organic Compounds
VSS	-	Volatile Suspended Solids

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CHAPTER 1

INTRODUCTION

1.1 Background

Household waste, any waste produced from a domestic source, represents over two-thirds of the municipal solid waste (MSW) stream. Internationally, almost 70% of MSW is disposed of to landfill (Zacarias-Farah and Geyer-Allely, 2003). MSW contains hazardous substances in the form of paints, vehicle maintenance products, mercury-containing waste, pharmaceuticals, batteries and many other diffuse products which are discussed in the review paper by Slack *et al*. (2004). As such, household hazardous waste (HHW) is disposed of to landfill along with general household waste. The amounts and significance of this disposal are poorly understood. Generally, it is assumed that amounts are small and therefore risks of disposal are negligible. Nevertheless, disposal information is lacking or, at best, unreliable and ambiguous. Changes to legislation requiring the separate disposal of MSW, industrial and other wastes, raises the importance of the hazardous element contained in MSW. Previous studies have found that, even without landfill disposal, leachates from MSW are very similar in composition to those from mixed or hazardous landfills (Schrab *et al*., 1993; Kjeldsen *et al*., 2002).

Emissions and effluent from landfill take a number of forms: gaseous emissions of volatile organic compounds (VOCs), airborne particulate matter and leachate. The contamination of groundwater by landfill leachates has been recognized by a number of researchers (Christensen *et al*., 2001; Kjeldsen *et al*., 2002). Leakage potential may be mitigated by a number of factors, many enshrined in legislation, including landfill capping.

Failure of any of the engineered control measures can result in the release of leachate, as reported by Schwarzbauer *et al*. (2002). For older landfills, the implementation of measures to prevent contaminants release into the environment is less well defined with the result that aquifer contamination was far more common as were elevated levels of localized VOCs (Reinhard *et al*., 1984). Discharge of treated leachate also possesses risks to the environment through ineffective treatment and/or discharge to particularly sensitive receiving waters (Silva *et al*., 2004). Whilst leachate contamination of the groundwater environment is less likely from modern landfills as a consequence of engineered barriers and leachate collection, the risk still exists.

Knowledge of leachate composition is necessary for the implementation of site remediation following barrier breakdown and for installation of practicable treatment processes. Although major components of landfill leachate, especially ammonical nitrogen, can be predicted with some certainty using models to predict the possible typical leachate resulting from the deposition of generic waste groups, the trace composition of leachate is inherently variable due to the heterogeneity of specific waste composition and other factors relating to the landfill (Reinhart, 1993; Blight *et al*., 1999). Leachate composition is also an indication of the types of waste disposed and the processes occurring within the landfill. The presence of heavy metals and hazardous organic contaminants in leachate, such as halogenated aliphatic compounds, aromatic hydrocarbons, phenolic compounds and pesticides, are direct indicators of the hazardous wastes in MSW (Christensen *et al*., 2001; Kjeldsen *et al*., 2002; Isidori *et al*., 2003). However, care must be taken with MSW leachate analyses that reveal the presence of harmful substances due to the disposal of industrial liquid wastes and manufacturing wastes with MSW.

As concern about chemicals in household products increases, the potential consequences to the environment from the disposal of HHW are also moving to the fore. It is therefore important to ascertain the level of risk inherent in the disposal of HHW to landfill, as permitted by current legislation. The contamination risks associated with the disposal of HHW at each stage of the disposal-to-landfill-to-emissions pathway have not been examined in detail before.

The world-wide controversy regarding the effects of magnetic fields on water results in part from the fact that surprisingly little is known about the physical structure of liquid water. Many of the extraordinary properties of "ordinary" water are explained by the tendency of the water molecules to form complexes $(H_2O)_n$ with $20<n<200$. Hydrogen bonds hold neighboring H_2O molecules together, forming clusters which cause the abnormal freezing habits of the water (Fletcher, 1970). Internal vibratory motion accounts for the uniquely high specific heat of the liquid water (Knight, 1967). The complexes form cage-like structures preferably around ions and foreign particulate matter. The hypothetical nature of the knowledge of the structure and the potentialities of liquid water became emparrassingly obvious by the scientific debacle concerning "Polywater" during the 1970s.

Reported observations of effects of magnetic fields on water have proliferated with the improvements of available permanent magnets, particularly in countries where chemical capabilities for water conditioning are less developed and therefore physical water conditioning is widely in use.

Unprofessional claims of "magnetized water" or a "memory" of the water for magnetic fields have clouded the concept and abhorred scientists. It has been shown theoretically that the interaction between magnetic fields and the hydrogen bonds between the water molecules are by orders of magnitude too weak for direct, significant effects.

1.2 Problem Statement

Leachate 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 leachate discharges it is likely that tightening regulatory requirements will inevitably lead to increasing leachate disposal costs. Therefore leachate treatment is important for long-term environmental protection and conservation. Usage of magnetic treatment as an alternative form of leachate treatments are stills remain anecdotal and limited due to lack of credible and proven mechanisms.

Previously most studies regarding to magnetic treatment system were only concentrating on the water treatment. Magnetic treatment attracts a special attention due to their safety, ecological purity, simplicity and low operating costs. This study was carried out in order to determine the feasibility and effectiveness of applying magnetic technology for leachate. The study are carried out to investigate the feasibility of magnetic technology in assisting heavy metal removal and to understand the mechanism and impact of magnetic application in leachate.

1.3 Objectives

The objectives of this study are:

(i) To study the effect of magnetic field on heavy metal removal i.e. Chromium, Iron and Manganese; and Phosphorus.

(ii) To compare the effectiveness of removal through circulation flow system either with magnet or without magnet.

(iii) To study the parameters that affect the heavy metal removal such as flow rates, magnet strengths, circulation times and settling times.

1.4 Scope of Study

This study focuses in removing heavy metal from leachate using magnetic field system. Each experiment was using a few control parameters which are magnet strength, flow rates and circulation times. This study will use the existing system which has been developed by Johan (2003). The control parameters are:

(i) Different magnet strength which are 0 Tesla and 0.55 Tesla,
(ii) Treatment method operation with flow rates between 1 and 3 mL/s, and
(iii) Time of exposure to magnet between 1 and 8 hour.

All experiments were carried out in Environmental Engineering Laboratory, Civil Engineering Faculty, Universiti Teknologi Malaysia. Leachate samples were taken from Pasir Gudang Sanitary Landfill.

1.5 Thesis Outline

This thesis is divided into five chapters, including the current one which is included the introduction, problem statement, objectives and scope of study. Chapter 2 presents the literature survey that was done at the earlier stage of the study such as leachate, current technology development and the magnetic treatment. Chapter 3 presents the research methodology for this study including the system that has been used and the experimental equipments. Chapter 4 presents the results of the experiments and the analyses of the data. Also, include the discussion. Finally, Chapter 5 consist the summary of works and contributions made in this thesis. It also included with the future works that can be further from this field.

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