REMOVAL OF HYDROGEN SULFIDE BY PHYSICO- BIOLOCAL FILTERATION USING BIOFILM AND RICE HUSK MEDIA

Seyed Mahmoud Mehdinia*, Puziah Abdul Latif, Ahmad Makmom Abdullah, Latifah Abd Manaf, Hassan Taghipour

Ph.D (GS18451)
5th Semester

1. Introduction:

There is increasing concern about environmental pollutions, because over the course of recent decades, human activities have led to a considerable increase in air pollution. That is why control and treatment of air pollutants is one of the most important environmental challenges today. Therefore need to treat and control air pollution has become an emerging and seriously health and environmental concern for these years.

In recent years the influence of even low concentrations of air pollutants on human health has re-emerged as an important scientific issue. Numerous studies have linked various acute and chronic health impacts to air pollution (Perez Ballesta et al., 2008).

The malodor caused by H_2S has been an environmental and public nuisance in recent years. Of particular significance is the odors emanating from food processing industry, common effluent treatment systems, night soil and solid waste processing plants. Inhalation of low concentrations of H_2S can cause headache, dizziness, nausea, cramps, staggering, excitability and drowsiness. In real situations such as industrial emissions, the strong odor threshold and vapor density makes them travel several kilometers from the emission site (Jeong, Lee, Cha, & Park, 2008)

Many technologies have been used to treat malodorous compounds from contaminated air. As regulatory measures move toward more stringent control of malodorous compounds, the demand for cost-efficient air pollution control technology will increase (Chung, Huang, & Tseng, 2001).

The most widely used bioreactors for air pollution control are biofilters and biotrickling filters (Kun, 2005). Since the heart of a biofiltration system is the filter bed or packing material, many studies have been carried out about packing material for biofilters, such as: Peat, compost, soil, activated carbon, etc. but unfortunately there is no report about physico- biological filter for removal of H_2S using rice husk media.

Rice husk is a major agricultural byproduct obtained from the production of rice. For every four tons of rice produced, one ton of waste rice husk is generated. Rice husk has a chemical composition that typically corresponds to the following: cellulose (40-45%), lignin (25-30%), ash (15-20%), and moisture (8-15%). Ash is derived mainly from the opaline which is present in the cellular structure of the husk and about 90% of which is silica (Mohamed Kutty, 2001) . At burning temperatures of 550 ºC to 800 ºC, amorphous silica is formed, but at higher temperatures crystalline silica is produced. The silica content is between 90 and 96% which is a very cost-effective alternative to silica fume (Alvarez, 2006).

2. Problem Statement

For treatment of malodorous gases, physical and/or chemical methods have been popularly used. The disadvantages of the traditionally used air treatment technologies are high energy costs, the use of chemicals, which can be costly to purchase or dispose of and require special operational safety procedures and the production of waste products (Taghipour, Shahmansoury, Bina, & Movahdian, 2006).

These issues were the main reasons to start-up physico-biological filter using new packing material. In order to remove malodorous gases, many studies have been carried out about biofilter packing material, such as peat, compost, soil, activated carbon, etc., but unfortunately there are no reports about physico- biological filters for removal of H_2S using both rice husk and dry activated sludge as a packing material.

Both biofilters and biotrickling filters have significant practical limitations. One of these limitations is that the maximum elimination capacity of biofilters rarely exceeds 100 g of pollutant per cubic meter bed per hour. The low volumetric performance means that treatment will usually require large reactors (Eungsung, 2005). It is proposed to tackle this problem by using rice husk and activated sludge as packing material in physico – biological filter since this is much expected to increase the elimination capacity and efficiency.

The physico-chemical characteristics of rice husk lead us to investigate its potential use as a packing material both in filtration systems for removal of hydrogen sulfide. The heart of a biofiltration system is the filter bed or packing material, therefore in this study determination of H_2S removal by physico-biological filter using biofilm or dry activated sludge and rice husk media will be carried out.

3. Objectives:

The main objective is to investigate the removal efficiency of hydrogen sulfide using biofilm (activated sludge) and rice husk in a physico-biological filtration.

The specific objectives are:

I) To determine H_2S removal efficiency (RE) % in each filter using different packing material (Rice husk, dried sludge and both rice husk and dried sludge).

II) To determine H_2S elimination capacity (EC) [g/ m^3. hr] by each filter.

III) To determine the effect of different H_2S loading rates upon removal efficiency

IV) To determine amount of pressure head lose in each filter

4. Literature Review:

In the history of development of biofiltration systems for gas pollutant treatment, packing materials or filter beds have been a key factor in modification as a heart of system.

A great variety of packing materials have been used in biofilters, such as peat, compost (from various sources), bark, and wood chips. Packing materials are selected to provide high specific surface area, high porosity, and compressive strength. Many materials provide satisfactory support for bacterial growth and generally this is not a problem. “Natural” packing such as compost, peat, and soil has been widely used. Compost provides a rich community of microorganisms as well as some mineral nutrients. Both compost and peat decompose with time, causing deterioration of the bed structure and increases in head loss. Adding a bulking agent such as vermiculite, perlite, or woodchips considerably extends the life of natural packing. To keep the pressure drop across the

biofilter to a certain maximum (10 cm water column), the vast majority of biofilters contain a packed bed with a height typically less than 1.2 m (Iranpour, Cox, Deshusses, & Schroederc, 2005).
Elias, Barona et al. (2002) mentioned that the most commonly used biofilter media cited in literature are activated carbon, soil, compost, peat and wood bark.
Morgan-Sagastume and Noyola (2006) carried out a study to remove hydrogen sulfide by biofiltration. In this study the media used as biofilter packing was mature compost produced from food, and yard waste as well as horse manure.
Alvarez (2006) has shown at burning temperatures of 550 ºC to 800 ºC, amorphous silica is formed, but at higher temperatures crystalline silica is produced. The silica content is between 90 and 96% which is a very cost-effective alternative to silica fume.
Della, Kuhn et al. (2002) developed a procedure for obtaining and characterization active silica with a high specific surface area from rice husk ash. The relative amount of silica was increased after burning out the carbonaceous material at different times and temperatures. A 95% silica powder could be produced after heat-treating at 700 ºC for 6 h. The specific surface area of particles was increased after wet milling from 54 to 81m^2/ g.

5. Research Methodology:
This research will be carried out at the laboratory of Environmental Science department in the University Putra Malaysia. The main objective of the present study is to investigate the physico-biological filtration system's performance (removal efficiency (RE %), elimination capacity (EC $g/m^3.h$), and pressure loss) in removal of hydrogen sulfide as a single pollutant using rice husk and dried activated sludge as a packing materials. Figure 1 below is a schematic diagram of the proposed treatment process.

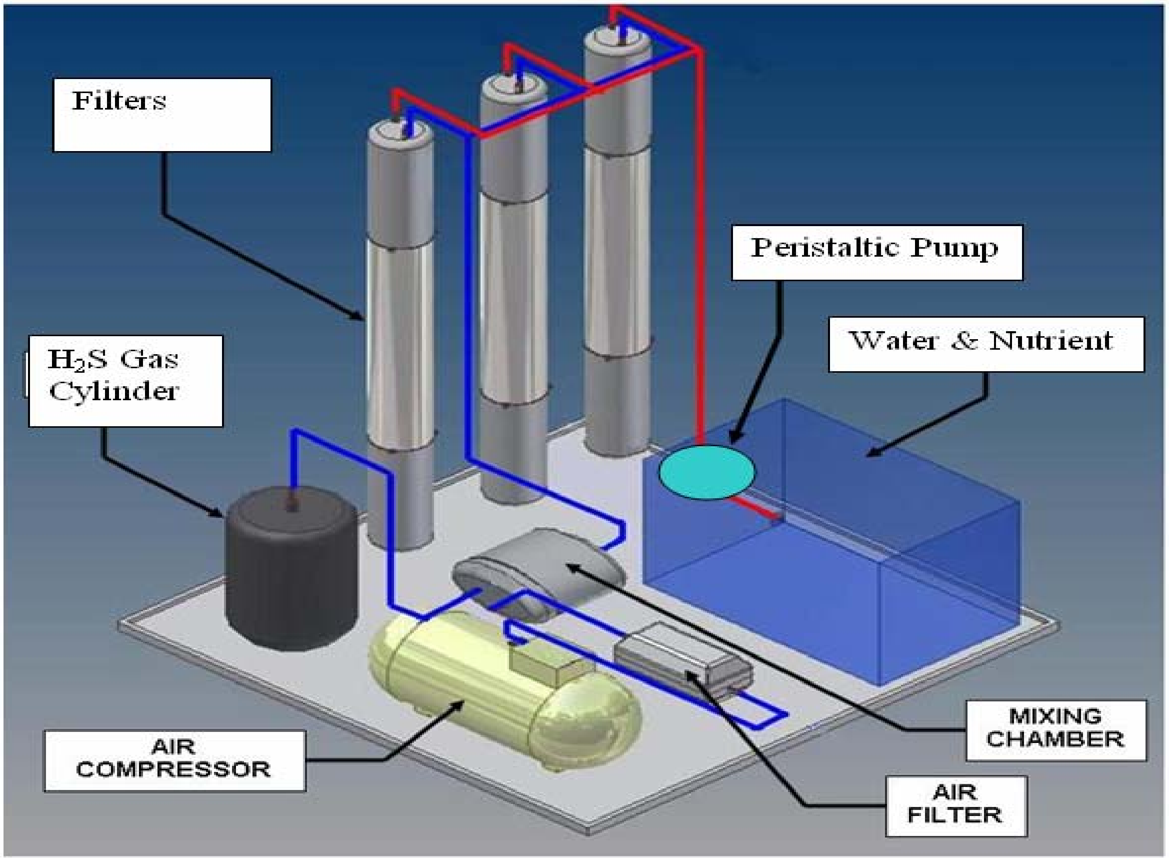

Figure 1: A schematic flow diagram of pilot.

Preparation of Fiters and Packing Materials:

Three separate filters; physical, biological, and physico- biological, about 50 cm in height and 7.5 cm in diameter each have been designed. The malodorous gas (hydrogen sulfide) will be passed through each of the filters using different media. Three packing materials will be prepared for three filters including rice husk as physical filter packing material; dried activated sludge as biological filter packing material; and mixed rice husk and dried activated sludge with rice husk as a physico-biological filter packing material.

In the first filter (the physical filter), rice husk will be used as a filter medium. In the second filter (the biological filter), only dried activated sludge will be used as a filter medium (sludge from Putrajaya sewage treatment plants two, or Putrajaya STP 2). Finally, in the third filter, i.e., the physico- biological filter, a combination of rice husk and biofilm (dried activated sludge) will be used as filter medium.

Following method described by Jamwal and Mantri (2007), the rice husk was washed with water to remove the dirt and other contaminants and then dried in an oven at 110 ºC for 24 hours.

The washed and dried rice husk was then subjected to acid leaching. This was done by reflux in 3% (v/v) chloridric acid (HCl) and 10% (v/v) sulphuric acid (H_2SO_4) for two hours at a concentration of 50 g husk/L. After leaching; the husk was thoroughly washed with distilled water and then dried in an air oven at 100 ºC.

The cleaned husks were then burned inside a muffle furnace in static air at incineration temperature of 600 ºC for four hours.

Sampling:
Inlet and outlet hydrogen sulfide concentrations of each filter will be measured using H_2S sampler pump and the relevant H_2S gas detector tubes.
In biological and physico-biological filters, it is predicted that microorganisms need about two weeks to adapt to gas, packing material, etc., and reach stability conditions. During the adaptation period, biofilter and physico-biofilter will operate at low concentration (about 10 ppm). After adaptation, H_2S concentration will be increased gradually from 50 to 100 to 300 ppm over a period of three weeks. During this period, pressure head loss will be measured every day.
The removal efficiency (RE) and elimination capacity (EC) of hydrogen sulfide are given below and they will be used for evaluation of the performance of the filters (Jeong, Lee, Cha, & Park, 2008; Kun, 2005):
RE (%) = $(CGi - CG_o) / CG_i \times 100\%$
EC (g/ m³. hr) = $[(CG_i - CG_o) \times Q] / V_f$
Where
Q = gas flow rate (m³ / h)
V_f = volume of the filter bed (m³)
CG_i = inlet hydrogen sulfide concentration (ppm; g / m³)
CG_o = outlet hydrogen sulfide concentration (ppm; g / m³)

Statistical Data Analysis:
The relationship between different gas loading rates, hydrogen sulfide concentrations, and filter performance will be explored and quantified using Pearson product moment correlation analysis. This aims at identifying the optimum operation conditions for the proposed filter in terms of removal efficiency (RE%), elimination capacity (EC), and pressure drop) in the different filters.

References:

1.Alvarez, M. (2006). Strength and Durability of Rice Husk Ash-Modified Concrete in the Marine Environment. Florida Atlantic University, Florida.
2.Chung, Y.-C., Huang, C., & Tseng, C.-P. (2001). Biological elimination of H2S and NH3 from wastegases by biofilter packed with immobilized heterotrophic bacteria. Chemosphere, 43(8), 1043-1050.
3.Della, V. P., Kühn, I., & Hotza, D. (2002). Rice husk ash as an alternate source for active silica production. Materials Letters, 57(4), 818-821.
4.Eungsung, K. (2005). Development of a foamed Emulsion Bioreactor for Air Pollution Control. University of California, Riverside.
5.Iranpour, R., Cox, H. H. J., Deshusses, M. A., & Schroederc, E. D. (2005). Literature Review of Air Pollution Control Biofilters and Biotrickling Filters for Odor and Volatile Organic Compound Removal: Published online 30 March 2005 in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/ep.10077.

6.Jamwal, R. S., & Mantri, S. (2007). Utilisation of rice husk for derivation chemicals. from http://www.nandinichemical.com/2007febjournal.html

7.Jeong, G. T., Lee, G. Y., Cha, J. M., & Park, D. H. (2008). Comparison of packing materials in biofilter system for the biological removal of hydrogen sulfide: polypropylene fibrils and volcanic stone. Korean J. Chem.Eng, 25(1), 118-123.

8.Kun, E. (2005). Development of a Foamed Emulsion Bioreactor for Air Pollution Control. University of California Reverside.

9.Mohamed Kutty, S. R. (2001). Removal of heavy metals using rice husk ash. The University of Memphis.

10.Morgan-Sagastume, J. M., & Noyola, A. (2006). Hydrogen sulfide removal by compost biofiltration: Effect of mixing the filter media on operational factors. Bioresource Technology, 97(13), 1546-1553.

11.Perez Ballesta, P., Field, R. A., Fernadez-Patier, R., Gal لn Madruga, D., Connolly, R., Baeza Caracena, A., et al. (2008). An approach for the evaluation of exposure patterns of urban populations to air pollution. Atmospheric Environment, 42(21), 5350-5364.

12,Taghipour, H., Shahmansoury, M. R., Bina, B., & Movahdian, H. (2006). Comparison of the biological NH3 removal characteristics of a three stage biofilter with a one stage biofilter. International Journal of Enviornmental Science and Technology, Vol. 3, No. 4, pp.417-424.