RESEARCH ARTICLE

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Removal of Hydrogen Sulfide from Septic Tank by Vermicomposting Bio Filter

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Background & Aims of the Study: Hydrogen sulfide (H_2S) is a colorless and highly toxic, easily dissolved in water, flammable and explosive gas. Hydrogen sulfide gas is the main cause of odor emissions from municipal sewage plants. One method for removal of hydrogen sulfide gas is the use of biological systems, biofilter. The aim of this study was to survey removal hydrogen sulfide provide in septic tank by vermicomposting biofilter.

Materials and Methods: In this study pilot-scale biofilter has been made of bed vermicompost and wood trash. To survey biofilter performance under real condition, the pilot installed in one wastewater pumping station of Ahwaz city, Iran. The study was carried out over 80 days. Inlet and outlet H_2S concentration were measured on regular basis. To provide an optimal condition for bacterial growth, moisture was adjusted between 40% and 60% throughout the experiment.

Results: Results showed that H_2S concentration emitted from the pumping station during the study varied greatly between 33 and 54ppm .The maximum adsorption capacity of the biological bedding was recorded at 22.4 g/m^3.hr and the mean efficiency of H_2S removal account the startup time was 89.31% .The mean performance efficiency during the biological activity after the startup was recorded at 96.88%.

Conclusion: use up biofilter with vermicompost bed and woodchip is an economic method for H_2S removal of septic tanks. Removal efficiency of more than 96% is expected with this method.

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Background

Septic tank system is the oldest and most common anaerobic treatment system. A septic tank system consists of a tank and an absorption area. The main function of the tank is a biological digestion of an organic waste under anaerobic conditions and then separating bio solids from inlet sewage (1). During wastewater treatment, odor compounds generator engender by anaerobic decomposition of an organic matter containing sulfur and nitrogen (2-3). Odorous compounds have a threshold odor number (TON), which is the concentration of odor not detected by human smell (1-2). When carbohydrates and fat degredated under a septic process, alcohols, short-chain acids and other minor compounds produced such as acetate, ethanol, methane, other organic acids; many of these organic compounds are volatile organic carbons (VOC) and volatile fatty acids (VFA) (2-6). When amino acids, proteins or organic sulfur compounds decomposed under the septic conditions, a group of unsavory sulfur compounds are produced (such as alkyl mercaptane, dimethyl sulfide, dimethyl disulfide) (1-4). In addition an organic compound and several inorganic compounds are generated during anaerobic decomposition (such as ammonia, CO_2, CS_2, CO, H_2S) (2-3). Vermin-composting, a bio-organic fertilizer is obtained from constant passing and slow decaying the organic material by gastrointestinal tract of earthworms' species and disposal of these wastes from their bodies (2-4). The material passes through the gastrointestinal mucosa inoculate with vitamins and enzymes, that ultimately become a rich organic fertilizer and very useful for building and improving soil nutrient. So, vermicompost is worms waste with a percentage of the organic matter and dead worms (3-5). Advantages of vermicomposting to the conventional compost, due to pit-like substance that transformed well and its porosity, ventilation, drainage and water holding capacity are excellent. Vermicompost production reduces plant pathogenic microorganisms (6-8). Aerobic composting process leads to nitrogen mineralization, vermicomposting earthworm accelerate the process (3,9). Hydrogen sulfide gas is main responsible for this situation. Maximum allowable concentration for inhalation of this gas is 10 ppm while the olfactory threshold concentration is 4.7 ppb approximately (9-11). Among toxic material and hazardous gases, hydrogen sulfide is intensity toxic and has a potential damage to central nervous system, even with low exposure dose. This gas is produced from industrial processes such as steam-gas generated from sewage treatment plants and food processing (10). Several processes based on physicochemical principles have been developed for an effective removal of hydrogen sulfide gas from air and waste gases industrial (4); included chemical scrubber, activated carbon adsorption etc. Many of these methods require chemical addition and also require high energy consumption (10-12). In early eighties of 20th century biological systems for H_2S removal are taken into consideration due to secondary pollution reduction, good performance in atmospheric pressure and reducing energy consumption (10-13). It is safe to say that biological process was successful for removing sulfur from natural gas (4,13). In recent years bio filtration is a new technology to control air pollution with low price and high efficiency. Its operation and maintenance is simple without fecal waste (4, 14). In a study carried out at a laboratory scale hydrogen sulfide gas is produced synthetically and injected into the system. Few studies performed to evaluate the performance of biofilter in a pilot-scale with real hydrogen sulfide gas generated from full scale septic tank such as sewage pumping station. Obviously, flow rates and concentration of hydrogen sulfide gas in a sewage pumping station is different with controlled laboratory conditions and consequently results are very impressive (10-15).

Aims of the study:

The purpose of this study was to assess the biofilter for odor treatment in a sewage pump station located at Ahvaz University Town, to determine the biofilter performance for odor removal in real conditions.

Materials & Methods

Methods:

This research carried out in sewage pumping station located at University town of Ahvaz, in Khuzestan province of Iran. Sewage pumping station had two pumps with a maximum discharge of raw sewage with 300 m^3/h. The dimensions of septic tank station were about

3m width in 5 m length and the maximum height was 2 m. In most seasons of a year, especially summer, that temperatures averaging rise up to 43 degrees Celsius, unpleasant odor is caused mainly by emission of hydrogen sulfide gas, which led to widespread dissatisfaction among people. To make the pilot, we used a polyethylene tube with an inner diameter of 20 cm and the height of 160 cm (biological bed height was 70 cm) as a column. At the end of the column a galvanized mesh plate with 2mm diameter holes installed to keep bed material and redistributing air flow inside low part. five air sampling valve with a mesh tube is placed within the column section so we could sampled the air from that point which represent air pass through the sections. At the end of the column, a siphon was installed for drainage. A sprinkling was placed on top of the column to directly control moisture and nutrients. Air supply source was a fan on top of the column, air flow from the bottom to the top of the bed. Inlet air flow rate was calculated from equation (1).

$$Q=\pi d^2/4*v \qquad (1)$$

Where Q is inlet air flow rate, d is diameter of inlet pipe and v is air velocity that measured with velocity meter. Schematic of biofilter pilot is shown in Figure 1.

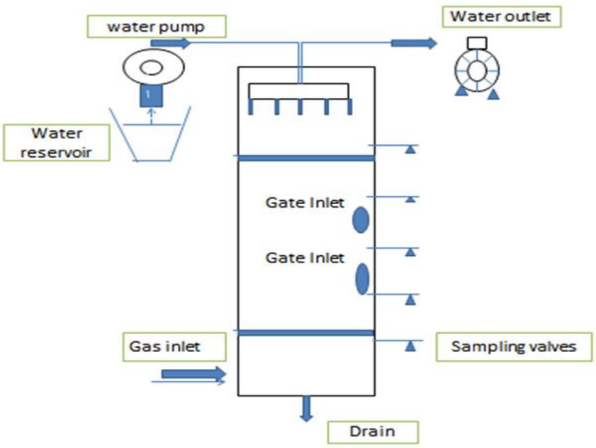

Figure 1) Schematic diagram of the pilot scale vermicomposting bio filter system

Biofilter bed was a mixture of vermicompost and wood chips with weight ratio of 1:4. Reasons for this mixture are to enhance porosity, appropriate conditions for biofilm growth, reducing pressure drop, preventing compaction and root canals. First, bed moisture controlled in 40% to 60% ranges by direct water injection and in the second phase an activated sludge of sewage treatment plant was applied on biofilter bed. Applied activated sludge had BOD equal to 160 mg/l. This sludge was used as a microbial and substrate source to control moisture.

Sampling:

Study period was 80 days. To give microorganisms opportunity to grow, the adaptation period was 20 days. Then every other day samples took from inlet, outlet and intermediate 3 valves of the biofilter pilot. Samples were taken from mid-December 2015 to mid-February 2016. Sampling was done in peak hours of odor emissions which were in morning.

Two samples were taken before biofilter adaptation. Then after system adaptation, every other day sampling continued for 50 days. In each sampling series hydrogen sulfide concentration were measured at intervals of 15 seconds contact time for inlet, three heights and outlet.

Analysis Methods

Portable TESTTO 350 gas detector was used for measuring hydrogen sulfide which measure hydrogen sulfide gas from 0 to 300 ppm range. Gravimetric method was used to measure the bed content moisture. Such that 10 grams of biofilter bed sample weighed, then sample was put in oven at a temperature of 104°C for 24 hours and weighed again. After that substrate moisture content was calculated. To measure bed pH, 10 grams of bed substrate sample mixed with 100 ml of distilled water and stirred for 20 minutes, then after 10 minutes pH measured, using a digital PH meter. To measure bed content temperature a thermometer was used. Retention time calculated, using the following equation (t=Q/V); Where t is detention time, Q is air flow entering the system and V is bed volume. Sampling valves was embedded at intervals of 17.5 cm of bed column height to obtain detention times of 15, 30 and 45 seconds. Air flow velocity measured by TES 1369B Heat Stress Monitor. To adjust retention time in biofilter bed air flow adjusted for 0.1 meter per second. Bed volume was 0.371 cubic meter; Therefore, total retention time was 12 seconds. Bed height was 70 cm, sampling valves intervals was 17.5 cm; therefore, retention times were 15, 30 and 45 seconds for valves 1, 2 and 3, respectively.

Results

Survey the biofilteration performance at the time of operation

Biofilteration system efficiency base on equation 2 to determination hydrogen sulfide gas removal efficiency was analyzed (RE). (16)

$$RE=C_{in}–C_{out}/C_{in}*100 \qquad (2)$$

In this equation C_{in} and C_{out} are inlet and outlet concentrations hydrogen sulfide gas at PPM. Figure 2 presented the removal efficiency percentage for 80 pilot operation period for retention time of 12 seconds (bed thickness 70 cm) with hydrogen sulfide gas inlet and outlet concentrations. As showed in Figure 2, the operation period divided three phases which include start-up phases (first three weeks). Water injection period for adjust the optimum moisture and increase the efficiency of biological wastewater injection. Base on figure 2, the first 20 days period titled the start-up and microorganisms adaptation with environmental and system efficiency are in medium level. What was occurred in this period? the adsorption of hydrogen sulfide was occurred which usually in first days complete adsorption bed capacity.

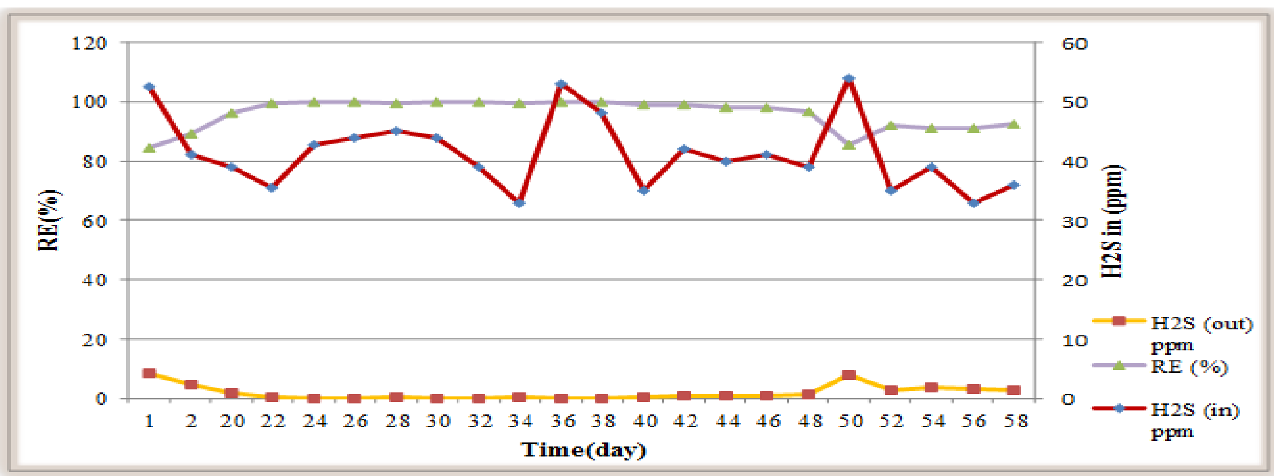

Figure 2) Hydrogen sulfide gas removal ration at inlet and outlet concentration of the vermicomposting bio filter

Table1) Mean and Std. deviation quality parameters in removal efficiency H_2S

	Mean	Std. Deviation
Influent	41.4000	6.18439
H_2S_{eff}	1.7182	2.43909
Removal Efficiency	95.9727	5.04321

Biofilter removal capacity

Removal capacity according to equation 3 and inlet mass load is defined base on the equation 4 (18).

$$EC= (C_{in}-C_{out})*Q/V \qquad (3)$$

$$ML=C_{in}*Q/V_B \qquad (4)$$

In above equations EC is removal capacity. ML is inlet mass load. C_{in} and C_{out} are inlet and outlet concentration at ppm. Q_{in} is passing air volume of bed at cubic meter per hour and V_B is bed volume at cubic meter. Hydrogen sulphide gas concentration measured at the sampling time which was between 33 to 54 ppm for retention time of 12 seconds, the entrancing air flow was adjusted equal 3.14 liter per second. In figure 3, hydrogen sulfide gas removal capacity variations has been shown versus inlet mass load variations.

Effect of pH on removal hydrogen sulphide gas by vermin-composting biofilter

Figure 4 showed the effect of pH bed on removal hydrogen sulfide gas by vermicomposting biofilter. The first day of start-up biofilter media pH equivalent vermicompost pH was 7.87, which used titled media.

Effect of retention time on biofilter removal efficiency

Effect retention time on biofilter removal efficiency showed in Figure 5. This Figure shows that in retention times between 15, 30 and 45 seconds the removal efficiency in the second 15 decreased 87.92 percent.

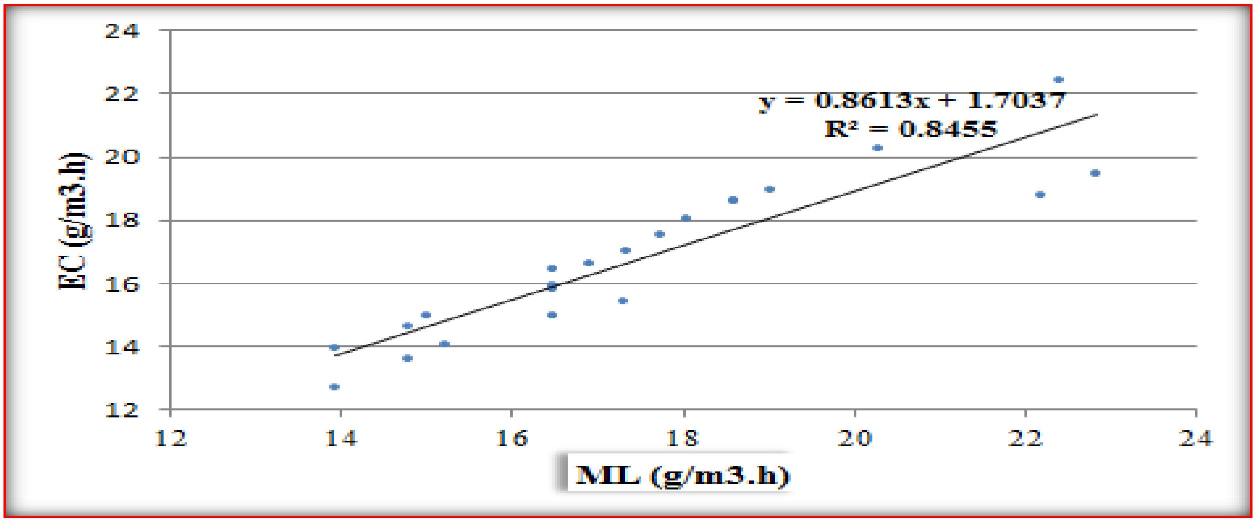

Figure 3) The relation between the elimination capacities (EC) of H_2S and Mass loading (ML).

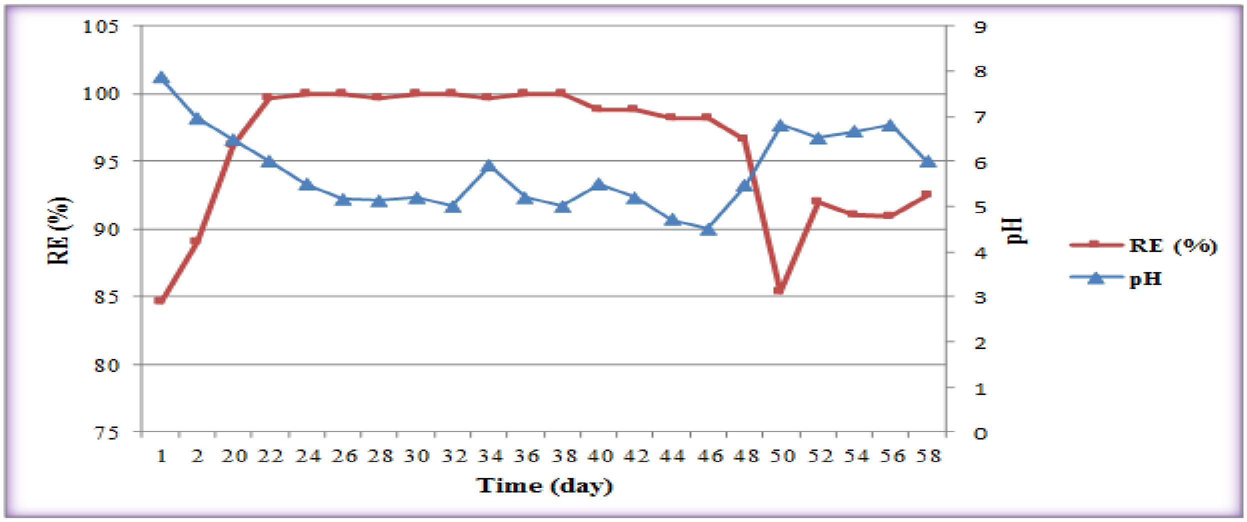

Figure 4) Effect of pH bed on removal hydrogen sulfide gas by vermicomposting biofilter

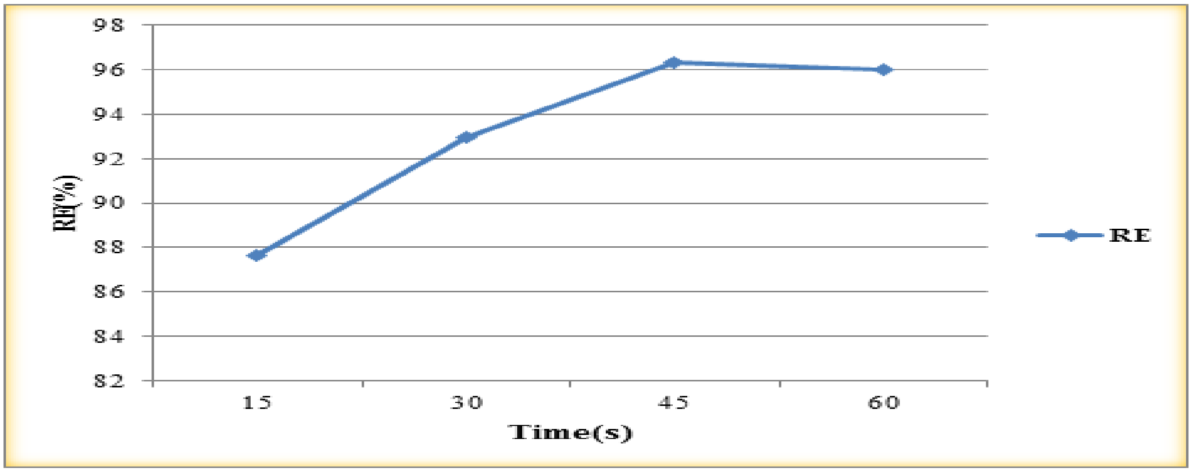

Figure 5) Effect retention time on biofilter removal efficiency

Discussion

Beginning of the system biological operation improvement could be seen in third week. After this time, the removal efficiency receive to 100 percent. One of factors that can shorten bed operation time is inlet concentration which pollutant concentration is greater. Time of beginning biodegradation activity is reducing. The average biofilter performance with computation start-up period was 89.31 percent and average performance in biological period was 96.88 percent. In some previous studies that had been done on compost had attained the result which was close to this study (9,17-18). According to figure 3, the greatest capacity of hydrogen sulphide removal by vermicomposting bed and wood trenches was equal 22.4 g/m^3.hr. Too relationship loading rate with biofilter removal capacity for hydrogen sulphide treatment was linearly which was demonstrator inlet mass high correlation with bed removal capacity the correlation coefficient between removal capacity and inlet mass load was equal 0.92. Some point located in underline associate with start-up period which system had low efficiency. In some studies which was done on compost results get similar shapes (9,18-20). Based on the result of this study, hydrogen sulfide gas in side system bed pH was decreasing so that at day of 34, it received to 4.7. From day 20 to 38, hydrogen sulphide removal efficiency was excellent in optimal level; so that, the average removal efficiency was obtained 99.52 percent. In this period, pH fluctuation was in range of 5 to 6. After day of 46, removal efficiency decreased and one of the reasons added more moisture to the bed for increase the bed pH to determine the effect of pH on the removal efficiency (4,18). By regression analysis distincted that it was a direct correlation between pH and H_2S and the correlation coefficient between this two parameters was 0.72.

According to the result of this study, the removal efficiency in the second 15 decreased with 87.92 percent. The best removal efficiency obtained in 45 second (4,18).

Conclusion

In this research biofilter system in a pilot scale was evaluated for treating odors emitted of the Ahwaz university sewage pumping station. The biofilter start-up period was about 14 days. In the pilot made of third day with drinking water for bed moisture control and also the efficiency increased with the injection of raw sewage to the biological bed. According to the obtained results, the average removal was at retention times of 30, 45 and 60 seconds were 87.25%, 92.98% and 96.3% respectively. The greatest capacity of hydrogen sulfide gas removal with vermicompost bed and trenches wood was 22.4 $g/m^3.h$. Also, the average removal efficiency account of the start-up period was 89.31% and the average removal efficiency in biological activity was 96.88 percent. As use of vermin-composting bed with wood chips ratio (1:4); it seems that one of the effective ways to impressive reduction odor and use of that is to bed biofilteration.

Footnotes

Conflict of Interest:

The authors declared no conflict of interest.

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