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Detection and removal of hydrogen sulphide gas from food sewage water collected from Vellore

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ABSTRACT

The Present research deals with the detection of hydrogen sulphide a malodorous and subsequent removal of the gas by using bi sulphide ion consuming photosynthetic bacteria for the treatment of household sewage water. The detection of the hydrogen sulphide is estimated by using methylene blue method. The gas hydrogen sulphide is the cause of many health effects especially is combination with ammonia which is estimated to be the maximum in concentration in household sewage water. The ammonia is removed by a chemical method followed by the removal hydrogen sulphide gas by the biological method. Hydrogen sulphide and ammonia are most commonly seen malodorous gases encountered during sewage water treatment. Ammonia gas is found in almost all household sewage water in the maximum concentration. This gas in combination with the other gases released during treatment or accumulation of sewage waste water shows a greater impact on the health of human compared to individual gases. Odour emitted by wastewater treatment is an indication of an anaerobic process. Early stages of processing leads to the formation of toxic gases, like Hydrogen sulphide (H_2S), Sulphur dioxide (SO_2), Bromine, Chlorine and oxides of nitrogen. Malodorous gases require gas phase filters prior to exhausting from irrigation tanks. Detection and removal of hydrogen sulphide gas from food sewage water collected from Vellore was achieved within 15 days.

Keywords: Hydrogen sulphide, ammonia, struvite, N, N-dimethyl-p-phenylenediamine

INTRODUCTION

Waste water treatment is the process of removal of contaminants from wastewater and household sewage. Waste water treatment plant in residential areas causes a lot of legal, political and health problems. The waste water treatment odour is a very common problem associated with this. Over the years chemicals and enzymes have been used for treatment of odour arising from sewage treatment plants. Effluents collected from various residential and industrial sources. The treatment levels vary according to the level of biodegradability of the influent sewage.

Odour emitted by wastewater treatment is an indication of an anaerobic process. Early stages of processing leads to the formation of toxic gases, like Hydrogen sulphide (H_2S), Sulphur dioxide (SO_2), Bromine, Chlorine and oxides of nitrogen. Malodorous gases require gas phase filters prior to exhausting from irrigation tanks. [2, 5, 7]

The substances responsible for the diffusion of odours into the atmosphere in the vicinity of treatment plants are generally gaseous inorganic products or highly volatile compounds. The former are mainly the result of biological activity in the sewage, the latter are often caused by the presence in the sewer of industrial wastes. The following compounds are associated with bad odours: mercaptans, skatoles, indoles, inorganic acids, aldehydes, ketones and organic compounds containing nitrogen or sulphur atoms. These compounds can originate from the anaerobic decomposition of compounds with a high molecular weight, especially proteins. These are recognized as being among the causes of bad-smelling odours at the outlet of sewer lines and in treatment plants in general [3, 8]

Hydrogen sulphide (H_2S) is generated in aqueous phase of sewage water by bacterial reduction of sulphate under anaerobic conditions [2, 6]. The hydrogen sulphide pile up causes many problems during sewage or waste water treatment. Oxidation of hydrogen sulphide causes corrosion of concrete and metal substances due to formation of sulphuric acid. This gas poses significant risk to sewage treatment plant workers and communities exposed to this gas for longer period of time. The prolonged causes many health problems in women and infants.

High sulphate contents may cause a laxative effect in infants and cause extreme dehydration. Also high hydrogen sulphide content is an indicative of the presence of coliform bacteria and is needs to be tested for it. It can affect if it is inhaled or comes in contact of eyes, nose or throat. Low concentration inhalation causes dizziness, headache and nausea. If the gas is inhaled in higher concentration then it may cause unconsciousness and even death of the individual. The gas paralysis the respiratory centre of brain and olfactory nerve deadening the sense of smell [4].

There are many sensor systems available to measure the hydrogen sulphide concentration in a sample. In aqueous phase bi sulphide exists in equilibrium with hydrogen sulphide and absorbs the light in ultraviolet wavelength [9, 13].

The most commonly present gases in sewage water are ammonia, hydrogen sulphide, mercaptans and biphenyl sulphate. The parameters to express the concentration of odour are absolute threshold concentration, threshold odour number, threshold limit value, maximum allowable concentration. The values of these parameters for standard. (Table 1)

Table 1: standard values of parameters associated with malodorous gases in sewage water

Compound	ATC (ppm)	TLV (ppm)	MAC (ppm)	Olfactory sensation
Hydrogen sulphide	0.00047	10	50 (US), 20(UK)	Rotten Eggs
Ammonia	46.8	25	37.5 (UK)	Pungent
Methyl Mercaptans	0.0021	10		Rotten cabbage
Carbon disulphide	0.21	20		Sweet/pungent
Biphenyl sulphide	0.0047			Burned rubber
Dimethyl sulphide	0.001			Rotting vegetables

Ammonia gas is found in almost all household sewage water in the maximum concentration. This gas in combination with the other gases released during treatment or accumulation of sewage waste water shows a greater impact on the health of human compared to individual gases.

Inhalation of ammonia acutely causes variety of respiratory condition like including laryngitis, trachea bronchitis, bronchiolitis, bronchopneumonia and pulmonary oedema.The patients that survive the acute phase may develop a disabling pulmonary disease characterized by bronchiectasis, airway hyper reactivity, bronchiolitis obliterans, chronic obstructive pulmonary diseaseand occasionally interstitial lung disease [16]

Ammonia

Ammonia is a pungent smelling gas present in the maximum concentration in all household sewage water. Ammonia is removed using a chemical precipitation method in which ammonia is removed in the form struvite orthorhombic white precipitate. The precipitate can also be used as a potential slow acting fertilizer.

Chemical reaction of ammonia test

The concentration of ammonia in a sample is determined by titrating with known concentration of sulphuric acid. The tittered value can be used to analyse amount of ammonia removed after treatment. The treatment involves the addition of potassium hydro phosphate (KH_2PO_4, $MgCl_2$) to precipitate the ammonia as white orthorhombic crystalline structure Struvite.

$$Mg^{2+} + NH_4^{+} + H_nPO_4^{3-n} + 6H_2O \leftrightarrow MgNH_4PO_4{\cdot}6H_2O + n\,H^{+}$$

Hydrogen sulphide

The gas hydrogen sulphide reduces the redox potential and prevents the natural re-aeration. Low speed sewage triggers intense activity of sulphur reducing bacteria and increases hydrogen sulphide production particularly and high temperatures. Hydrogen sulphide consuming photosynthetic bacteria like *Thiocystis violacea, Thiodictyan elegans, Lamprocystis* species, Allochromatium etc. that are commonly found in marshy soil. These bacteria consume the free hydrogen sulphide, present in the sewage water and prevent the rotten egg smell typical to the gas. The gas may also display certain different smell after mixing of different malodorous gases.

The hydrogen sulphide gas and the bi sulphide exists in equilibrium in aqueous phase at neutral pH value. The equilibrium can shifted by changing the pH of the sample. This helps in easier detection of the bi sulphide ion instead of the hydrogen sulphide gas by spectrophotometric analysis. The UV spectrophotometric analysis has shown.

The hydrogen sulphide gas is detected using a UV spectrophotometer method. The procedure requires N, N-dimethyl-p-phenylenediamine dihydrochloride (methylene blue dye), ferric chloride ($FeCl_3$, 1.6 g dissolved in 100 mL 6M HCl), the dye binds to the gas and forms a complex that can indicate the concentration of the gas in the sample. The concentration of hydrogen sulphide in the sample sewage water sample was measured before and after treatment with photosynthetic sulphur bacteria, to determine the reduction in sulphide ion concentration after treatment [fig. 1]

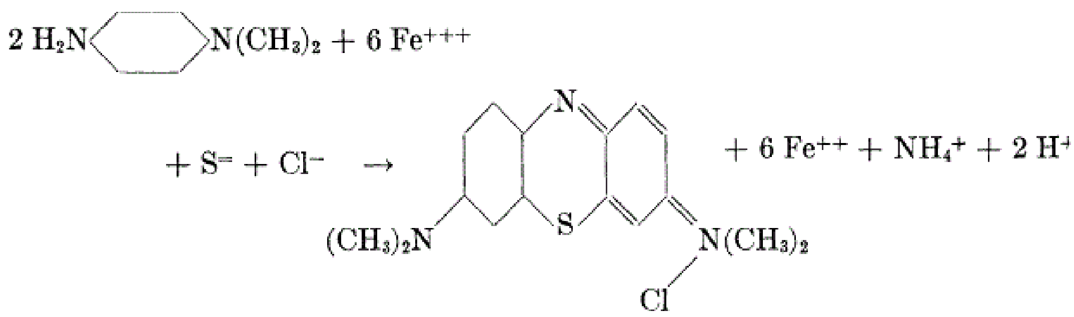

Fig 1: methylene blue method reaction

Chemical reaction of sulphide test

The sulphide test is based on the ability of hydrogen sulphide and acid-soluble metallic sulphides to convert N, N-dimethyl-p-phenylenediamine directly to methylene blue in the presence of a mild oxidizing agent (acidified ferric chloride). Intensity of the methylene blue colour development is directly proportional to the amount of sulphide present in the original sample. A colorimetric measurement of this intensity provides an accurate means to determine the sulphide concentration. This method is called the methylene blue technique [12, 15, 11].

MATERIALS AND METHODS

The ammonia in the sewage water is removed using a chemical method for easier removal of hydrogen sulphide gas. Microorganisms living in the marshy soil are sulphur consuming bacteria. At 10^{-6} concentration the bacteria are cultured and inoculated in the sewage water samples. The concentration of the of hydrogen sulphide present in the sample is quantified using spectrophotometric analysis on the sample. The overall sulphide ion removal is determined by spectrophotometric analysis.

Ammonia treatment

For this analysis, 10 ml of sewage water samples from the sewage treatment plants from the nearest source was collected [fig. 2]. Equal volume of KH_2PO_4 and $MgCl_2$ with same volume of sewage water sample was added. After that the mixture was vortexed and let the precipitate to be settled as shown in fig 4. The remaining sewage water sample was decanted and transferred to the aqueous part for hydrogen sulphide treatment.

Hydrogen Sulphide treatment

13.5 g of nutrient broth medium was added to 200ml distilled water, and mixed thoroughly. Then about 2 g of agar was added to the mixture and mixed well. One gram each of the salts mentioned in the materials requirements was added to it. The mixture was plugged and autoclaved for 30 min and then transferred into a laminar airflow. The petri dishes along with the media were sterilized. The media was poured into two petri dishes and allowed to solidify. Marshy soil sample was serially diluted in the laminar airflow. [fig 3] After the medium solidified 1 ml of the serially diluted sample of concentration 10^{-6} was poured on the media. The sample was spread using an L-rod without damaging surface of the agar medium. The petri dish was labelled as culture and the other as control and was placed in incubator for 18-24 hours. Sewage water samples was collected from different sewage treatment plant in the institute and labelled. Replicate of each tubes was also prepared. A standard solution was prepared using sodium sulphate salt by adding 1 g of Na_2S to 1ltr of distilled water. The colonies of different microorganisms were inoculated into the sewage water sample. [fig 5, 6] 2ml of each sample was taken and 0.16ml of N, N-dimethyl-p-phenylenediamine is added along with 0.16ml ferric chloride is added and mixed thoroughly and kept for two hours. The O.D value of sample was noted at 230 nm for each sample and replicate. The sewage water samples were placed on a shaker for uniform mixing and for the microbial culture to grow. The O.D value of treated sample was noted after the treatment time. After determining the O.D values the replicates were used as controls to determine any change in hydrogen sulphide concentration in the absence of inoculated microorganism. The difference was used to analyze the changes caused by the microorganisms in the marshy soil. The values were tabulated and the concentrations hydrogen sulphide was determined.

Fig 2: sewage water sample

Fig 3: marshy soil sample

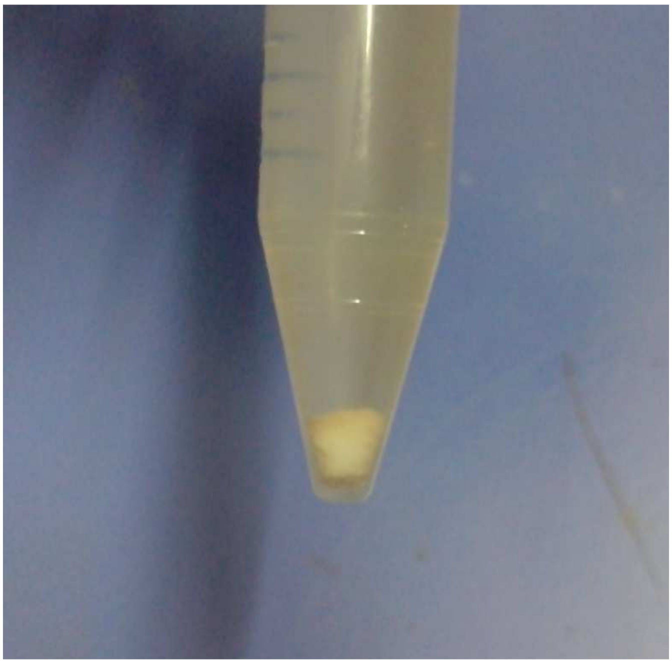

Fig 4: struvite precipitated

Fig 5: control plate of culture plate

Fig 6: sulphur bacteria colonies found in marshy soil

RESULTS AND DISCUSSION

The addition of sulphur consuming photosynthetic microorganisms have shown a decrease in the levels of hydrogen sulphide in the sewage water samples. The sulphur consuming microorganisms are able to consume hydrogen sulphide and convert them into less malodorous and less toxic gases compared to hydrogen sulphide. There are also significant indication of the presence of certain organisms other than the one's inoculated into the food sewage water that consume the malodorous gases (Table 2).

Table 2: O.D values of hydrogen sulphide analysis by methylene blue method

Samples	O.D values before treatment	O.D values after treatment	O.D values of sample controls
After 2 hours			
S1	0.134	0.126	0.130
S2	0.126	0.121	0.123
S3	0.136	0.130	0.134
After 4 hours			
S1	0.134	0.125	0.127
S2	0.126	0.120	0.122
S3	0.136	0.129	0.132

The O.D readings of the sewage water suggests that there is a decrease in the amount of the untreated sewage sample for hydrogen sulphide for the first two hours, but after a period of four hours there is no further decrease due to the microorganisms present already in the sample. The inoculated sewage water sample exhibits an increased consumption of hydrogen sulphide compared to the untreated sample.

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