Volatile Organic Compounds Emission From Wastewater Treatment Plant- A Review

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Abstract- *Volatile organic compounds are the chemicals with low boiling point that can be volatilized under normal atmospheric temperature and pressure. Sources of these compounds can be biogenic, natural, or anthropogenic. Wastewater treatment plants are among the anthropogenic sources of VOC which have the potential to release tremendous amount of these pollutants to atmosphere every year. It has been investigated that many of these VOCs have potential to pose health risks to human being and environment. Various sampling techniques have been adopted for VOC emission from wastewater treatment plant. Wastewater samples can be collected and then injected to GC-MS to detect dissolved VOC and VOC meter can also be used to find out gaseous VOC. In this review paper all the above aspects of VOC emissions have been discussed.*

Keywords- Biogenic source, GC-MS, VOC emission, wastewater treatment plant

I. INTRODUCTION

Volatile organic compounds, usually written as VOC, are organic chemicals that have low boiling point and can be evaporated in low atmospheric temperature. Sources of these compounds can biogenic or anthropogenic. Biogenic sources refer to the natural sources that these organic compounds evaporate from the surface of vegetables and leaves of trees.
Biogenic sources make largest rate of the emissions that releases to atmosphere and it is difficult to control it, while anthropogenic sources like wastewater treatment plants, chemical industries, petrochemical industries, paints, municipal solid waste landfill, fossil fuels and ... etc have less impact on overall emissions of VOC and can be controlled by taking controlling measures.

It has been observed that volatile organic compounds have the potential to create secondary air pollutants while they release to atmosphere. Ground level ozone (O_3) is formed from reaction of volatile organic compounds and NO_X in presence of light. It has been estimated that volatile organic compounds, due to rapid dispersion, have less effect on global warming and climate change.

II. HEALTH IMPACTS OF VOLATILE ORGANIC COMPOUNDS

It is clear that volatile organic compounds emission has adverse effect on human health and environment. Main parameters that cause these adverse effects are chemical composition, size and concentration of these chemicals. An important group of aromatic VOCs is formed by Benzene, toluene, ethyl benzene and Xylene. From the four aromatic VOCs benzene is included in Group 1 carcinogen by international agency for research on cancer. Toluene, ethyl benzene and Xylene have also been found that poses risks to neurological and respiratory systems. Wastewater treatment plants as a source of aromatic VOC emissions have the potential to cause serious problems to human health and environment.

Health problems that can be caused by VOC are nose and eye irritation, fatigue, headache, asthma and in worst condition, where the concentration of these chemicals is high, cause cancer.

Odorous VOCs and risk of exposure to these compounds has been investigated by J. Lehtinen and A. Veijanen [5]. A wastewater treatment plant with activated sludge process was considered for this research study. The said plant treats municipal as well as industrial wastewater and the capacity of plant is 4.3 million m^3 per year. Analysis of wastewater samples was done by GC-MS. They found that odour is mainly caused by sulphur containing compounds and some aromatic compounds such as toluene, styrene and 4-methylphenol.

The concentration of volatile organic compounds, found in this research work, was compared with Finnish occupational exposure limit. It has been observed that the concentration of most of these chemicals exceeds the prescribed limits.

Majumdar, Mukherjee and Sen [6] investigated the concentration of volatile organic compounds and estimated the risk of exposure to these compounds in Kolkata, India. They calculated the daily occupational exposure to these chemicals

using equation given by US Environmental Protection Agency, 1990.

E= C*IRa *ED/BWa

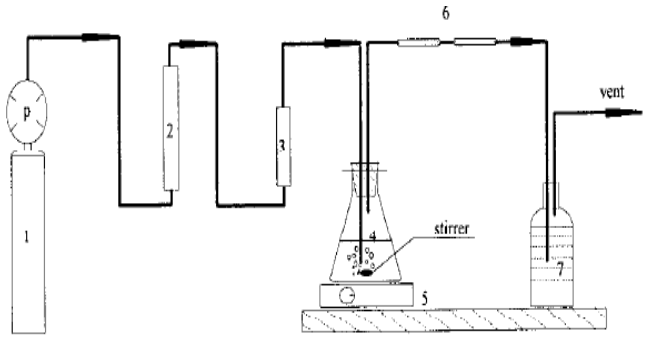
Where C is concentration (mg m^{-3}) of the target pollutant; IRa is the adult Inhalation Rate (0.83 m^3h^{-1}, US Environmental Protection Agency, 1997) (0.63 m^3h^{-1}, US Environmental Protection Agency, 1990); ED is exposure duration, (8 hd^{-1}); and BWa is adult body weight (70 kg).

Similar kind of equation can be adopted for calculating effective yearly exposure to volatile organic compounds. After calculating non cancer hazard and cancer risk for different age groups, they concluded that the estimated values are exceeding prescribed limits. This research indicated that significant cancer risk can be posed to people living in Kolkata city.

III. SAMPLING TECHNIQUES OF VOC

Different sampling methods are available for detection of volatile organic compounds. Common practice is that either it has to be detected in aqueous form or in gaseous form. Static headspace purge and trap and closed loop stripping analysis were the methods for detection of VOC previously.

Lawrence C.C.Koe and W.Shen [3] investigated the emissions of volatile organic compounds in a wastewater treatment plant using Gas chromatography- Mass spectroscopy (GC-MS) technique. Sewage samples were collected from a municipal sewage treatment plant which has capacity of 286 m^3/day. Samples were taken from various treatment units, primary sedimentation tank, aeration tank, secondary sedimentation tank and a sludge digester.PVC bottles were provided for sampling and samples were transported to environmental laboratory immediately after collection. The volume of wastewater sample used for each air stripping run was 300ml and sludge sample was diluted in distilled water. Diluted sample was purged with nitrogen gas to assure absence of organic volatiles. Process of stripping has been done on wastewater and sludge samples in room temperature.



1. nitrogen cylinder 2. dryer 3. flow meter 4. 500 mL flask
5. magnetic stirrer 6. Tenax tubes 7. activated absorber

Figure 1: Sample stripping assembly

It has been found that the halogenated compounds' concentration was less, eg. Tetrachloroethene 1.397 $\frac{\mu g}{L}$ but the aliphatic compounds were found in high concentration up to $10\frac{\mu g}{L}$.

Ben-Zen Wu et al [8] investigated VOC emissions from wastewater treatment plant and drain system near an industrial park in Hsinchu, Taiwan. Sampling points were selected in the wastewater streams that receive rainwater and in wastewater streams that effluent is discharged. Additional sampling points were also selected for monitoring in nearby areas. Spatial variation of VOC was determined by taking air samples (grab sample) from various treatment units (1m above water surface). Wastewater samples have been taken from said units simultaneously.

In order to investigated temporal variation of VOC emissions online GC/MS system equipped with automatic sampling device was installed on site. The average VOC concentration was found to be 93.3 ppbv and the highest VOC concentration was observed during 1:00-2:00 PM. According to meteorology department of Taiwan there was a 7.7 ◦C (33.1 ◦C at noon and 25.4 ◦C at dawn) increase during that time. Minor data fluctuations were observed due to influence of wind.

IV. CONTROL OF VOC EMISSIONS FROM WASTEWATER TREATMENT PLANT

Several methods are available for controlling VOC emissions from wastewater treatment plant. Previously air stripping or activated carbon treatment were the solution for VOC emissions but soon after it has been shown that air stripping cause to another problem which is air pollution. Nowadays pervaporation is adopted for VOC removal from wastewater treatment plants. Pervaporation (PV) is a

separation process in which minor components of a liquid mixture are preferentially transported by partial vaporization through a non-porous permselective (selectively permeable) membrane.

Krystyna Konieczny, Michad Bodzek, Dorota Panek [4] investigated application of pervaporation to the treatment of industrial wastewater generated from chemical industry. Two types of pervaporation membranes have been utilized, polydimethylsiloxane (PDMS), and its modificationpolyoctylmethylsiloxane (POMS). Each experiment took 5 h. Every hour a sample was taken from the feed tank and the concentration of the toluene content was measured by GC-FID analysis.

It has been observed that both PDMS and POMS membranes gave reasonable results. Toluene removal efficiency from these membranes was achieved about 90 percent. It can be concluded from this research study that PDMS and POMS can be alternatives for removal of VOC from wastewater.

Riyad J. Abumaizar et al [1] investigated the biofiltration of BTEX contaminated air streams using compost-activated carbon filter media. Three laboratory-scale biofilter columns were utilized to investigate the removal of benzene, toluene, ethylbenzene, and o-xylene _BTEX from a waste gas stream.

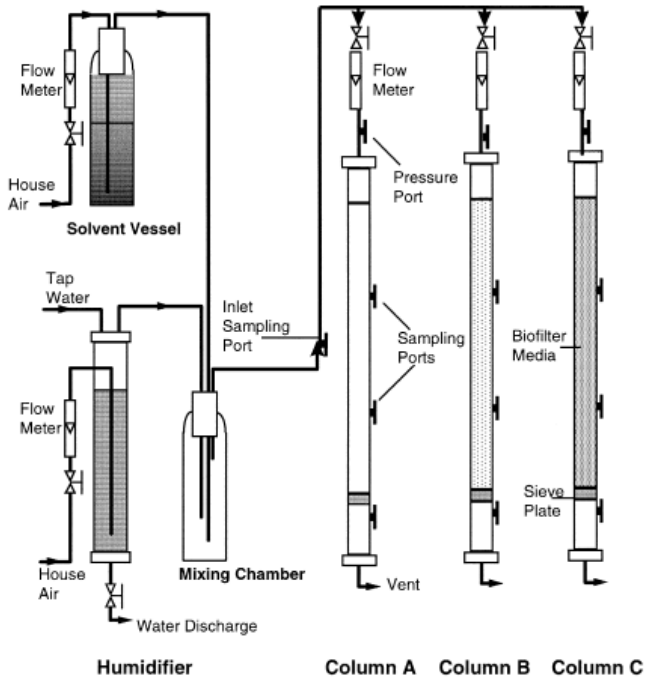


Figure 2: Schematic of three column biofilter system

Mixture of yard waste and sludge compost was used as biofilter material in the columns. Removal efficiencies of ≥90% were achieved for inlet concentrations of ≥200 ppm of each of the BTEX compounds.

V. CONCLUSION

From the above study it can be concluded that VOC emission from wastewater treatment plant is major concern for downwind receptors, plant operators and flora and fauna exist in the premises of plants. VOCs emission can be determined by various sampling techniques followed by GC-MS. It has been investigated that a number of VOCs are carcinogenic and has adverse effect on central nervous system.

To control the emissions of these VOCs some modern techniques are adopted, pervaporation is one of them. It has been shown that pervaporation has the potential to remove almost 90 percent of the VOCs exist in wastewater.

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