

Assessment of Toxic and Flammable Gas Formation in Sewer System of A City

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Abstract- Several numbers of accidents has occurred while performing a job inside sewage manholes and pit many of them are fatal accidents this is due to lack of basic awareness of worker working in confined space are and dealing toxic as well as flammable gases present inside the sewer system. This paper deals with various hazards related to working in sewer system and tells us about what are the safety precautions that need to be taken before entering the sewer system so as to reduce the number of death of sewage cleaning workers.

Keywords- Flammable, Toxic, Lethal, Hazardous.

I. INTRODUCTION

Sewage system is water conveying system that carries waste water from different part of cities to a predefined place which mainly is effluent treatment plant this water carrying system is network of sewage mains and manholes with different diameters. Since this sewage system is used every day it is important to maintain it after a period of time while performing this there is threat to life because of confined space and the presence of toxic and flammable mixture present in sewer manholes. The concentration of this mixture can be huge if the sewer was closed for a long period of time due to anaerobic condition.

There several case studies that shows how hazardous this sewer cleaning job is, several number of fatalities has occurred while performing this work, Some of them are even lethal that may cause death of the sewage worker this is due to following reasons given below which are discussed in detail further-

1. Oxygen deficiency
2. Presence of toxic and poisonous gases inside sewers
3. Explosion hazard due to the presence flammable gases inside sewers
4. Musculoskeletal Disorders
5. Infections

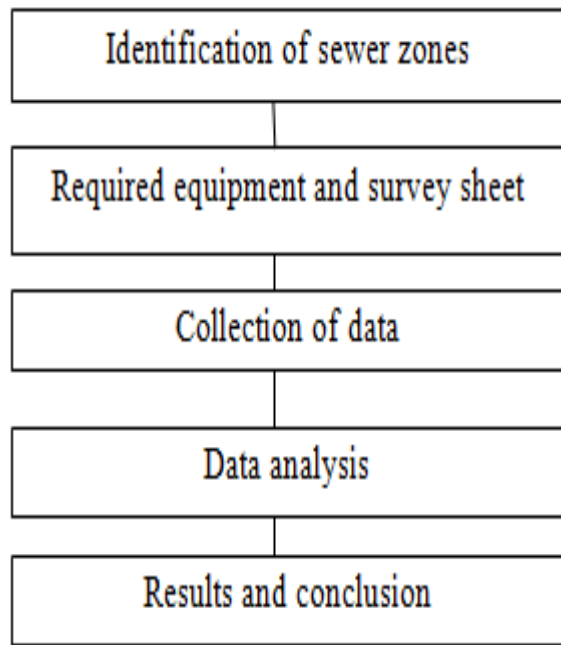
II. METHODOLOGY

A limited study has been done for emission of methane inside sewer but since it is explosive in nature it has high risk of fire and explosive hazard also Methane is a highly potent greenhouse gas, which is significantly contributing to climate change. A live survey method to determine the level of flammable gas which is present inside the sewer system. As per OSHA standards the LEL of methane is given below-

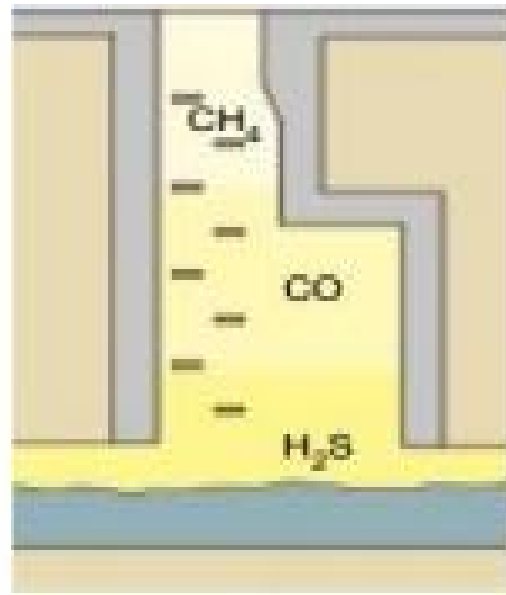
TABLE 1: Properties of methane

S.No	Hazardous gas	OEL (ppm)	Relative density	LEL/UEL
01	Methane	----	0.6	5.3-15%

This can be done in two parts continuous monitoring of methane concentration in both gaseous and liquid phase is important for the accurate quantification and overall understanding of methane production and emission from sewer. Since the determination of Methane from liquid state will take longer period of time and lot of laboratory work so we have used the gas monitoring with help of detector. This is the best way to obtain data because it is realistic and accurate. It is done by help of flammable gas detector which shows the lower explosive limit (LEL) concentration of flammable gas.



Methodology process Fig. : 1



Accumulation of methane in sewer Fig. 2.

Down below are some important points on the basis of which a survey sheet has been made-

1. General information.
2. Pre entry requirement check list.
3. Environmental factor.
4. Entry and work precautions safety equipment used.
5. Methane concentration in sewer.
6. Emergency response plan.
7. after work completion.
8. Summary of work.

III. DATA OBTAINED

The data obtained as an experimental data taken by the monitoring instrument which detects the lower flammability of methane gas inside the sewers at different areas in three different zones. For calculations we have taken the average of these obtained values so as to determine which zone has the maximum concentration of methane gas inside the sewer.

After obtaining these data of different part of the city an observation table is made in which the concentration of methane gas is noted which is present inside the sewers with the help of monitor. These readings are just after opening the sewerage because the methane gas is lighter than air therefore it accumulates at the upper region of the sewers as given in the figure below.

TABLE 2: Data collection table

S.NO.	AREA/ZONE	PERMISSIBLE EXPOSURE LIMIT	OBSERVED LEL
1	Location P Sample 1	LEL%(<5)	8.0
2	Location P Sample 2		6.58
3	Location P Sample 3		7.43
4	Location Q Sample 1		6.7
5	Location Q Sample 2		5.8
6	Location Q Sample 3		6.9
7	Location R Sample 1		6.6
8	Location R Sample 2		7.4
9	Location R Sample 3		6.9
10	Location S Sample 1		5.93
11	Location A Sample 1		5.7
12	Location A Sample 2		6.6
13	Location A Sample 3		6.2
14	Location B Sample 1		5.9
15	Location B Sample 2		5.6
16	Location B Sample 3		5.7
17	Location C Sample 1		4.3
18	Location C Sample 2		5.0
19	Location C Sample 3		5.4
20	Location D Sample 1		4.0
21	Location W Sample 1		4.3
22	Location W Sample 2		2.0
23	Location W Sample 3		4.5
24	Location X Sample 1		5.7
25	Location X Sample 2		5.6
26	Location X Sample 3		5.0
27	Location Y Sample 1		4.9
28	Location Y Sample 2		5.7
29	Location Y Sample 3		6.8
30	Location Z Sample 1		3.0

1. Graph for Observation Table 1-

The First zone has the highest value of concentration of methane gas which is 6.8, so this region is more dangerous as compared to different parts of the city it could be due to low frequency of maintenance of sewer system and presence of lake near it.

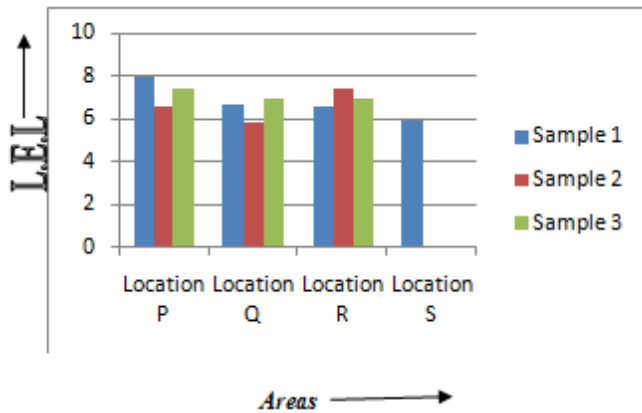


Fig. 3 Graph of data obtained

$$\begin{aligned} &\text{Average of zone 1} \\ &= \frac{8.0+6.58+7.43+6.7+5.8+6.9+6.6+7.4+6.9+5.93}{10} \\ &= \frac{68.24}{10} = 6.824 \end{aligned}$$

2. Graph for Observation Table 2-

While the second zone has low value of methane concentration as compared to the western zone which is 5.4 but it is still in the flammable range of methane it is to be found it is due the population density of this area is very high and in the region some small scale industries are also there.

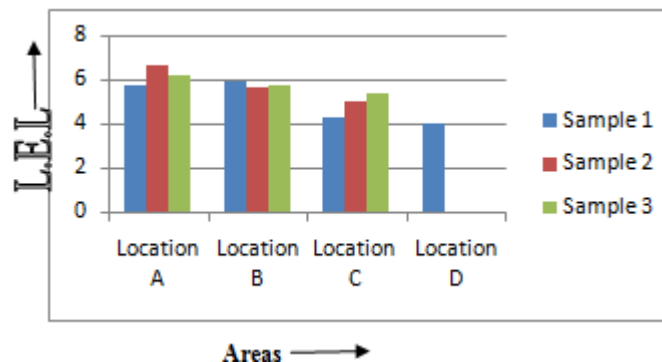


Fig. 3 Graph of data obtained

$$\begin{aligned} &\text{Average of zone 2} \\ &= \frac{5.7+6.6+6.2+5.9+5.6+5.7+4.3+5.0+5.4+4.0}{10} \\ &= \frac{54.4}{10} = 5.44 \end{aligned}$$

3. Graph for Observation Table 3-

In the third zone has the lowest concentration which is 4.75 which is lower than then flammable range of methane it is due to because of the less area is covered by the central zone sewage treatment plant.

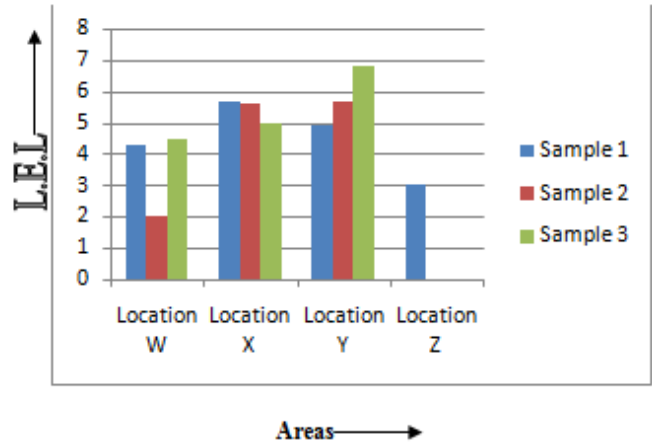


Fig. 4 Graph of data obtained

$$\begin{aligned} &\text{Average of zone 3} \\ &= \frac{4.3+2.0+4.5+5.7+5.6+5.0+4.9+5.7+6.8+3.0}{10} \\ &= \frac{47.5}{10} = 4.75 \end{aligned}$$

IV. RESULTS

The lower explosive limit of the sewer gas is to be found that the two zones has the concentration more than then the permissible exposure limit which is more than 5% as per OSHA standards.

TABLE 3: Result obtained

S.No	Zones/Location	Average value of Methane Concentration	Remark
1.	Western zone	6.8	More than PEL
2.	Eastern zone	5.4	More than PEL
3.	Central zone	4.75	Less than PEL

V. CONCLUSION

It is to be concluded that there is presence of flammable gas which is methane inside the sewer due to

decomposition of waste material in anaerobic conditions inside the sewer and this gas has maximum concentration in the first zone of the city because of high populated area and low capacity of sewage treatment plant as well as the frequency of cleaning of sewage lines should be done within 6 months which was not there. Before entering inside the sewer one need to take some safety precaution which are given below which should be the safe operating procedure while cleaning as sewage line to prevent the death of the sewage cleaning worker-

1. It is necessary to appoint trained workers who have experience of this task should be appointed with a qualified supervisor.
2. Complete description of hazard should be explained by the supervisor should be given to the worker along with the emergency rescue operation.
3. All the necessary equipments and protective gears should be provided with proper work permit.
4. Before commencement of the work the area of work shall be clearly marked and barricading should be done along the site.
5. Ventilation should be provided inside the sewer line by opening the adjacent two or three manhole on the both sides of lines 1 hour prior to work and if this is not possible then mechanical ventilation should be provided before entering inside the sewer.
6. Use of gas monitors for toxic as well as flammable gas like Methane, Hydrogen sulfide, Carbon monoxide, etc.
7. If there is a traces of any gas then the team should wait and again check for the presence of the gas using a long handle gas monitoring pole and extend the period of wait until there level of gas are within the limits.
8. While performing this work it is necessary that one should a safety harness whose one end should be held by a person standing outside the manhole so that the worker cleaning inside the sewer line gets unconscious he may be rescued with help of harness.
9. No equipment should be used which could ignite a spark inside the sewer manhole electrical flame proof flashlights should be used.
10. All the workers should have proper knowledge about the emergency first aid like Cardio pulmonary resuscitation (CPR).
11. After completion of work all the equipment and safety gears should be cleaned and it is necessary for all the workers to take a bath for prevention from any kind of infection and all the barricades, sign boards shall be removed from work place.

12. The entire operation shall be monitored and documented by supervisor.

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