International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Low-Cost Device to Mitigate Economic Impacts of Sewer Gases on Human Productivity

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Abstract: ***In this paper, we present the design and development of a low-cost sewer gas monitoring system using MQ gas sensors and an Arduino Mega microcontroller. Real-time sewer gas monitoring is essential for maintaining public health and safety. A large class of citizens living and/or working in the vicinity of sewer canals are prone to various health issues and financial setbacks. This research paper additionally conducts a survey to comprehend the impact of sewer gas on diverse factors associated with productivity and the economy. The findings underscore the necessity for the development of an affordable handheld device for promoting health awareness. The suggested system in this paper provides an efficient and reasonable solution to monitor gas levels and indicate possible health hazards. The concept and execution of the system, including sensor selection, circuit design, and microcontroller programming, which are explained in depth. Experimental results confirm the system's precision and dependability in detecting harmful chemicals often found in sewer gas, such as methane and hydrogen sulfide. The system's potential uses in other contexts, including residential buildings and wastewater treatment facilities are also covered in the article. Overall, this research helps to create accessible, affordable tools for environmental monitoring and safeguard public health.***

Keywords: Low Cost, MQ, Sewer, Economy, Productivity

1. Introduction

Sewer canals produce toxic gasses which spread in its vicinity. Citizens living in the vicinity of sewer canals are prone to health issues. Though they don't come into contact with sewers directly, gasses coming out of sewers can spread in the environment and exposure to it can cause health issues for them. These gasses contain methane which is explosive and a major contributor to climate change[1], carbon monoxide which is very poisonous[2], hydrogen sulfide which is corrosive and poisonous[3] and ammonia which is toxic and has adverse effects on human health[4,5]. Hydrogen sulfide, carbon monoxide, methane, and ammonia are all present in sewer gas, which poses a major threat to the public's health and safety. Monitoring sewage gas is therefore essential for maintaining both the environment and public health. However, conventional methods of monitoring sewage gas require expensive equipment and skilled people. This may be unaffordable for many communities, particularly those in developing countries or low-income areas. Individuals employed in sewer canals face a heightened vulnerability to the harmful impact of toxic gasses emitted from these environments. Conversely, a significant portion of the population not directly involved in the sewage industry is either unaware of the effects of sewer gasses or are ignorant about them due to the expensive nature of gas measurement equipment. Thus, there is a critical need to develop an affordable system that can detect harmful gasses and indicate the level of toxins in it. In addition to the health concern mentioned above, the presence of sewage gas in the environment can also result in a number of problems, including decreased productivity, a decline in property value, increased environmental cleanup costs, etc. Sewer gas contamination leads to illness, which reduces productivity.

It's important to note that the economic effects of sewer gas on public wealth can vary depending on the specific circumstances and the level of exposure. Mitigation measures, such as regular inspection and maintenance of sewer systems, the implementation of safety protocols, and public education campaigns, can help minimize the economic impact by reducing the occurrence and severity of health issues associated with sewer gas exposure.

MQ gas sensors and an Arduino Mega microcontroller are utilized in the low-cost sewer gas monitoring system that is described in this work. The system is designed to offer a practical and affordable option for real-time monitoring of sewer gas, enabling the early detection and reduction of any risks. Residential buildings and wastewater treatment facilities could both benefit from the widespread use of this technology, which would enhance environmental and public health management.

2. Literature Survey

To make the objective of our research work we started with a literature review, which is written below. The research conducted by Umapathi et. al [6] says that worker safety can be improved in drainage systems by integrating MQ series gas sensors with an Arduino microcontroller. The focus was on detecting methane, carbon monoxide, and hydrogen sulfide in order to provide early warnings to people in the area and notify authorities, thereby limiting potential threats.

"Early Warning System To Detect Sewage Blocks And Hazardous Gases Using IoT"Brindha, S., Priya,[7] says the research investigates the early detection of sewage blockages through the implementation of an IoT-based underground drainage monitoring system. The primary objectives include providing cost-effective, easily maintainable and rapidly

deployable solutions to mitigate the risk of sewage floods and exposure to hazardous gasses.

According to Hema, L. K., Velmurugan, S., Suriya, Pa., and R. Indumathi's research, "Smart Manhole Toxic Gas Identification and Alerting System[8], this research aims to address the crucial issue of manual sewer system cleaning by introducing a smart manhole system for toxic gas detection and alerting. The primary purpose is to protect workers by quantifying hazardous gasses and proactively applying safety measures.

Below literature is written for Sewer Gas Composition and Health Risks:
Sewer gasses, which contain carbon monoxide (CO), hydrogen sulfide (H_2S), ammonia(NH_3) and methane(CH_4) provide a variety of health concerns at various concentration levels.

a) CO (Carbon Monoxide):
CO can cause headaches, dizziness, nausea, and, at higher amounts, asphyxiation.

Long-term exposure may cause chronic health problems.Table 01. Shows the effect of CO for different ranges of PPM.

Table 1: Effect of Carbon Monoxide on health [2]

Concentration	Effect
0-9 PPM	Safe
10-35 PPM	Mild Headaches and dizziness after several hours of exposure
36-99 PPM	Exposure to these levels of CO can cause severe headaches, dizziness, nausea, and fatigue within 1-2 hours
100-200 PPM	At these levels, CO can cause a range of symptoms, including confusion, disorientation, and loss of consciousness within 2–3 hours. Prolonged exposure to these levels can be life-threatening
200-400 PPM	These levels of CO can cause severe symptoms ,including unconsciousness and even death within an hour or two of exposure
400-800 PPM	Exposure to these levels of CO can cause convulsions, coma, and death within 2-3 hours
>800 PPM	Can be lethal within 1-2 Hours of exposure

b) H_2S (Hydrogen Sulfide):
H_2S can cause eye and nose irritation and headache. Long-term exposure may lead to smell and respiratory irritation. Table 02. Shows the effect of H_2S for different ranges of PPM.

Table 2: Effect of Hydrogen Sulfide on health [9]

Concentration	Effect
0-1 PPM	Safe
1-5 PPM	Can cause eye and nose irritation, headache and nausea within a few hours of exposure
5-10 PPM	Can cause eye and nose irritation, headache and dizziness within a few minutes of exposure
10-50 PPM	At these levels, hydrogen sulfide can cause eye and nose irritation, headaches, dizziness and nausea within a few minutes of exposure. Prolonged exposure can lead to loss of smell and respiratory tract irritation
50-100 PPM	Lethal after an exposure for 1-2 hours.

c) NH_3(Ammonia):
NH_3 can cause eye and nose irritation and headache. Long-term exposure may lead to chest pain and coughing. Table 3 shows effects of N_{H3} for different ranges of PPM.

Table 3: Effect of Ammonia on health[10]

Concentration	Effect
0-25 PPM	Safe
25-50 PPM	Eye and nose irritation, coughing and a sore throat within a few hours of exposure.
50-100 PPM	Exposure to these levels of ammonia can cause severe eye and nose irritation, coughing and shortness of breath within 30 minutes to an hour of exposure.
100-500 PPM	At these levels, ammonia can cause severe eye and respiratory tract irritation, chest pain and difficulty in breathing within 10–30 minutes of exposure. Prolonged exposure can be life-threatening.
500-1000 PPM	These levels of ammonia can cause severe eye and respiratory tract irritation, chest pain and coughing within a few minutes of exposure. Prolonged exposure can be lethal.
>1000 PPM	Lethal after exposure of 1 - 2 hours.

A. CH_4(Methane):
CH_4 can cause irritation in the eye and headache, dizziness and nausea. Long-term exposure may lead to death. Table 4 shows effects of CH_4 for different ranges of PPM.

Table 4: Effect of Methane on health[11]

Concentration	Effect
0-5000 PPM	Safe
5000-400000 PPM	At these levels, methane may cause headaches, dizziness and nausea within a few hours of exposure
40000-100000 PPM	Exposure to these levels of methane can cause symptoms such as difficulty breathing, rapid heart rate and chest pain within 1-2 hours of exposure
100000 -500000 PPM	At these levels methane can cause unconsciousness and even death within a few minutes to a few hours of exposure

Understanding these effects is critical for setting up suitable safety measures and detection systems in sewage environments in order to maintain the health and well-being of people who reside and/or operate in these areas. Further to study the effects we have performed a survey in Noida to capture real-life data related to sewer toxic gasses and its effect on population living and or/working in the vicinity.

3. Methodology

To address the risks associated with dangerous sewage gasses, this research is divided into two sections:

Part 1: Survey on Effects of Toxic Sewer Gases
Part 2: Solution to Detect Gas Levels for Further Actions

1) Survey on Effects of Toxic Sewer Gases:
A survey was conducted amongst the people of Noida city and following are the visual data representation.

The Data is categorized into four major categories, which are as given in Table 5

Table 5: Survey cases

Survey on effects of toxic sewer gasses			
Case 1	Case 2	Case 3	Case 4
Citizens living in vicinity of sewer canals	Citizens working in vicinity of sewer canals	Citizens living and working in vicinity of sewer canals	other cases

Through our survey, we aimed to collect the data from residents or workers' tenure in the area in terms of the frequency of health issues, financial impacts, property value implications, productivity effects and awareness regarding sewer gas effects.

Apart from local authorities'/management's ignorance, residents in the area are careless about the impact of sewage gasses on health and are unwilling to buy or implement any system, or are ready to pay only if the solution is cost-effective. As shown in Figure 9, if we combine all three groups, hardly half of the population is ready to implement or purchase a system to reduce concerns, and the majority of the people who agree want it to be a cost-effective system.

So from observation we can make out that due to the presence of sewer gasses, residential or commercial properties may experience a significant loss in value. Property owners may experience decreased property values and possible financial losses as a result of unpleasant odors, possible health risks, and the need for remediation. In order to reduce any contamination, environmental cleanup measures may be required if sewer gas leaks or spills happen outside the sewer system. These cleanup tasks can be expensive, necessitating specialized equipment and knowledge, burdening regional governments or private organizations in charge of operating and maintaining sewer systems. Legal and regulatory actions, such as investigations, penalties, or lawsuits, may result from health problems caused by sewer gas. If sewer system management organizations are found to have neglected maintenance or to have systems that do not adhere to health and safety regulations, they may be subject to legal liability and financial penalties. All of this ultimately results in financial loss in one way or another.

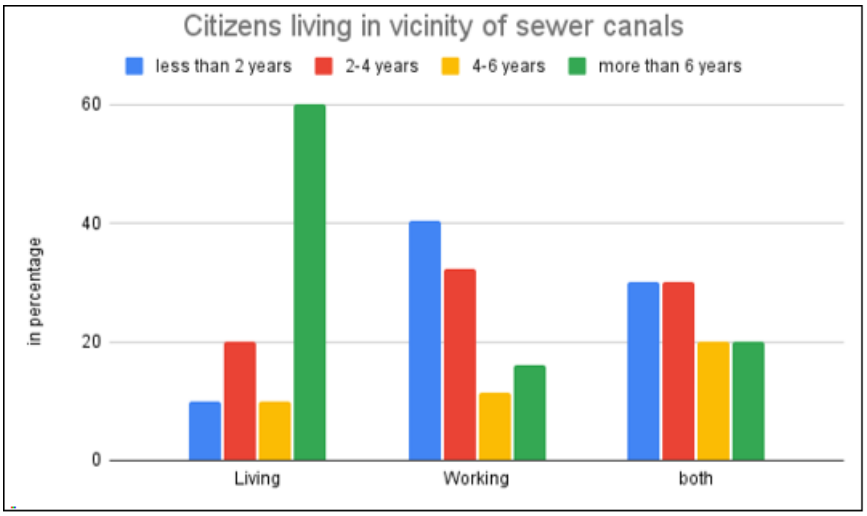

Figure 1: Distribution of since when you are living and /or working in this house/workplace

Figure 1 reveals that, across all categories, a minimum of 60% of the population has been living or working for a period exceeding 4 years. Such a prolonged duration is substantial and may contribute to the development of health issues.

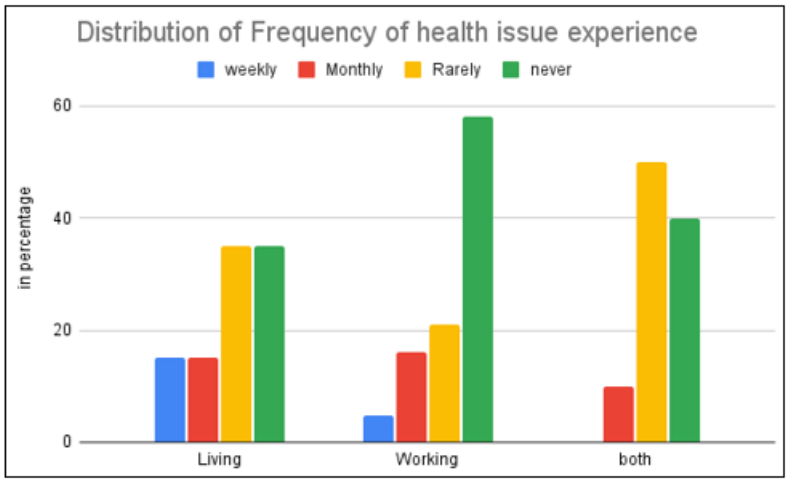

Figure 2: Distribution of Frequency of health issue experience

The depicted figure 2 indicates that a significant portion, exceeding 41%, of individuals frequently encounter health symptoms.

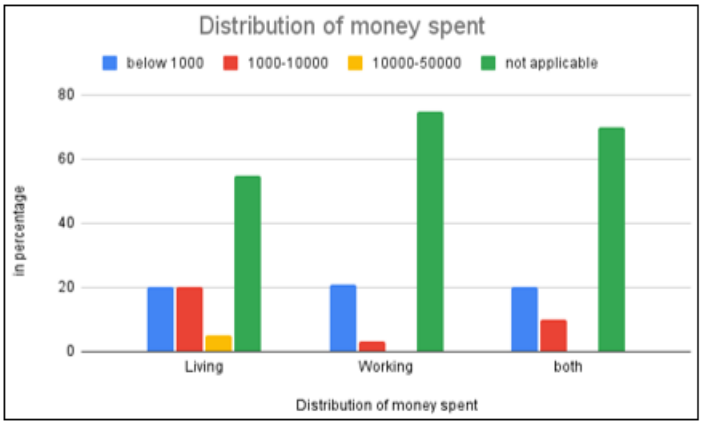

Figure 3: Distribution of money spent on treatment

From Figure 3 we can infer that, Given that toxic gasses lead to health problems, individuals are compelled to allocate funds for addressing the resultant medical issues. It is evident that a minimum of 25% of the population incurs expenses on healthcare This percentage rises for other demographic categories.

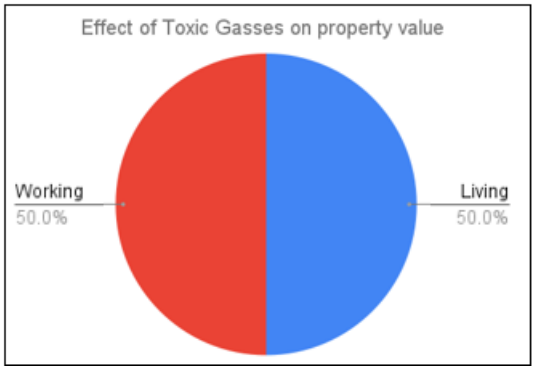

Figure 4: Effect of Toxic Gasses on property value

The depicted Figure 4 illustrates that the existence of toxic gasses influences property values. Sewer gasses emit an unpleasant and enduring foul odor, rendering properties unappealing to potential renters and buyers.

Figure 5: Distribution for If a person had to skip work

From Figure 5 it can be inferred that toxic gasses can significantly impact an individual's productivity, as recurring health issues may compel them to miss work for several days. Moreover, the health issues resulting from exposure can make it challenging to concentrate on tasks while at work. If a person is working or residing in close proximity to these hazardous gasses, they are likely to experience health complications, diminishing their capacity to perform effectively in their professional or daily life.

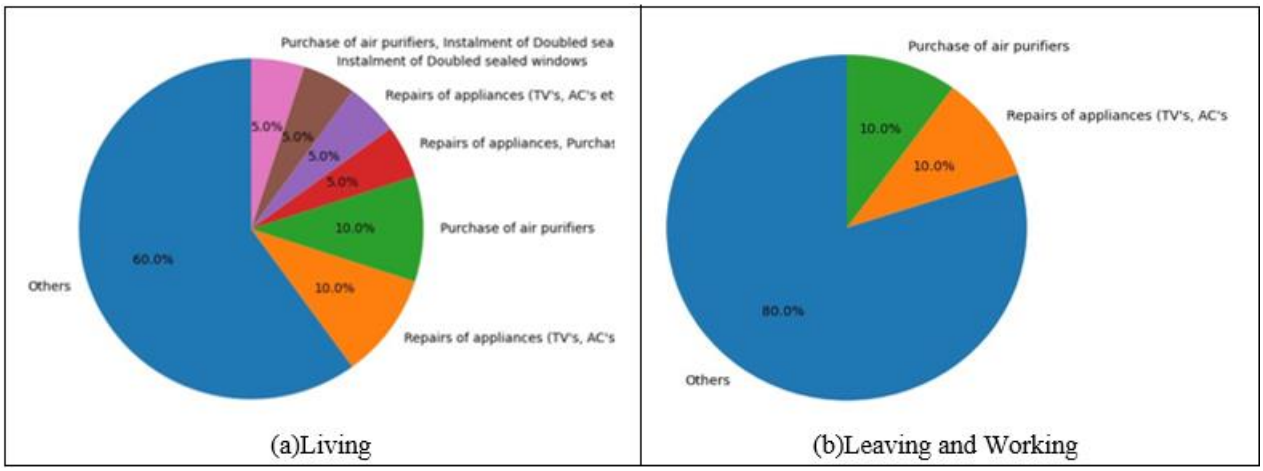

Figure 6: Additional Household Expenses

In Figure 6, the illustrated graph indicates that, beyond health concerns and associated medical costs, toxic gasses impose supplementary expenses for the repair of household devices. Sewer gasses, being poisonous, explosive, and corrosive, exert detrimental effects on the electrical and electronic components of household appliances.

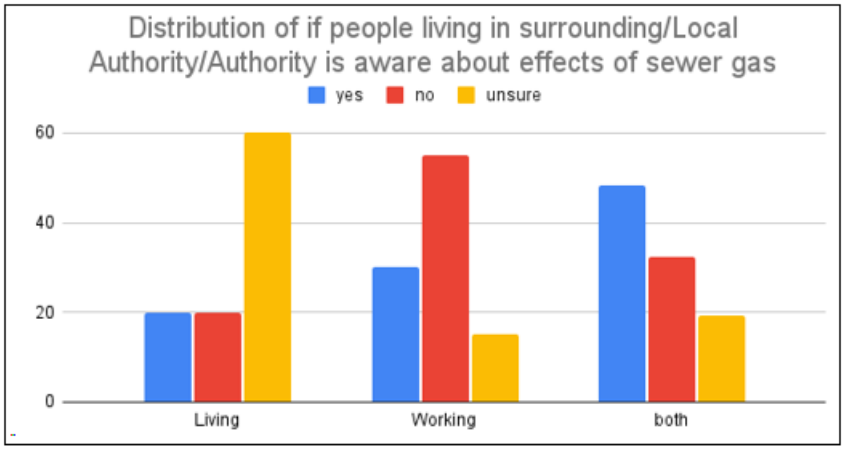

Figure 7: Distribution of if people living in surrounding/Local Authority/Authority is aware about effects of sewer gas

Figure 7 gives information that if there is awareness amongst people about toxic gasses coming out of sewer canals and the effect of it on the health of human beings.It can be seen that there is uncertainty over the awareness about the effects of sewer gasses. For all three categories there is a common pattern that indicates that the authority or local governing body is unaware about the effects of sewer gas on health.

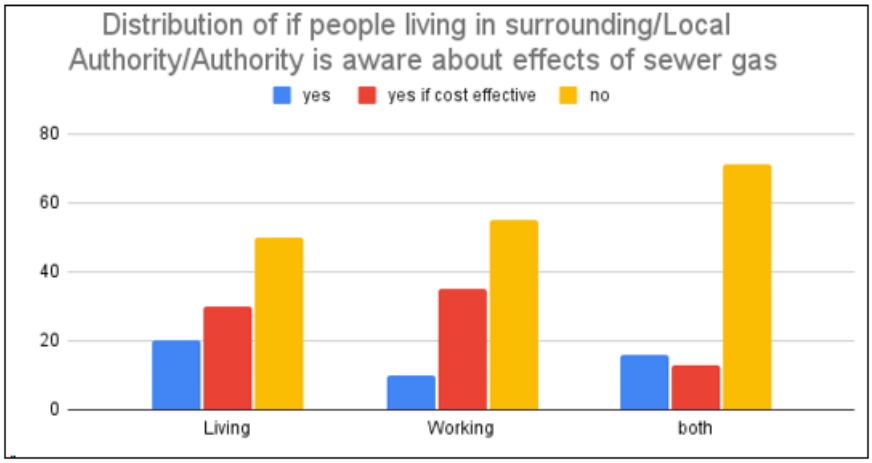

Figure 8: Distribution of citizens living in the vicinity if they would like to implement some system to overcome issues caused by Gases

Figure 8. Depicts that even if authority /local governing body knows about the issue, they haven't taken any steps to mitigate the issue. 70% of the living societies,85% of workplaces and almost 50 for combined workplace and living societies have not taken any action for mitigating these effects.

According to the results, there is a lack of information and indifference regarding the effects of sewage gasses on health, productivity, and the economy. As a result, there's a demand for the development of a low-cost electronic device which is capable of detecting hazardous gas concentrations in the air and an alerting system. Implementing this project can be essential to minimize health risks, reduce financial losses and maintain productivity.

2) Solution to Detect Gas Levels for Further Actions:

a) Sensor Technology Selection:

We used different MQ series sensors to detect harmful gasses in sewage. This includes the MQ2 for methane, MQ7 for carbon monoxide, MQ135 for ammonia, and MQ136 for hydrogen sulfide. These sensors generate diverse values indicative of potential emissions from sewage. Subsequently, the acquired readings are transmitted to the control circuit, which exhibits the data and activates alerts for the designated audience upon surpassing the predefined threshold.

b) System Design:

Figure 9: 3D- Model of prototype`

Autodesk Fusion 360 can be an efficient 3D design software tool to design our system to the fixed position of sensors and display components.

c) Block diagram:

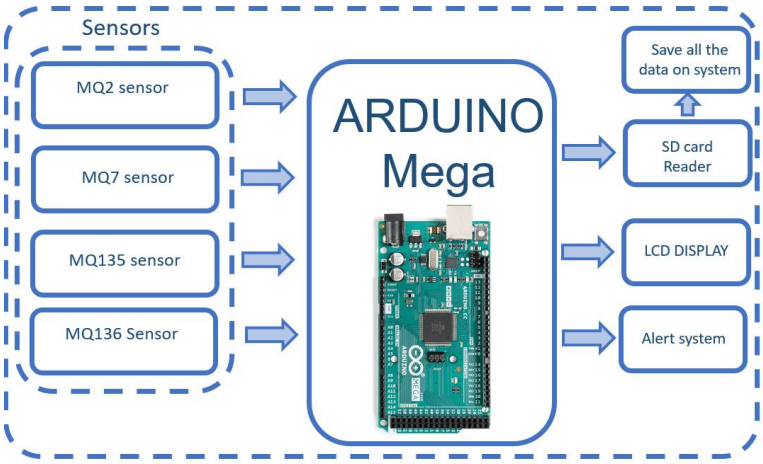

Figure 10: Block diagram of the proposed system

The Arduino Microcontroller, Bluetooth, sensors and display are shown in the block diagram. The Arduino UNO board serves as the brain of the system, which is powered by an ATmega328 IC and coupled with a variety of sensors. MQ-2, MQ-7, MQ-135, and MQ-136 sensors are used to detect gasses such as ammonia, methane, carbon monoxide, hydrogen sulfide and carbon dioxide. Through the Arduino IDE software, the Arduino Reads analog values to digital values. The board functions according to a set of instructions. If the level of gasses rises above the normal level, an alarm is triggered immediately. The data collected by SD cards is analyzed on a daily basis.

d) Integration with Display and Alert System:

In this diagram, you can observe the connection of an Arduino Mega to a diverse set of gas sensors. The system is designed to showcase the gas levels in parts per million (PPM) and issue warnings about potential hazards. This is determined by analyzing the data collected by the sensors, which is then transmitted to the memory module. In addition to the gas sensor, a booster circuit was used to increase the voltage to the necessary level and supply enough current.

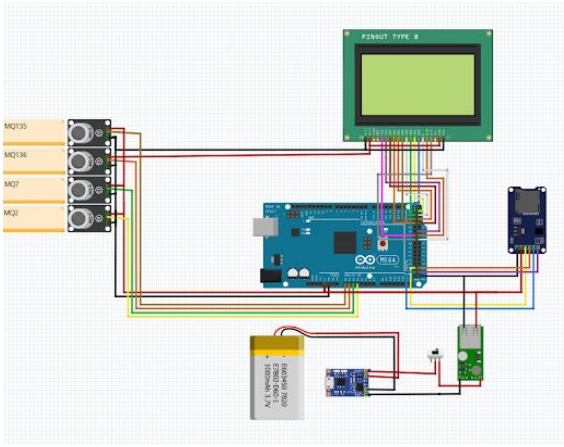

Figure 11: Circuit diagram of the proposed system

3) Comparative analysis:

Our product, which costs approximately Rs. 6800/-, offers itself as a low-cost solution with competitive features in the gas detection industry.

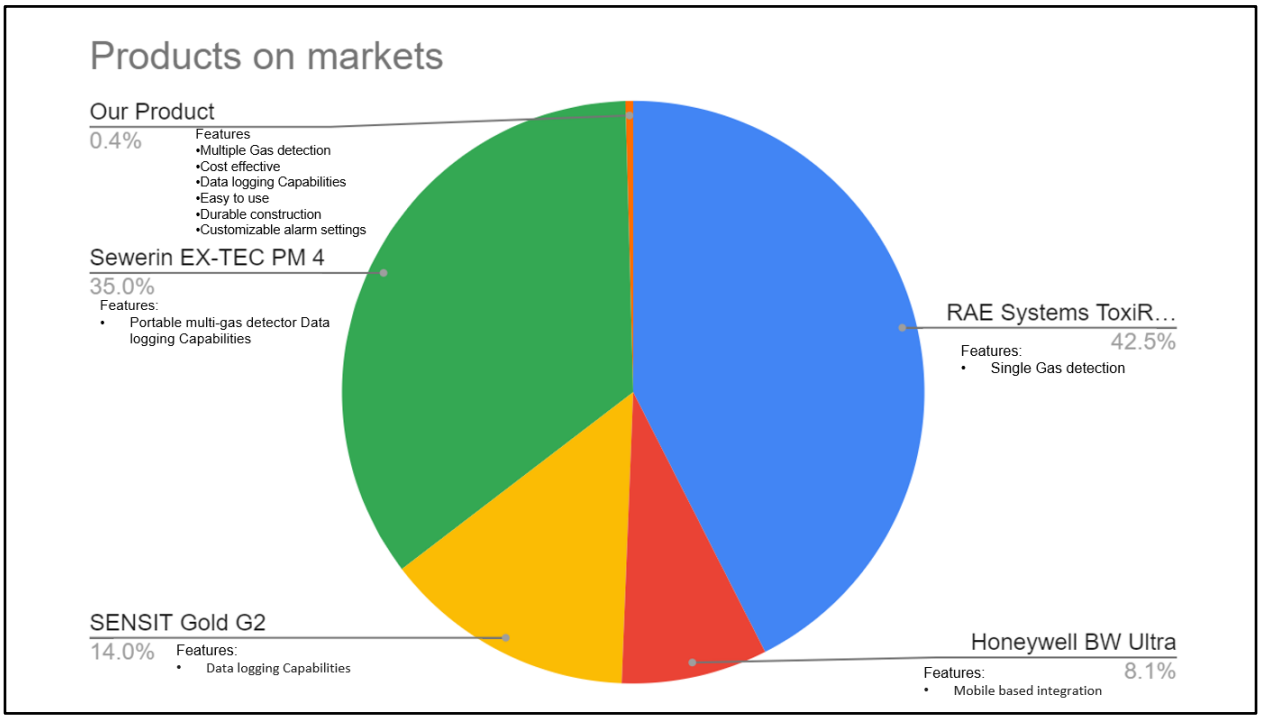

Figure 12: Comparison with other products

4. Result and Discussion

All of the project's requirements have been met, and the circuit has been activated to check for any unusual changes in the physical parameters. If there are any changes, the sensors detect them and send the information to the microcontroller, which then takes appropriate action.

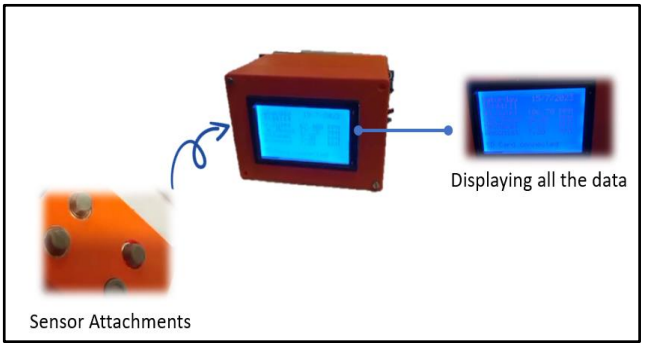

Figure 13: Working Prototype

5. Conclusion

The presence of toxic gasses emanating from sewer canals adversely impacts the health of sewer workers and other individuals residing or working in proximity to sewer canals. This leads to financial losses and decreased productivity. Many individuals are either unaware of the negative effects or choose to ignore them, as the solution often involves a significant financial investment. Therefore, there is a need to develop a device that can monitor the level of gasses and send an alert about the potential hazards.

This system will help in monitoring levels of gasses in sewers and it will help in spreading awareness about possible health hazards. This will help sewage workers to save their lives and prevent expenses for the treatment of diseases. In addition to sewage workers, other residents who live close to the sewer run the risk of developing health problems over a period of time due to exposure to sewer gas. This can also have negative effects on the economy. This system can be useful for tracking gas levels and warning of potential health risks.

This system makes use of inexpensive and readily accessible microcontrollers, such as Arduino Mega and MQ gas sensors. They are much cheaper if compared with the currently existing detection system. Implementing this solution will enable numerous individuals to monitor their surroundings, mitigating the adverse effects of gasses on health and, consequently, preventing financial losses or decline in productivity.

Given the exponential growth in population and rigorous advancement in industrialization, it is anticipated that pollution levels will rise. As a toxic gas detector, this product is designed not only to identify the effects of sewer gas but also to detect other gasses with minimal changes to its architecture. Furthermore, aside from providing indications, we can incorporate an analysis feature. This feature can be utilized to map the potential correlation with diseases resulting from short and long-term exposure to these gasses.

6. Consent and Recommendation

In conducting this research on the impact of sewer gasses on health and productivity, ethical considerations were paramount. Informed consent was obtained from all participants, ensuring they were fully aware of the study's purpose, potential risks, and the voluntary nature of their participation. Anonymity and confidentiality were strictly maintained throughout the study to protect the privacy of the participants.

References

[1] Kim, Jihyoung, Jung Soo Lim, Jonathan Friedman, Uichin Lee, Luiz Vieira, Diego Rosso, Mario Gerla, and Mani B. Srivastava. "SewerSnort: A drifting sensor for in-situ sewer gas monitoring." In 2009 6th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks, pp. 1-9. IEEE, 2009.
[2] Stewart, Richard D. "The effect of carbon monoxide on humans." Annual review of pharmacology 15.1 (1975): 409-423.
[3] Lewis, R. Jeffrey, and G. Bruce Copley. "Chronic low-level hydrogen sulfide exposure and potential effects on human health: a review of the epidemiological evidence." Critical Reviews in Toxicology 45, no. 2 (2015): 93-123.
[4] Ryer-Powder, Jill E. "Health effects of ammonia." Plant/operations progress 10, no. 4 (1991): 228-232.
[5] Badrinath, S., J. Devaganesh, B. Santhi, and S. Saravanasankar. "The Adverse Human Health Effects Due To Ammonia, Hydrogen Sulphide and Chlorine in the Process Industry: A Review." Int. J. Mech. Prod 8 (2018): 394-402.
[6] Umapathi, N., SaiTeja, SaiKiran, Roshini. (2019). "Detection of Explosive Sewage Gases in Drainage Systems Using an Arduino." JETIR, March 2019, Volume 6, Issue 3, Jyothishmathi Institute of Technology & Science – Karimnagar, Telangana, India. Retrieved from www.jetir.org (ISSN-2349-5162).
[7] Brindha, S., Priya, D., Brintha Shree, S. S., Siranjeevi Srinivasan, S., Lakshmipriya, N. (Year). "Early Warning System To Detect Sewage Blocks And Hazardous Gases Using IoT." PSG Polytechnic College, Coimbatore, India.
[8] Hema, L. K., Velmurugan, S., Suriya, Pa., R. Indumathi. (Year). "Smart Manhole Toxic Gas Identification and Alerting System."
[9] Lambert, Timothy William, Verona Marie Goodwin, Dennis Stefani, and Lisa Strosher. "Hydrogen sulfide (H2S) and sour gas effects on the eye. A historical perspective." Science of the total environment 367, no. 1 (2006): 1-22.
[10] Timmer, Björn, Wouter Olthuis, and Albert Van Den Berg. "Ammonia sensors and their applications—a review." Sensors and Actuators B: Chemical 107, no. 2 (2005): 666-677.
[11] Mohajan, Haradhan. "Dangerous effects of methane gas in the atmosphere." (2011): 3-10.