IOT Based Unmanned Aerial Vehicle For Mobile Monitoring And Management Of Municipal Solid Waste (MSW) Landfill Sites And Air Quality Index (AQI)

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Abstract: With ever increasing population limits, Solid and Air pollution levels in the major cities of India are at appalling limits. One major obstacle to effective waste management is the lack of monitoring sources at the site of pollution. This is primarily due to inaccessibility of the site or the cost involved in monitoring. Due to ineffective monitoring, Municipal solid waste landfill sites (MSWLF) expand rapidly and encroach upon fresh water sources. These landfill sites also pose other hazards such as a fire risks from methane emissions which may subsequently increase particulate matter (PM 2.5) levels in the air. Furthermore, due to the significant growth of industries in and around the major urban centers of India, monitoring the Air quality index (AQI) has become imperative. The AQI readings in most of the major cities in India are biased due to the short ranges of Monitoring stations. With periodic and frequent monitoring of the MSWLF sites and AQI limits, Authorities can undertake more decisive actions to combat pollution. This article reviews the perspective of using an IOT based drone connected to the cloud for effectively monitoring the MSWLF sites and AQI levels very frequently in a short span of time. The suggested drone would have sensors categorized into two sets of components. The components for monitoring the MSWLF site would consist of a light detection and ranging (LIDAR) sensor along with a thermal imaging camera while the AQI monitoring component will include a PM 2.5 sensor along with a gas detection chamber. These two components would be connected to a cloud server and the obtained information would be updated to a crowd sourced database. The obtained data from the landfill monitoring component will be analyzed using suitable machine learning algorithms to prevent events like fire outbreaks from methane emissions, slippage of wastage slopes, expansion of the site from defined limits etc.

Index Terms: Drones, IoT, MSWLF, AQI, Machine Learning, Predictive Maintenance.

1. INTRODUCTION

Most of the Municipal solid waste landfill sites in India are expired and exhausted. These Landfill sites are neither scientifically constructed nor managed. They are located near residential areas and waterbodies. For example, The Landfill Sites in Perungudi, Chennai, have destroyed the marshland ecosystem over the years as it expanded to meet the city’s demand. Together with expanding landfill sites, Due to rapid industrialization and increasing traffic levels, Air pollution has become a serious problem across all the major cities in India. Landfill sites and poor air quality pose several hazards to general living conditions. Thus, it has become imperative for authorities to Manage and control pollution sources. The first step in Management of these pollution sources is effective monitoring in a short span of time. Conventional monitoring methods employed to survey landfill sites and Monitor AQI are ineffective, biased and Time consuming. With recent Advancements in drone technology and IoT based cloud servers, monitoring of pollution sources can be done more efficiently to a substantial degree than Existing methods. Furthermore, the obtained data can be processed using suitable Machine learning algorithms for predictive maintenance.

2 REVIEW OF LANDFILL SITES

A. Chennai Landfills

According to the Solid Waste Department of Chennai Corporation, Per capita generation of solid waste per day is 650 grams and about 5400 MT of garbage is generated from the city. The garbage is collected and dumped into two landfill sites in Kodungaiyur, located in northern part of the city and Perungudi, located in the southern part of the city. The landfill sites in Chennai are being managed by the Greater Chennai Corporation. the mode of disposal of waste is 100% by landfills. The mode of disposal of waste is 100% by landfills. The emission flux in Kodungaiyur Landfill site ranged from 0.9 to 433 mg CH\textsubscript{4} m\textsuperscript{-2} h\textsuperscript{-1}, 2.7 to 1200 µg N\textsubscript{2}O m\textsuperscript{-2} h\textsuperscript{-1} and 12.3 to 964.4 mg CO\textsubscript{2} m\textsuperscript{-2} h\textsuperscript{-1} [1] the average values of methane emission is found to be highest at Perungudi Landfill site amongst all the other landfill sites in Chennai[2]. Figure 2.1 shows the gradual expansion of Perungudi landfill site from the year 1995 to 2015. The area in the grey represents the marshland surrounding the landfill. The area in the yellow represents the landfill site. We can see the increase in landfill size and reduction in marshlands.

B. Kodungaiyur Landfill

The Kodungaiyur Landfill site is located in the northern part of Chennai and has an area of 228 acres of land. Around 2400 to 2600 MT of solid waste generated within the city are disposed here. Residential areas are within 0.5 Km from the Landfill Site. The emission flux in Perungudi Landfill Site ranged from 0.9 to 433 mg CH\textsubscript{4} m\textsuperscript{-2} h\textsuperscript{-1}, 2.7 to 1200 µg N\textsubscript{2}O m\textsuperscript{-2} h\textsuperscript{-1} and 12.3 to 964.4 mg CO\textsubscript{2} m\textsuperscript{-2} h\textsuperscript{-1} [1] the average values of methane emission is found to be highest at Perungudi Landfill site amongst all the other landfill sites in Chennai[2]. Figure 2.1 shows the gradual expansion of Perungudi landfill site from the year 1995 to 2015. The area in the grey represents the marshland surrounding the landfill. The area in the yellow represents the landfill site. We can see the increase in landfill size and reduction in marshlands.
and 39 to 906 mg CO₂ m⁻² h⁻¹ [1].

B. Delhi Landfills

1. Ghazipur Landfill Site

Ghazipur is the oldest landfill site in Delhi which was established in 1984. The year of saturation of the landfill site is 2002, but it is still in use. The height of Ghazipur landfill site is about 65m. The waste dumped into the landfill is 1800 – 2000 MT. The landfill is spread over 70 acres. The Ghazipur landfill site is managed by East Delhi Municipal Corporation (EDMC). Residential areas are within 0.2 Km from the Landfill sites and around 3 million people live within 10 km radius of the landfill site. In 2017, part of the landfill collapsed killing 2 people and injuring 5 more. A waste -to-energy plant has been set up by IL & FS Environmental company at the Ghazipur dumpsite, which processes more than 2000 tons per day from Delhi's solid waste. Set up to initially process 1300 tons per day (TPD) of municipal solid waste and generate 12 MW of green power, the plant is built with a capacity to process 2000 TPD of waste.

C. Mumbai Landfills

Mumbai is the highest solid waste generating megacity in India, followed by Delhi, Kolkata, Chennai. Mumbai generates about 7000 MT of garbage daily, which are being dumped into Deonar and Kanjurmarg landfill sites. The landfill sites in Mumbai are being managed by the Brihanmumbai Municipal Corporation (BMC). the mode of disposal of waste is 91% by landfills and 9% by composting in Mumbai [1].

1. Deonar Landfill Site

Deonar landfill site is India’s oldest and largest landfill site in terms of area being established in 1927. The dumping ground extends over 132 hectares and receives over 5500 MT of solid waste and 25 Tons of Bio – Medical Waste daily. In August 2008, BMC decided to close section of a landfill site and used it to generate 7 to 8 MW of electrical power from methane extraction. In January 2016, a major fire broke out in the landfill site due to undetected methane emissions. Frequent fires at the dump site has caused conditions harsh for residents near the landfill site Infant Mortality rate in the nearby areas is 60 – 80 per 1000 live births, which is almost double that of the average (35.2) for Mumbai City.

<table>
<thead>
<tr>
<th>Landfill site &amp; year of construction</th>
<th>Planned Capacity (MT per day)</th>
<th>Actual Capacity (MT per day)</th>
<th>Area occupied when constructed (acres)</th>
<th>Current area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perungudi 1998</td>
<td>1600</td>
<td>5400</td>
<td>80</td>
<td>220</td>
</tr>
<tr>
<td>Kodungaiyur 1992</td>
<td>900</td>
<td>2800</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Ghazipur 1984</td>
<td>2000</td>
<td>9500</td>
<td>13</td>
<td>55</td>
</tr>
<tr>
<td>Deonar 1995</td>
<td>2500</td>
<td>5500</td>
<td>15</td>
<td>48</td>
</tr>
</tbody>
</table>

3 AQI MONITORING IN INDIA

An Air Quality Index (AQI) is used by government agencies to denote Current and forecasted air pollution levels. Increased AQI signify risk to the public. In India, the national Air Quality Index was launched in New Delhi on September 17, 2014. The Central Pollution Control Board and State Pollution Control Boards is operating more than 342 monitoring stations under National Air Monitoring Program (NAMP) in over 240 cities across India. Most of these Stations are stationary and are designed to Monitor eight pollutants (PM₁₀, PM₂.₅, NO₂, SO₂, CO, O₃, NH₃, and Pb). According to a 2017 Greenpeace Report, The Number of operational AQI monitoring stations in India is less when compared to other major developing countries like China. Furthermore, the AQI data collected by most monitoring stations tend to be biased and continue to be plagued by several discrepancies as most of these stations tend to be located far away from the industrial zones and Urban areas. Thus, the AQI data across some tier 1 cities and most of the tier 2 and tier 3 cities are full of discrepancies due to improper positioning and inadequate covered Range of the monitoring stations.

4 GROUND SURVEYING VS AERIAL SURVEYING

Topological Survey method is one of the most commonly used surveying methods for determining the landfill capacity. Topographical mapping is the process of graphically representing natural and man-made features for a given locality and for the determination of the configuration of the terrain on a map. Topographical maps can be developed using ground or aerial surveys. The type of survey is based on landfill parameters such as landfill size, total costs, availability of a survey crew. Airspace is an important parameter in maintaining the landfill which needs monitoring.

A. Ground Survey:

A ground survey is conducted using a ground crew to develop a topographic map representing the existing terrain. Ground surveys are usable in essentially all situations where topographic or boundary data is needed for landfill operations. Ground surveys are most likely to be cost-effective for smaller landfills, usually about 10 acres or less.

B. Aerial (Photogrammetric) Survey:

Photogrammetry is defined as the branch of science which deals with making measurements and preparing maps from aerial photographs. The horizontal distances, elevation, profiles and cross – sections can be measured from aerial imagery from UAVs. Aerial imagery is usually done for larger landfills more than 10 acres. Aerial imagery had higher operational cost before the usage of UAVs such as drones. By using drones, the cost of surveying can be brought down to less than that of ground surveying.

C. Use of UAVs for Monitoring Air pollution

UAVs affixed with the appropriate gas sensors can be used to detect the presence of harmful pollutants. The monitoring process of AQI through an UAV involves the detection of presence of gases and PM levels for a short period of time rather than continuous monitoring. However, it can be used to monitor the required parameters for inaccessible areas or extend the range of Monitoring stations [4].
5 INTERNET OF THINGS (IOT) ARCHITECTURE
Sensory Data From the drone is processed and sent to a cloud server via its own modified IoT Architecture. The Sensory Data from the drone is passed through five layers of IoT architecture before being finally sent to the end Network.

![Figure 5.1 IoT Architecture](image)

Perception Layer
This is the initial layer consisting of sensors to collect data from its environment. Data is Acquired from both the Landfill and AQI monitoring Subsystems.

Data Acquisition Layer
The collected Data is converted from its analog form into its digital form for further processing. Suitable microprocessors along with microcontrollers are present.

IoT Gateway Layer
This is the primary Gateway that serves to route data to a WLAN/LTE for Further Data processing.

Processing Layer
Edge analytics allows the data to be preprocessed before being sent to the cloud. Further analysis of data can be performed using cloud analytics.

Application Layer
The Application Layer delivers the application specific service to the End User.

6 ARTIFICIAL NEURAL NETWORKS(ANN)
Artificial Neural Networks are computational models based on structure and function of biological Neural Networks. ANNs is useful in modeling the nonlinear relationship in the data, the complex relationships between inputs and outputs can be modeled with higher precision using ANN. Suitable Artificial Neural Network can be used for finding the AQI. The Hyperparameters for the ANN are found using Genetic algorithm. The ANN is deployed in the cloud platform for automating the task. The output layer of the neural network consists of the AQI of a given area based on the input parameters.

7 MACHINE LEARNING PIPELINE

![Figure 7.1 Machine learning Model Process](image)

Data Collection
The datasets for the training phase of ML model is collected. Data collection is one of the hardest parts of the ML pipeline as not many sources are already available. The data is taken from the data.gov website for which the AQI has been found. The ML models mentioned in this paper is of supervised learning.

Data Preprocessing
Missing data is a problem when comes to data preprocessing. The datasets are first analyzed, and the missing data are identified. The input parameters are selected (feature extraction). The input parameters which has the highest impact on the output are identified in this process (feature selection). Feature scaling is then done for normalizing the data. Feature extraction, feature selection is done so that the model does not overfit or underfit the data and also to make sure that there is no bias in the ML model. Dimensionality reduction is done further if required by Principal Component Analysis (PCA).

Data Sampling & ML Algorithm training
The dataset is further split into training and testing data. The training data is used for training the ML model and the testing data is used to evaluate the model’s accuracy in prediction. ML algorithm is then trained using the training data.

Hyper Parameter Optimization
After the training phase of ML algorithm on training data, the algorithm’s performance is tuned by optimizing the hyper parameters such as the number of hidden layers in the neural
network.

**Post-Processing**

Post-Processing generally involves validating whether the model is performing well on the test dataset (Generalization) with the help of performance metrics such as loss function, cost function and back propagation in neural network.

**Generalization**

The ML model is now trained on the dataset and optimized. The data from the sensors can now be fed into the model for prediction.

8 **LANDFILL MONITORING SYSTEM**

The Landfill Monitoring sub-system consists of a LIDAR, thermal imaging camera, Optical Camera and a methane gas sensor.

Methane Gas Sensor

The methane gas sensor is used to find the levels of methane gas produced from the landfill sites and the data is further used to find if the landfill site has a vicinity to get fire accident, and it can be also used for finding the resources for methane collection from the landfill sites.

Methane Production from landfill sites

Methane (CH₄) is a colorless, odorless, and highly flammable gas, when burned in the presence of oxygen, it produces carbon dioxide and water vapor. Of all the greenhouse gases, methane is one of the most potent because of its ability to efficiently absorb heat in Earth’s atmosphere. Methane is the primary component of natural gas and is used to produce heat and electricity around the world. The gas is also a significant contributor to climate change. In 2017, methane accounted for roughly 10 percent of all human-driven greenhouse gas emissions in the U.S., according to the EPA. In the US, landfills are the third largest source of methane. Methane is produced when organic wastes decomposes in landfills. Landfill gas consists of forty to sixty percent methane, with the remainder being mostly carbon dioxide. A CPCB report of 2015 states that since 2011, 7 megacities of India accounted for nearly 48 percent of total methane emissions in the country, courtesy of the large landfills in these cities. When MSW is first deposited in a landfill, it undergoes an aerobic decomposition stage with little methane generation, carbon dioxide and water vapor is produced as a by-product. Then typically after one-year, anaerobic conditions are established and methane producing bacteria begin to decompose the waste and generate methane. The bioreaction in landfill sites in anaerobic conditions takes place in acetogenesis and methanogenesis reactions.

Acetogenesis

\[ C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO \]

Methanogenesis

\[ CH_3COOH \rightarrow CH_4 + CO \]

\[ CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O \]

The methane gas which is produced from the landfill sites are collected in landfill sites such as Deonar rather than escaping into the atmosphere. The methane gas detection system helps in identifying methane gas levels in a certain area for preventing fires in landfill sites and the wastes from that area can also be used for methane collection. The landfills that capture biogas in US collect about 2.6 million tons of methane annually, 70% of which is used for generating heat and electricity. Theoretical studies indicate that complete anaerobic degradation of MSW generates about 200Nm³ of methane per dry ton of contained biogas [5].

**Thermal Imaging**

Thermal imaging cameras work by detecting radiation in the long infrared range of the electromagnetic spectrum (9 – 14 µm) and produce images of that radiation. Landfill sites has a vicinity to get frequent fires. Thermal hotspots and methane emission in landfills turn out to be the root cause for fire accidents.
Drones can be equipped with thermal imaging cameras for taking aerial images of landfill sites. Thermal imaging cameras can be used for finding areas with thermal hotspots.

**LIDAR**

LIDAR (Light Detection And Ranging) is an airborne or terrestrial surveying method where a pulsed laser light is used to determine the distance to a target [6]. Recent advancements have made the possibility of using LIDAR sensors in drones to acquire data such as area covered, distance between two subsequent objects, height of an object, etc., in a short span of time. The Lidar sensor used for drones performs laser scanning when the drone is airborne. This active remote sensing technique can be used to provide Digital Elevation Models (DEMs) for characterization of trees, shrubs and other vegetation. This method allows efficient survey of difficult terrain and large areas [7]. The lidar sensor will form an integral part of the landfill monitoring subsystem. Important parameters to be measured include the area covered by the landfill site, height of landfill slopes and periodic checks to determine if set boundary limits are encroached. Determination of covered area and prevention of expansion beyond defined boundary limits.

**Determination of covered area and prevention of expansion beyond defined boundary limits**

**Methods**

Slope stability can be found out by using methods of limits equilibrium. This method requires information about the strength parameters and geometrical parameters of the soil. The slope stability is found in methods of limit equilibrium by finding the factor of safety. Factor of Safety is found out for the surface, which is more likely to fail, critical slip surface. There are two types of mechanisms of modes of failure, circular critical failure mechanism and wedge critical failure mechanism. This method has varying degrees of accuracy based on the assumptions. The factor of safety is defined as the ratio of reaction over action. While evaluating the slope stability, it is important to find the location of the critical slip surface and its value of factor of safety.

**Limit Equilibrium Method**

Determination of slope stability is a complex task as it involves modeling of multi-variate dynamic systems of non-linear behavior. The slope stability was finding out using Artificial Neural Networks. Slope stability was found out by using the method of limit equilibrium. Slope stability estimation is a complex problem which involves parameters from geotechnical and geometrical parameters. The slope stability was found out using Factor of Safety (FOS) which can be modeled as a function approximation problem or a classification model. Slope estimation is a complex problem as only a rough overall description of the physical and geometrical characteristics of the slope is given as an input to the ANN. Neural Networks provide descriptive as well as predictive analysis. The relative importance of the parameters can also be studied.

**9 USING ANN**

The wedge failure mechanism is considered as the mode of critical failure. The input parameters for wedge mode of failures are the unit weight(γ), cohesions (C₁ & C₂), angles of internal friction (φ₁ & φ₂), angle of the line of intersection of two joint sets (θ₁) and slope angle (θ₂).
Figure 9.1  ANN for determining Slope Stability

joint sets($\Psi_p$), slope angle($\Psi_f$), height($H$). Some of these parameters can be calculated from the UAV and the other parameters are calculated manually. The output layer consists of a single neuron which gives the value of Factor of Safety (FoS), from which the Status of Stability of the landfill can be found out.

10 AQI MONITORING SYSTEM

AQI in India

AQI is an index used for finding level of air pollution at a particular place. Different countries have their own methods for finding the Air Quality Index. The National Air Quality Index has been launched in New Delhi on September 17, 2014 under Swach Bharat Abhiyan. The Central Pollution Control Board and the State Pollution Control Board in India monitors more than 342 AQI Monitoring Stations under National Air Monitoring Program. Monitoring AQI levels in many small industrial cities and towns around India has proved to be difficult due to the lack of monitoring stations. To overcome this, UAV’s can act as a cost effective and viable mobile monitoring unit.

Table 10.1  AQI Standards in India

<table>
<thead>
<tr>
<th>AQI Category (Range)</th>
<th>PM$_{10}$ (24hr)</th>
<th>PM$_{2.5}$ (24hr)</th>
<th>NO$_2$ (24hr)</th>
<th>O$_3$ (8hr)</th>
<th>CO (24hr)</th>
<th>SO$_2$ (24hr)</th>
<th>NH$_3$ (24hr)</th>
<th>Pb (24hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (0-50)</td>
<td>0-50</td>
<td>0-30</td>
<td>0-40</td>
<td>0-50</td>
<td>0-1.0</td>
<td>0-40</td>
<td>0-200</td>
<td>0-0.5</td>
</tr>
<tr>
<td>Satisfactory (51-100)</td>
<td>51-100</td>
<td>31-60</td>
<td>41-80</td>
<td>51-100</td>
<td>1.1-2.0</td>
<td>41-80</td>
<td>201-400</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>Moderately Polluted (101-200)</td>
<td>101-250</td>
<td>81-180</td>
<td>101-168</td>
<td>2.1-10</td>
<td>81-380</td>
<td>401-800</td>
<td>1.1-2.0</td>
<td></td>
</tr>
<tr>
<td>Poor (201-300)</td>
<td>251-350</td>
<td>91-120</td>
<td>169-280</td>
<td>10-17</td>
<td>381-800</td>
<td>801-1200</td>
<td>2.1-3.0</td>
<td></td>
</tr>
<tr>
<td>Very Poor (301-400)</td>
<td>351-430</td>
<td>121-250</td>
<td>209-400</td>
<td>17-34</td>
<td>801-1600</td>
<td>1200-1800</td>
<td>3.1-3.5</td>
<td></td>
</tr>
<tr>
<td>Severe (401-500)</td>
<td>430+</td>
<td>250+</td>
<td>400+</td>
<td>748+</td>
<td>1600+</td>
<td>1800+</td>
<td>3.5+</td>
<td></td>
</tr>
</tbody>
</table>

There are six AQI categories in India, they are Good, Satisfactory, Moderately Polluted, Poor, Very Poor, Severe. The AQI Model consists of eight pollutants such as PM$_{10}$, PM$_{2.5}$, NO$_2$, SO$_2$, CO, Ground level Ozone, NH$_3$ and Pb. Based on the concentrations of these constituents in the ambient air the corresponding AQI Standards and the likely health impact are calculated.

Table 10.2  AQI limits and Health impacts

<table>
<thead>
<tr>
<th>AQI Category (Range)</th>
<th>Associated Health Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (0-50)</td>
<td>Minimal Impact</td>
</tr>
<tr>
<td>Satisfactory (51-100)</td>
<td>May cause minor breathing discomfort to sensitive people</td>
</tr>
<tr>
<td>Moderately Polluted (101-200)</td>
<td>May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart diseases, children and older adults</td>
</tr>
<tr>
<td>Poor (201-300)</td>
<td>May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease.</td>
</tr>
<tr>
<td>Very Poor (301-400)</td>
<td>May cause respiratory illness to the people on prolonged exposure. People with lung and heart disease are more susceptible</td>
</tr>
</tbody>
</table>

In the recent years, the AQI levels in Indian cities are at an alarming level especially in densely populated and industrialized areas. The use of an UAV for monitoring the AQI levels is an effective way and replaces the need for stationary monitoring systems which could cost more to the government from the developing countries.

Figure 10.1  AQI Monitoring system components

The World Health Organization report from 2018 suggests that 9 out of 10 people breathe air containing high levels of air pollutants and estimates that 7 million people die due to fine particles in air they cause lung and cardiovascular diseases when inhaled. The inefficient use of energy by households, the agriculture industry, transport sectors, and coal-fired power plants contribute as the major source of particulate air pollution. Sand, desert dust, deforestation, and waste burning are additional sources of air pollution in some regions. Air quality can also be influenced by natural elements such as geographic, meteorological and seasonal factors. The AQI monitoring system monitors the air pollution level and using the results obtained from the system, the people around the area can be warned for wearing masks.

[9] suggests how AQI can be monitored effectively in an area through selective monitoring. The UAV is used for complete monitoring in the first and a 3D map of the AQI has been obtained from the data. Then the UAV selectively

Figure 10.2  ANN for AQI levels
monitors using optimized models for monitoring the area’s where there is higher AQI due to the battery concerns in a drone.

[10] talks on how short-term air quality monitoring can be done using neural networks for taking preventive and evasive actions against air pollution. The author further talks about how AQI monitoring can be used for restricting the traffic, industry in a particular area.

[11] The paper shows how neural network can perform better than multiple regression models. The author says that the pollution-weather relationships are complex and non-linear which can be modeled using neural networks for better results.

[12] The author fits a linear model to a NO2 time series and compares it with a neural network prediction and finds that neural network generally does well. The AQI monitoring subsystem consists of PM 2.5 Sensor, Gas sensors for monitoring NO2, SO2, CO, Ground level Ozone, NH3. The UAV is affixed with a PM 2.5 sensor gas sensors and an air pump to draw air into the detection chamber of the gas sensor. The distinct detection board circuit in its enclosure is affixed to the bottom of the UAV chassis. Once the UAV reaches the sufficient altitude, the detection board can be activated to collect parameters. By using a fleet of UAVs to form a coordinated network across a widespread geographical area, sufficient and vital data can be collected, crowd sourced and shared without constraints. The collected data is aggregated using a microprocessor, the data is then sent to the cloud via 4G LTE module. The data is then pre-processed and analyzed using the regression algorithm. The Multi-Layered Perceptron is selected for finding the AQI from the data collected from the sensors into the six AQI categories. The data is then visualized using a website or an app for displaying the data.

11 CONCLUSION

Conventional Methods of monitoring Landfill sites are inconsistent, time consuming and non-periodic while the lack of adequate AQI monitoring stations which are present in ideal locations pose a challenge to collecting accurate data. These problems may be potentially solved with the use of an Unitary UAV system to effectively Collect Data in a short span of time. Furthermore, the implementation of Proper ML algorithms and ANNs allow the data to be classified and sorted in a short time, allowing authorities to undertake defined actions without the need to spend much time on making decisions. Frequent updates of MSWLF site limits and AQI levels near industrial zones will also act as further incitement to take more action and will increase awareness among the general population.

12 REFERENCES


